SECTION 01 11 00

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. The work covered under this contract will be performed at seven pump stations across the Town of Newton, MA. These pump stations will be rehabilitated, with major equipment replaced to improve the condition of the aging infrastructure.

1.02 DESCRIPTION OF OWNER'S PROJECT

A. The overall project will consist of rehabilitation and replacement work at the following seven pump stations: Quinobequin Road, Elliot Street, Islington Road, Edgewater Park, Hamlet Street, Grayson Lane, and Oldham Road, as shown on the Contract Drawings and related Specification Sections.
   1. Work at 136 Quinobequin Road and 391 Elliot Street will consist of
      a. Demolition and replacement of the pump stations HVAC systems and unitary components.
      b. Demolition and replacement of existing failed dehumidifiers
      c. Demolition and replacement existing odor control system
      d. Replacement of the main influent gate at Quinobequin Road Pump Station
      e. Replacement of the main influent gate at Elliot Street Pump Station
      f. Replacement or removal of channel gates within Elliot Street Pump Station
      g. Installation of wetwell bubble mixing system at Quinobequin Road Pump Station
      h. Wiring of alarms back to SCADA
   2. Work at Islington Road (located in Auburndale Park, access from the south entrance) and Edgewater Park (located in Auburndale Park, accessed from W Pine St) will consist of
      a. Demolition and replacement of the pump stations HVAC systems and unitary components.
      b. Demolition and replacement of existing failed dehumidifiers
      c. Install gas monitoring and loss of ventilation alarming where required and wired back to SCADA.
   3. Work at 24-26 Hamlet Street and Grayson Lane (end of the cul-de-sac) will consist of replacement of the force main and suction piping within the wet wells of each pump station.
   4. Work at Oldham Road (within the road right-of-way adjacent to 60 Oldham Road) will consist of the following
      a. Conversion of the existing dry well pump station into a submersible pumping station includes but is not limited to:
         1) Demolition of dry well interior
         2) Modification of the dry well structure to bring it to grade and be utilized as a wetwell
         3) Installation of submersible pumps and piping

4) Installation of a new valve vault
5) Installation of a new sanitary manhole
6) Relocation of adjacent utilities as required
7) Installation of new electrical and instrument equipment

END OF SECTION

SECTION 01 11 80

ENVIRONMENTAL CONDITIONS

PART 1 GENERAL

1.01 ENVIRONMENTAL CONDITIONS

A. This section describes the environmental conditions which have been observed at the site of the work and which may reasonably be anticipated throughout the life of the project.

1.02 CLIMATE CONDITIONS

A. The site of the work is at an elevation of approximately 100 feet above mean sea level.

B. Climate conditions are described as follows:

Description	Range of Conditions
Winter	-5°F - 50°F (snow/Ice accumulation potential)
Summer	64°F – 82°F
Relative humidity, percent	
• Indoors	50%- 80%
• Average outdoors	69% - 75%
Air temperature, degrees F	
• Outdoors	-5°F - 82°F
• Indoors	50°F - 80°F
Barometric pressure, inches, mercury	29.9 – 30.1

1.03 ADDITIONAL CONDITIONS

A. Additional conditions which may be applicable are specified in other sections.

END OF SECTION

SECTION 01 12 16

WORK SEQUENCE

PART 1 GENERAL

1.01 CONTINUITY OF PLANT OPERATIONS

A. The pump stations are currently and continuously receiving sewage, and those functions shall not be interrupted except as specified herein. The Contractor shall coordinate the work to avoid any interference with normal operation of pump station equipment and processes.

1.02 BYPASSING

A. Bypassing of untreated sewage to surface waters or drainage courses is prohibited during construction. In the event accidental bypassing is caused by the Contractor's operations, the Owner shall immediately be entitled to employ others to stop the bypassing without giving written notice to the Contractor.

B. Penalties imposed on the Owner as a result of any bypass caused by the actions of the Contractor, his employees, or subcontractors, shall be borne in full by the Contractor, including legal fees and other expenses to the Owner resulting directly or indirectly from the bypass. Under the terms of discharge permits issued to the Owner, in the event accidental bypassing occurs, the Owner is liable for the following penalties:

1.03 SUBMITTAL

A. In accordance with Section 01 33 00, the Contractor shall submit a detailed outage plan and time schedule for operations which will make it necessary to remove a pipeline, channel, electrical circuit, equipment, or structure from service. The schedule shall be coordinated with the construction schedule specified in the General Conditions of the Contract Documents and shall meet the restrictions and conditions specified in this section. The detailed plan shall describe the Contractor's method for preventing bypassing of other treatment units, the length of time required to complete said operation, the necessary plant, and equipment which the Contractor shall provide in order to prevent bypassing of associated treatment units.

B. The Contractor shall observe the following restrictions:
   1. Systems or individual equipment items shall be isolated, dewatered, decommissioned, deenergized, or depressurized in accordance with the detailed outage plan and schedule.
   2. The Construction Manager shall be notified in writing at least one week in advance of the planned operation.
   3. The contractor shall prioritize the Work located at Oldham Road Pump Station. This shall be reflected in the contractors submitted construction schedule. Construction activities shall be sequenced to limit the duration of bypass pumping.
   4. The Work within the wet well side of Quinobequin Road and Elliot Street Pump Stations shall be performed during periods of dry weather (June - August). Influent flows must be under 2.5 MGD in order to isolate Quinobequin Road PS and perform work within the wetwell.

5. HVAC outages shall not be conducted during times when ambient temperatures may impact pump station equipment or operations. Contractor shall provide temporary provisions when necessary to maintain normal indoor temperatures and air exchange rates dictated by NFPA 820.
6. Work performed at Oldham Road Pump Station will be limited to the hours between 9AM and 5PM and shall not occur during or interfere with the Boston Marathon.

1.04 SCHEDULE OF CONSTRUCTION

A. The Contractor shall sequence and conduct the Work in order to meet the following Project Milestones:
   1. Project Substantial Completion 300 days following NTP
   2. Project Completion within 60 days of substantial completion

END OF SECTION

SECTION 01 14 19

USE OF SITE

PART 1 GENERAL

1.01 SUMMARY

A. The Owner's operating personnel will be responsible for operating the existing pump station throughout the execution of this contract. Equipment presently installed must be available to plant personnel at all times for use, maintenance, and repair. If it is necessary in the course of operating the plant, for the Contractor to move his equipment, materials, or any material included in the work, he shall do so promptly and place that equipment or material in an area which does not interfere with the plant operation. The Contractor shall not adjust or operate serviceable or functioning equipment or systems except as specifically required by this contract.

B. The existing pump stations will remain in operation throughout the execution of this contract. The Contractor shall schedule and conduct his work to minimize necessary shutdowns and interference with normal operations and maintenance.

C. The Contractor shall notify the Construction Manager, in accordance with Section 01 12 16, 1 week in advance of the time it is necessary to take out of service any existing tank, pipeline, channel, electrical circuit, equipment or structure. The Contractor shall be responsible for providing whatever temporary piping, pumping, power, and control facilities as are required to maintain continuous pump station operation except as otherwise specified. The integrity of existing plant utilities shall be maintained by the Contractor at all times.

END OF SECTION

SECTION 01 22 00

MEASUREMENT AND PAYMENT

I. General

A. The following sections describe the measurement and payment for the work to be performed under the respective items listed in Part 1, 3 BID FORM.

B. The lump sum price stated in Part 1, 3 BID FORM shall constitute full compensation as herein specified, for all of the work completed in accordance with the drawings and specifications. All other activities required in connection with performance of the work, including all work required under Division 1, GENERAL REQUIREMENTS, whether described in the contract documents or mandated by applicable codes, permits and laws, will not be separately paid for unless specifically provided for in the form of general bid, but will be considered to be incidental to performance of the overall project.

II. Item 1

A. The lump sum price for Item 1 shall constitute full compensation for furnishing all labor, materials, tools and equipment and constructing the project, complete to the project limits shown on the contract drawings and called for in the specifications; except for the items specifically included under Item 2 (Sub-bids) and Item 3 (unit price), as shown on the contract drawings and called for in the specifications.

III. Item 2 - Sub-bids

Item 2a Heating, Ventilating, and Air Conditioning (HVAC)
Item 2b Electrical

A. The lump sum prices for the subdivisions of Items 2a to 2b shall constitute full compensation for furnishing all labor, materials, tools, and equipment and performing all work indicated on the drawings and specified for the respective subtrades listed under the subdivisions of Item 2.

IV. Item 3, Unit Price Items

Item 3a Existing Utility Relocation (Allowance)

A. Item 3a – Specific Allowance – Existing Utility Relocation

1. Description

a. The Allowance amount stipulated for this Allowance item shall be the amount shown on the Bid Form to be used to reimburse the CONTRACTOR for the following items:
i. Relocation by third parties of telephone, gas, fiber-optic, cable television, electric, or other underground or overhead utilities that conflict with the new Work, including by not limited to the design of utility relocations, utility company fee to relocate utilities or turn services on or off.

ii. Stormwater, sewer, and water service line relocations that are specifically shown on the Contract drawings shall not be included in this Allowance
iii. This Allowance may also be used, at the discretion of the OWNER, for temporary or permanent relocation of utilities including third party/private utilities, and water, storm, or sanitary utilities to facilitate activities deemed necessary by the OWNER and not shown in the Contract Documents. This is applicable only for work not specifically referenced in the Contract Documents with prior written permission

2. Measurement for Payment

a. Measurement will be based on the actual services performed as determined by the Engineer. The scope of services is not shown on the Contract Drawings and has yet to be determined.

Item 3a Existing Utility Relocation (Allowance)

B. Item 3b – Contingency Allowance

1. Description

a. Under this Item, the Contractor shall include a stipulated lump sum price to be utilized in paying for unspecified additional work. Contractor shall furnish all work necessary to complete miscellaneous additional work when authorized in writing by the Engineer. Miscellaneous additional work is not included in other lump sum bid items.
b. The work included under this item:
i. Providing all labor, materials, tools, and incidentals required to perform unspecified additional work.

2. Measurement and Payment

a. Payment for this item will be made on a lump sum basis in accordance with an approved Contractor's change proposal and written authorization by the Engineer.

END OF SECTION

SECTION 01 32 16

CONSTRUCTION PROGRESS SCHEDULE

PART 1 GENERAL

1.01 SCOPE

A. This section specifies the procedures for preparing and revising the critical path method construction schedule used for planning and managing construction activities. The schedule provides a basis for determining the progress status of the project relative to specific dates and completion time.

1.02 DESCRIPTION

A. The Contractor shall provide a graphic construction schedule prepared by the critical path method of analysis. The critical path schedule shall be prepared from estimates of the required duration and sequence for each item of work and function to be performed. A general guide for preparing such a schedule is contained in "The Use of CPM in Construction, A Manual for Contractors," published by the Associated General Contractors of America.

B. The schedule shall depict all significant construction activities and all items of work listed in the breakdown of contract prices submitted by the Contractor in accordance with the General Conditions of the Contract Documents. The dependencies between activities shall be indicated so that it may be established what effect the progress of any one activity has on the schedule.

C. Time for completion and all specific dates as specified in the Contract Documents and sequencing requirements described in Section 01 12 16 shall be shown on the schedule. Activities making up the critical path shall be identified.

D. No activity on the schedule shall have a duration longer than 21 days or assigned value greater than $100,000, except activities comprising only fabrication, and delivery may extend for more than 21 days. Activities which exceed these limits shall be divided into more detailed components. The schedule duration of each activity shall be based on the work being performed during the normal 40-hour workweek with allowances made for legal holidays and normal weather conditions.

1.03 SUBMITTAL PROCEDURES

A. Within 20 days after the date of Notice to Proceed, the Contractor shall complete a construction schedule conforming to paragraph 1.02 Description and representing in detail all planned procurement and on-site construction activities. The schedule shall be prepared on reproducible paper and may be in draft form with legible freehand lines and lettering. Upon completion of the schedule, the Contractor shall submit the original and two copies to the Construction Manager in accordance with Section 01 33 00.

B. Within 7 days after receipt of the submittal, the Construction Manager shall review the submitted schedule and return one copy of the marked-up original to the Contractor. If the Construction Manager finds that the submitted schedule does not comply with specified requirements, the corrective revisions will be noted on the submittal copy,

returned to the Contractor for corrections and resubmitted as specified in Section 01 33 00.

1.04 SCHEDULE REVISIONS

A. Revisions to the accepted critical path construction schedule may be made only with written approval of the Contractor and Owner. Changes in timing for activities which are not on the critical path may be modified with written agreement of the Contractor and Construction Manager. A change affecting the contract value of any activity, the timing of any activity on the critical path, the completion time and specific dates as specified in the Contract Documents, and work sequencing (Section 01 12 16) may be made only in accordance with applicable provisions of the General Conditions of the Contract Documents.

1.05 PROJECT STATUS UPDATE

A. Project status review and update shall be provided each month as specified in the General Conditions of the Contract Documents.

END OF SECTION

SECTION 01 32 23

SURVEY AND LAYOUT DATA

PART 1 GENERAL

1.01 SURVEY AND LAYOUT

A. The Owner will establish reference benchmarks and baselines as specified.

B. From the information provided, the Contractor shall develop and make such additional surveys as are needed for construction, such as control lines, slope stakes, batter boards, stakes for pipe locations and other working points, lines, and elevations.

C. Survey work shall be performed under the supervision of a licensed land surveyor or registered civil engineer. Contractor shall reestablish reference benchmarks and survey control monuments destroyed by his operations at no cost to the Owner.

END OF SECTION

SECTION 01 32 33

PHOTOGRAPHIC DOCUMENTATION

PART 1 GENERAL

1.01 PRECONSTRUCTION PHOTOGRAPHS

A. The Contractor shall provide preconstruction photographs prior to commencement of work on the site. The photographs shall be digital, and shall indicate on the front of each print the date, name of work, and the location where the photograph was taken. Before construction may start, prints, shall be delivered to the Engineer. Preconstruction photographs shall be taken at locations to be designated by the Engineer. The photographer shall be equipped to photograph either interior or exterior exposures.

1.02 CONSTRUCTION PHOTOGRAPHS

A. The Contractor shall provide construction photographs showing the progress of the work. The photographs shall be taken of such subjects as may be directed, and shall indicate on the front of each print the date, job title and brief description of the photograph including the location where the photograph was taken. Starting one month after the date of the preconstruction photographs and continuing as long as the work is in progress, 10 monthly photographs shall be taken at each site while work is being conducted.

B. Upon acceptance of the work, color photographs shall be made of the work where directed by the Engineer. The photographer shall be equipped to take either interior or exterior exposures, with lenses ranging from wide angle to 135 mm.

C. Photos shall be delivered to the Construction Manager within 10 days following each set of exposures.

1.03 REQUIRED NUMBER OF PHOTOGRAPHS

A. For the work of this contract, photographs shall be provided as listed:

	Black and White	Color
Preconstruction	15	15
Construction	10 per Month	10 per Month
Acceptance	15	15

B. Photographs required in excess of the total number of exposures required shall be paid for as additional work.

END OF SECTION

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes administrative and procedural requirements for submittals.

1.02 ADMINISTRATIVE REQUIREMENTS

A. General:
   1. Furnish submittal items as specified in the contract documents.
   2. Review submittal information to verify it is accurate and fulfills specified submittal requirements before submitting for review and comment.
   3. Edit submittal content to clearly indicate only those items, models, or series of equipment, which are being submitted for review. Cross out or otherwise obliterate extraneous materials.
   4. Ensure there is no conflict with other submittals and notify the Owner's Representative in each case where the submittal may affect the work of another contractor or the Owner.
   5. Coordinate submittals among subcontractors and suppliers including those submittals complying with unit responsibility requirements specified in the contract documents.
   6. For each submittal, certify field conditions, compliance with the Contract Documents, and review of the submittal prior to submitting for review.
   7. Designate the installation location within the facility, application, or intended purpose for each submittal item. Review comments are solely applicable to the circumstances designated in the submittal.
   8. Coordinate submittals with the work so that work will not be delayed. Coordinate and schedule different categories of submittals, so that one will not be delayed for lack of coordination with others.
   9. No extension of time will be allowed because of failure to properly schedule, coordinate or compile submittals.
   10. Submittals will be rejected for lack of legibility, lack of coordination, ambiguity, or are incomplete. Incomplete submittals will be returned without review.
   11. Do not proceed with work related to a submittal until the submittal process is complete. This requires that submittals for review and comment be returned to the Contractor stamped "No Exceptions Taken" or "Make Corrections Noted."
   12. If desired, authorize material or equipment suppliers to deal directly with the Owner's Representative regarding a submittal. Such dealings require written authorization from the Contractor and are limited to contract interpretations to clarify and expedite the work.

1.03 DEFINITIONS

A. Action Submittals
   1. Action Submittals content require review and response by the Owner's Representative before proceeding with incorporating the subject equipment, materials, or procedure into the work.
   2. Review comments on Action Submittals, and perform subsequent actions based on the REVIEW ACTION requirements specified below.

B. Informational Submittals
   1. Informational Submittals are examined to verify that the specified submittal contents have been furnished as specified.
   2. The Contractor's actions are not contingent on the disposition of review comments on Informational Submittals.
   3. Review comments on Informational Submittals, and perform subsequent actions based on the REVIEW ACTION requirements specified below.

C. Closeout Submittals
   1. Closeout Submittals consist of documentation that is not available for review at the time Action Submittals are submitted for review or documentation that is typically generated or furnished following incorporation of the equipment, materials, or procedure into the work. Closeout submittals include spare parts inventory listing, spare parts, extra stock materials, special tools and other materials or components that are furnished separate from the installed and completed work.
   2. Review comments on Closeout Submittals, and perform the subsequent actions based on the REVIEW ACTION requirements specified below.

D. Samples
   1. Samples include partial sections of components, cuts, or containers of materials, color range sets, and swatches showing color, texture and pattern.
   2. Samples may be Action or Informational submittals.

E. Mock-Ups
   1. Mock-ups are scale representations of items to be constructed as part of the work as required in the Contract Documents.
   2. Mock-ups are Action Submittals.

F. Review Actions
   1. The following definitions and actions are associated with the REVIEW ACTIONS DEFINED below:
      a. NO EXEPTIONS TAKEN: If the review indicates that the material, equipment or work method complies with the Contract Documents, submittal will be marked "NO EXCEPTIONS TAKEN." Implement the work method or incorporate the material or equipment covered by the submittal.
      b. MAKE CORRECTIONS NOTED: If the review indicates limited corrections are required, submittals will be marked "MAKE CORRECTIONS NOTED." Implement the work method or incorporate the material and equipment covered by the

submittal in accordance with the noted corrections. Where submittal information will be incorporated in O&M data, provide a corrected copy.

c. AMEND AND RESUBMIT: If the review reveals that the submittal is insufficient or contains incorrect data, submittals will be marked "AMEND AND RESUBMIT." Do not undertake work until the submittal has been revised, resubmitted and returned marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED".

d. REJECTED – SEE REMARKS: If the review indicates that the material, equipment, or work method does not comply with Contract Documents, the submittal will be marked "REJECTED - SEE REMARKS." Do not undertake the work covered by such submittals until a new submittal is made and returned marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED" except at your own risk.

1.04 MASTER SUBMITTAL LIST

A. A minimum of five (5) business days prior to Notice to Proceed, the Owner's Representative will provide a Master Submittal List listing submittal requirements for the contract.

B. After receiving the Master Submittal List, update the list as submittals are completed and transmitted to the Owner's Representative. Provide updated list to Owner's Representative monthly.

C. Include the following as a minimum in the updated list:
   1. Submittal number.
   2. Date submitted.
   3. Requested time for return of comments.
   4. Special requests, if any, for that particular submittal.

PART 2 - NOT USED

PART 3 - EXECUTION

3.01 SUBMITTAL PROCEDURES

A. General
   1. Owner's Representative will review submittal information and indicate a REVIEW ACTION. Review of submittals does not relieve the Contractor of responsibility for performance of the work according to the Contract Documents.
   2. Coordinate submittal transmittal for related elements of work to ensure the submittals are processed as needed to meet the intent of the work and that delays are minimized.
   3. Submittal review activity will be prioritized based on the order received unless otherwise requested by the Contractor.
   4. Submittal sequencing should coincide with the Construction Schedule in Section 01 32 16.
   5. A review duration of 35 calendar days is allotted for each submittal, from the date of receipt by the Owner's Representative to the date of return to the Contractor.

B. Submittal Preparation:
   1. Excepting, mock-ups, spare parts, physical samples, and other items that cannot be converted to electronic media, furnish submittal contents electronically in a searchable PDF format.
      a. Include a table of contents and labeled divider sheets that are coordinated with the table of contents.
      b. Diagrams, drawings, pictures, and illustrations presented with a consistent orientation.
   2. If electronic submittals are not possible, place a permanent label or title block on each hard copy submittal for identification and submit the following:
      a. Action and Closeout Submittals: 4 copies of submitted information plus one reproducible original.
      b. Informational Submittals: 4 copies of submitted information.
   3. Shop Drawings, Samples and Mock-ups:
      a. Submit one electronic copy per the requirements described above and the following:
         1) Shop Drawings: 1 reproducible and 4 prints for job site reference. One marked up print will be returned to the Contractor when the review is complete.
         2) Samples: 2 samples
         3) Mock-up: As required by individual specification
         4) Demonstrations: As required to facilitate installation and inspection
      b. Reference applicable specifications for additional requirements

C. Submittal Completeness:
   1. Submittals without all required information are not acceptable and may be marked “REJECTED” and returned without review.
   2. For a submittal to be deemed complete, provide the information required below and specified in specification sections, including those elements in the special transmittal procedures where required.

D. In the event of the need to “revise and resubmit”, provide a complete stand-alone submittal with corrections, revisions, and new information clearly identified.

E. Resubmit changes to submittals that require a stamp and signature by a licensed engineer or other certification with the requisite stamp and signature or certifications.

3.02 TRANSMITTAL PROCEDURE

A. General:
   1. Include the following information on the submittal transmittal form:
      a. Project names and date, including Owner’s Project Number as follows: Pump Station Rehabilitation Project 1
      b. Name of Contractor and Subcontractor
      c. Name of supplier and name of manufacturer
      d. Number and title of appropriate specification section
      e. Drawing number and detail references, as appropriate

2. Equipment and Material Submittals: Unless otherwise specified, complete the Transmittal Form 01 33 00-A specified in Section 01 99 90.
3. Operation and maintenance manuals, information and data Submittals: Complete the Transmittal Form 01 78 23-A specified in Section 01 99 90.
4. Use a separate form for each specific item, class of material, equipment, and items specified in separate, discrete sections, for which a submittal is required. Identify the appropriate equipment numbers for submittal documents common to more than one piece of equipment. Submit a single form for multiple items, if the items taken together constitute a manufacturer's package or are functionally related, to facilitate checking or reviewing the group or package as a whole.
5. Assign a unique sequential number to each transmittal form accompanying each item submitted.
    a. Format submittal numbers as follows: "XXX"; where "XXX" is the sequential number assigned to the original submittal.
    b. Format resubmittals as follows: "XXX-Y"; where "XXX" is the originally assigned submittal number and "Y" is a sequential letter assigned for resubmittals, i.e., A, B, or C being the 1st, 2nd, and 3rd resubmittals, respectively. Submittal 25B, for example, is the second resubmittal of submittal 25.
6. Deviation from contract: If deviations from the material, equipment or method of work are proposed, describe the proposed deviation and explain the reason for proposing the deviation under "deviations" on the transmittal form accompanying the submittal copies.

B. Provide a Certificate of Unit Responsibility assigning unit responsibility in accordance with the requirements of the specification Section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with the Specifications.

C. Samples and Mock-ups:
1. Submit samples and mock-ups in accordance with the Contract Documents. Package samples to facilitate review. Include the following with the Submittal Transmittal Form:
    a. Generic description of the sample
    b. Sample source
    c. Product name and name of manufacturer
    d. Compliance with recognized standards
    e. Submittal Number
    f. Availability and delivery time
    g. Specification Section
2. Submit samples and mock-ups before installation. Where variation in color, pattern, texture or other characteristics are inherent in the material, submit four units to show variation range.
3. Where samples are for selection of appearance characteristics from a range of standard choices, submit a full set of choices for the material or products.
4. Maintain sets of approved samples and mock-ups at the Project Site, for quality comparisons throughout the course of construction.
5. Demolish and remove all samples and mock-ups prior to substantial completion.

3.03 REVIEW PROCEDURE

A. General:
   1. Owner's Representative will review each submittal, indicate a REVIEW ACTION, and return to the Contractor.
   2. Returned submittals indicate one of the following REVIEW ACTIONS: NO EXEMPTIONS TAKEN, MAKE CORRECTIONS NOTED, AMEND AND RESUBMIT, or REJECTED – SEE REMARKS.

3.04 EFFECT OF REVIEW OF CONTRACTOR'S SUBMITTALS:

A. General:
   1. Review of contract drawings, methods of work, or information regarding materials or equipment the Contractor proposes to provide, does not relieve the Contractor of responsibility for errors therein and is not regarded as an assumption of risks or liability by the Owner's Representative or the Owner, or by any officer or employee thereof, and the Contractor has no claim under the contract on account of the failure, or partial failure, of the method of work, material, or equipment reviewed. A mark of "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED" means that the Owner has no objection to the Contractor, upon his own responsibility, using the plan or method of work proposed, or providing the materials or equipment proposed.

END OF SECTION

SECTION 01 35 29

HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES

PART 1 GENERAL

1.01 REQUIREMENTS

A. Portions of the pump stations are exposed to raw wastewater. The Contractor certifies that he is experienced and qualified to anticipate and meet the safety and health requirements of this project.

B. Workmen involved in the removal, renovation, or installation of equipment within the pump station may be exposed to disease-producing organisms in wastewater. The Contractor shall require his personnel to observe proper hygienic precautions.

C. Solvents, gasoline, and other hazardous materials enter the plant with incoming sewage, and, therefore, certain areas are hazardous to open flame, sparks, or unventilated occupancy. The Contractor shall take measures to assure his personnel observe proper safety precautions when working in these areas.

1.02 SAFETY AND HEALTH REGULATIONS

A. The Contractor shall comply with Safety and Health Regulations for Construction, promulgated by the Secretary of Labor under Section 107 of the Contract Work Hours and Safety Standards Act, as set forth in Title 29, C.F.R. Copies of these regulations may be obtained from Labor Building, 14th and Constitution Avenue N.W., Washington, DC 20013.

B. The Contractor shall also comply with the provisions of the Federal Occupational Safety and Health Act, as amended.

END OF SECTION

SECTION 01 35 43

ENVIRONMENTAL PROCEDURES

PART 1 GENERAL

1.01 SITE MAINTENANCE

A. The Contractor shall keep the work site clean and free from rubbish and debris. Materials and equipment shall be removed from the site when they are no longer necessary. Upon completion of the work and before final acceptance, the work site shall be cleared of equipment, unused materials, and rubbish to present a clean and neat appearance.

1.02 TEMPORARY DAMS

A. Except in time of emergency, earth dams are not acceptable at catch basin openings, local depressions, or elsewhere. Temporary dams of sand bags, asphaltic concrete, or other acceptable material will be permitted when necessary to protect the work, provided their use does not create a hazard or nuisance to the public. Such dams shall be removed from the site as soon as they are no longer necessary.

1.03 AIR POLLUTION CONTROL

A. The Contractor shall not discharge smoke, dust, and other contaminants into the atmosphere that violate the regulations of any legally constituted authority. He shall also abate dust nuisance by cleaning, sweeping, and sprinkling with water, or other means as necessary. The use of water, in amounts which result in mud on public streets, is not acceptable as a substitute for sweeping or other methods.

1.04 NOISE CONTROL

A. Between 7:30 p.m. and 7:00 a.m., noise from Contractor's operations shall not exceed limits established by applicable laws or regulations and in no event shall exceed 86 dBA at a distance of 50 feet from the noise source.

END OF SECTION

SECTION 01 42 19

REFERENCE STANDARDS

PART 1 GENERAL

1.01 ABBREVIATOINS

A. Wherever used in the project manual, the following abbreviations will have the meanings listed:

Abbreviation	Meaning
AA	Aluminum Association Incorporated P.O. Box 753 Waldorf, MD 20604
AABC	Associated Air Balance Council 1518 K Street N.W. Washington, DC 20005
AAMA	American Architectural Manufacturers Association 1540 East Dundee Road, Suite 310 Palatine, IL 60067
AASHTO	American Association of State Highway and Transportation Officials 444 North Capitol Street, N.W., Suite 249 Washington, DC 20001
ABMA	American Bearing Manufacturers Association 1200 19th Street N.W., Suite 300 Washington, DC 20036
ACI	American Concrete Institute 22400 West Seven Mile Road P.O. Box 19150, Redford Station Detroit, MI 48219
AEIC	Association of Edison Illuminating Companies 600 North 18th Street P.O. Box 2641 Birmingham, AL 35291
AGA	American Gas Association ATTN: Records 1515 Wilson Boulevard Arlington, VA 22209
AGMA	American Gear Manufacturer's Association, Inc. 1500 King Street, Suite 201 Alexandria, VA 22314
AHA	American Hardboard Association 1210 West Northwest Highway Palatine, IL 60067
AISC	American Institute of Steel Construction One East Wacker Drive, Suite 3100 Chicago, IL 60601

Abbreviation	Meaning
AISI	American Iron and Steel Institute 1101 Seventeenth Street, NW, Suite 1300 Washington, DC 20036
AITC	American Institute of Timber Construction 7012 South Revere Parkway, Suite 140 Englewood, CO 80112
ALSC	American Lumber Standard Committee P.O. Box 210 Germantown, MD 20875
AMCA	Air Movement and Control Association, Inc. 30 West University Drive Arlington Heights, IL 60004
ANSI	American National Standards Institute 11 West 42nd Street, 13th Floor New York, NY 10036
APA	American Plywood Association 7011 South 19th Street Tacoma, WA 98466
API	American Petroleum Institute 1220 "L" Street N.W. Washington, DC 20005
ARI	Air-Conditioning and Refrigeration Institute 4301 North Fairfax Drive, Suite 425 Arlington, VA 22203
ASCE	American Society of Civil Engineers United Engineering Center 345 East 47th Street New York, NY 10017
ASCII	American Standard Code for Information Interchange United States of America Standards Institute 10 East 40th Street New York, NY 10016
ASE Code	American Standard Safety Code for Elevators, Dumbwaiter and Escalators American National Standards Institute 1430 Broadway New York, NY 10018
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. 1791 Tullie Circle, NE Atlanta, GA 30329
ASME	American Society of Mechanical Engineers 345 East 47th Street New York, NY 10017

Abbreviation	Meaning
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive West Conshohocken, PA 19428
AWPA	American Wood-Preservers' Association 9549 Old Fredrick Road Ellicott City, MD 21042
	or P.O. Box 286 Woodstock, MD 21163-0286
AWS	American Welding Society 550 NW LeJeune Road P.O. Box 351040 Miami, FL 33135
AWWA	American Water Works Association 6666 West Quincy Avenue Denver, CO 80235
BOCA	Building Officials and Code Administrators, International, Inc. 4051 West Flossmoor Road Country Club Hills, IL 60478
CALTEST	Materials Manual, State of California, Business and Transportation Agency Department of Public Works State of California, Department of Transportation 6002 Folsom Boulevard Sacramento, CA 95819
CALTRANS	Standard Specifications, State of California, Department of Transportation State of California, Business and Transportation Agency P.O. Box 1499 Sacramento, CA 95807
CBM	Certified Ballast Manufacturers 2120 Keith Building Cleveland, OH 44115
CMAA	Crane Manufacturers Association of America, Inc. (Formerly called: Overhead Electrical Crane Institute) (OECI) 8720 Red Oak Boulevard, Suite 201 Charlotte, NC 28217
CRSI	Concrete Reinforcing Steel Institute 933 N Plum Grove Road Schaumburg, IL 60173
CSA	Canadian Standards Association 178 Rexdale Boulevard Rexdale, Ontario, M9W IR3, Canada
DEMA	Diesel Engine Manufacturer's Association 30200 Detroit Road Cleveland, OH 44145

Abbreviation	Meaning
DHI	Door and Hardware Institute 14170 Newbrook Drive Chantilly, VA 22021
DIS	Division of Industrial Safety California Department of Industrial Relations 2422 Arden Way Sacramento, CA 95825
EEI	Edison Electric Institute 90 Park Avenue New York, NY 10016
EIA	Electronic Industries Association Order from: Global Engineering Documents 18201 McDurmott West Irvine, CA 92714
EJMA	Expansion Joint Manufacturers Association 25 North Broadway Tarrytown, NY 10591
ESO	Electrical Safety Orders California Administrative Code, Title 8, Chap. 4, Subarticle 5 Office of Procurement, Publications Section P.O. Box 20191 8141 Elder Creek Road Sacramento, CA 95820
FEDSPEC	Federal Specifications General Services Administration Specification and Consumer Information Distribution Branch Washington Navy Yard, Bldg. 197 Washington, DC 20407
FEDSTDS (see FEDSPECS)	Federal Standards
FM	Factory Mutual Engineering and Research Corporation 1151 Boston-Providence Turnpike P.O. Box 9102 Norwood, MA 02062
HEI	Heat Exchange Institute 1300 Sumner Avenue Cleveland, OH 44115
HI	Hydraulic Institute 9 Sylvan Way, Suite 180 Parsippany, NJ 07054
HPVA	Hardwood Plywood & Veneer Association 1825 Michael Faraday Drive P.O. Box 2789 Reston, VA 22090-2789

Abbreviation	Meaning
IAPMO	International Association of Plumbing and Mechanical Officials 20001 Walnut Drive S Walnut, CA 91789
ICBO	International Conference of Building Officials 5360 Workman Mill Road Whittier, CA 90601
ICEA	Insulated Cable Engineers Association P.O. Box 440 South Yarmouth, MA 02664
IEEE	Institute of Electrical and Electronics Engineers 445 Hoes Lane P.O. Box 1331 Piscataway, NJ 08855
IES	Illuminating Engineering Society of North America 120 Wall Street New York, NY 10017
ISA	Instrument Society of America 67 Alexander Drive P.O. Box 12277 Research Triangle Park, NC 27709
JIC	Joint Industrial Council 7901 West Park Drive McLean, VA 22101
MFMA	Metal Framing Manufacturers Association 401 N. Michigan Avenue Chicago, IL 60611
MILSPEC	Military Specifications Naval Publications and Forms Center 5801 Tabor Avenue Philadelphia, PA 19120
MSS	Manufacturers Standardization Society of the Valve & Fittings Industry, Inc. 127 Park Street, N.E. Vienna, VA 22180
NAAMM	National Association of Architectural Metal Manufacturers 11 South La Salle Street, Suite 1400 Chicago, IL 60603
NACE	National Association of Corrosion Engineers 1440 South Creek Drive Houston, TX 77084
NBC	National Building Code Published by BOCA

Abbreviation	Meaning
NEC	National Electric Code National Fire Protection Association One Batterymarch Park P.O. Box 9101 Quincy, MA 02269
NELMA	Northeastern Lumber Manufacturers Association, Inc. P.O. Box 87A Cumberland Center, ME 04021
NEMA	National Electrical Manufacturer's Association 2101 L Street, NW, Suite 300 Washington, DC 20037
NESC	National Electric Safety Code American National Standards Institute 1430 Broadway New York, NY 10018
NFOR	National Forest Products Association (Formerly National Lumber Manufacturer's Association) 1111 19 Street NW, Suite 700 Washington, DC 20036
NFPA	National Fire Protection Association One Batterymarch Park P.O. Box 9101 Quincy, MA 02269
NHLA	National Hardwood Lumber Association 6830 Raleigh LaGrange P.O. Box 34518 Memphis, TN 38184-0518
NSF	National Sanitation Foundation 3475 Plymouth Road P.O. Box 130140 Ann Arbor, MI 48113
OSHA	Occupational Safety and Health Act U.S. Department of Labor Occupational and Health Administration San Francisco Regional Office 450 Golden Gate Avenue, Box 36017 San Francisco, CA 94102
PCI	Precast/Prestressed Concrete Institute 175 West Jackson Blvd., Suite 1859 Chicago, IL 60604
PPIC	The Plumbing & Piping Industry Council, Inc. 510 Shatto Place, Suite 402 Los Angeles, CA 90020

Abbreviation	Meaning
RIS	Redwood Inspection Service California Redwood Association 405 Enfrente Dr., Suite 200 Novato, CA 94949
RMA	Rubber Manufacturers Association 1400 K Street NW, Suite 900 Washington, DC 20005
SAE	Society of Automotive Engineers, Inc. 400 Commonwealth Drive Warrendale, PA 15096
SAMA	Scientific Apparatus Makers Association One Thomas Circle Washington, DC 20005
SBC	Standard Building Code Published by SBCCI
SBCCI	Southern Building Code Congress International Inc. 900 Montclair Road Birmingham, AL 35213
SCMA	Southern Cypress Manufacturers Association 400 Penn Center Boulevard, Suite 530 Pittsburg, PA 15235
SDI	Steel Door Institute 30200 Detroit Road Cleveland, OH 44145
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc. P.O. Box 221230 Chantilly, VA 22021
SPI	Society of the Plastics Industry, Inc. 1275 K Street NW, Suite 400 Washington, DC 20005
SPIB	Southern Pine Inspection Bureau 4709 Scenic Highway Pensacola, FL 32504
SSPC	Society for Protective Coatings 40 24th Street, 6th Floor Pittsburgh, PA 15222
SSPWC	Standard Specifications for Public Works Construction Building News, Inc. 3055 Overland Avenue Los Angeles, CA 90034
TEMA	Tubular Exchanger Manufacturer's Association 25 North Broadway Tarrytown, NY 10591
TPI	Truss Plate Institute 583 D'Onofrio Drive, Suite 200 Madison, WI 53719

Abbreviation	Meaning
UBC	Uniform Building Code Published by ICBO
UL	Underwriters Laboratories Inc. 333 Pfingsten Road Northbrook, IL 60062
UMC	Uniform Mechanical Code Published by ICBO
UPC	Uniform Plumbing Code Published by IAPMO
USBR	Bureau of Reclamation U.S. Department of Interior Engineering and Research Center Denver Federal Center, Building 67 Denver, CO 80225
WCLIB	West Coast Lumber Inspection Bureau 6980 SW Varns St. P.O. Box 23145 Portland, OR 97223
WWPA	Western Wood Products Association (Formerly called: West Coast Lumbermen's Association (WCLA)) Yeon Building 522 SW 5th Avenue Portland, OR 97204

END OF SECTION

SECTION 01 45 00

CONTRACTOR QUALITY CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies administrative and procedural requirements for quality control services, field inspections and field testing of civil and structural constructs required for this project.

B. The Contractor is responsible for the quality assurance and quality control of their respective work for the construction of this project in accordance with the Contract Documents.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related section. Additional related sections may apply that are not specifically listed below.

1. Section 01 45 20 Equipment and System Performance and Operational Testing

1.03 DEFINITIONS

A. Quality Control System (QCS): The quality control, assurance, and inspection system established and carried out to ensure compliance with the Plans and specifications.

B. QCS Supervisor: That person in responsible charge of the work occurring, as designated by the Contractor in the QCS Plan.

C. QCS Inspector: Responsible, certified personnel inspecting the various constructs at specified milestones and during the project overall and designated by the Construction Manager.

D. Factory Test: Tests made on various materials, products and component parts prior to shipment to the job site.

E. Field Tests: Tests and analyses made at or in the vicinity of the job site in connection with the actual construction.

F. Certified Inspection Report: Reports signed by approved inspectors attesting that the items inspected meet the specification requirements other than any exceptions included in the report.

G. Certificate of Compliance: Certificate from the manufacturer of the material or equipment identifying said manufacturer, product and stating that the material or equipment meet specified standards, and shall be signed by a designated officer of the manufacturer.

H. Standard Compliance: Condition whereby specified materials or equipment must conform to the standards of organizations such as the American National Standard Institute (ANSI), American Society for Testing and Materials (ASTM), Underwriters Laboratories (UL) or similar organization.

I. Quality Assurance: The day-to-day, in-process supervisory observations of work and materials conducted by the Contractor to assure that the proper methods and materials are being used and installed by tradesmen.

J. Source Quality Control: The in-process testing and inspections conducted by the QCS Inspector(s) to verify that the materials, equipment; workmanship and shop manufactured constructs are in compliance with the Contract Documents, applicable Codes and standards.

K. Field Quality Control: The testing and inspections conducted by the QCS Inspector(s) in the field during and at the completion of each construct to verify that the in-process and completed construction is in compliance with the Contract Documents, applicable Codes and standards.

L. Special Inspector – A qualified individual employed or retained by an approved agency and approved by the local governing authorities having jurisdiction (AHJ) as having the competency necessary to inspect a particular type of construction requiring special inspection.

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance with the specification. Include a detailed, written justification for each deviation. Failure to include a copy of this marked-up specification section, along with justification(s) for requested deviations, with the submittal, is cause for rejection of the entire submittal with no further consideration.
   4. Written description of Contractor's proposed QCS plan in sufficient detail to illustrate adequate measures for verification and conformance to defined requirements. The QCS plan and submittal shall include a log showing anticipated inspections, QCS Inspectors, Special Inspections, and source and field Quality Assurance procedures. Submittal of the QCS plan shall be made prior to commencing field work.
   5. Contractor's proposed QCS Supervisor and QCS Inspectors (other than the Special Inspectors provided by Owner), including qualifications, responsibilities, and if requested, references.
   6. Complete structural system information describing Contractor designed structural systems, including sealed calculations, shop and erection drawings, product literature for the various components, International Code Council (ICC) Evaluation Reports for structural components, and a discussion of risk issues associated with the proposed system which could adversely impact overall project completion.
   7. If requested by the Construction Manager during the work, manufacturer's field services and reports.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Manufacturers' field services and reports unless requested by Construction Manager to be submitted for review.
   3. Special Inspection reports, unless otherwise directed in each technical specification Section.

1.05 REGULATORY REQUIREMENTS

A. GENERAL: Comply with all Federal, State, and local Codes as referenced herein. Such regulations apply to activities including, but not limited to, site work and zoning, building practices and quality, on and offsite disposal, safety, sanitation, nuisance, and environmental quality.

B. SPECIAL INSPECTION: Special Inspection shall be performed by the Special Inspector under contract with the Owner or registered design professional in responsible charge acting as the Owner's agent in conformance with the IBC. Special Inspection is in addition to, but not replacing, other inspections and quality control requirements herein. Where sampling and testing required herein conforms to Special Inspection standards, such sampling and testing need not be duplicated.

C. STRUCTURAL OBSERVATION: Registered Design Professional shall make visual inspections of the work to assess general conformance with the Contract Documents at significant construction stages and at completion of the structural system in accordance with IBC 1704.6 Structural Observations requirements.

1.06 CONTRACTOR'S RESPONSIBILITIES

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

B. Coordinate with, schedule specified inspections by, and provide normal and customary assistance to the QCS Inspectors and Owner provided Special Inspectors.

C. Coordinate with, schedule specified structural observations by Engineer, and provide normal and customary assistance to Engineer performing structural observations.

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

E. Should manufacturers' instructions conflict with Contract Documents, request clarification before proceeding from Construction Manager.

F. Comply with specified standards as a minimum quality for the work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

G. The Contractor shall retain the services of a licensed land surveyor, registered in the State of Massachusetts, to perform survey work including but not limited to establishing line and grade, in advance of the construction; and to perform other surveying services for the work included under the Contract. The surveyor to be retained by the Contractor shall not be the same surveyor engaged for the Engineer's use. The surveyor shall be

subject to the approval of the Engineer. Survey drawings shall be submitted to the Engineer for approval.

H. The Contractor shall take all necessary measurements in the field to verify pertinent data and dimensions shown on the Drawings or to determine the exact dimensions of the Work.

1.07 FIELD SAMPLE PROCEDURES

A. When field samples are specified in a unit of work, construct each field sample to include work of all trades required to complete the field sample prior to starting related field work. Field samples may be incorporated into the project after acceptance by Construction Manager. Remove unacceptable field samples when directed by Construction Manager. Acceptable samples represent a quality level for the work.

1.08 CONTRACTOR DESIGNED STRUCTURAL SYSTEMS

A. DESIGN ENGINEERING: Contractor shall employ and pay for engineering services from a Professional Engineer registered in the State of Massachusetts for structural design of Contractor designed structural systems including but not limited to temporary shoring and bracing, formwork support, interior wall and ceiling systems, and support systems for fire sprinkler, plumbing, mechanical, and electrical systems and equipment.

B. TESTS AND INSPECTIONS OF CONTRACTOR DESIGNED STRUCTURAL SYSTEMS: Contractor shall pay for preliminary testing of concrete, grout, and mortar mix designs where required by Code or these specifications prior to start of work. Contractor shall pay for required shop and site inspection of Contractor designed structural systems where required by Code or these specifications.

1.09 JOB SITE CONDITIONS

A. Schedule to ensure all preparatory work has been accomplished prior to proceeding with current work. Proceeding with the work constitutes acceptance of conditions. Allow adequate time for materials susceptible to temperature and humidity to “stabilize” prior to installation. Establish and maintain environmental conditions (i.e., temperature, humidity, lighting) as recommended by the various material manufacturers for the duration of the work.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. CONTRACTOR RESPONSIBILITIES: Provide source quality control according to the reviewed and accepted QCS plan and paragraph 1.06 herein. Coordinate with Construction Manager to facilitate the work of the Testing Laboratory specified in Section 01 45 20 and Special Inspector. Provide ready access to sampling and inspection locations and incidental labor customary in such sampling and inspections. Timely prepare and submit submittals, and revise as indicated by review comments. Comply with technical requirements in each specification Section that applies to the work.

B. CONSTRUCTION MANAGER RESPONSIBILITIES: Review Contractor’s tracking of QCS activities at monthly meetings. Facilitate completion of submittal review per Section 01

33 00. Assist Contractor to ensure that Special Inspection occurs where and when specified.

C. ACCEPTANCE CRITERIA: Acceptable characteristics and quality of a particular item or construct is defined in that item's or construct's specification Section.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Field quality control responsibilities of the Contractor and Construction Manager are substantially the same as described in paragraph 2.01, with the exception that this work occurs primarily on the jobsite as the work progresses, and Special Inspection will occur more often than at the source.

B. Acceptable characteristics and quality of a particular item or construct is defined in that item's or construct's specification Section.

3.02 REGULATORY COMPLIANCE – SPECIAL INSPECTIONS

A. The types of work requiring Special Inspection are specified in the Construction Documents and required to obtain regulatory approval by State or required by local governing authorities having jurisdiction over the building permit of the project.

B. Section 01 45 20 describes Testing Laboratory sampling, testing and reporting.

C. Contractor designed structural systems are subject to the same Special Inspection requirements as all other work.

3.03 CORRECTION OF DEFECTIVE WORK

A. Any defective or imperfect Work, equipment, or materials furnished by the Contractor which is discovered before the Final Acceptance of the Work, or during a warranty period, shall be removed immediately even though it may have been overlooked by the Engineer and approved for payment. The Contractor shall repair such defect, without compensation, in a manner satisfactory to the Engineer.

B. Unsuitable materials and equipment may be rejected, notwithstanding that such defective Work, materials and equipment may have been previously overlooked by the Engineer and accepted or approved for payment.

C. If any workmanship, materials or equipment shall be rejected by the Engineer as unsuitable or not in conformity with the Specifications or Drawings, the Contractor shall promptly replace such materials and equipment with acceptable materials and equipment at no additional cost to Owner. Equipment or materials rejected by the Engineer shall be tagged as such and shall be immediately removed from the site.

D. The Engineer may order tests of imperfect or damaged Work equipment, or materials to determine the required functional capability for possible acceptance, if there is no other reason for rejection. The cost of such tests shall be borne by the Contractor, and the nature, tester, extent and supervision of the tests will be as determined by the Engineer. If the results of the tests indicate that the required functional capability of the Work,

equipment, or material was not impaired, the Work, equipment or materials may be deemed acceptable, in the discretion of the Engineer. If the results of such tests reveal that the required functional capability of the questionable Work, equipment or materials has been impaired, then such Work, equipment or materials shall be deemed imperfect and shall be replaced. The Contractor may elect to replace the imperfect Work, equipment or material in lieu of performing the tests.

END OF SECTION

SECTION 01 45 20

EQUIPMENT AND SYSTEM PERFORMANCE AND OPERATIONAL TESTING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for the Contractor's performance in documenting testing work required under this contract. In addition, this section contains requirements the for the Contractor's performance during installed performance testing of all mechanical, electrical, instrumentation, and HVAC equipment and systems, including structures for watertight construction, provided under this contract. This section supplements but does not supersede specific testing requirements found elsewhere in this project manual.

1.02 QUALITY ASSURANCE

A. Contractor's Quality Assurance Manager:
   1. The Contractor shall appoint an operations engineer or equally qualified operations specialist as Quality Assurance Manager to manage, coordinate, and supervise the Contractor's quality assurance program. The Quality Assurance Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the startup commissioning of mechanical, electrical, instrumentation, HVAC, and piping systems. The quality assurance program shall include:
      a. A testing plan setting forth the sequence in which all testing work required under this project manual will be implemented.
      b. A documentation program to record the results of all equipment and system tests.
      c. An installed performance testing program for all mechanical, electrical, instrumentation, and HVAC equipment and systems installed under this contract.
      d. A calibration program for all instruments, meters, monitors, gages, and thermometers installed under this contract.
      e. A calibration program for all instruments, gages, meters, and thermometers used for determining the performance of equipment and systems installed under this contract.
   2. For the purposes of this section, a system shall include all items of equipment, devices and appurtenances connected in such a fashion as their operation or function complements, protects or controls the operation or function of the others. The Quality Assurance Manager shall coordinate the activities of all subcontractors and suppliers to implement the requirements of this section.

B. Calibration:
   1. All test equipment (gages, meters, thermometers, analysis instruments, and other equipment) used for calibrating or verifying the performance of equipment installed under this contract shall be calibrated to within plus or minus 2 percent of actual value at full scale. Test equipment employed for individual test runs shall be selected so that expected values as indicated by the detailed performance specifications will fall between 60 and 85 percent of full scale.

C. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ASME B40.1	Gauges Pressure Indicating Dial Type—Elastic Element
ASTM E77	Method for Verification and Calibration of Liquid-in-Glass Thermometers
ASHRAE 41.8	Standard Methods of Measurement of Flow of Gas
Dye Dilution Calibration Method	Flow Measurements in Sanitary Sewers By Dye Dilution, Turner Designs Mountain View, California,
	Flow Measurement in Sewer Lines by the Dye Dilution Method, Journal of the Water Pollution Control Federation, Vol. 55, Number 5, May, 1983, pg. 531
	Flow Measurement in Open Channels and Closed Conduits, Vol 1, U.S. Department of Commerce, National Bureau of Standards, pg. 361
	Techniques of Water-Resources Investigations of the United States Geological Survey, Chapter 16, Measurement of Discharge Using Tracers

1.03 SUBMITTALS

A. Submittal material, to be submitted in accordance with Section 01 33 00, shall consist of the following:

1. A complete description of the Contractor's plan for documenting the results from the test program, including:
   a. Proposed plan for documenting the calibration of all test instruments.
   b. Proposed plan for calibration of all instrument systems, including flow meters and all temperature, pressure, weight, and analysis systems.
   c. Sample forms for documenting the results of field pressure and performance tests.
2. Preoperational check-out procedures, reviewed and approved by the respective equipment manufacturers.

3. Detailed testing plans, setting forth step-by-step descriptions of the procedures proposed by the Contractor for the systematic testing of all equipment and systems installed under this contract.
4. A schedule and subsequent updates, presenting the Contractor's plan for testing the equipment and systems installed under this contract.
5. A schedule establishing the expected time period (calendar dates) when the Contractor plans to commence operational testing of the completed systems, along with a description of the temporary systems and installations planned to allow operational testing to take place.
6. A summary of the Quality Assurance Manager's qualifications.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall prepare test plans and documentation plans as specified in the following paragraphs. The Construction Manager will not witness any test work for the purpose of acceptance until all test documentation and calibration plans and the specified system or equipment test plans have been submitted and accepted.

2.02 DOCUMENTATION

A. Documentation Plans:
   1. The Contractor shall develop a records keeping system to document compliance with the requirements of this Section. Calibration documentation shall include identification (by make, manufacturer, model, and serial number) of all test equipment, date of original calibration, subsequent calibrations, calibration method, and test laboratory.
   2. Equipment and system documentation shall include date of test, equipment number or system name, nature of test, test objectives, test results, test instruments employed for the test and signature spaces for the Construction manager's witness and the Contractor's quality assurance manager. A separate file shall be established for each system and item of equipment. These files shall include the following information as a minimum:
      a. Factory performance tests
      b. Field calibration tests[1]
      c. Field pressure tests[1]
      d. Field performance tests[1]
      e. Field operational tests[1]
   3. The Contractor is advised that these are samples only and are not specific to this project nor to any item of equipment or system to be installed under this contract. The Contractor shall develop test documentation forms specific to each item of equipment and system installed under this contract. Acceptable documentation forms for all systems and items of equipment shall be produced for review by the Construction Manager as a condition precedent to the Contractor's receipt of progress payments in excess of 50 percent of the contract amount. Once the

[1]Each of these tests is required even though not specifically noted in detailed specification section.

Construction Manager has reviewed and taken no exception to the forms proposed by the Contractor, the Contractor shall produce sufficient forms, at his expense, to provide documentation of all testing work to be conducted as a part of this contract.

B. Test Plans:
   1. The Contractor shall develop test plans detailing the coordinated, sequential testing of each item of equipment and system installed under this contract. Each test plan shall be specific to the item of equipment or system to be tested. Test plans shall identify by specific equipment or tag number each device or control station to be manipulated or observed during the test procedure and the specific results to be observed or obtained. Test plans shall also be specific as to support systems required to complete the test work, temporary systems required during the test work, subcontractors' and manufacturers' representatives to be present and expected test duration. As a minimum, the test plans shall include the following features:
      a. Step-by-step proving procedure for all control and electrical circuits by imposing low voltage currents and using appropriate indicators to affirm that the circuit is properly identified and connected to the proper device.
      b. Performance testing of each individual item of mechanical, electrical, and instrumentation equipment. Performance tests shall be selected to duplicate the operating conditions described in the project manual.
      c. System tests designed to duplicate, as closely as possible, operating conditions described in the project manual.
   2. Test plans shall contain a complete description of the procedures to be employed to achieve the desired test environment.
   3. As a condition precedent to receiving progress payments in excess of 75 percent of the contract amount, or in any event, progress payments due to the Contractor eight weeks in advance of the date the Contractor wishes to begin any testing work (whichever occurs earliest in the project schedule), the Contractor shall have submitted all test plans required for the systematic field performance and operational tests for all equipment and systems installed under this contract. Once the Construction Manager has reviewed and taken no exception to the Contractor's test plans, the Contractor shall reproduce the plans in sufficient number for the Contractor's purposes and an additional ten copies for delivery to the Construction Manager. No test work shall begin until the Contractor has delivered the specified number of final test plans to the Construction Manager.

C. Testing Schedule:
   1. The Contractor shall produce a testing schedule setting forth the sequence contemplated for performing the test work. The schedule shall be in bar chart form, plotted against calendar time, shall detail the equipment and systems to be tested, and shall be coordinated with the Contractor's construction schedule specified in Section 01 32 16. The schedule shall show the contemplated start date, duration of the test and completion of each test. The test schedule shall be submitted no later than 4 weeks in advance of the date testing is to begin. The Engineer will not witness any testing work for the purpose of acceptance until the Contractor has submitted a schedule to which the Engineer takes no exception. The test schedule shall be updated weekly, showing actual dates of test work, indicating systems and equipment testing completed satisfactorily and meeting the requirements of this project manual.

2.03 SYSTEM AND EQUIPMENT PERFORMANCE TESTS

A. Each item of mechanical, electrical, instrumentation, and HVAC equipment installed under this contract shall be tested to demonstrate compliance with the performance requirements of this project manual. Each electrical, instrumentation, mechanical, piping, and HVAC system installed or modified under this contract shall be tested in accordance with the requirements of this project manual.

2.04 OPERATIONAL TESTS

A. NOT USED

2.05 PRODUCT DATA

A. Product data, to be provided in accordance with Section 01 33 00, shall be the original and three copies of all records produced during the testing program.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor's quality control manager shall organize teams made up of qualified representatives of equipment suppliers, subcontractors, the Contractor's independent testing laboratory, and others, as appropriate, to efficiently and expeditiously calibrate and test the equipment and systems installed and constructed under this contract. The objective of the testing program shall be to demonstrate, to the Construction Manager's complete satisfaction, that the structures, systems, and equipment constructed and installed under this contract meet all performance requirements and the facility is ready for the commissioning process to commence. In addition, the testing program shall produce baseline operating conditions for the Owner to use in a preventive maintenance program.

3.02 CALIBRATION OF FIXED INSTRUMENTS

A. Calibration of analysis instruments, sensors, gages, and meters installed under this contract shall proceed on a system-by-system basis. No equipment or system performance acceptance tests shall be performed until instruments, gages, and meters to be installed in that particular system have been calibrated and the calibration work has been witnessed by the Construction Manager.

B. All analysis instruments, sensors, gages, and meters used for performance testing shall be subject to recalibration to confirm accuracy after completion, but prior to acceptance of each performance test. All analysis instruments, sensors, gages, and meters installed under this contract shall be subject to recalibration as a condition precedent to commissioning under the provisions of Section 01 91 00.

3.03 PERFORMANCE TESTS

A. General:
   1. Performance tests shall consist of the following:
      a. Pressure and/or leakage tests.

b. Electrical testing as specified in Division 26.
c. Wiring and piping, individual component, loop, loop commissioning and tuning testing.
d. Preoperational checkout for all mechanical and HVAC equipment. Preoperational check-out procedures shall be reviewed and approved by the respective equipment manufacturers.
e. Initial operation tests of all mechanical, electrical, HVAC, and instrumentation equipment and systems to demonstrate compliance with the performance requirements of this project manual.

2. In general, performance tests for any individual system shall be performed in the order listed above. The order may be altered only on the specific written authorization of the Construction Manager after receipt of a written request, complete with justification of the need for the change in sequence.

B. Pressure And Leakage Tests:
1. Pressure and leakage tests shall be conducted. All acceptance tests shall be witnessed by the Construction Manager. Evidence of successful completion of the pressure and leakage tests shall be the Construction Manager's signature on the test forms prepared by the Contractor.

C. Functional Checkout:
1. Prior to energization (in the case of electrical systems and equipment), all circuits shall be rung out and tested for continuity and shielding in accordance with the procedures required in Division 26.

D. Component Calibration And Loop Testing:
1. Prior to energization (in the case of instrumentation system and equipment), all loops and associated instruments shall be calibrated.

E. Electrical Resistance:
1. Electrical resistance testing shall be in accordance with Division 26.

F. Preoperational Tests:
1. Preoperational tests shall include the following:
a. Alignment of equipment using reverse dial indicator method.
b. Pre-operation lubrication.
c. Tests per the manufacturers' recommendations for prestart preparation and preoperational check-out procedures.

G. Functional Tests:
1. General: Once all affected equipment has been subjected to the required preoperational check-out procedures and the Engineer has witnessed and has not found deficiencies in that portion of the work, individual items of equipment and systems may be started and operated under simulated operating conditions to determine as nearly as possible whether the equipment and systems meet the requirements of these specifications. The equipment shall be operated a sufficient period of time to determine machine operating characteristics, including noise, temperatures and vibration; to observe performance characteristics; and to permit initial adjustment of operating controls. When testing requires the availability of

auxiliary systems such as looped piping, electrical power, compressed air, control air, or instrumentation which have not yet been placed in service, the Contractor shall provide acceptable substitute sources, capable of meeting the requirements of the machine, device, or system at no additional cost to the Owner. During the functional test period, the Contractor shall obtain baseline operating data on all equipment with motors greater than 1 horsepower to include amperage, bearing temperatures, and vibration. The baseline data shall be collected for the Owner to enter in a preventive maintenance system.

a. Test results shall be within the tolerances set forth in the detailed specification sections of this project manual. If no tolerances have been specified, test results shall conform to tolerances established by recognized industry practice. Where, in the case of an otherwise satisfactory functional test, any doubt, dispute, or difference should arise between the Construction Manager and the Contractor regarding the test results or the methods or equipment used in the performance of such test, then the Construction Manager may order the test to be repeated. If the repeat test, using such modified methods or equipment as the Construction Manager may require, confirms the previous test, then all costs in connection with the repeat test will be paid by the Owner. Otherwise, the costs shall be borne by the Contractor. Where the results of any functional test fail to comply with the contract requirements for such test, then such repeat tests as may be necessary to achieve the contract requirements shall be made by the Contractor at his expense.

b. The Contractor shall provide, at no expense to the Owner, all power, fuel, compressed air supplies, water, and chemicals, all labor, temporary piping, heating, ventilating, and air conditioning for any areas where permanent facilities are not complete and operable at the time of functional tests, and all other items and work required to complete the functional tests. Temporary facilities shall be maintained until permanent systems are in service.

2. Retesting: If under test, any portion of the work should fail to fulfill the contract requirements and is adjusted, altered, renewed, or replaced, tests on that portion when so adjusted, altered, removed, or replaced, together with all other portions of the work as are affected thereby, shall, unless otherwise directed by the Construction Manager, be repeated within reasonable time and in accordance with the specified conditions. The Contractor shall pay to the Owner all reasonable expenses incurred by the Owner, including the costs of the Construction Manager, as a result of repeating such tests.

3. Post-test Inspection: Once functional testing has been completed, all machines shall be rechecked for proper alignment and realigned, as required. All equipment shall be checked for loose connections, unusual movement, or other indications of improper operating characteristics. Any deficiencies shall be corrected to the satisfaction of the Construction Manager. All machines or devices which exhibit unusual or unacceptable operating characteristics shall be disassembled and inspected. Any defects found during the course of the inspection shall be repaired or the specific part or entire equipment item shall be replaced to the complete satisfaction of the Construction Manager at no cost to the Owner.

3.04 OPERATIONAL TESTS

A. As-built documents specified in Section 01 78 39 of facilities involved shall be accepted and ready for turnover to the Owner at the time of functional testing.

END OF SECTION

SECTION 01 51 00

TEMPORARY UTILITIES

PART 1 GENERAL

1.01 OFFICE

A. The Contractor shall maintain a suitable office to serve each of the work sites.

B. No on-site storage or staging area is provided for Oldham Road Pump Station.

1.02 POWER

A. The Contractor shall provide power for construction at the plant site. He shall make arrangements with the electrical utility and with the Owner for power takeoff points, voltage and phasing requirements, transformers and metering and shall pay the costs and fees arising therefrom. The Contractor shall provide the special connections required for his work.

1.03 TELEPHONE

A. The Contractor shall provide telephone service at his construction site office. Radio-telephone service is not acceptable as a substitute for telephone service.

1.04 SANITARY FACILITIES

A. The Contractor shall provide toilet and washup facilities for his work force at the site of work. The facilities shall comply with applicable laws, ordinances, and regulations pertaining to the public health and sanitation of dwellings and camps.

END OF SECTION

SECTION 01 61 45

AREA EXPOSURE DESIGNATIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. SCOPE:
   1. This section designates area exposure types for each location, room, area, or space at the site of the Work.
   2. Area exposures are used to specify materials based on the corrosion environment that the material is exposed to when the materials for the component are not scheduled or otherwise identified for each specific installation (e.g., pipe, anchor bolts, pipe supports, coatings, etc.). Where materials are scheduled for specific individual components (e.g., equipment, instruments, conduit, panels, etc.), furnish materials as specified.

1.02 RELATED SECTIONS:

A. Section 01 11 80 – Environmental Conditions

1.03 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Atmospheric: Air space surrounding a structure or process.
   2. Solution: Liquid or solid which may contain water or other free liquid.

B. EXPOSURE TYPE: Included as a supplement to this Section, the Area Exposure Table designates an Exposure Type for each room or area. Each Exposure Type, listed from least to most severe corrosion potential, is defined below:
   1. Indoor Dry: locations inside a building or other enclosed structure not subjected to wash down and not in contact with a liquid holding or earth retaining wall.
   2. Indoor Wet: locations inside a building or structure that are damp, subject to wash down, or surfaces of structures that are in contact with a liquid holding or earth retaining wall or slab.
   3. Outdoor: locations not protected from the weather, or only partly protected by a roof or open enclosure, and exposed to exterior ambient conditions. Local ambient conditions may be expected to vary, generally within the ranges specified in Section 01 11 80.
   4. Buried: below grade wall or roofs; locations covered and in contact with earth/soil.
   5. Submerged: locations inside a covered liquid or solids holding structure that are below a plane located 12 inches below the minimum operating level of the liquid in the tank or structure.
   6. Process Corrosive: locations exposed to high humidity, frequent wash down and/or corrosive gases or vapors from the process stream. Process corrosive includes locations inside an open (not covered) liquid or solids holding structure that are above a plane located 12 inches below the minimum operating level of liquid in the structure and below the top of the wall of the structure.

7. Head Space: locations inside a covered liquid or solids holding structure that are above a plane that starts 1-foot below the minimum operating liquid level in the structure.
8. Chemical Corrosive: walls, ceilings, floors, trenches and other surfaces exposed to delivery, storage, transfer, use or containment of corrosive chemicals.

C. ENVIRONMENTAL CONDITIONS: Environmental conditions for each Exposure Type are tabulated below:

Exposure Type	Environment	Chemical Exposure	Chemical Concentration
Indoor Dry	Atmospheric, Dry	None	Not Applicable
Indoor Wet	Atmospheric, Wet	None	Not Applicable
Outdoor	Atmospheric, Wet	None	Not Applicable
Buried	Solution	Earth/Soil	Not Applicable
Submerged	Solution	Various Chemicals	Dilute
Process Corrosive	Atmospheric	Hydrogen Sulfide	1 - 10 ppm
		Chlorides	Dilute
		Ferric chloride	Dilute
		Sodium hypochlorite	Dilute
		Sulfuric acid	Dilute
		Trace Chemicals	
Head Space	Low Oxygen, Wet	Hydrogen Sulfide	10 - 1500 ppm
		Other trace gases	Dilute
Chemical Corrosive	Atmospheric, Wet	Ferric chloride	45% wt
		Sodium hypochlorite	12% wt
		Sulfuric acid	98% wt

D. AREA EXPOSURE TABLE: The Area Exposure Table schedules an Exposure Type for each location, room, area, or space at the site of the Work. The Area Exposure Table is provided in Part 4 of this Section.

PART 2 NOT USED

PART 3 EXECUTION

A. MATERIALSELECTION

1. Provide construction materials, coating systems, and lining systems consistent with materials requirements specified in individual equipment/material Specifications for the exposure assigned in the area exposure table. In the event of a conflict between the individual equipment/material specification and this Section, the individual equipment/material specification governs. In the event an area exposure is not designated for a particular location, the area exposure with the most severe corrosion potential from all area exposures for adjacent locations, rooms, areas, or spaces governs, and shall be the basis of the Contract Price.

2. Where components are assigned multiple area exposures, select the material and coating specified for the area exposure that has the most severe corrosion potential. When components cross, span, or straddle the boundary separating two or more area exposures, select materials specified for the area exposure that has the most severe corrosion potential. Where materials change at a boundary between exposures, change the material at the boundary or within the less severe exposure. At material transitions, separate dissimilar metals by a dielectric coupling or other suitable barrier.

PART 4 AREA EXPOSURE TABLE

Facility Number	Facility Name	Room Number	Room Name / Delineation	Exposure Type	Notes
10	*Quinobequin Rd PS*	*---*	*Dry well side of the pump station*	*Indoor Dry*	
	"	*---*	*Wet well side of pump station, above the wet well*	*Process Corrosive*	
	"	*---*	*Wet well, above water line*	*Head space*	*Contractor to confirm elevations with Engineer*
	"	*---*	*Wet well, below water line*	*Submerged*	*Contractor to confirm elevations with Engineer .*
20	*Elliot Street PS*	*---*	*Dry well side of the pump station*	*Indoor Dry*	
	"	*---*	*Wet well side of pump station, above the wet well*	*Process Corrosive*	
	"	*---*	*Wet well, above water line*	*Head space*	*Contractor to confirm elevations with Engineer*
	"	*---*	*Wet well, below water line*	*Submerged*	*Contractor to confirm elevations with Engineer*
30	*Hamlet Street*	*---*	*site*	*Outdoor*	
	"	*---*	*wet well, above water line*	*Head space*	
	"	*---*	*Wet well, below water line*	*Submerged*	
40	*Grayson*	*---*	*site*	*Outdoor*	
	"	*---*	*wet well, above water line*	*Head space*	
	"	*---*	*Wet well, below water line*	*Submerged*	
50	*Edgewater Park PS*	*---*	*Generator Room, Pump Room*	*Indoor Dry*	
60	*Islington PS*	*---*	*Generator Room, Pump Room*	*Indoor Dry*	
70	*Oldham Rd PS*	*---*	*Wet well Above el. 73.34*	*Head space*	
	"	*---*	*Wet well below el. 73.34*	*Submerged*	

END OF SECTION

SECTION 01 66 00

PRODUCT STORAGE AND HANDLING REQUIREMENTS

PART 1 GENERAL

1.01 DAMAGE

A. Equipment, products and materials shall be shipped, handled, stored, and installed in ways which will prevent damage to the items. Damaged items will not be permitted as part of the work except in cases of minor damage that have been satisfactorily repaired and are acceptable to the Construction Manager.

1.02 PIPE

A. Pipe and appurtenances shall be handled, stored, and installed as recommended by the manufacturer. Pipes with paint, tape coatings, linings or the like shall be stored to protect the coating or lining from physical damage or other deterioration. Pipes shipped with interior bracing shall have the bracing removed only when recommended by the pipe manufacturer.

PART 2 EQUIPMENT

2.01 PACKAGE AND MARKING:

A. All equipment shall be protected against damage from moisture, dust, handling, or other cause during transport from manufacturer's premises to site. Each item or package shall be marked with the number unique to the specification reference covering the item.

B. Stiffeners shall be used where necessary to maintain shapes and to give rigidity. Parts of equipment shall be delivered in assembled or subassembled units where possible.

2.02 IDENTIFICATION:

A. Each item of equipment and valve shall have permanently affixed to it a label or tag with its equipment or valve number designated in this contract. Marker shall be of stainless steel. Location of label will be easily visible.

2.03 SHIPPING:

A. Bearing housings, vents and other types of openings shall be wrapped or otherwise sealed to prevent contamination by grit and dirt.

B. Damage shall be corrected to conform to the requirements of the contract before the assembly is incorporated into the work. The Contractor shall bear the costs arising out of dismantling, inspection, repair and reassembly.

2.04 FACTORY APPLIED COATINGS:

A. Unless otherwise specified, each item of equipment shall be shipped to the site of the work with the manufacturer's shop applied epoxy prime coating as specified in Section 09 90 00 . The prime coating shall be applied over clean dry surfaces in accordance with the coating manufacturer's recommendations. The prime coating will serve as a base for

field-applied finish coats. Electrical equipment and materials shall be painted by manufacturer as specified in Section 09 90 00.

2.05 STORAGE:

A. During the interval between the delivery of equipment to the site and installation, all equipment, unless otherwise specified, shall be stored in an enclosed space affording protection from weather, dust and mechanical damage and providing favorable temperature, humidity and ventilation conditions to ensure against equipment deterioration. Manufacturer's recommendations shall be adhered to in addition to these requirements.

B. Equipment and materials to be located outdoors may be stored outdoors if protected against moisture condensation. Equipment shall be stored at least 6 inches above ground. Temporary power shall be provided to energize space heaters or other heat sources for control of moisture condensation. Space heaters or other heat sources shall be energized without disturbing the sealed enclosure.

2.06 PROTECTION OF EQUIPMENT AFTER INSTALLATION:

A. After installation, all equipment shall be protected from damage from, including but not limited to, dust, abrasive particles, debris and dirt generated by the placement, chipping, sandblasting, cutting, finishing and grinding of new or existing concrete, terrazzo and metal; and from the fumes, particulate matter, and splatter from welding, brazing and painting of new or existing piping and equipment. As a minimum, vacuum cleaning, blowers with filters, protective shieldings, and other dust suppression methods will be required at all times to adequately protect all equipment. During concreting, including finishing, all equipment that may be affected by cement dust must be completely covered. During painting operations, all grease fittings and similar openings shall be covered to prevent the entry of paint. Electrical switchgear, unit substation, and motor load centers shall not be installed until after all concrete work and sandblasting in those areas have been completed and accepted and the ventilation systems installed.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 01 73 24

DESIGN REQUIREMENTS FOR
NON-STRUCTURAL COMPONENTS AND NON-BUILDING STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Minimum structural requirements for the design, anchorage, and bracing of non-structural components such as architectural/mechanical/HVAC/electrical components, equipment, or systems, and non-building structures such as tanks.

B. The requirements of this section apply to design of the structural elements and features of equipment and to platforms/walkways that are provided with equipment or non-building structures.

C. This section applies to non-building structures and non-structural components that are permanently attached to structures as defined below and in ASCE 7.

D. Design and conform to criteria and design codes listed within this section. Engineering design is not required for attachments, anchorage, or bracing detailed on the Drawings or where the size of attachments, anchorage, or bracing is defined in specific technical specification sections.

E. The following non-structural components are exempt from seismic design loading requirements of this section.
   1. Components in Seismic Design Category A.
   2. Furniture (except permanent floor supported storage cabinets over 6 ft tall).
   3. Temporary or movable equipment.
   4. Architectural components in Seismic Design Category B other than parapets supported by bearing walls or shear walls provided that the component importance factor, I_p, is equal to 1.0.
   5. Mechanical and electrical components in Seismic Design Category B.
   6. Mechanical and electrical components in Seismic Design Category C provided that the component importance factor, I_p, is equal to 1.0.
   7. Mechanical and electrical components in Seismic Design Categories D, E, or F where all of the following apply:
      a. The component importance factor, I_p, is equal to 1.0;
      b. The component is positively attached to the structure;
      c. Flexible connections are provided between the component and associated ductwork, piping, and conduit;
      d. And either:
         1) the component weighs 400 lb or less and has a center of mass located 4 ft or less above the adjacent floor level; or
         2) the component weighs 20 lb or less, or in the case of a distributed systems, 5 lb/ft or less.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related section. Additional related sections may apply that are not specifically listed below.
   1. Section 05 05 20 Anchor Bolts
   2. Section 05 50 00 Metal Fabrications

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
AAMA	American Architectural Manufacturer's Association
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.3	Seismic Design of Liquid-Containing Concrete Structures
AISC 341	Seismic Provisions for Structural Steel Buildings
ACI 360	Specification for Structural Steel Buildings
ASCE 7	Minimum Design Loads for Buildings and Other Structures
ASTM C635	Manufacture, Performance and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings
ASTM C636	Installation for Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings
AWS D1.1	Structural Welding Code – Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.6	Structural Welding Code – Stainless Steel
AWS D1.8	Structural Welding Code – Seismic Supplement
FFSHC	MA Field Federal Safety and Health Councils
IBC	International Building Code with local amendments
NFPA-13	Installation of Sprinkler Systems
OSHA	U.S. Dept. of Labor, Occupational Safety and Health Administration
SMACNA	Seismic Restraint Manual Guidelines for Mechanical Systems

1.04 DEFINITIONS

A. Structure: The structural elements of a building that resist gravity, seismic, wind, and other types of loads. Structural components include columns, posts, beams, girders, joists, bracing, floor or roof sheathing, slabs or decking, load-bearing walls, and foundations.

B. Non-structural Components: Non-structural portions of a building include every part of the building and all its contents, except the structural portions, that carry gravity loads and that may also be required to resist effects of wind, snow, impact, temperature and

seismic loads. Non-structural components include, but are not limited to, ceilings, partitions, windows, equipment, piping, ductwork, furnishings, lights, etc.

C. Non-building Structures: Self-supporting structures that carry gravity loads and that may also be required to resist the effects of wind, snow, impact, temperature and seismic loads. Non-building structures include, but are not limited to, pipe racks, storage racks, stacks, tanks, vessels and structural towers that support tanks and vessels.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for requested deviations to specification requirements, with the submittal is sufficient cause for rejection of the entire submittal with no further consideration.
   4. For structural elements of non-structural components and non-building structures required to be designed per this section, provide Drawings and design calculations stamped by a Massachusetts licensed professional engineer qualified to perform structural engineering.
   5. List of non-structural components and non-building structures requiring wind and seismic design and anchorage.
   6. Shop drawings showing details of complete wind and seismic bracing and anchorage attachment assemblies including connection hardware, and embedment into concrete.
   7. Shop drawings showing plans, elevations, sections and details of equipment support structures and non-building structures, including anchor bolts, structural members, platforms, stairs, ladders, and related attachments.
   8. Identify interface points with supporting structures or foundations, as well as size, location, and grip of required attachments and anchor bolts. Clearly indicate who will be providing each type of attachment/anchor bolt. Equipment vendor shall design anchor bolts, including embedment into concrete, and submit stamped calculations.
   9. Calculations for supports, bracing, and attachments shall clearly indicate design criteria applied. Coordinate concrete embedment calculations with thickness and strength of concrete members. Submit a tabulation of the magnitude of unfactored (service level) equipment loads at each support point, broken down by type of loading (dead, live, wind, seismic, etc.). Indicate impact factors applied to these loads in design calculations.

1.06 QUALITY ASSURANCE

A. Quality Control By Owner:
   1. Special Inspection of non-structural components and non-building structures, and their anchorages shall be performed by the Special Inspector under contract with the Owner and in conformance with IBC Chapter 17. Special Inspector(s) and laboratory shall be acceptable to the Owner in their sole discretion. Special Inspection is in addition to, but not replacing, other inspections and quality control requirements. Where sampling and testing required conforms to Special Inspection standards, such sampling and testing need not be duplicated.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide materials in conformance with information shown on the Drawings and in other technical specification sections. See individual component and equipment specifications for additional requirements.

2.02 DESIGN CRITERIA

A. Design Codes

Design	Code
Buildings/Structures:	International Building Code 2015 and ASCE 7-10
Reinforced concrete:	ACI 350-06 and ACI 350.3-06 for Concrete Liquid Containing Structures, ACI 318-14 for all other reinforced concrete
Structural steel:	AISC 360-10 and AISC 341-10
Aluminum:	Aluminum Design Manual, Latest Edition
Welding:	AWS Welding Codes, Latest Edition
Occupational health and safety requirements:	OSHA and DOSH

Note: When conflicting requirements occur, the most stringent requirements will govern the design.

B. Design Loads
   1. Design non-structural components and non-building structures for the following minimum loads: (Do not apply wind and snow loads to non-structural components and non-building structures that are located inside buildings.)
   2. Dead Loads:
      a. Add an additional allowance for piping and conduit when supported and hung from the underside of equipment and platforms.
      b. Typical allowance for piping and conduit: 20 psf

3. Uniform Live Loads:

Elevated grating floors:	100 psf
Columns:	No column live load reduction allowed
Exitways, stairs and landings:	100 psf
Equipment platforms, walkways/catwalks (other than exitways):	60 psf
Utility bridges:	75 psf per level

4. Snow Loads:

Code:	IBC 2015 & ASCE 7
Risk Category:	III (Wastewater Treatment facilities are Risk Category III)
Ground Snow Load (p_g):	40 psf
Exposure Factor (C_e):	C
Thermal Factor (C_t):	1.0
Importance Factor (I_s):	1.1
Drifting:	Per ASCE 7

5. Wind Loads:

Code:	IBC 2015 & ASCE 7-10
Risk Category:	III (Wastewater Treatment Facilities are Risk Category III)
Basic Wind Speed (Ultimate, 3-second gust) for Risk Category Shown Above:	127 mph
Exposure:	C
Topographic Factor (K_{zt})	1.0

Note:

1. *Design exterior non-structural components and non-building structures, unless located in a pit or basin, to withstand design wind loads without consideration of shielding effects by other structures.*

6. Seismic Loads:

Code:	IBC 2015 & ASCE 7-10
Risk Category:	III (Wastewater Treatment Facilities are Risk Category III)
0.2 Sec. Mapped Spectral Response, S_S:	0.208 g
1.0 Sec. Mapped Spectral Response, S_1:	0.068 g
Site Class:	D
0.2 Sec. Design Spectral Response, S_{DS}:	0.222 g
1.0 Sec. Design Spectral Response, S_{D1}:	0.109 g
Importance Factor (I_e):	1.25

Component Importance Factor (I_p):	1.0, except I_p=1.5 for components identified in Section 13.1.3 of ASCE 7
Seismic Design Category	B

Notes:

1. *Calculate seismic loads on the basis of governing building code. Include equipment operating loads in structure dead load.*
2. *Check individual members for seismic and full member live load acting simultaneously, except that flooded equipment loads (infrequent occurrence) need not be combined with seismic loads. Combine equipment operating loads with seismic loads.*

7. Impact Loads:
   a. Consider impact loads in design of support systems.
   b. Use the following impact load factors unless recommendations of the equipment manufacturer will cause a more severe load case:

Rotating machinery:	20% of moving load
Reciprocating machinery:	50% of moving load
Monorail Hoists:	
• Vertical	25% of lifted load
• Longitudinal	10% of lifted load
Hangers supporting floors and platforms:	33% of live and dead load

8. Temperature:
   a. Include effects of temperature in design where non-structural components and non-building structures are exposed to differential climatic conditions. See climatic conditions below for temperature extremes.

C. Load Combinations
   1. Design non-structural components and non-building structures to withstand load combinations as specified in the governing building code. Where the exclusion of live load or impact load would cause a more severe load condition for the member under investigation, ignore the load when evaluating that member.

D. Design Considerations
   1. Design non-structural components and non-building structures for the following conditions:
   2. Climatic Conditions:

Maximum design temperature:	90	degrees Fahrenheit
Minimum design temperature:	15	degrees Fahrenheit

E. Column Base Fixity
   1. Design column bases as pinned connections. No moments shall be assumed to be transferred to foundations.
   2. Where significant shear loads (greater than 5,000 lb. per anchor bolt) are transferred at column base plates, provide a shear key designed to transfer shear load.

F. Deflection
   1. Maximum beam deflection as a fraction of span for walkways and platforms: L/240 for total load and L/360 for live load.
   2. Maximum total load deflection for equipment support: L/450.

PART 3 EXECUTION

3.01 GENERAL

A. Make attachments and braces in such a manner that component force is transferred to the lateral force-resisting system of the structure. Base attachment requirements and size and number of braces per calculations submitted by Contractor.

B. Anchorage of equipment is specified to be made by cast-in anchor bolts in concrete elements unless specifically noted otherwise on the Drawings or other specification sections. Contractor is responsible for remedial work or strengthening (of concrete elements because of superimposed seismic loading) if anchor bolts are improperly installed or omitted due to lack of submittal review or improper placement for any reason, at no additional cost to Owner.

C. Provide anchor bolts in accordance with Section 05 05 20. Base size of anchor bolts and embedment on submitted calculations.

D. Submit details of and calculations for anchorages prior to placement of concrete or erection of other structural supporting members. Submittals received after structural supports are in place will be rejected if proposed anchorage method would create an overstressed condition of the supporting member. Contractor is responsible for revisions to anchorages and/or strengthening of structural support so that there is no overstress condition, at no additional cost to Owner.

END OF SECTION

SECTION 01 73 29

CUTTING AND PATCHING

PART 1 GENERAL

1.01 STRUCTURES

A. The Contractor shall take all precautions necessary to protect the integrity and usefulness of all existing plant facilities. If necessary, the Contractor may, with the approval of the Owner, remove such existing structures, including curbs, gutters, pipelines and utility poles as may be necessary for the performance of the work, and shall rebuild the structures thus removed in as good a condition as found with the requirements specified. He shall also repair existing structures which may be damaged as a result of the work under this contract.

1.02 ROADS AND STREETS

A. Unless otherwise specified, roads and streets in which the surface is removed, broken, or damaged, or in which the ground has caved or settled during the work under this contract, shall be resurfaced and brought to the original grade and section. Roadways used by the Contractor shall be cleaned and repaired. Before resurfacing material is placed, edges of pavements shall be trimmed back far enough to provide clean, solid, vertical faces, and shall be free of loose material. All paved surfaces shall be cut with a pavement saw. Rough cuts are not allowed. Repair work shall conform to the paving specifications.

1.03 CULTIVATED AREAS AND OTHER SURFACE IMPROVEMENTS

A. Cultivated or planted areas and other surface improvements which are damaged by actions of the Contractor shall be restored as nearly as possible to their original condition. Restoration shall take place within 1 week or sooner as directed by the Construction Manager.

B. Existing guard posts, barricades, and fences shall be protected and replaced if damaged.

1.04 PROTECTION OF EXISTING INSTALLATIONS

A. The Contractor shall protect all existing operating facilities and structures from damages. However, if damage occurs, the Contractor shall immediately correct or replace existing equipment, controls, systems, structures, or facilities which are damaged in any way as a result of his operations.

END OF SECTION

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SCOPE

A. Operation and maintenance (O&M) instructions shall be provided in accordance with this section and as required in the technical sections of this project manual. O&M information shall be provided for each maintainable piece of equipment, equipment assembly or subassembly, and material provided or modified under this contract.

B. O&M instructions must be submitted and accepted before on-site training may start.

1.02 TYPES OF INFORMATION REQUIRED

A. General:
   1. O&M information shall contain the names, addresses, and telephone numbers of the manufacturer, the nearest representative of the manufacturer, and the nearest supplier of the manufacturer's equipment and parts. In addition, one or more of the following items of information shall be provided as applicable.

B. Operating Instructions:
   1. Specific instructions, procedures, and illustrations shall be provided for the following phases of operations:
      a. Safety Precautions: List personnel hazards for equipment and list safety precautions for all operating conditions.
      b. Operator Prestart: Provide requirements to set up and prepare each system for use.
      c. Start-Up, Shutdown, And Post-shutdown Procedures: Provide a control sequence for each of these operations.
      d. Normal Operations: Provide control diagrams with data to explain operation and control of systems and specific equipment.
      e. Emergency Operations: Provide emergency procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Include emergency shutdown instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance on emergency operations of all utility systems including valve locations and portions of systems controlled.
      f. Operator Service Requirements: Provide instructions for services to be performed by the operator such as lubrication, adjustments, and inspection.
      g. Environmental Conditions: Provide a list of environmental conditions (temperature, humidity, and other relevant data) which are best suited for each product or piece of equipment and describe conditions under which equipment should not be allowed to run.

C. Preventive Maintenance:
   1. The following information shall be provided for preventive and scheduled maintenance to minimize corrective maintenance and repair:

a. Lubrication Data: Provide lubrication data, other than instructions for lubrication in accordance with paragraph 1.02 Operator Service Requirements.
    1) A table showing recommended lubricants for specific temperature ranges and applications;
    2) Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities; and
    3) A lubrication schedule showing service interval frequency.
b. Preventive Maintenance Plan And Schedule: Provide manufacturer's schedule for routine preventive maintenance, inspections, tests, and adjustments required to ensure proper and economical operation and to minimize corrective maintenance and repair. Provide manufacturer's projection of preventive maintenance man-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft.

D. Corrective Maintenance:
1. Manufacturer's recommendations shall be provided on procedures and instructions for correcting problems and making repairs.
    a. Troubleshooting Guides And Diagnostic Techniques: Provide step-by-step procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the checkout is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or require replacement.
    b. Wiring Diagrams And Control Diagrams: Wiring diagrams and control diagrams shall be point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job-specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type identically to actual installation numbering.
    c. Maintenance And Repair Procedures: Provide instructions and list tools required to restore product or equipment to proper condition or operating standards.
    d. Removal And Replacement Instructions: Provide step-by-step procedures and list required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings, and adjustments required. Instructions shall include a combination of test and illustrations.
    e. Spare Parts And Supply Lists: Provide lists of spare parts and supplies required for maintenance and repair to ensure continued service or operation without unreasonably delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead time to obtain.
    f. Corrective Maintenance Manhours: Provide manufacturer's projection of corrective maintenance man-hours including craft requirements by type of craft. Corrective maintenance that requires participation of the equipment manufacturer shall be identified and tabulated separately.

E. Appendices:
1. The following information shall be provided; include information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment.

a. Parts Identification: Provide identification and coverage for all parts of each component, assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by make, model, serial number, and source of supply to allow reordering without further identification. Provide clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing shall show the index, reference, or key number which will cross-reference the illustrated part to the listed part. Parts shown in the listings shall be grouped by components, assemblies, and subassemblies.

b. Warranty Information: List and explain the various warranties and include the servicing and technical precautions prescribed by the manufacturers or contract documents to keep warranties in force.

c. Personnel Training Requirements: Provide information available from the manufacturers to use in training designated personnel to operate and maintain the equipment and systems properly.

d. Testing Equipment And Special Tool Information: Provide information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components.

1.03 TRANSMITTAL PROCEDURE

A. Unless otherwise specified, O&M manuals, information, and data shall be transmitted in accordance with Section 01 33 00 accompanied by Transmittal Form 01 78 23-A and Equipment Record Forms 01 78 23-B and/or 01 78 23-C, as appropriate, all as specified in Section 01 99 90. The transmittal form shall be used as a checklist to ensure the manual is complete. Only complete sets of O&M instructions will be reviewed for acceptance.

B. Three (3) copies of the specified O&M information shall be provided. For ease of identification, each manufacturer's brochure and manual shall be appropriately labeled with the equipment name and equipment number as it appears in the project manual. The information shall be organized in the binders in numerical order by the equipment numbers assigned in the project manual. The binders shall be provided with a table of contents and tab sheets to permit easy location of desired information. Binders shall be provided with a table of contents and tab sheets to permit easy location of desired information.

C. If manufacturers' standard brochures and manuals are used to describe O&M procedures, such brochures and manuals shall be modified to reflect only the model or series of equipment used on this project. Extraneous material shall be crossed out neatly or otherwise annotated or eliminated.

1.04 PAYMENT

A. Acceptable O&M information for the project must be delivered to the Construction Manager prior to the project being 65 percent complete. Progress payments for work in excess of 65 percent completion will not be made until the specified acceptable O&M information has been delivered to the Construction Manager.

1.05 FIELD CHANGES

A. Following the acceptable installation and operation of an equipment item, the item's instructions and procedures shall be modified and supplemented by the Contractor to reflect any field changes or information requiring field data.

END OF SECTION

SECTION 01 78 36

WARRANTIES

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies general administrative and procedural requirements for warranties required by the Construction Documents, including manufacturer's Standard Product Warranties and Special Warranties.

B. Refer to the Standard Form of General Conditions of Contract Between Owner and Contractor for terms of the Contractor's Warranty of Construction. The maximum warranty period shall be 24-months from the date of Substantial Completion.

C. If there is any discrepancy in the Construction Documents regarding the warranty period or its date of commencement, the passage granting the Owner the longest warranty period ending on the latest date shall govern.

D. Manufacturer's disclaimers and limitations on product warranties shall not apply. All warranties shall be in full accordance with this section, unless explicitly agreed to in writing by both the Contractor and Owner, prior to commencement of supply or work. Further no manufacturer disclaimers and limitations on product warranties shall relieve suppliers, manufacturers, and Subcontractors that are required to countersign Special Warranties with the Contractor.

1.02 DEFINITIONS

A. Standard Product Warranties are preprinted written warranties published by individual manufacturers for particular products and are specifically endorsed by the manufacturer to the Owner.

B. Special Warranties are written warranties required by or incorporated in the Construction Documents, either to extend time limits provided by Standard Product Warranties or to provide greater rights to the Owner. Refer to individual sections of the Specifications for Special Warranty requirements.

1.03 WARRANTY REQUIREMENTS

A. All warranties begin at the date of Substantial Completion of the Work.

B. 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 access the failed, warranted Work.

C. When Work covered by a warranty has failed and been corrected, replaced, retested, and recommissioned, reinstate the warranty by written endorsement. The reinstated warranty shall equal the original warranty with a depreciation adjustment equal to the time previously covered.

D. Upon determination that Work covered by a warranty has failed, correct or replace the Work to an acceptable condition complying with requirements of Construction

Documents. The Contractor is responsible for the cost of correcting, replacing, retesting, and recommissioning defective Work regardless of whether the Owner has benefited from use of the Work.

E. Written warranties made to the Owner are in addition to implied warranties, and shall not limit the duties, obligations, right and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitations on time in which the Owner can enforce such other duties, obligations, rights, or remedies.

F. The Owner and Contractor or Contractor's Representative reserve the right to reject warranties and to limit selections to products with warranties not in conflict with requirements of the Construction Documents.

G. The Owner and Contractor or Contractor's Representative reserve the right to refuse to accept Work for the Project where a Special Warranty, certification, or similar commitment is required on such Work or part of the Work, until evidence is presented that entities required to countersign such commitments are willing to do so.

H. Owner and/or Contractor or Contractor's Representative acceptance of warranties does not relieve the Contractor of the warranty requirements specified in the Standard Form of General Conditions of Contract Between Owner and Contractor.

I. Ensure all Standard Product Warranties and Special Warranties are transferrable to Owner.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Warranties and Bonds Manual: Assemble executed licenses, certificates, warranties, bonds, and any required service and maintenance contracts from the respective manufacturers, suppliers, and Subcontractors. Provide two (2) preliminary review copies, identified "Preliminary." Provide four (4) final signed copies of the Warranties and Bonds Manual following review and acceptance of the preliminary manual by the Owner and/or Contractor or Contractor's Representative.
   1. Out of the four final signed copies, one (1) shall be an original.
   2. Provide one (1) CD with scanned Adobe Acrobat (.pdf) files, including an index with hyperlinks to the individual sections.

C. Include complete information for each of the following:
   1. Neatly typed Table of Contents, in a complete and orderly sequence.
   2. Product or work item, including applicable specification section number(s) per the Construction Documents
   3. Firm, with name of principal, address, telephone number, email address, and web site address
   4. Scope of warranty
   5. Start date of warranty or service and maintenance contract
   6. Duration of warranty or service and maintenance contract
   7. Proper procedure in case of failure

8. Instances which might affect validity of warranty or bond
9. Contractor, name or responsible principal, address, and telephone number.
10. For Special Warranties, prepare a written document containing all pertinent information and ready for execution by the required parties.

D. Copies shall be bound in slant-D, 3 ring view binders with an insert accepting clear vinyl overlay on the front cover and spine.
   1. Provide cover slip sheet typed with "WARRANTIES AND BONDS", Project name, Project number, Contractor, and blank field for the date. Label volumes consecutively.
   2. Each copy shall have a typewritten index and tabbed dividers between equipment categories or specification sections.
   3. The contents of the manual shall be printed on white 8-1/2" x 11" acid free, recycled copy paper and shall not exceed 75% capacity of the binder.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 01 78 39

PROJECT RECORD DOCUMENTS

PART 1 GENERAL

1.01 DRAWINGS

A. Record drawings refer to those documents maintained and annotated by the Contractor during construction and are defined as
   1. a neatly and legibly marked set of contract drawings showing the final location of piping, equipment, electrical conduits, outlet boxes and cables;
   2. additional documents such as schedules, lists, drawings, and electrical and instrumentation diagrams included in the specifications; and
   3. Contractor layout and installation drawings.

B. Unless otherwise specified, record drawings shall be full size and maintained in a clean, dry, and legible condition. Record documents shall not be used for construction purposes and shall be available for review by the Construction Manager during normal working hours at the Contractor's field office. At the completion of the work, prior to final payment, all record drawings shall be submitted to the Construction Manager.

C. Marking of the drawings shall be kept current and shall be done at the time the material and equipment are installed. Annotations to the record documents shall be made with an erasable colored pencil conforming to the following color code:
   1. Additions - Red
   2. Deletions - Green
   3. Comments - Blue
   4. Dimensions - Graphite*

**Legibly mark to record actual depths, horizontal and vertical location of underground raceways, cables, and appurtenances referenced to permanent surface improvements.*

END OF SECTION

SECTION 01 79 00

DEMONSTRATION AND TRAINING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for training the Owner's personnel, by persons retained by the Contractor specifically for the purpose, in the proper operation and maintenance of the equipment and systems installed under this contract.

1.02 QUALITY ASSURANCE

A. Where required by the detailed specifications, the Contractor shall provide on-the-job training of the Owner's personnel. The training sessions shall be conducted by qualified, experienced, factory-trained representatives of the various equipment manufacturers. Training shall include instruction in both operation and maintenance of the subject equipment.

1.03 SUBMITTALS

A. The following information shall be submitted to the Construction Manager in accordance with the provisions of Section 01 33 00. The material shall be reviewed and accepted by the Construction Manager as a condition precedent to receiving progress payments in excess of 50 percent of the contract amount and not less than 3 weeks prior to the provision of training.
   1. Lessons plans for each training session to be conducted by the manufacturer's representatives. In addition, training manuals, handouts, visual aids, and other reference materials shall be included.
   2. Subject of each training session, identity and qualifications of individuals to be conducting the training, and tentative date and time of each training session.

PART 2 PRODUCTS

2.01 GENERAL

A. Where specified, the Contractor shall conduct training sessions for the Owner's personnel to instruct the staff on the proper operation, care, and maintenance of the equipment and systems installed under this contract. Training shall take place at the site of the work and under the conditions specified in the following paragraphs. Approved operation and maintenance manuals shall be available at least 30 days prior to the date scheduled for the individual training session.

2.02 LOCATION

A. Training sessions shall take place at the site of the work

2.03 LESSON PLANS

A. Formal written lesson plans shall be prepared for each training session. Lesson plans shall contain an outline of the material to be presented along with a description of visual

aids to be utilized during the session. Each plan shall contain a time allocation for each subject.

B. One complete set of originals of the lesson plans, training manuals, handouts, visual aids, and reference material shall be the property of the Owner and shall be suitably bound for proper organization and easy reproduction. The Contractor shall furnish ten copies of necessary training manuals, handouts, visual aids and reference materials at least 1 week prior to each training session.

2.04 FORMAT AND CONTENT

A. Each training session shall be comprised of time spent both in the classroom and at the specific location of the subject equipment or system. As a minimum, training session shall cover the following subjects for each item of equipment or system:
   1. Familiarization
      a. Review catalog, parts lists, drawings, etc., which have been previously provided for the plant files and operation and maintenance manuals.
      b. Check out the installation of the specific equipment items.
      c. Demonstrate the unit and indicate how all parts of the specifications are met.
      d. Answer questions.
   2. Safety
      a. Using material previously provided, review safety references.
      b. Discuss proper precautions around equipment.
   3. Operation
      a. Using material previously provided, review reference literature.
      b. Explain all modes of operation (including emergency).
      c. Check out Owner's personnel on proper use of the equipment.
   4. Preventive Maintenance
      a. Using material previously provided, review preventive maintenance (PM) lists including:
         1) Reference material.
         2) Daily, weekly, monthly, quarterly, semiannual, and annual jobs.
      b. Show how to perform PM jobs.
      c. Show Owner's personnel what to look for as indicators of equipment problems.
   5. Corrective Maintenance
      a. List possible problems.
      b. Discuss repairs--point out special problems.
      c. Open up equipment and demonstrate procedures, where practical.
   6. Parts
      a. Show how to use previously provided parts list and order parts.
      b. Check over spare parts on hand. Make recommendations regarding additional parts that should be available.
   7. Local Representatives
      a. Where to order parts: name, address, telephone.
      b. Service problems:

1) Who to call.
2) How to get emergency help.

8. Operation and Maintenance Manuals
   a. Review any other material submitted.
   b. Update material, as required.

2.05 VIDEO RECORDING:

A. The Owner will retain the services of a commercial video taping service to record each training session. After taping, the material will be edited and supplemented with professionally produced graphics to provide a permanent record. The Contractor shall advise all manufacturers providing training sessions that the material will be video taped and shall make available to the Owner's video taping contractor such utility services and accommodation as may be required to facilitate the production of the video tape record.

PART 3 EXECUTION

3.01 SUMMARY

A. Training shall be conducted in conjunction with the operational testing and commissioning periods. Classes shall be scheduled such that classroom sessions are interspersed with field instruction in logical sequence. The Contractor shall arrange to have the training conducted on consecutive days, with no more than 6 hours of classes scheduled for any one day. Concurrent classes shall not be allowed. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

B. Acceptable operation and maintenance manuals for the specific equipment shall be provided to the Owner prior to the start of any training. Video taping shall take place concurrently with all training sessions.

C. The following services shall be provided for each item of equipment or system as required in individual specification sections. Additional services shall be provided, where specifically required in individual specification sections.
   1. As a minimum classroom equipment training for operations personnel will include:
      a. Using slides and drawings, discuss the equipment's specific location in the plant and an operational overview.
      b. Purpose and plant function of the equipment.
      c. A working knowledge of the operating theory of the equipment.
      d. Start-up, shutdown, normal operation, and emergency operating procedures, including a discussion on system integration and electrical interlocks, if any.
      e. Identify and discuss safety items and procedures.
      f. Routine preventative maintenance, including specific details on lubrication and maintenance of corrosion protection of the equipment and ancillary components.
      g. Operator detection, without test instruments, of specific equipment trouble symptoms.
      h. Required equipment exercise procedures and intervals.

i. Routine disassembly and assembly of equipment if applicable (as judged by the Owner on a case-by-case basis) for purposes such as operator inspection of equipment.

2. As a minimum, hands-on equipment training for operations personnel will include:
   a. Identify location of equipment and review the purpose.
   b. Identifying piping and flow options.
   c. Identifying valves and their purpose.
   d. Identifying instrumentation:
      1) Location of primary element.
      2) Location of instrument readout.
      3) Discuss purpose, basic operation, and information interpretation.
   e. Discuss, demonstrate, and perform standard operating procedures and round checks.
   f. Discuss and perform the preventative maintenance activities.
   g. Discuss and perform start-up and shutdown procedures.
   h. Perform the required equipment exercise procedures.
   i. Perform routine disassembly and assembly of equipment if applicable.
   j. Identify and review safety items and perform safety procedures, if feasible.
3. Classroom equipment training for the maintenance and repair personnel will include:
   a. Theory of operation.
   b. Description and function of equipment.
   c. Start-up and shutdown procedures.
   d. Normal and major repair procedures.
   e. Equipment inspection and troubleshooting procedures including the use of applicable test instruments and the "pass" and "no pass" test instrument readings.
   f. Routine and long-term calibration procedures.
   g. Safety procedures.
   h. Preventative maintenance such as lubrication; normal maintenance such as belt, seal, and bearing replacement; and up to major repairs such as replacement of major equipment part(s) with the use of special tools, bridge cranes, welding jigs, etc.
4. Hands-on equipment training for maintenance and repair personnel shall include:
   a. Locate and identify equipment components.
   b. Review the equipment function and theory of operation.
   c. Review normal repair procedures.
   d. Perform start-up and shutdown procedures.
   e. Review and perform the safety procedures.
   f. Perform Owner approved practice maintenance and repair job(s), including mechanical and electrical adjustments and calibration and troubleshooting equipment problems.

END OF SECTION

SECTION 01 91 00

COMMISSIONING

PART 1 GENERAL

1.01 DESCRIPTION:

A. This section contains requirements for the Contractor's performance during the commissioning of the structures, equipment and systems constructed and installed during the course of this contract. All commissioning work, as described in this section, shall be performed by the Contractor.

1.02 QUALITY ASSURANCE

A. Cleanup:
   1. Following completion of the functional and operational testing period, the Contractor shall remove, clean, and replace all permanent and temporary filters and strainers in all pipeline systems; replace all HVAC filters; dewater and clean all sumps; and dewater all process units for final inspection as a condition precedent to commissioning.

B. Commissioning Team:
   1. The Contractor shall assemble a commissioning team under the direction of an individual duly authorized to commit the Contractor's personnel and resources to respond to requests for assistance on the part of the Engineer or, through the Engineer, the Owner. The commissioning team shall consist of representatives of the Contractor's mechanical, electrical, and instrumentation subcontractors, and others as appropriate. The commissioning team shall be available at the site of the work during normal working hours (8 hours a day, 5 days a week, Saturdays, Sundays, and legal holidays excepted) and shall be available within 2 hours' notice at all other times upon notice by telephone. The commissioning team shall at all times be equipped and ready to provide for emergency repairs, adjustments, and corrections to the equipment and systems installed and modified as a part of this contract.

1.03 SUBMITTALS

A. The following information shall be submitted to the Engineer in accordance with the provisions of Section 01 33 00:
   1. Detailed plans for commissioning each process unit and each system constructed or modified as a part of the work performed under this contract.
   2. The Contractor's plan for providing a commissioning team during the commissioning period. The plan shall be complete with a daytime staffing plan and names, qualifications, and telephone numbers of those assigned to off-hour standby duty.

PART 2 PRODUCTS

2.01 SUMMARY

A. Working with representatives of the Owner and the Engineer, the Contractor shall develop and produce a detailed, written plan for the startup and initial operation, under

actual operating conditions, of the equipment and systems installed and constructed under this contract. The document, after acceptance by the Engineer, shall serve as the guidance manual for the commissioning process.

PART 3 EXECUTION

3.01 SUMMARY

A. After completion of the equipment and system performance and operational testing, where required, and agreement on the part of the Engineer that the systems did meet all test requirements, commissioning will begin. The commissioning period for each modified or new unit process system shall be 1 week (5 days). The Contractor shall remove all temporary piping, bulkheads, controls and other alterations to the permanent systems that may have been needed during the performance and operational testing and shall perform the tasks necessary to make the improvements constructed under this contract fully operational. The Engineer shall confirm in writing the date(s) that the system is ready for commissioning and on which actual commissioning activities commence. Activities conducted prior to such written confirmation shall not constitute commissioning.

B. The Owner's operation and maintenance personnel will be responsible for operation of the systems to be commissioned. The portion of the work to be commissioned shall be fully operational, performing all functions for which it was designed.

C. The Contractor shall be available at all times during commissioning periods to provide immediate assistance in case of failure of any portion of the system being constructed. At the end of the commissioning period and when all corrections required by the Engineer to assure a reliable and completely operational facility are complete, the Engineer shall issue a completion certificate. Each system shall have been issued a completion certificate as a condition precedent to the final acceptance of the work of this contract.

D. During the commissioning period, the Owner shall be responsible for all normal operational costs and the Contractor shall bear the costs of all necessary repairs or replacements, including labor and materials, required to keep the portion of the plant being commissioned, operational.

END OF SECTION

SECTION 01 99 90

REFERENCE FORMS

PART 1 FORMS

1.01 DESCRIPTION

A. The forms listed below and included in this section are referenced from other sections of the project manual:

Form No.	Title
01 33 00-A	Submittal Transmittal Form
01 45 20-A	Equipment Test Report Form
01 78 23-A	Operation and Maintenance Transmittal Form
09 90 00-A	Coating System Inspection Checklist
26 05 00-A	Wire and Cable Resistance Test Data Form
26 05 00-B	Installed Motor Test Data Form
26 05 00-C	Dry Transformer Test Data Form
26 05 00-D	Motor Control Center Test Form
26 05 00-L	Neutral Grounding Resistor Test
40 61 13-A	Loop Wiring and Insulation Resistance Test Data Form
40 61 13-B	Control Circuit Piping Leak Test Form
40 61 13-C	Controller Calibration Test Data Form
40 61 13-D	Panel Indicator Calibration Test Data Form
40 61 13-E	Recorder Calibration Test Data Form
40 61 13-F	Signal Trip Calibration Test Data Form
40 61 13-G	Field Switch Calibration Test Data Form
40 61 13-H	Transmitter Calibration Test Data Form
40 61 13-I	Miscellaneous Instrument Calibration Test Data Form
40 61 13-J	Individual Loop Test Data Form
40 61 13-K	Loop Commissioning Test Data Form
43 05 11-A	Manufacturer's Installation Certification Form
43 05 11-B	Manufacturer's Instruction Certification Form
43 05 11-C	Unit Responsibility Certification Form
43 05 21-A	Motor Data Form

01 33 00-A. SUBMITTAL TRANSMITTAL FORM

Submittal Transmittal

Submittal Description:	Submittal No:[1]	Spec Section:

	Routing	Sent	Received
Owner:	Contractor/CM		
Project:	CM/Engineer		
	Engineer/CM		
Contractor:	CM/Contractor		

We are sending you:
☐ Attached
☐ Under separate cover via _____
☐ Submittals for review and comment
☐ Product data for information only

Remarks: _____

Item	Copies	Date	Section No.	Description	Review action[a]	Reviewer initials	Review comments attached

[a]*Note: NET = No exceptions taken; MCN = Make corrections noted; A&R = Amend and resubmit; R = Rejected*
Attach additional sheets if necessary.

Contractor

Certify either a or b:

a. ☐ We have verified that the material or equipment contained in this submittal meets all the requirements, including coordination with all related work, specified (no exceptions).

b. ☐ We have verified that the material or equipment contained in this submittal meets all the requirements specified except for the attached deviations.

No.	Deviation

Certified by: _____

Contractor's Signature: _____

[1]See *Section 01 33 00-1.04. A, Transmittal Procedure.*

01 45 20-A. EQUIPMENT TEST REPORT FORM

NOTE: This example equipment test report is provided for the benefit of the Contractor and is not specific to any piece of equipment to be installed as a part of this project. The example is furnished as a means of illustrating the level of detail required for the preparation of equipment test report forms for this project.

City Of Sample

Example Water Treatment Plant

Stage IV Expansion Project

ABC Construction Company, Inc., General Contractor
XYZ Engineering, Inc., Construction Manager

Equipment Test Report

- Equipment Name: Sludge Pump 2
- Equipment Number: P25202
- Specification Ref: 11390
- Location: East Sedimentation Basin Gallery

	Contractor		Construction Manager	
	Verified	Date	Verified	Date
A. Preoperational Checklist				
1. Mechanical				
a. Lubrication				
b. Alignment				
c. Anchor bolts				
d. Seal water system operational				
e. Equipment rotates freely				
f. Safety guards				
g. Valves operational				
h. Hopper purge systems operational				
i. Sedimentation tank/hopper clean				
j. O&M manual information complete				
k. Manufacturer's installation certificate complete				
2. Electrical (circuit ring-out and high-pot tests)				
a. Circuits:				
1) Power to MCC 5				
2) Control to HOA				
3) Indicators at MCC:				
a) Red (running)				
b) Green (power)				
c) Amber (auto)				
4) Indicators at local control panel				
b. Wiring labels complete				
c. Nameplates:				
1) MCC				
2) Control station				
3) Control panel				

	Contractor		Construction Manager	
	Verified	Date	Verified	Date
d. Equipment bumped for rotation				
3. Piping Systems				
a. Cleaned and flushed:				
1) Suction				
2) Discharge				
b. Pressure tests				
c. Temporary piping screens in place				
4. Instrumentation and Controls				
a. Flowmeter FE2502F calibration				
1) Calibration Report No.				
b. Flow recorder FR2502G calibrated against transmitter				
c. VFD speed indicator calibrated against independent reference				
d. Discharge overpressure shutdown switch calibration				
e. Simulate discharge overpressure Shutdown				
B. Functional Tests				
1. Mechanical				
a. Motor operation temperature satisfactory				
b. Pump operating temperature satisfactory				
c. Unusual noise, etc?				
d. Pump operation: 75 gpm/50 psig				
(1) Measurement:				
(a) Flow:				
(b) Pressure:				
(c) Test gage number:				
e. Alignment hot				
f. Dowelled in				
g. Remarks:				
2. Electrical				
a. Local switch function:				
1) Runs in HAND				
2) No control power in OFF				
3) Timer control in AUTO				
b. Overpressure protection switch PS2502C functional in both HAND and AUTO				
c. Overpressure protection switch PS2502C set at 75 psig				
d. PLC 2500 set at 24-hour cycle, 25 min ON				
C. Operational Test				
1. 48-hour continuous test. Pump cycles as specified, indicators functional, controls functional, pump maintains capacity, overpressure protection remains functional, hour meter functional				

RECOMMENDED FOR BENEFICIAL OCCUPANCY:

Construction Manager	Date

ACCEPTED FOR BENEFICIAL OCCUPANCY

Owner's Representative	Date

01 78 23-A. OPERATION AND MAINTENANCE TRANSMITTAL FORM

Date:	Submittal No:[2]
To:	Contract No:
	Spec. Section:
	Submittal Description:
Attention:	From:

Checklist	Contractor		Construction Manager	
	Satisfactory	N/A	Accept	Deficient
1. Table of contents				
2. Equipment record forms				
3. Manufacturer information				
4. Vendor information				
5. Safety precautions				
6. Operator prestart				
7. Start-up, shutdown, and postshutdown procedures				
8. Normal operations				
9. Emergency operations				
10. Operator service requirements				
11. Environmental conditions				
12. Lubrication data				
13. Preventive maintenance plan and schedule				
14. Troubleshooting guides and diagnostic techniques				
15. Wiring diagrams and control diagrams				
16. Maintenance and repair procedures				
17. Removal and replacement instructions				
18. Spare parts and supply list				
19. Corrective maintenance man-hours				
20. Parts identification				
21. Warranty information				
22. Personnel training requirements				
23. Testing equipment and special tool information				

Remarks:

Contractor's Signature :

[2] See Section 01 33 00-1.04.A, Transmittal Procedure.

01 78 23-B. EQUIPMENT RECORD FORM

Equip Descrip		Equip Loc	
Equip No.	Shop Dwg No.	Date Inst	Cost
Mfgr		Mfgr Contact	
Mfgr Address			Phone
Vendor		Vendor Contact	
Vendor Address			Phone

Maintenance Requirements	D	W	M	Q	S	A	Hours

Lubricants: Recommended:

Alternative:

Misc. Notes:

Recommended Spare Parts					Electrical Nameplate Data			
Part No	Quan	Part Name	Cost		Equip			
					Make			
					Serial No.		Id No.	
					Model No.		Frame No.	
					Hp	V	Amp	Hz
					Ph	Rpm	Sf	Duty
					Code	Insl. Cl	Des	Type
					Nema Des	C Amb	Temp Rise	Rating
					Misc.			
					Mechanical Nameplate Data			
					Equip			
					Make			
					Serial No.		Id No.	
					Model No.		Frame No.	
					Hp	Rpm	Cap	Size
					Tdh	Imp Sz	Belt No.	Cfm
					Psi	Assy No.	Case No.	
					Misc			

01 78 23-C. EQUIPMENT RECORD FORM

Equip Descrip		Equip Loc	
Equip No.	Shop Dwg No.	Date Inst	Cost
Mfgr		Mfgr Contact	
Mfgr Address			Phone
Vendor		Vendor Contact	
Vendor Address			Phone

Maintenance Requirements	D	W	M	Q	S	A	Hours

09 90 00-A COATING SYSTEM INSPECTION CHECKLIST

Project Name			
Owner		Coating System Manufacturer (CSM)	
General Contractor (GC)		Coating System Applicator (CSA)	
Area or Structure		Location within Structure	
Coating System (eg E-1)		Coating Type (eg Epoxy, etc.)	

Coating System Inspection Checklist

Step	Description		Name	Signature	Date
1	Completion of cleaning and substrate decontamination prior to abrasive blast cleaning.	GC QC			
		CSM QC			
		CSA QC			
2	Installation of protective enclosure of structure or area and protection of adjacent surfaces or structures that are not to be coated.	GC QC			
		CSM QC			
		CSA QC			
3	Completion of ambient condition control in structure or building area and acceptance of ventilation methods in structure or Area.	GC QC			
		CSM QC			
		CSA QC			
4	Completion of Surface Preparation for Substrates to Be Coated.	GC QC			
		CSM QC			
		CSA QC			
5	Completion of Primer Application.	GC QC			
		CSM QC			
		CSA QC			
6	Completion of Concrete Repairs If Required and Related Surface Preparation Rework Prior to Coating System Application.	GC QC			
		CSM QC			
		CSA QC			
7	Completion of Concrete Filler/ Surface Application to Concrete.	GC QC			
		CSM QC			
		CSA QC			
8	Completion of First Finish Coat Application and of Detail Treatment at Transitions or Terminations.	GC QC			
		CSM QC			
		CSA QC			

Coating System Inspection Checklist

Step	Description		Name	Signature	Date
9	Completion of Second Finish Coat Application and of Detail Treatment at Transitions and Terminations.	GC QC			
		CSM QC			
		CSA QC			
10	Completion of Full and Proper Cure of Coating System.	GC QC			
		CSM QC			
		CSA QC			
11	Completion of Testing of Cured Coating System including Adhesion, Holiday (Continuity) Testing and Dry Film Thickness.	GC QC			
		CSM QC			
		CSA QC			
12	Completion of Localized Repairs to Coating System Following Testing.	GC QC			
		CSM QC			
		CSA QC			
13	Final Acceptance of Coating System Installation Including Final Clean-Up Complying with Specification Requirements and the CSM's Quality Requirements.	GC QC			
		CSM QC			
		CSA QC			

26 05 00-A. WIRE AND CABLE RESISTANCE TEST DATA FORM

Wire or Cable No.:_____ Temperature, °F: _____

Location of Test	Insulation resistance, megohms
1.	
2.	
3.	
4.	
5.	
6.	
7.	

.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-B. INSTALLED MOTOR TEST DATA FORM

Motor Equipment Number: _____ Date of test: _____

Equipment Driven: _____

MCC Location: _____

						Ambient temp	°F
Resistance:							
Insulation resistance phase-to-ground megohms:							
Phase A		Phase B		Phase C			
Current at Full Load:							
Phase				Current, amps			
Phase				Current, amps			
Phase				Current, amps			
Thermal Overload Device:		Manufacturer/catalog #			Amperes		
Circuit breaker (MCP) setting:							

Motor Nameplate Markings:

Mfr		Mfr Model		Frame		HP	
Volts		Phase		RPM		Service factor**	
Amps		Freq		Ambient temp rating			°C
Time rating				Design letter**			
	(NEMA 1-10.35)				(NEMA MG-1.16)		
Code letter				Insulation class			

**Required for 3-phase squirrel cage induction motors only.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-C. DRY TRANSFORMER TEST DATA FORM

(Note: Use Data Form for dry type transformers with voltage rating of 600 Vac or less and sizes to 167 kVA single phase and 500 kVA three phase. Use NETA Test Forms and Test Procedures for higher voltages and larger transformers.)

Equipment Tag No.: _____ Temperature Rating: _____

Description/Location: _____ Feeder size/Source: _____

Primary Voltage: _____ Secondary Voltage: _____ Winding Connection: _____

A. VISUAL INSPECTION

Transformer Inspection	Pass	Fail	Note
1. Nameplate data as specified			
2. Mechanical condition			
a. Free of dents and scratches			
b. Anchored properly			
c. Shipping brackets removed			
d. Spacing from wall per nameplate			
3. Grounding *			
a. Equipment grounding			
b. System grounding			

B. INSULATION-RESISTANCE TESTS:

Perform tests with calibrated megohmeter. Apply 1000 Vdc test voltage for 60 seconds and record readings in megohms at 30-seconds and 60-seconds intervals.

Test Group	Resistance between		30-second reading	60-second reading	Absorption Ratio Index 60-sec. / 30-sec.
Primary Winding to ground	A	GRD			
	B	GRD			
	C	GRD			
Secondary Winding to ground with * N-G Bond removed	a	GRD			
	b	GRD			
	c	GRD			
Primary Winding to Secondary Winding	A	a			
	B	b			
	C	c			

Submit resistance readings to the Construction Manager immediately after the tests that are less than the manufacturer's recommended value or less than 10-megohms. Record the Absorption Ratio Index values for future reference. Ratio must be 1.0 or greater, with infinity (∞) equal to 1.0.

Contractor Representative Certified: _____ Date _____

Owner Representative Witnessed:_____ Date _____

26 05 00-D. MOTOR CONTROL CENTER TEST FORM

Equipment No.: _____ Ambient room temperature: _____

Location: _____

A. MECHANICAL CHECK:

All bolted connections either bus to bus or cable to bus shall be torqued to the manufacturer's recommendations.

B. ELECTRICAL TESTS:

1. Measure insulation resistance of each bus section phase to phase and phase to ground for 1 minute using a megohmmeter at 1000 volts.

Test results (megohms)			
Phase		Phase	
A-GRD		A-B	
B-GRD		B-C	
C-GRD		C-A	

2. Set the circuit breaker in the starter unit to comply with the requirements of NEC, Article 430-52 and Table 430-152.

3. Motor overload heater elements shall be sized and installed based on the actual nameplate full load amperes of the motor connected to the starter.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-K. AUTOMATIC TRANSFER SWITCH TEST FORM

Equipment Number: _____

Location: _____

Date: _____

1. Perform an insulation resistance test (1000 volts DC for 1 minute):

Phase	A		B		C		
Pole to ground							megohms
Pole to pole	AB		BC		CA		megohms

2. Perform the following operations and initial:

   a. Manual transfer _____

   b. Loss of normal power; __sec delay

   c. Return to normal power; _____sec delay

The results shall be recorded and signed. A copy shall be given to the Construction Manager in accordance with paragraph 26 05 00-2.06 Product Data.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

26 05 00-L. NEUTRAL GROUNDING RESISTOR TEST

Equipment No.: _____

Location: _____

The pickup and time delay setting on the ground fault relay shall be set in accordance with Section 26 05 74.

1. The transformer neutral insulation resistance shall be measured with and without the grounding resistor connected to insure no parallel ground paths exist.
2. The protective relay pickup current shall be determined by injecting test current into the current sensor. The pickup current should be within 10 percent of the dial setting. Record the dial setting and actual pickup tie.
3. The relay timing shall be tested by injecting 150 and 300 percent of pickup current into the current sensor. The relay timing shall be in accordance with the manufacturer's published time-current characteristic curves. Record the relay timing at 150 and 300 percent of pickup current.
4. The circuit interrupting device shall be operated by operating the relay.

The results shall be recorded and signed by the Contractor and Construction Manager. A copy shall be given to the Construction Manager in accordance with paragraph 26 05 00-2.06 Product Data.

40 61 13-A. LOOP WIRING AND INSULATION RESISTANCE TEST DATA FORM

Loop No.: _____

List all wiring associated with a loop in table below. Make applicable measurements as indicated after disconnecting wiring.

Wire No.	Panel Tie	Field TB	Continuity Resistance[a]		Insulation Resistance[b]			
			Cond./ Cond.	Cond./ Shield	Shield/ Gnd.	Shield/ Cond.	Cond./ Gnd.	Shield/ Shield
A			--	(A/SH)				
B			(A/B)	--				
C			(A/C)	--				
D			(A/D)	--				
etc.								

NOTES:

a. Continuity Test. Connect ohmmeter leads between wires A and B and jumper opposite ends together. Record resistance in table. Repeat procedure between A and C, A and D, etc. Any deviation of ±2 ohms between any reading and the average of a particular run indicates a poor conductor, and corrective action shall be taken before continuing with the loop test.

b. Insulation Test. Connect one end of a 500 volt megger to the panel ground bus and the other sequentially to each completely disconnected wire and shield. Test the insulation resistance and record each reading.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-B. CONTROL CIRCUIT PIPING LEAK TEST FORM

Loop No.:_____

List tubing associated with loop in table below. Make applicable measurements after isolating any air consuming pilots from circuit.

Tube No.	Tubing Equivalent Length of 1/4-Inch Copper[a]	Test Period (seconds)	Permitted Pressure Drop (psi)[b]	Measured Pressure Drop (psi)
A				
B				
C				
D				
etc.				

NOTES:

a. Convert actual tubing and air motor volume to equivalent 1/4-inch copper tubing.

b. Pressure drop shall not exceed 1 psi per hundred feet 1/4-inch tubing per 5 seconds.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-C. CONTROLLER CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____ Process Variable (PV) Scale: _____

Output: _____ Output Scale: _____

PV Scale Calibration

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

Connect output to PV for following tests:

Set Point (SP) Indicator Accuracy			Output Meter Accuracy			Controller Accuracy		
SP	PV Reading	Expected % Dev.	Actual Reading	Expected Reading	Actual % Dev.	OUTPUT	OUTPUT	% Dev.
(0%)								
(50%)								
(100%)								
% Deviation Allowed:			% Deviation Allowed:			% Deviation Allowed:		

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-D. PANEL INDICATOR CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____

Scale: _____ Range: _____

PV Scale Calibration

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-E. RECORDER CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____ Chart: _____

Scale: _____ Range: _____

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-F. SIGNAL TRIP CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____

Scale: _____ Range: _____

Set Point(s): _____

After setting set point(s), run signal input through entire range and calculate deadband.

Set Point	Incr. Input Trip Point	Decr. Input Trip Point	Calc. Deadband	Required Deadband

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-G. FIELD SWITCH CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No: _____

Input: _____

Range: _____

Set Point(s): _____

Simulate process variable (flow, pressure, temperature, etc.) and set desired set point(s). Run through entire range of switch and calculate deadband.

Set Point	Incr. Input Trip Point	Decr. Input Trip Point	Calc. Deadband	Required Deadband

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-H. TRANSMITTER CALIBRATION TEST DATA FORM

Tag No. and Description: _____

Make & Model No.: _____ Serial No.: _____

Input: _____

Output: _____

Range: _____ Scale: _____

Simulate process variable (flow, pressure, temperature, etc.) and measure output with appropriate meter.

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-I. MISCELLANEOUS INSTRUMENT CALIBRATION TEST DATA FORM

(For instruments not covered by any of the preceding test forms, the Contractor shall create a form containing all necessary information and calibration procedures.)

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-J. INDIVIDUAL LOOP TEST DATA FORM

Loop No.: _____

Description: (Give complete description of loop's function using tag numbers where appropriate.)

P&ID No.: (Attach copy of P&ID.)

a. Wiring tested:

(Attach test form 40 61 13-A)

b. Instrumentation tubing/piping tested:

(Attach test form 40 61 13-B)

c. Instruments calibrated:

(Attach test forms 40 61 13-C through I)

d. List step-by-step procedures for testing loop parameters. Test loop with instruments, including transmitters and control valves, connected and functioning. If it is not possible to produce a real process variable, then a simulated signal may be used with the Construction Manager's approval.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

40 61 13-K. LOOP COMMISSIONING TEST DATA FORM

Loop No.: _____

a. Loop tested:

(Attach test form 40 61 13-J)

b. Controlled or connected equipment tests confirmed:

c. Give complete description of loop's interface with process.

d. With associated equipment and process in operation, provide annotated chart trace of loop response to changes in set points for verification of performance. This chart should demonstrate 1/4-amplitude damping as output adjusts to set point change. Show set points, starting and finishing times on chart, as well as any other pertinent data.

Connect 2-pen recorder to process variable (PV) and to controller output. Use 1 inch/second chart speed.

Pen 1 - PV - Connections:

Pen 2 - Output - Connections:

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

43 05 11-A. MANUFACTURER'S INSTALLATION CERTIFICATION FORM

Contract No:	Specification section:
Equipment name:	
Contractor:	
Manufacturer of equipment item:	

The undersigned manufacturer of the equipment item described above hereby certifies that he has checked the installation of the equipment and that the equipment, as specified in the project manual, has been provided in accordance with the manufacturer's recommendations, and that the trial operation of the equipment item has been satisfactory.

Comments:

Manufacturer	Contractor
Signature of Authorized Representative	Signature of Authorized Representative
Date	Date

43 05 11-B. MANUFACTURER'S INSTRUCTION CERTIFICATION FORM

Contract No:	Specification Section:
Equipment name:	
Contractor:	
Manufacturer of equipment item:	

The undersigned manufacturer certifies that a service engineer has instructed the wastewater treatment plant operating personnel in the proper maintenance and operation of the equipment designated herein.

Operations Check List (check appropriate spaces)	
Start-up procedure reviewed	
Shutdown procedure reviewed	
Normal operation procedure reviewed	
Others:	

Maintenance Check List (check appropriate spaces)	
Described normal oil changes (frequency)	
Described special tools required	
Described normal items to be reviewed for wear	
Described preventive maintenance instructions	
Described greasing frequency	
Others:	

Manufacturer	Signature of Contractor Representative Date
Signature of Authorized Representative	
Date	Signature of Authorized Representative Date

43 05 11-C. UNIT RESPONSIBILITY CERTIFICATION FORM

PUMP STATION REHABILITATION PROJECT 1

CERTIFICATE OF UNIT RESPONSIBILITY

FOR SPECIFICATION SECTION _____

_____

[SECTION TITLE]

In accordance with Section 43 05 11-1.02 Unit Responsibility of the contract documents, the undersigned manufacturer of driven equipment ("manufacturer") accepts unit responsibility for all components of equipment furnished to the Project under specification Section_____ , and for related equipment manufactured under sections**_____, _____, and _____ .**

We have reviewed the requirements for sections 43 05 11 and 43 23 03 where applicable) and all sections referencing this (these) section(s), including but not limited to drivers, supports for driving and driven equipment and all other specified appurtenances to be furnished to the Project by manufacturer. And, we have further reviewed, and modified as necessary, the requirements for associated variable speed drives and motor control centers. We hereby certify that all specified components are compatible and comprise a functional unit suitable for the specified performance and design requirements whether or not the equipment was furnished by us. We will make no claim nor establish any condition that problems in operation for the product provided under this specification Section _____ are due to incompatibility of any components covered by this Certificate of Unit Responsibility. Nor will we condition or void any warranty for the performance of the product of this specification Section _____ due to incompatibility of any components covered under this Certificate of Unit Responsibility.

Our signature on this Certificate of Unit Responsibility does not obligate us to take responsibility for, nor to warrant the workmanship, quality, or performance of related equipment provided by others under specification sections _____, _____, and _____. Our obligation to warranty all equipment provided by us shall remain unaffected.

Notary Public	Name of Corporation
Commission expiration date	Address
Seal:	By:
	Duly Authorized Official
	Legal Title of Official
	Date

43 05 13-A. RIGID EQUIPMENT MOUNT INSTALLATION CHECKLIST

CITY OF NEWTON, PUMP STATION REHABILITATION PROJECT 1

Equipment Tag No.: _____ Date: _____

Grout Product Name and Type: _____

Grouting System Manufacturer: _____

Grouting Application Contractor: _____

General Contractor: _____

Step 1: Verify Equipment Anchor Installation Conformance to Equipment Pad Details		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Millwright		Date
Step 2: Completion of Cleaning and Concrete Substrate Preparation Prior to Grouting		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 3: Equipment Leveling		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Millwright		Date
Step 4: Installation of Protection of Adjacent Surfaces or Structures NOT TO BE GROUTED		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 5: Preparation and Construction of Forms and Epoxy Grout Filling Standpipes		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 6: Completion of Ambient Condition Control in Structure or Building Area and Acceptance of Ambient Conditions as They Apply to Application and Curing Requirements for the Grouting System		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 7: Epoxy Grout Installation		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 8: Completion of Full and Proper Cure of Epoxy Grout		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date

Name: Grout Manufacturer's Technical Rep.		Date
Step 9: Completion of Localized Repair of Grout Voids		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 10: Final Acceptance of Grouting System Installation Including Final Clean-Up of the Work Site Complying with All Specification Requirements and the GSM's Quality Requirements		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date

43 05 21-A. MOTOR DATA FORM

Equipment Name: _____ Equipment No(s): _____

Project Site Location: _____

Nameplate Markings

Mfr:		Mfr Model:		Frame:		Horsepower:	
Volts:		Phase:		RPM:		Service Factor:	
FLA:		LRA:		Frequency:		Amb Temp Rating:	ºC

Time rating:		Design Letter:	
	(NEMA MG1-10.35)		(NEMA MG-1.16)
KVA Code Letter:		Insulation Class:	

The following information is required for explosion-proof motors only:

A. Approved by UL for installation in Class _____, Div _____, Group _____
B. UL frame temperature code ____ (NEC Tables 500-8B)

The following information is required for all motors 1/2 horsepower and larger:

A. Guaranteed minimum efficiency _____

(Section 43 05 21-2.04 Motor Efficiency)

B. Nameplate or nominal efficiency _____

Data Not Necessarily Marked on Nameplate

Type of Enclosure:			Enclosure Material:		
Temp Rise:		ºC (NEMA MG1-12.41,42)			
Space Heater included?	☐ Yes	☐ No	If Yes:	Watts	Volts
Type of motor winding over-temperature protection, if specified:					

Provide information on other motor features specified:

_____

SECTION 03 11 00

CONCRETE FORMING

PART 1 GENERAL

1.01 DESCRIPTION

A. Formwork requirements for concrete construction.

1.02 QUALITY ASSURANCE

A. References:

1. The references listed below are part of this section. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict, the requirements of this section shall prevail.

Reference	Title
ACI 117	Tolerances for Concrete Construction and Materials
ACI 301	Specifications for Structural Concrete
ACI 318	Building Code Requirements for Structural Concrete
National Institute of Standards - PS1	Construction and Industrial Plywood

B. Design – General:

1. Provide design of formwork, shoring and reshoring systems by the Contractor's Professional Engineer currently registered in the Commonwealth of Massachusetts.
2. Design, engineering, and construction of formwork, shoring, and reshoring systems is the responsibility of the Contractor.
3. Develop a procedure and schedule for removal of shores (and installation of reshores).
4. Structural record calculations, signed and sealed by the Contractor's Engineer, are required to prove that all portions of the structure, in combination with the remaining forming and shoring systems, have sufficient strength to safely support their own weight plus the loads placed thereon.
5. When developing procedures, schedules, and structural calculations; consider the structural system that exists, effects of imposed loads, and the strength of concrete at each stage of construction.

C. Design Criteria:

1. Design formwork in accordance with ACI 301 and ACI 318 for building structures and ACI 350 and 350.5 for environmental structures to provide concrete finishes as specified in Section 03 30 00.
2. Design systems for full height of wet concrete pressure.
3. Design formwork to limit maximum deflection of form facing materials, as reflected in concrete surfaces exposed to view, to 1/240 of span.

1.03 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. Manufacturer's product data with installation instructions:
      a. Form materials.
      b. Form ties (with waterstops).
      c. Form release compound.
      d. Void forms.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Letter of certification:
      a. Stating that formwork has been designed in accordance with this specification and referenced documents, sealed and stamped by the Contractor's registered design Engineer.

PART 2 PRODUCTS

2.01 FORMS

A. Wood Forms:
   1. Provide new and unused exterior grade plywood panels manufactured in accordance with American Plywood Association (APA) and bearing the trademark of that group.
      a. Forms for concrete surfaces exposed to view: use APA High Density Overlay (HDO) Plyform Class I Exterior 48" X 96" X 3/4".
      b. Forms for other concrete surfaces: use APA Douglas Fir B-B Plyform Class I Exterior 48" X 96" X 3/4-inch.
   2. When approved, plywood may be reused.

B. Metal Forms:
   1. Do not use aluminum. Provide forms free of rust and straight without dents to provide members of uniform thickness.

2.02 FORM TIES

A. Commercially fabricated for use in form construction. Fabricated so that ends or end fasteners can be removed without causing spalling at surfaces of the concrete. Cone on ends shall be 3/4 inch to 1 inch diameter. Provide embedded portion of tie not less than 1 1/2 inch from face of concrete after cone ends have been removed. Provide ties with integral waterstops at water-retaining and below grade structures.

B. Tapered through-bolts may be used when approved. Use 1-inch minimum diameter at the smallest end. Fill tapered tie holes after cleaning to produce watertight construction. Use a mechanical waterstop plug near the center of the wall and fill each side with non-shrink cement grout. Mechanical waterstop plug shall be Greenstreak Group, Inc. "X-Plug"; or equal.

2.03 FORM RELEASE COMPOUND

A. Coat form surfaces in contact with concrete using a non-staining, non-residual, water based, bond-breaking form coating. [Use NSF approved form release agents in potable water containment structures.]

PART 3 EXECUTION

3.01 PREPARATION

A. Cover surface of forms with form release compound prior to form installation in accordance with manufacturer's recommendations.

B. Do not permit excess form coating material to stand in puddles on forms or hardened concrete surfaces against which fresh concrete is to be placed.

C. Clean surfaces of forms, reinforcing steel and other embedded items of accumulated mortar, grout, or other foreign materials from previous concreting or construction activities before concrete is placed.

3.02 FORMWORK CONSTRUCTION

A. Form vertical surfaces of cast-in-place concrete including sides of footings.

B. Construct and place forms so that the resulting concrete will be of the shape, lines, dimensions, and appearance indicated on the Drawings. Brace or tie forms together to maintain position and shape under the load of freshly-placed concrete.

C. Tighten forms to prevent leakage.

D. Provide temporary openings(windows) at base of column and wall forms and at other points where necessary to facilitate cleaning and observation immediately before concrete is placed.

E. Provide temporary openings to limit height of free fall of concrete and to limit the lateral movement of concrete during placement. Openings are required in wall placements greater than 20 feet in height, spaced no more than 8 feet on center measured horizontally and vertically.

F. Place a 3/4-inch chamfer strip at exposed to view corners of formed surfaces.

G. At construction joints, overlap hardened concrete surface by at least 1 inch. Brace forms against hardened concrete to prevent movement, offsets, or loss of mortar at construction joint and to maintain a true surface. Where possible, locate juncture of built-in-place forms at architectural lines, control joints, or at other inconspicuous lines.

H. [Where circular sections are formed using flat faced materials, use flat form lengths not exceeding 2 feet wide and the resulting deflection angles at the joints is not greater than 3-1/2 degrees.

I. Construct wood forms for openings to facilitate loosening. Anchor forms so that movement of any part of the formwork system is prevented during concrete placement.

J. At platforms constructed to move equipment over in-place reinforcement, provide beams, struts, and/or legs, supported directly on formwork or other structural members without resting on reinforcing steel.

K. Provide a positive means of adjustment (wedges or jacks) at shores and struts to take up settlement during concrete placement. Brace forms against lateral deflection. Fasten in-place wedges and shims used for final adjustment of forms prior to concrete placement.

L. Place tapered through-bolt form ties with the larger end on the side of the structure in contact with liquid.

3.03 TOLERANCES

A. Install formwork with tolerances in accordance with ACI 117 and the following (the more stringent requirement controls):

1. Install formwork in accordance with manufacturer's written instructions.
2. Vertical surface tolerance from plumb; walls, columns, piers, and risers:
   ± 1/2 inch for entire height
   ± 1/4 inch in any 10 feet of height
3. Vertical surface tolerance from plumb; exposed wall corners, end columns, control-joint grooves, and other exposed to view vertical lines:
   ± 1/2 inch for entire height
   ± 1/4 inch in any 20 feet of height
4. Horizontal variation from level or from grade; top of slabs, slab soffits, ceilings, and beam soffits, measured before removal of supporting shores:
   ± 3/4 inch for entire length
   ± 3/8 inch for any bay or 20 foot length
   ± 1/4 inch in any 10 feet of length
5. Horizontal variation from level or from grade; exposed lintels, sills, parapets, horizontal grooves, and other exposed-to-view horizontal lines:
   ± 1/2 inch for entire length
   ± 1/4 inch in any 20 feet of length.
6. Plan position variation; columns, walls, and partitions:
   ± 3/4 inch for entire length
   ± 3/8 inch for any bay or 20 foot length
7. Plan location and size; sleeves, floor openings, walls, wall openings, beams, and columns:
   ± 1/2 inch
8. Cross sectional dimensions; columns and beams and thickness of slabs and walls:
   ± 3/8 inch
9. Plan dimensions; footings and foundations:
   minus 1/2 inch
   + 2 inches

10. Misplacement or eccentricity; footings and foundations:
    2 percent of footing width in direction of misplacement
    not more than 2 inches
11. Thickness; footings and foundations:
    minus 5 percent
    no limit on the maximum increase except that which may interfere with other construction.
12. Step variance in flight of stairs:
    Rise $\pm$ 1/16 inch
    Tread from level $\pm$ 1/8 inch

B. Use control points and benchmarks for reference purposes to check tolerances. Establish and maintain reference points in an undisturbed condition until final completion and acceptance of the work.

C. Regardless of tolerances listed, no portion of a structure shall extend beyond the legal boundary of work site.

D. Camber formwork to compensate for anticipated deflections in formwork under wet load of concrete. Adjust camber to maintain above specified tolerances in hardened concrete after forms and shoring are removed.

3.04 REMOVAL OF FORMS

A. Do not impose construction loads or remove shoring from any part of the structure until that portion of the structure in combination with remaining forming and shoring systems has sufficient strength to safely support its weight and loads placed thereon.

B. If forms are loosened and not removed, proceed same day with wet curing operations to soak surfaces of concrete where forms are loosened. When wet curing is not practical or not planned, loosen, remove, and start approved curing procedures on the same day.

C. When required for concrete curing in hot weather, required for repair of surface defects, or when required for finishing at an early age; remove forms as soon as concrete has hardened sufficiently to resist damage from removal operations or lack of support.

D. Remove top forms on sloping surfaces as soon as concrete has attained sufficient stiffness to prevent sagging. Make repairs or finishing treatment on such sloping surfaces immediately after form removal.

E. Remove wood forms for wall openings as soon as this can be accomplished without damage to concrete.

F. Remove formwork from columns, walls, sides of beams, and other parts not supporting weight of concrete as soon as concrete has hardened sufficiently to resist damage from removal.

G. When shores and supports are so arranged such that non-load-carrying form facing material can be removed without loosening or disturbing other shores and supports,

facing material may be removed when concrete has sufficiently hardened to resist damage from removal.

H. In all cases, proceed with curing same day as form removal.

I. Where no reshoring is planned, forms and shoring used to support weight of concrete shall be left in place until concrete has attained its specified 28-day compressive strength.

END OF SECTION

SECTION 03 20 00

CONCRETE REINFORCING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Reinforcing steel for use in reinforced concrete.

1.02 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318	Building Code Requirements For Structural Concrete
ACI SP-66	ACI Detailing Manual
ASTM A615	Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706	Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Epoxy-Coated Steel Reinforcing Bars
ASTM A884	Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM A1064	Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
AWS D1.4	Structural Welding Code - Reinforcing Steel
CRSI-PRB	Placing Reinforcing Bars
CRSI-MSP	Manual of Standard Practice
FEDSPEC QQ-W-461H	Wire, Steel, Carbon (Round, Bare, and Coated)

1.03 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Mill certificates of mill analysis, tensile, and bend tests for all reinforcing.

5. Manufacturer and type of proprietary reinforcing steel splices. Submit a current ICC Report and manufacturer's literature that contains instructions and recommendations for each type of coupler used.
6. Qualifications of welding operators, welding processes and procedures.
7. Reinforcing steel shop drawings showing reinforcing steel bar quantities, sizes, spacing, dimensions, configurations, locations, mark numbers, lap splice lengths and locations, concrete cover and reinforcing steel supports. Reinforcing steel shop drawings shall be of sufficient detail to permit installation of reinforcing steel without reference to the contract drawings. Shop drawings shall not be prepared by reproducing the plans and details indicated on the contract drawings but shall consist of completely redrawn plans and details as necessary to indicate complete fabrication and installation of reinforcing steel, including large scale drawings at joints detailing bar placement in congested areas. Placement drawings shall be in accordance with ACI 315. Reinforcing details shall be in accordance with ACI SP-66.

1.04 DELIVERY, STORAGE AND HANDLING

A. Ship reinforcing steel to the jobsite with attached plastic or metal tags having permanent mark numbers which match the shop drawing mark numbers. All reinforcing shall be supported and stored above ground. Use only plastic tags secured to the reinforcing steel bars with nylon or plastic tags for epoxy coated reinforcing steel bars.

PART 2 PRODUCTS

2.01 BAR REINFORCEMENT

A. Reinforcing steel bars shall be deformed billet steel in conformance with ASTM A615, Grade 60. Bars to be welded shall be deformed billet steel conforming to ASTM A706. Where specified, reinforcing steel shall be epoxy-coated in conformance with ASTM A775.

2.02 WIRE FABRIC

A. Wire fabric shall be welded steel mesh conforming to ASTM A1064.

2.03 WIRE AND PLAIN BARS

A. Wire used as reinforcement and bars used as spiral reinforcement in structures shall be cold drawn steel conforming to ASTM A1064.

2.04 SMOOTH DOWEL BARS

A. Smooth dowel bars shall conform to ASTM A615, Grade 60, with a metal end cap at the greased or sliding end to allow longitudinal movement.

2.05 REINFORCING STEEL MECHANICAL SPLICES

A. Reinforcing steel mechanical splices shall be a positive connecting threaded type mechanical splice system manufactured by Erico, Inc., Dayton Superior, Williams Form Engineering Company, or approved equal.

B. Type 1 mechanical splices shall develop in tension or compression a strength of not less than 125 percent of the ASTM specified minimum yield strength of the reinforcement and shall meet all other ACI 318 requirements. Where splices at the face of wall are shown or approved, form saver-type mechanical couplers may be used. Form-saver couplers shall have integral plates designed to positively connect coupler to formwork. Type 1 mechanical splices are typical except for locations noted below where Type 2 mechanical splices are required.

2.06 TIE WIRE

A. The wire shall be minimum 16 gage annealed steel conforming to FEDSPEC QQ-W-461H.

2.07 BAR SUPPORTS

A. Bar supports coming into contact with forms shall be CRSI Class 1 plastic protected or Class 2 stainless steel protected and shall be located in accordance with CRSI-MSP and placed in accordance with CRSI-PRB. Plastic coating on legs shall extend at least 0.5-inch upward from form surface.

B. Provide precast concrete blocks, four inches square in plan, with embedded tie wires (wire dobies) as specified by CRSI 1 MSP for footing and slabs on grade. Do not use brick, broken concrete masonry units, spalls, rocks, construction debris, or similar material for supporting reinforcing steel. Precast concrete blocks shall have same or higher compressive strength as specified for concrete in which they are located.

C. Provide stainless steel or plastic protected plain steel supports for other work.

2.08 FABRICATION:

A. Fabricate reinforcing steel bars in accordance with ACI 315 and the following tolerances:
   1. Sheared lengths: +/-1 inch.
   2. Overall dimensions of stirrups, ties, and spirals: +/-1/2 inch.
   3. All other bends: +0 inch, -1/2 inch
   4. Minimum diameter of bends of reinforcing steel bars: Per ACI 318.

PART 3 EXECUTION

3.01 PLACEMENT TOLERANCE

A. Reinforcing steel placement tolerance shall conform to the requirements of ACI 117, ACI 318, and the following:
   1. Reinforcing steel bar clear distance to formed surfaces shall be within +/-1/4 inch of specified clearance and minimum spacing between bars shall be a maximum of 1/4 inch less than specified.
   2. Reinforcing steel top bars in slabs and beams shall be placed +/-1/4 inch of specified depth in members 8 inches deep or less and -1/4", +1/2 inch of specified depth in members greater than 8 inches deep.
   3. Reinforcing steel spacing shall be placed within +/- one bar diameter or +/- 1 inch, whichever is greater.

4. The minimum clear distance between reinforcing steel bars shall be equal to the greater of 1 inch or the reinforcing steel bar diameter for beams, walls and slabs, and the greater of 1 1/2 inches or 1.5 times the reinforcing steel bar diameter for columns.
5. Beam and slab reinforcing steel bars shall be threaded through column vertical reinforcing steel bars without displacing the column reinforcing steel bars and still maintain clear distances for beam and slab reinforcing steel bars.

3.02 CONCRETE COVER

A. Unless specified otherwise on the Drawings, reinforcing steel bar cover shall conform to the following:
   1. Reinforcing steel bar cover shall be 3 inches for concrete cast against earth.
   2. Reinforcing steel bar cover shall be 2 inches for reinforcing steel bars for formed concrete surfaces exposed to earth and weather.
   3. Reinforcing steel bar cover shall be 2 inches for any formed surfaces exposed to or above any liquid.
   4. Reinforcing steel bar cover shall be 1 ½ inches for reinforcing not in the above categories unless noted otherwise on the design drawings.

3.03 SPLICING

A. Reinforcing steel splicing shall conform to the following:
   1. Use Class B splice lengths in accordance with ACI 318 for all reinforcing steel bars unless shown otherwise on the drawings.
   2. For welded wire fabric the splice lap length measured between the outermost cross wires of each fabric sheet shall not be less than one spacing of cross wires plus 2 inches, nor less than 1.5 times the development length nor less than 6 inches.
   3. Splices of reinforcement steel bars not specifically indicated or specified shall be subject to the approval of the Owner's Representative. Mechanical proprietary splice connections may be used when approved by the Owner's Representative or as indicated on the drawings.
   4. Welding of reinforcing steel bars is not allowed unless approved by the Owner's Representative.

3.04 CLEANING

A. Reinforcing steel bars at time of concrete placement shall be free of mud, oil, loose rust, or other materials that may affect or reduce bond. Reinforcing steel bars with rust, mill scale or a combination of both may be accepted without cleaning or brushing provided dimensions and weights including heights of deformation on a cleaned sample are not less than required by applicable ASTM standards.

3.05 PLACEMENT

A. Reinforcing steel bar placement shall conform to the following:
   1. Uncoated reinforcing steel bars shall be supported and fastened together to prevent displacement by construction loads or concrete placement. For concrete placed on ground, furnish concrete block supports or metal bar supports with non-metallic

bottom plates. For concrete placed against forms furnish plastic or plastic coated metal chairs, runners, bolsters, spacers and hangers for the reinforcing steel bar support. Only tips in contact with the forms require a plastic coating.

2. Fasten coated reinforcing steel bars together to prevent displacement. Use plastic or nylon ties to hold the coated reinforcing steel bars rigidly in place. Support coated reinforcing steel bars with plastic or plastic coated chairs, runners, bolsters, spacers and supports as required.
3. Support reinforcing steel bars over cardboard void forms by means of concrete supports which will not puncture or damage the void forms nor impair the strength of the concrete member.
4. Where parallel horizontal reinforcement in beams is indicated to be placed in two or more layers, reinforcing steel bars in the upper layers shall be placed directly over the reinforcing steel bars in the bottom layer with the clear distance between each layer to be 2 inches unless otherwise noted on the Drawings. Place spacer reinforcing steel bars at a maximum of 3'-0" on center to maintain the minimum clear spacing between layers.
5. Extend reinforcement to within 2 inches of formed edges and 3 inches of the concrete perimeter when concrete is placed against earth.
6. Reinforcing steel bars shall not be bent after embedding in hardened concrete unless approved by the Owner's Representative.
7. Tack welding or bending reinforcing steel bars by means of heat is prohibited.
8. Where required by the contract documents, reinforcing steel bars shall be embedded into the hardened concrete utilizing an adhesive anchoring system specifically manufactured for that application. Installation shall be per the manufacturer's written instructions.
9. Bars with kinks or with bends not shown shall not be used.
10. Heating or welding bars shall be performed in accordance with AWS D1.4 and shall only be permitted where specified or approved by the Owner's Representative. Bars shall not be welded at the bend.

3.06 FIELD QUALITY CONTROL

A. Field quality control shall include the following:
   1. Notify the Owner's Representative whenever the specified clearances between the reinforcing steel bars cannot be met. The concrete shall not be placed until the Contractor submits a solution to the congestion problem and it has been approved by the Owner's Representative.
   2. The reinforcing steel bars may be moved as necessary to avoid other reinforcing steel bars, conduits or other embedded items provided the tolerance does not exceed that specified in this section. The Engineer's approval of the modified reinforcing steel arrangement is required where the specified tolerance is exceeded. No cutting of the reinforcing steel bars shall be done without written approval of the Owner's Representative.
   3. Coated reinforcing steel bars will be inspected on the jobsite for handling defects, coating abrasion, coating thickness and continuity of coating. The Owner's Representative may defer final inspection of the coated reinforcing steel bars until bar erection and handling is complete. Repair coated areas as directed by the Owner's Representative and completed prior to concrete placement.

4. An independent laboratory shall be employed to review and approve Contractor welding procedures and qualify welders in accordance with AWS D1.4. The laboratory shall visually inspect each weld for visible defects and conduct non-destructive field testing (radiographic or magnetic particle) on not less than one sample for each 10 welds. If a defective weld is found, the previous 5 welds by the same welder shall also be tested.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Cast-in-place concrete, which consists of providing material, mixing, transporting equipment, and labor for the proportioning, mixing, transporting, placing, consolidating, finishing, curing, and protection of concrete in the structure.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related specification sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 60 00 Grouting
   2. Section 05 50 00 Metal Fabrications
   3. Section 07 91 26 Joint Fillers
   4. Section 07 92 00 Joint Sealants
   5. Section 09 90 00 Painting and Coating

1.03 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	Guide to Evaluation of Strength Test Results in Concrete
ACI 301	Specifications for Structural Concrete
ACI 305.1	Specification for Hot Weather Concreting
ACI 306.1	Standard Specification for Cold Weather Concreting
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.1	Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures
ACI 503.7	Specification for Crack Repair by Epoxy Injection
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM C31	Making and Curing Concrete Test Specimens in the Field
ASTM C33	Concrete Aggregates
ASTM C39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C42	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C94	Ready-Mixed Concrete
ASTM C117	Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

Reference	Title
ASTM C131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C143	Slump of Hydraulic Cement Concrete
ASTM C150	Portland Cement
ASTM C157	Length Change of Hardened Hydraulic-Cement Mortar and Concrete
ASTM C172	Sampling Freshly Mixed Concrete
ASTM C192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Air-Entraining Admixtures for Concrete
ASTM C309	Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Chemical Admixtures for Concrete
ASTM C511	Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
ASTM C595	Blended Hydraulic Cements
ASTM C618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881	Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989	Slag Cement for use in Concrete and Mortars
ASTM C1059	Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1077	Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1240	Silica Fume Used in Cementitious Mixtures
ASTM C1260	Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1293	Determination of Length Change of Concrete Due to Alkali-Silica Reaction
ASTM C1315	Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
ASTM C1567	Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602	Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D75	Sampling Aggregates
ASTM D2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM E329	Agencies Engaged in Construction Inspection, Testing, or Special Inspection
CRD-C572	U.S. Corps of Engineer's Specifications for Polyvinylchloride Waterstop
IBC	International Building Code with local amendments

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance with the specification. Include a detailed, written justification for each deviation. Failure to include a copy of this marked-up specification section, along with

justification(s) for requested deviations, with the submittal, is cause for rejection of the entire submittal with no further consideration.

4. Each proposed mix design showing:
    a. Expected strength at 7 and 28-days
    b. Slump, before and after introduction of high-range water-reducing admixture
    c. Water/cement ratio
    d. Weights and test results, certifications, and mill reports of the ingredients
    e. Chemical analysis report and report of other specified test analyses for supplementary cementitious material
    f. Aggregate gradation and documentation of test results classifying aggregate as non-potentially reactive
    g. Test results of mix design prepared by an independent testing laboratory
    h. Shrinkage test results for liquid containing structures
    i. Other physical properties necessary to review each mix design for conformance with these specifications
5. Mix designs proposed shall be sealed by a Professional Engineer registered in the state where the project is located.
6. Product literature, technical data, and dosage of proposed admixtures including, but not limited to, air entraining, water reducing, retarding, shrinkage reducing, etc.
7. Anticipated average delivery time from batch plant to site. If this time exceeds the limit specified in Part 3, include proposed method to extend set time without deleterious effects on final product. Owner's Representative reserves the right to accept or reject such proposed methods.
8. Lift Drawings: Submit shop drawings for concrete placements on the project before on-site construction begins. The drawings shall be organized by structure and submitted as a complete set for the Engineer's review. The drawings shall be drawn to scale and show dimensions, forming details, and placement volumes. Show location of construction joints, details of surface preparation, scheduled finish, embedments (including conduits, inserts, and anchor bolts), penetrations (including pipe sleeves), openings, keyways, blockouts, bulkheads, etc. The drawings shall clearly show the placement sequence and will be accompanied by a schedule that shows the schedule dates for forming, placement, and stripping for each section of concrete placed within each structure.
9. Curing program description in sufficient detail to demonstrate that the Contractor will provide acceptable strength, finish, and crack control within the completed structure. Detailed plan for curing and protection of concrete in cold and hot weather.
10. Product literature and technical data for waterstops, curing and sealing compounds, bonding compounds, surface hardeners, epoxy and chemical grout for crack injection.
11. Concrete delivery truck tickets showing the information listed in ASTM C94, section 14.

1.05 QUALITY ASSURANCE

A. Quality Control By Owner:
    1. Special Inspection of concrete work shall be performed by the Special Inspector under contract with the Owner and in conformance with the IBC Chapter 17. Special

Inspection of concrete is in addition to, not replacing, other inspections and quality control requirements specified herein. Where sampling and testing specified herein conforms to Special Inspection standards, such sampling and testing need not be duplicated.

2. All structural concrete work shall receive Special Inspection in accordance with IBC Chapter 17. Structural concrete includes elements which resist code-defined loads and whose failure would impact life safety. Non-structural site work concrete does not require Special Inspection. Anchor bolts and anchors installed in hardened concrete require Special Inspection.

B. Quality Control By Contractor:
   1. Where required to demonstrate conformance with the specified requirements for cast-in-place concrete, the Contractor shall provide the services of an independent testing laboratory which complies with the requirements of ASTM E329 and ASTM C1077. The testing laboratory shall sample and test concrete materials as specified in this section. Costs of testing laboratory services shall be borne by the Contractor.
   2. Concrete testing laboratory personnel shall be certified in accordance with the ACI Concrete Laboratory Testing Technician – Level 1 Certification Program or the ACI Concrete Strength Testing Technician Certification Program, or an equivalent program.
   3. Refer to Section 01 45 00 Contractor Quality Control.

C. Basis For Quality:
   1. Cast-in-place concrete shall conform to the requirements of ACI 301, except as modified herein.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement:
   1. Portland cement shall be ASTM C150, Type II or Type V, low alkali, containing less than 0.60 percent alkalis. In addition to standard requirements, cement shall satisfy optional chemical and physical requirements of ASTM C150, Tables 2 and 4, respectively.
   2. Portland-pozzolan cement shall be ASTM C595, Type IP (MS), interground, low alkali.
   3. Portland blast-furnace slag cement shall be ASTM C595, Type IS (MS), interground, low alkali.
   4. Use cementitious materials that are of the same brand and type and from the same plant of manufacture as the cementitious materials used in the concrete represented by the submitted field test records or used in the trial mixtures. See Change of Materials paragraph below.

B. Ground granulated blast-furnace slag (GGBFS), if used in conjunction with portland cement, shall be per ASTM C989, Grade 100 or Grade 120, limited to 50 percent of the weight of cementitious materials. If GGBFS is combined with pozzolans and/or silica fume, the total weight of GGBFS, pozzolans, and silica fume shall not exceed 50 percent of the weight of cementitious materials.

C. Silica fume, if used in conjunction with portland cement, shall be per ASTM C1240, limited to 10 percent of the weight of cementitious materials. Silica fume shall be used with a high-range water-reducing admixture.

D. Aggregates:
   1. General:
      a. Except as modified herein, fine and coarse aggregates shall conform to ASTM C33. Fine and coarse aggregates are regarded as separate ingredients. Aggregates shall be non-reactive and washed before use.
      b. Check aggregates for alkali-silica reactivity to meet the following criteria. Aggregates or combinations of cementitious materials and aggregates shall have less than 0.10% expansion at 16 days when tested in accordance with ASTM C1260 or ASTM C1567. Alternatively, aggregate tested independently in accordance with ASTM C1293 shall have less than 0.04% expansion at one-year, or combinations of aggregate and cementitious materials tested in accordance with ASTM C1293 shall have less than 0.04% expansion at two years. Test results shall be no older than two years.
      c. Tests for size and grading of fine and coarse aggregates shall be in accordance with ASTM C136. Combined aggregates shall be well and uniformly graded from coarse to fine sizes to produce a concrete that has optimum workability and consolidation characteristics. Establish the final combined aggregate gradation during mix design.
      d. Aggregates used in the project production concrete shall be obtained from the same sources and have the same size ranges as the aggregates used in the concrete represented by the submitted historical data or trial mixtures. See Change of Materials paragraph below.
   2. Fine Aggregate:
      a. Fine aggregate shall be hard, dense, durable particles of either sand or crushed stone regularly graded from coarse to fine. Gradation shall conform to ASTM C33. For classes of concrete which will be used in liquid retaining structures, fine aggregate shall not exceed 40 percent by weight of combined aggregate total, except for concrete with coarse aggregate of less than maximum size 1/2 inch.
      b. Variations from the specified gradations in individual tests will be acceptable if the average of three consecutive tests is within the specified limits and the variation is within the permissible variation listed below:

U.S. standard sieve size	Permissible variation in individual tests, percent
30 and coarser	2
50 and finer	0.5

c. Other tests shall be in accordance with the following specifications:

Test	Test method	Requirements
Amount of material	ASTM C117	3 percent passing No. 200 sieve maximum by weight
Sand equivalent	ASTM D2419	Minimum 70 percent

3. Coarse Aggregate:
   a. Coarse aggregate shall be hard, dense and durable gravel or crushed rock free from injurious amounts of soft and friable particles, alkali, and organic matter. Other deleterious substances shall not exceed the limits listed in ASTM C33, Table 4 for Class Designation 4S. Gradation of each coarse aggregate size specified shall conform to ASTM C33, Table 3.
   b. Variations from the specified gradations will be acceptable in individual tests if the average of three consecutive tests is within the specified limits.

E. Pozzolan:
   1. Pozzolan shall be Class F fly ash conforming to ASTM C618. Class C fly ash is not allowed. Pozzolan supplied during the life of the project shall have been formed at the same single source. See Change of Materials paragraph below.
   2. The pozzolan color shall not substantially alter the resulting concrete from the normal gray color and appearance.
   3. Use pozzolan materials that are of the same brand and type and from the same plant of manufacture as the materials used in the concrete represented by the submitted field test records or used in the trial mixtures.
   4. The loss on ignition shall be a maximum of four percent.
   5. The maximum percent of sulfur trioxide (SO3) shall be 4.0

F. Admixtures:
   1. General:
      a. Admixtures shall be compatible with the concrete and with each other. Calcium chloride or admixtures containing calcium chloride are not acceptable. Use admixtures in accordance with the manufacturer's recommendations and add separately to the concrete mix. Water reducing retarders and admixtures shall reduce the water required by at least 11 percent for a given concrete consistency and shall comply with the water/cement ratio standards of ACI 211.1. Retarder dosage shall result in set time consistent with requirements specified in Part 3.
   2. Water Reducing Admixtures:
      a. Conform to ASTM C494, Type A. Acceptable products include: BASF Corporation “MasterPozzolith Series”; SIKA Chemical Corp. “Plastocrete 161”; Euclid Chemical Co. “Eucon WR 91”; or approved equal.
   3. Water Reducing and Retarding Admixtures:
      a. Conform to ASTM C494, Type D. Acceptable products include: BASF Corporation “MasterSet R Series”; Sika Chemical Corp. “Plastiment”; Euclid Chemical Co. “Eucon Retarder 75”; or approved equal.
   4. High Range Water Reducing (Superplasticizing) Admixtures:
      a. Conform to ASTM C494, Type F. Acceptable products include: BASF Corporation “MasterGlenium” Series; Sika Chemical Corp. “Viscocrete 2100” or “Viscocrete

2110" (Hot Weather) or "Viscocrete 6100" (Cold Weather); Euclid Chemical Co. "Eucon 37"; GCP Applied Technologies "ADVA 195"; or approved equal.

5. High Range Water Reducing And Retarding Admixtures:
   a. Conform to ASTM C494, Type G. Acceptable products include: GCP Applied Technologies "Daracem 100"; Sika Chemical Corp. "Sikaplast 200" ; Euclid Chemical Co. "Eucon 537"; or approved equal.
6. Air Entraining Agent:
   a. Conform to ASTM C260 and produce air entrained concrete as specified in the Mix Proportioning table below. Acceptable products include: BASF Corporation "MasterAir Series"; Sika Chemical Corp. "Sika AEA-14" or "Sika AIR" ; Euclid Chemical Co. "Eucon AEA-92"; or approved equal.

G. Water:
1. For washing aggregate, mixing, and for curing shall be free from oil and deleterious amounts of acids, alkalis, and organic materials; comply with the requirements of ASTM C1602. Additionally, water used for curing shall not contain an amount of impurities sufficient to discolor the concrete.

H. Change of Materials:
1. After each concrete mix design is approved, no changes of any sort or source will be allowed without prior written approval from the Engineer. When brand, type, size, or source of cementitious materials, aggregates, water, ice, or admixtures are proposed to be changed, new field data, data from new trial mixtures, or evidence that indicates that the change will not affect adversely the relevant properties of the concrete shall be submitted for approval by the Engineer before use in concrete.

2.02 CONCRETE CHARACTERISTICS

A. Mix Proportioning:
1. Concrete shall be normal weight concrete composed of cement, pozzolan, admixtures, aggregates, and water; proportioned and mixed to produce a workable, strong, dense, and impermeable concrete. It is acceptable to substitute interground Portland-pozzolan cement conforming to ASTM C595, containing the specified amount of pozzolan in lieu of Portland cement and pozzolan. Water-cementitious material (w/cm) ratio is based on the combined contents of cement and pozzolan.
2. Provide concrete mix designs in accordance with the following guidelines:

Concrete class	Minimum[a] 28-day compressive strength, psi	ASTM coarse aggregate size	Maximum water-cementitious materials (w/cm) ratio	Minimum cementitious materials content (pounds/CY)	Pozzolan, percent by weight of cementitious materials	Air content (percent)	Slump range[f] (inches)
C-1	4500	57 or 67	0.40	560	15-25	4-6	3-5
C-2	5000	57 or 67	0.42	560	15-25[d]	4-6	3-5
D-1	4000	8	0.42	600	15-25[d]	4-6	3-5

[a] *Determine compressive strength at the end of 28 days based on test cylinders made and tested in accordance with ASTM C39.*

[b] *Compressive strength of Class A concrete may be determined at 56 days.*

[c] *Concrete encasement for electrical conduit shall contain 3 pounds of red oxide per sack of cement.*

[d] *Pozzolan use is optional for this class of concrete.*

[e] *Minimum 28-day compressive strength shall be 500 psi and maximum 28-day compressive strength shall be 1,000 psi.*

[f] *Slump before addition of high range water reducing admixture (superplasticizer). Maximum slump after addition of high range water reducing admixture shall be 8".*

[[g] Do not use high-range water reducing admixtures for Class G concrete.]

B. Use:

1. Provide concrete by class for the uses listed below.

Concrete class	Type of use
B	Non-structural concrete (sidewalks, curbs, pavers, etc.)
C-1	Typical cast-in-place structural concrete
C-2	Precast concrete
D-1	Topping concrete (Precast Concrete Topping), flume interstitial "grout", and 2" concrete topping at clarifiers

[a] *Contractor's option to use the same concrete mix for pipe encasement as the concrete slab above.*

C. Control Tests:

1. General:
   a. Select and adjust proportions of ingredients in accordance with ACI 211.1. Verification of mix characteristics for submittal may be achieved using either the Trial Mix Design method or Field Experience Data method. Do not place concrete prior to submittal and acceptance of proposed mix.
2. Trial Mix Design:
   a. Mixes verified by this method shall have the samples produced for testing, manufactured at the batch plant which will supply concrete to the project, using materials proposed for the Work and material combinations listed above. Testing, data, and reporting shall conform to ACI 318 and the following:
      1) Required compressive strength used as the basis for selecting concrete proportions (f'cr) shall be the specified concrete strength (f'c) + 1000 psi for specified concrete strengths less than 3,000 psi and f'c + 1200 psi for specified concrete strengths between 3000 psi and 5000 psi.
      2) Make at least three different trial mixtures for each class of concrete qualified by the Trial Mix Design. Each trial mixture shall have a different w/cm ratio or different cementitious materials content that will produce a range of compressive strengths encompassing f'cr.
      3) Design trial mixtures to produce a slump within ¾ inch of the maximum specified and an air content within 0.5 percent of the maximum specified.
      4) For each w/cm ratio or cementitious materials content, cast and cure at least twelve standard test cylinders in accordance with ASTM C192. Four cylinders from each batch tested at age 7-days, 14-days, and 28-days or as required to comply with ACI 318.
      5) From results of the cylinder tests, plot a curve showing the relationship between w/cm ratio and compressive strength.

6) From the curve of w/cm ratio versus compressive strength, select the w/cm ratio that will produce f'cr. This is the maximum w/cm ratio to be used unless a lower w/cm ratio is specified above.

3. Field Experience Data:
   a. When sufficient test data for a particular mix design is available which is identical or substantially similar to that proposed for use, Contractor may substitute use of this data in lieu of a trial mix design. Field data, reports, and analysis shall conform to ACI 318, except as modified herein.
      1) Historical mix design proportions for which data are submitted may vary from the specified mix within the following limits:
      a) f'c as specified or up to 500 psi above
      b) w/cm ratio as specified or lower
      c) pozzolan content within 5 percent of that specified
      d) maximum coarse aggregate size may not vary smaller, but gradation of coarse aggregate may vary
      e) slump after introduction of admixtures +0/-1 inch.
   b. Use of historical Field Experience Data does not allow modification of the project mix specifications herein without review and acceptance by the Engineer.

2.03 WATERSTOPS

A. Polyvinyl Chloride (PVC):
   1. Manufacture PVC waterstops from virgin polyvinyl chloride conforming to the Corps of Engineers Specification No. CRD-C572.
   2. Use 6-inch by 3/8-inch ribbed flat waterstop in construction joints. Acceptable products include: Greenstreak Group, Inc. "Model 679"; Vinylex Waterstops and Accessories "Model R638" or approved equal.
   3. Use 9 inch by 3/8-inch ribbed with center bulb waterstop in expansion joints. Acceptable products include: Greenstreak Group, Inc. "Model 696"; Vinylex Waterstops and Accessories Model "RLB9-38"; or approved equal.
   4. Use molded crosses, tees, and other shapes for changes of direction, intersections, and transitions as recommended by manufacturer.

B. Non-expanding Waterstops:
   1. Acceptable products include: Henry Company "SF302 Synko-Flex Waterstop with primer" or approved equal.

2.04 BONDING COMPOUNDS

A. Epoxy resin bonding compounds for use in wet areas shall conform to ASTM C881 Types IV or V, Class A, B, or C depending on temperature at use. Acceptable products include: BASF Corporation "MasterEmaco ADH 327RS"; Sika Chemical Corporation "Sikadur 32"; or approved equal.

B. Non-epoxy bonding compounds for use in dry areas for non-structural bonding or as noted on the drawings shall conform to ASTM C1059 Type II. Acceptable products include: Penetron Specialty Products "Acrylic Bondcrete"; ChemMasters "Cretelox"; or approved equal.

C. Apply bonding compounds in accordance with the manufacturer's instructions.

2.05 EPOXY FOR CRACK INJECTION

A. Use a two-component, moisture insensitive, high modulus, injection grade, 100 percent solids, epoxy-resin blend. Consistency as required to achieve complete penetration into cracks. Material shall conform to ASTM C881 Type 1 Grade 1. Acceptable products include: Sika Corporation "Sikadur 52"; Adhesives Technology Corporation "Crackbond SLV302"; or approved equal.

B. Use epoxy injection for structural crack repairs except as noted below for non-structural cracks in liquid-containing concrete structures. The Engineer shall determine whether a crack is classified as structural or non-structural.

2.06 CHEMICAL GROUT FOR CRACK INJECTION

A. Use hydrophobic polyurethane grout at the Engineer's discretion as an alternative for sealing non-structural cracks in concrete structures intended to be watertight. Acceptable products for sealing hairline cracks include: GCP Applied Technologies "DE NEEF Flex SLV PURe" (must be used with DE NEEF Flex Cat PURe); or Sika Corporation "SikaFix HH LV" as appropriate for crack width; or approved equal. Coordinate with product supplier to verify and select appropriate product for crack widths to be injected.

2.07 CURING AND SEALING COMPOUNDS

A. Acceptable products include: BASF Corporation "MasterKure CC 250SB"; Dayton Superior "Cure & Seal 25% J22UV"; or approved equal, conforming to ASTM C1315.

B. Compound shall be clear and applied in accordance with the manufacturer's instructions.

C. Curing and sealing compound shall be certified compliant with final finish system if applicable, including compatibility with floor hardeners in areas where floor hardeners are specified to be used.

PART 3 EXECUTION

3.01 GENERAL

A. Use only truck-mixed, ready-mixed concrete conforming to ASTM C94. Proportion materials by weighing.

B. Introduce pozzolan into the mixer with cement and other components of the concrete mix; do not introduce pozzolan into a wet mixer ahead of other materials or with mixing water.

C. Introduce water at the time of charging the mixer; additional water may be introduced within 45 minutes from charging the mixer, provided the specified w/c ration and slump is not exceeded and the maximum total water per the approved mix design is not exceeded.

D. Arrange with the testing laboratory for inspection as required to comply with these specifications.

E. Deliver concrete to the site and complete discharge within 90 minutes after introduction of water to the mixture. Extension of allowable time beyond this limit requires a Contractor proposed remedial action plan to be reviewed and accepted by the Owner's Representative.

3.02 CONVEYING AND PLACING CONCRETE

A. Convey concrete from the mixer to the forms in accordance with ACI 301. Remove concrete that has segregated in conveying from the site of the work.

B. Placing Concrete:
   1. General:
      a. Place concrete in accordance with ACI 301. Do not permit concrete to drop freely more than 4-ft (6-ft when superplasticizer is used).
   2. Placing Concrete By Pumping:
      a. Concrete placed by pumping is at Contractor's discretion and shall not be the cause to change or relax specified mix design characteristics. Concrete shall possess the specified characteristics at the point of placement.
      b. Measure slump at the hose discharge, except as follows: Initial slump testing in each placement shall occur at both the pumping unit inlet hopper and hose discharge. Slump loss in pumping, measured between the inlet hopper and the hose discharge, shall not exceed 1 inch. After these criteria have been satisfied, slump may be measured at the inlet hopper with allowable slump increased by the earlier measured difference, not to exceed 1 inch.
      c. Before starting each pumping operation, prime the pump and line with a cement slurry to lubricate the system. Waste cement slurry outside the forms. Equip hose tip with a safety chain for recovery in case of hose blowout during pumping. Hose or accessories shall not remain in the freshly placed concrete.
      d. Use tremie placing techniques and equipment for pump placed concrete. Pump discharge system shall remain full of concrete from pump to discharge point at all times. Concrete pumping shall not occur until Owner's Representative has verified equipment including the tremie plug. Should the discharge line become open, with zones empty of concrete, cease pumping and re-primed with tremie plug installed before continuing.
   3. Placing Concrete In Hot Weather:
      a. In temperatures above 80 degrees F, place concrete in accordance with ACI 305.1.
   4. Placing Concrete In Cold Weather:
      a. In temperatures below 40 degrees F, place concrete in accordance with ACI 306.1.

3.03 CONSOLIDATING CONCRETE:

A. Consolidate concrete in accordance with ACI 301. If evidence of inadequate consolidation is observed, concrete placement will be suspended until Contractor provides a revised plan to achieve proper consolidation.

3.04 CURING AND SEALING

A. General:
   1. Cure concrete using water (including form curing and use of moister retaining covers), a clear membrane curing compound, or by a combination of both methods. Coordinate repairs or treatment of concrete surfaces so that interruption of curing will not be necessary.
   2. Maintain concrete surface temperature between 50 degrees F and 80 degrees F for at least 5 days. Cure concrete in hot weather (above 80 degrees F) in accordance with ACI 305.1. Cure concrete in cold weather (below 45 degrees F) in accordance with ACI 306.1.

B. Water Curing:
   1. Keep concrete continuously wet for a minimum of 10-days after placement (14 days after placement for sections over 3-feet thick). Absorptive mats or fabric may be used to retain moisture during the curing period. Absorptive covers shall comply with AASHTO M182, Class 3, and moisture retaining covers shall comply with ASTM C171.
   2. Use water curing in hot weather for liquid containment structures. Cover forms and keep moist. Loosen forms as soon as possible without damage to the concrete and make provisions for curing water to run down inside them. During form removal, take care to provide continuously wet cover to newly exposed surfaces.

C. Curing Compound:
   1. When curing compound is allowed, apply it as soon as the concrete has set sufficiently so as not to be marred by the application or apply it immediately following form removal for vertical and other formed surfaces. Preparation of surfaces, application procedures, and installation precautions shall follow manufacturer's instructions. For liquid containing structures, apply curing compound at twice the manufacturer's recommended dosage rate, applied in two coats perpendicular to each other.
   2. Do not use curing compound on concrete surfaces to be coated, waterproofed, moisture-proofed, tiled, roofed, or where other coverings are to be bonded. In these cases, use water curing unless the curing compound is first removed or is compatible with the final finish covering.

3.05 PROTECTION

A. Protect concrete from injurious action by sun, rain, wind, flowing water, frost, excessive vibration and mechanical means.

B. Loading green concrete is not permitted. Green concrete is defined as concrete with less than 100 percent of the specified strength.

C. Backfill shall not be placed against concrete walls until the concrete has reached the specified strength, connecting slabs and beams have been cast and have also reached the specified strength, and watertightness testing and repairs have been completed for liquid containing structures to the satisfaction of the Owner's Representative.

D. Arrangements for covering, insulating, heating, and protecting concrete in cold weather shall be in accordance with ACI 306.1.

3.06 CONSTRUCTION JOINTS

A. General:
   1. Place concrete in each unit of construction continuously. Before new concrete is placed on or against concrete which has set, retighten forms and clean foreign matter from the surface of the set concrete. Provide waterstops as specified.

B. Construction:
   1. Form construction joints by producing a rough surface of exposed aggregates using a surface retardant; include joints between the slab and topping concrete. The limit of the treated surfaces shall be 1 inch away from the joint edges. Within 24 hours after placing, remove retarded surface mortar either by high pressure water jetting or stiff brushing or combination of both so as to expose coarse aggregate. A rough surface of exposed aggregate may also be produced by sandblasting followed by high pressure water jetting. Sandblasting, if used, shall remove 1/4 inch of laitance film and expose coarse aggregate to ensure adequate bond and watertightness at the construction joints.

C. Locations:
   1. Provide construction joint locations as follows:
      a. Cast walls exceeding 50 feet in length in panels not to exceed 30 feet in length. Cast adjoining panels only after 5-days have elapsed. Joints are not allowed within the lesser of 10 feet or 25 percent of the wall length from a corner unless specifically detailed thus on the drawings.
      b. Locate joints in beams or girders at or near the quarter point between supports.
      c. Make joints in the members of a floor system at or near the quarterpoint of the span.
      d. Make joints in walls and columns at the underside of floors, slabs, beams or girders and at the tops of footings or floor slabs.
      e. Cast slab panels in checkerboard patterns not to exceed 40 feet in length and not to exceed 900 square feet in area, with maximum 1 ½ to 1 ratio of side lengths. Minimum lapsed time between placing adjacent panels shall be 3-days. The requirements for size of slab panel is waived if joints are located on the Drawings.
   2. Vertical construction joints shall have edges grooved or beveled at faces exposed to view including interior faces of basins and tanks. Seal grooves subjected to wetting or weather with joint sealant.
   3. Continue reinforcing steel through construction joints. Beams, girders, and floor slabs shall not be constructed over columns or walls until at least one day has elapsed to allow for initial shrinkage in the column or wall. No joint will be allowed between a slab and a beam or girder unless otherwise shown. Joints shall be perpendicular to the main reinforcement. Provide waterstops in construction joints as specified.

3.07 INSERTS AND EMBEDMENTS

A. Inserts:
   1. Where pipes, castings, or conduits are to pass through structures, position in forms before placing concrete; or where shown on Drawings or approved by the Owner's Representative, provide openings in the concrete for subsequent insertion of such

pipes, castings, or conduits. Provide waterstops and a slight flare in the form to facilitate grouting and permit the escape of entrained air during grouting.

2. Provide additional reinforcement around openings. Use non-shrink grout to infill around inserts.
3. Place horizontal conduits and pipes, in slabs and beams, between the top and bottom layers of reinforcement. Spacing and size limitations shall conform to ACI 318.
4. Conduits and pipes shall not run directly beneath a column.
5. Position conduit, pipe, and other ferrous items such that there will be a minimum of 2-inches clearance between said item and concrete reinforcement. Welding inserts to reinforcement is not permitted.
6. The outside diameter of conduit or pipe shall not exceed one-fourth the slab or beam thickness.

B. Embedments:

1. Gate frames, gate thimbles, special castings, channels, grating frames, or other miscellaneous metal parts to be embedded in concrete shall be secured in the forms prior to concrete placement.
2. Embed anchor bolts and inserts in concrete as shown. Provide inserts, anchors, or other bolts necessary for the attachment of piping, valves, metal parts, and equipment.
3. Provide nailing blocks, plugs, strips, and the like necessary for the attachment of trim, finish, and similar work. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent entry of concrete. Do not use continuous anchor slots or strips in concrete intended to be watertight.
4. Position operators or sleeves for gate or valve stems to clear reinforcing steel, conduit, and other embedments, and to align accurately with equipment.

3.08 EXPANSION JOINTS

A. Expansion joints shall be as shown. Do not extend reinforcement or other embedded metal items through expansion joints. Provide waterstops where indicated.

3.09 WATERSTOPS

A. Waterstops shall conform to ACI 301. Tie waterstops in position prior to placement of concrete to prevent movement and deformation.

B. Provide waterstops in construction and expansion joints as follows:

1. Joints in parts of structures exposed to ground or water on one side and occupied by non-submerged equipment or by personnel on the other.
2. Wall and slab joints of tanks and channels subject to water pressure.
3. Waterstops shall be provided for the full height of the walls.
4. Provide at other locations shown on the Drawings.

C. Field splices shall be at straight sections using heat fused welded, butt splices only. Lapping of splices or joining by means other than heat fused welding is not allowed.

D. Install hydrophilic waterstops according to manufacturer's recommendations. Surfaces of concrete shall be prepared level/plumb and to the smoothness required by manufacturer. Grind surface as necessary. Provide bonding adhesive and concrete nails with fender washers to hold waterstop in position during concrete placement.

3.10 MODIFICATION OF EXISTING CONCRETE

A. General:
   1. Verify structural dimensions related to or controlled by previously constructed or existing structures prior to concrete work.

B. Cutting or Coring Concrete:
   1. Saw cut concrete to a depth of 1 inch to form straight outlines of concrete areas to be removed. Where reinforcement is exposed due to saw cutting or core drilling and no new material is to be placed on the cut surface, provide a protective epoxy coating to the entire cut surface.
   2. Coat surfaces of oversized openings with an epoxy bonding compound prior to re-finishing with profiling mortar to the required opening size.
   3. Grind existing joint edges to create a chamfer matching those used on adjacent construction.
   4. Investigate concrete to be drilled, cored, or sawcut to determine location of reinforcing steel. Locate penetrations to clear existing reinforcing steel. Where not possible to avoid reinforcing steel, consult the Engineer as to acceptability of cutting reinforcing steel and provide new reinforcing systems as directed.
   5. Locating methods include chipping to expose reinforcing steel, ground penetrating radar, X-ray, or magnetic flux devices. Locates of existing reinforcing shall be by the Contractor.

C. Joining New Concrete To Existing:
   1. Existing concrete surfaces to be joined with new concrete shall be cleaned and roughened by abrasive blasting, bush hammering, or other method to achieve ¼-inch amplitude surface. Remove existing metalwork, embeds, or other interfering items. Coat existing surface with epoxy bonding compound prior to placement of new concrete.

D. Post-Installed Anchors and Dowels:
   1. Use non-destructive methods for locating reinforcement prior to drilling operations. For anchor and dowel locations that interfere with reinforcement, attempt to relocate to avoid drilling through the reinforcement if possible.
   2. For situations that do not allow relocation, cutting of reinforcement for installation is subject to the following:
      a. Prior to drilling through reinforcement, the Contractor shall consult the Owner's Representative or Engineer.
      b. Drill holes with a hammer drill and carbide bit (core drilled holes are not allowed), followed by brushing and air-cleaning with oil-free compressed air.
      c. Holes drilled through reinforcement must be in compliance with adhesive anchor assumptions for roughened hole surface typical of a hammer drill and carbide bit. No smooth hole surfaces are allowed.

d. Do not cut slab rebar within 24 inches of a supporting wall, column, or an opening in the slab.
e. No cutting of rebar is allowed in the middle third of slab spans for anchors with diameters equal to or greater than 3/4 inch.
f. Maximum of two rebar may be cut in any 10 foot width of slab.
g. Maximum of two rebar may be cut within any 10 foot width of concrete wall.
h. Maximum of one rebar may be cut within any 8 foot width of CMU wall.

3. For anchors that cannot be moved and that conflict with the above requirements, consult Engineer for direction. It is not acceptable to cut reinforcement in beams, columns, precast members, or stairs.
4. Use a pre-manufactured, self-mixing, injectable, two-component, epoxy adhesive, as per Section 03 60 00. Follow manufacturer's recommendations and ICC Evaluation Report for installation.

E. Waterstops:
1. Where a waterstop between new and existing concrete is required, install a hydrophilic waterstop, or a retrofit waterstop where indicated on the design drawings for the specific location.

3.11 FORMED SURFACE FINISHES

A. Repair Of Surface Defects:
1. Repair surface defects, including tie holes, minor honeycombing, or otherwise defective concrete in accordance with ACI 301. Clean areas to be repaired. Cut and chip out honeycombed or otherwise defective areas to solid concrete, to a depth of at least 1-inch. If defective area includes exposed reinforcing steel, correct by removing concrete a minimum of 1-inch beyond the reinforcing. Make edges of the cut perpendicular to the surface of the concrete in a neat rectangular pattern.
2. Joints shall be grooved to a radius or bevel of ¾-inch depth.
3. Finish patches on exposed surfaces to match and blend with adjoining work. Cure patches as specified for the concrete. Protect finished surfaces from stains and abrasions.

B. Formed Surface Finishes:
1. Finish A - Grout Rubbed Finish
a. After repair of surface defects, apply a grout rubbed finish in accordance with ACI 301 except that all form fins and other protrusions shall be completely removed. Lightly sandblast surfaces prior to sacking. Sandblasting shall occur after the specified curing period.
b. Add a PVA bonding compound to the mix water used in sacking mortar; as recommended by the manufacturer.
c. Provide Finish A at uncoated surfaces of stair wells, at interior surfaces of equipment rooms, galleries, tunnels, operations areas, exposed channels and tanks from 1 foot below minimum water surfaces and up, at exposed exterior surfaces to 1 foot below grade, and at permanently exposed vertical and sloped surfaces such as pipe chases.
d. Do not provide Finish A at concrete surfaces receiving a coating.

2. Finish B - Smooth Surface Finish
    a. Initial surface preparation is the same as Finish A; repair surface defects and remove all form fins.
    b. Provide Finish B at surfaces to be coated, at interior surfaces of exposed channels and tanks from 1 foot below minimum water surfaces and down (Finish A applied above this level), and full height at surfaces of wet wells, tanks, and channels not exposed to view. See Section 09 90 00 for additional concrete surface preparation, including filling of bug holes, and coating requirements.
3. Finish C - Rough Form Finish
    a. Repair surface defects and imperfections greater than 3/8 inch in any dimension. Remove form fins and protrusions down to less than 3/8 inch projection.
    b. Provide Finish C or smoother at exterior surfaces from 1 foot below grade and down, at other vertical surfaces not exposed to view and not specified above to receive Finish A or B.
    c. Also apply Finish C to unoccupied interior areas not otherwise specified.
4. Finish D – Unfinished Surface
    a. Repair surface defects and otherwise leave the surfaces as they come from the forms, except plug tie holes and repair or remove defects greater than 1/2 inch in any dimension.

C. Sample Of Formed Surface Finish A:
1. Provide a sample concrete panel, minimum 4 feet by 4 feet; representative of formed surface Finish A. The panel shall be representative of the workmanship and finish required, including repair of defects, filling of tie holes, sandblasting, and rubbing.
2. The sample shall be approved by the Owner's Representative prior to the start of production work. The sample shall be on display at the job site, and finished surfaces shall match sample.

3.12 SLAB FINISHES

A. General:
1. The finishes specified herein include surface finishes, treatments and toppings for floors and slabs. Do not use dry cement on new concrete surfaces to absorb excess moisture. Round edges to a radius of 1/2 inch.
2. Slope floors to drain uniformly within a room or space. Unless otherwise specified, slope shall be a minimum of 1/8 inch per foot toward nearest drain. Restrict use of floor drains with only locally depressed slabs to locations specifically noted.
3. Immediately after final finish is applied, the surface shall be cured and protected as specified in Curing, Sealing, and Protection paragraphs above.
4. Where finish is not specified, floor slabs shall receive a Steel Trowel Finish.

B. Float Finish:
1. Perform floating with a hand or power-driven float in accordance with ACI 301. Begin floating when the bleed water sheen has disappeared and the surface has stiffened sufficiently. Float as required to meet tolerance requirements of ACI 117 for a conventional surface.

2. Floating shall close cracks and checks plus compact and smooth the surface. Refloat the slab to a uniform texture.
3. Apply float finish to surfaces of channels, tank bottom slabs, exterior below grade horizontal surfaces, including tops of footings, and surfaces to receive insulation or roofing.

3.13 TOPPING CONCRETE

A. Subfloor Finish:
   1. Slabs to receive a topping concrete, topping grout, or tile; shall be float finished to required elevations. Immediately following the final finishing, either:
      a. treat slab with a retardant and abrasive blast to create expose aggregate with ¼ inch amplitude, or
      b. create the ¼ inch amplitude roughened surface by raking the freshly floated surface using a standard garden rake.
   2. Immediately after finishing, proceed with required curing and protection of the slab as stated above.

B. Topping Concrete or Grout:
   1. Remove dirt, laitance, and loose aggregate. Keep cleaned base slab saturated surface dry for a period of 24 hours prior to the application of topping. Remove excess water.
   2. Apply and scrub a neat cement grout into the surface of the base slab using a stiff broom. The cement grout shall not be allowed to dry and shall be spread within 15 minutes ahead of the topping placement.
   3. The topping shall then be placed, compacted, and floated. Test surface with a straight edge to detect and correct high and low spots to a tolerance of 1/8 inch in 10 feet.
   4. Incorporate float finish, surface hardener, steel trowel finish, etc. as specified.

3.14 FIELD SAMPLING AND TESTS

A. General:
   1. Field sampling and tests shall be performed by an independent testing laboratory. Samples of aggregates and concrete will be obtained at such times to represent the quality of the materials and work throughout the project.
   2. The laboratory shall provide necessary labor, materials and facilities for sampling aggregate and for casting, handling, and initially storing the concrete samples at the work site.
   3. The minimum number of samples and tests are specified in Testing paragraph below.

B. Sampling:
   1. Aggregates:
      a. General:
         1) Sample fine and coarse aggregates in accordance with ASTM D75 not less than 30 days prior to the use of such aggregates in the work.
         2) Take samples at the discharge gates of the bins feeding the weigh hopper. Repeat sampling when the source of material is changed or

when unacceptable deficiencies or variations from the specified requirements of materials are found.

3) Aggregate samples shall be tagged and their sources identified.

b. Coarse Aggregate:

1) Take a sample weighing between 50 and 60 pounds after the batch plant is brought up to full operation.

2) Take samples to obtain a uniform cross section, accurately representing the materials on the belt or in the bins for sieve analysis.

c. Fine Aggregate:

1) Take samples as specified for coarse aggregate.

2) Take samples of sand when the sand is moist for sieve analysis and specific gravity tests.

2. Concrete:

a. Take samples of plastic concrete in accordance with ASTM C172.

b. Take samples at the hopper of mixing equipment or transit mix truck, except as noted in the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

C. Testing:

1. Aggregate:

a. A minimum of one test of coarse aggregate per 400 cubic yards of concrete used and a minimum of one test of fine aggregate per 200 cubic yards of concrete used shall be made to confirm continuing conformance with specifications for gradation, cleanliness and sand equivalent.

b. A maximum of one test per day of each aggregate is required.

c. Repeat of the entire concrete mix design test program is required before source changes will be accepted.

2. Concrete:

a. Strength Tests:

1) The strengths specified for the design mix shall be verified by the independent testing laboratory during placement of the concrete. Verification shall be accomplished by testing standard cylinders of concrete samples taken at the job site. Cylinders shall be 4 by 8 inch or 6 x 12 inch.

2) Concrete samples shall represent the concrete placed in the forms. One set of six standard 6 x 12 inch (or nine 4 x 8 inch) cylinders shall be cast of each class of concrete for each 100 cubic yards or less, or for each 5,000 square feet of slab or wall surface area placed per day. Provide additional cylinders when an error in batching is suspected. Each set of cylinders are cast from material taken from a single load of concrete.

3) Casting, handling and curing of cylinders shall be in accordance with ASTM C31. For the first 24 hours after casting, keep cylinders moist in a storage box constructed and located so that its interior air temperature will be between 60 and 80 degrees F. At the end of 24 hours, the testing laboratory will transport the cylinders to their laboratory.

4) Testing of specimens for compressive strength shall be in accordance with ASTM C39. Each test shall consist of two 6 x 12 inch (or three 4 x 8

inch) test cylinders from each group of six (or nine) specimens. Test at the end of 7 days and at the end of 28 days. The remaining cylinders shall be tested at the end of 56 days if the 28-day strength reports below specification.

5) A strength test shall consist of the average strength of two 6 x 12 inch (or three 4 x 8). If one cylinder shows evidence of low strength due to improper sampling, casting, handling, or curing, the result of the remaining cylinders may be used if approved by the Owner's Representative.

6) The average of any three consecutive 28-day strength test results of the cylinders representing each class of concrete for each structure shall be equal to or greater than the specified strength. Not more than 10 percent of the individual strength test results shall have values less than the specified 28-day strength for the total job concrete. No individual strength test result shall be less than the specified strength by more than 500 pounds per square inch.

7) Provide certified reports of the test results directly to the Owner's Representative and the Engineer. Test reports shall include sufficient information to identify the mix used, the stationing or location of the concrete placement, and the quantity placed. Slump, water/cement ratio, air content, temperature of concrete, and ambient temperature shall be noted.

8) The 28-day strength test results shall be evaluated in accordance with ACI 214R. Quality control charts showing field test results shall be included with the test results for each class of concrete in each major structure. Charts shall be prepared in accordance with ACI 214R. Quality control charts shall be maintained throughout the entire project and shall be available for the Owner's Representative's inspection at any time.

9) If the 28-day test results fall below the specified compressive strength for the class of concrete required for any portion of the work, adjustment in the proportions, water content, or both, shall be made as necessary at the Contractor's expense. Report changes and adjustments in writing to the Owner's Representative.

10) If compressive test results indicate concrete in place may not meet structural requirements, tests shall be made to determine if the structure or portion thereof is structurally sound. Tests may include, but not be limited to, cores in accordance with ASTM C42 and any other analyses or load tests acceptable to the Engineer. Costs of such tests and/or analysis shall be borne by the Contractor.

b. Tests for Consistency of Concrete:

1) Measure slump in accordance with ASTM C143. Take samples for slump determination from concrete during placement. Tests shall be made at the beginning of concrete placement operation, whenever test cylinders are cast, and at subsequent intervals to ensure that the specification requirements are met.

2) For pumped concrete, measure slump in accordance with the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

3) When high range water reducer is added at the site, slump tests shall be taken before and after addition of the admixture.

c. Tests for Temperature and Air Content:

1) Temperature tests shall be made at frequent intervals during hot or cold weather conditions until satisfactory temperature control is established. Perform temperature tests whenever test cylinders are cast.

2) Measure air content in accordance with ASTM C231 whenever test cylinders are cast. For pumped concrete, measure air content in accordance with the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

D. Final Laboratory Report:

1. The testing laboratory shall provide a final report at the completion of all concreting. This report shall summarize the findings concerning concrete used in the project and provide totals of concrete used by class and structure.
2. Include final quality control charts for compressive strength tests for classes of concrete specified in each major structure. Also include the concrete batch plant's coefficient of variation and standard deviation results for each class of concrete.

3.15 REPAIR OF DAMAGED AND CRACKED CONCRETE:

A. Acceptance Of Concrete:

1. Completed cast-in-place concrete work shall conform to the applicable requirements of ACI 301 and the Contract Documents. Concrete work that fails to meet these requirements shall be repaired, as approved by the Engineer, to bring the concrete into compliance. Repair methods shall be in accordance with ACI standards, including ACI 503.7, and are subject to the approval of the Engineer.
2. Concrete that cannot be brought into compliance by approved repair methods will be rejected. Remove and replace rejected concrete work.
3. The cost of repairs and replacement of defective concrete shall be borne by the Contractor.

B. Repair Methods:

1. Damaged/defective concrete or concrete with crack widths exceeding 0.004 inches at liquid-containing and conveying structures or crack widths exceeding 0.006 inches for other structures shall be repaired by one of the following methods (only the Engineer may determine that a defect or crack does not require repair):
   a. Perform watertightness testing and repair as needed to meet leakage criteria in this specification even when liquid-containing and conveying structures meet the crack width criteria defined above.
   b. Damaged or defective concrete includes surface defects, honeycomb, rock pockets, indentations greater than 3/16 inch, spalls, chips, air bubbles greater than 1/2 inch diameter, pinholes, bugholes, embedded debris, lift lines, sand lines, bleed lines, leakage from form joints, fins, projections, form popouts, texture irregularities, and stains or other color variation that cannot be removed by cleaning.
      1) Damaged or defective concrete is repaired according to procedures outlined above under finish requirements, Repair of Surface Defects.

2. Crack Repair Method 1:
    a. Fill the joint or crack by drilling holes to the affected area (following the product manufacturer's details), install injection ports, and force epoxy or chemical grout (expanding urethane) into the joint under pressure.
    b. Material type and repair procedures shall be approved by Engineer.
    c. After injection and curing; ports, sealing mix, and surface shall be cleaned and worked to match the adjacent specified finish.
3. Crack Repair Method 2:
    a. Fill cracks with low viscosity epoxy, applied by pouring/flooding crack zone until cracks are filled. Prepare surface, install, and cure according to manufacturer's recommendations.
    b. At a minimum, prepare surface to be clean and dry with no visible detrimental material in cracks to be filled. Conform to temperature limitations of epoxy. Clean and refinish to match adjacent surfaces.
4. Crack Repair Method 3:
    a. Cut a bevel groove 3/8 to 1/2 inch in width and depth, use backer rod or tape, and fill with sealant in accordance with manufacturer's instructions.
    b. This repair method is only used where approved by Engineer.
    c. Groove and sealant shall be applied on wet or hydrostatic pressure side of surface.

C. Repair Method Use:
1. Repair Method 1: For cracks in walls, surfaces sloped 1:1 or greater, beams, columns, structural slabs, overhead surfaces, and liquid retaining surfaces. Need for repair depends upon crack width, location, and leakage.
2. Epoxy grout is used for repair of structural cracks and chemical grout (expanding urethane) for repair of non-structural cracks at liquid-containing structures. The Engineer shall determine whether a crack is classified as structural or non-structural.
3. Repair Method 2: Utilized in lieu of Method 1 for slabs when approved by Owner's Representative. Final finish shall match adjacent surfaces.
4. Repair Method 3: Limited to dry-surface slabs, walls subject to less than three feet of liquid pressure, or as approved by Engineer. Repair Method 3 is not an equivalent repair method to Repair Methods 1 or 2, which shall be considered the standards.

3.16 WATERTIGHTNESS TESTING AND REPAIR

A. Liquid Containing Concrete Tanks and Channels:
1. Watertightness testing shall comply with ACI 350.1 and the following requirements.
2. Concrete tanks, basins, reservoirs and channels which have walls or slabs subjected to hydrostatic pressure shall be tested for watertightness. The tests shall be made after the structure is complete and the concrete has achieved its specified 28-day strength, but prior to application of waterproof coating or backfill.
3. Filling of the tank for watertightness testing shall not exceed a rate of 4 feet/hour. Fill with water to the maximum operating water surface. Keep water at this level for at least 72 hours prior to start of test.
4. Testing includes visual inspection of the dry sides of all walls, wall base construction joint at top of the slab, and the soffit of elevated slabs for evidence of leakage. Damp

spots, leakage, or seepage revealed by the test, including those caused by shrinkage of concrete, honeycombed areas, construction joints, or other sources shall be repaired by Repair Method 1 (see Repair Methods paragraph in the Repair of Damaged Concrete and Cracking article above).

5. Damp spots are defined as areas from which water that can be picked up on dry hand and smeared across the dry concrete surface.
6. Re-test tanks or channels which have been repaired to check the suitability of repairs.
7. Provide water required for testing and re-testing and dispose of in an approved manner.
8. After repair of visual leakage, liquid containing or conveying concrete structures supported on soil must also meet maximum leakage criteria into the soil through their base slab or mat foundation as follows:

Structure Type	Tightness Criterion
Containment structures fully lined prior to hydrostatic test	No measurable loss
Cylindrical water and wastewater storage tanks and reservoirs other than digesters	0.050 percent per day
Digesters	0.050 percent per day (surcharged hydrostatic test)
Rectangular basins and tanks	0.050 percent per day
Concrete paved reservoirs and channels	0.10 percent per day

Note: All damp spots and/or leakage through walls, wall-to-slab joints, and elevated slabs shall first be repaired as described above.

9. Record volume loss by measuring the vertical distance from the water surface to a fixed point on the tank above the water surface. Account for evaporation from open surfaces.
10. If the drop in water surface during the test period exceeds the values given in the table above, exclusive of evaporation, the leakage is considered excessive and shall be remedied. The test period shall be per ACI 350.1.

3.17 CLEANUP

A. Upon completion of the work and prior to final inspection, clean all concrete surfaces as follows: Sweep with a broom to remove loose dirt, then mop and/or flush with clean water. Scrub by hand or machine as required to remove and blend stains or discolored areas .

B. Clean floors that have curing and sealing compound as stated above, followed by the final application of curing and sealing compound.

END OF SECTION

SECTION 03 60 00

GROUTING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Grout for column base plates, other structural supports, equipment bases, reinforcing bar dowels, surface repair, grout toppings, patching of fresh concrete, and uses other than masonry. Adhesive anchor bolt grouting is specified in Section 05 05 20. Topping concrete over precast elements and clarifier topping concrete is specified in Section 03 30 00.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-In-Place Concrete
   2. Section 05 05 20 Anchor Bolts

1.03 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM C109	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm Cube Specimens)
ASTM C230	Flow Table for Use in Tests of Hydraulic Cement
ASTM C307	Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings
ASTM C939	Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C531	Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
ASTM C579	Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
ASTM C882	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C942	Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C1107	Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

Reference	Title
ASTM C1181	Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts
ASTM E329	Agencies Engaged in Construction Inspection, Testing, or Special Inspection
COE CRD-C611	Flow of Grout for Preplaced Aggregate Concrete
COE CRD-C621	Non-shrink Grout
IBC	International Building Code

1.04 SUBMITTALS

A. Action Submittals
   1. Procedure: Section 01 33 00:
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Complete product literature, including mixing, handling and placement instructions for the following: Cementitious non-shrink grout, epoxy grout, adhesive for reinforcing bar dowel grouting, concrete repair mortar, and prepackaged cement grout products to be used on the project.
   5. Mix design for cement grout that is not prepackaged, including product data for aggregates and cement in accordance with Section 03 30 00.
   6. Current ICC Evaluation Service reports for adhesives used for reinforcing dowels.
   7. Installer certification in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined reinforcing bar dowels grouted using adhesive.
   8. Certified test results verifying the compressive strength, shrinkage and expansion requirements specified herein.

1.05 QUALITY ASSURANCE

A. Quality Control by Owner
   1. The Owner will provide the services of a qualified Special Inspector in accordance with Section 01 45 20.
   2. Adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be continuously inspected during installation by a Special Inspector.
      a. The Special Inspector shall furnish a report to the Engineer, Owner's Representative and Building Official that the work covered by the report has been

performed and that the materials used and the installation procedures used conform with the approved Project Manual and the Manufacturer's Printed Installation Instructions (MPII).

B. Quality Control by Contractor
   1. Provide the services of an independent testing laboratory which complies with the requirements of ASTM E329 if a product other than those listed below is proposed and test data is not available from the supplier to demonstrate equivalence to the specified grout. The testing laboratory shall sample and test the proposed grout materials. Costs of testing laboratory services shall be borne by the Contractor.

C. Certifications
   1. Installer certification shall be in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined reinforcing bar dowels grouted using adhesive.

D. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to insure continued compliance with these Specifications.
   1. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time period as appropriate.
   2. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days, 28 days and any additional time period as appropriate.

E. Manufacturer Qualifications
   1. Manufacturer shall have a minimum of five years experience of producing products substantially similar to that required and shall be able to submit documentation of at least five satisfactory installations that have been in successful operation for at least five years each.
   2. When required, provide services of manufacturer's full-time employee, factory-trained in handling, use, and installing the products required, with at least five years of experience in field applications of the products required.

PART 2 PRODUCTS

2.01 CEMENTITIOUS NON-SHRINK GROUT

A. The grout material shall be an approved ready to use mixture requiring only water for use at the job site. The 2-inch cubes shall have a minimum compressive strength of 3,000 psi at 7 days and 7,000 psi at 28 days.

B. Cementitious non-shrink non-metallic aggregate grout shall be:
   1. BASF, Masterflow 928
   2. Euclid Chemical Company, Hi-Flow Grout
   3. Five Star Products, Inc., Five Star Grout

4. Sika Corporation, SikaGrout 212
5. Approved Equal

C. Non-shrink grout shall conform to CRD-C 621 and ASTM C1107, Grade B or C when tested at a maximum fluid consistency of 30 seconds per ASTM C939 at temperature extremes of 45 degrees Fahrenheit and 90 degrees Fahrenheit and an extended working time of 15 minutes.

D. Fluid grout shall pass through the flow cone, with continuous flow, one hour after mixing.

2.02 EPOXY GROUT FOR EQUIPMENT MOUNTING:

A. Epoxy grout shall be a pourable, non-shrink, 100-percent solids system.

B. Epoxy grout for equipment mounting shall be a non-cementitious, resin based, multi-component formulation. Epoxy grout shall be flowable, with shrinkage minimized to achieve minimum 98% effective bearing area. Epoxy grout shall be:
   1. BASF, Masterflow 648
   2. Euclid Chemical Company, E3-G
   3. Sika Corporation, Sikadur 42
   4. Approved Equal.

C. The following properties shall be attained with the minimum quantity of aggregate allowed by epoxy grout manufacturer.
   1. Length change after hardening shall be less than 0.0006-inch per inch and coefficient of thermal expansion shall be less than 0.00003-inch per inch per degree F when tested in accordance with ASTM C531.
   2. Compressive creep at one year shall be less than 0.001-inch per inch when tested under a 400-psi constant load at 140 degrees F in accordance with ASTM C1181.
   3. Minimum seven-day compressive strength shall be 14,000 psi when tested in accordance with ASTM C579
   4. Grout shall be capable of maintaining at least a flowable consistency for minimum of 30 minutes at 70 degrees F.
   5. Shear bond strength to portland cement concrete shall be greater than shear strength of concrete when tested in accordance with ASTM C882/C882M.

2.03 ADHESIVE FOR GROUTING REINFORCING BAR DOWELS

A. Adhesive for setting dowels in concrete shall be an injectable two-component epoxy adhesive. Adhesive shall be approved for the intended use per the product ICC Report. Adhesive shall be:
   1. Hilti, HIT-RE 500v3
   2. Simpson Strong Tie, SET XP
   3. Approved Equal (equivalent product must have ICC approval for use in cracked concrete in areas with high seismic risk).

B. Adhesive for setting dowels in concrete masonry shall be an injectable two-component epoxy adhesive. Adhesive shall be approved for the intended use per the product ICC Report or IAPMO Report. Adhesive shall be:

1. Hilti, HIT-HY 70
2. Simpson Strong Tie, SET XP
3. Approved Equal

2.04 CONCRETE REPAIR MORTAR

A. Horizontal Applications: Repair mortars shall be:
   1. BASF, MasterEmaco S 466CI
   2. Sika Corporation, SikaTop 111 Plus
   3. Approved Equal

B. Vertical and Overhead Applications: Repair mortars shall be:
   1. BASF, MasterEmaco 1500HCR Vertical Overhead
   2. Sika Corporation, SikaTop 123 Plus
   3. Approved Equal

2.05 CEMENT GROUT

A. Cement grout shall be comprised of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed in accordance with this Section.
   1. Minimum Compressive Strength: 4,500 psi at 28 days.
   2. Maximum Water Cement Ratio: 0.42 by weight.
   3. Coarse Aggregate: ASTM C33/C33M, No. 8 size.
   4. Fine Aggregate: ASTM C33/C33M, approximately 60 percent by weight of total aggregate.
   5. Air Content: Five percent (plus or minus one percent).
   6. Minimum Cement Content: 564 pounds per cubic yard.
   7. Slump for grout fill shall be adjusted to match placing and finishing conditions, and shall not exceed four inches.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

3.02 CEMENTITIOUS NONSHRINK GROUT

A. Non-shrink, cementitious, nonmetallic aggregate grout shall be used for column base plates, structural bearing plates, and all locations where the general term “non-shrink grout” is indicated on the Drawings. Use of this grout to support the bearing surfaces of machinery shall be as specified in Section 43 05 11 or as detailed on the Drawings for specific locations or pieces of equipment. If guidance is not provided in locations noted above, use of non-shrink grout for equipment mounting shall be limited to equipment less than 25 horsepower or 750 pounds. Grout shall be placed and cured in accordance with the manufacturer's instructions.

B. Non-shrink cementitious grout shall not be used as a surface patch or topping. Non-shrink cementitious grout must be used in confined applications only.

3.03 EPOXY GROUT FOR EQUIPMENT MOUNTING

A. Prepare concrete surfaces of equipment pads as indicated in details on the Drawings and as required by the epoxy grout manufacturer. Epoxy grout for equipment mounting shall be placed and cured in accordance with the requirements of Section 43 05 11, details on the Drawings, and in conformance with manufacturer's recommendations.

3.04 ADHESIVE FOR GROUTING REINFORCING BAR DOWELS

A. Follow manufacturer's instructions.

3.05 CONCRETE REPAIR MORTAR

A. Concrete repair materials and procedures shall be submitted for review to the Owner's Representative and shall be accepted prior to commencement of the repair work.

B. Follow all manufacturer's instructions, including those for minimum and maximum application thickness, surface preparation and curing. Add aggregate as required per manufacturer's recommendations. Any deviations from the manufacturer's instructions shall be submitted for review to the Owner's Representative and shall be accepted prior to commencement of the work.

3.06 CEMENT GROUT

A. Cement grout shall be used for grout toppings less than four inches thick and for patching of fresh concrete.

B. Grouting shall comply with temperature and weather limitations in Section 03 30 00.

C. Cure grout in accordance with grout manufacturer's instructions for prepackaged grout and Section 03 30 00 for non-prepackaged cement grout.

END OF SECTION

SECTION 05 05 20

ANCHOR BOLTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bolts and all-thread rods used to attach structural elements and equipment to concrete. Included are cast-in-place and post-installed anchors (adhesive systems and wedge type expansion anchors), nuts and washers.

B. Cast-in-place and post-installed anchors shall be Type 316 stainless steel unless noted otherwise.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 73 24 Design Requirements for Nonstructural Components and Nonbuilding Structures
   2. Section 03 30 00 Cast-In-Place Concrete
   3. Section 03 60 00 Grouting

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 318	Building Code Requirements for Structural Concrete
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A320	Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A563	Carbon and Alloy Steel Nuts
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
ASTM F844	Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F1554	Anchor Bolts, Steel, 36, 55, 105-ksi Yield Strength
IBC	International Building Code with local amendments
Massachusetts State Building Code	Building Code with local amendments

1.04 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Anchor bolt placement plans.
   5. Anchor bolt, nut, and washer material information, including material certifications.
   6. Record copy of design calculations and details showing the required diameter, length, embedment, edge distance, confinement, anchor reinforcement, anchor bolt sleeves, connection redesign, and other conditions, stamped and signed by a Professional Engineer currently registered in the state of Massachusetts. Calculations shall comply with the provisions of ACI 318-14, Chapter 17. Base anchor capacity determination on cracked concrete condition and compressive strength of new concrete per Section 03 30 00. Assume compressive strength of existing concrete is 3,000 psi unless otherwise noted.
   7. Submit record copy of proof loading test results within five days after test.
   8. Product Data:
      a. ICC Evaluation Service Reports for post-installed adhesive type anchors and expansion (wedge type) anchors when allowed. Products shall be ICC approved for use in cracked concrete in high seismic areas (Seismic Design Category D, E and F).
      b. Product data indicating load capacity charts/calculations.
      c. Chemical resistance.
      d. Temperature limitations.
      e. Manufacturers written installation instructions.
   9. Installer certification for horizontal or upwardly inclined adhesive anchors in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program.

1.05 QUALITY ASSURANCE

A. Quality Assurance By Owner
   1. Special inspection of anchor bolts shall be performed by the Special Inspector under contract with the Owner and in accordance with IBC Chapter 17.
   2. A five percent sample of installed post-installed anchors shall be proof-loaded by an independent laboratory contracted by the Contractor. The quantity of samples and locations shall be coordinated with the Owner's Representative.

3. Adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be continuously inspected during installation by a Special Inspector.
4. The Special Inspector shall furnish a report to the Engineer, Owner's Representative, and Building Official that the work covered by the report has been performed and that the materials used and the installation procedures used conform with the approved Project Manual and the Manufacturer's Printed Installation Instructions (MPII).

B. Certifications
1. Installer certification shall be in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined adhesive anchors.

PART 2 PRODUCTS

2.01 GENERAL

A. Anchor bolt holes in equipment support frames shall not exceed the bolt diameters by more than 1/4 inch. Minimum anchor bolt diameter shall be 1/2 inch. Anchor bolts for equipment mounting and vibration isolation systems shall be provided as specified in Sections 43 05 13.

B. Tapered washers shall be provided where mating surface is not square with the nut.

C. Anchor bolts shall be cast-in-place anchors unless post-installed anchors are specified or shown on the Drawings. Substitution of post-installed anchors will not be permitted unless specifically requested by the Contractor and approved by the Engineer.

2.02 PERFORMANCE/DESIGN CRITERIA

A. Anchor bolts for equipment shall be designed by the equipment manufacturer to include equipment operational loads combined with seismic and wind forces when applicable. Design criteria provided in Section 01 73 24.

B. Design anchor bolts for support and bracing of non-structural components and non-building structures for loading specified in Section 01 73 24.

2.03 MATERIALS

A. Anchor bolt materials shall be as specified in the following table:

Material	Specification
Stainless Steel Anchor Bolts	ASTM A193 or A320, Type 316
Stainless Steel Threaded Rods	ASTM F593, Type 316
Stainless Steel Nuts	ASTM A194 Heavy Hex Nuts, Type 316 ASTM F594 Heavy Hex Nuts at Adhesive Anchors, Type 316
Stainless Steel Washers	Type 316 to match bolt material
Carbon Steel Anchor Bolts	ASTM F1554, Grade 36, Hot Dip Galvanized
High-Strength Carbon Steel Anchor Bolts	ASTM F1554, Grade 55, Weldable per Supplementary Requirement S1, Hot Dip Galvanized

Material	Specification
Carbon Steel Nuts and Washers	ASTM A563 and F844, Heavy Hex, Hot-Dip Galvanized
Concrete Adhesive Anchors	Hilti “HIT-RE 500v3”, Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods
Concrete Masonry Adhesive Anchors	Hilti "HIT-HY 70", Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods
Concrete Masonry Expansion (wedge) Anchors*	Hilti "KWIK BOLT 3", or approved equal, Type 316 Stainless Steel
Concrete Expansion (wedge) Anchors *	Hilti “KWIK BOLT TZ”, or approved equal, Type 316 Stainless Steel

**Post installed anchors shall always be an adhesive type anchor system except where noted otherwise or when Contractor makes a request for a specific application and Engineer approves.*

2.04 STAINLESS STEEL FASTENER LUBRICANT (ANTI-SEIZING)

A. Anti-seizing Lubricant for Stainless Steel Threaded Connections:
   1. Formulated to resist washout.
   2. Acceptable manufacturers are Bostik, Saf-T-Eze, or equal.

2.05 ANCHOR BOLT SLEEVES

A. Provide anchor bolt sleeves as shown on design drawings and as required by equipment manufacturer’s design.
   1. Provide high density polyethylene plastic sleeves of single unit construction with deformed sidewalls such that the concrete and grout lock in place.
   2. The top of the sleeve shall be self-threading to provide adjustment of the threaded anchor bolt projection.
   3. Acceptable manufacturers are Contec, Wilson, or equal.

PART 3 EXECUTION

3.01 GENERAL

A. Anchor bolts shall be cast-in-place anchors unless post-installed anchors are specified or shown on the Drawings.

B. Grouting of anchor bolts using plastic sleeves with non-shrink or epoxy grout, where specified, shall be in accordance with Section 03 60 00.

C. The threaded end of anchor bolts and all-thread rods shall be long enough to project through the entire depth of the nut and if too long, shall be cut off at ½-inch beyond top of nut and ground smooth.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Anchor bolts to be embedded in concrete shall be placed accurately and held in correct position using templates while the concrete is placed.

B. After anchor bolts have been embedded, their threads shall be protected by grease and the nuts run on.

3.03 ADHESIVE ANCHOR BOLTS

A. Note that adhesive anchors shall not be substituted for cast-in-place anchor bolts unless the adhesive anchors have been specified or shown on the Drawings, or approval has been obtained from the Engineer that substitution of adhesive anchors is acceptable for the specific use and location. Use of adhesive anchors shall be subject to the following conditions:
   1. Limit to locations where intermittent or continuous exposure to the following is extremely unlikely:
      a. Acid concentrations higher than 10 percent
      b. Chlorine gas
      c. Machine or diesel oils
   2. Limit to applications where exposure to the following is extremely unlikely:
      a. Fire
      b. Concrete or rod temperature above 120 degrees F
   3. Overhead applications (such as pipe supports) shall not be allowed unless approved by the Engineer and installation is by an Installer specially certified for overhead applications.
   4. Approval from Engineer for specific application and from supplier of equipment to be anchored, if applicable.
   5. Anchor diameter and material shall be per Contract Documents or equipment manufacturer's specifications. Anchor shall be threaded or deformed the full length of embedment and shall be free of rust, scale, grease, and oils.
   6. Embedment depth shall be as specified or as required by the equipment manufacturer.
   7. Follow the anchor system manufacturer's installation instructions.
   8. Holes shall have rough surfaces created by using a hammer drill with carbide bit. Core drilled holes are not allowed.
   9. Holes shall be blown clean with oil-free compressed air and be free of dust or standing water prior to installation. Follow additional requirements of the adhesive manufacturer.
   10. Concrete and air temperature shall be compatible with curing requirements of adhesives per adhesive manufacturer's instructions. Anchors shall not be placed in concrete when the temperature is below 25 degrees F.
   11. Anchors shall be left undisturbed and unloaded for full adhesive curing period, which is based on temperature of the concrete.

3.04 EXPANSION ANCHORS

A. Expansion (wedge type) anchors shall not be substituted for cast-in-place anchor bolts or adhesive anchors unless approved by the Engineer for a specific application. Use of expansion anchors shall be subject to conditions 4 through 9 as specified above for adhesive anchors. Expansion anchors shall not be used in a submerged condition or in mounting of equipment subject to vibration or cyclic motion.

3.05 REINFORCING STEEL CONFLICTS WITH POST-INSTALLED ANCHOR INSTALLATION

A. When reinforcing steel is encountered in the drill path, slant drill to clear obstruction and provide beveled washer to match angle of anchor. Drill shall not be slanted more than 10 degrees.

B. Where slanting the drill does not resolve the conflict, notify the Owner's Representative and resolve the conflict to the satisfaction of the Owner's Representative in consultation with the Engineer.

C. Abandoned post-installed anchor holes shall be cleaned and filled with non-shrink grout and struck off flush with adjacent surface.

D. The costs of determining and executing the resolution shall be borne by the Contractor. The determination and execution of the resolution shall not result in additional cost to the Owner.

E. Reinforcing steel in masonry shall not be damaged.

F. In order to avoid or resolve a conflict, locate embedded reinforcing steel using non-destructive methods and/or redesign the attachment.
   1. Redesign shall be done by the Contractor's Professional Engineer currently registered in the state of Massachusetts.
   2. Calculations and details for redesign shall be submitted.

END OF SECTION

SECTION 05 50 00

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Custom fabricated metal items and certain manufactured units not otherwise indicated to be provided under work of other specification sections.
   2. Seat angle frames
   3. Fall arrest anchors
   4. Cover plates and frames
   5. Pipe sleeves
   6. Bollards
   7. Miscellaneous metal fabrications not covered elsewhere

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 73 24 Design Requirements for Nonstructural Components and Nonbuilding Structures
   2. Section 05 05 20 Anchor Bolts
   3. Section 09 90 00 Painting and Coating

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	The Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
AISC 303	Code of Standard Practice for Steel Buildings and Bridges
AISC 360	Specification for Structural Steel Buildings
AISC Steel Construction Manual	American Institute of Steel Construction, Manual of Steel Construction
ANSI A14.3	Standard for Ladders - Fixed - Safety Requirements
ASTM A36	Carbon Structural Steel
ASTM A48	Gray-Iron Castings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A108	Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123	Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware

Reference	Title
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A240	Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276	Stainless Steel Bars and Shapes
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	Carbon Steel Bolts, Studs, and Threaded Rod 60000 psi Tensile Strength
ASTM A312	Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320	Alloy-Steel Bolting Materials for Low Temperature Service
ASTM A325	Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength
ASTM A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A489	Carbon Steel Lifting Eyes
ASTM A500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A554	Welded Stainless Steel Mechanical Tubing
ASTM A563	Carbon and Alloy Steel Nuts
ASTM A572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A653	Steel Sheet, Zinc Coated (Galvanized) or Zinc Iron Alloy Coated (Galvannealed) by the Hot Dip Process
ASTM A780	Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
ASTM A786	Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
ASTM A793	Rolled Floor Plate, Stainless Steel
ASTM A924	Steel Sheet, Metallic-Coated by Hot-Dip Process
ASTM A992	Structural Steel Shapes
ASTM A1011	Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B210	Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B211	Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B241	Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B308	Aluminum-Alloy 6061-T6 Standard Structural Profiles
ASTM B429	Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM B632	Aluminum-Alloy Rolled Tread Plate
ASTM D1056	Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM F436	Hardened Steel Washers
ASTM F468	Nonferrous Bolts, Hex Cap Screws, SocketHead Cap Screws and Studs for General Use
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AWS D1.1	Structural Welding Code - Steel

Reference	Title
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.6	Structural Welding Code - Stainless Steel
OSHA 29 CFR 1910.27	Fixed Ladders
OSHA 29 CFR 1926.502	Fall Protection Systems Criteria and Practices
SSPC SP5	White Metal Blast Cleaning
IBC	International Building Code

1.04 DEFINITIONS

A. Galvanize: Hot-dip galvanize per ASTM A123 or ASTM A153, per Section 05 05 14.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration
   4. Manufacturer's product data.
   5. Detailed Shop Drawings:
      a. Fabrication drawings showing layouts, connections to structural system, and anchoring details.
      b. Erection and installation drawings indicating thickness, type, grade, class of metal, coating system and dimensions.
      c. Construction details, reinforcement, anchorage, and installation with relation to the building construction.
   6. Welding procedures and welder certificates and qualifications.
   7. U-Channel Concrete Inserts: Manufacturer’s product description and allowable load tables.
   8. Passivation method for stainless steel fabrications.
   9. Fall Arrest Anchor Certificate:
      a. Certify fall arrest system is designed to meet OSHA 29 CFR 1926.502 specified performance requirements.
      b. Signed and sealed by a Professional Engineer licensed in the state in which the project is located.

1.06 QUALITY ASSURANCE

A. Qualifications
   1. Fabricator shall have a minimum of five years experience in fabrication of metal specified.

B. Certificates
   1. Certified welding procedures and welding operators in accordance with AWS. Welding operator certificates shall be no more than one-year old and the welder shall have used the welding process to be performed within the last six months.

C. The use of salvaged, reprocessed or scrap materials will not be permitted.

D. Shop Assembly: Items in the shop shall be preassembled to the greatest extent possible, so as to minimize field splicing and assembly of units. Units shall be disassembled only to the extent necessary for shipping and handling limitations. Units shall be clearly marked for reassembly and coordinated installation.

1.07 DELIVERY, STORAGE AND HANDLING

A. Avoid damage during delivery and handling of fabrications.

B. Store off the ground on skids or other supports to keep items free of dirt and other foreign debris and to protect against corrosion.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials for miscellaneous metalwork are specified in the following table.

Material	Specification
Steel	
Sheets, plates and shapes (except W shapes)	ASTM A36
W shapes	ASTM A992
Pipe	ASTM A53, Grade B
Square/rectangular tubing	ASTM A500, Grade B
Headed Anchor Studs	ASTM A108
Carbon steel bolts	ASTM A307, Grade A
High strength bolts	ASTM A325 (Type 1)
Nuts	ASTM A563
Washers	ASTM F436
Stainless Steel	
Sheet and Plates	ASTM A240, Type 316 or 316L
Shapes, bars, and similar items	ASTM A276, Type 316 or 316L
Pipe	ASTM A312, Type 316 or 316L

Material	Specification
Headed Anchor Studs	ASTM A276, Type 316L
Bolts	ASTM F593, Type 316
Nuts	ASTM F594, Type 316
Aluminum	
Sheets and plates	ASTM B209, Type 6061-T6
Bars, flats and similar items	ASTM B211 or B221, Type 6061-T6
Shapes	ASTM B308, Type 6061-T6
Round tubing and pipe	ASTM B241, Type 6061-T6
Square and rectangular tubing	ASTM B221, Type 6063-T52
Pipe	ASTM B211 or B241, Type 6061-T6
Bolts, Stainless Steel	ASTM F593, Type 316
Nuts, Stainless Steel	ASTM F594, Type 316
Checker Plate	
Steel	ASTM A786
Stainless steel	ASTM A793, Type 304
Aluminum	ASTM B632, Type 6061-T6
Other steel items	
Iron castings	ASTM A48
Eyebolts	ASTM A489
Threaded rods	ASTM A36

2.02 FABRICATION

A. General

1. Conform to AISC or Aluminum Association standards as applicable. Where Code defined loads apply, also conform to IBC requirements.
2. Shop and field welding shall conform to the requirements of AISC, the Aluminum Design Manual, and applicable AWS procedures and specifications as required by the material being welded.
3. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt, tight, flush, and hairline. Remove burrs and weld splatter. Ease exposed edges to small uniform radius.
4. Holes shall be punched 1/16 inch larger than the nominal size of the bolts, unless otherwise specified. Whenever needed, because of the thickness of the metal, holes shall be subpunched and reamed or shall be drilled.
5. Fabrication, including cutting, drilling, punching, threading and tapping required for fabrications or adjacent work, shall be performed prior to galvanizing.

B. Seat Angle Frames

1. Provide recessed seat angle frames for grating and floor plates. Miter corners to ensure accurate fit. Match depth of recess with grating or floor plate thickness.

Anchor frames in concrete with headed studs. Steel angle support frames shall be stainless steel, ASTM A276, Type 316, unless indicated otherwise.

C. Fall Arrest Anchors

1. Fall arrest anchors shall meet requirements of OSHA 29 CFR 1926.502. Anchorages attached to personal fall arrest equipment shall be capable of supporting at least 5,000 pounds per employee attached, or shall be designed, installed, and used as part of a complete personal fall arrest system which maintains a safety factor of at least two. Type of anchor shall fit the application and substrate material.
2. Fall arrest anchors shall be manufactured by:
   a. Thaler Metal Industries
   b. DBI-SALA
   c. Approved Equal

D. Cover Plates and Frames

Fabricate aluminum cover plates weighing not more than 80 pounds per cover with a raised pattern nonslip top surface conforming to ASTM B632. Reinforce to sustain a live load of 100 pounds per square foot (foot traffic only) or as indicated on the Drawings. Frames shall be stainless steel angles and plates, with stainless steel

headed anchors welded to frame for anchoring to concrete. Miter and weld corners and butt joint straight runs. Provide flush drop handles for removal. Remove sharp edges and burrs from cover plates and exposed edges of frames. Weld connections and grind top surface smooth. Provide 1/8 inch clearance at edges.

E. Pipe Sleeves

1. Unless otherwise indicated on the Drawings, fabricate pipe sleeves from schedule 40 steel pipe with 3/16 inch thick by 3 feet wide seep ring continuously seal welded to the outside of the pipe. Galvanize after fabrication in accordance with ASTM A123.

F. Bollards

1. Provide minimum 6 inch galvanized standard weight steel pipe or as indicated on the Drawings. Pipe to be in accordance with ASTM A53. Anchor posts in concrete and fill solidly with concrete of a minimum compressive strength of 2500 psi. Coat galvanized pipe above grade in accordance with Section 09 90 00. Top coat cover color shall be safety yellow.

G. Other Miscellaneous Steel Metalwork

1. Other miscellaneous steel metalwork including embedded and non-embedded steel metalwork, hangers and inserts shall be as specified or shown on the Drawings, and shall be galvanized after fabrication unless otherwise noted.

2.03 FINISHES

A. Galvanizing

1. Galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing in accordance with ASTM A123, ASTM A153, ASTM A653 or ASTM A924, Z275 G90, as applicable. Galvanize anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.

2. Repair damaged Zinc-Coated surfaces with galvanizing repair method and paint conforming to ASTM A780 or by application of stick or thick paste material specifically designed for repair of galvanizing, as approved by Owner's Representative.
3. Safeguard against warpage and distortion during galvanizing of steel in accordance with ASTM A384. Straighten items after galvanizing so that they are straight, free of racking and distortion.

B. Shop Painting
1. Prepare and coat surfaces in accordance with Section 09 90 00.
2. Steel to be embedded in concrete shall be free of dirt and grease.

C. Aluminum Surfaces
1. Surface condition aluminum before finishes are applied. Remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.
2. Aluminum finishes for unexposed sheet, plate and extrusions may have mill finish as fabricated.
3. Provide other aluminum items with a standard mill finish.
4. Provide a coating thickness not less than that specified for protection.
5. Provide decorative type finishes for items used in interior occupied locations or architectural type finish for items used in exterior locations.
6. Provide a polished satin finish on items to be anodized.

D. Stainless Steel Passivation
1. Stainless steel to be cleaned, descaled, and passivated after fabrication in accordance with ASTM A380. Passivate to remove iron compounds from the surface of the stainless steel.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify measurements at the site. Include field dimensions in shop drawings.

B. Examine and accept existing conditions before beginning work.

3.02 PREPARATION

A. Make provisions for erection loads with temporary bracing. Keep work in alignment.

B. Supply items required to be cast into concrete or embedded in masonry with setting templates.

3.03 INSTALLATION

A. Install items plumb, level and square, accurately fitted, and free from distortion or defects. Install rigid, substantial, and neat in appearance.

B. Allow for erection loads and provide temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.

C. Fieldwork shall not be permitted on galvanized items. Drilling of bolts or enlargement of holes to correct misalignment will not be allowed.

D. Protect encased or embedded dissimilar metals (both metals must be encased or embedded) from galvanic corrosion by means of pressure tapes, coatings or isolators.

E. Place metalwork to be embedded in concrete accurately and hold in correct position while the concrete is placed or, if indicated, form recesses or blockouts in the concrete. Thoroughly clean the surfaces of metalwork in contact with or embedded in concrete.

F. Seat angles, supports and guides: Set seat angles for grating and supports for floor plates so that they maintain the grating and floor plates flush with the floor.

G. Ladder Safety Post: Comply with manufacturer's installation instructions.

H. Pipe Sleeves: Provide where pipes pass through concrete or masonry. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls. Provide a center flange for water stoppage on sleeves in exterior or water bearing walls. Provide a rubber caulking sealant or a modular mechanical unit to form a watertight seal in the annular space between pipes and sleeves.

I. Concrete: Pan-filled stairs to be constructed in accordance with Section 03 30 00. Finish concrete with a "nonslip" finish with "very flat" tolerance as specified in ACI 301.

J. Fastening to Construction-In-Place: Provide anchorage devices and fasteners where necessary for fastening fabricated items to construction-in-place. Design anchorage devices in accordance with Section 01 73 24. Anchor bolts to be in accordance with Section 05 05 20.

K. Set steel stair baseplates on wedges, or shims. After stairs have been positioned and aligned, tighten anchor bolts. Do not remove wedges or shims, but if protruding, cut off flush with edge of bearing plate before packing with grout.

L. Railing: Adjust railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing required by design loads and as limited on Drawings. Plumb posts in each direction.

3.04 REPAIR/RESTORATION

A. Galvanized
   1. Maximum area to be repaired shall not be more than 1/2 of 1 percent of the surface area or 36 sq. in. per ton of piece weight, whichever is less. Damage in excess of this requirement shall be repaired by stripping and recoating entire piece.
   2. Clean damaged areas to SSPC-SP5. Repair with zinc-rich paint in accordance with the manufacturer's instructions and with ASTM A780, Annex A2. Minimum thickness requirements shall be in accordance with ASTM A123.
   3. Use zinc-rich repair paint. Acceptable manufacturers:
      a. LPS, Cold Galvanize

b. ZRC Worldwide, ZRC Galvilite
c. Approved Equal

B. Painted
1. After installation, clean and touch up damaged areas with the same materials used for the shop coat.

3.05 FIELD QUALITY CONTROL

A. Electrolytic Protection

B. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Aluminum in contact with concrete or grout shall be protected with a heavy coat of bituminous paint.

C. Stainless Steel
1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
3. Remove contamination in accordance with requirements of ASTM A380.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.

END OF SECTION

SECTION 06 74 13

FIBERGLASS REINFORCED GRATINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fiberglass-reinforced plastic (FRP) grating, hold down attachments and supports.

B. FRP grating shall be molded type grating unless noted otherwise.

1.02 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM A276	Stainless Steel Bars and Shapes
ASTM D635	Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM E84	Test Method for Surface Burning Characteristics of Building Materials
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ISO 9001	Quality Management Systems
IBC	International Building Code

1.03 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Fabrication and erection drawings and schedules of all materials included under this Section. Include plans, elevations, and details, including connection details. Show anchorage and accessory items. Shop Drawings shall indicate location of planned field cut-outs in grating. Sample: Each type of grating.

5. Product data information and catalog cuts showing materials and allowable loads, spans, and deflections; include manufacturer's specifications.

1.04 QUALITY ASSURANCE

A. Qualifications
   1. Items to be provided under this section shall be furnished only by manufacturers having a minimum of 10 years experience in the design and manufacture of fiberglass reinforced grating.

B. Certifications
   1. Manufacturer shall be certified to the ISO 9001 standard.
   2. Manufacturer shall provide proof of certification from at least two other quality assurance programs for its facilities or products (DNV, ABS, USCG, and AARR).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers are listed below. The manufacturer's standard product may require modification to conform to specified requirements.
   1. American Grating, LLC
   2. Fibergrate Composite Structures Inc.
   3. Seasafe, Inc.
   4. Strongwell Corp.
   5. Approved Equal

2.02 PERFORMANCE/DESIGN CRITERIA

A. Design FRP grating in accordance with the following:
   1. Unless otherwise indicated, design live loads for FRP grating shall 100 psf minimum.
   2. Maximum deflection shall be the quotient of the grating span divided by 180 or 1/4 inch, whichever is less.
   3. The minimum thickness of FRP grating shall be 1 1/2 inches.
   4. Grating sheet sizes shall be compatible with the support spans shown on the Drawings and shall require a minimum of field cutting.
   5. Corrosion Resistance:
      a. Exterior surfaces of grating shall have a synthetic surfacing veil.
      b. FRP grating shall be suitable for continuous service under the following conditions:

Service	Concentration by Weight (percent)	Maximum Temperature (degrees F)
Chlorine gas[1]	20	100
Chlorine solution	Saturated	100
Ferrous chloride	30	
Hydrogen sulfide[1]	5	100
Hypochlorite solution	5	100
Hypochlorous acid	5	100
Potassium permanganate	10	100
Sodium hydroxide	25	100
Sodium hypochlorite	15	
Sulfuric acid	15	100

Note:

1. Wet or dry

2.03 MATERIALS

A. Molded Type Grating:
   1. Open-molded fiberglass grating made in one piece by interweaving continuous, thoroughly wetted, glass strand with vinyl ester resin with UV inhibitor additives. Polyester resin shall not be used.
   2. Square mesh, 1 1/2 inch maximum spacing for 1 1/2 inch thick grating; 2 inch maximum spacing for 2 inch thick grating.
   3. Cut ends, holes and abrasions of FRP shapes shall be sealed with resin to prevent moisture wicking.
   4. Load bars in both directions with equal stiffness.
   5. Color shall be manufacturer's standard at Water Quality Facility treatment bay pit covers and at walkway inside pump station. Color shall be selected by Owner or Owner's Representative.
   6. Meet self-extinguishing requirements of ASTM D635.
   7. Fire Rating: Flame spread of 25 or less as measured by ASTM E84.
   8. Skid-Resistant Surface: Grit adhesively bonded, manufacturer's standard.

B. FRP Embedment Angles: Fiberglass reinforced plastic with slate-gray, vinyl ester, fire-retardant resin. Size FRP embed angle as required for the thickness of grating.

C. Hold Down Clips: ASTM A276 Type 316 stainless steel.

D. Bolts and Connectors: Corrosion resistant FRP or ASTM F593 Type 316 stainless steel. Size and strength to meet IBC requirements.

2.04 ASSEMBLY/FABRICATION

A. Measurements: Grating supplied shall meet the dimensional requirements and tolerances as shown or specified. Provide and/or verify measurements in field for work fabricated to fit field conditions as required by grating manufacturer. When field dimensions are not required, determine correct size and locations of required holes or cutouts from field dimensions before grating fabrication.

B. Layout: Each grating section shall be readily removable (no single piece shall weigh more than 80 pounds), except where indicated on the Drawings. Manufacturer to provide openings and holes where located on the Drawings. Grating openings that fit around protrusions (pipes, cables, machinery, etc.) shall be discontinuous at approximately the centerline of opening so that each section of grating is readily removable.

C. Sealing: Shop fabricated grating cuts shall be coated with vinyl ester resin to provide maximum corrosion resistance. Field fabricated grating cuts shall be coated similarly in accordance with the manufacturer's instructions.

D. Hardware: Hold down clips shall be provided and spaced at maximum of four feet apart with a minimum of four per piece of grating, or as recommended by the manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

3.02 INSTALLATION

A. Provide FRP grating with hold-down attachments, end panel attachments, and appurtenances to make the work complete and operable.

B. Provide adequate quantities of resin sealing kits comprised of pre-measured quantities of thixotropic resin and catalyst, mixing containers, chip brushes, and stirring sticks.

C. Seal field cut holes, edges, and abrasions.

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

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

F. Install each grating section in accordance with manufacturer’s assembly drawings.

G. Follow manufacturer's instructions when cutting or drilling fiberglass products or using resin products; provide adequate ventilation.

H. Clearance (Grating to Vertical Surfaces): 1/4 inch (±1/8 inch tolerance).

END OF SECTION

SECTION 07 91 26

JOINT FILLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies preformed joint fillers.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D994	Preformed Expansion Joint Filler for Concrete (Bituminous Type)
ASTM D1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

PART 2 PRODUCTS

2.01 PREFORMED ASPHALT FIBERBOARD

A. Preformed asphalt fiberboard joint filler shall be in accordance with ASTM D994 and shall be 1/2 inch thick unless otherwise specified.

2.02 PREFORMED RESIN-BONDED CORK

A. Preformed resin-bonded cork joint filler shall be in accordance with ASTM D1752, Type II. Cork joint filler thickness shall match the specified joint width.

2.03 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's recommendations for handling and installation of the material.

PART 3 EXECUTION

3.01 GENERAL

A. Preformed joint fillers shall be placed into position before the concrete is poured. Where it is necessary for the filler to be fixed to existing concrete or other building materials, a suitable adhesive recommended by the filler manufacturer shall be used. Filler surfaces shall be clean and dry prior to the placement of the concrete.

3.02 PREFORMED ASPHALT FIBERBOARD

A. Preformed asphalt fiberboard joint fillers shall be used for expansion joints in concrete sidewalks, curbs, and roadways.

3.03 PREFORMED RESIN-BONDED CORK

A. Preformed resin-bonded cork joint filler shall be used for expansion joints in concrete structures. The expansion joint shall be sealed with backer rod and sealant as specified in Section 07 92 00.

END OF SECTION

SECTION 07 92 00

JOINT SEALANTS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies sealants for vertical and horizontal joints.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
FEDSPEC TT-S-00230C	Sealing Compound: Elastomeric Type, Single Component
FEDSPEC TT-S-00227E	Sealing Compound: Elastomeric Type, Multi-Component

PART 2 PRODUCTS

2.01 POLYURETHANE SEALANT

A. Acceptable Products:

1. Acceptable products shall be Sikaflex by Sika Chemical Corporation, Vulkem by Mameco International, U-Seal Joint Sealant by Burke Company, or Rubber Calk by Products Research and Chemical Corporation.

B. General:

1. Polyurethane sealants shall conform to FEDSPEC TT-S-0230C for one-component systems and FEDSPEC TT-S-00227E for two-component systems. Polyurethane sealant shall be one of the following two types.
   a. Self-Leveling:
      1) Self-leveling polyurethane sealant shall be Type I, Class A as specified by the FEDSPECs referenced above.

b. Nonsag:
    1) Nonsag polyurethane sealant shall be Type II, Class A as specified by the FEDSPECs referenced above.

C. Primer:
    1. Primer shall be as recommended by the sealant manufacturer.

D. Backer Rod or Backer Tape:
    1. Backer rod shall be open cell polyethylene or polyurethane foam. Rod shall be cylindrical unless otherwise specified. Backer tape shall be polyethylene or polyurethane with adhesive on one side.

2.02 MASTIC SEALANT

A. General:
    1. Mastic joint sealant shall consist of a blend of refined asphalts, resins and plasticizing compounds, reinforced with fiber. Sealant shall be compatible with joint fillers and shall be pressure grade.

B. Primer:
    1. Primer shall be as recommended by the mastic sealant manufacturer.

2.03 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
    1. Manufacturer's product data showing conformance to the specified products.
    2. Manufacturer's recommendations for storage, handling and application of sealants and primers.

PART 3 EXECUTION

3.01 GENERAL

A. Sealants and primers shall be applied according to the sealant manufacturer's recommendations. Polyurethane sealants shall be used on all expansion joints and specified construction joints.

B. Joints and spaces to be sealed shall be clean, dry and free of dust, loose mortar, concrete and plaster. Additional preparation of joints and spaces shall be provided in accordance with manufacturer's recommendations. Primer shall be applied only to the surfaces that will be covered by the sealant.

3.02 POLYURETHANE SEALANTS

A. General:
    1. Nonsag polyurethane sealants shall be used on vertical joints. Self-leveling polyurethane sealants shall be used on horizontal joints.

B. Joint Dimensions:

1. Unless otherwise specified, joints and spaces to be filled shall be constructed to the following criteria. Joints and spaces shall have a minimum width of 1/4 inch and a maximum width of 1 inch. The depth of the sealant shall be one-half the width of the joint, but in no case less than 1/4 inch deep. Sealant depth shall be measured at the point of smallest cross section. When joints exceed the depth requirements, backing rod shall be inserted to provide the joint depth specified. If the joint sealant depth is within the specified tolerances, backer tape shall be placed in the bottom of the joint.

3.03 MASTIC SEALANT

A. Joint Dimensions:

1. Joints to be sealed shall be 2 inches deep, 1 inch wide at the top, and 3/4 inch wide at the base.

END OF SECTION

SECTION 09 90 00

PAINTING AND COATING

TABLE OF CONTENTS

SECTION 09 90 00

PAINTING AND COATING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This Section specifies coating systems, surface preparations, and application requirements for coating systems.

B. Definitions:
   1. Specific coating terminology used in this Section is in accordance with definitions contained in ASTM D16, ASTM D3960, and the following definitions.
      a. Definitions:
         1) Abrasive: Material used for blast cleaning, such as sand, grit or shot.
         2) Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
         3) Anchor Pattern: Profile or texture of prepared surface(s).
         4) ANSI: American National Standards Institute.
         5) Bug Holes: Small cavities, usually not exceeding 15 mm in diameter, resulting from entrapment of air bubbles in the surface of formed concrete during placement and compaction.
         6) Coating/Paint/Lining Thickness: The total thickness of primer, intermediate and/or finish coats.
         7) Coating System Applicator (CSA): A generic reference to the specialty subcontractor or subcontractors retained by the Contractor to install the coating systems specified in this Section.
         8) Coating System Manufacturer (CSM): Refers to the acceptable coating system manufacturer, abbreviated as the CSM.
         9) Coating System Manufacturer's Technical Representative(s) (CTR): Refers to the technical representative(s) of the acceptable Coating System Manufacturer and is abbreviated as CTR.
         10) Dew point: Temperature of a given air/water vapor mixture at which condensation starts.
         11) Dry Film Thickness (DFT): Depth of cured film, usually expressed in mils (0.001 inch). Use this definition as opposed to existing definition.
         12) Drying Time: Time interval between application and curing of material.
         13) Dry to Recoat: Time interval between application of material and ability to receive next coat.
         14) Dry to Touch: Time interval between application of material and ability to touch lightly without damage.
         15) Feather Edging: Reducing the thickness of the edge of paint.
         16) Feathering: Operation of tapering off the edge of a point with a comparatively dry brush.

17) Field Coat: The application or the completion of application of the coating system after installation of the surface at the site of the work.
18) Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
19) Holiday: a discontinuity, skip, or void in coating or coating system film that exposes the substrate.
20) Honeycomb: Segregated condition of hardened concrete due to non-consolidation.
21) ICRI: International Concrete Repair Institute.
22) Incompatibility: Inability of a coating to perform well over another coating because of bleeding, poor bonding, or lifting of old coating; inability of a coating to perform well on a substrate.
23) Laitance: A layer of weak, non-durable concrete containing cement fines that is brought to the surface through bleed water because of concrete finishing and/or over-finishing.
24) Mil: 0.001 inch.
25) NACE: National Association of Corrosion Engineers.
26) Overspray: Dry spray, particularly such paint that failed to strike the intended surface.
27) Pinhole: A small diameter discontinuity in a coating or coating system film that is typically created by outgassing of air from a void in a concrete substrate resulting in exposure of the substrate or a void between coats.
28) Pot Life: Time interval after mixing of components during which the coating can be satisfactorily applied.
29) Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-base material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
30) Shelf Life: Maximum storage time for which a material may be stored without losing its usefulness.
31) Shop Coat: One or more coats applied in a shop or plant prior to shipment to the site of the work, where the field or finishing coat is applied.
32) Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
33) SSPC: The Society for Protective Coatings.
34) Stripe Coat: A separate coat of paint applied to all weld seems, pits, nuts/bolts/washers and edges by brush. This coat shall not be applied until any previous coat(s) have cured and, once applied, shall be allowed to cure prior to the application of the subsequent coat(s).
35) Surface Saturated Dry (SSD): Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.
36) Tie Coat: An intermediate coat used to bond different types of paint coats. Coatings used to improve the adhesion of a succeeding coat.
37) Touch-Up Painting: The application of paint on areas of painted surfaces to repair marks, scratches, and areas where the coating has deteriorated to restore the coating film to an unbroken condition.
38) TPC: Technical Practice Committee.

39) Volatile Organic Compound (VOC) Content: The portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing, expressed in grams per liter (g/l) or pounds per gallon (lb/gal).

40) Immersion: Refers to a service condition in which the substrate is below the waterline or submerged in water or wastewater at least intermittently if not constantly.

41) Weld Splatter: Beads of metal scattered near seam during welding.

42) Wet Film Thickness (WFT): The primer or coating film's thickness immediately following application. Wet film thickness is measured in mils or thousandths of an inch (0.001 inch) and is abbreviated WFT.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ANSI/ASC 29.4 Exhaust Systems	Abrasive Blasting Operations – Ventilation and Safe Practice
ANSI/NSF 61	Drinking Water System Components Health Effects
ANSI B74.18	Grading of Certain Abrasive Grain on Coated Abrasive Material
ASTM D16	Standard Terminology for Paint, Related Coatings, Materials, and Applications
ASTM D2200 (SSPC-VIS1)	Pictorial Surface Preparation Standards for Painting Steel Surfaces
ASTM D3960	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4262	Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces
ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4414	Standard Practice for Measurement of Wet Film Thickness by Notch Gages
ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D4541	Standard Test Methods for Pull-Off Strength of Coatings On Metal Substrates Using Portable Adhesion Testers
ASTM D4787	Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates

Reference	Title
ASTM D5162	Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
ASTM D7234	Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Adhesion Testers.
ASTM E337	Standard Test Method for Measuring Humidity With a Psychrometer
ASTM F1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
FS 595b	Federal Standard Colors
ICRI 03732	Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays
NACE Publication 6D-163	A Manual for Painter Safety
NACE Publication 6F-163	Surface Preparation of Steel or Concrete Tank/Interiors
NACE Publication 6G-164 A	Surface Preparation Abrasives for Industrial Maintenance Painting
NACE Standards	January 1988 Edition of the National Association of Corrosion Engineers, TPC.
NACE Standard RP0188	Standard Recommended Practice – Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NACE Standard RP0288	Standard Recommended Practice, Inspection of Linings on Steel and Concrete
NACE Standard RP0892	Standard Recommended Practice, Linings Over Concrete in Immersion Service
NACE Publication TPC2	Coatings and Linings for Immersion Service
NAPF 500-03	Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings
NAPF 500-03-04	Abrasive Blast Cleaning for Ductile Iron Pipe
NAPF 500-03-05	Abrasive Blast Cleaning for Cast Ductile Iron Fittings
OSHA 1910.144	Safety Color Code for Marking Physical Hazards
OSHA 1915.35	Standards – 29CFR - Painting
SSPC	Paint Application Specification No. 1.
SSPC-AB 1	Mineral and Slag Abrasives
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages
SSPC-PA 9	Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages
SSPC-PA Guide 1	Guide for Illumination of Industrial Painting Project
SSPC-PA Guide 3	A Guide to Safety in Paint Application
SSPC-PA Guide 6	Guide for Containing Debris Generated During Paint Removal Operations
SSPC-PA Guide 11	Guide for Coating Concrete
SSPC SP1	Solvent Cleaning
SSPC SP2	Hand Tool Cleaning
SSPC SP3	Power Tool Cleaning
SSPC SP5	White Metal Blast Cleaning
SSPC SP6	Commercial Blast Cleaning
SSPC SP7	Brush-Off Blast Cleaning
SSPC SP10	Near-White Blast Cleaning
SSPC SP11	Power Tool Cleaning to Bare Metal
SSPC SP12	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating
SSPC SP13	Surface Preparation of Concrete
SSPC-TR2	Wet Abrasive Blast Cleaning
SSPC-TU-3	Overcoating

Reference	Title
SSPC-TU-4	Field Methods for Retrieval and Analysis of Soluble Salts on Substrates.
SSPC V2	Systems and Specifications: Steel Structures Painting Manual, Volume 2
SSPC-VIS 1	Visual Standard for Abrasive Blast Cleaned Steel
SSPC-VIS 3	Visual Standard for Power and Hand – Tool Cleaned Steel
SSPC-VIS 4	Visual Standards (Waterjetting)
SSPC-VIS 5	Visual Standards (Wet Abrasive Blast Cleaning)
WPCF Manual of Practice No. 17	Paints and Protective Coatings for Wastewater Treatment Facilities. Guide and Paint Application Specifications.

B. Standardization:
   1. Materials and supplies provided shall be the standard products of CSMs. Materials in each coating system shall be the products of a single CSM.
   2. The standard products of CSMs other than those specified may be acceptable when it is demonstrated to the Construction Manager that they are equal in composition, durability, usefulness, and convenience for the purpose intended. Requests for consideration of CSMs other than those specified in this Section will be considered, provided the following minimum conditions are met. Such requests are not a substitution for submittals after the alternative CSMs have been considered and accepted.
      a. The proposed coating system shall use an equal or greater number of separate coats to achieve the required total dry film thickness.
      b. The proposed coating system shall use coatings of the same generic type as that specified including curing agent type.
      c. Requests for consideration of products from CSMs other than those specified in this Section shall include information listed in paragraph 1.04, demonstrating that the proposed CSM's product is equal to the specified coating system.
      d. The Contractor and the proposed alternative CSM shall provide a list of references for the proposed product where the coating of the same generic type has been applied. The reference list shall include the project name, city, state, owner, phone number of owner; coating system reference and number from this Section 09 90 00; type of facility in which it was used, generic type, and year coating was applied.

C. Quality Control Requirements:
   1. The Contractor is responsible for the workmanship and quality of the coating system installation. Inspections by the Construction Manager or the CTR will not relieve or limit the Contractor's responsibilities.
   2. The Contractor's methods shall conform to requirements of this specification and the standards referenced in this Section. Changes in the coating system installation requirements will be allowed only with the written acceptance of the Construction Manager before work commences.
   3. Only personnel who are trained by the CTR specifically for this contract or who are approved by the CSM specifically for this contract shall be allowed to perform the coating system installation specified in this Section.
   4. Contaminated, outdated, diluted materials, and/or materials from previously opened containers shall not be used.

5. For repairs, the Contractor shall provide the same products, or products recommended by the CSM, as used for the original coating.
6. The Contractor shall identify the points of access for inspection by the Owner or the Construction Manager. The Contractor shall provide ventilation, ingress and egress, and other means necessary for the Construction Manager's personnel to access safely the work areas.
7. The Contractor shall conduct the work so that the coating system is installed as specified and shall inspect the work continually to ensure that the coating system is installed as specified. Coating system work that does not conform to the specifications or is otherwise not acceptable shall be corrected as specified.
8. The Contractor shall complete the Coating System Inspection Checklist, Form 09 90 00-A, included in Section 01 99 90, for coating system installations. Follow the sequential steps required for proper coating system installation as specified and as listed in the Coating System Inspection Checklist. For each portion of the work, install the coating system and complete sign-offs as specified prior to proceeding with the next step. After completing each step as indicated on the Coating System Inspection Checklist, the Contractor shall sign the checklist indicating that the work has been installed and inspected as specified.
9. The Contractor shall provide written daily reports that present, in summary form, test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system installation.

D. Inspection at Hold Points:
   1. The Contractor shall conduct inspections at Hold Points during the coating system installation and record the results from those inspections on Form 09 90 00-A. The Contractor shall coordinate such Hold Points with the Construction Manager such that the Construction Manager may observe Contractor's inspections on a scheduled basis. The Contractor shall provide the Construction Manager a minimum of two (2) hours of notice prior to conducting Hold Point Inspections. The Hold Points shall be as follows:
      a. Environment and Site Conditions. Prior to commencing an activity associated with coating system installation, the Contractor shall measure, record, and confirm acceptability of ambient air temperature and humidity as well as other conditions such as proper protective measures for surfaces not to be coated and safety requirements for personnel. The acceptability of the weather and/or environmental conditions within the structure shall be determined by the requirements specified by the CSM of the coating system being used.
      b. Conditions Prior to Surface Preparation. Prior to commencing surface preparation, the Contractor shall observe, record, and confirm that oil, grease, and/or soluble salts have been eliminated from the surface.
      c. Monitoring of Surface Preparation. Spot checking of degree of cleanliness, surface profile, and surface pH testing, where applicable. In addition, the compressed air used for surface preparation or blow down cleaning shall be checked to confirm it is free from oil and moisture.
      d. Post Surface Preparation – Upon completion of the surface preparation, the Contractor shall measure and inspect for proper degree of cleanliness and surface profile as specified in this Section 09 90 00 and in the CSM's written instructions.

e. Monitoring of Coatings Application – The Contractor shall inspect, measure, and record the wet film thickness and general film quality (visual inspection) for lack of runs, sags, pinholes, holidays, etc. as the application work proceeds.

f. Post Application Inspection – The Contractor shall identify defects in application work including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness and other problems as may be observed.

g. Post Cure Evaluation – The Contractor shall measure and inspect the overall dry film thickness. The Contractor shall conduct a DFT survey, as well as perform adhesion testing, holiday detection, or cure testing as required based on the type of project and the specific requirements in this Section 09 90 00 and/or in the CSM's written instructions.

h. Follow-up to Corrective Actions and Final Inspection. The Contractor shall measure and reinspect corrective coating work performed to repair defects identified at prior Hold Points. This activity also includes final visual inspection along with follow-up tests such as holiday detection, adhesion tests, and DFT surveys.

1.03 DELIVERY AND STORAGE

A. General:

1. Materials shall be delivered to the job site in their original, unopened containers. Each container shall be properly labeled. Materials shall be handled and stored to prevent damage to or loss of label.
2. Labels on material containers shall show the following information:
   a. Name or title of product.
   b. CSM's batch number.
   c. CSM's name.
   d. Generic type of material.
   e. Application and mixing instructions.
   f. Hazardous material identification label.
   g. Shelf life expiration date.
3. Materials shall be stored in enclosed structures and shall be protected from weather and excessive heat or cold in accordance with the CSM's recommendations. Flammable materials shall be stored in accordance with state and local requirements.
4. Containers shall be clearly marked indicating personnel safety hazards associated with the use of or exposure to the materials.
5. Material Safety Data Sheets (MSDS) for each material shall be provided to the Construction Manager.
6. The Contractor shall store and dispose of hazardous waste according to federal, state and local requirements. This requirement specifically addresses waste solvents and coatings.

1.04 SUBMITTALS:

A. Action Submittals:

1. Provide in accordance with Section 01 33 00:

a. A copy of this specification section, with addendum updates included, and referenced and applicable sections, with addendum updates included, with each paragraph check-marked (✓) to indicate specification compliance or marked to indicate requested deviations from specification requirements or those parts which are to be provided by the Contractor or others. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined shall signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for requested deviations to the specification requirements shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.

b. CSM's current printed recommendations and product data sheets for coating systems including:
   1) Volatile organic compound (VOC) data.
   2) Surface preparation recommendations.
   3) Primer type, where required.
   4) Maximum dry and wet-mil thickness per coat.
   5) Minimum and maximum curing time between coats, including atmospheric conditions for each.
   6) Curing time before submergence in liquid.
   7) Thinner to be used with each coating.
   8) Ventilation requirements.
   9) Minimum atmospheric conditions during which the paint shall be applied.
   10) Allowable application methods.
   11) Maximum allowable moisture content.
   12) Maximum shelf life.

c. Affidavits signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements.

d. Material Safety Data Sheets (MSDS) for materials to be delivered to the job site, including coating system materials, solvents, and abrasive blast media.

e. List of cleaning and thinner solutions allowed by the CSMs.

f. Storage requirements including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.

g. CSM's detailed, written instructions for coating system treatment and graphic details for coating system terminations in the structures to be coated including pipe penetrations, metal embedments, gate frames, and other terminations to be determined from the contract drawings. This information shall also include detail treatment for coating system at joints in concrete.

B. Informational Submittals:
   1. Provide in accordance with Section 01 33 00:

2. The Contractor and CSA shall provide a minimum of five project references each including contact name, address, and telephone number where similar coating work has been performed by their companies in the past five years.
3. Site visit reports prepared by the CTR following each site visit.
4. Final Report prepared by the CTR.

1.05 RESPONSIBILITIES OF THE CTR

A. General:
1. The Contractor shall retain or obtain the services of the CTR to be on site to perform the Contractor and/or CSA application training and to routinely inspect and verify in writing that the application personnel have successfully performed surface preparation, filler/surface application, coating system application, and Quality Control Inspection in accordance with this Section 09 90 00 and to warrantable level of quality. This must include checking the required degree of cleanliness, surface pH for concrete substrates, surface profile of substrates, proper mixing of coating materials, application (including checking the wet and dry film thickness of the coating systems), proper cure of the coating systems, and proper treatment of coating systems at terminations, transitions, and joints and cracks in substrates. Refer to paragraph 1.05 Coating System Installation Training. for further details on these CTR requirements. This inspection is in addition to the inspection performed by the Contractor in accordance with this Section 09 90 00.

B. Coating System Installation Training:
1. Provide a minimum of 8 hours of classroom and off site training for application and supervisory personnel (both the Contractor's and CSA's). Provide training to a minimum of two supervisory personnel from the CSA and one supervisor from the Contractor. Alternatively, the CTR shall provide a written letter from the CSM stating that the application personnel (listed by name) who shall perform coating work are approved by the CSM without further or additional training.
2. One CTR can provide training for up to fourteen application personnel and three supervisory personnel at one time. The training shall include the following as a minimum:
    a. A detailed explanation of mixing, application, curing, and termination details.
    b. Hands-on demonstration of how to mix and apply the coating systems.
    c. A detailed explanation of the ambient condition requirements (temperature and humidity) and surface preparation requirements for application of the coating system as well as a detailed explanation of re-coat times, cure times, and related ambient condition requirements.
    d. When training is performed, the CTR shall provide a written letter stating that training was satisfactorily completed by the personnel listed by name in the letter.

C. Coating System Inspection:
1. While on site to routinely inspect and verify, the CTR shall perform the following activities to confirm acceptability and conformance with the specifications:
    a. Inspect ambient conditions during various coating system installation at hold points for conformance with the specified requirements.

b. Inspect the surface preparation of the substrates where the coating system will terminate or will be applied for conformance to the specified application criteria.
c. Inspect preparation and application of coating detail treatment (for example, terminations at joints, metal embedments in concrete, etc.).
d. Inspect application of the filler/surface materials for concrete and masonry substrates.
e. Inspect application of the primers and finish coats including wet and dry film thickness of the coatings.
f. Inspect coating systems for cure.
g. Review adhesion testing of the cured coating systems for conformance to specified criteria.
h. Review coating system continuity testing for conformance to specified criteria.
i. Inspect and record representative localized repairs made to discontinuities identified via continuity testing.
j. Conduct a final review of completed coating system installation for conformance to the specifications.
k. Prepare and submit a site visit report following each site visit that documents the acceptability of the coating work in accordance with the CSM's Recommendations.

D. Final Report:
1. Upon completion of coating work for the project, the CTR shall prepare a final report. That report shall summarize daily test data, observations, drawings, and photographs in a report to be submitted in accordance with paragraph 2.02. Include substrate conditions, ambient conditions, and application procedures, observed during the CTR's site visits. Include a statement that the completed work was performed in accordance with the requirements of this Section 09 90 00 and the CSM's recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
1. Notwithstanding the listing of product names in this Section 09 90 00, the Contractor shall provide affidavits, signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements. No coatings shall be applied to a surface until the specified affidavits have been submitted and have been reviewed and accepted. Failure to comply with this requirement shall be cause for rejection and removal of such materials from the site.
2. The following list specifies the material requirements for coating systems. Coating systems are categorized by generic name followed by an identifying abbreviation. If an abbreviation has a suffix number, it is for identifying subgroups within the coating system. Coating Systems E-5 and E-6 shall be NSF 61 certified.

Material Requirements for Coating Systems: All of U.S. Except California

Coating System	CSM	First Coat(s)		Finish Coat(s)
Epoxy Coatings				
E-1	PPG PMC	Amerlock 2/400 Series		Amerlock 2/400 Series
	Carboline	Carboguard 890		Carboguard 890
	International Paint/ICI *	Devran 224 HS		Devran 224
	Sherwin Williams	Macropoxy 646		Macropoxy 646
	Tnemec	Series V69		Series V69
E-2	PPG PMC	Amerlock 2/400 Series		Amerlock 2/400 Series
	Carboline	Carboguard 890		Carboguard 890
	International Paint/ICI	Bar-Rust 236		Bar-Rust 236
	Sherwin Williams	Sea Guard 6000 Epoxy N11-400		Sea Guard 6000 Epoxy N11-400
	Tnemec	Series V27 or V69		Series V69
E-3	PPG PMC	Amerlock 2/400 Series		Amerlock 2/400 Series
	Carboline	Carboguard 890		Carboguard 890
	International Paint/ICI	Bar-Rust 236		Bar-Rust 236
	Sherwin Williams	Sea Guard 6000 Epoxy N11-400		Sea Guard 6000 Epoxy N11-400
	Tnemec	Series V69		Series V69
E7	PPG PMC	Amercoat 385		Amercoat 385
	Carboline	Sanitile 120		Carboguard 890
	International Paint/ICI	Bar-Rust 236		Bar-Rust 236
	Sherwin Williams	Macropoxy 646		Macropoxy 646
	Tnemec	Series V69		Series V69
E-10	PPG PMC	Amerlock 2/400 Series		Amerlock 2/400 Series
	Carboline	Carboguard 890		Carboguard 890
	International Paint/ICI	Bar-Rust 236		Bar-Rust 236
	Sherwin Williams	Macropoxy 646		Macropoxy 646
	Tnemec	Series V69		Series V69
Specialty Epoxy Linings				
EA-1	Carboline	Plasite 4500S		Plasite 4500S
	Sauereisen	Sewergard 210S		Sewergard 210S
	Tnemec	Series 435		Series 435
Coating System	CSM	Base Coat	Filler/Surfacer	Glaze Coat
EA-3	Carboline	N/A	Carboguard 510	Plasite 5371
	Sauereisen	N/A	Series 209 HB	Sewergard 210T
	Tnemec	N/A	Series 218	Series 434

Material Requirements for Coating Systems: All of U.S. Except California

Coating System	CSM	First Coat(s)			Finish Coat(s)	
Coating System	CSM	Primer	Base Coat		Glaze Coat	
Epoxy Polyurethane						
EU-1	PPG PMC	Amercoat	Amercoat 385		Amercoat 450H	
	Carboline	Carbozinc 859	Carboguard 890		Carbothane 134 VOC	
	International Paint/ICI	Cathacoat 313	Devran 233 or 224HS		Devthane 379	
	Sherwin Williams	Zinc Clad IV	Macropoxy 646		Hi Solids Polyurethane	
	Tnemec	Series 90-97	Series V69		Series 1075	
Coating System	CSM	Primer	Filler/ Surfacer	Base Coat w/Scrim Cloth	Saturation Coat w/Silica Sand	Finish Coats
Latex Acrylic						
L-2	PPG PMC	Amercoat 220			Amercoat 220	
	Carboline	Carbocrylic 120			Carbocrylic 3359	
	International Paint/ICI	Prep and Prime Gripper			Ultrahide 250-1406	
	Sherwin Williams	Sher Cryl HPA			Sher Cryl HPA	
	Tnemec	Series 1028 or 1029			Series 1028 or 1029	
Miscellaneous						
M-1	Carboline	Carbowrap Priming Paste			Tape A, B, or C (temp. dependent)	
	Denso	Denso Paste			Densyl Tape	
	Trenton	Waxtape Primer			#1 Wax Tape	
M-2	Carboline	Carbomastic 15			Carbomastic 15	
	International Paint/ICI	Bar-Rust 231 (231K 9100)			Bar-Rust 231 (231K 9100)	
	Sherwin Williams	Epoxy Mastic Aluminum II			Epoxy Mastic Aluminum II	
	Tnemec	Series 135 (1243)			Series 135 (1243)	

**See CSM's Product Data Sheets for acceptable thinners for VOC compliance or do not thin.*

2.02 PRODUCT DATA

A. General:

1. Prior to application of coatings, submit letter(s) from the CTR(s) identifying the application personnel who have satisfactorily completed training as specified in paragraph 1.05 or a letter from the CSM stating that personnel who shall perform the work are approved by the CSM without need for further or additional training.
2. Submit reports specified in paragraph 1.02 Quality Control Requirements and 1.05 Coating System Inspection when the work is underway.
3. Submit the Coating System Inspection Checklists, using Form 09 90 00-A, included in Section 01 99 90, for the coating work.
4. CTR final report in accordance with paragraph 1.05 Final Report.

PART 3 EXECUTION

3.01 COATINGS

A. General:

1. Coating products shall not be used until the Construction Manager has accepted the affidavits specified in paragraphs 1.04 and 2.01, the Construction Manager has inspected the materials, and the CTR has trained the Contractor and CSA in the surface preparation, mixing and application of each coating system.
2. Erect and maintain protective enclosures as stipulated per SSPC-Guide 6 Guide for Containing Debris Generated During Paint Removal Operations.

B. Shop and Field Coats:

1. Shop Applied Prime Coat: Except as otherwise specified, prime coats may be shop-applied or field-applied. Shop-applied primer shall be compatible with the specified coating system and shall be applied at the minimum dry film thickness recommended by the CSM. Data sheets identifying the shop primer used shall be provided to the on-site coating application personnel. Adhesion tests shall be performed on the shop primer as specified in paragraph 3.01 Adhesion Confirmation. Damaged, deteriorated and poorly applied shop coatings that do not meet the requirements of this Section 09 90 00 shall be removed and the surfaces recoated. If the shop primer coat meets the requirements of this Section 09 90 00, the field coating may consist of touching up the shop prime coat and then applying the finish coats to achieve the specified film thickness and continuity.
2. Field Coats: Field coats shall consist of one or more prime coats and one or more finish coats to build up the coating to the specified dry film thickness. Unless otherwise specified, finish coats shall not be applied until other work in the area is complete and until previous coats have been inspected.
3. Adhesion Confirmation: The Contractor shall perform an adhesion test after proper cure in accordance with ASTM D3359 to demonstrate that (1) the shop applied prime coat adheres to the substrate, and (2) the specified field coatings adhere to the shop coat. Test results showing an adhesion rating of 5A on immersed surfaces and 4A or better on other surfaces shall be considered acceptable for coatings 5 mils or more in thickness (Method A). Test results showing an adhesion rating of 5B on immersed surfaces and 4B or better on other surfaces shall be considered acceptable for coating thicknesses less than 5 mils.

C. Application Location Requirements:

1. Equipment, Nonimmersed: Items of equipment, or parts of equipment that are not immersed in service, shall be shop primed and then finish coated in the field after installation with the specified or acceptable color. If the shop primer requires topcoating within a specified period, the equipment shall be finish coated in the shop and then touch-up painted after installation. If equipment removal and reinstallation is required for the project, touch-up coating work shall be performed in the field following installation.
2. Equipment, Immersed: Items of equipment, or parts and surfaces of equipment that are immersed when in service, with the exception of pumps and valves, shall have surface preparation and coating work performed in the field. Coating systems applied to immersed equipment shall be pinhole free.

3.02 PREPARATION

A. General:

1. Surface preparations for each type of surface shall be in accordance with the specific requirements of each coating specification sheet (COATSPEC) and the following. In the event of a conflict, the COATSPEC sheets shall take precedence.
2. Surfaces to be coated shall be clean and dry. Before applying coating or surface treatments, oil, grease, dirt, rust, loose mill scale, old weathered coatings, and other foreign substances shall be removed. Oil and grease shall be removed before mechanical cleaning is started. Where mechanical cleaning is accomplished by blast cleaning, the abrasive used shall be washed, graded and free from contaminants that might interfere with the adhesion of the coatings. The air used for blast cleaning shall be sufficiently free of oil and moisture so as not to cause detrimental contamination of the surfaces to be coated.
3. Where deemed necessary by the Owner's representative, a NACE International certified coatings inspector, provided by the Owner, will inspect and approve surfaces to be coated before application of a coating. Surface defects identified by the inspector shall be corrected by the Contractor at no additional cost to the Owner.
4. Cleaning and painting shall be scheduled so that dust and spray from the cleaning process shall not fall on wet, newly coated surfaces. Hardware, hardware accessories, nameplates, data tags, machined surfaces, sprinkler heads, electrical fixtures, and similar uncoated items which are in contact with coated surfaces shall be removed or masked prior to surface preparation and painting operations. Following completion of coating, removed items shall be reinstalled. Equipment adjacent to walls shall be disconnected and moved to permit cleaning and painting of equipment and walls and, following painting, shall be replaced and reconnected.

B. Blast Cleaning:

1. When abrasive blast cleaning is required to achieve the specified surface preparation the following requirements for blast cleaning materials and equipment shall be met:
    a. Used or spent blast abrasive shall not be reused on this project.
    b. The compressed air used for blast cleaning shall be filtered and shall contain no condensed water and no oil. Moisture traps shall be cleaned at least once every four hours or more frequently as required to prevent moisture from entering the supply air to the abrasive blasting equipment.
    c. Oil separators shall be installed just downstream of compressor discharge valves and at the discharge of the blast pot discharges. These shall be checked on the same frequency as the moisture traps as defined above.
    d. Regulators, gauges, filters, and separators shall be in use on compressor air lines to blasting nozzles times during this work.
    e. An air dryer or desiccant filter drying unit shall be installed which dries the compressed air prior to blast pot connections. This dryer shall be used and maintained for the duration of surface preparation work.
    f. The abrasive blast nozzles used shall be of the venturi or other high velocity type supplied with a minimum of 100 psig air pressure and sufficient volume to obtain the blast cleaning production rates and cleanliness/specified.
    g. The Contractor shall provide ventilation for airborne particulate evacuation (meeting pertinent safety standards) to optimize visibility for both blast cleaning and inspection of the substrate during surface preparation work.

h. If, between final surface preparation work and coating system application, contamination of prepared and cleaned metallic substrates occurs, or if the prepared substrates' appearance darkens or changes color, recleaning by water blasting, reblasting and abrasive blast cleaning shall be required until the specified degree of cleanliness is reclaimed.

i. The Contractor is responsible for dust control and for protection of mechanical, electrical, and other equipment adjacent to and surrounding the work area.

C. Solvent Cleaning:

1. Any solvent wash, solvent wipe, or cleaner used, including but not limited to those used for surface preparation in accordance with SSPC SP-1 Solvent Cleaning and shall be of the emulsifying type which emits no more than 340 g/l VOCs for AIM regions, 250 g/l for CARB regions and 100 g/l for SCAQMD regions, contains no phosphates, is biodegradable, removes no zinc, and is compatible with the specified primer.
2. Clean white cloths and clean fluids shall be used in solvent cleaning.

D. Metallic Surfaces:

1. Metallic surfaces shall be prepared in accordance with applicable portions of surface preparation specifications of the Society for Protective Coatings (SSPC) specified for each coating system. See Coat Spec for each coating system in this Section 09 90 00. The profile depth of the surface to be coated shall be in accordance with the COATSPEC requirements in this Section measured by Method C of ASTM D4417. Blast particle size shall be selected by the Contractor to produce the specified surface profile. The solvent in solvent cleaning operations shall be as recommended by the CSM.
2. Preparation of metallic surfaces shall be based upon comparison with SSPC-VIS1-89 (ASTM D2200), and as described in the Coat Spec for each coating system. If dry abrasive blast cleaning is selected and to facilitate inspection, the Contractor shall, on the first day of cleaning operations, abrasive blast metal panels to the standards specified. Plates shall measure a minimum of 8-1/2 inches by 11 inches. Panels meeting the requirements of the specifications shall be initialed by the Contractor and the Construction Manager and coated with a clear non-yellowing finish. One of these panels shall be prepared for each type of abrasive blasting and shall be used as the comparison standard throughout the project.
3. Blast cleaning requirements for steel, ductile iron and stainless steel substrates are as follows:
    a. Steel piping shall be prepared in accordance with SSPC SP-6 (Commercial Blast Cleaning) and primed before installation. Ductile iron piping surfaces including fittings shall be prepared in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05.
    b. Stainless steel surfaces shall be abrasive blast cleaned to leave a clean uniform appearance with a minimum surface profile of 1.5 to 2.5 mils that is uniform.
    c. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products or embedded abrasive from substrate by vacuum cleaning prior to coating application.
    d. Care must be taken to prevent contamination of the surface after blasting from worker’s fingerprints, deleterious substances on workers’ clothing, or from atmospheric conditions.

e. Ambient environmental conditions in the enclosure must be constantly monitored and maintained to ensure the degree of cleanliness is held and no “rust back” occurs prior to coating material application.

E. Concrete Surfaces:

1. Inspection of concrete surfaces prior to surface preparation and surface preparation of concrete surfaces shall be performed in accordance with SSPC-SP13 (also called NACE 6).
2. Prepare substrate cracks, areas requiring resurfacing and perform detail treatment including but not limited to, terminating edges, per CSM recommendations. This shall precede surface preparation for degree of cleanliness and profile.
3. The surface profile for prepared concrete surfaces to be coated shall be evaluated by comparing the profile of the prepared concrete with the profile of graded abrasive paper, as described in ANSI B74.18 or by comparing the profile with the ICRI 03732 (surface profile replicas). Surface profile requirements shall be in accordance with the Coat Spec requirements and the CSM’s recommendations.
4. Surface cleanliness of prepared concrete substrates shall be inspected after cleaning, preparation, and/or drying, but prior to making repairs or applying a coat in the coating system. If concrete surfaces are repaired, they shall be reinspected for surface cleanliness prior to application of the coating system.
5. Surface preparation of concrete substrates shall be accomplished using methods such as dry abrasive blast cleaning, high, or ultra high-pressure water blast cleaning in accordance with SSPC-SP-13. The selected cleaning method shall produce the requirements set forth below.
    a. A clean substrate that is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances shall be achieved. Blast cleaning and other means necessary shall be used to open up air voids or bugholes to expose their complete perimeter. Leaving shelled over, hidden air voids beneath the exposed concrete surface is not acceptable. Concrete substrate must be dry prior to the application of filler/surface or coating system materials.
    b. Acceptable surface preparation must produce a concrete surface with a minimum pH of 8.0 to be confirmed by surface pH testing. If after surface preparation, the surface pH remains below 8.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
    c. Following inspection by the Contractor of the concrete surface preparation, thoroughly vacuum clean concrete surfaces to be coated to remove loose dirt, and spent abrasive (if dry blast cleaning is used) leaving a dust free, sound concrete substrate. Debris produced by blast cleaning shall be removed from the structures to be coated and disposed of legally off site by the Contractor.
6. Should abrasive blast cleaning or high or ultrahigh pressure water blasting not remove degraded concrete, chipping or other abrading tools shall be used to remove the deteriorated concrete until a sound, clean substrate is achieved which is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances. Concrete substrates must be dry prior to the application of filler/surfacers or coating system materials.
7. Surface cleanliness of prepared concrete substrates shall be inspected after cleaning, preparation, and/or drying, but prior to application of coating materials. If

concrete surfaces are repaired, they shall be reinspected for surface cleanliness and required surface profile prior to application of the coating system.

8. Moisture content of concrete to be coated shall be tested in accordance with ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method and ASTM F 1869, Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride. The ASTM D4263 plastic sheet test shall be conducted at least once for every 500 sq. ft. of surface area to be coated. The presence of any moisture on plastic sheet following test period constitutes a non-acceptable test. For concrete surfaces to be coated which are on the negative or back side of concrete walls or structures exposed to soils (back filled) or immersed and waterproofed in accordance with Section 07 10 00, perform calcium chloride tests in accordance with ASTM F-1869 once for each 500 sq. ft. of surface area to be coated. Comply with CSM's written recommendations regarding acceptance/non-acceptance of moisture vapor emissions.

F. Masonry Surfaces:

1. Prepare masonry surfaces such as Concrete Masonry Units (CMU) to remove chalk, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
2. Be certain masonry surfaces are dry prior to coating application. If pressure washing or low-pressure water blast cleaning is used for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or when the minimum ambient temperature is 70 degrees F prior to coating application work.

G. Fiberglass Reinforced Plastic (FRP) Surfaces:

1. Prepare FRP surfaces by sanding to establish uniform surface roughness and to remove gloss from the resin in the FRP. Next, vacuum clean to remove loose FRP dust, dirt, and other materials. Next, solvent clean using clean white rags and allow solvent to evaporate completely before application of coating materials.

3.03 APPLICATION

A. Workmanship:

1. Coated surfaces shall be free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce an even film of uniform thickness completely coating corners and crevices.
2. The Contractor's equipment shall be designed for application of the materials specified. Compressors shall have suitable traps and filters to remove water and oils from the air. A paper blotter test shall be performed by the Contractor when requested by the Construction Manager to determine if the air is sufficiently free of oil and moisture so as not to produce deteriorating effects on the coating system. The amount of oil and moisture in spray air shall be less than the amount recommended by the CSM. Spray equipment shall be equipped with mechanical agitators, pressure gages, and pressure regulators, and spray nozzles of the proper sizes.
3. Each coat of coating material shall be applied evenly and sharply cut to line. Care shall be exercised to avoid overspraying or spattering paint on surfaces not to be coated. Glass, hardware, floors, roofs, and other adjacent areas and installations shall be protected by taping, drop cloths, or other suitable measures.

4. Coating applications method shall be conventional or airless spray, brush or roller, or trowel as recommended by CSM.
5. Allow each coat to cure or dry thoroughly, according to CSM's printed instructions, prior to recoating.
6. Vary color for each successive coat for coating systems when possible.
7. When coating complex steel shapes, prior to overall coating system application, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer coat. This involves applying a separate coat using brushes or rollers to ensure proper coverage. Stripe coat via spray application is not permitted.

B. Coating Properties, Mixing and Thinning:
1. Coatings, when applied, shall provide a satisfactory film and smooth even surface. Glossy undercoats shall be lightly sanded to provide a surface suitable for the proper application and adhesion of subsequent coats. Coating materials shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Coatings consisting of two or more components shall be mixed in accordance with the CSM's instructions. Where necessary to suit the conditions of the surface, temperature, weather and method of application, the coating may be thinned as recommended by the CSM immediately prior to use. The volatile organic content (VOC) of the coating as applied shall comply with prevailing air pollution control regulations. Unless otherwise specified, coatings shall not be reduced more than necessary to obtain the proper application characteristics. Thinner shall be as recommended by the CSM.

C. Atmospheric Conditions:
1. Coatings shall be applied only to surfaces that are dry, and only under conditions of evaporation rather than condensation. Coatings systems shall not be applied during rainy, misty weather, or to surfaces upon which there is frost or moisture condensation. During damp weather, when the temperature of the surface to be coated is within 10 degrees F of the dew point, forced dehumidification equipment may be used to maintain a temperature of minimum 40 degrees F and 10 degrees F above the dew point for the surfaces to be coated, the coated surface, and the atmosphere in contact with the surface. These conditions shall be maintained for a period of at least 8 hours or as recommended by the CSM. Where conditions causing condensation are severe, dehumidification equipment, fans, and/or heaters shall be used inside enclosed areas to maintain the required atmospheric and surface temperature requirements for proper coating application and cure.

D. Concrete Substrate Temperatures and Detail Treatment:
1. When the surface temperatures of the concrete substrates to be coated are rising or when these substrates are in direct sunlight, outgassing of air from the concrete may result in bubbling, pinhole formations, and/or blistering in the coating system. The application of the filler/surface and the coating system will only be allowed during periods of falling temperature. This will require that application of the filler/surface and coating system shall only occur during the cooler evening hours. Contractor shall include any cost for working outside of normal hours in the bid.
2. Should bubbles, pinholes, or discontinuities form in the applied coating system material, they shall be repaired as recommended by the CSM. Should pinholes develop in the filler/surfacer material or in the first coat of the coating material, the pinholes shall be repaired in accordance with the CSM's recommendations prior to

application of the next coat of material. Whenever pinholes occur, the air void behind or beneath the pinhole shall be opened up completely and then completely filled with the specified filler/surfacer material. Next, the coated area around the pinhole repair shall be abraded and the coating reapplied over that area.

3. Perform application detail work per CSM's current written recommendations and/or drawings.

E. Protection of Coated Surfaces:

1. Items that have been coated shall not be handled, worked on, or otherwise disturbed, until the coating is completely dry and hard. After delivery at the site, and upon permanent erection or installation, shop-coated metalwork shall be recoated or retouched with specified coating when it is necessary to maintain the integrity of the film.

F. Method of Coating Application:

1. Where two or more coats are required, alternate coats shall contain sufficient compatible color additive to act as indicator of coverage, or the alternate coats shall be of contrasting colors. Color additives shall not contain lead, or lead compounds, which may be destroyed or affected by hydrogen sulfide or other corrosive gas, and/or chromium.
2. Mechanical equipment, on which the equipment manufacturer's coating is acceptable, shall be touch-up primed and coated with two coats of the specified coating system to match the color scheduled. Electrical and instrumentation equipment specified in Divisions 26 and 40 shall be coated as specified in paragraph 3.03 Electrical and Instrumentation Equipment and Materials.
3. Coatings shall not be applied to a surface until it has been prepared as specified. The primer or first coat shall be applied by brush to ferrous surfaces that are not blast-cleaned. Coats for blast-cleaned ferrous surfaces and subsequent coats for nonblast-cleaned ferrous surfaces may be either brush or spray applied. After the prime coat is dry, pinholes and holidays shall be marked, repaired in accordance with CSM's recommendations and retested before succeeding coats are applied. Unless otherwise specified, coats for concrete and masonry shall be brushed, rolled, or troweled.

G. Film Thickness and Continuity:

1. WFT of the first coat of the coating system and subsequent coats shall be verified by the Contractor, following application of each coat.
2. The surface area covered per gallon of coating for various types of surfaces shall not exceed those recommended by the CSM. The first coat, referred to as the prime coat, on metal surfaces refers to the first full paint coat and not to solvent wash, grease emulsifiers or other pretreatment applications. Coatings shall be applied to the thickness specified, and in accordance with these specifications. Unless otherwise specified, the average total thickness (dry) of a completed protective coating system on exposed metal surfaces shall be not less than 1.25 mils per coat. The minimum thickness at any point shall not deviate more than 25 percent from the required average. Unless otherwise specified, no less than two coats shall be applied.
3. In testing for continuity of coating about welds, projections (such as bolts and nuts), and crevices, the Construction Manager shall determine the minimum conductivity for smooth areas of like coating where the dry-mil thickness has been accepted. This

conductivity shall be the minimum required for these rough or irregular areas. Pinholes and holidays shall be recoated to the required coverage.

4. The ability to obtain specified film thickness is generally compromised when brush or roller application methods are used and, therefore, more coats may need to be applied to achieve the specified dry film thickness.
5. For concrete substrates, the Contractor shall apply a complete skim coat of the specified filler/surfacer material over the entire substrate prior to application of the coating system. This material shall be applied such that all open air voids and bugholes in the concrete substrate are completely filled prior to coating application.

H. Special Requirements:

1. Before erection, the Contractor shall apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces that are inaccessible after assembly. The final coat shall be applied after erection. Structural friction connections and high tensile bolts and nuts shall be coated after erection. Areas damaged during erection shall be hand-cleaned or power-tool cleaned and recoated with primer coat prior to the application of subsequent coats. Touch-up of surfaces shall be performed after installation. Surfaces to be coated shall be clean and dry at the time of application. Except for those to be filled with grout, the underside of equipment bases and supports that have not been galvanized shall be coated with at least two coats of primer specified for system E-2 prior to setting the equipment in place. Provide coating system terminations at leading edges and transitions to other substrates in accordance with the CSM's recommendations or detail drawings.

I. Electrical and Instrumentation Equipment and Materials:

1. Electrical and instrumentation equipment and materials shall be coated by the equipment manufacturer as specified below.
    a. Finish: Electrical equipment shall be treated with zinc phosphate, bonderized or otherwise given a rust-preventive treatment. Equipment shall be primed, coated with enamel, and baked. Minimum dry film thickness shall be 3 mils.
        1) Unless otherwise specified, instrumentation panels shall be coated with system E-1 for indoor mounting and system EU-1 for outdoor mounting.
        2) Before final acceptance, the Contractor shall touch up scratches on equipment with identical color coating. Finish shall be smooth, free of runs, and match existing finish. Prior to touching up scratches, Contractor shall fill them with an appropriate filler material approved by the CSM.
    b. Color: Exterior color of electrical equipment shall be FS 26463 (ANSI/NSF 61) light gray. Interior shall be painted FS 27880 white. Nonmetallic electrical enclosures and equipment shall be the equipment manufacturer's standard grey color.
        1) Exterior color of instrumentation panels and cabinets mounted indoors shall be FS 26463 light gray; unless otherwise specified, exterior color for cabinets mounted outdoors shall be FS 27722, white. Cabinet interiors shall be FS 27880, white.

J. Soluble Salt Contamination of Metallic Substrates:

1. Contractor shall test in accordance with SSPC-TU-4 metallic substrates to be coated that have been exposed to seawater or coastal air or to industrial fallout of

particulate or other sources of soluble chlorides (such as wastewater exposure). If testing indicates detrimental levels of soluble salts, those in excess of 25 ppm, the Contractor shall clean and prepare these surfaces to remove the soluble salts.

3.04 CLEANUP

A. General:
   1. Upon completion of coating, the Contractor shall remove surplus materials, protective coverings, and accumulated rubbish, and thoroughly clean surfaces and repair overspray or other coating-related damage.

3.05 COATING SYSTEM SPECIFICATION SHEETS (COATSPEC)

A. General:
   1. Coating systems for different types of surfaces and general service conditions for which these systems are normally applied are specified on the following COATSPEC sheets. Surfaces shall be coated in accordance with the COATSPEC to the system thickness specified. Coating systems shall be as specified in paragraph 3.06. In case of conflict between the schedule and the COATSPECS, the requirements of the schedule shall prevail.
   2. Coating Specification Sheets included in Table A are included this paragraph 3.05.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
E-1	Epoxy	Metal	Interior; exterior, covered, not exposed to direct sunlight, non-corrosive exposure.
E-2	Epoxy	Metal	Immersed, nonpotable; non-immersed, moderately corrosive environment, color required.
E-3	Epoxy	Concrete or Masonry	Immersed, nonpotable; non-immersed, corrosive environment, color required.
E-7	Epoxy	Plastic	Interior; exterior covered, not exposed to direct sunlight.
E-10	Polyamidoamine epoxy	Metal or concrete	Below grade (buried).
EA-1	Blended Amine Cured Epoxy	Metal	Immersed, nonpotable; non-immersed, corrosive environment, color not required especially for headspace environments that are corrosive due to biogenic sulfide corrosion.
EA-3	Blended Amine Cured Epoxy	Concrete or Masonry	Immersed, nonpotable; non-immersed, corrosive environment, color not required, new or existing construction, especially for headspace environments that are corrosive due to biogenic sulfide corrosion.
L-2	Latex	PVC and CPVC pipe	Exterior, direct sunlight exposure.
M-1	Petrolatum based mastic or wax based wrapping tapes	Metal	Below grade (buried) or where little to no surface preparation can be performed on piping or structural steel.
M-2	Epoxy mastic or equal	Ferrous Metal	Interior, corrosive environment, confined enclosures, where minimal surface preparation is possible.
EU-1	Zinc-epoxy-polyurethane system	Ferrous Metal	Exterior, exposed to direct sunlight, moderately corrosive non-immersed.

Coating System Specification Sheets (COATSPEC)

A.	**Coating System Identification: E-1**	
1.	Coating Material:	Epoxy
2.	Surface:	Metal
3.	Service Condition:	Interior; exterior, covered, not exposed to direct sunlight, non-corrosive exposure.
4.	Surface Preparation:	
a.	General:	Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning surfaces in accordance with SSPC SP-2 (Hand Tool Cleaning). Damaged shop coated areas shall be cleaned in accordance with SSPC SP-5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive and vacuum cleaning blasting prior to receiving finish coats.
b.	Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC SP-6 (Commercial Blast Cleaning) to achieve a uniform, surface profile of 2.0 to 2.5 mils.
		Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC SP-1 (Solvent Cleaning). Areas of rust penetration shall be spot blasted to SSPC SP-10 (Near White Blast) (to achieve the 2.0- to 2.5-mil surface profile) and spot primed with the specified primer. For ductile iron surfaces, refer to the requirements in paragraph 3.02 Metallic Surfaces.
c.	Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC SP-7 (Brush-off Blast Cleaning) to achieve uniform, minimum surface profile 1.0 to 1.5 mils.
5.	Application:	Field
a.	General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b.	Ferrous Metal:	Prime coats shall be an epoxy primer compatible with the specified finish coats and applied in accordance with the written instructions of the CSM.
c.	Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be cleaned prior to the application of the prime coat in accordance with SSPC SP-1 (Solvent Cleaning).
6.	System Thickness:	10 mils dry film.
7.	Coatings:	
a.	Primer:	One coat at CSM's recommended dry film thickness.
b.	Finish:	One or more coats at CSM's recommended dry film thickness per coat to achieve the specified system thickness.
B.	**Coating System Identification: E-2**	
1.	Coating Material:	Epoxy
2.	Surface:	Metal
3.	Service Condition:	Immersed, nonpotable; non-immersed, moderately corrosive environment, color required.
4.	Surface Preparation:	
a.	Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC SP-5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils.
		Damaged shop coating shall be cleaned in accordance with SSPC SP-5 (White Metal Blast Cleaning) and vacuum cleaning and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive blasting or abrading prior to receiving finish coats if the maximum recoat time for the primer has been exceeded. This cleaning must produce a uniform 1.0- to 1.5-mil profile in the intact shop primer. For ductile iron surfaces, refer to the requirements in paragraph 3.02 Metallic Surfaces.
b.	Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC SP-7 (Brush-off Blast Cleaning) to achieve a uniform surface profile of 1.0 to 1.5 mils.

	Galvanized steel with this E-2 coating system shall not be used in immersion service in wastewater.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coat shall be an epoxy primer compatible with the specified finish coats.
c. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal, non-immersed, shall be coated prior to the application of the prime coat with a grease emulsifying agent in accordance with the CSM's written instructions. Nonferrous metal to be immersed shall not be painted. Galvanized metal shall not be immersed even if it is painted.
6. System Thickness:	16 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended dry film thickness.
b. Finish:	Two or more coats at CSM's recommended dry film thickness per coat to the specified system thickness.
C. Coating System Identification: E-3	
1. Coating Material:	Epoxy
2. Surface:	Concrete or masonry
3. Service Condition:	Immersed, nonpotable; non-immersed, corrosive environment, color required.
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM before coating work proceeds. Moisture content may be tested by the Construction Manager with a Delmhorst Instrument Company moisture detector, or equal. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting and chipping, and voids and cracks shall be repaired as specified in Section 03 30 00. Surface preparation can be performed by abrasive blast cleaning or water blast cleaning and must achieve a uniform concrete surface profile of CSP3 in accordance with ICRI 03732. After cleaning, air voids or bugholes in the concrete shall be filled with a surfacer or block filler compatible with the specified primer and finish coats.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping.
	Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign, loose, and deleterious substances.
	Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Application:	Field
a. General:	Apply filler/surfacer as recommended by CSM to fill bugholes and air voids or block texture, etc. leaving a uniformly filled surface that does not produce blowholes or outgassing causing pinholing of the coating system. Filler/surfacers shall dry a minimum of 48 hours prior to application of prime coat or as required by the CSM.
	Prime coat shall be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
	Drying time between coats shall be as recommended by CSM.
6. System Thickness:	15 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM’s recommended dry film thickness.
b. Finish:	Two or more coats at CSM’s recommended dry film thickness per coat to the

	specified system thickness.
D. Coating System Identification: E-7	
1. Coating Material:	Epoxy
2. Surface:	Plastic
3. Service Condition:	Interior; exterior covered, not exposed to direct sunlight.
4. Surface Preparation:	Plastic shall be prepared in accordance with SSPC SP-1 (Solvent Cleaning) and light sanding to produce a uniform surface roughness(uniform surface profile of 1.0 to 1.5 mils) on the plastic.
5. Application:	Field
6. System Thickness:	5 mils dry film.
7. Coatings:	One or more coats at CSM's recommended dry film thickness per coat to the specified system thickness.
E. Coating System Identification: E-10	
1. Coating Material:	Polyamidoamine epoxy
2. Surface:	Metal or concrete
3. Service Condition:	Below grade (buried, exterior) in contact with soil
4. Surface Preparation:	
a. Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC SP-5 (White Metal Blast Cleaning).
b. Nonferrous Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC SP-7 (Brush-off Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils.
c. Concrete:	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content may be tested by the Construction Manager with a Delmhorst Instrument Company moisture detector, or equal. Except as otherwise specified, loose concrete and laitance shall be removed from surfaces by abrasive blasting and chipping, and voids and cracks shall be repaired as specified in Section 03 30 00. Concrete surface preparation can be performed using abrasive blast cleaning or water blast cleaning methods and must achieve a concrete surface profile of CSP-3 in accordance with ICRI 03732.
5. Application:	Field
6. System Thickness:	16 mils
7. Coating:	Two or more coats at CSM's recommended dry film thickness per coat to the specified system thickness.
F. Coating System Identification: EA-1	
1. Coating Material:	Blended Amine Cured Epoxy
2. Surface:	Metal
3. Service Condition:	Immersed, nonpotable; non-immersed, corrosive environment, color not required especially for headspace environments that are corrosive due to biogenic sulfide corrosion.
4. Surface Preparation:	
a. Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC SP-5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 3.0 to 3.5 mils. Blast Cleaning shall produce a minimum surface profile of 3.0 mils.
	Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning surfaces in accordance with SSPC SP-11 (Power Tool Cleaning to Bare Metal). Damaged shop coated areas shall be cleaned in accordance with SSPC SP-5 (White Metal Blast Cleaning) and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive blasting and blow down cleaning prior to receiving finish coats. Cast or ductile iron surfaces to be coated shall be abrasive blast cleaned to a clean, gray uniform metal appearance free of variations in color and loose materials. Ductile iron surfaces shall be prepared in

	accordance with paragraph 3.02 Metallic Surfaces.
b. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC SP-7 (Brush-off Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils. Galvanized metal should generally not be used in these environments.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
	Drying time between coats shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions.
b. Ferrous Metal:	If shop priming is required or field priming is necessary, the prime coat shall be an epoxy primer compatible with the specified coating system. Generally, the EA-1 coating system is self-priming and does not require a primer unless there is a special reason to prime the steel to hold the blast cleaning from rusting back.
6. System Thickness:	30 to 40 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended dry film thickness only if required by special circumstances.
b. Finish:	One or more coats at CSM's recommended dry film thickness per coat to the specified system thickness.
c. Testing:	Holiday detection shall be performed over 100% of the coated surface area to identify any holidays or pinholes that must be repaired.
d. Pinhole and Holiday Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows:
	• Using a pencil grinder, remove a ½-inch diameter area of the coating system material back to the ferrous metal substrate. The metal must be shiny
	• Aggressively sand or abrade the intact coating system surface 2 inches around the complete periphery of the ½-inch diameter removal area to produce a uniform 6 to 8 mils profile
	• Vacuum clean the prepared area to remove all dust and dirt to achieve a clean, sound surface. Tape the peripheral area to prevent coating application onto unprepared surfaces
	• Brush apply one coat of the finish coating material. Following proper recoat cure time, apply additional coats of the finish coating system to achieve 60 mils DFT at the coating removal area and feather the coating onto the roughened coated surfaces to form a neat repair outline
G. Coating System Identification: EA-3	
1. Coating Material:	Blended Amine Cured Epoxy
2. Surface:	Concrete or masonry
3. Service Condition:	Immersed, nonpotable; non-immersed, corrosive environment, color not required, new or existing construction, especially for headspace environments that are corrosive due to biogenic sulfide corrosion.
4. Surface Preparation:	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, pipe penetration treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the owner, the engineer, or any other party.
	If wet abrasive or water blasting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials.

Coating System Specification Sheets (COATSPEC)

a. Concrete:	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content may be tested by the Construction Manager with a Delmhorst Instrument Company moisture detector, or equal. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting and chipping, and voids and cracks shall be repaired as specified in Section 03 30 00. Concrete shall be abraded also to achieve a uniform concrete surface profile of CSP 5 minimum. If the parge coat (filler/surfacer material) is non-polymer modified, it shall be brush blasted following adequate cure per the CSM's instructions to produce a uniform concrete surface profile of CSP-4 in accordance with ICRI 03732 prior to coating application. After cleaning, air voids or bugholes in the concrete shall be filled with a surfacer or block filler. The filler/surfacer material shall be applied as a complete parge coat of the substrate. For existing concrete that has been degraded, apply a skim coat of a surfacer or filler material to restore the substrate to a coatable condition. Be certain the filler surfacer material is compatible with the coating system.
b. Masonry:	Masonry surfaces shall be allowed to age for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed. Loose or splattered mortar shall be removed by scrapping and chipping.
	Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances.
	Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with sealer or block filler compatible with the specified coating system.
5. Application:	Field
a. General:	Surfacer or filler shall be applied and dry per CSM's recommendations prior to application of coating.
	Drying time between filler/surfacer and coating system shall be as specified by the CSM for the site conditions. If the maximum recoat time is exceeded, surface preparation shall require solvent washing, light abrasive blasting, or other procedures per CSM's instructions. The parge coat shall completely fill all bugholes and voids in the substrate and it will also completely cover the substrate unless specified otherwise above such filled voids by 1/8 inch of thickness.
6. System Thickness:	125 mils dry film (or 1/8 inch) in addition to the parge coat.
7. Coatings:	
a. Primer:	Self-priming.
b. Finish:	One coat at CSM's recommended dry film thickness – trowel applied.
c. Testing:	Holiday detection shall be performed over 100% of the coated surface area to identify any holidays or pinholes that could compromise coating system performance. Holiday detection shall be performed after adequate cure of the spray applied epoxy coating material. Holiday detection shall be performed in accordance with NACE RP0188.
d. Pinhole and Holiday Repair Procedure:	Pinholes and holidays identified by Holiday Detection shall be repaired as follows:
	• Using a grinder or other suitable power tool, remove the coating system at all pinholes or holidays in an area at least 2 inches in diameter or in both dimensions around the defect back to the concrete substrate.
	• Chip out and remove the concrete to expose the full dimensions in all three directions of the air void responsible for the defect.
	• Aggressively abrade or sand the intact coating system surface at least 3-inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
	• Vacuum clean the prepared area to remove all dust, dirt, etc. leaving clean sound surfaces.
	• Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.

	• Using a putty knife or other suitable tool, fill the opened void with the approved filler/surfacer material completely and strike-off. Allow to cure per CSM's recommendations.
	• Apply the coating system in the number of coats necessary to achieve the specified 60 mils DFT over the defect and coating removal area and feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline. Allow to cure properly.
H. Coating System Identification: EU-1	
1. Coating Material:	Zinc-Epoxy-Polyurethane System
2. Surface:	Ferrous Metal
3. Service Condition:	Exterior, exposed to direct sunlight, moderately corrosive, non-immersed.
4. Surface Preparation:	
a. General:	Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning surfaces in accordance with SSPC SP-2 (Hand Tool Cleaning). Damaged shop coated areas shall be cleaned in accordance with SSPC SP-3 (Power Tool Cleaning) and recoated with the primer specified.
b. Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC SP-6 (Commercial Blast Cleaning) 2.5 – 3.0. Ductile iron surfaces to be coated shall be abrasive blast cleaned in accordance with paragraph 3.02 Metallic Surfaces.
	Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC-SP-11 (Power Tool Cleaning to Bare Metal). Areas of rust penetration shall be spot blasted to SSPC SP-10 (Near White Blast) and spot primed with the specified primer.
c. Galvanized Metal:	Damaged galvanized steel areas with exposed ferrous metal and/or rusted shall be cleaned in accordance with SSPC SP-5 (White Metal Blast Cleaning) or Power Tool Cleaned to Bare Metal in accordance with SSPC-SP-11 to achieve a uniform 1.0- to 1.5-mil profile and spot primed with the primer specified.
	Nonferrous and galvanized metal shall be prepared in accordance with SSPC SP-7 (Brush-off Blast Cleaning) to impart a 1.0- to 2.0-mil profile to the galvanized steel surfaces. Where this cannot be performed, prepare by abrading in accordance with SSPC-SP-3, Power Tool Cleaning to impart a 1.0- to 1.5-mil profile uniformly to the galvanized steel surfaces.
	For EU-1 over galvanized steel, delete the zinc rich primer.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coats shall be a zinc rich epoxy or polyurethane primer compatible for use with urethane finish coats and applied in accordance with written instructions of the CSM or in the case of CARB or SCAQMD applications, prime with specified primer that is not zinc rich. In these cases, only a two-coat system is applied.
6. System Thickness:	3 to 4 mils of zinc rich primer, one intermediate or primer epoxy coat at 5 to 6 mils and one finish coat of polyurethane at 2 to 3 mils DFT.
7. Coatings:	
a. Primer:	One coat at CSM's recommended dry film thickness.
b. Intermediate:	One coat at CSM's recommended dry film thickness.
c. Finish:	One coat at CSM's recommended dry film thickness per coat to meet the specified system thickness.
I. Coating System Identification: EU-1-FRP	
1. Coating Material:	Specialty Primer plus Polyurethane Finish Coat
2. Surface:	Exterior of FRP Pipe and Tanks, etc.
3. Service Condition:	Exterior, exposed to direct sunlight, non-immersed.
4. Surface Preparation:	

a. General:	Clean to remove loose dirt, dust, or other contaminants.
	Prepare surfaces by sanding to produce roughness to achieve a uniform, minimum surface profile of 1.5 to 2.0 mils.
	Solvent clean thoroughly using solvent as recommended by the CSM.
	Thoroughly clean to remove loose debris by vacuum cleaning.
5. Application:	Field
a. General:	Apply primer coat and thin as recommended by the CSM provided the coating applied complies with prevailing air pollution control regulations.
	Apply finish coat as recommended by the CSM.
6. System Thickness:	Primer to 2 to 4 mils and finish coat is 2 to 3 mils DFT.
7. Coatings:	
a. Primer:	One coat at CSM's recommended dry film thickness.
b. Finish:	One coat at CSM's recommended dry film thickness per coat to meet the specified system thickness.
J. Coating System Identification: L-2	
1. Coating Material:	Latex
2. Surface:	PVC and CPVC pipe.
3. Service Condition:	Exterior, direct sunlight exposure.
4. Surface Preparation:	Plastic pipe shall be cleaned with solvent compatible with the specified primer and sanded to roughen surfaces to achieve a uniform surface profile of 1.0 to 1.5 mils. Vacuum clean after sanding to remove all loose dust, plastic particles, and dirt.
5. Application:	Field
6. System Thickness:	3 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended dry film thickness.
b. Finish:	One or more coats at CSM's recommended dry film thickness per coat to the specified system thickness.
K. Coating System Identification: M-1	
1. Coating Material:	Petrolatum based mastic or wax based wrapping tapes.
2. Surfaces:	Metal
3. Service Condition:	Below grade (buried) or where little to no surface preparation can be performed on piping or structural steel.
4. Surface Preparation:	Remove loose scale, rust, dirt, excessive moisture, or frost from the surface in accordance with SSPC SP-2 (Hand Tool Cleaning).
5. Application:	All surfaces shall be hand rubbed or brushed with a priming paste recommended by the CSM. Sharp projections such as threads, irregular contours, or badly pitted areas shall receive a liberal amount of priming paste to ensure maximum protection of metal throughout.
	On irregular shaped surfaces, i.e., nuts, bolts, flanges, valves, etc., the Contractor shall use either of the following systems recommended by the CSM.
	A. Apply recommended mastic by hand in sufficient quantity to build an even contour over entire surface. The Contractor shall pay particular attention to ensure that folds and air pockets within the mastic layer are thoroughly pressed out prior to subsequent application of tape.
	OR:
	B. An extra layer of tape shall be cut and carefully molded around sharp projections, nuts, bolts, etc., before final application of tape, in order to meet specified system thickness.
	Tape shall be spirally wrapped with a 55 percent overlap and sufficient tension and pressure to provide continuous adhesion without stretching the tape. Edges of tape

	must be continuously smoothed and sealed by hand during wrapping. On vertical application, contractor shall begin at bottom and proceed upward creating a weatherboard overlap.
6. System Thickness:	Smooth contours shall have a minimum thickness of 50 mils while nuts, bolts, and sharp projections shall be 100 mils.
7. Tape:	Number and types of tape wraps shall be in accordance with the CSM's written instructions.
L. Coating System Identification: M-2	
1. Coating Material:	Epoxy mastic or equal
2. Surface:	Ferrous Metal
3. Service Condition:	Interior, corrosive environment, confined enclosures, where minimal surface preparation is possible.
4. Surface Preparation:	
a. Ferrous Metal:	All uncoated ferrous metal surfaces shall be prepared in accordance with SSPC SP-3 (Power Tool Cleaning), or SSPC-SP-11 (Power to Cleaning to Bare Metal) prior to assembly. Surface preparation to achieve a uniform surface profile of 2.0 to 2.5 mils. Shop primed ferrous metal surfaces and fabricated assemblies shall be clean and dry prior to the application of field coats. Following assembly, the Contractor shall smooth welds and prominences using power tools prior to the application of the field applied coatings.
5. Application:	Field
a. General:	Prior to the application of field applied coatings, welds, back-to-back angles, sharp or rough edges and weld splatter shall be brushed with the specified prime coat and allowed to cure overnight.
6. System Thickness:	15 mils dry film.
7. Coatings:	
a. Prime:	One coat of the CSM's recommended dry film thickness.
b. Finish:	One or more coats of CSM's recommended dry film thickness per coat to the specified system thickness.

3.06 COATING SYSTEMS SCHEDULE (FINISH SCHEDULE)

A. General:

1. Specific coating systems, colors, and finishes for rooms, galleries, piping, equipment, and other items that are coated or have other architectural finishes are specified in the following coating system schedule. Unless otherwise specified in the coating system schedule, the word "interior" shall mean the inside of a building or structure, and the word "exterior" shall mean outside exposure to weather elements.
2. Piping System Schedules Section 40 05 02 1.01 C presents pipe marker background colors for specified process services.

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
A. General: All Surfaces not Specified by Area or Structure		
1. Structural Steel	Uncoated or E-2	
2. Equipment and Metal Appurtenances		
a. Equipment, non immersed, unless otherwise specified		
1) Indoors	E-1	FS 25051 Blue
2) Outdoors	EU-1	FS 20040 Brown

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
b. Equipment, immersed, unless otherwise specified	E-2	Beige
c. Existing equipment		
1) Not damaged nor modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Indoors	E-1 (see paragraph 3.02)	Match existing color
b) Outdoors	EU-1 without primer (see paragraph 3.02)	Match existing color
d. Existing diffusers and grilles		
1) Not damaged not modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Indoors	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
b) Outdoors	EU-1 without primer (see paragraph 3.02 Masonry Surfaces)	Match existing color
e. Electrical switchgear panels, unit substations, motor control centers, power transformers, distribution centers, and relay panels; indoors and outdoors	See paragraph 3.03 Electrical and Instrumentation Equipment and Materials	ANSI 61 Grey (outside) FS 27880 White (inside)
f. Instrumentation panels, graphic indicating panels, indicating and transmitting field panels, unless otherwise specified		
1) Indoors	See paragraph 3.03 Electrical and Instrumentation Equipment and Materials	FS 26306 Grey (outside) FS 27880 White (inside)
2) Outdoors	See paragraph 3.03 Electrical and Instrumentation Equipment and Materials	FS 27722 White (outside) FS 27880 White (inside)
g. Existing electrical and instrumentation panels		
1) Not damaged by work in this contract	Uncoated	--
2) Damaged or exposed to outside surfaces by work in this contract		
a) Indoors	E-1 (see paragraph 3.02 Masonry Surfaces)	FS 26306 Grey
b) Outdoors	EU-1 without primer (see paragraph 3.02 Masonry Surfaces)	FS 26306 Grey (Electrical) FS 27722 White (Instrumentation)
3. Conduit, Piping and Ductwork		
a. Ferrous, non-ferrous and galvanized piping, and appurtenant hangers and supports, non-immersed, unless otherwise specified.		
1) Indoors – noncorrosive	E-1	FS 25051 Blue
2) Outdoors – noncorrosive	EU-1	FS 20040 Brown

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
3) Indoors – in corrosive environment	EA-1	To be determined
4) Buried piping	M-1 or M-2	Not required
b. Ferrous piping, appurtenant and supports, immersed	E-2	To be determined
c. Conduit, outlet and junction boxes, lighting transformers, lighting, communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps, and supports on coated surfaces, unless otherwise specified.		
1) Indoors	E-1	Match background color
2) Outdoors	EU-1	Match background color
d. Conduit, outlets and junction boxes, lighting transformers, lighting, communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps and supports on uncoated surfaces, unless otherwise specified		
1) Indoors	E-1	FS 25051 Blue
2) Outdoors	EU-1	FS 20040 Brown
e. Existing conduit, outlet and junction boxes, lighting transformers, lighting communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps, and supports		
1) Not damaged nor modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Indoors	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
b) Outdoors	EU-1 without primer (see paragraph 3.02 Masonry Surfaces)	Match existing color
f. Racked conduits and cable trays	Uncoated	--
g. Insulated pipe jacketing	Uncoated	--
h. Plastic, fiberglass and flexible conduit and piping		
1) Unless otherwise specified	Uncoated	--
2) PVC and CPVC Piping	L-2	FS 25051 Blue
a) Exposed to direct sunlight	L-2	FS 25051 Blue
b) Not exposed to direct sunlight	E-7	FS 25051 Blue
i. Exposed ductwork, unless otherwise specified	Uncoated	--
4. Concrete, Grout, Masonry and Plaster		
a. Immersed tank and channel walls and bottoms unless otherwise specified	Uncoated	--
b. Walls and ceilings		
1) Precast concrete or colored masonry	Uncoated	--
2) Outdoors, unless otherwise specified	Uncoated	--
3) Indoors, unless otherwise specified	E-4	FS 23617 Beige
c. Concrete equipment bases unless otherwise specified	E-4	Match equipment color
5. Door and Door Frames		

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
a. Doors unless otherwise specified		
1) Ferrous metal		
a) Indoors	E-1	FS 20040 Brown
b) Outdoors	EU-1	FS 25051 Blue
2) Aluminum	Uncoated	--
3) Other	Plastic laminate	Formica 947 Brown
4) Existing		
a) Not damaged by work in this contract	Uncoated	--
b) Damaged, exposed, or modified by work in this contract		
(1) Indoors	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
(2) Outdoors	EU-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
b. Door frames unless otherwise specified		
1) Adjacent wall coated		
a) Indoors	E-1	Match wall color
b) Outdoors	EU-1	Match wall color
2) Adjacent wall uncoated		
a) Indoors	E-1	FS 20040 Brown
b) Outdoors	EU-1	FS 25051 Blue
3) Aluminum	Uncoated	--
4) Existing		
a) Not damaged by work in this contract	Uncoated	--
b) Damaged, exposed, or modified by work in this contract		
(1) Indoors	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
(2) Outdoors	EU-1 without primer (see paragraph 3.02 Masonry Surfaces)	Match existing color
6. Handrails, Gratings, Floor Plates, Manhole Covers, and Hatches		
a. Unless otherwise specified	Uncoated	
b. Existing		
1) Not damaged by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Indoors	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
b) Outdoors	EU-1 without primer (see paragraph 3.02 Masonry Surfaces)	Match existing color

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
7. Metal Stairs, Ladders, Platforms, and Supports Except Tread and Grating		
a. Indoors	E-1	FS 25051 Blue
b. Outdoors	EU-1	FS 20040 Brown
c. Existing		
1) Not damaged nor modified by work in this contract	Uncoated	--
2) Damaged, exposed, or modified by work in this contract		
a) Indoors	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color
b) Outdoors	EU-1 without primer (see paragraph 3.02 Masonry Surfaces)	Match existing color
8. Aluminum Flashing, Light Standards, Supports, and Louvers		
a. Indoors and outdoors, unless otherwise specified	Uncoated	--
9. Precast Concrete Metalwork		
a. Fasteners, anchors, supports, etc.	EU-1	Match wall
10. Other		
a. Stainless steel slide gates	Uncoated	--
b. Pipe, ductwork, equipment and appurtenances made from fiberglass, plastic, rubber, including flexible hose, conduit, and plastic coated tubing, in areas not exposed to view (indoors) (metal hangers and supports are coated with E-1)	Uncoated	--
c. Buried, sleeve-type and flanged pipe, couplings, valves, mechanical and electrical penetrations	M-1 or M-2	Manufacturer's color
B. Wet Well		
1. Piping and appurtenant hangers and supports above max. water level elevation 73.5-feet.	EA-1	--
2. Piping and appurtenance hangars and supports below max. water level elevation 73.5-feet.	E-2	--
3. Walls and ceiling	EA-3	--

Note: Owner will select color from coating manufacturer's list of EPA approved colors for potable water.

3.07 INSPECTION AND TESTING BY OWNER

A. General:

1. Inspection by the Owner or others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Inspection by the Owner is in addition to any inspection required to be performed by the Contractor.
2. The Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section 09 90 00. These inspections may include the following:
   a. Inspect materials upon receipt to ensure that are supplied by the CSM.

b. Inspect to verify that specified storage conditions for the coating system materials, solvents and abrasives are provided.
c. Inspect and record findings for the degree of cleanliness of substrates.
d. Inspect and record the pH of concrete and metal substrates.
e. Inspect and record substrate profile (anchor pattern)
f. Measure and record ambient air and substrate temperature.
g. Measure and record relative humidity.
h. Check for the presence of substrate moisture in the concrete.
i. Inspect to verify that correct mixing of coating system materials is performed in accordance with CSM's instructions.
j. Inspect, confirm, and record that the "pot life" of coating system materials is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
k. Perform adhesion testing.
l. Measure and record the thickness of the coating system.
m. Inspect to verify proper curing of the coating system in accordance with the CSM's instructions.
n. Perform holiday or continuity testing for coatings that will be immersed or coatings that will be exposed to aggressively corrosive conditions.

3.08 FINAL INSPECTION

A. General
1. Contractor shall conduct a final inspection to determine whether coating system work meets the requirements of the specifications.
2. The Construction Manager will subsequently conduct a final inspection with the Contractor to determine the work is in conformance with requirements of the contract documents.
3. Any rework required shall be marked. Such areas shall be recleaned and repaired as specified at no additional cost to the Owner.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 00 00

HEATING, VENTILATING, AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

PART 1 GENERAL

1.00 GENERAL PROVISIONS REQUIRED

A. A filed sub-bid shall be submitted for the entire HVAC work shall include the complete work specified in all of the following sections plus the HVAC drawings.

   a. 23 05 93 Testing Adjusting Balancing HVAC
   b. 23 09 00 HVAC Instrumentation Control Performance
   c. 23 82 00 Heating Units
   d. 23 31 13 Metal Ducts
   e. 23 34 16.26 Centrifugal In-Line HVAC Fans
   f. 23 34 16.33 Centrifugal HVAC Wall Exhaust Fans
   g. 23 37 13.13 Diffusers, Registers and Grilles

B. The instructions to Bidders, Bid Form, Agreement, General Conditions and complete specifications are hereby made a part of these Specifications and Subcontractor shall consult them in detail for instructions.

C. Sub bids for the work under this section of the specification must be filed under the appropriate item as provided in Division 0 of these specifications

D. For additional work the HVAC Contractor (i.e. – spec # 23 00 00) shall completely review all of the related project contract drawings.

E. In accordance with Massachusetts General Laws, Chapter 149, Sections 44F, as amended. the engineer hereby declares that all work of this Section shall be estimated under the appropriate item.

1.01 SUMMARY

A. Scope: This Section specifies the general requirements for all of the HVAC materials, labor, tools, permits, incidentals, and other services included in Division 23 and elsewhere wherever specifically mentioned in the Specifications.
   1. Piping, pipe supports, valves, and accessories which are not an integral part of the equipment or are not specified herein are covered in other sections.
   2. Ductwork shall be per Section 23 31 13.

B. Environmental Conditions: See Section: 01 11 80

C. Fasteners: unless indicated otherwise.
   1. Bolts - ASTM A193, grade B8M Class 1 or ASTM A320 B8M Class 1
   2. Nuts – ASTM A194, grade 8M
   3. Washer – 316 SS

D. Governing Standards:
   1. Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance the more stringent requirements shall govern.
   2. All work shall comply with UL safety requirements.

E. Suitable connections shall be provided for each fixture, piece of equipment, and appurtenance.

F. Coordinate with other trades (e.g., Plumbing, Fire Protection, Structural) for routing of equipment and connection points

G. Power Supply:
   1. Power supply to equipment with motors shall be as indicated by manufacturer. Power supply for controls shall be 120 volts, 60 Hz, single phase unless otherwise required for a properly operating system.

H. Metal Thickness:
   1. Metal thickness and gages specified herein are minimum requirements. Gages refer to US Standard gage.

1.02 DEFINITIONS

A. Terminology used in this specification conforms to the following definitions:
   1. Authorities Having Jurisdiction: Indicates reviewing authorities, including local building official, local fire marshal, Owner, and other reviewing entity whose approval is required to obtain system acceptance.
   2. ACH: Air changes per hour.
   3. SCFM: Standard cubic feet per minute.
   4. ACFM: Actual cubic feet per minute
   5. Ft^2: Square foot.
   6. TAB: Testing and Balancing.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00.
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and therefore requested by the Manufacturer, underline each deviation and denote by a number in the margin to the right of the identified paragraph. Provide a detailed, written justification for each deviation. The Owner Representatives shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Failure to include a copy of the marked-up specification sections,

along with justification(s) for requested deviations with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration

B. Action Submittal Items for this Section:
   1. A copy specification section, with addendum updates included and each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   2. If the specification includes the submittal item, revise the text of the submittal item to conform to the phrasing listed in the specifications.
   3. Manufacturer's data including materials of construction, construction details of equipment, wiring diagrams, weight of equipment, mounting, seismic bracing, and support.
   4. Drawings showing general dimensions and confirming the size of equipment, fixtures, motors and drives, and piping connections. (Shop drawings)
   5. Performance curves for pumps and fans developed for the specific application. Performance curves shall show speed, capacity, pressure, and power for specified conditions.
   6. Shop and field painting systems. Include manufacturer's descriptive technical catalog literature and specifications.
   7. Shop Drawings including the physical characteristics of all systems, equipment, and piping layout plans, and control wiring diagrams.
   8. Operation and Maintenance Information: Section 01 78 23.
   9. Samples, where required by the specification section.
   10. Rigid Equipment Mount Installation Checklist (Form 46 05 29-A).
   11. See Division 23 specifications sections for additional requirements.
   12. Certificates of Unit Responsibility.
   13. Sound Power rating for both fan inlet and outlets at rated capacity.
   14. Installation forms in accordance with Section 43 05 11.
   15. Testing and Commissioning forms in accordance with Sections 23 05 93.

C. Informational Submittal for this Section:
   1. Structural Design and Anchorage: Section 01 73 24.

D. Operations and Maintenance Data and Manuals:
   1. Adequate operation and maintenance information shall be supplied as required in the Submittals section and Equipment Operating and Maintenance
   2. Manual Information section: Operation and maintenance manuals shall be submitted in accordance with the Submittals section and Equipment Operating and Maintenance Manual Information section.

E. Drawings and Data:
   1. The data and specifications for each unit shall include, but shall not be limited to, the following:
      a. Makeup Air Units
         1) Name of manufacturer.
         2) Type and model.

3) Construction materials, thickness, and finishes.
4) Input and output heating capacities.
5) Filter velocities.
6) Overall dimensions and required clearances.
7) Net weight and load distribution.
8) Performance curves with the specified operating point clearly identified for each unit, type, and model, with capacity in SCFM as the abscissa and brake horsepower, total static pressure, and efficiency as the ordinate. The fan curves shall include a family of curves for at least 5 different rotational speeds on a single chart.
9) Certified AMCA standard test code sound power output data for the fan outlet and casing when operating at the specified volume flow rate. Sound data shall list dB re 10-12 watts in each octave band, with midrange frequencies starting at 63 Hz and ending at 8,000 Hz.
10) Multiline wiring diagrams clearly indicating factory installed and field installed wiring with all terminals identified.
11) Electrical requirements including voltage, number of phases, and amperage.
12) Where specified, information on equipment manufacturers' representatives.

b. Fans:
1) Name of manufacturer.
2) Type and model.
3) Construction materials, thickness, and finishes.
4) Overall dimensions and required clearances.
5) Net weight and load distribution.
6) Performance curves with the specified operating point clearly identified for each unit, type, and model, with capacity in SCFM as the abscissa and brake horsepower, total static pressure, and efficiency as the ordinate. The fan curves shall include a family of curves for at least 3 different rotative speeds on a single chart.
7) Certified AMCA standard test code sound power output data for the fan outlet and casing when operating at the specified volume flow rate. Sound data shall list dB re 10-12 watts in each octave band, with midrange frequencies starting at 63 Hz and ending at 8,000 Hz.
8) Where specified, information on equipment manufacturers' representatives.

c. Equipment (all other types):
1) Name of manufacturer.
2) Type and model.
3) Construction materials, thickness, and finishes.
4) Manufacturer's performance data.
5) Overall dimensions and required clearances.
6) Net weight and load distribution.
7) Wiring diagrams.

d. Ductwork:

1) Duct fabrication drawings indicating dimensions of individual shop and field fabricated sections, top and/or bottom duct elevations, joint locations, and dimensions of duct from walls or column rows.
2) Pressure and seal classifications.
3) Reinforcement types and spacing.
4) Joint and seam types.
5) Hanger and support types, spacing, and attachment methods.
6) Access panel and door construction, sizes, and locations.
7) Duct sealant, adhesive, gasket, and tape information.
8) Product data for adhesives and sealants shall include VOC content.
9) Coatings.
10) Ductwork materials and thicknesses.
11) Coils
12) Product data demonstrating compliance with ASHRAE 90.1
13) Ductwork leakage test report.

e. Temperature controls:
1) Published descriptive data on each item of equipment and accessories, indicating all specific characteristics and options and identified with the designation used herein and on the Drawings.
2) Schematic control diagrams giving specific data on all settings, ranges, actions, adjustments, and normal positions. Although schematic, these diagrams shall, as closely as possible, represent the actual system with all significant equipment and devices identified and located relative to each other. These diagrams shall also show detailed multiline wiring with all terminals accurately identified. The wiring diagrams shall show the internal connections of the temperature control panels and all field wiring to equipment remote from the control panels, including wiring to Owner-furnished equipment. The wiring diagrams shall be complete, showing all connections necessary to place the temperature control systems in operation. Wiring diagrams shall be detailed to the degree necessary for field construction and shall include all related wiring.
3) Sequence of operation for each system corresponding to the control schematics.
4) Detailed panel construction drawings, including description of all materials and finishes, complete internal wiring and piping schematics, panel face layout, and complete data on all mounted components.
5) Space thermostat schedule indicating the types of covers and means of adjustment for each space.
6) Conduit and wire types.
7) Where specified, information on equipment manufacturers' representatives.

f. Seismic Design Requirements:
1) Confirmation of compliance with the requirements of the Special Provisions section.

g. Operation and Maintenance Data and Manuals:
1) Adequate operation and maintenance information shall be supplied as required in Section 01 78 23 and Section 01 33 00. Operation and

maintenance manuals shall be submitted in accordance with Section 01 33 00. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the rules and regulations of Authorities Having Jurisdiction over the work specified herein, including all adopted state and local building codes including plumbing, mechanical, fire, building, and electrical.

B. Welding Qualifications:
   1. All welding procedures and welding operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of AWS or ASME Standard Qualification Procedures.
   2. All procedure and operator qualifications shall be in written form and subject to Engineer review.
   3. Accurate records of operator and procedure qualifications shall be maintained by Supplier and made available to Engineer upon request.
   4. The mechanical system installer shall be licensed as stipulated by the authority having jurisdiction.

C. Manufacturers Experience: Unless the equipment manufacturer is specifically named in this Section, the manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years.

D. Reference Standards:
   1. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
   2. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
AABC	Associated Air Balance Council, National Standards for Total System Balance
ADA	Americans with Disabilities Act
AHRI	Air-Conditioning Heating & Refrigeration Institute
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASSE	American Society of Sanitary Engineering
ASTM	ASTM International

Reference	Title
AWWA	American Water Works Association
CISPI	Cast Iron Soil Pipe Institute
CSA	CSA International
ETL	Electrical Testing Laboratories
EPA	Environmental Protection Agency
FDA	Food & Drug Administration
FM	Factory Mutual Global
IAPMO	International Association of Plumbing and Mechanical Officials
HI	Hydraulic Institute Standards
ISO	International Organization for Standardization
MSS	Manufacturers Standardization Society
NEBB	National Environmental Balancing Bureau, Procedural Standards for Testing Adjusting and Balancing of Environmental Systems
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Administration
SMACNA	Sheet Metal and Air Conditioning Subcontractors' National Association, Inc.
UL	Underwriters Laboratories Inc.
IBC	International Building Code
IFC	International Fire Code
IMC	International Mechanical Code
IPC	International Plumbing Code
UPC	Uniform Plumbing Code
UL 1995	Heating and Cooling Equipment

E. Unit Responsibility:

1. The Supplier shall furnish and install equipment assemblies made up of two or more components to be provided as a working unit by the unit responsibility manufacturer, where specified. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement. The requirement for unit responsibility shall in no way relieve the Supplier of his responsibility to the Owner's Representative and Owner for performance of all systems in the contracted scope of supply.
2. The Supplier shall ensure that all equipment assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility

manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Supplier to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, form and style of Form 43 05 11-C specified in Section 01 99 90, shall be signed by an officer of the unit responsibility manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.

3. Complete assembly and installation drawings, and wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with Section 01 33 00 - Submittal Procedures. Device tag numbers indicated on the Drawings shall be referenced on the wiring and schematic diagrams where applicable.

F. Manufacturer’s Instructions:
   1. Follow manufacturer's written instructions.
   2. If in conflict with Construction Documents, obtain clarification.
   3. Notify the Owner’s Representative in writing before starting work.

G. Drawings:
   1. The Drawings shall be taken as diagrammatic, unless otherwise noted.
   2. Size of ductwork and pipes and general method of running them are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

1.05 DELIVERY, STORAGE AND HANDLING

A. Shipping, handling and storage shall be in accordance with the Delivery, Storage, and Handling section.

1.06 COORDINATION

A. Supplier shall verify that each component of the HVAC system is compatible with all other parts of the system; that all piping, ductwork, equipment, and appurtenances are appropriate; and that all devices necessary for a properly functioning system have been provided.

B. Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

C. Each manufacturer shall have a local service center, or with written consent of Engineer, shall be able to provide service from other locations within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply.

D. Information on equipment manufacturers' representatives shall be included with the submittals.

E. The equipment as shown on the plans and specified herein, is based on the equipment furnished by one manufacturer. An equipment which is offered as a substitute to the specific requirements of these Specifications, and which differs in detail and arrangement from that shown may require changes in design and construction. All costs which result from such changes in design and construction are to be borne entirely and unconditionally by the Subcontractor and/or the manufacturer; said costs to include but not be limited to structural, piping, mechanical and electrical changes and all engineering costs incurred as a result of the substitution, in the revision of Plans and Specifications, review of design changes by others, preparation of change orders, and any other costs directly resulting from said substitution.

1.07 APPURTENANCES

A. Furnish and install all necessary guides, inserts, anchors and assembly bolts, washers and nuts, hangers, supports, gaskets, couplings, and flanges; and all other appurtenant items shown on the Drawings, specified, or required for the proper installation and operation of the piping; devices included in or on the piping equipment; and piping accessories.

PART 2 PRODUCTS

2.01 SERVICE CONDITIONS

A. All equipment shall be designed and selected to meet the specified conditions.

2.02 MANUFACTURERS AND FABRICATION

A. Provide like items from one manufacturer, including but not limited to: fans, air handlers, air conditioning units, heat pump units, heaters, vibration isolation devices, etc.

B. Unless the equipment manufacturer is specifically named in this section, the manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years.

C. Anchor Bolts and Expansion Anchors: Section 05 05 20.
   1. Anchor Bolts and Expansion Anchors. Anchor bolts, expansion anchors, nuts, and washers shall be designed for lateral forces for both pullout and shear in accordance with the provisions of Section 05 05 20. Unless otherwise stated in the individual equipment specifications, anchor bolt, washer and nut materials shall conform to the requirements above with the provisions of Section 05 05 20 unless otherwise indicated on the Drawings.

2.03 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers shall be as listed in the respective product description paragraphs.

2.04 PERFORMANCE REQUIREMENTS

A. See Section 43 05 11.

B. All air moving equipment fans shall be sized such that the correct SFCM is the output ACFM at the hottest, most humid condition with enough horsepower for the coldest inlet temperature. All controls shall have a temperature reset based on the outside temperature adjusting for the proper SCFM or ACH.

C. Coordination:
   1. Subcontractor shall verify that each component of the system is compatible with all other parts of the system; that all piping, ductwork, materials, fans, and motor sizes are appropriate; and that all devices necessary for a properly functioning system have been provided.
   2. Where individual equipment paragraphs specify the requirement for local service, each manufacturer shall have a local service center, or with written consent of Owner's Representative, shall be able to provide service from other locations within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply. Information on equipment manufacturers' representatives shall be included with the submittals.
   3. Where several manufacturers' names have been listed in this section as possible suppliers, only the products of the first manufacturer listed have been checked for size, functions, and features.
   4. The independent TAB agency shall be contracted prior to construction to do "balancability reports". The TAB agency shall perform periodic site walk throughs to identify items prior to testing. These include but are not limited to finding located or missing dampers and valves, variable air volume (VAV) box sizing, piping issues, duct sealing, and issues with building pressures.
   5. Prior to official cleaning, testing, adjusting, and balancing, the mechanical subcontractor shall pre-test each section prior to any air balance agency testing, inspector witnessing, mechanical engineer witnessing, duct insulation installation, duct shafts are closed up, or any other structural construction that will have an impact is continued. Return air ducts and exhaust may be tested with positive pressure.
   6. Equipment bearings shall be lubricated in accordance with the manufacturer's recommendations.
   7. Mechanical subcontractor is responsible for coordinating with the project air balance agency.
   8. For additional TABB coordination requirements consult Division 23 and the following Specifications:
      a. Testing Adjusting and Balancing for HVAC: Specification 23 05 93.
      b. Sheetmetal Ductwork and Accessories: Section 23 31 13.
      c. Other ductwork as required
   9. Air systems shall be complete and operating, with dampers, filters, ductwork, air outlet and inlet devices, duct-mounted equipment, and control components.

D. General Equipment Stipulations:
   1. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the Special Provisions section, the requirements specified herein shall take precedence.
   2. Unless otherwise noted, all equipment handling air shall meet the duct seal and leakage classes per Section 23 31 13. Manufacturer shall provide test data confirming cabinet construction can meet the requirement

E. Seismic Design Requirements: Seismic design requirements for products specified herein shall be as indicated in the Section 01 73 24.

F. Design Criteria:
   1. Design of HVAC equipment shall be based on the atmospheric conditions at the project site. Temperature, humidity, prevailing wind speed and direction, elevation, corrosive or contaminated environments, and human comfort shall be considered, as applicable.
   2. Equipment sizing shall be based on Environmental Conditions: See Section 01 11 80

G. Dimensional Restrictions:
   1. Layout dimensions will vary between manufacturers. At least 3 feet of clear access space shall be provided on all sides of the unit
   2. Equipment shall be designed to operate at the elevation indicated ENVIROMENTAL CONDITIONS: See Section: 01 11 80. All equipment furnished for sites above 2000 feet above sea level shall be properly derated to operate and meet the specified capacities at the site conditions.

H. Type, Performance, Characteristics, Arrangement, Accessories: As noted in the Division 23 specification sections.

I. Fans and Shafts:
   1. Statically and dynamically balanced per AMCA 204 fan application category BV-3 (ISO 1940 Grade 6.3) or better and designed for continuous operation at maximum rated fan speed and motor horsepower.
   2. Each fan's operating selection point on the fan curves shall be selected to the right of the peak pressure/efficiency point and below the lowest point along the fan curve to the left of the peak pressure/efficiency point.
   3. For additional requirements see Section 23 34 16.26 and 23 34 16.33.

J. Electric Motor General Requirements:
   1. Designed for continuous operation in 40°C environment.
   2. For temperature rise in accordance with NEMA MG-1 limits for insulation class, service factor, and motor enclosure type.
   3. Type specified, scheduled, or noted for respective units.
   4. The use of ECM motors on HVAC equipment, up to 10 HP is acceptable with engineering concurrence. Coordinate with engineer

K. V-Belt Drives: 1.4 minimum service factor, fixed or adjustable type depending on motor horsepower and specifications for respective unit, generally as follows:
   1. 15 HP and under: Variable and adjustable pitch sheaves, selected so required rpm is obtained with sheaves set at mid-position.
   2. 20 HP and over: Fixed sheave, matched belts, rated as recommended by manufacturer or minimum 1.5 times nameplate rating of motor.
   3. Sheaves: Cast iron or steel, dynamically balanced, keyed to shaft.
   4. Belts: Oil-resistant, non-sparking, and non-static.
   5. Belt guard:
      a. Provide for all belt drives not enclosed in fan housing.
      b. Fabricated from diamond mesh expanded metal or sheet stock.
      c. Welded assembly with frame and mounting brackets.
      d. With provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
      e. Secured to fan or fan support without short-circuiting vibration isolation.
      f. Meet OSHA requirements.

L. Provide ductwork and equipment supports, hangers, guides, and anchors as specified herein.

M. When standard hangers, supports, and accessories are not adequate the Subcontractor shall employ a registered Structural Engineer, registered in the state where the work is to be installed, to prepare design calculations for all such supports, hangers, and accessories for seismic restraint needed for the ductwork and equipment installation. Calculations and shop drawings shall be signed by the above-named engineer and submitted to the Owner's Representative.

N. Special Features for Hazardous Environments:
   1. Provide for particular units when noted or scheduled on Drawings, spark proof fan wheels and explosion proof motors.

2.05 MATERIALS

A. Base contract upon furnishing materials as specified.

B. Materials, equipment, and fixtures used for construction are to be new, latest products as listed in manufacturer's printed catalog data and are to be UL, ETL, or CSA approved, or have adequate approval or be acceptable the Authorities Having Jurisdiction.

C. Articles, fixtures, and equipment of a kind to be standard product of one manufacturer.

D. Gas piping shall be A53 Grade B seamless or A106 Grade B.

2.06 COATINGS

A. Surface Preparation:
   1. All fabricated surfaces from ferrous metal, except motors and speed reducers, shall be shop cleaned by sandblasting or equivalent, in strict conformance with the paint manufacturer's recommendations.

2. All mill scale, rust, and contaminants shall be removed before shop primer is applied.

B. Coatings shall be electrostatically coated (e-coat) and uniformly applied. The electro-coat process shall ensure complete encapsulation of all conductive surfaces with uniform dry film thickness. After e-coat cure, equipment shall receive a spray-applied, polyurethane black topcoat to prevent UV degradation of epoxy e-coat film. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

C. Submit product data on the type coating selected, the coating thickness, the application process used to meet the requirements below and verification of conformance with the salt spray test requirement.
1. Surface finish damaged during installation shall be repaired to the satisfaction of Engineer.

D. Coils/HX exposed to ambient
1. No material bridging is allowed, including enhanced and micro-channel fin designs
2. Submit the estimated heat transfer loss of the coil. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation

E-Coating Requirements

Coating Quality	Test Procedure	Coating Performance (Nominal plus)
Dry Film Thickness	ASTM D7091	1 mil
Water Immersion	ASTM D870	1000 hrs
Cross Hatch Adhesion	ASTM B3359	4B-5B Rating
Salt Spray	ASTM B117 ASTM B117-G85	6000 hrs 2000 hrs
Heat Transfer Reduction (Coils Only)	AHRI 410	<1%
Humidity	ASTM D1735	1000
Operating pH Range	N/A	3-12
Temperature		-40 F to 300 F (Coils Only) See 01 11 80
Weathering (topcoat)	ASTM 4587	2200

2.07 COLOR

A. Equipment shall have the manufacturer's standard color unless otherwise indicated in the schedules or specifications.

B. Equipment may use the manufacturer's finish if it meets the criteria above or otherwise indicated in the schedules or individual specifications.

2.08 ELECTRICAL

A. Electrical controls and disconnects shall be furnished and installed under the Electrical section, except where specified herein.

B. All electrical controls shall have enclosures suitable for the environment and NEMA rating as indicated on the electrical Drawings.

C. See Section 23 09 00 and 40 67 00 for controls and control panel requirements.

2.09 PIPING ACCESSORIES

A. General: Final pressure gauge and thermometer ranges shall be between 1.1 and 1.3 times the system operating conditions. Shut off if testing pressure exceeds the gauge range during testing.

B. Thermometers:
   1. Section 40 05 06.33: If not in the bid set, use the following:
      a. Thermometers shall conform to ASTM E1. Mercury shall not be used in thermometers.
      b. Thermometers shall be Weksler Instruments "Adjust Angle", Ashcroft "Series EI Everyangle" or Weiss Instruments, Inc. “Vari angle”.
      c. Thermometers shall be bimetal type and shall have a dial at least 4 1/2-inch diameter, with black markings on a white background. Pointer travel shall span not less than 200 degrees nor more than 270 degrees. Each thermometer shall have a stainless-steel case, bezel, fittings, and stem and shall be hermetically sealed, with external pointer adjustment and an acrylic or shatterproof glass window.
      d. Each indicator shall be furnished with an angularly adjustable frame for convenient viewing. Unless otherwise indicated, thermometer range shall be 0 to 200°F.
      e. Each thermometer shall be furnished with a stainless steel thermowell for installation in the piping systems. The thermowells shall have ¾-inch NPT thread mounts, a minimum pressure rating of 250 psig, and a nominal 4-inch insertion length.

C. Pressure Gauges:
   1. Section 40 05 06.33. If not in the bid set, use the following:
      a. Pressure gauges shall be Ashcroft "Duragauge 1279", Weksler, or Weiss Instruments, Inc.
      b. Except as modified or supplemented herein, all gauges shall conform to the requirements of ANSI B40.1 and ASME B40.100. Accuracy shall be ANSI Grade A or better.
      c. Gauges shall be indicating dial type with C type phosphor bronze Bourdon tube, stainless steel rotary geared movement, phenolic open-front turret, stainless steel or phenolic ring, case, adjustable pointer, and acrylic or shatterproof glass window.
      d. The dial shall be 4 1/2 inch in diameter with black markings on a white background. The units of measurement shall be psi and shall be indicated on the

dial face. The pointer shall span not less than 200 degrees nor more than 270 degrees. The range shall be selected so that the normal operating reading is near the midpoint of the scale.

e. Each gauge shall be provided with a threaded end ball-type shutoff valve as specified in the Ball Valves section.

f. All stem-mounted gauges shall be provided with 1/2 inch NPT connections.

D. Diaphragm Seals:

1. Pipe-mounted diaphragm seals shall be provided where indicated on the Drawings.
2. Diaphragm seals shall be thread-attached type with cleanout ANSI Type 316 stainless steel diaphragm, plated carbon steel upper housing, and stainless steel lower housing.
3. The diaphragm seal shall be of "continuous" design to safely contain the process fluid in the event of gauge failure or removal from the system under pressure.
4. The lower housing shall be provided with a tapped ¼ inch [6.3 mm] NPT flushing connection and an MxF stainless steel needle valve.
5. Each gauge isolator and the gauge served shall be factory assembled, filled with a suitable fluid, and calibrated as a unit.
6. Gauge isolators shall be as manufactured by Ashcroft "Type 101", Weksler, or Weiss Instruments, Inc.

E. Flow Meters: Section 40 71 00.

F. Pressure Switches and Transmitters: Section 40 73 00.

G. Temperatures Switches and Transmitters:

1. Installation: Temperature switches and transmitters installed in accordance with the manufacturer's instructions and to the specified requirements with Union couplers provided.
2. Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
3. For installations with less than a 4-inch diameter, temperature elements installed an elbow where possible. Where an elbow is not available, a wye fitting installed in the process piping for installation of the temperature element at a 45-degree angle with the flow.
4. Temperature switch assembly shall utilize class 2 filled thermal element connected by a capillary tube.
5. Temperature switch performance shall not be altered by bulb exposure to the specified over-range temperature.
6. Contact outputs used for alarm actuation shall be normally closed or normally open as required by the process condition; open to initiate an alarm or close to start the necessary equipment.

7. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
8. Switch electrical enclosures rated at NEMA 250, Type 4 minimum.
9. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers.
10. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.
11. Transmitter enclosures shall be rated NEMA 250, Type 4 unless otherwise specified.
12. Transmitter output shall increase with increasing measurement.

2.10 ACCESS PANELS/DOORS

A. General: Provide flush mounting access panels as required for service of valves, drains, and test connections and other Item requiring maintenance or inspection. Where access panels are located in fire-rated assemblies of building, rate access panels accordingly. Ceiling access panels to be minimum 24-inch x 24-inch or required and approved size. Wall access panels to be minimum 12-inch x 12-inch or required and approved size. Babcock-Davis Series BN (non-rated), BI series (rated) or equal. All panels/doors shall incorporate doors/access panels with air seals suitable to provide airtight seal shall be provided between door and frame. The door swing shall be such as to open against system pressures.

2.11 AIR FILTRATION

A. General: Air filters in air handlers shall be 2 inch thick, MERV 8, pleated, disposable filters unless noted otherwise in Division 23 sections.

2.12 ROOF CURBS: FOR ROOF MOUNTED FANS AND AIR CONDITIONER UNITS

A. Each unit shall be provided with a prefabricated mounting curb.

B. AHRI Guideline B except as modified below
   1. 1997 version Table 1
      a. Up to 24 inch width shall be 16 inch above roof surface
      b. 49 inch to 60 inch Width shall be 30 inches
      c. See details in guide

C. Comply with local code requirements for minimum curb height, but in no case shall curb height be less than 16 inches, as measured from top of bar joist to top of curb, nor shall curb height be less than 8 inches as measured from top of roof membrane to top of curb. Roof curb to be manufactured of prime galvanized steel construction, 14 gauge as required, meeting ASTM A653/653M, with fully welded corners and with seams joined by continuous water and airtight welds. Roof curb shall be internally reinforced with angles 48 inch on center and factory installed wood nailer. Top of all roof curbs shall be level, with pitch built into curb when deck slopes. 2 inch by 4 inch (nominal dimension) pressure treated continuous wood nailers mechanically fastened with corrosion resistant fasteners at 12 inches on center to exterior face of curb. Shop prime welded connections with zinc-rich paint complying with SSPC-Paint 20. Label curbs with "INTAKE" designating

to align with the intake of the equipment. Fans shall be labeled “FRONT” to designate where the equipment nameplate coincides. Frame duct openings with 18 gauge curb sections level with perimeter curb sections, minimum height 18 inches.

D. The outer shell of the curb shall be formed with an integral cant strip and mounting flange. The bottom of the curb shall have a baseplate which encloses the lower edge of the roof insulation. A damper holding tray shall be provided. Provide curb for flat, pitched or ridged roof as required.

E. Coating per Section 09 90 00.

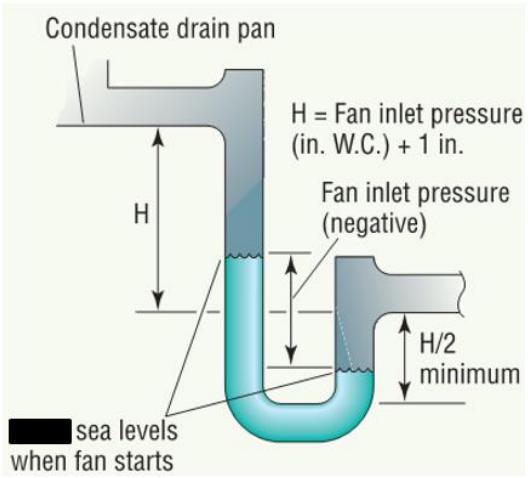
F. Insulate interior of the curb with 2 inches of 1.5-lb/cu ft neoprene-coated fiberglass insulation.

G. Provide seismic restraints to secure the unit to the curb in accordance with Section 01 73 24.

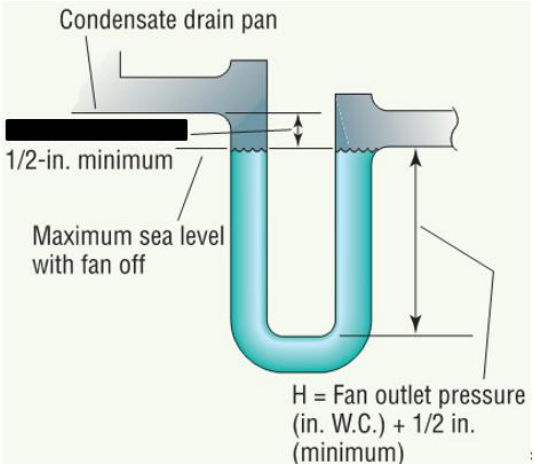
2.13 CONDENSATE DRAINS

A. Subcontractor to confirm that pad elevation is tall enough to meet the following minimum criteria with the equipment point of connection. Immediately contact the engineer if not.

B. Draw through unit



C. Blow Through unit



PART 3 EXECUTION

3.01 INSTALLATION

A. Equipment Mounting:
   1. Procedures: Section 43 05 11
      a. Install equipment for the Equipment Mounting Systems specified in Division 23 and in accordance with the Equipment Mounting Schedule specified in Section 43 05 11.
   2. Install equipment requiring access (i.e., drain pans, drains, control operators, valves, motors, cleanouts, and water heaters) so that they may be serviced, reset, replaced, or recalibrated. Do not install equipment in obvious passageways, doorways, scuttles, or crawlspaces which would impede or block intended usage.
   3. Install equipment and fixtures in accordance with manufacturer's installation instructions
      a. Maintain manufacturer's recommended clearances.
      b. Install plumb, level, and firmly anchored to vibration isolators per manufacturer’s requirements.
      c. Obtain installation instructions from manufacturer prior to rough-in of equipment and examine instructions thoroughly.
      d. When requirements of installation instructions conflict with Construction Documents, request clarification from the Engineer prior to proceeding with installation. This includes proper installation methods, sequencing, and coordination with other trades and disciplines
   4. Furnish and install all supports, bracing and blocking required for the proper installation of the work specified.
   5. Furnish and install miscellaneous supports/metal required for installation of equipment, ductwork, piping, and vents

B. Piping and Equipment Identification: Divisions 33, 40, and 43.

C. Piping and Valves:
   1. Coordinate work to account for expansion and contraction of piping materials and building as well as anticipated settlement or shrinkage of building. Install work to prevent damage to piping, equipment, and building and its contents. Provide piping offsets, loops, expansion joints, sleeves, anchors, or other means to control pipe movement and minimize forces on piping. Verify anticipated settlement and/or shrinkage of building. Verify construction phasing, type of building construction products, and rating for coordinating installation of piping systems.
   2. Include provisions for servicing and removal of equipment without dismantling piping.
   3. Provide unions, couplings, or flanges where equipment is installed in piping. Unions shall be dielectric unions or couplings at points of connection of ferrous to non-ferrous metal piping, unions, couplings, or flanges shall by dielectric type.
   4. Provide a shut-off stop valve in the branch of every water, air, gas, or vacuum pipe service upstream of every fixture or outlet.
   5. Except for condensate drains, provide valves where equipment drain connections are furnished and carry the discharge pipe to the nearest floor drain, drain trench, or sump. Where no receptacle for drain exists, install drain piping to 1-inch above the floor. Drain piping and valve materials shall conform to the requirements of the system served.
   6. Install escutcheons secured to pipe with set-screw where pipes or tubing pass through exposed walls or ceilings.

D. See the Division 23 specifications sections for additional requirements.

E. In plenums, provide plenum rated materials that meet the requirements to be installed in plenums. Immediately notify the Owner's Representative of discrepancy.

F. Where equipment motors are to be electrically interlocked with other equipment for simultaneous operation, utilize equipment wiring diagrams to coordinate with electrical systems so that proper wiring of equipment involved is affected.

3.02 COATINGS

A. Per this specification and Section 09 90 00.

3.03 CLEANING

A. Prestartup Requirements: Section 01 74 23. If not in the bid set, use the following as a minimum
   1. Prior to testing, thoroughly clean the inside of each completed piping system of all dirt, loose scale, sand, and other foreign material.
   2. Cleaning shall be by sweeping, flushing with water or blowing with compressed air, as appropriate for the size and type of pipe.
   3. Flushing shall achieve a velocity of at least 3 feet per second.
   4. The subcontractor shall install temporary strainers, temporarily disconnect equipment, or take other appropriate measures to protect equipment while cleaning piping.

B. Post Startup Requirements:
   1. At the completion of the testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired by Subcontractor at no additional cost to Owner.
   2. Upon completion of the duct system cleaning, the duct system shall be visually inspected for cleanliness to verify no visible contaminants are present to the satisfaction of Owner's Representative.
   3. If the visual inspection is inconclusive, then additional tests in accordance with the National Air Duct Cleaners Association shall be performed. Any ducts that are considered not to be clean by the Owner's Representative shall be re-cleaned and re-tested. Any damaged materials or surfaces shall be repaired or replaced.
   4. A report shall be provided indicating the successful cleaning of the ductwork, method used to determine the cleanliness, and results of any tests is required.

3.04 STARTUP REQUIREMENTS

A. System equipment shall be subject to preliminary field tests as indicated in Equipment Startup and Checkout section

3.05 FIELD TESTING AND INSPECTIONS

A. Test all HVAC systems and arrange for inspection by the Authorities Having Jurisdiction.

B. General:
   1. Furnish all equipment, material, personnel, and supplies to perform the tests and make all taps and other necessary temporary connections.
   2. Field performance tests shall be conducted for each system to demonstrate each is functioning as specified and to the satisfaction of Owner's Representative.
   3. All tests shall be conducted in a manner acceptable to Owner's Representative and shall be repeated as many times as necessary to secure Owner's Representative acceptance of each system.
   4. If inspection or tests indicate defects, the defective item or material shall be replaced, and the inspection and tests shall be repeated.
   5. All repairs to piping shall be made with new materials.
   6. Caulking of threaded joints or holes will not be acceptable.

C. Perform leakage tests on all pipe installed in this project or on any alterations or extensions of existing. Furnish all equipment, material, personnel, and supplies to perform the tests and make all taps and other necessary temporary connections. Leakage tests shall be performed on all piping at a time agreed upon and in the presence of the Owner. All visible leaks shall be repaired, regardless of the test results.

D. The test pressure, allowable leakage, and test medium shall be as specified for the piping systems. Test pressure shall be measured at the highest point on the line, except that pressure at lowest point shall not exceed pipe manufacturer's rated test pressure, unless specifically noted otherwise.

E. All visible leaks shall be repaired, regardless of the test results.

F. Perform following operations and checks before units are operated for any purpose:
   1. Verify shipping blocking and bracing have been removed.
   2. Verify unit is secure on mountings and supporting devices and connections for ductwork, electrical, etc. are complete. Verify proper thermal overload protection is installed in motors, starters and disconnects.
   3. Perform specified cleaning and adjusting. Disconnect fan drives from motors, verify proper motor rotation, and verify fan wheel free rotation and smooth operation of bearings. Reconnect fan drive systems, align belts, and install belt guards.
   4. Lubricate bearings and other moving parts with factory-recommended lubricants.
   5. Verify manual and automatic volume control dampers are positioned properly and that fire and smoke dampers in related ductwork are in full-open position.
   6. Disable automatic temperature control operators, where applicable.

G. Startup equipment, in accordance with manufacturer's startup instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
   1. Do not place equipment in sustained operation prior to initial balancing of systems.
   2. Conduct tests of equipment and systems to demonstrate compliance with requirements specified. Document tests and include in Operation and Maintenance Manuals.

H. The equipment and controls of this Section shall be completely tested, adjusted, and placed in operating condition.

I. Retest equipment and controls, as necessary, during the progress of the work. No work shall be covered until it is properly tested and made tight.

J. Replace damaged or malfunctioning controls and equipment with new. Refurbished is not acceptable.

K. When about to turn the apparatus over to the Owner, put all parts of the apparatus in perfect working order and thoroughly clean out all parts of the equipment.

L. Clean exterior and interior surfaces of each unit. Vacuum clean fan wheel and surfaces exposed to the air handled by the unit.

M. Check damper operation and linkages. Adjust for proper damper operation.

N. Air filters which are subject to a pressure loss exceeding the dirty filter values shall be removed and replaced. The spare air filters furnished with equipment shall not be used as the replacement filters. Dirty filter values shall be as follows:

Filter Type	Dirty Filter Conditions
1 inch pleated	1.0 inch water column
2 inch pleated	1.0 inch water column

O. Perform ductwork pressure test prior to air balancing per Section 23 31 13 Sheet Metal Ductwork and Accessories.

P. All heating, ventilating, and air conditioning systems installed under this Section shall be carefully adjusted by a qualified Air Balancing Subcontractor to deliver and exhaust air quantities as specified or described herein while maintaining the spaces served at the design temperature and design air pressure differentials. A final balancing report shall be produced and submitted to the Owner showing the airflow SCFMs, fan statics, and motor amperages.

3.06 TESTING, TRAINING, AND COMMISSIONING

A. In accordance with Section 01 45 20 – Equipment and System Performance and Operational Testing

B. Upon completion of work and adjustment of equipment and systems testing, demonstrate to the Owner's Representative that equipment furnished and installed or connected under provisions of these Specifications functions in manner required.

C. Manufacturer's Field Services:
   1. Furnish services of a qualified person at time approved by Owner's Representative, to instruct maintenance personnel, correct defects or deficiencies, and demonstrate to satisfaction of Owner's Representative that entire system is operating in satisfactory manner and complies with requirements of other trades that may be required to complete work.
   2. Complete instruction and demonstration prior to final job site observations.

D. TABB Procedures and Requirements: See Section 23 05 93.

3.07 ROOF CURBS

A. Roof curbs to be mounted level on roof in accordance to NRCA manuals and details. Secure to structure per engineered/sealed seismic installation details.

B. Seal openings between curb, roof opening, ducts, electrical conduits, piping, and building interior.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Scope:
   1. This Section covers the cleaning, testing, adjusting, and balancing of the air and hydronic system(s) associated with the process Hot Water and heating, ventilating, and air conditioning (HVAC) and odor control system(s).

B. Governing Standards:
   1. Except as modified or supplemented herein, all work covered by this Section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between any state law or local ordinance and this Section the latter shall take precedence.
   2. All work shall comply with the latest edition of AABC, NEBB, or SMACNA standard manuals for testing, adjusting, and balancing of air and hydronic systems.

C. Work Included: Provisions for testing, adjusting, and balancing of HVAC systems under actual operating conditions and design flow rates, including:
   1. Taking pre-tests of existing systems as identified on the Drawings.
   2. Balancing airflow and water flow within distribution systems, including sub-mains, branches, and terminals, to specified quantities according to specified tolerances.
   3. Adjusting total HVAC systems to provide specified quantities.
   4. Measuring electrical performance of HVAC equipment.
   5. Setting quantitative performance of HVAC equipment.
   6. Verifying that automatic control devices are functioning properly.
   7. Measuring sound and vibration.
   8. Reporting results of the activities and procedures specified in this Section.

1.02 RELATED SECTIONS

A. As required by Section 23 00 00 and Division 01 - General Requirements.

1.03 SUBMITTALS (IN ADDITION TO 23 00 00)

A. Action Submittal Items for this Section:
   1. Drawings showing general dimensions and confirming the size of equipment, fixtures, motors and drives, and piping connections.
   2. Testing Forms in accordance with industry standards. Submit example for engineer's approval.
   3. Testing, Adjusting and Balancing Report as specified in this Section.

1.04 QUALITY ASSURANCE (IN ADDITION TO 23 00 00)

A. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
AABC	Associated Air Balance Council, National Standards for Total System Balance
ASHRAE Standard 70	Methods of Testing for Rating the Air Flow Performance of Outlets and Inlets
NEBB	National Environmental Balancing Bureau, Procedural Standards for Testing Adjusting and Balancing of Environmental Systems

B. Testing Agency: Procure the services of an independent air balancing and testing agency, belonging to the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB), to perform balancing, testing and adjustment of systems. One organization shall perform the testing and balancing services.

C. Codes and Standards: Comply with applicable procedures and standards of the certification sponsoring association referenced above, in addition to the following:
   1. Calibration and maintenance of instruments and accuracy of measurements shall comply with the requirements of the standards.

D. Special Requirements:
   1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
   2. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.
   3. Tests and adjustments shall include the complete testing and balancing of heating, ventilating, and air conditioning systems and necessary adjustments to the heating, air conditioning, and ventilating equipment to accomplish the specified design flow rates.
   4. Should any apparatus, material or work fail to meet the specified requirements in these tests, make the necessary corrections and retest the apparatus, material, or work at no additional cost to the Owner.

E. Coordination: Section 23 00 00.
   1. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.
   2. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.05 BALANCING

A. General: Characteristics to be tested and adjusted to conform to the values specified include the following:
   1. Total airflow rates delivered by fans and air-handling units adjusted to SCFM.
   2. Flow rates at all louvers, grilles, registers, diffusers, supply and exhaust, and return ducts adjusted to SCFM.
   3. Capacity and temperature rise or drop across each heating and cooling coil.
   4. Flow rates across all dampers in foul air ductwork adjusted to SCFM.
   5. Distribution patterns at air outlets.
   6. Adjustment Tolerances
      a. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 5 percent of design for return and exhaust systems.
      b. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
      c. Hydronic Systems: Adjust to within plus or minus 10 percent of design at coils and plus or minus 5 percent at system pumps and equipment.
      d. Adjust supply, return, and exhaust air quantities to maintain pressurization in spaces specified on plans. Note and document room-to-room pressurization and maintain these relationships. Adjust pressure controlled spaces to within plus or minus 0.01 in WC.

B. Airflow Rate Measurements:
   1. Airflow rates shall be obtained by adjustment of the fan speeds, dampers, or registers. All flow rates shall be measured with supply, return, and exhaust systems operating with heating and cooling coils wet, with filter bank resistance midway between the design values specified for clean and dirty filters, with auxiliary systems in operation and with all doors and windows closed.
   2. Flow rates at grilles, registers, branch ductwork, and air distribution patterns shall be tested in strict accordance with ASHRAE Standard 70.

C. Hydronic Flow Rate Measurements:
   1. Hydronic flow rates shall be obtained by adjustment of the pump speeds and balancing valves. All flow rates shall be measured with coils wet.
   2. Systems installed with pressure independent valves require terminal level hydronic system balancing. Verify total system flow and ensure it is +/- 10% of system design. Randomly check 20 percent of all installed products for individual conformance. Coordinate exact location of tested products with engineer. Any individual adjustments for the pressure independent valve assembly (valve and actuator combination) for field conditions shall be performed using the pressure independent control valve manufacturer's documented procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).

PART 2 PRODUCTS

2.01 REPORT DATA

A. The final certified balancing report shall include the following actual field-verified data:
   1. Equipment data:
      a. Manufacturer and model, size, arrangement, class, location, and equipment number.
      b. Motor horsepower, voltage, phase, and full load amperage.
      c. Fan curves including ACFM, SCFM, Air Stream Temperature, Total static pressure, RPM, and operating motor BHP.
      d. Pump curves including GPM, TDH, RPM, efficiency, and operating motor BHP.
      e. Coil size, GPM, MBH, and differential pressure.
         1) Duct size, supply or exhaust recorded ACFM, SCFM, velocity, pressure measurements, and location of all measurements.
         2) Pump size, GPM, pressure measurements, and locations of all measurements.
         3) Differential pressure, GPM, inlet and outlet air and water temperatures at heating and cooling coils.

B. Report Requirements:
   1. Each individual final reporting form must bear the signature of the person who recorded the data and that of the supervisor of the reporting organization.
   2. All instruments which were used shall be listed and identified including the last date each was calibrated.

C. Final Report: Final report shall be submitted prior to Supplier's request for final inspection. In addition to providing all specified data and information on applicable reporting forms, report shall include the following:
   1. A schedule for testing and balancing parts of the systems which must be delayed due to seasonal, climatic, occupancy, or other conditions beyond control of the Supplier. Delayed work shall be completed as early as the proper conditions will allow, after consultation with the Owner.
   2. Due to delayed testing, reports shall be submitted after execution of those services.
   3. A total balance report shall include the following components:
      a. General Information and Summary
      b. Instrument Calibration
      c. Air and Hydronic Systems
         1) Pump curves.
         2) Fan curves.
         3) Manufacturers' test data.
         4) Field test reports prepared by system and equipment installers.
      d. Other information relative to equipment performance.
      e. Record drawings with specified and measured flow rates

D. Complete apparatus report sheets for all air or hydronic systems shall be accurately and completely filled out. The testing and balancing results shall be submitted on the TAB report forms of the applicable standard. Copies of the final test readings and report sheets shall be submitted in accordance with the Submittals section. A description of the standard procedures used during testing, adjusting, and balancing shall be included in the submittal. The submittal shall include a reduced set of drawings, with the air outlet devices, air inlet devices, and equipment identified to correspond with the report sheets. Test dates shall be recorded on the individual TAB report forms indicating when the actual testing was performed.

E. The apparatus report sheets shall include the following information:
   1. Title Page:
      a. Company name
      b. Company address
      c. Company telephone number
      d. Project name
      e. Project location
      f. Project Engineer
      g. Project Subcontractor
      h. Project altitude
      i. Date
   2. Instrument List:
      a. Instrument
      b. Manufacturer
      c. Model
      d. Serial number
      e. Range
      f. Calibration date
      g. Equipment type/style (e.g., Rotating Vane anemometer)
   3. Air Moving Equipment:
      a. Unit number
      b. Location
      c. Manufacturer
      d. Model and serial number
      e. Airflow, design and actual (SCFM)
      f. Total static pressure (total external), design and actual
      g. Static pressure, inlet and discharge
      h. Total pressure
      i. Fan RPM, design and actual
   4. Electric Motors:
      a. Manufacturer
      b. Motor type and frame
      c. HP/BHP
      d. Phase, voltage, amperage, nameplate, actual, no load.

e. RPM
f. Service factor
g. Starter size, rating, heater elements

5. V-Belt Drive:
   a. Required driven RPM
   b. Driven sheave make, diameter, and RPM
   c. Belt make, size, and quantity
   d. Motor sheave make, diameter, and RPM
   e. Center to center distance, maximum, minimum, and actual
6. Return Air/Outside Air Data:
   a. Unit number
   b. System airflow, design and actual (SCFM)
   c. Return airflow, design and actual (SCFM)
   d. Outside airflow, design and actual (SCFM)
   e. Return air temperature
   f. Outside air temperature
   g. Mixed air temperature, design and actual
   h. Outside/return air ratio, design and actual (SCFM)
7. Duct Traverse:
   a. System zone/branch
   b. Duct size
   c. Area
   d. Velocity, design and actual
   e. Airflow, design and actual (SCFM)
   f. Duct static pressure
   g. Air temperature
   h. Air correction factor
8. Outlet and Inlet Devices:
   a. Air outlet and inlet device number
   b. Room number/location
   c. Air outlet and inlet device type
   d. Air outlet and inlet device size
   e. Area factor
   f. Velocity, design, preliminary, and final
   g. Air flow, design, preliminary, and final (SCFM)
   h. Percent of design airflow
9. Sound Level Report:
   a. Location
   b. Octave bands - equipment off
   c. Octave bands - equipment on

10. Package Air Conditioning/Heat Pump Unit.
    a. Unit number
    b. Location
    c. Manufacturer and model
    d. Refrigerant type and capacity
    e. Airflow, design and actual(SCFM)
    f. Return airflow, design and actual (SCFM)
    g. Outside airflow, design and actual (SCFM)
    h. Dry bulb temperature, entering and leaving
    i. Wet bulb temperature, entering and leaving
    j. Outside air temperature, dry and wet bulb
11. Air Terminal Unit Data
12. Electric Duct Heater: Not used.
13. Air Cooled Condenser/Heat Pump
14. Chillers.
15. Pump Data.
16. Heat Exchanger.
17. Combustion Test.
18. Odor Control Vessels:
    a. Unit number
    b. Manufacturer and model
    c. Air pressure drop across media bed(s), design and actual
19. Mist Eliminators
    a. Manufacturer and model
    b. Equipment served
    c. c. Air pressure drop, design and actual

F. Product data indicating cleaning materials and treatment, chemicals, and reports on the analysis of system water after cleaning and after treatment, shall be submitted in accordance with the Submittals section.

2.02 CERTIFICATE OF COMPLETION

A. At completion of testing and balancing, Supplier shall submit a Certificate of Compliance stating that each apparatus, device, outlet, and system has been tested, adjusted, and balanced so that it is operating in conformance with manufacturer's recommendations and with the specified conditions.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS: SECTION 23 00 00

3.02 INSPECTION

A. Before testing and balancing the air system, doors and windows surrounding the area served by the system shall be closed. Fans shall be checked for correct rotation and rotative speed. Dampers shall be open and access doors and panels shall be closed during the testing and balancing period.

B. Before starting the hydronic system testing and balancing, all valves and control components shall be opened or set to direct flow through the heat transfer element.

C. The pumps shall be checked for correct rotation and rotative speed.

D. A resistance shall be placed at all filter locations to simulate dirty filter conditions per 23 00 00 3.06 without incurring AMCA defined system effects

3.03 TESTING, TRAINING AND COMMISSIONING

A. Following completion of testing and balancing the system shall be left in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.04 PERFORMANCE OF WORK

A. General:
   1. Testing, adjusting, and balancing shall be performed after the system installation is complete but prior to acceptance of the project.
   2. Perform testing and balancing procedures on each system according to the procedures contained in AABC national standards or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
   3. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish. Coordinate with mechanical subcontractor to identify locations prior to insulation to avoid re-work
   4. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

B. Airflow System Measurements:
   1. Measure and adjust air supply and exhaust units to deliver at least 100 percent of the design air volume at 100 percent cooling and heating.
   2. Measure static air pressure conditions on fans, including filter and coil pressure drops, and total pressure across the fan.
   3. Adjust fan speeds and motor drives within drive limitations, for required air volume. Set a speed to provide air volume farthest distance from the fan without excess static pressure. Check amp draw of fans on initial startup. If running amps exceed

nameplate, shut off motor immediately, notify Owner, and make necessary drive changes as directed.

4. Airflow rates shall be measured with supply, return, and exhaust systems operating with heating and cooling coils wet, with filter bank resistance midway between design values specified for clean and dirty filters, with auxiliary systems in operation.
5. Airflow rates supplied, exhausted, or returned shall be within plus or minus 5 percent of the design values specified.
6. Measure and adjust air exhaust dampers to deliver at least 100 percent of the design air volume. Measure static air pressure conditions on fans and total pressure across the fan.

C. Hydronic System Measurements:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gauge heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
2. Check system resistance. With valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved. Report flow rates that are not within the range stipulated above.
3. Verify pump-motor amperage. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Set calibrated balancing valves, if installed, at calculated pre-settings.
5. Measure flow at stations and adjust, where necessary, to obtain first balance. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
6. Measure flow at main balancing station and set main balancing device or adjust pump speed to achieve flow within the range stipulated above.
7. Adjust balancing stations to within specified tolerances of design flow rate as follows:
    a. Determine the balancing station with the highest percentage over design flow.
    b. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
    c. Record settings and mark balancing devices.
8. Measure pump flow rate and make final measurements of pump amperage, voltage, RPM, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.
9. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

D. Systems to be Balanced:

1. All heating, ventilating, air conditioning, hydronic, and foul air equipment and systems shall be balanced.

3.05 FINAL INSPECTION

A. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new reports submitted, and new inspection test made.

B. Following acceptance of the reports by the Owner's Representative, Supplier shall permanently mark all damper positions so that they can be restored to their correct position if disturbed at any time. Devices shall not be marked until after final inspection.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 09 00

HVAC INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Work Included: Design (including detailed sequence of operations), materials, installation and testing of:
   1. Communications
   2. Operator Interface (Owner will provide computer, Subcontractor to furnish and install controller software, configure software to integrate specified system controls and features, and fully commission)
   3. Web Based Access
   4. BAS Graphics
   5. Building Controllers
   6. Application Specific Controllers
   7. Application Specific Controller - Terminal Unit Controllers
   8. Input/Output Interface
   9. Power Supplies and Line Filtering
   10. Control Panels
   11. Auxiliary Control Devices
   12. Wiring and Raceways
   13. Laboratory Control System

B. This is a performance specification and Subcontractor is responsible for design tasks and engineering.

C. Unit Responsibility: Assign unit responsibility, as specified in Section 23 00 00, for Building HVAC Systems and the Building Automation System.
   1. The HVAC Subcontractor has unit responsibility, as defined in Section 23 00 00, for the design, equipment selection, installation, controls, and proper operation of building ventilation, building heating, and building cooling systems.
   2. Unit responsibility extends to the preparation of detailed mechanical, electrical, instrumentation drawings for submittal to the Owner for review; design of control systems (hardware and software) to achieve the operational performance requirements specified herein; development and installation of communication systems that are needed for components to function together; integration of all system components, electrical and instrumentation devices, and mechanical equipment; and start-up, troubleshooting, adjusting and placing into proper operation all elements of the Building HVAC Systems and Building Automation Systems.
   3. Provide a completed and signed certificate of unit responsibility (Section 23 00 00).

1.02 RELATED SECTIONS

A. As required by Section 23 00 00 and Division 01 - General Requirements.

1.03 QUALITY ASSURANCE (IN ADDITION TO 23 00 00)

A. Reference Standards:
   1. This Section incorporates by reference the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
   2. References and Standards as required by Section 23 00 00 and Division 01, General Requirements.
   3. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
      a. Current edition of ANSI/ASHRAE Standard 135 and addendum, BACnet.
      b. Current edition of UL 916 Underwriters Laboratories Standard for Energy Management Equipment, Canada, and the US.
      c. Current edition of FCC Part 15, Subpart J, Class A.
      d. Current edition of BACnet Testing Laboratories (BTL).

B. Quality assurance as required by Section 23 00 00 and Division 01, General Requirements.

1.04 WARRANTY

A. Warranty of materials and workmanship as required by in Section 23 00 00 and Division 01, General Requirements.

1.05 SPECIAL WARRANTY

A. In accordance with Division 01, provide the following Special Warranties:
   1. 2 years of on-call service for software issues and control problems.
   2. 2 years technical support by telephone and email.
   3. All products and system controls warranted for proper operation for 2 years.

1.06 SYSTEM DESCRIPTION

A. Control system referenced throughout specifications and drawings as Building Automation System (BAS), Building Management System (BMS), or Energy Management System (EMS) interchangeably consists of high-speed, peer-to-peer network of DDC controllers, control system server, and operator workstation.

B. System software based on server/thin-client architecture, designed around open standards of web technology. Control system server accessed using a web browser over control system network.

C. Intent of thin-client architecture is to provide operators complete access to control system via web browser. No special software other than web browser required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming.

D. Local Area Network (LAN) either 1000 Mpbs Ethernet network.

E. System will consist of open architecture that is capable of:
   1. High speed Ethernet communication using TCP/IP protocol
   2. Native BACnet communications according to ANSI/ASHRAE Standard 135, latest edition.
      a. Provide necessary BACnet-compliant hardware and software to meet the system's functional specifications. Controller devices must be BTL tested and listed by an official BACnet Testing Laboratory and have the BTL mark issued.
   3. OPC server communications according to OPC Data Access 2.0 and Alarms and Events 1.0.
   4. LonTalk protocol.
   5. Modbus (RTU/TCP) protocol.

F. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation valves and dampers.

G. Prepare individual hardware layouts, interconnection drawings, building conduit diagrams and sequence of control from the project design data. Any architecture diagrams on design drawings have been included as schematics only and are not meant to portray quantity of devices or power/data requirements.

H. Design, provide, and install equipment cabinets, panels, data communication network infrastructure (including cables, conduits, outlets, connections, etc.) needed, and associated hardware.

I. Provide complete manufacturer's specifications for items that are supplied. Include vendor name and model number of every item supplied.

J. Provide a comprehensive operator and technician training program as described in these specifications.

K. Provide as-built documentation, operator's terminal software, diagrams, and other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

L. Provide 120V power, low voltage power, transformers, etc. for control panels, transformer panels, and BAS devices. Install per Division 26 specifications. Power for devices within this specification section is solely the responsibility of the HVAC Controls Subcontractor.

M. Conduit and raceway systems. Install per Division 26 specifications.

N. All devices, components, controllers, and software to be manufacturer's most current version at the time of installation.

PART 2 PRODUCTS

2.01 CANDIDATE BUILDING AUTOMATION SYSTEM MANUFACTURERS/INSTALLERS & PRODUCTS

A. Siemens

B. Johnson Controls

C. Alerton

D. Delta Controls

E. Schneider Electric/TAC-IA

F. Or Approved Equal.

2.02 CANDIDATE LABORATORY CONTROL MANUFACTURERS/INSTALLERS AND PRODUCTS

A. Phoenix Controls

B. Lab Control Systems Inc.

C. Siemens

D. Or Approved Equal.

2.03 SYSTEM PERFORMANCE

A. Performance Standards: System conforms to following minimum standards over network connections:
   1. Graphic Display: Graphic with 20 dynamic points display with current data within 10 seconds.
   2. Graphic Refresh: Graphic with 20 dynamic points update with current data within 8 seconds.
   3. Object Command: Devices react to command of binary object within 2 seconds. Devices begin reacting to command of analog object within 2 seconds.
   4. Object Scan: Data used or displayed at controller or workstation have been current within previous 6 seconds.
   5. Alarm Response Time: Object that goes into alarm shall be annunciated at workstation within 45 seconds.
   6. Program Execution Frequency: Custom and standard applications be capable of running as often as once every 5 seconds. Select execution times consistent with mechanical process under control.
   7. Performance: Programmable controllers are able to completely execute DDC PID control loops at frequency adjustable down to once per second. Select execution times consistent with mechanical process under control.
   8. Multiple Alarm Annunciation: Each workstation on network receives alarms within 5 seconds of other workstations.

B. Reporting Accuracy. System reports values with minimum end-to-end accuracy listed in Reporting Accuracy Table below.
   1. Reporting Accuracy Table:

Measured Variable	Reported Accuracy
Space Temperature	±1 degree F
Ducted Air	±1 degree F
Outside Air	±2 degree F
Dew Point	±3 degree F
Water Temperature	±1 degree F
Delta-T	±0.25 degree F
Relative Humidity	±5 percent RH
Water Flow	±2 percent of full scale

C. Control Stability and Accuracy: Control loops maintain measured variable at setpoint within tolerances listed in Control Stability and Accuracy Table below.
   1. Control Stability and Accuracy Table:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	+0.2 in wg	0-6 inc. wg
	+0.01 in wg	-0.1 to 0.1 in wg
Airflow	+10 percent of full scale	
Space Temperature	+2.00 degree F	
Duct Temperature	+30 degree F	
Humidity	+5 percent RH	
Fluid Pressure	+1.5 PSI	1-150 PSI
	+1.0 in wg	0-50 in wg differential

2.04 COMMUNICATIONS

A. Each controller to have communication port for connection to the Operator interface.
   1. Internetwork operator interface and value passing to be transparent to internetwork architecture.
   2. Operator interface connected to controller to allow operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs to be viewable and editable from each internetwork controller.

B. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers to be readable by each controller on internetwork.

C. Operator Workstation to be capable of simultaneous direct connection and communication with BACnet/IP, OPC, and TCP/IP networks without use of interposing devices such as PC or gateway with hard drive.

D. Workstations, Building Control Panels and Controllers with real-time clocks use time synchronization service. System automatically synchronizes system clocks daily from

operator-designated device via internetwork. System automatically adjusts for daylight savings and standard time as applicable.

E. Wireless Network Communications:
   1. Wireless communications take place using modular wireless transceivers at each device, which eliminates need for communication cabling.
   2. Wireless transceiver utilizes 2.4 GHz in license free global Industrial Scientific & Medical (ISM) band.
   3. Wireless transceiver is encased in plenum-rated enclosure. If application dictates, wireless transceiver is able to be installed in metal enclosure utilizing remote mounted antenna.
   4. Wireless transceiver channel be factory set and capable of being field set to different channel if interference with IEEE 802.11 devices or other 2.4 GHz products is encountered.
   5. Wireless transceiver be 24 VAC powered.
   6. Wireless transceiver gives a visual indication that it is powered and communicating.
   7. Wireless transceiver has field settable network identifier that allows multiple networks to occupy same channel for maximum scalability.

2.05 OPERATOR INTERFACE

A. Operator Interface: Owner will provide one PC-based workstations that shall be integrated into the HVAC control system by the HVAC Controls Subcontractor.

B. Hardware: Each operator workstation will comply with the following specifications:
   1. Computer: Hardware will meet or exceed DDC system manufacturer's specifications and response times specified elsewhere in this document. Hard disk will have sufficient memory to store required operator station software and one year of trend data.
      a. Minimum Hardware Configuration will Include:
         1) Intel quad core processor
         2) 8 GB of RAM
         3) 48x CD-RW/DVD optical drive
         4) 1 TB hard disk drive providing data at 6 GB/sec
         5) Ethernet 10/100/1000 network interface card
         6) High performance graphics card
         7) 21-in LCD monitor with at least 1920x1080 resolution
         8) Keyboard and mouse
         9) UPS (uninterruptible power supply) installed at server, sized with sufficient capacity to allow full operation for 10 minutes or more.
   2. Modem (Subcontractor Provided): Auto-dial modem and associated cables transmit over voice-grade telephone lines at nominal 56Kb between workstation or web server and remote buildings and workstations.

C. System Software:
   1. Operating System (Subcontractor Provided and Installed): Furnish concurrent multi-tasking operating system. Operating system also supports use of and includes other common software applications such as Microsoft Excel, Word, Microsoft Access, and Adobe Acrobat. Acceptable operating systems are Windows 10 or Window Server 2016.
      a. Operating system shall be field installed by Subcontractor on Owner-supplied workstation.
   2. Dynamic Color Graphics:
      a. Real-time color graphic displays dynamic and able to update displays.
      b. Provide operator ability to change values (setpoints) and states in system controlled equipment directly from graphic display.
      c. CUSTOM GRAPHICS: Provide custom graphics generation package.
      d. GRAPHICS LIBRARY: Furnish library of standard HVAC equipment graphics and include standard symbols for fans, pumps, coils, valves, piping, dampers, and ductwork.
   3. All software to be manufacturer's most current version at the time of installation.

D. System Applications: Each workstation provides operator interface and off-line storage of system information. Provide following applications at each workstation:
   1. Automatic System Database Save and Restore. Each workstation stores on hard disk copy of current database of each Building Controller. This database automatically updated whenever change is made in any system panel.
   2. Manual Database Save and Restore. System operator able to manually save or clear database and initiate download of specified database from/to any panel.
   3. System Configuration: Workstation software provides method of configuring system to allow for changes or additions by users and performs following tasks:
      a. Create, delete, or modify control strategies.
      b. Add/delete objects to system.
      c. Tune control loops through adjustment of control loop parameters.
      d. Enable or disable control strategies.
      e. Generate hard copy records of control strategies on printer.
      f. Select points to be alarmed and define alarm state.
      g. Select points to be trended and initiate automatic recording of values.
      h. Start/Stop binary objects and adjust analog objects.
         1) Security: Operator required to log on to system with user name and password in order to view, edit, add, or delete data. System security selectable for each operator.
         2) System Diagnostics: System automatically monitors operation of workstations, printers, modems, network connections, building management panels, and controllers. Failure of any device to be annunciated.
         3) Alarm Indication And Handling:
      i. Workstation provides visual means of alarm indication. Alarm indication becomes highest priority regardless of application(s) running.

j. System provides and archive log of alarm messages to hard drive. Alarm messages to include description of event-initiating object, source, location, and time/date of alarm.

4. Trend Logs: Operator able to define custom trend log for any data object and include interval, start time, and stop time. Trend data sampled and stored on building controller panel, be archived on hard disk, and be retrievable for use in spreadsheets and standard database programs.
   a. System server to periodically gather historically recorded data stored in the building controllers and archive the information. Archived files to be appended with new sample data, allowing samples to be accumulated.
   b. Software to be included that is capable of graphing the trend logged object data. Software capable of creating two-axis (x,y) graphs that display object values relative to time.
   c. Operator able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. Input, output, and value object types in the system may be logged. Provide operations password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.
5. Standard Reports: Standard system reports provided for this project. Provide ability for Owner to readily customize these reports for this project:
   a. Objects: System (or subsystem) objects and their current values.
   b. Logs:
      1) Alarm History
      2) System Messages
      3) System Events
      4) Trends
6. Electrical and Energy:
   a. System server capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files appended with new data, allowing data to be accumulated.
   b. Operator able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. Meters monitored by the system may be logged.
   c. System to display archived data in tabular format form for both consumption and peak values. Data shown in hourly, daily, weekly, monthly, and yearly formats. In each format the user able to select a specific period of data to view.
   d. Electrical Meter Report: Provide monthly report showing daily electrical consumption and peak electrical demand with time and date stamp for each building meter and for each electrical sub-meter on individual building panels, circuits, equipment (such as chillers), and variable frequency drives. Provide an annual (12-month) report showing monthly electrical consumption and peak electrical demand with time and date stamp for each individual meter.
   e. Energy Consumption Report.

E. Interfaces to Third Party Systems: BAS connects to third party systems (VFDs, chillers, emergency generators, rooftop AC units, etc.). Communication protocol specified for third party system, and BAS provides compatible protocol to assure proper two way communication. Points, alarms, and commands displayed on BAS as indicated.

F. Workstation Applications Editors: Each PC workstation supports editing of system applications, which downloaded and executed at one or more controller panels.

2.06 CONTROLLER SOFTWARE

A. Furnish following applications software for building and energy management. Software applications reside and operate in system controllers. All software to be manufacturer's most current version at the time of installation. All software and associated functions (scheduling, optimum start/stop, etc.) noted in this specification are to be configured and enabled for this project. Incorporate into sequence of operation submittals for review prior to installation.

B. System Security:
   1. User access secured using individual security passwords and user names.
   2. Restrict user passwords to objects, applications, and system functions as assigned by system manager. Provide monitoring only access to Owner for period of one year for trouble shooting purposes.
   3. Record user Log On/Log Off attempts.
   4. Provide passwords, user names, and access assignments adjustable at the operator's terminal. Each user to have a set security level, which defines access to displays and individual objects the user may control. System to include 10 separate and distinct security levels for assignment to users.
   5. System to include an Auto Logout Feature that will automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period to be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal to display message on screen that user is logged out after Auto Logout occurs.

C. Scheduling: Provide capability to schedule each object or group of objects in system. Coordinate schedule with Owner and program accordingly. Each schedule consists of:
   1. Operator's workstation to show information in easy-to-read daily format. Priority for scheduling: Events, holidays and daily with events being the highest.
   2. Holiday and special event schedules to display data in calendar format. Operator able to schedule holidays and special events directly from these calendars.
   3. Operator able to change information for a given weekly or exception schedule if logged on with the appropriate security access.

D. Optimum Start/Stop: Provide software and program system to start equipment on sliding schedule based upon indoor and outdoor conditions. Determine minimum time of HVAC system operation needed to satisfy space environmental requirements and also determine earliest possible time to stop mechanical systems (i.e., hut down cooling/heating and only provide ventilation one hour prior to scheduled unoccupied period.) Optimum start/stop program operates in conjunction with scheduled start/stop and night setback programs.

E. Alarms:
   1. Operator's workstation to provide visual means of alarm indication. The alarm dialog box to always become the top dialog box regardless of the application(s), currently running.
   2. System to provide log of alarm messages. Alarm log to be archived to the hard disk of the system operator's terminal. Each entry to include a description of the event-initiating object generating the alarm. Entry to include time and date of alarm occurrence.
   3. Alarm messages in user-definable text and entered either at the operator's terminal or via remote communication.
   4. Each binary object set to alarm based on operator-specified state.
   5. Each analog object has both high and low alarm limits.
   6. Alarms must be able to be automatically and manually disabled.
   7. Route alarms to appropriate workstations based on time and other conditions. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.
   8. System shall have ability to dial out in event of alarm.

F. Demand Limiting:
   1. System to include demand limiting program that includes two types of load shedding. One type of load shedding to shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding to adjust operator selected control set points in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.
   2. Status of each and every load shed program capable of being displayed on every operator terminal connected to system. Status of each load assigned to an individual shed program displayed along with the description of each load.
   3. Demand-limiting program monitor building power consumption from signals generated by pulse generator (provided by BAS subcontractor) mounted at building power meter or from watt transducer or current transformer attached to building feeder lines.
   4. Demand-limiting program predicts probable power demand so that when demand exceeds demand limit, action will be taken to reduce loads in predetermined manner. When demand limit will not be exceeded, action will be taken to restore loads in predetermined manner.
   5. Demand limits, load shed priorities and other settings shall be field programmed by the Subcontractor.

G. Maintenance Management: System monitors equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits. Coordinate settings with Owner.

H. Sequencing: Provide application software based upon sequences of operation specified to properly sequence designated systems. Provide all points to achieve specified sequences.

I. Staggered Start: This application prevents controlled equipment from simultaneously restarting after a power outage. Order in which equipment (or groups of equipment) is started, along with time delay between starts to be user-selectable.

J. Energy Calculations: Provide software to allow instantaneous power (e.g., kW) or flow rates (e.g. L/s (gpm)) to be accumulated and converted to energy usage data.

K. Anti-Short Cycling: Binary output objects protected from short cycling by allowing minimum on-time and off-time to be selected.

L. On/Off Control with Differential: Provide algorithm that allows binary output to be cycled based on controlled variable and set point. Algorithm direct-acting or reverse-acting and incorporate adjustable differential.

M. Run-Time Totalization: Provide software to totalize run-times for binary input objects.

2.07 BAS GRAPHICS

A. Develop customized graphics showing the project building(s) and their floor plans, mechanical, and electrical equipment, flow and control diagrams, and other relevant features on Workstation graphic screens. Associated input, output, and virtual objects (e.g., temperature & pressure set points) listed in the Sequence of Operation, and shown on the Input/Output Objects List included in the graphic screens and bound to the database. Real-time value of objects updated on the display of each graphic automatically. For projects where existing campus and/or building controls systems exist, replicate graphics used in the existing BAS graphics screens.

B. Graphics to have links to the Print function and to display a Standard Legend in the corner of the graphic. Graphics, except pop-ups, to have the date and time displayed in the upper corner of the graphic. Each graphic titled.

C. Weather: Graphics, except pop-ups, to have the outdoor temperature and humidity in the upper corner of the graphic.

D. Alarms - System and component summary alarms located near the top of each relevant graphic screen. Provide links to the associated system/component as part of these tags to assist trouble shooting. Other alarms placed near the associated system/device as depicted in the graphic. Provide text and color of information tags that describe each object and alarm value consistent with a graphics color legend.

E. The Following Graphics Provided as a Minimum:
   1. A building graphic, typically a photograph of the building, with links to each floor plan and other links as defined below.
   2. A central plant graphic with equipment (chillers, boilers, pumps, heat exchangers, storage tanks, etc.), temperature sensors, pressure sensors, flow sensors, and refrigeration leak detectors. The central plant graphic to have links to each building on the campus.
   3. Central equipment such as air handler, package rooftop equipment, supply fans, exhaust fans, and smoke control systems.

4. Floor plans of each floor, with temperature sensors, pressure sensors, temperature control zones, heating/cooling zones, ventilation zones, and supply air zones identified. Rooms grouped on a graphic only to the extent that detailed and complete sensing information can be comfortably viewed by an operator and the bound points updated in less than 10 seconds. Each zone to have a temperature symbol that changes color over the range from low (blue) through normal (green) to high (red) and indicate an alarm (flashing red). The zone temperature and or pressure symbol(s) to be a link to a zone control pop-up graphic. Individual floor plan graphics to provide links to related mechanical systems. The mechanical room plan graphics to show the relative location of, and provide links to, either the equipment pop-up or flow & control graphic for mechanical equipment monitored or controlled by the BAS.
5. Pop-up graphics provided for each zone control system showing a flow diagram and related monitoring & control points and system parameters. Pop-up graphics provided for each piece of equipment that is not shown on a flow and control graphic.
6. Flow and control diagrams for each system including but not limited to central plant, fan coils, generators, packaged equipment, chilled water systems, heating hot water systems, heat exchangers, pumps, storage tanks, zone terminal units, isolation room systems, operating room systems, cath lab systems, procedure room systems, smoke damper status and combination fire and smoke dampers status, ventilation systems, and medical gas monitoring systems. The flow and control graphics to have parameters grouped in the lower portion of the graphics. Standard equipment graphics used. Pumps, fans, dampers and other elements to dynamically indicate their state (i.e., pumps and fans to rotate when on and damper positions to dynamically adjust and be shown in their current position, etc.). System flow and control graphics displayed in a general left to right flow or loop arrangement. Return and exhaust air flow shown on top and return water shown on the bottom of the graphic.
7. Individual equipment/component screens showing sensing and control information available for each device provided.

F. Penetration: The graphic interface to consistently apply a convention whereby a left-click to always penetrate to more detailed information. The text windows to represent the deepest level of penetration. A right-click to always produce a menu of options that are specific to the item selected.

G. Navigation: Graphics organized to provide a "branching structure" that allows an operator to move from a "macro view" to a "micro view" and return. These links to other associated graphics, or allow a return to a previous macro view, provided and arranged horizontally along the bottom of each graphic screen. From left to right, the graphic links as follows: site/building map, building/trailer floor plans, and major mechanical systems at each building. Pop-up right click menus provided as needed on the lower button bar to allow for uncluttered navigation.

H. Clutter Minimization: Each graphic to have separate check boxes in the lower right corner that show/hide setpoints, alarms/safeties, and Devices/Equipment.

I. Templates: To the maximum extent possible, use standard graphics as templates to provide a consistent look throughout the interface.

J. Color Scheme: The graphics to use dynamic color changes to communicate equipment type, or object status consistent with the graphics color legend.

K. Symbols and Animations: Fans, pumps, dampers, coils, and generation equipment to be dynamic symbols indicating rotation, state, or position, movement, flow, etc.

L. Macros: When macros are used to add functionality to the graphics, detailed documentation provided.

M. Configure Mode: Access to “Configure Mode” for editing of the graphics password protected to prevent unauthorized changes to the graphics. This password supplied to the appropriate personnel.

N. Graphics Version: Graphics provided in the most current format available at time of control system programming.

O. Points and graphics checked for the proper binding and graphic programming, settings to ensure that the correct system, location, point values, and dynamics are shown in the proper location and rotate in the proper directions.

P. After graphics have been accepted, provide, on a CD ROM in an agreed upon file structure. If the graphics have active-x controls or other files that must be placed outside the graphics folder structure a set-up program provided on the disk to place the files in the correct locations.

2.08 BUILDING CONTROLLERS

A. General: Provide adequate number of building controllers to achieve performance specified. Panels to meet the following requirements.
   1. Building Automation System (BAS) to be composed of one or more independent, stand-alone, microprocessor-based building controllers to manage global strategies described in Controller Software section.
   2. Provide sufficient memory to support operating system, database, and programming requirements.
   3. Share data between networked building controllers.
   4. Distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
   5. Controllers that perform scheduling have real-time clock.
   6. Continually check status of its processor and memory circuits and if abnormal operation is detected, controller:
      a. Assume predetermined failure mode.
      b. Generate alarm notification.
   7. Building Controller communicates with other devices on internetwork including BACnet communications according to specified protocol.

B. Communication:
   1. Each building controller resides on network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and performs routing to network of custom application and application specific controllers.
   2. Controller provides a service communication port for connection to a portable operator's terminal.

C. Environment:

1. Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
2. Controllers used in conditioned space be mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.

D. Keypad: Local keypad and display to be provided for each controller. Security password to be available to prevent unauthorized use of keypad and display.

E. Serviceability: Provide diagnostic LEDs for power, communication, and processor. Wiring connections are made to modular terminal strips or to termination card connected by ribbon cable.

F. Memory: Building controller maintains BIOS and programming information in event of power loss for at least 72 hours.

G. Immunity to Power and Noise: Controller able to operate at 90 percent to 110 percent of nominal voltage rating and performs an orderly shutdown below 80 percent nominal voltage. Operation is protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 feet).

H. Controller to have a battery to provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery backup to maintain real-time clock functions for a minimum of 10 days.

2.09 APPLICATION SPECIFIC CONTROLLERS

A. Application specific controllers (ASCs) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers to be fully programmable using graphical programming blocks.
1. ASC controllers communicate with other devices on internetwork.
2. Each ASC capable of stand-alone operation without being connected to network.
3. Each ASC will contain sufficient I/O capacity to control target system.
4. Application controllers to include universal inputs with minimum 10-bit resolution that accept thermistors, 0-10VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on a controller may be either analog or digital with at least 1 input that accepts pulses. Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller to include binary and analog outputs on board. Provide analog outputs switch selectable as either 0-10VDC or 0-20mA. Software to include scaling features for analog outputs. Application controller to include 24VDC voltage supply for use as power supply to external sensors.
5. Program sequences stored on board application controller in EEPROM. No batteries needed to retain logic program. Program sequences executed by controller 10 times per second and capable of multiple PI and PID loops for control of multiple devices. Calculations completed using floating-point math and system to support display of information in floating-point nomenclature at operator's terminal. Programming of application controller completely modifiable in the field over installed BAS LANs or remotely via modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen.
6. Application controller to include support for room sensor. Display on room sensor programmable at application controller and include an operating mode and a field

service mode. Provide button functions and display data programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

B. Communication
   1. Controller resides on network using MS/TP Data Link/Physical layer protocol.
   2. Each controller connected to building controller.
   3. Each controller capable of connection to laptop computer or portable operator's tool.

C. Environment
   1. Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
   2. Controllers used in conditioned space mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.

D. Serviceability: Provide diagnostic LEDs for power, communication, and processor.

E. Memory: ASC use nonvolatile memory and maintains BIOS and programming information in event of power loss.

2.10 APPLICATION SPECIFIC CONTROLLER - TERMINAL UNIT CONTROLLERS

A. Provide one application controller for each terminal unit that adequately covers objects listed in object list for unit. Controllers to interface to building controller via LAN using specified protocol. Controllers to include on board flow sensor, inputs, outputs, and programmable, self-contained logic program as needed for control of units.

B. Application controllers to include universal inputs with 10-bit resolution that can accept thermistors, 0-5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display (digital display to indicate setpoint only). Controller to also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller to include microprocessor driven flow sensor for use in pressure independent control logic. Terminal units to be controlled using pressure independent control algorithms and flow readings to be in CFM.

C. Program sequences stored on board application controller in EEPROM. No batteries needed to retain logic program. Program sequences executed by controller 10 times per second and capable of multiple PI loops for control of multiple devices. Provide programming of application controller completely modifiable in the field over installed specified protocol LANs or remotely via modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller programmed using the same programming tool as Building Controller and as described in operator workstation section.

D. Application controller to include support for intelligent room sensor. Display on room sensor programmable at application controller and include an operating mode and a field service mode. Button functions and display data programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence for specific display requirements for intelligent room sensor.

E. Provide duct temperature sensor at discharge of each terminal unit that is connected to controller for reporting back to operator workstation. Provide analog inputs for the duct temperatures.

2.11 INPUT/OUTPUT INTERFACE

A. Input/output points protected such that shorting of point to itself, to another point, or to ground will cause no damage to controller. Input and output points protected from voltage up to 24 V.

B. Binary inputs (BI or DI) allow monitoring of On/Off signals from remote devices. Binary inputs sense “dry contact” closure without external power (other than that provided by controller) being applied.

C. Pulse accumulation input objects accept up to 10 pulses per second for pulse accumulation.

D. Analog inputs (AI) allow monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD).

E. Binary outputs (BO or DO) provide for On/Off operation or pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers have three-position (On/Off/Auto) override switches and status lights. Outputs selectable for either normally open or normally closed operation.

F. Analog outputs (AO) provide a modulating signal for control of end devices. Outputs provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building controllers have status lights and two-position (AUTO/MANUAL) switch and adjustable potentiometer for manual override. Analog outputs not exhibit drift of greater than 0.4 percent of range per year.

G. Tri-State Outputs: Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms run zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.12 POWER SUPPLIES AND LINE FILTERING

A. Control transformers UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits. Limit connected loads to 80 percent of rated capacity.

B. DC power supply output match output current and voltage requirements. Unit operates between 32 degrees F and 120 degrees F.

C. Line voltage units UL listed and CSA approved.

D. Power line filtering. Provide transient voltage and surge suppression for workstations and controllers.

2.13 CONTROL PANELS

A. Control Panels:
   1. Enclosures may be NEMA 1 rated. Outdoor enclosures shall be NEMA 3R. Provide (hinged door) key-lock latch and removable subpanels. Single key common to field panels and subpanels. In existing campus or building settings, key lock to match existing keys.
   2. Interconnections between internal and face-mounted devices prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection individually identified per control drawings.
   3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.
   4. Provide laminated plastic nameplates for enclosures in any mechanical room or electrical room labeled with TCP number. Laminated plastic to be 1/8 inch thick sized appropriately to make label easy to read.
   5. Control panels shall meet the panel construction requirements of Specification Section 40 67 00, Control System Equipment Panels and Racks.
   6. Section 40 67 00 paragraph 1.01 B.2 specifically describes voltage isolation requirements for control power distribution.

2.14 AUXILIARY CONTROL DEVICES

A. Temperature Instruments:
   1. Low-voltage or Line-voltage Thermostats: Bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating, exposed set point adjustment on cover with heat anticipator. Thermostat operates within 55 degrees F to 85 degrees F setpoint range, with 2 degrees F maximum differential.
   2. Averaging Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of ±0.5 degrees F at 32 degrees F, consisting of array of single point sensing elements, securely mounted in duct or plenum; operating range 20-120 degrees F; linear signal; 1-foot element per 2 SF of duct cross sectional area. Use when duct is 9 SF or larger or where air is subject to temperature stratification.
   3. Probe Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of ±0.5 degrees F at 32 degrees F, consisting of single point sensing elements, securely mounted in duct or plenum; operating range 20-120 degrees F; linear signal; 24-inch rigid probe. Use where duct is less than 9 SF cross sectional area.
   4. Outside Air Temperature Sensor: Thermistor or platinum RTD element with accuracy of ±0.5 degrees F at 32 degrees F; Range -58-120 degrees F, single element, linear, with weather and sun shield for exterior mounting.
   5. Low Temperature Limit Thermostat: Minimum 20-foot capillary sensing element, triggering on low temperature as sensed by any 12-inch segment; snap acting, normally open contacts, manual reset, line voltage.

6. Liquid Immersion Temperature Sensor: Thermistor or platinum RTD element, with accuracy of ±0.5 degrees F at 32 degrees F, stainless steel well and assembly, range 30-250 degrees F.
7. Pneumatic Room Thermostat: Two-pipe relay type with concealed adjustment, and no thermometer, blank cover secured with Allen screws.

B. Humidity Sensors:
1. Space Humidity Sensors: Operating range 10 to 95 percent relative humidity, accuracy ±2 percent RH, surface mounted ventilated enclosure for wall mounting.
2. Duct Humidity Transmitter: Capacitive type sensor and transmitter, linear output signal; automatic temperature compensating; air filter; ±2 percent RH accuracy from 0 to 100 percent RH.
3. Humidity sensor's drift not exceed 1 percent of full scale per year.

C. Pressure Transmitters and Transducers:
1. Transducer have linear output signal; field adjustable zero and span. Sensing elements withstand continuous operating conditions of positive or negative pressure 50 percent greater than calibrated span without damage.
2. Differential Pressure Switch: Setpoint adjustable with operating range of 0.5 to 12-inch WG for fans, and 5 to 30-feet WC for pumps. Switches UL listed; SPDT snap-acting; pilot duty rated (125 VA minimum); NEMA 1 enclosure; scale range and differential suitable for intended application.
3. Filter Differential Pressure Switch: Setpoint adjustable with operating range of 0.1 to 5-inch WG; auto reset. Contactor to close when pressure differential setting is met or exceeded. Provide mounting bracket, metallic tubing, and appropriate fittings for connection to duct or air-handling unit.
4. Duct Static Differential Pressure Transducer: Operating range 0 to 5-inch WC for duct mounted transmitter; ceramic capacitive sensing element with probe securely mounted in duct; digital input terminal and push button to zero output. Accuracy ±1 percent of full scale; maximum response time 2 seconds.
5. Building Static Pressure Transducer: Operating range of -0.1 to 0.1-inch WC, linear signal. Sensing tubes located inside and outside building use shielding and/or surge tanks to minimize effects of wind. Accuracy ±1 percent of full scale.
6. Piping Pressure Transmitter: Operating range 0 to 50 PSIG, linear signal; stainless steel diaphragm; digital input terminal and push button to zero output. Accuracy ±1 percent of full scale.

D. Motorized Control Dampers: Provide motorized dampers meeting the requirements of Section 23 31 13.

E. Motorized Control Valves:
1. Body pressure rating and connection type construction conforms to pipe, fitting, and valve schedules.
2. Fluid valve close-off ratings and spring ranges operate at maximum flows and maximum available pump heads scheduled without leakage.
3. Screwed ends except 2-1/2-inch and larger valves with flanged ends.

4. Fluid Two-Way Modulating Valves:
    a. 2-inch and smaller fail-in-place characterized ball valves; ANSI 250 body rating; bronze body and stainless steel trim.
    b. 2-1/2-inch and larger cast iron ANSI Class 125, other with guided equal percentage plug; PTFE packing.
5. Fluid three-way valves globe valves with linear plug with composition disc for tight shutoff.
6. Pressure drop equal to twice pressure drop through heat exchanger (load), 50 percent of pressure difference between supply and return mains, or 5 PSI, whichever is greater, except two-position valves be line size.
7. Bubble-tight line size butterfly valves acceptable on 2-1/2-inch lines and above for two-position action only; cast iron body; aluminum bronze disc; EPDM seat, 200 PSI wg

F. Electric Damper/Valve Actuators:
1. Provide mechanical or electronic stall protection for each actuator.
2. Where indicated provide internal mechanical, spring-return mechanism or provide uninterruptible power supply (UPS). Non-spring-return actuators have external manual gear release to position damper/valve when actuator is not powered.
3. Proportional actuators accept 0 to 10 VDC or 0 to 20 mA control signal and provide 2 to 10 VDC or 4 to 20 mA operating range.
4. Actuator sized for torque required plus 25 percent; UL or CSA listed; electronic current overload protection.
5. VAV Actuators: Actuators proportional 24 VAC actuators using a 4 to 20 mA range of control signals; stops automatically at end of travel; include permanently lubricated gear train.

G. Air Flow Meters:
1. Duct Mounted Air Flow Station: Self-supporting aluminum alloy tube with stainless steel mounting brackets. Probe and sensor density quantity as recommended by manufacturer. Sensor use thermal dispersion technology with two “bead in glass,” hermetically sealed thermistor probes at each measuring point. Provide electronic flow transmitter with CFM readout display and capable of 4-20 mA output signal. Ebtron GTA116-PC.

H. Room Pressure Monitor: Active room pressure monitor and alarm which provides local audio alarm and analog and alarm signals to DDC system. Wall mounted panel with LED differential pressure readout; audible and visual alarm; mute button; range of -0.05 to +0.05-inch WC; accurate to 1 percent of full scale; repeatability ±1.0 percent of full scale per year, alarm delay ability between 0-30 seconds. Provide door switch to deactivate alarm when space door(s) are open. Input status from BAS to deactivate alarm in unoccupied or shutdown modes. Phoenix Controls APM100.

I. Duct Mounted Carbon Dioxide Sensor:
1. Duct mounted CO2 sensor consists of infrared sensing element with heated stannic dioxide semiconductor. Operating range 0-2000 ppm + 50 ppm + 2 percent of measured value; maximum duct velocity of 1500 fpm; duct mounting kit.

J. Occupancy Sensor: Dual technology infrared and ultrasonic sensing device, ceiling, or wall mounted, built-in self-adjusting settings, timer settings of 30 seconds to 30 minutes, with manual and automatic modes. Provide multiple devices in parallel when area served is greater than a single device sensing capability. Provide integral power pack, 120 VAC input, 24 VDC output, with manual override switch. Leviton OSC-MOW series.

K. Paddle Type Flow Switches: Paddle type switches (water service only) UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum) and have adjustable sensitivity with NEMA 1 enclosure.

L. Relays
   1. Control relays UL listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage be suitable for application.
   2. Time delay relays UL listed solid-state plug-in type with adjustable time delay. Delay adjustable ±200 percent (minimum) from set point or as indicated. Contact rating, configuration, and coil voltage be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

M. Override Timers: Override timers spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer suitable for flush mounting on control panel face and located on local control panels or where shown.

N. Current Transmitters:
   1. AC current transmitters be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges 20 A full scale, with internal zero and span adjustment and ±1 percent full-scale accuracy at 500 ohm maximum burden.
   2. Transmitter meets or exceeds ANSI/ISA S50.1 requirements and UL/CSA recognized.
   3. Unit split-core type for clamp-on installation on existing wiring.

O. Current Transformers: AC current transformers UL/CSA recognized and completely encased (except for terminals) in approved plastic material; ±1 percent accuracy at 5 A full-scale.

P. Voltage Transmitters: AC voltage; self-powered single-loop (two-wire) type; 4 to 20 mA output with zero and span adjustment; UL/CSA recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1. Ranges include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ±1 percent full-scale accuracy with 500 ohm maximum burden.

Q. Voltage Transformers: AC voltage transformers UL/CSA recognized, 600 VAC rated; built-in fuse protection; suitable for ambient temperatures of 40 degrees F-130 degrees F; ±0.5 percent accuracy at 24 VAC and a 5 VA load.

R. Power Monitors: Selectable rate pulse output for kWh reading; 4-20 mA output for kW reading; N.O. alarm contact; ability to operate with 5.0 amp current inputs or 0-0.33 volt inputs; +1.0 percent full-scale true RMS power accuracy; + 0.5 Hz, voltage input range 120-600 V, and auto range select; NEMA 1 enclosure. Current transformers having 0.5 percent FS accuracy, 600 VAC isolation voltage with 0-0.33 V output. If 0-5 A current

transformers are provided, a three-phase disconnect/shorting switch assembly is required.

S. Overflow Switch: Insertion flow sensor, brass, impeller flow design with analog transmitter unit. Data Industrial Model 220BR.

T. Emergency Stop Switch: Red, mushroom type, pull out to operate.

U. End Switches: Turret head Type SPDT. Square D Class 9007, Type C54B2, or equal.

V. Water Detector: Cast aluminum enclosure with adjustable legs; gold plated probes for water detection; LED for water detection; SPDT alarm contacts; 24 VAC/VDC. Kele WD-1B, or approved equivalent.

2.15 WIRING AND RACEWAYS

A. General: Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire to be copper conductors, UL labeled for 90 degrees C minimum service.

C. Field panels and controllers to be supplied by building emergency power system where systems being monitored or controlled are on emergency power. Run control wiring as follows:
   1. Mechanical Rooms: In conduit
   2. Exposed in Building Spaces: In conduit
   3. Concealed in Building Walls and Ceilings: Plenum rated cable
   4. Concealed in Building Ceilings: Plenum rated cable in cable tray

D. Field and Subfield Panels: Voltage in panels not to exceed 120 volts.

E. Motor Control Centers: Responsibility for correct voltage of holding coils and starter wiring in pre-wired motor control centers interfacing with automatic controls is included hereunder.

F. Wiring for BAS systems communications buses two conductor minimum 18 gauge foil-shielded, stranded twisted pair cable rated at 300 VDC or more than 80 degrees C.

PART 3 EXECUTION

3.01 REQUIREMENTS: SECTION 23 00 00

3.02 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Owner in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until unsatisfactory conditions are resolved.

3.03 CONTROL SYSTEM CHECKOUT AND TESTING

A. Testing completed before Owner is notified of system demonstration.

B. Calibrate and prepare for service of instruments, controls, and accessory equipment furnished under this specification.

C. Verify that control wiring is properly connected and free of shorts and ground faults.

D. Enable control systems and verify calibration and operation of input and output devices.

E. Verify that system operation adheres to sequences of operation.

F. Commissioning and Verification: In addition to commissioning requirements specified elsewhere, provide the following commissioning on the HVAC instrumentation and controls system:
   1. Control systems completely commissioned to ensure aspects of the system are operating as intended and at optimum tuning.
   2. Wiring connections verified and traced from field device to panel to ensure proper connections.
   3. Measured values verified by a hand held calibrated device to validate that value indicated by the control system is in fact the actual measured value.
   4. Loops properly tuned to obtain the desired control value. Each loop to be "upset" and put back in control to demonstrate its ability to stabilize quickly.
   5. Provide a final point-by-point report submitted that indicates the date of each verification, the results, and initialed on each page by the person performing the reading.

3.04 ACCEPTANCE TESTING AND TRAINING

A. Site Testing:
   1. Subcontractor provides personnel, equipment, instrumentation, and supplies necessary to perform testing. Owner's Representative will witness and sign off on acceptance testing.
   2. Subcontractor demonstrates compliance of completed control system with Contract Documents. Using approved test plan, physical and functional requirements of project demonstrated.

B. Training:
   1. General: Subcontractor conducts training courses for up to 3 other designated personnel in operation and maintenance of system. Training manuals provided for each trainee, with two additional copies provided for archival at project site. Manuals include detailed description of subject matter for each lesson. Copies of audiovisuals delivered to Owner. Training day is defined as 8 hours of classroom instruction, including two 15-minute breaks and excluding lunch time, Monday through Friday, during normal first shift in effect at training facility. Notification of any planned training given to Owner's representative at least 15 days prior to training.
   2. Operator's Training I: First course taught at supplier's facility for period of one consecutive training day. Upon completion, each student should be able to perform

elementary operations with guidance and describe general hardware architecture and functionality of system.

3. Operator's Training II: Second course taught at project site for a period of one training day after completion of subcontractor's field testing. Course includes instruction on specific hardware configuration of installed system and specific instructions for operating installed system. Upon completion, each student should be able to start system, operate the system, recover system after failure, and describe specific hardware architecture and operation of system.
4. Operator's Training III: Third course taught at project site for period of one training day no later than six months after completion of the acceptance test. Course will be structured to address specific topics that students need to discuss and to answer questions concerning operation of system. Upon completion, students should be fully proficient in system operation and have no unanswered questions regarding operation of installed system.

3.05 WIRING

A. Provide electrical wiring required to control systems specified in this section. Control and interlock wiring complies with national, state and local electrical codes and Division 26 of this specification.

B. Power wiring required for building control panel(s) to be dedicated circuit(s).

C. Verify location of operator work station with Owner prior to installation.

D. NEC Class 1 (line voltage) wiring UL listed in approved raceway according to NEC and Division 26 requirements.

E. Low-voltage wiring meets NEC Class 2 requirements. (Low-voltage power circuits subfused when required to meet Class 2 current limit.)

F. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL Listed for intended application.

G. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for purpose of interfacing (e.g., relays and transformers).

H. Where Class 2 wiring is run exposed, wiring is to be run parallel along surface or perpendicular to it and tied at 10 ft intervals.

I. Where plenum cables are used without raceway, supported from structural members. Cables not to be supported by ductwork, electrical raceways, piping, or ceiling suspension systems.

J. Wire-to-device connections made at terminal block or terminal strip. Wire-to-wire connections at terminal block.

K. Maximum allowable voltage for control wiring 24 V. If only higher voltages are available, provide step-down transformers.

L. Wiring installed as continuous lengths, with no splices permitted between termination points.

M. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at penetrations.

N. Include one pull string in each raceway 1 in. or larger.

O. Control and status relays are to be located in designated enclosures. Enclosures include packaged equipment control panels unless they also contain Class 1 starters.

P. Install raceway to maintain a minimum clearance of 6 in. from high-temperature equipment (e.g., steam pipes or flues).

Q. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

R. Install insulated bushings on raceway ends and openings to enclosures. Seal top end of vertical raceways.

S. Flexible metal raceways and liquid-tight, flexible metal raceways not-to-exceed 3-feet in length and be supported at each end. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways to be used.

T. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections joined with couplings. Terminations made with fittings at boxes.

U. Input and output terminations to be labeled at the controller to identify if they are AI, DI, AD, DO, and function (i.e., pump start, OM Sensor.)

3.06 COMMUNICATION WIRING

A. Follow manufacturer's installation recommendations for communication cabling.

B. Verify integrity of network following cable installation.

C. Communication wiring unspliced length when that length is commercially available; labeled to indicate origination and destination data.

D. Grounding of coaxial cable in accordance with NEC regulations article on “Communications Circuits, Cable, and Protector Grounding.”

3.07 INSTALLATION OF AUXILIARY CONTROL DEVICES

A. General:
   1. Install sensors in accordance with manufacturer's recommendations.
   2. Room sensors installed on concealed junction boxes properly supported by wall framing.
   3. Low-limit sensors used in mixing plenums installed in a serpentine manner horizontally across duct.

4. Pipe-mounted temperature sensors installed in wells with heat-conducting fluid in thermal wells.
5. Install outdoor air temperature sensors on north facing wall or screen, complete with sun shield at designated location.

B. Flow Switch: Use correct paddle for pipe diameter. Adjust flow switch in accordance with manufacturer's instructions.

C. Actuators:
   1. General:
      a. Mount and link control damper actuators according to manufacturer's instructions.
      b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
   2. Actuator Mounting For Damper And Valve Arrangements to Comply to the Following:
      a. Damper Actuators: Do not install in the air stream
      b. Use a weather proof enclosure (clear and see through) if actuators are located outside.
      c. Damper or valve actuator ambient temperature not-to-exceed 122 degrees F through any combination of medium temperature or surrounding air. Provide appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation as necessary. Mount per manufacturer's recommendations.
      d. Actuator cords or conduit to incorporate a drip leg if condensation is possible. Do not allow water to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point to be avoided to prevent water from condensing in conduit and running into actuator.
      e. Damper mounting arrangements to comply to the following:
         1) Furnish and install damper channel supports and sheet metal collars.
         2) Jack shafting of damper sections not allowed.
         3) Multi-section dampers arranged so that each damper section operates individually. Provide one electronic actuator direct shaft mounted per section.
      f. Size damper sections based on actuator manufacturers specific recommendations for face velocity, differential pressure, and damper type. In general: Damper section not to exceed 24 ft-sq. with 1500 FPM face velocity.
      g. Multiple section dampers of two or more arranged to allow actuators to be direct shaft mounted on the outside of the duct.
      h. Multiple section dampers of three or more sections wide arranged with a 3-sided vertical channel (8-inch wide by 6-inch deep) within the duct or fan housing and between adjacent damper sections. Vertical channel anchored at the top and bottom to the fan housing or building structure for support. Connect sides of each damper frame to the channels. Holes in the channel to allow damper drive blade shafts to pass through channel for direct shaft mounting of actuators. Face open side of channel downstream of the airflow, except for exhaust air dampers.
      i. Multiple section dampers to be mounted flush within a wall or housing opening to receive either vertical channel supports as described above or sheet metal standout collars. Sheet metal collars (12-inch minimum) to bring each damper

section out of the wall to allow direct shaft mounting of the actuator on the side of the collar.

D. Control Valve:
   1. Valves installed in accordance with manufacturer's recommendations.
   2. Slip-stem control valves installed so that stem position is not more than 60 degrees from vertical up position. Ball type control valves installed with stem in horizontal position.
   3. Control valves accessible and serviceable.
   4. Install isolation valves so that control valve may be serviced without draining supply/return side piping system. Install unions at connections to screw-type control valves.
   5. Valve Sizing for Water Coil:
      a. On/Off Control Valves: Line size.
      b. Modulating Control Valve Body Size may be reduced at most two pipe sizes from the line size or not less than 1/2 the pipe size. BAS subcontractor to size all water coil control valves for the application as follows:
   6. Booster-heat valves sized not-to-exceed 4-9PSI differential pressure. Size valve for 50 percent Valve Authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
   7. Primary valves sized not-to-exceed 5-15PSI differential pressure. Size valve for 50 percent Valve Authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
   8. Butterfly valves sized for modulating service at 60-70 degree rotation. Design velocity 12-feet per second or less when used with standard EPDM seats.
      a. Valve Mounting Arrangements to Comply to the Following:
         1) Provide unions on all ports of two-way and three-way valves.
         2) Install three-way equal percentage Characterized Control valves in a mixing configuration with the “A” port piped to the coil.
         3) Install 2½-inch and above, Three-Way globe valves, as manufactured for mixing or diverting service to the coil.

E. Control Damper:
   1. Dampers installed in accordance with manufacturer's instructions. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
   2. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

F. Air Flow Station: Install where required in ductwork and/or equipment with manufacturer's recommended straight ductwork upstream and downstream of air flow station, whichever is greater. Where equipment manufacturer's standard airflow measuring station cannot read airflows at required design velocities, provide appropriate air flow measuring station to provide accurate reading throughout system design operations range.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 31 13

METAL DUCTS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies plenums, sheet metal housings, ductwork, equipment connections, reinforcing and other devices required to make the air distribution systems complete and operational.

B. Type:

1. Ductwork and appurtenances shall be designed and fabricated specifically for the applications described under the conditions specified.

C. Design Criteria and Considerations:

1. General: Unless otherwise specified, sheet metal gage, reinforcing, hanger and support systems, ductwork joint types and other basic design construction details shall be in accordance with the 1985 Sheet Metal and Air Conditioning Subcontractors National Association (SMACNA) HVAC Duct Construction Standards. Ductwork shall be fabricated to the configurations and dimensions specified. Dimensions specified indicate net free area; dimensions shall be increased by the thickness of the lining where internal lining is required.
2. Low Pressure Ductwork: Low pressure ductwork shall convey air with a velocity less than 2000 fpm and maximum static pressure of 2 inches of water column. Low-pressure ductwork shall conform to 2-inch w.c. pressure class.
3. Medium Pressure Ductwork: Medium pressure ductwork, where specified, shall convey air with a velocity greater than 2000 fpm and a maximum static pressure of 6 inches of water column. Medium pressure ductwork shall conform to 6-inch w.c. pressure class.
4. System Leakage: All joints shall be sealed as required to limit total system leakage to a maximum of 1 percent of the specified equipment airflows.
5. Change In Duct Size: Change in duct size shall be made by a uniformly tapering section. The change in direction of the tapering section shall not be more than 1 inch in 5 inches of run, unless otherwise specified.
6. Bends In Duct: With the exception of mitered bends, all bends in ducts shall have inside radii equal to the duct width or diameter. Double wall turning vanes shall be provided at all 90-degree mitered bends.
7. Duct Sleeves: Whenever ducts extend through concrete or masonry walls, floors or ceilings, they shall be provided with a sleeve as specified in paragraph 2.04. Concrete inserts shall be provided before pour to support all ductwork under this section.
8. Duct Openings: Access doors or hand holes shall be provided in ducts at locations to reach modulating dampers, fusible links, controllers and any other moveable devices in the ducts. The opening shall be 1 inch less duct size or of adequate size to reach in and maintain these devices. Two-inch diameter nipples with threaded caps shall

be welded to the duct where specified or directed by the engineer for balancing the system.

9. Vibration Isolation Flexible Connections: Flexible connections shall be provided at duct connections to motor-driven air handling equipment and other locations specified. Flexible connections shall be UL approved and provided with the necessary angle, straps, bolts, clips, or other fasteners to secure the flexible material to the equipment and ducts. Flexible connections exposed to the weather shall be provided with approved sheet metal weather covers.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASHRAE CH 1	Handbook - Equipment Volume, Duct Construction
ASHRAE CH 33	Handbook - Fundamentals Volume, Duct Design
ASTM A525	General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A527/A527M	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM B209	Aluminum and Aluminum Alloy Sheet and Plate
ASTM B211	Aluminum and Aluminum Alloy Bar, Rod, and Wire
ASTM B308	Aluminum - Alloy 6061-T6 Standard Structural Shapes, Rolled or Extruded
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems
SMACNA	HVAC Duct Construction Standards Metal and Flexible
UBC	Uniform Building Code
UMC	Uniform Mechanical Code
UL 181	Factory-made Air Ducts and Connectors

B. Requirements Of Regulatory Agencies:

1. Ductwork construction, installation, and air system performance shall comply with UMC, ASHRAE CH-1 and CH-33, and SMACNA Duct Construction Standards.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Subcontractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Subcontractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. An 8-1/2-inch by 11-inch manual with detail sheets or catalog data of flexible duct connectors, duct sleeves, duct access doors, turning vanes, volume dampers, supports, hangers, etc.

PART 2 PRODUCTS

2.01 GENERAL

A. The Subcontractor shall provide all ductwork, plenums, and all auxiliary work and products of any kind necessary to make the HVAC systems complete and ready for operation. Ductwork shall comply with the following restrictions and conditions:
   1. Ductmate systems shall be used as an option by the Subcontractor for low pressure systems only.
   2. Snap lock seams shall not be permitted.
   3. Where space conditions permit, full radius turns shall be used at offsets.
   4. Turning vanes shall be provided where tees, bends, and elbows are not 1-1/2 times the width at centerline and in all rectangular elbows.
   5. Ductwork elbows, takeoffs, and fittings shall be in accordance with the SMACNA and ASHRAE standards for the pressure class and conditions specified.
   6. Visible duct deflection, loss of shape, or unwarranted noise or vibration resulting from faulty or inadequate support, reinforcing, metal gage, fabrication, or joint spacing shall be corrected at no expense to the Owner.

2.02 MATERIALS

A. Low and Medium Pressure Systems:

Component	Material
Duct	Galvanized steel, ASTM A525 and ASTM A527 or aluminum, alloy 3003-H14, conforming to ASTM B209 and ASTM B211
Duct sleeve	Galvanized steel, 10 gage or aluminum, alloy 3003-H14, conforming to ASTM B209 and ASTM B211

Component	Material
Flexible duct connector	Noncombustible, weather and ozone resistant, abrasion-proof woven fiberglass fabric with coating weighing not less than 24 ounces per square yard. Maximum flame spread rating of 25, smoke rating of 50 for all materials including connecting tape, etc. UL 181 approved.
Turning vanes	Galvanized steel or aluminum to match duct material.
Hangers and supports, rivets and bolts, reinforcing	Galvanized steel or aluminum, alloy 6061-T6 conforming to ASTM B308 to match duct material.

2.03 JOINTS AND REINFORCING

A. Transverse stiffeners and joints shall be appropriately spaced to maintain duct cross-section integrity in accordance with the pressure class specified and at the prevailing operating velocities. After joints are crimped, they shall be further secured by bottom punching or riveting. Longitudinal seams shall be Pittsburgh lock and shall be cross-broken outward. Intake, or exhaust, side ducts shall be cross-broken inward. Discharge ducts shall be cross-broken outward. All plenums and casings shall be similarly cross-broken and further reinforced with 1-inch x 1-inch x 1/8-inch angles running diagonally between joints, riveted to the casings.

B. Low pressure ductwork shall have slip joints. Medium pressure ductwork shall have flanged or welded joints. Joints shall not interfere with airflow in the ducts. Interior ducts shall be suitably braced and stiffened at floor and roof penetrations as well as over their unsupported length in a manner designed to maintain duct integrity and limit vibration and noise in accordance with recognized standards of the industry.

C. Ducts over 17 inches in largest dimension shall be cross-broken or beaded on all four sides. In ducts over 72 inches at each transverse joint 3/8-inch stay rods shall be installed. Spacing between rods or rods on side of duct shall not exceed 48 inches.

2.04 DUCT SLEEVES

A. Sleeve flanges shall not be less than 4 inches wide and shall be installed tight against each side of the barrier. Sleeves shall be 2 inches larger than the duct or external duct insulation. The space between the duct (or insulation) and the sleeve shall be packed with fiberglass or material of original wall. Duct flanges not less than 4 inches wide shall be installed tight against the wall on each side and fastened to the duct sleeves.

2.05 HANGERS AND SUPPORTS

A. General:
   1. Duct support spacing shall be in accordance with the SMACNA standards for the pressure class and conditions specified and prevailing in the system. Supports shall be spaced to prevent visible duct deflection and loss of system integrity. Aluminum ductwork shall be constructed with strength and dimensional stability comparable to conventional steel duct. In the absence of other criteria, aluminum sheet and reinforcing shall have a moment of inertia three times greater than that recommended for steel ductwork.

B. Concealed Ceiling Spaces:
   1. Rectangular ductwork shall be supported with metal strap hanger screwed to the sides and bottom of duct. One strap each side with minimum of two screws in side and one in bottom of each strap.

C. Exposed Areas:
   1. Rectangular ductwork shall be supported with shelf angle trapeze hanger or unistrut with rods or angles by welding or bolting. Sway bracing shall be provided, minimum of one at right angle to each duct run.
   2. Round ductwork shall be supported with two half round bands with rods bolted to the bands. Sway bracing shall be provided, minimum of one at right angle to each duct run.

2.06 ACCESS DOORS

A. The doors shall be rigid and shall be provided with airtight gaskets and shall not vibrate or cause noise under service. Doors in insulated ducts shall be the insulated type. Doors shall be continuous hinged type with ventlock latch on outside.

B. Plenum access doors shall be 24 inches by 66 inches or as specified.

2.07 FLEXIBLE CONNECTIONS

A. Flexible connection joints shall be airtight and have a minimum allowance of 1-inch slack all around. Flexible connections shall be designed to be removed from the line and be reinstalled without disassembling adjacent ductwork.

B. Connections shall be installed with a minimum 4-inch clearance between metal parts on fan connections, equipment connections, and our distribution devices.

2.08 TURNING VANES

A. Turning vanes shall be 2-inch blades for ducts up to 18 inches in either dimension and shall be 4-1/2-inch blades for larger ducts. All turning vane assemblies shall be finished with an air-dried phenolic corrosion resistant coating prior to installation. All turning vanes shall be constructed of double thickness vanes.

2.09 DAMPERS

A. Manually operated, opposed blade or single blade, quadrant-type balancing dampers shall be provided in each branch duct take-off after leaving the main duct on low pressure systems. Balancing dampers shall be provided on medium pressure systems where specified. Splitter dampers shall be provided only where specified.

B. Single-blade dampers shall be constructed for ducts 9-1/2 inches by 30 inches and smaller. Opposed blade dampers shall be constructed with a maximum blade size of 12 inches by 72 inches.

2.10 DUCTWORK COATING

A. Exposed uninsulated or internally insulated ductwork shall be coated on all external surfaces in accordance with Section 09 90 00 except in mechanical rooms.

PART 3 EXECUTION

3.01 INSTALLATION

A. Ductwork shall be installed in accordance with SMACNA and NFPA. All ductwork indicated on the drawings is schematic. Therefore, changes in duct size, duct configuration, and location may be necessary to conform to field conditions.

B. Ductwork and accessories shall be installed to provide a system free from buckling, warping, breathing, and vibration. Ductwork installation shall permit installation of other required services without piercing, crimping, or reducing duct sizes. Where space conditions permit, full radius turns shall be used at offsets. The inside of all ducts visible through grilles and registers shall be painted flat black.

C. All ductwork shall be made airtight. Flanged joints shall be sealed with closed-cell neoprene gaskets compressed between mating flanges. All other joints and seams shall be sealed with liquid or mastic type sealants. Taped joints shall not be permitted. All joints shall comply with the requirements of SMACNA Seal Class A.

D. All duct fittings shall be fabricated with continuously welded seams and joints.

3.02 TESTS

A. Tests shall be as specified in Section 23 05 93. Duct test holes with patches in ducts shall be provided where directed or necessary for testing and balancing purposes.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 34 16.26

CENTRIFUGAL HVAC IN-LINE FANS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies duct-mounted, in-line fans complete with fans, motors, and accessories required for ventilation systems.

B. Operating Requirements:

1. Fan motors shall be nonoverloading on all points of the operating curve. Fans shall be designed for continuous duty service and to comply with the equipment schedules in the drawing package.

C. Sound and Vibration:

1. Fans specified in this section shall operate at noise levels below 30 sones, as defined by AMCA Standard 300, and at tip speeds below 8000 FPM.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AMCA Standard 210	Laboratory Methods of Testing Fans for Rating
AMCA Standard 300	Test Code for Sound Rating

B. Certification:

1. Fans shall bear the AMCA rating seal.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with the requirements of Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Subcontractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Subcontractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Fan performance curves for the specified operating conditions.
4. Motor data Section 43 05 21-Form A as required in Section 43 05 21.

1.04 ENVIRONMENTAL CONDITIONS

A. Environmental conditions referenced in Section 01 11 80.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Fans shall be straight-through centrifugal, in-line fans manufactured by Carnes, Greenheck, Penn, or equal, modified as necessary to provide the specified features and to meet the specified operating conditions.

2.02 MATERIALS

Component	Material
Fan wheel	Aluminum
Fan wheel shaft	Steel
Fan housing	Spun Aluminum
Fasteners	Stainless steel

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Subcontractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 EQUIPMENT

A. Fan:
   1. The fan housing shall be square or rectangular in design and shall be provided with duct mounting collars at the inlet and outlet for connection to rectangular ductwork.
   2. Fan housing shall be designed to provide access to the motor and fan unit through a gasketed access door. The fan inlet shall be provided with a venturi throat that is overlapped by the fan wheel.
   3. The fan wheel shall have backward inclined blades as provided standard by the manufacturer for the specified conditions. The wheel shall be statically and dynamically balanced at the factory. The fan wheel shaft, on belt-driven fans, shall be mounted in a heavy duty, permanently sealed, permanently lubricated, ball bearing pillow block. Bearings shall be rated for a minimum AFBMA L-10 bearing life of 100,000 hours.
   4. The entire drive assembly, as a unit, shall be removable without removing the fan assembly from the ductwork. Belt-driven fans shall be furnished with adjustable pitch sheaves and adjustable motor bases suitable for a plus or minus 5 percent adjustment in operating speed. The V-belt drive shall be as specified in Section 43 05 11-2.03.

B. Motor:
   1. Unless otherwise specified, the motor shall operate at 1750 rpm and shall be Type 2 as specified in Section 43 05 21. Motors 1 HP and larger shall be the high efficiency type. Motors 1/12 HP and smaller shall be the fan manufacturer's standard motor. Motors shall be mounted on vibration isolators and shall be sealed from the exhaust air stream. A motor and belt cover shall be provided on all belt-driven fans. A unit mounted disconnect switch shall be provided on each fan housing. A flexible conduit, connecting the disconnect to the fan motor, shall be provided. The conduit shall be of sufficient length to permit access to the motor and drive assembly without disconnecting the wiring.

C. Accessories:
   1. Each fan shall be provided with vibration isolators for fan mounting as specified. Fan inlet guards shall be provided on fans with nonducted inlets.

2.04 SPARE PARTS

A. One set of V-belts shall be provided for each belt-driven fan.

2.05 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Motor data as specified in Section 43 05 21-2.05.

2. Certification that the units have been tested and rated in accordance with the applicable AMCA Standard Test Code and Certified Ratings Program.
3. Applicable operating and maintenance data in accordance with Section 01 78 23.

PART 3 EXECUTION

3.01 INSTALLATION

A. Each fan shall be installed as specified and in accordance with manufacturer's recommendations. Flexible duct connections shall be provided where the fan connects to ductwork.

3.02 FIELD TESTING

A. Each fan shall be completely field tested in accordance with Section 23 05 93 to guarantee compliance with the project manual.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 34 16.33

CENTRIFUGAL HVAC WALL EXHAUST FANS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies wall mounted exhaust fans complete with fans, motors, dampers and accessories required for ventilation systems.

B. Operating Requirements:

1. Fan motors shall be non-overloading on all points of the operating curve. Fans shall be designed for continuous duty service and to comply with the equipment schedule in the drawing package.

C. Sound and Vibration:

1. Fans specified in this section shall operate at noise levels below 30 sones, as defined by AMCA Standard 300, and at tip speeds below 8000 fpm.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AMCA Standard 210	Laboratory Methods of Testing Fans for Rating
AMCA Standard 300	Test Code for Sound Rating

B. Certification:

1. Fans shall bear the AMCA rating seal.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with the requirements of Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Subcontractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Subcontractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Fan performance curves for the specified operating conditions.
4. Motor data as required in Section 43 05 21.

1.04 ENVIRONMENTAL CONDITIONS

A. Environmental conditions referenced in Section 01 11 80.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Fans shall be weatherproof, horizontal discharge, centrifugal exhaust fans manufactured by Aerovent, Greenheck, Loren Cook, Penn, or equal, modified to provide the specified features and to meet the specified operating conditions.

2.02 MATERIALS

Component	Material
Mounting plate	Aluminum
Fan wheel	Aluminum
Fan wheel shaft	Steel
Fan housing	Spun aluminum
Windband	Aluminum

Component	Material
Fasteners	Stainless steel
Damper	Aluminum

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Subcontractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 EQUIPMENT

A. Fan:
   1. Fan housing shall be designed to provide easy access to the motor and fan unit. The fan inlet shall be provided with a venturi throat that is overlapped by the fan wheel.
   2. The fan wheel shall have backward inclined blades as provided standard by the manufacturer for the specified conditions. The wheel shall be statically and dynamically balanced at the factory. The fan wheel shaft, on belt-driven fans, shall be mounted in a heavy duty, permanently sealed, permanently lubricated, ball bearing pillow block. Bearings shall be rated for a minimum AFBMA L-10 bearing life of 100,000 hours.
   3. The entire drive assembly, as a unit, shall be removable without removing the fan assembly from the wall. Belt-driven fans shall be furnished with adjustable pitch sheaves and adjustable motor bases suitable for a plus or minus 5 percent adjustment in operating speed. The V-belt drive shall be as specified in Section 43 05 21-2.03.

B. Motor:
   1. Unless otherwise specified, the motor shall operate at 1750 rpm and shall be Type 2 as specified in Section 43 05 21. Motors 1 HP and larger shall be the high efficiency type. Motors 1/12 HP and smaller shall be the fan manufacturer's standard motor. Motors shall be mounted on vibration isolators and shall be sealed from the exhaust airstream. Air for the motor shall be introduced by means of an air intake tube, from a location free of discharge contaminants.
   2. Each fan housing shall contain a weatherproof motor shutoff switch and a watertight conduit penetration.

C. Damper:
   1. Each fan shall be provided with spring loaded barometric type, aluminum backdraft dampers at the fan inlet.

D. Accessories:
   1. All fans shall be provided with aluminum or galvanized steel bird screens.

2.04 SPARE PARTS

A. One set of V-belts shall be provided for each belt-driven fan.

2.05 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00.
   1. Motor data as specified in Section 43 05 21.
   2. Certification that the units have been tested and rated in accordance with the applicable AMCA Standard Test Code and Certified Ratings Program.
   3. Applicable operation and maintenance data in accordance with Section 01 78 23.

PART 3 EXECUTION

3.01 INSTALLATION

A. Each fan shall be installed as specified and in accordance with manufacturer's recommendations.

3.02 FIELD TESTING

A. Each fan shall be completely field tested in accordance with Section 23 05 93 to guarantee compliance with the project manual.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 37 13.13

DIFFUSERS, REGISTERS AND GRILLES

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies all diffusers, registers, and grilles associated with the heating, ventilating, and air conditioning systems.

1.02 QUALITY ASSURANCE

A. Reference:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI / ASHRAE 70	Method of Testing the Performance of Air Outlets and Air Inlets
SMACNA	Sheet Metal and Air Conditioning Subcontractors' National Association

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Subcontractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting

the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Subcontractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Catalog data and a complete description of the diffusers, registers, grilles, and accessories.
3. Specified air quantity, discharge pattern, throw, static pressure drop, and acoustical performance.

PART 2 PRODUCTS

2.01 GENERAL

A. A factory applied finish shall be provided as scheduled on the drawings. Color for diffusers installed in ceilings shall match ceiling tile color. Each unit shall be set flat against the room surface finish and shall have a felt gasket or seal to prevent air leakage. Diffusers, grilles, and registers shall be as specified on the drawings. All air outlets shall be factory painted and protected prior to shipment. Color shall be as selected by the Engineer. All diffusers, registers, and grilles shall be by a single manufacturer.

2.02 MANUFACTURERS

A. The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement however shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed to mean that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include Titus, Hart & Cooley, or equal.

2.03 DAMPERS

A. Dampers where specified shall be of the same material as the diffuser, furnished by the diffuser manufacturer, and shall be operated by a key through the diffuser face.

PART 3 EXECUTION

3.01 INSTALLATION

A. Diffusers, registers, and grilles shall be aligned, connected, and installed in accordance with the manufacturer's recommendations and with SMACNA Standards. Adjust diffuser vanes to maximize air coverage in the room being ventilated.

3.02 TESTING AND BALANCING

A. Testing, adjusting, and balancing shall be as specified in Section 23 05 93.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 23 82 00

HEATING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies provisions for the selection, installation and testing of heating units, including:
   1. Electric Heaters

1.02 RELATED SECTIONS

A. As required by Section 23 00 00 and Division 01 - General Requirements.

1.03 QUALITY ASSURANCE (IN ADDITION TO 23 00 00)

A. Reference Standards:
   1. This Section incorporates by reference the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
AHRI 410	Standard for Forced Circulation Air-Heating and Air-Cooling Coils
AGA Z83.8	Gas Unit Heaters
IFGC	International Fuel Gas Code

PART 2 PRODUCTS

2.01 GENERAL

A. Motors shall comply with Section 43 05 21.

B. Thermostats shall be either 24-volt or 120-volt type for remote mounting unless noted otherwise. See Section 23 09 00 for specific control requirements.

2.02 ELECTRIC HEATERS

A. Electric Unit Heaters: Electric unit heaters shall be factory fabricated unit heater assembly bearing the UL label. Heaters shall be assembled in heavy gauge steel cabinets, shall have horizontal air flow discharge and shall be furnished with wall or ceiling mounting support brackets, disconnect switch, contactors, relays, transformers,

thermostats, internal wiring, adjustable air flow louvers, and interwiring between the components. Unit heaters shall be Trane UHEC; Reznor Model EGEB; Chromalox Model LUH; Qmark Model MUH; or Approved Equal.

B. Corrosion Resistant Electric Unit Heaters: Corrosion resistant unit heaters shall be installed in all chemical storage areas. Corrosion resistant unit heaters shall be factory fabricated assemblies bearing the UL label. Heaters shall be assembled in powder coated steel cabinets, furnished with wall or ceiling mounting support brackets, adjustable louvers, factory assembled control center, steel core heat exchanger with aluminum fins and aluminum fan blade. Corrosion resistant unit heaters shall be Reznor Model EWHB; Chromalox Model HD3D; Qmark JUW; or Approved Equal.

C. Electric Duct Heaters: Duct heater shall be assembled with heavy gauge steel frame for duct installation and shall be supplied with a NEMA 4X temperature control panel equipped with disconnect switch, contactors, relays, transformers, thermostat, internal wiring, interwiring between the components and a fan interlock relay. Electric duct heater shall be Nailor Model DH; Carnes Model AX; Chromalox Model CAB; or Approved Equal.

D. Electric Wall Heaters: Electric wall heaters shall be factory fabricated assembly bearing the Underwriters Laboratories label. Units shall have horizontal airflow discharge and shall be suitable for either recessed wall mounting or surface mounting as shown on the Drawings, internal wiring, contactors relays, and transformers. Thermostats shall be integral, unit mounted. Unit heaters shall be QMark Model CRA; INDEECO Model WLI; or Approved Equal.

E. Electric Baseboard Heaters: Electric baseboard heaters shall be factory fabricated assembly bearing the Underwriters Laboratories label. Units shall be suitable for surface mounting utilizing steel support brackets as shown on the Drawings. Heating element wire shall be encased in steel sheath with bonded aluminum fins. Enclosure shall be fabricated with minimum 0.024 inch steel with 0.040 inch junction boxes and 0.048 inch steel front cover. Enclosure shall be provided with a powder coated finish. Unit shall be complete with all required internal wiring, contactors relays, and transformers. Provide factory installed thermal cut-out and double pole disconnect switch. Thermostats shall be remote mounted, line voltage. Unit heaters shall be QMark Model QMKC; or Approved Equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. General Requirements: Section 23 00 00.

B. Install in accordance with manufacturer's instructions. Comply with NEC and UL listings.

C. Install thermostat where shown on the Drawings or coordinate with the engineer. Provide control wiring from thermostat to unit.

D. Avoid interference with structure and with work of other trades, preserving adequate headroom and clearing doors and passageways. Check each piece of equipment for defects, verifying that items function properly and that adjustments have been made.

E. Damaged Coils: Make every effort to prevent damage to both built-up coils and coils of packaged equipment. Comb damaged coil fins to be straight.

F. Electric Duct Heaters: Support units rigidly from structure. Seal air tight around frame. Provide access to each side of elements. Electric coils to comply with voltage, wattage, number of steps and accessories as specified, and installed in uniform air flow entering and leaving. Provide controls that are completely accessible as installed.

G. Hot Water And Electric Unit Heaters: Suspend from structure with 5/8-inch diameter rods and per manufacturer instructions.

H. Electric Wall Heaters: Install heaters in place with box trim flush with finished wall.

3.02 TESTING

A. Procedures: Section 23 05 93.

3.03 WARRANTY

A. The heating units shall also be warranted by the Manufacturer for a minimum of 12 months from the date of start-up or 18 months from the date of delivery to the project site, whichever occurs first. Warranty shall cover the entire system, the equipment and the components provided as part of this system. Whenever available, longer warranties on subassemblies or individual equipment items shall be given. Wear items may be prorated for any warranty over one year.

END OF SECTION

(FILED SUB-BID REQUIRED)

SECTION 26 05 00.01

COMMON WORK RESULT FOR ELECTRICAL

PART 1 – GENERAL

1.00 GENERAL PROVISIONS REQUIRED

A. A filed sub-bid shall be submitted for the entire electrical work as specified herein.

B. The instructions to Bidders, Bid Form, Agreement, General Conditions and complete specifications are hereby made a part of these Specifications and Subcontractor shall consult them in detail for instructions.

C. Sub bids for the work under this section of the specification must be filed under the appropriate item as provided in Division 0 of these specifications

D. The drawings on which the work of this section is based on drawings “E-00-001” through “E-70-602” This listing of Contract Drawings shall not limit the responsibility of the Electrical Subcontractor to determine the full extent of their electrical work as required by all of the Contract Drawings. Note, for a detailed list of the project drawings refer to the drawing index.

E. In accordance with Massachusetts General Laws, Chapter 149, Sections 44A through 44J, the engineer hereby declares that all work of this Section shall be estimated under the appropriate item.

1.01 DESCRIPTION

A. Scope: This section specifies general requirements for electrical work. Project Detailed requirements specified in other sections are subject to the general requirements of this section.
   1. Furnish labor, equipment, tools, materials, supplies, and perform operations necessary to install a complete and operable electrical system. Furnish incidental material and perform work shown on the Drawings and in the Specifications.
   2. Perform electrical work and provide material and equipment in compliance with applicable National, State, and Local codes, regulations, laws, and ordinances.
   3. Obtain electrical permits, arrange for required inspections, correct deficiencies resulting from inspections, and pay permit fees and inspections charges. Pay fines and the cost of extra work incurred by action or inaction of the Subcontractor, at no additional cost to the Owner.
   4. Furnish properly executed certificates of final electrical inspection and approval from the Code Authority Having Jurisdiction (AHJ) at the conclusion of the work, before final acceptance.
   5. Adhere to the Area Classification shown for the product required and the installation required. Provide products in Hazardous Classified Areas in accordance with NEC Article 500 for the Class and Division specified or identified and products in corrosion areas in accordance with this specification.

6. Maintain a complete set of Contract Drawings in “Record” condition, available for review by the Owner or Engineer. Mark, initial, and date changes, modifications, or corrections, as they occur. Refer to Section 01 78 39 Project Record Documents for record drawing requirements.
7. Field verify the exact locations of equipment or equipment terminations. Use accepted equipment submittals as the basis of the conduit openings and slab penetrations.

B. NOT USED

C. Drawing Definitions and Requirements:
   1. Elementary or Schematic Diagram: Shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement that facilitates tracing the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.
   2. One-Line Diagram: Shows by means of single lines and graphical symbols the course of an electrical circuit or system of circuits and the components, devices or parts used therein. Physical relationships are usually disregarded.
   3. Block Diagram: Diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
   4. Wiring Diagram or Connection System: Includes all of the devices in a system and shows their physical relationship to each other including terminals and interconnecting wiring in an assembly. A panel layout diagram shows the physical location of devices and the wiring connections.
   5. Interconnection Diagram:
      a. Shows external connections between terminals of equipment in panels or electrical assemblies and outside points, such as motors, auxiliary devices, control devices, and instruments. Provide references to connection diagrams that interface to the interconnection diagrams of the continuous line type.
      b. Show bundled wires as a single line with the direction of entry/exit of the individual wires clearly shown. Show each wire identification as actually installed. Wireless diagrams and wire lists are not acceptable.
      c. Provide wire identification for each end of the same wire for devices and equipment, indicate terminal blocks identification actually installed with individual terminal identification.
      d. Show jumpers, shielding and grounding termination details not shown on the equipment connection diagrams on the interconnection diagrams. Wires or jumpers shown on the equipment connection diagrams shall not be shown again on the interconnection diagram. Signal and DC circuit polarities and wire pairs shall be shown. Show spare wires and cables.
   6. Arrangement, Layout, or Outline Drawings: Shows the physical space and mounting requirements of a piece of equipment and may indicate ventilation requirements, space provided for connections, or the location connections are to be made.
   7. Drawing Cross-Referencing:
      a. Reference each submittal drawing submitted to the associated Contract Document and indicate the one-line diagrams, schematics, control diagrams, block diagrams, and Process and Instrumentation Diagrams (P&IDs) cross-referenced on the submittal drawings.

b. Internally cross-reference submittal drawings related to the same subject shall be referenced to other submittal drawings. Failure to cross-reference Contract Documents with the submittal shall be cause for rejection of the entire submittal with no further consideration.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI A58.1 / ASCE 7	Minimum Design Load in Buildings and Other Structures, 1982
ANSI C80.1	Rigid Steel Conduit - Zinc Coated, 1994
ASTM B3	Standard Specification for Soft or Annealed Copper Wire, 2001
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft, 1999
ASTM B33	Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes, 2000
ICEA S-68-516 / NEMA WC 70, 71, & 74	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
ICEA S-95-658	Standard for Non-Shielded Power Cables Rated 2000 Volts or Less, 2000
IEEE 81	Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System, 1983
IEEE 383	Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations, 1974 (1992)
NEMA TC2	Electrical Polyvinyl Chloride (PVC) Conduit, 2003
NEMA 250	Enclosures for Electrical Equipment (1000 Volt Maximum)
NEMA WC-70	Non-Shielded Power Cable 2000V or Less (ICEA S-95-658), 1999 (2001)
NEMA WD-1	General Requirements for Wiring Devices, 1999
NFPA 70	National Electrical Code (NEC)
UBC	Uniform Building Code
UL 6	Electrical Rigid Metal Conduit – Steel, 12th Edition, 2000 (2003)
UL 44	Thermoset-Insulated Wires and Cables, 15th Edition, 1999 (2002)

Reference	Title
UL 67	Panelboards, 11th Edition, 1993 (2003)
UL 83	Thermoplastic-Insulated Wires and Cables, 13th Edition, 2003 (2004)
UL 263	Fire Tests of Building Construction and Materials, 13th Edition, 2003
UL 360	Liquid-Tight Flexible Steel Conduit, 5th Edition, 2003
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, 10th Edition, 2002 (2003), Adopted: NEMA AB 1-1999
UL 1277	Electrical Power and Control Tray Cables with Optional Optical-Fiber Members, 4th Edition, 2001 (2003)

B. Listed and Labeled Products:
   1. Provide electrical equipment and materials listed or labeled by an independent testing laboratory for the purpose for which they are to be used and provide associated testing laboratory label.
   2. The independent testing laboratory shall be acceptable to the inspection authority having jurisdiction. Test Laboratory examples: Underwriters Laboratories (UL), Electrical Testing Laboratories (ETL), and Canadian Standards Association (CSA).
   3. Include costs and expenses incurred for special inspections in the contract price for electrical products required to undergo a special inspection either at the manufacturer's place of assembly or at the installed location by the local inspection authority when a product is not available with a testing laboratory listing or labeling.

C. Factory Tests:
   1. Perform factory tests at the place of fabrication and on completion of manufacture or assembly where specified in the individual product specification section.
      a. Include the costs of factory tests in the contract price.
      b. Include the costs of Engineer witness of factory tests in the contract price.

1.03 SUBMITTALS

A. The following information shall be provided for all electrical equipment and materials in accordance with Section 01 33 00:
   1. Catalog cuts of equipment, devices, and materials requested by the individual specification sections.
      a. Catalog information with technical specifications and application information including ratings, range, weight, accuracy, and other pertinent product information.
      b. Edit catalog cuts to show only the items, model numbers, and information that apply.
      c. Assemble catalog cuts in a folder or three ring binders with a cover sheet, indexed by item, and cross-referenced to the appropriate specification paragraph.
   2. Arrangement, layout, and outline drawings with dimensions and weight, as appropriate.
   3. Control schematics and interconnection wiring diagrams depicting internal and external wire and cable terminations. Drawing cross-reference to specification and Contract Document drawings.

1.04 DRAWINGS

A. Prepare specified drawings on 11-inch by 17-inch drafting media complete with borders and title blocks clearly identifying project name, equipment and the scope of the drawing.

B. Prepare drawings to reflect the final constructed state of the project installation or supplied equipment. Provide drawing quality, clarity, and size of presentation to permit insertion in operation and maintenance manuals.

1.05 PROJECT/SITE CONDITIONS

A. General:
   1. Unless otherwise specified, equipment and materials shall be sized and de-rated for the ambient conditions specified in Section 01 11 80, but not less than an ambient temperature of 40 degrees C at an elevation ranging from sea level to 3000 feet without exceeding the manufacturer's stated tolerances.

B. The following areas are designated as corrosive:
   1. Areas as indicated on drawings.

C. Hazardous (Classified) Areas:
   1. Wet Wells and areas as indicated on drawings.

D. Seismic:
   1. Electrical equipment and supports shall be braced in accordance with all applicable building codes.

E. Construction Materials:
   1. Refer to the individual specification section for each component for material composition and installation practices.
   2. Construction materials required for each area classification are listed in the following table that specifies the type of raceway required for each location and application by RACESPEC sheet. Unscheduled conduit shall be galvanized rigid steel conduit: RACESPEC type RMC-Steel.

Location	Application/Condition	RACESPEC
Indoor non-corrosive	Exposed	RMC-Steel
Indoor corrosive	Exposed	PVC coated RMC-Steel
Outdoor	Exposed	RMC-Steel
Hazardous	Exposed	RMC-Steel
Concealed	Embedded in concrete structure or beneath slab-on-grade	RMC-Steel, RNC40, or RNC80, as shown
Underground	Instrumentation, communications and data signals encased in concrete, ductbank	RMC-Steel, RNC40, or RNC80, as shown
Underground	Instrumentation, communications and data signals directly buried	RMC-Steel, RNC40, or RNC80, as shown
Underground	Power directly buried (Non-Power Utility)	RNC40
Nonhazardous	Final connection to equipment	RMC-Steel

Location	Application/Condition	RACESPEC
Hazardous	Final connection to equipment	Fittings per NEC Article-500 for the Classified Hazardous Area identified.
Corrosive	Final connection to equipment	PVC coated RMC-Steel, NC40, RNC80, Flexible Steel Fittings, as appropriate

Notes:

1. *Install conduit connections to control stations, enclosures, and device boxes through threaded hubs.*
2. *Install flexible conduit for final connections to devices, equipment and motors not exceeding 18 inches. Limit length to 36 inches where flexibility is required.*
3. *Mount enclosures, device boxes, control stations, and raceway systems with 1/4-inch (minimum) air space between the electrical system and supporting structure.*

1.06 STORAGE OF MATERIALS AND EQUIPMENT

A. Store equipment and materials in the factory-sealed container and protect with additional covering and materials to avoid physical damage or weather damage.

1.07 ELECTRICAL NUMBERING SYSTEMS

A. Raceway Numbers:
   1. Tag raceways with brass tags at the access locations including manholes, pull boxes, junction boxes, and at the terminations.
   2. Tag raceways with aluminum tags where subject to hydrogen sulfide atmosphere typically found at wastewater treatment facilities.
   3. Raceway numbers are derived from the “Cable and Conduit Schedule” or the ductbank cross-sections. Where raceway numbers are not provided, use the circuit number on the power and control single line diagrams.

B. Wire and Cable Circuit Numbers:
   1. Identify wire and cable circuit numbers at both ends. Refer to the circuit labeling method specified and shown in the drawings to label circuits.
   2. .Include copies of schematic diagrams, wiring connection diagrams, and interconnection diagrams inside of the equipment enclosure, protected in a plastic container in the equipment print holder.

C. Motor Control Centers:
   1. Identify new field devices and circuit breakers at motor controls centers with a plastic laminate nameplate. At the circuit breaker, this nameplate shall be used to clearly convey the equipment fed by the new breaker and to clearly identify the conductor identification means used at that piece of equipment (i.e. Phase A=Brown, Phase B= Orange, C=Yellow).
   2. At the device, the nameplate shall be used to clearly convey which circuit breaker feeds it and the conductor identification means used at that piece of equipment (i.e. Phase A=Brown, Phase B= Orange, C=Yellow).

PART 2 – PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. General:
   1. Provide new equipment and materials free from defects. Provide material and equipment of the same or a similar type of the same manufacturer throughout the work. Use standard production materials wherever possible.

B. Paint Finish and Galvanizing:
   1. Paint installed and unpainted electrical construction materials as specified in Section 09 90 00. Galvanize products, supports, etc. as specified in the Hot-Dip Zinc Coating section.

2.02 RACEWAYS, BOXES, AND SUPPORTS

A. Raceways and Boxes:
   1. Pullboxes, handholes, and device boxes are generally called boxes herein. Size boxes, manholes, and handholes in accordance with the National Electrical Code. Provide separate raceways for lighting, receptacles, power, control, instrumentation, and signaling systems.

B. Boxes and Wireways:
   1. Provide indoor boxes, larger than FD boxes, constructed of stainless steel.
   2. Provide boxes constructed of Grade 316L stainless steel rated NEMA-4X for corrosive areas and for outdoor locations.
   3. Size and provide wireways at locations above and below boxes, panels and groups of devices. Comply with the NEC sizing for conductor fill requirements. Wireway NEMA type shall match the location and area classification and equipment NEMA enclosure ratings.

C. Terminal Cabinets:
   1. Provide cabinets located indoors-conditioned space with NEMA-12 rating. Provide cabinets located outdoors, in process areas and in corrosive areas with NEMA-4X rating of stainless steel. Provide cabinets with hinged doors and 2 or 3-point stainless steel quick release latches with locking features via handle or latching clasps with provisions for padlocks.
   2. Provide adjustable terminal strip mounting accessories and with channel mounted terminal blocks rated 30 amperes, 600 volt AC. Provide No. 8 minimum strap-screw type terminal strip, suitable for ring tongue, locking spade terminals. Provide Phoenix Contact products with capture feature and terminal identification method per terminal, as specified.

D. Handholes and Pullboxes:
   1. Handholes and pullboxes generally called boxes herein, contain wires, cables, and conductors. Provide box dimensions where shown. Provide boxes per NEC sizing rules where the dimensions are not sized or shown.

2. Provide concrete boxes with covers designed for H-20 loading in traffic areas. Engrave box cover: "ELECTRICAL". Provided boxes with hinged, aluminum checkered plate covers with pull-handle to open in non-traffic areas.
3. Provide precast Quazite Compsolite cement/polymer products, or equal, for handholes and pullboxes, for projects where precast concrete is not specifically shown or specified.

E. Raceway and Box Supports:
1. Provide stainless steel framing channel with end caps to support groups of conduit. Provide individual conduit supports that have one-hole stainless steel malleable iron pipe straps used with stainless steel clamp backs and nesting backs.
2. Provide stainless steel supports, channel, fittings, all-thread, and fasteners in outdoor locations, in corrosive areas, and as shown. Provide factory end-caps for supports and channels.
3. Independently support boxes by stainless steel brackets, expansion bolts, toggle bolts, or machine or wood screws as appropriate. Wooden or plastic plugs inserted in masonry or concrete shall not be used as a base to secure boxes, nor shall welding or brazing be used for attachment.

F. Underground Marking Tape:
1. Provide low-density, polyethylene plastic, underground marking tape and install above and centered for early warning protection for digging near electrical ductbanks.
2. Provide Brady "Identoline"; Services and Materials "Buried Underground Tape"; Somerset (Thomas & Betts) "Protect-A-Line"; or equal. Provide tape with nominal dimension of 6 inches wide, 4-mil thickness.
3. Provide underground marking tape 6-inch wide metallic-lined tape with red polyethylene film on top and with clear polyethylene film on the bottom of the tape for installation above and centered on direct buried cables and conduits without ductbank encasement.
4. Provide black over red marking tape clearly printed with: "CAUTION ELECTRIC LINE BURIED BELOW", or provide OSHA approved marking tape.

G. Nameplates:
1. Provide nameplates for all boxes and enclosures with nameplate wording as shown on the drawings. Provide the tag number or box number with device functional description on device nameplate. Nameplate wording may be changed without additional cost where changes are made during the submittal process or prior to commencement of engraving.
2. Provide machine engraved laminated white phenolic nameplates with black lettering for panel-mounted equipment with the instrument tag number/description in 5/32-inch minimum size lettering and attach to the panel or enclosure with a minimum of two self-tapping 316 stainless steel screws. Provide nameplates for power sources indicating the power loads and nameplates for power loads that indicate the power sources, in accordance with these specifications and the NEC.

H. Raceway Markers:
1. Provide raceway markers: 0.036-inch minimum thickness, solid brass tags or aluminum tags with raceway number or the circuit number, stamped in 3/16-inch

minimum height characters and attach tags to the raceway with 316 stainless steel wire. Install raceway markers inside of pull boxes, handholes, manholes, and where entering electrical equipment enclosures.

2. Provide raceway markers indicating the power source and circuit number for lighting and receptacle raceways to the associated panelboard. Interior lighting and receptacle raceways do not require raceway markers for conduit between components.

I. Identification Tags:

1. Provide the following:
   a. Equipment: Typical size 1-inch x 3-inch wide, white with black engraved equipment number and equipment description.
   b. Raceway/Conduit: Tags with raceway or conduit number or circuit shown.
   c. Instrument: 1.5-inch wide, aluminum tag with instrument number and description.
   d. Conductor: Power, control, or instrument cable with the circuit identified as shown; power source or power/control panel identified; power load, equipment, instrument, or device identified; purpose of the conductors identified.
   e. Fastener: nylon-coated 48-mil stainless steel wire. Manufacturer: Brady catalog number 23310 or equal with double ferrule type brass wire clamps. Manufacturer: Brady number 23312.

J. General Raceway Requirements:

1. Provide additional pullboxes for conduit runs with greater than 360 degrees in any run between pull boxes. Limit maximum conduit runs without additional pullboxes to 400 feet, less 100 feet for every 90 degrees for the conduit run change in direction.
2. Determine conduit routing that conforms to the installation requirements set forth herein and in accordance with the NEC requirements for size and number of pullboxes. The RACESPEC sheets with specified requirements begin on the next page.

2.03 RACEWAY SPECIFICATION SHEETS (RACESPEC) - RMC-STEEL

A. Raceway Identification:

1. RMC-Steel

B. Description:

1. Rigid Steel Conduit

C. Compliance:

1. ANSI C80.1, UL 6

D. Finish:

1. Hot-dip galvanized after fabrication, inside and outside. Smooth finished surfaces.

E. Manufacturers:

1. Allied Tube and Conduit Corp., Wheatland Tube Co., or equal.

F. Minimum size:
   1. Unless otherwise shown: 3/4-inch for exposed; 1-inch for concealed or embedded; 2-inch for ductbank encased.

G. Fittings:
   1. Hubs:
      a. Insulated throat with bonding locknut, hot-dip galvanized. The hubs shall utilize a neoprene "O" ring and shall provide a watertight connection. O-Z Gedney, CHM-XXT, or equal.
   2. Unions:
      a. Electro-galvanized ferrous alloy type Appleton UNF or UNY, Crouse-Hinds UNF or UNY, or equal. Threadless fittings are not acceptable.

H. Boxes:
   1. Indoor:
      a. Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square. NEMA-12 welded steel 6 inches square and larger. Door shall have hinges with clamp locks. Boxes in process areas shall be NEMA-4 watertight. Boxes in corrosion areas shall be NEMA-4X.
      b. Conduit bodies: ferrous alloy type with screw taps for fastening covers. Gaskets shall be made of neoprene.
   2. Outdoor:
      a. Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square. NEMA-4X stainless steel nonmetallic for 6 inches square and larger.

I. Elbows:
   1. (3/4" thru 2.5")
      a. Factory fabricated or field bent.
   2. (3" thru 6")
      a. Factory fabricated.

J. Conduit Bodies:
   1. (3/4" thru 4")
      a. Malleable iron, hot-dip galvanized, unless otherwise noted. Neoprene gaskets for all access plates. Tapered threads for all conduit entrances.
   2. (5" and 6")
      a. Electro-galvanized iron or cast iron box.

K. Expansion Fittings:
   1. Expansion fittings in embedded runs shall be watertight and shall be provided with an internal bonding jumper. The expansion material shall be neoprene and shall allow for 3/4-inch movement in any direction.

L. Manufacturers:
   1. Appleton, Crouse-Hinds, Hubbell, O. Z. Gedney, or equal.

M. Installation:
   1. Rigid steel conduit shall be made up tight and without thread compound. Joints shall be made with standard couplings or threaded unions. Steel conduit shall be supported away from the structures using hot-dip galvanized malleable iron straps with nesting backs.
   2. Conduit entering boxes shall be terminated with a threaded hub as specified or standard fittings with grounding bushing.
   3. Exposed male threads on rigid steel conduit shall be coated with zinc-rich paint.

2.04 RACEWAY SPECIFICATION SHEETS (RACESPEC) - LFSC

A. Raceway Identification:
   1. LFSC

B. Description:
   1. Liquid-Tight Flexible Steel Conduit

C. Application:
   1. Final connection to equipment subject to vibration or adjustment.

D. Compliance:
   1. UL 360

E. Construction:
   1. Spirally wound galvanized steel strip with successive convolutions securely interlocked and jacketed with liquid-tight plastic cover.

F. Minimum size:
   1. 3/4 inch

G. Fittings:
   1. Cadmium-plated malleable iron body and gland nut with cast-in lug, brass grounding ferrule threaded to engage conduit spiral and O-ring seals around the conduit and box connection and insulated throat. Forty-five and 90-degree fittings shall be used where applicable.

H. Installation:
   1. Do not exceed 36-inch length.

2.05 RACEWAY SPECIFICATION SHEETS (RACESPEC) - RNC40 AND RNC80

A. Raceway Identification:
   1. RNC40 and RNC80

B. Description:
   1. Rigid Nonmetallic Conduit, heavy wall thickness for direct bury, concrete encasement or surface mounting where not subject to physical damage. DZYR per NEC Article 352.

C. Compliance:
   1. NEMA TC2, UL 651

D. Construction:
   1. Schedule 40, high-impact, polyvinyl-chloride (PVC)
   2. Schedule 80, high-impact, polyvinyl-chloride (PVC)

E. Minimum size:
   1. 3/4 inch exposed; 2-inch embedded or encased

F. Fittings:
   1. PVC solvent weld type

G. Boxes:
   1. Indoor:
      a. NEMA Class 4, nonmetallic
   2. Outdoor and corrosive:
      a. NEMA Class 4X, nonmetallic

H. Installation:
   1. PVC conduit entering fiberglass boxes or cabinets shall be secured by threaded bushings on the interior of the box and shall be terminated with a threaded male terminal adapter having a neoprene O-ring. Joints shall be made with standard PVC couplings.
   2. PVC conduit shall have bell ends where terminated at manholes, handholes, or building walls. Bell ends shall terminate flush at the walls and floors and not extend or protrude.

2.06 RACEWAY SPECIFICATION SHEETS (RACESPEC) - PVC COATED RMC-STEEL

A. Raceway Identification:
   1. PVC Coated RMC-Steel

B. Description:
   1. Rigid Steel Conduit, Corrosion-Resistant, Polyvinyl Chloride (PVC) Coated

C. Compliance:
   1. ANSI C80.1, UL 6

D. Finish:
   1. Hot-dip galvanized rigid steel conduit, to which a minimum 40-mil thick PVC coating has been bonded to the outside of the conduit. A 2-mil coat of urethane coating shall be bonded to the inside. Coating shall be free of pinholes. Bond strength shall exceed the tensile strength of the PVC coat. Elbows and fittings shall be factory made and coated.

E. Fittings: (includes unions, condulet bodies and expansion fittings)
   1. Refer to RACESPEC RMC-Steel for additional requirements. Similarly coated to the same thickness as the conduit and provided with type 316 stainless steel hardware. Conduit and fittings shall be manufactured by the same company.
      a. Hubs:
         1) Hubs for connection of conduit to junction, device, or terminal boxes shall be threaded with the same PVC coating as the conduit and provide a watertight connection.
      b. Boxes:
         1) Refer to RACESPEC RMC-Steel. FD boxes shall be PVC coated.
      c. Elbows:
         1) Refer to RACESPEC RMC-Steel.

F. Manufacturers:
   1. PVC coated conduit shall be by Robroy Industries, PLASTI-BOND RED; Occidental Coating Company (OCAL), or equal.

G. Installation:
   1. Plastic coated conduit shall be made up tight, threaded, and installed using tools approved by the conduit manufacturer.
   2. Conduit threads shall be covered by a plastic overlap which shall be coated and sealed per manufacturer's recommendations. Painted fittings are not acceptable.
   3. Pipe wrenches and channel locks shall not be used for tightening plastic coated conduits. Damaged areas shall be patched, using manufacturer's recommended material.

2.07 RACEWAY SPECIFICATION SHEETS (RACESPEC) - WW

A. Raceway Identification:
   1. WW

B. Description:
   1. Wireway and Auxiliary Gutter with hinged covers.
   2. Match the area classification enclosure type where installed.

C. Compliance:
   1. NEC Article 366

D. Minimum size:
   1. 4-inch x 4-inch
   2. Length as shown or determined by the installation requirements.

E. Maximum size:
   1. Sized in accordance with NEC-366 fill rules

F. Finish:
   1. Smooth finished surfaces.

G. Application:
   1. As shown on the drawings and where required.

H. Hardware, Supports, Fittings, and Fasteners:
   1. Stainless steel

I. Fasteners:
   1. Quick release 1/4 turn type or suitable for the area classification.

2.08 NOT USED

2.09 NOT USED

2.10 CONDUCTORS, WIRE, AND CABLE

A. Provide products specified.

B. Unscheduled Conductor Sizing:
   1. Size conductors, wire, and cables in accordance with the National Electrical Code where not specified on the Drawings, and install in the minimum size raceway as specified in the RaceSpecs herein.

C. Control Wire Color Coding:
   1. Provide control wires with the following colors for the shown voltage:

120 Vac Power, line and load	Black
120 Vac Control	Red
24 Vac	Orange
12 Vac	Brown
Foreign Voltage (AC) (Interlock)	Yellow
AC Neutrals	White
Ground	Green
24 VDC (+ & -)	Violet
12 VDC (+ & -)	Blue
Foreign Voltage (DC)	Violet/White or Blue/White

D. Power Conductors:
   1. Provide power conductors with following colors for the shown voltage:

Wire	480Y/277V, 3Ø	208Y/120V, 3Ø	240/120V, 3Ø
Phase A	Brown	Black	Black
Phase B	Orange	Red	Orange per NEC 408.3(E) and 215.8
Phase C	Yellow	Blue	Blue
Ground	Green	Green	Green
Neutral	White or Gray per NEC 210.4(D)	White	White

2. Provide black insulation conductors larger than #10 AWG with colored 3/4-inch vinyl plastic tape to identify the phase color at each cable termination. Tape wrap with 25 percent overlay to provide minimum of 3 inches of coverage.

E. Scheduled and Unscheduled Wire and Cable:
   1. Provide the insulation and jacket material specified in the CABLESPEC sheets for scheduled and unscheduled (not shown) conductors. Provide stranded copper conductors for all wire and cable.

F. Electrical Enclosure Conductor Ratings:
   1. Provide conductors with 600-volt insulation ratings in panels and other electrical enclosures. Conductors with less than 600-volt insulation ratings are prohibited, unless specifically identified.
   2. Bundle and lace conductors in panels and electrical equipment at intervals not greater than 6 inches, spread into trees and connected to their respective terminals. Provide lacing using plastic cable ties that are tensioned and cut off using a tool specifically designed for the purpose such as a Panduit GS2B. Other methods of cutting cable ties are prohibited.
   3. Bundle conductors crossing hinges into groups not exceeding 10 to 15 conductors and protected using nylon spiral flexible covers to protect conductors and provide oversized plastic panel wiring duct within panels.
   4. Provide slack in junction boxes, pull boxes, handholes and manholes sufficient to allow cables or conductors to be routed along the walls with the amount of slack equal to largest dimension of the enclosure.
   5. Provide dedicated electrical wireways and insulated cable holders mounted and secured on stainless steel unistrut in manholes and handholes.

G. Instrument Signal Cable:
   1. Provide terminal blocks at instrument cable junctions within dedicated terminal boxes provided by the installer. Provide twisted shielded cable with individual shield for each pair. Provide twisted shielded cable multi-pair with overall shield and jacket.
   2. Install instrument, signal, and data communication circuits without splices between instruments, terminal boxes, or panels. Shields as a signal path, except for circuits operating at radio frequencies and utilizing coaxial cables are not acceptable. Common ground return conductors for two or more circuits are not acceptable.
   3. Bond shields to the signal ground bus at the control panel. Isolate shields from ground and other shields at other locations by cutting short or taping. Provide terminal strips for signal leads and shield drain wires.
   4. Terminate spare circuits and the shield drain wire on terminal blocks at both ends of the cable run. Shields or drain wires for spare circuit cables shall be bonded at control panel only with the other end insulated by tape cover.
   5. Provide an instrument stand with terminal box mounted approximately 3 feet above grade to center or as shown. Provide terminal boxes for instrument cable with the cable and conductor labels specified.
   6. Install and terminate conductors for paging, security, data communication, voice communication, and telephone systems in compliance with the manufacturer and the system utility recommendations.

H. Splicing and Terminating Materials:
   1. Use an UL listed tool for the applied compression type of connectors with the correct size and type. Provide tin-plated high conductivity copper connectors. Mechanical clamp, dimple, screw-type connectors are prohibited.
   2. Provide polymeric insulating material over motor terminations with high dielectric strength mastic or material to seal the ends against ingress of moisture and contamination.
   3. Cover splices with electrical products designed for the application, and insulate with a heat-shrinkable sleeve or boot.

I. Fire Stop Sealant Materials:
   1. Provide non-combustible silicone sealant for sealing apertures and cable through-penetrations for electrical conductors meeting UL 263 4-hour time-temperature requirements.
   2. Manufacturer: STI Inc., Pensil Silicone Sealants PEN300 SpecSeal Firestop, or equal.

J. Circuit Numbering Marking System:
   1. Identify each power, control, and signal conductor at each terminal connection. Machine print the letters and numbers with black on white alphanumeric characters representing the circuit numbering system.
   2. Identify conductors, including spares. Provide cable markers and wire markers for distribution and utilization equipment circuits identifying the power source and circuit source from which it is served.
   3. Provide the identification system of vinyl power cable strap-on cable markers, vinyl multi-conductor control cable strap-on cable markers, and vinyl or polyolefin wire slip-on sleeves and encircle the conductor.
   4. Provide conductor marker used in outdoor, damp, or wet locations on heat-shrinkable polyolefin shrinkable marking sleeves covered with clear heat-shrink sleeve or clear tape cover.
   5. Print conductor markers using the Brady Marker “XC PLUS”, the Brady LS2000 printer with the Brady sleeve wire marking system, or Engineer accepted equal.

K. Terminal Blocks:
   1. Provide terminal blocks with the following features:
      a. Voltage rated: 600 volts.
      b. Current rated: match largest conductor connected to the assembly.
      c. Integral marking strips.
      d. Terminal block assemblies: provide with mounting channels, barriers, and end clamps.
      e. Power and grounding terminal blocks: solderless box lug type.
      f. Control and signal terminal blocks. Manufacturer: Allen-Bradley 1492-HM1GY, NEMA type, 30-ampere.
      g. DIN-rail mount for direct wiring into terminal blocks.
      h. Pre-printed snap-in markers.

2.11 CABLE SPECIFICATION SHEETS (CABLESPEC)

A. CABLESPEC Sheets
   1. The following CABLESPEC sheets are included in this section:

Type	Volt	Product	Purpose
SIC	600	P-OS: 1-PR#16SH OR 1-TR#16SH (TC)	Instrument
XHHW	600	XLP Insulated Industrial Grade Conductor	Power cable
THWN-2	600	Building Wire, Control Wire	Lights, receptacles, control wire

2.12 NOT USED

2.13 CABLE SPECIFICATION SHEETS (CABLESPEC) – SIC

A. Cable System Identification:
   1. SIC

B. Description:
   1. Single twisted, shielded pair or triad, 16 AWG, instrumentation and signal cable, UL listed

C. Voltage:
   1. 600 volts

D. Conductor Material:
   1. Bare annealed copper; stranded in accordance with ASTM B8

E. Insulation:
   1. 15 mil, 90 degree C, polyvinylchloride (PVC) with 4 mil nylon conduit or jacket

F. Lay:
   1. Twisted on a 2-inch lay

G. Shield:
   1. 100 percent, 1.35 mil aluminum-Mylar tape with a 7-strand tinned copper drain wire

H. Jacket:
   1. 45 mil polyvinylchloride (PVC)

I. Flame Resistance:
   1. UL 1277

J. Manufacturer(s):
   1. Okonite, Okoseal-N type P-OS; or Cooper Industries-Belden equal

K. Execution:
   1. Installation:
      a. Install in accordance with Section 26 05 00.01
   2. Testing:
      a. Megger Test: use Form in Section 01 99 90

2.14 CABLE SPECIFICATION SHEETS (CABLESPEC) – XHHW

A. Cable System Identification:
   1. XHHW

B. Description:
   1. Industrial grade single conductor
   2. Sizes: 14 AWG through 750 kcmil as shown

C. Voltage:
   1. 600 volts

D. Conductor Material:
   1. Bare annealed copper; stranded per ASTM B8

E. Insulation:
   1. NEC Type XHHW-2, 90 degrees C dry or wet, Cross-Linked Polyethylene (XLP) per ICEA S-66-524 and UL-44, Color in sizes 14, 12 and 10 AWG: Black, Green, Yellow, White, Orange, Brown, Red, Blue

F. Jacket:
   1. None

G. Flame Resistance:
   1. UL 83

H. Manufacturer(s):
   1. Okonite, X-Olene; Cablec, Durasheath XLP; or equal.

I. Uses Permitted:
   1. Power, control, lighting and outlet circuits.

J. Execution:
   1. Installation:
      a. Install in accordance with Section 26 05 00.01.
   2. Testing:
      a. Test in accordance with paragraph 26 05 00.01-3.02 and Section 26 05 00.01.

2.15 CABLE SPECIFICATION SHEETS (CABLESPEC) – THWN-2

A. Cable System Identification:
   1. THWN-2

B. Description:
   1. Single conductor lighting and receptacle type indoor branch circuit conductor. Sizes: 12 AWG through as shown.

C. Voltage:
   1. 600 volts

D. Conductor Material:
   1. Bare annealed copper; stranded in accordance with ASTM B3 or B8

E. Insulation:
   1. THWN/THHN, 90 degrees C dry, 75 degrees C wet, polyvinylchloride (PVC) with nylon jacket per UL 83.
   2. May substitute XHHW2 with XLP insulation without a jacket.

F. Jacket:
   1. Nylon

G. Flame Resistance:
   1. UL 83

H. Manufacturer(s):
   1. Okonite, Okoseal-N, series 116-67-XXXX; or equal.

I. Uses Permitted:
   1. Lighting, receptacle, appliance circuits and control, no other location permitted

J. Execution:
   1. Installation:
      a. Install in accordance with Section 26 05 00.01
   2. Testing:
      a. Megger Test: use Form in Section 01 99 90

2.16 NOT USED

2.17 WIRING DEVICES

A. Unless specified otherwise, provide UL approved wiring ivory devices for the current and voltage ratings specified and comply with NEMA WD-1 with provisions for back wiring and side wiring with captive held binding screws.

B. Heavy Duty 120v Receptacles:
   1. Ground Fault Interrupting: Ground fault interrupting (GFI) receptacles: duplex, 20 amp, NEMA 5-20R, specification grade that accepts NEMA 5-15P and 5-20P plugs. Provide GFI receptacles outdoors and as shown, UL listed with provisions for testing and resetting. Manufacturer: Hubbell GF-5352-I, or equal.
   2. In-Use Covers: In areas designated NEMA-4X, Corrosive, or other areas specified, and in outdoor areas, provide in-use type weatherproof lift covers that maintain weatherproof rating with plug installed for equipment that is cord connected with plug and receptacle. Covers shall be cast aluminum. Manufacturer: Outdoor, NEMA 4X areas: In-use covers shall be Hubbell WP7, WP8, WP26, or equal. Corrosive areas; Manufacturer: TayMac Corporation 20510, Carlon E9UXXXX, Hubbell WP826XXX, or equal.
   3. Wet/Corrosive Switch Covers: In outdoor, areas, wet areas, areas designated NEMA-4X, Corrosive, or other areas specified, provide weatherproof, corrosion-resistant covers for switches to maintain weatherproof rating during operation of switch. Covers shall have flexible bubble of silicone or neoprene rubber for switch operation. Manufacturer: Cooper, Hubbell, or equal.

C. Pilot Devices:
   1. Provide heavy-duty push buttons, selector switches and indicating lights: 30mm, oil-tight, NEMA type as specified for the location, NEMA 4X minimum. Indicating lights shall be light emitting diode (LED) type lamps. Unless otherwise shown, provide push-to-test type indicating lights. Provide diode isolating type pilot indicating lights specified for remote-test. Provide red indicating lamps for “RUN” indication and green indicating lamps for “STOP”.
   2. Provide 120VAC control units: heavy-duty type Allen-Bradley 800H, or equal. For 24VDC: Allen-Bradley 800T, Square-D Class 9001 Type J, or equal.
   3. Provide local control stations (LCS) where indicated on drawings.
   4. NEMA Ratings:
      a. Non-hazardous outdoor, process and corrosive areas: NEMA 4X stainless steel.
      b. Hazardous Areas: NEMA 7.

D. Load-Switching Control Relays:
   1. Heavy-duty, machine tool type for switching load such as solenoids, actuators, contactors, motor starter coils, and other devices used for remote interlocking.
   2. Contacts: 4-pole and field interchangeable to either normally open or normally closed and capable of accepting a 4-pole contact block adder.
   3. AC relays: NEMA A600 contact ratings and electrical clearances for up to 600 volts.
   4. DC relays: NEMA P300 contact ratings and electrical clearances of up to 250 volts.
   5. Manufacturer: Allen Bradley Bulletin-700, Square D Class 8501 Type X, or equal.

E. Logic-Level Relays
   1. Logic-Level switching solid-state logic and signal circuits:
      a. Minimum of three SPDT, silver cadmium oxide contacts rated 10-amperes-resistive at 120VAC or 28VDC.
      b. Plug-in type with heavy-duty, barrier-protected screw terminal sockets.
      c. Clear polycarbonate dust cover with clip fastener.

d. AC models: neon lamp indicator wired in parallel with coil.
e. Manufacturer: Idec Series RH, Square D Class 8501, or equal

F. Timing Relays:
1. Multi-function, micro-controller based, socket mounted timing relay.
2. Single functions:
a. Delay on Make
b. Delay on Break
c. Recycle (on time first, equal recycle delays)
d. Single shot
e. Interval
f. Trailing edge single shot
g. Inverted single shot
h. Inverted delay on break
i. Accumulative delay on make
j. Retriggerable single shot
3. Dual functions:
a. Delay on make/delay on break
b. Delay on make/recycle (on time first, equal recycle delays.)
c. Delay on make/interval
d. Delay on make/single shot
e. Interval/recycle (on time first, equal recycle delays)
f. Delay on break/recycle (on time first, equal recycle delays)
g. Single shot/recycle (on time first, equal recycle delays)
h. Recycle – both times adjustable (on time first)
i. Recycle – both times adjustable (off time first)
j. Interval/delay on make
k. Accumulative delay on make/interval
4. Time delay range, switch selectable:
a. Single function 0.1 second to 1,705 hours in 8 ranges.
b. Dual function 0.1 second to 3,100 minutes in 8 ranges.
c. Setting accuracy +/- 1 percent or 50 milliseconds, whichever is greater.
d. Repeat accuracy +/- 0.1 percent or 16 milliseconds, whichever is greater.
5. Output: Two Form-C electromechanical isolated contacts rated 10-amperes resistive at 240VAC and 1/3-horsepower at 120 or 240VAC; double pole double threw: DPDT. Mechanical life: 10,000,000 operations and electrical life: 1,000,000 operations at full load.
6. Mounting: Magnal Plug 11-pin socket
7. Environment: -20 degrees C to +65 degrees C.
8. ABB/SSAC multifunction type TRDU time delay relay with dip-switch function setting with 12VDC, 24VAC, 120VAC, 240VAC inputs as required; Agastat, STA series; IDEC or Engineer accepted substitute.

G. Elapsed Time Indicators:
   1. Elapsed time indicators shall be panel mounted, non-resettable five-digit, hour indicator, rated 120 volts, 60 Hz.

2.18 GROUNDING SYSTEM

A. Provide electrical system grounding electrode conductors, equipment grounding conductors for equipment grounding and raceways, grounding electrodes, grounding electrode conductors, connections, and bonding in compliance with the National Electrical Code-Article 250 and the National Electrical Safety Code.

B. Provide annealed bare copper, concentric stranded grounding conductors. Provide the minimum sizes per NEC Article 250 for grounding conductors or service entrance conductors, if not sized on the drawings.

C. Bond grounding conductors entering enclosures together to metallic enclosure and to metallic raceways terminating at the enclosure. Clean the conductor and enclosure metal surface at the point of connection prior to making equipment grounding connections or bond connections.

D. Provide ground grid components of #4/0 AWG bare copper conductors connected to 10-foot ground rods installed at the four corners of a building, an equipment pad, or as shown on the Drawings. Provide UFER, concrete-encased electrodes per NEC 250.52(3), by embedding conductors in concrete near bottom of footing.

E. Make connections grounding conductor connections to equipment and ground rods by bolted clamps, compression connectors, or exothermic weld connections in accordance with manufacturer's installation and testing instructions. Make connections to buried grounding connections using compression connectors or exothermic weld connections. Make connections at the ground grid test wells using bolted clamps.

F. Connect the ground grid to the following with grounding conductor specified herein or connect to the ground grid with grounding conductor as shown on the drawings:
   1. Building steel columns with #4/0 AWG bare copper
   2. Electrical ductbank #4/0 embedded conductor with #4/0 bare copper
   3. Electrical distribution or utilization equipment metal enclosures with #4/0 AWG green insulated copper
   4. Metal enclosure not containing electrical distribution with #4 AWG green insulated copper
   5. Pump/motor frames with #4 AWG bare or insulated
   6. Lightning and surge arresters using #4 AWG bare or insulated
   7. Ground rods with #4/0 AWG bare copper
   8. Power utility service entrance equipment with #4/0 bare copper
   9. Equipment ground plate with #4/0 AWG bare copper.
   10. Other equipment: provide #1 AWG green insulated copper. Provide ¾" conduit protection where subject to damage.

G. Ground Rods:
   1. Ground rods: copper-clad steel, 3/4-inch diameter and 10-feet long, with threaded end for connectors or installation tools.

H. Compression Connectors:
   1. Compression connections: cast copper.
   2. Manufacturer: Thomas & Betts Company, or equal.

I. Bolted Connectors:
   1. Bolted connectors: copper. Manufacturer: Burndy, O. Z. Gedney, or equal.

J. Exothermic Connectors:
   1. Exothermic connections copper products. Manufacturer: Cadweld process or equal.

K. Equipment Ground Plate:
   1. Provide equipment ground plates embedded flush in equipment pads to provide a bolted connection between a grounding conductor from the equipment frame to the ground grid.
   2. Provide ground plates of copper alloy construction and 1/2 inch, threaded bolt connections and integral #4/0 welding stud. Manufacturer: Cadweld Series B-162, or equal.

L. Raceway Ground:
   1. Install metallic conduits to provide a continuous ground path. Use insulated grounding bushings and bonded to the ground grid system in compliance with Article 250 of the National Electrical Code.
   2. Provide an equipment-grounding conductor with green insulation in all metallic and non-metallic conduit, raceway, wireway, gutter, or ductbanks.
   3. Provide an equipment grounding conductor with green insulation for size up to #6 AWG and provide green color insulation tape band for conductor size #4 AWG and larger.

2.19 POWER, CONTROL, AND METERING EQUIPMENT

A. Coordinate demolition of existing equipment and installation of new equipment with electric power utility company.

B. Comply with the power utility service entrance section standards that includes the power utility metering equipment. Coordinate the correct meter socket requirements. Submit proposed equipment to power utility for acceptance prior to submitting to the Engineer. Provide and install equipment according to power utility requirements.

C. Metering Equipment:
   1. Provide analog or digital power meter with monitoring and protection features shown or specified. Provide stainless steel sunshields for metering equipment mounted outdoors.

D. Panelboards:
   1. Provide panelboards: circuit breaker, dead front type with bus bar construction composed of individually mounted circuit breakers with screw-connection, designed to be removed without disturbing other breakers. Provide lockable, hinged door-in-door construction for flush mounted panels and hinged-trim covers for surface mounted panels.
   2. Provide tin-plated copper bus and with the current rating as shown on the panel schedules sized in accordance with UL 67 and withstand rating equal to the interrupting rating of the smallest circuit breaker in the panel. Series rated products are prohibited. Silver plated equipment is prohibited.
   3. Provide panelboards with a separate ground bus and a full capacity neutral bus. Mount neutral bus on insulated standoffs. Provide removable link connector from the neutral bus to the ground bus. Provide listed and labeled panelboard for service entrance disconnect as shown.

E. Mini Power Centers:

   1. Mini-power centers (MPC) consists of an encapsulated dry-type transformer, primary and secondary main circuit breakers, and secondary panelboard all in one enclosure.

   2. Transformer Rating:
      a. KVA, primary voltage, secondary voltage, frequency and number of phases shall be as shown on the Drawings.

   3. Branch Circuits:
      a. Molded case circuit breakers, plug-in thermal magnetic type with number of poles and trip ratings as shown on the Drawings.

   4. Enclosure:
      a. Weatherproof, NEMA 3R.

   5. Manufacturer:
      a. ABB
      b. Eaton
      c. Siemens
      d. Schneider - Square D Company
      e. or equal

F. Combination Motor Starters:
   1. Provide NEMA rated for the horsepower for combination motor starters, minimum size 1, with motor circuit protector and solid-state type overload relay. Provide a reset button located on the unit door exterior.
   2. Provide adjustable motor circuit protector with magnetic only trip setting adjustable over a range of 600 to 1300 percent of full load current of the motor served. Field adjust motor circuit protector setting per NEC and manufacture's recommendations. Provide 22,000 symmetrical ampere interrupt rating, where not shown on the power single line diagrams.

3. Provide solid-state adjustable overload relay to latch in the open position. Provide adjustable trip settings with minimum adjustable range from 85 to 115 percent of full load current of motor served. Field adjust overload setting per NEC and manufacture's recommendations.
4. Provide control power transformers with two primary fuses rated at 100,000 amperes at 600VAC and one secondary fuse rated at 10,000 at 250VAC and sized at 125 percent of the control circuit full load current. Ground the non-fused leg of the secondary circuit.
5. Provide switchboard type MTW or SIS control circuit conductors rated 90 degrees C above ambient temperature. Conductors shall be identified with tag numbers.
6. Provide motor contactor "Run" status contact and "Overload" alarm contact. Provide "Hand-Off-Auto" (HOA) and other shown selector switches with a "Auto Mode" status contact wired to terminal block.
7. Provide heavy-duty selector-switches and pushbutton and indicating lights with rating to match enclosure type. Provide control devices rated at 600VAC, 10-ampere continuous with
8. Provide start/stop pushbuttons with "Run" and "Stop" indicating lights including other control devices as shown. Provide push-to-test transformer type pilot lights or LED pilot lights. Lens color as shown on the drawings or specified herein.
9. Motor starters installed in existing motor control centers shall be provided as a complete assembly including all new parts including steel, components, stab assembly and mounting hardware, with UL listing, and shall be as manufactured by the original manufacturer or their authorized supplier.

G. Circuit Breakers:
1. Provide circuit breakers: molded-case type provided for the current ratings and pole configurations as shown or as specified on the panelboard schedule and with a minimum interrupting current rating as shown on drawings or schedules, but not less than 22,000 AIC for 240 volt rated devices or 65,000 AIC for 480 volt rated devices. Series rated branch, main, or other devices are prohibited.
2. Provide circuit breakers listed in accordance with UL 489 for the service specified and load terminals with solderless connectors. Provide bolt-on type circuit breakers. Provide circuit breakers with machine-printed, circuit number labels indicting the load served.
3. Circuit breakers being installed in existing panelboards and/or motor control centers shall be of manufacturer, type and ratings to match existing. KAIC shall match existing equipment.
    a. Circuit breakers installed in existing motor control centers shall be provided as a complete assembly including all new parts including steel, components, stab assembly and mounting hardware with UL listing, and shall be as manufactured by the original manufacturer or their authorized supplier.

H. Manual Starters:
1. Provide manual starters with horsepower rated, quick-make, quick-break, toggle mechanism with overloads in each phase. Provide NEMA-12 enclosures indoor and NEMA-4X stainless steel enclosures outdoor, process areas, and corrosive areas. Provide NEMA 7 enclosures in hazardous classified locations. Provide label for power source and load as shown.

I. Safety Disconnect Switches:
   1. Provide safety disconnect switches:
      a. Motor horsepower rated, heavy-duty, non-fusible
      b. Safety type rated 600 volts AC
      c. Ratings and fuse size as shown
      d. Rating and fuse size as required by the utilization equipment manufacturer
      e. Disconnect “open status” switch rated 1-ampere
      f. Switch operator with a positive, quick-make, quick-break mechanism
      g. NEMA-12 indoor-conditioned space, or as shown
      h. NEMA-4X stainless steel below grade, process areas, outdoors, corrosive areas, or as shown
      i. NEMA-7 aluminum in hazardous classified areas.
      j. Tin-plated copper products. Silver-plated products are prohibited.
      k. Manufacturer: Square-D, GE, Allen-Bradley and Eaton or approved equal.

2.20 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 01 78 23.
   2. One 11” x 17” set of drawings in a protective covering and shipped with the equipment in the internal equipment pocket at the time of equipment delivery to the project site.
   3. Record documents as specified in Section 01 78 39.
   4. Certificates of final electrical inspection and approval from the Code Authority Having Jurisdiction (AHJ) as specified in paragraph 26 05 00.01-1.01 A 4.

PART 3 – EXECUTION

3.01 GENERAL

A. Construction:
   1. Perform the work specified by Contract Documents in accordance with these specifications.
   2. Coordinate the location of electrical material or equipment with the work and adjust conduit location to accommodate equipment in accordance with the accepted submittal drawings from the manufacturer.

B. Housekeeping:
   1. Protect electrical equipment from dust, water and damage. Cover the exterior to keep dry. Electrical distribution equipment such as motor control centers, panelboards, and other power source buses shall be clean and free of dust and dirt.
   2. Protect electrical equipment temporarily exposed to weather, debris, liquids, or damage during construction as specified in Shipment, Protection, and Storage section. Touch up scratches on equipment as specified in Coating Systems section before final acceptance.
   3. Wipe clean and vacuum equipment on the inside prior to acceptance testing and energization and again prior to detailed inspection and acceptance of the work.

C. Installation:
   1. Perform the installation work specified in accordance with these specifications.
      a. Splices are not allowed except by permission. Submit proposed splice locations to the Engineer and Construction Manager for review prior to installation. Splices and terminations are subject to inspection prior to and after insulating and may require re-termination after inspection. Underground splices will not be allowed.
      b. Adhere to the NEC raceway fill limitations. Provide separate conduits for signal and instrument conductors and cables.
      c. Install power conductors derived from uninterruptible power supply systems in separate raceways.
      d. Provide terminations at 460-volt motors by bolt-connecting the lugged connectors and insulating. Alternately, provide Tyco Electronics GelCap Motor Connection Kit by Raychem.
      e. Install pre-approved in-line splices and tees with tubular compression connectors and insulate. Splices and tees in underground handholes or pull boxes shall be insulated using Scotch-cast epoxy resin splicing kits.
      f. Provide self-insulating tubular butt-splice type of compression connectors for terminations at solenoid valves, 120-volt motors, and other devices furnished with pigtail leads.
      g. Adjust motor circuit protectors in accordance with manufacturer's instructions and NEC requirements.
      h. Adjust motor overload device in accordance with manufacturer's instructions and NEC requirements.

D. Conductors, Wire, and Cable Installation:
   1. Identify conductors at each connection terminal and at splice points with the identification marking system specified.
   2. Install wire and cable into raceways, conduit, cable trays, or wireways without damaging or putting undue stress on the insulation or jacket. Provide manufacture's recommended and UL Listed pulling compounds lubricants for pulling wire and cable. Grease is prohibited.
   3. Raceway construction shall be complete, cleaned, and protected from the weather before cable is installed. Provide wire or cable support where wire or cable exits a raceway. Provide reusable stainless steel Kellums grips or equal product where cable support is required and where loads are removable.
   4. Scratch-brush the contact areas and tinplate the connection where flat bus bar connections are made with tinplated or unplated flat bus bar. Provide non-oxide material approved for the function. Torque bolts to the bus manufacturer's recommendations.
   5. Adhere to raceway fill limitations defined by NEC and the following: Lighting and receptacle circuits may be in the same conduit in accordance with de-rating requirements of the NEC. Lighting and receptacle circuits shall not be in conduits with power or control conductors. Signal conductors shall be in separate conduits.
   6. Install pre-approved in-line splices and tees made with tubular compression connectors and insulated as specified for terminations and for motor terminations. Splices and tees in underground handholes or pull boxes shall be insulated using Scotch-cast epoxy resin or equal splicing kits.

7. Conductors in all handholes and manholes shall have adequate slack to be tied up around the perimeter of the vault and will be suspended by insulators around the vault's perimeter as needed to support the cable.

E. Raceway Installation:
   1. Provide additional pullboxes for conduit runs with greater than 360 degrees in any run between pull boxes. Limit maximum conduit runs without additional pullboxes to 400 feet, less 100 feet for every 90 degrees for the conduit run change in direction.
   2. Determine conduit routing that conforms to the installation requirements set forth herein and in accordance with the NEC requirements for size and number of pullboxes.
      a. Install exposed conduit either parallel or perpendicular to structural members and surfaces.
      b. Route two or more exposed conduits in the same general routing parallel with symmetrical bends.
      c. Install exposed conduit on supports spaced not more than 10 feet apart.
      d. Install conduits out from the wall using framing channel where three or more conduits are located in parallel run.
      e. Install conduits between the reinforcing steel in walls or slabs that have reinforcing in both faces. Verify installation method for conduits larger than 2-inch with Construction Manager prior to installation.
      f. Install conduit in slabs that have only a single layer of reinforcing steel, under the reinforcement.
      g. Install conduits with large radii under the slab in a one-sack concrete slurry.
      h. Route conduit clear of structural openings and shown future openings.
      i. Provide conduit roofs or wall penetrations with flashing sealed watertight and fire-stop, as required to maintain the structural rating.
      j. Grout conduit into any openings cut into concrete and masonry structures.
      k. Cap conduits during construction to prevent entrance of dirt, trash, and water.
      l. Terminate exposed conduit stubs for future use with pipe-caps and provide couplings and pipe-plugs where flush with the slab.
      m. Determine concealed conduit stub-up locations from the manufacturer's shop drawings.
      n. Terminate conduit in equipment with conduit couplings with pipe-plugs flush with structural surfaces for empty conduit.
      o. Install conduit horizontally with at least 7-feet headroom clearance.
      p. Terminate conduit with fittings that ensure that the NEMA rating of the enclosure and provide conduit hubs, as required heretofore.
      q. Connect underground metallic or nonmetallic conduit that turns out of concrete, masonry, or earth to a 90-degree elbow of PVC-coated rigid steel conduit before emergence. Taped or painted RMC-Steel or RNC is prohibited.
      r. Provide conduit crossing structural joints with structural movement with O-Z "Type DX" or Crouse-Hinds "Type XJG-SA," aluminum, bonded, weather-tight expansion fitting of the same size and type as the conduit.
      s. Seal conduits in corrosive areas using removable mastic material.

t. VFD motor feeder circuits shall be routed a minimum of 12 inches from any control conduits. Should they cross they shall cross at 90 degrees.

F. Underground Raceway Installation:
   1. Adhere to the Power Utility underground service entrance requirement for excavation, raceways installation and termination, pads and reinforcement, backfilling, and location criteria. Provide excavation, backfilling, and concrete work as specified and shown.
   2. Provide underground conduit installations that conform to the following requirements:
      a. Direct bury underground conduits that are not shown to be installed in an electrical ductbank.
      b. PVC coated RMC-steel elbows for underground to above ground transitions.
      c. Underground conduit bend radius: not less than 2 feet minimum at vertical risers nor less than 3 feet elsewhere for up to 2-inch diameter conduit.
      d. Determine conduit manufacturer's bending radius requirement for 3-inch and larger diameter conduit and use factory "long radius" ells.
      e. Underground ductbanks and direct-buried conduits: 2-feet minimum earth cover, except where shown otherwise.
      f. Concrete encased conduit:
         1) Minimum concrete thickness of 2 inches between conduits 2.5-inch and smaller.
         2) 3 inches between 3-inch conduit and larger or per NEC requirements.
         3) 1-inch between conduit and reinforcing.
         4) 3 inches over reinforcing.
         5) Embed #4/0 bare ground in the concrete encasement and installed with direct buried raceways.
         6) Standard detail or typical details shown supersede these general requirements.
         7) Provide 3-pounds of red-oxide dye-color per sack of cement for in the concrete encasement for electrical ductbanks.
         8) Provide 467-ASTM coarse aggregate size with 3-cement sacks per cubic yard concrete.
         9) Provide concrete with 28-day, 2000-psi compressive strength unless specified at higher value in the cast-in-place concrete specification.

G. Electrical Equipment Labeling – Arc Flash
   1. Electrical equipment shall have field marked signs and labeling to warn qualified persons of the potential electric arc flash hazards per NEC Article 110.16 Flash Protection.

3.02 TESTING

A. Provide electrical equipment acceptance tests in accordance with the latest version of NETA Acceptance Testing Specification for electrical distribution and utilization equipment to demonstrate that all electrical equipment is functioning as designed.

B. Test lighting system for proper function. Test wiring devices for correct connections. Test outlet grounding and polarity using a plug-in test device. Test motor control stations and control devices for proper function.

C. Test power, control, instrument, and signal conductors to verify free from grounds. Megger test all conductors with the test voltage appropriate to the conductor insulation voltage. Use a 600 or 1,000-volt megohmmeter for resistance measurements for 600VAC rated insulation and all motors. Test between conductors and from conductor to ground. Insulation with resistance of less than 10-megohms is not acceptable. Record the insulation resistance measurements in a format similar to or on the Form 26 05 00.01-A in Section 01 99 90.

D. Pre-test conductors prior to installation, as appropriate. Replace damaged conductors. Test all conductors after installation.

E. Measure motors insulation resistance before they are connected. For 50-horsepower and larger motor, measure the motor insulation resistance at the time of delivery and after they are connected. Insulation resistance values less than 10 megohms are not acceptable. Complete the Installed Motor Test Form: 26 05 00.01-B in Section 01 99 90, for each motor after installation.

3.03 FUNCTIONAL CHECKOUT

A. Prior to energization of equipment, perform a functional checkout of the control circuit. Prior to functional testing, adjust and make protective devices operative. Energizing each control circuit and operating each control, status, alarm, protective device, and each interlock to verify that the specified action occurs. Submit a description of his proposed functional test procedures prior to the performance of functional checkout.

B. Verify motors are connected to rotate in the correct direction by momentarily energizing the motor. Prior to motor rotation test, confirm that the motor, the driven equipment, nor personnel will be damaged by reverse operation.

3.04 GROUNDING SYSTEM TESTS

A. Test each grounding connection to determine the ground resistance per the IEEE Standard 81. Submit a plot of ground resistance readings for each isolated ground rod or ground mat to the Construction Manager on 8-1/2 x 11-inch size graph paper.

B. The current reference rod shall be driven at least 100 feet from the ground rod or grid under test. Make measurements at 10-foot intervals, beginning 25 feet from the test electrode and ending 75 feet from it, in direct line between the ground rod or center of grid and the current reference electrode.

C. A grounding system that shows greater than 2-ohm resistance, for the flat portion of the plotted data, is considered inadequately grounded. Add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurements meet the 2-ohm requirement. Additional ground rods and ground grid work will be paid for as extra work. Use of salts, water, or compounds to attain the specified ground resistance is prohibited.

3.05 NOT USED

3.06 RECORD DOCUMENTS

A. Provide Record Drawings and documents maintained and annotated during construction. Submit drawings in accordance with Section 01 78 39 and the following.

B. Include addendum items, requests for information, change orders, and field changes posted or drawn on the Record Drawings. Include the following drawings with the Record Drawings:
   1. Interconnection Diagrams specified herein.
   2. Original Submittal Drawings specified herein.

C. Schedule a meeting with the Engineer in the Engineer's office to review the Record Drawings at the end of the project. Make corrections to the Record Drawings prior to re-submitting the Record Drawings to the Engineer.

D. Submit Record Drawings and Operations and Maintenance (O&M) Manuals as specified in Sections 01 78 23 and 01 78 39, to be included in the completed project Record Document Set for the Owner.

END OF SECTION

SECTION 31 05 19

GEOSYNTHETICS FOR EARTHWORK

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, incidental materials, tools, supervision, transportation, and installation equipment necessary for the installation of geosynthetic materials (i.e., geosynthetic clay liner [GCL], textured 60-mil high density polyethylene (HDPE) or 40-mil linear low density (LLDPE) geomembrane, a geocomposite drainage layer [GDL], and geotextiles to be installed as part of the landfill liner) as specified herein, as shown on the Drawings and as otherwise required for a complete and functional installation. The Contractor shall provide and install all geosynthetic materials.

B. Be prepared to install the geosynthetic materials in conjunction with the earthwork and other components of this project.

1.02 RELATED SECTIONS

A. Section 31 23 00 – Excavation and Fill

B. Section 40 05 01 – Piping Systems

1.03 REFERENCES

A. Geosynthetics Research Institute Standards.

B. Latest version of the American Society for Testing and Materials (ASTM) standards:

ASTM Number	Description
ASTM D 413	Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate
ASTM D 638	Standard Test Method for Tensile Properties of Plastics
ASTM D 746	Standard Test Method for Brittleness, Temperature of Plastics and Elastomers by Impact
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D 904	Standard Test Method for Comparison of Bond Strength or Ply Adhesion of Similar Laminates Made from Flexible Materials
ASTM E 946	Water Absorption of Bentonite by Porous Plate Method
ASTM D 1004	Test for Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 1204	Test for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting of Film at Elevated Temperatures
ASTM D 1238	Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D 1239	Standard Test Method for Resistance of Plastic Films to Extraction by Chemicals
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D 1603	Test Method for Carbon Black in Olefin Plastics
ASTM D 1693	Standard Test Method for Environmental Stress Cracking of Ethylene Plastics
ASTM D 1790	Test Method for Brittleness Temperature of Plastic Film by Impact
ASTM D 1987	Test Method for Biological Clogging of Geotextile or Soil/Geotextile Fillers
ASTM D 3015	Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds

ASTM Number	Description
ASTM D 3020	Specification for Polyethylene and Ethylene Copolymer Plastic Sheeting for Pond, Canal, and Reservoir Lining
ASTM D 3776	Standard Test Method for Mass Per Unit Area (Weight) of Fabric
ASTM D 3786	Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabric-Diaphragm Bursting Strength Test Method
ASTM D 4218	Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
ASTM D 4354	Practice for Sampling of Geosynthetics for Testing
ASTM D 4355	Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
ASTM D 4437	Standard Test Method for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Geomembranes
ASTM D 4439	Terminology for Geosynthetics
ASTM D 4491	Standard Test Method for Water Permeability of Geotextiles by the Permittivity Method
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D 4545	Practice for Determining the Integrity of Factory Seams Used in Joining Manufactured Flexible Sheet Geomembranes
ASTM D 4595	Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
ASTM D 4632	Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile-Related Product
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 4873	Guide for Identification, Storage, and Handling of Geotextiles
ASTM D 4885	Test Method for Determining Performance Strength of Geomembranes by the Wide Strip Tensile Method
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible-Wall Permeameter
ASTM D 5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
ASTM D 5261	Test Method for Measuring Mass Per Unit Area of Geotextiles
ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 5493	Test Method for the Permittivity of Geotextiles Under Load
ASTM D 5596	Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
ASTM D 5993	Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners
ASTM D5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane
ASTM D6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

1.04 RESPONSIBILITIES OF PARTIES INVOLVED

A. The following information on qualifications for the Contractor, Geosynthetics Manufacturer(s) and/or Fabricator(s), and Installer shall be submitted to the Owner's Representative as specified in paragraph 1.06 herein. The Owner's Representative reserves the right to waive any portion of this submittal requirement.

B. Contractor:
   1. Contract the Geosynthetics Manufacturer(s) and/or Fabricator(s) to supply geosynthetic materials.
   2. Contract the Geosynthetics Installer, as a Subcontractor, if the Contractor is not a qualified installer.
   3. Accept and retain full responsibility for installation and be responsible for any defects in the completed work.
   4. Responsible for coordination of geosynthetic installation with earthwork activities.

C. Geosynthetic Manufacturer(s) and/or Fabricator(s):
   1. Responsible for the production and delivery of geosynthetics, as specified herein.
   2. Responsible for the production of geosynthetic materials and shall have sufficient production capacity and qualified personnel to meet the demands (e.g., quantity, production, schedule, quality control, etc.) of this project.

D. Geosynthetics Installer:
   1. The installer of the geomembranes, geocomposite drainage layer (GDL), geosynthetic clay liner (GCL), and associated geotextile(s) shall be the Geosynthetic Installer and shall be responsible for field handling, storing, deploying, seaming, temporarily restraining (against wind), maintaining temporary cover, and other site aspects of the geosynthetic materials and other components of the project.
   2. All personnel performing geomembrane seaming operations shall be qualified by experience or by successfully passing seaming tests.
   3. At least one seamer shall have experience seaming geosynthetic material seams using the same type of seaming methods to be used at this site. Seamers with such experience will be designated "master seamers".

1.05 WARRANTY

A. The Geomembrane Manufacturer(s) and/or Fabricator(s) shall confirm in writing, prior to shipment, that the material to be furnished will meet the intent of the specifications, and shall guarantee the material to be free of defects in materials and workmanship at the time of sale and against deterioration due to the effects of ozone, ultraviolet or other normal weathering on a pro-rata basis for a minimum of 5 years from the date of acceptance.

B. The Geomembrane Manufacturer(s) and/or Fabricator(s) shall furnish a sample warranty for review and approval prior to shipment.

C. The Geosynthetic Installer shall furnish the Owner a written warranty with a period of at least 2 years against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

1.06 SUBMITTALS

A. Qualification Information
   1. Submit the following information in writing describing each geosynthetic manufacturer and/or fabricator to be used on the project:
      a. Corporate background and information

b. Reference project descriptions that show that the company has successfully manufactured and/or fabricated a minimum of five (5) million square feet of geosynthetic materials of the type(s) specified herein. The following information shall be provided for each reference project:
    1) name, location, and purpose of facility, and date of installation;
    2) names of Owner, Project Manager, Engineer, General Contractor, Fabricator (if any), and Installer; and
    3) thickness and surface area of geomembrane manufactured for the referenced projects.

2. Submit the following information in writing describing the geosynthetics installer to be used on the project:
    a. Corporate background and information.
    b. Copy of installer's letter of approval or license by the Geosynthetic Manufacturer and/or Fabricator.
    c. Installation capabilities, including:
        1) information on equipment and personnel;
        2) average daily production anticipated for this project;
        3) quality control procedures; and
        4) samples of field seams, a certified list of minimum values for seam properties, and the test method employed.
    d. A list of at least five similar completed facilities for which the installer has successfully installed a minimum of five (5) million square feet of polyethylene geomembrane and has installed other geosynthetics as specified herein. This experience shall be available, at a minimum, at the field crew foreman level. The following information shall be provided for each facility.
        1) the name and purpose of the facility, its location, and dates of installation;
        2) the names of the Owner, Project Manager, Engineer, General Contractor, Geosynthetic Manufacturer and/or Fabricator, and the name of a contact at the facility who can discuss the project;
        3) name and qualifications of the installer's supervisor(s);
        4) thickness and surface area of installed geomembrane material; and surface area and type of other installed geosynthetics;
        5) type of seaming and type of seaming apparatus used; and
        6) duration of installation.
    e. Resumes of all personnel who will perform seaming operations on this project.
    f. Resume of the installation supervisor to be assigned to this project. The superintendent shall have supervised the installation of a minimum of two (2) million square feet of polyethylene geomembrane and 500,000 square feet of GDL, GCL, and geotextile.

B. Prior to transporting any geosynthetic materials to the site, the Contractor shall obtain from the Geosynthetic Manufacturer(s) and/or Fabricator(s), and have available for the Owner's Representative's inspection, the following documentation on the resin and/or raw materials used to manufacture the geosynthetics.

1. Copies of quality control certificates issued by the resin and/or raw materials supplier, including the production dates and the origin of the resin and/or raw materials used to manufacture the geosynthetic materials for the project.
2. Results of tests conducted by the Geosynthetic Manufacturer(s) and/or Fabricator to verify the quality of the resin used to manufacture the geosynthetic materials rolls assigned to the project and the origin of the resin and the quality control certificates issued by the resin supplier.
3. Certification that no reclaimed polymer is added to the resin during the manufacture of the geosynthetic (i.e., geomembrane and geonet) to be used in this project. (The use of polymer recycled during the manufacturing process may be permitted for the geomembrane if performed with appropriate cleanliness and if the recycled polymer does not exceed 2% by weight of the total polymer weight).

C. The Contractor will obtain from the Geosynthetic Manufacturer(s) and/or Fabricator(s), and have available for the Owner's Representative's inspection, the following documentation on geosynthetic materials roll production prior to the shipment of the geosynthetic rolls.
   1. Manufacturing quality control certificates for each shift's production of geosynthetic materials, signed by responsible parties employed by the Geosynthetic Manufacturer(s) and/or Fabricator(s) (such as the production manager), and notarized.
   2. The quality control certificate shall include:
      a. roll numbers and identification;
      b. sampling procedures; and
      c. results of quality control tests, including description of the test methods used.
   3. The Geosynthetics Manufacturer(s) and/or Fabricator(s) quality control tests to be performed, as specified in the Manufacturing Quality Control section for each geosynthetic product.

D. Certified test results from the Manufacturer and/or Fabricator on the stock of material to be delivered to the site showing the minimum acceptable and actual test values for the physical characteristics specified in paragraph 2.02 of this section for the geomembrane material shall be submitted to the Owner's Representative at least two weeks prior to the start of installation of the geomembrane.

E. Prior to commencement of the installation, the Geomembrane Installer shall submit;
   1. Panel layout drawings for the geomembranes showing the installation layout, field seams, details, as well as any variance that deviates from the Drawings. These drawings shall indicate the geomembrane configuration, dimensions, details, locations of seams, etc. The layout drawings must be approved by the Owner's Representative prior to the installation of any geomembranes. The panel layout shall be adequate for use as a construction plan once approved by the Owner's Representative. The panel layout shall become part of the Drawings.
   2. Geomembrane installation schedule.
   3. A list of the personnel who shall perform field seaming operations and details of their experience.
   4. Seaming method and list of equipment to be used.
   5. Method and list of equipment for performing non-destructive seam tests.

F. During the installation, the Contractor shall provide the following information on a timely basis:
   1. Quality control documentation
   2. Continuous subgrade acceptance certificates, signed by the Installer, for each area to be covered by the geosynthetic materials.

G. The results of the pre-construction tests described in paragraph 1.08 of this section shall be submitted prior to initiation of construction activities. Also, the Contractor shall submit a detailed description of the test protocol to the Owner's Representative for approval prior to testing. The protocol shall describe in detail the means of configuring the test specimens and test methods.

H. A Certificate of Calibration less than 12 months old shall be submitted for the field tensiometer referenced in paragraph 3.04 Size of Samples of this Section.

I. Upon completion of the installation, the warranty from the Installer as specified in paragraph 1.05 of this section shall be submitted by the Contractor.

1.07 CONSTRUCTION QUALITY ASSURANCE BY OWNER'S REPRESENTATIVE

A. The installation of the geosynthetic materials shall be monitored and tested by the Owner's Representative as outlined herein.

B. The Contractor shall be aware of the testing activities outlined herein and shall account for these testing activities in the installation schedule (i.e. allow time for receipt of CQA analysis of delivered materials).

C. Manufacturing Plant Visits:
   1. The Geomembrane Manufacturer and/or Fabricator shall permit the Owner's Representative to visit the manufacturing plant for project specific visits. If possible, such visits will be prior to or during the manufacturing of the geomembrane rolls for the specific project.
   2. During the visit, the Owner's Representative may review the manufacturing process, quality control procedures, laboratory facilities, testing procedures; verify that properties guaranteed by the Geomembrane Manufacturer and/or Fabricator comply with the Specifications and that the measurements of properties are properly documented and test methods are acceptable; spot inspect geomembrane rolls for evidence of holes, blisters, or any sign of contamination by foreign matter; review packaging and transportation procedures to verify that these procedures are not damaging the geomembrane; and verify that rolls packages are labeled in compliance with this Specification.

1.08 PRE-CONSTRUCTION TESTING

A. Prior to construction, the Contractor shall have three (3) laboratory tests performed (for each interface) on the liner cross section using the approved geosynthetics and earthen materials to determine the lowest interface friction angle (i.e. between the geotextile side of the GDL and the protective soil layer, the geocomposite and the 60-mil HDPE geomembrane material, the 60-mil geomembrane and the GCL, and the GCL and the compacted subgrade at a minimum). These tests shall be performed at the Contractor's expense. The cap cross section tests, to be performed by the Geosynthetic Manufacturer

and/or Fabricator, shall be in accordance with ASTM D 5321 and shall be tested under the following conditions:

1. Three (3) different normal stresses shall be applied in the test to represent appropriate field conditions. These stresses shall equal 2880, 5760, and 11520 psf (i.e., 20, 40, and 80 psi, respectively).
2. Contact area shall equal 12 inch x 12 inch.
3. Configuration of the test profile shall consist of a recompacted soil subgrade material layer, a GCL, a 60-mil HDPE geomembrane, a GDL (geotextile bonded to both sides), and a protective soil layer.
4. Both the soils in contact with the geotextile and geomembrane and the geosynthetics shall be fully wetted for the test.
5. Rate of displacement shall be held at 1 mm/min.

PART 2 PRODUCTS

2.01 GENERAL

A. Manufacturing Quality Control:

1. All geosynthetics shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.
2. The Contractor shall obtain from the geosynthetics manufacturer(s) periodic sample and test results for the geosynthetics to demonstrate that the materials and fabrication practices comply with the specifications. This quality control (QC) sampling and testing shall be performed at the Contractor's expense.
3. The Contractor shall not accept or install any geosynthetics which exhibit defects.
4. In the event that any geosynthetic sample does not comply with these specifications, it will result in rejection of the roll from which that sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to the Owner.
5. If a geosynthetic sample fails to meet the quality control requirements of this Section, the Owner’s Representative will require sampling and testing of each roll manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until the Contractor verifies, in writing, that each and every QC problem has been identified and corrected, and that all affected rolls have been replaced; all at no additional expense to the Owner.
6. Additional sampling and testing may be performed, at the Contractor's discretion and expense, to more rapidly identify any non-complying rolls and/or to qualify individual rolls.
7. Sampling shall, in general, be performed on sacrificial portions of the geosynthetic materials, such that repair is not required. The geosynthetics shall be sampled and tested at a minimum of once for every 20,000 square feet (unless specified otherwise) of that material delivered to the site to demonstrate that its properties conform to these specifications.
    a. Samples taken from stored rolls shall be taken across the entire width of the roll and shall not include the first wrapping or outer layer of the roll.
    b. Samples taken at the time of manufacturing may be obtained from the end of the roll.

c. Unless otherwise specified, samples shall be 2 ft long by the roll width. For geomembrane material, the machine direction shall be marked on the samples with an arrow by the manufacturer or fabricator.

8. The Contractor shall comply with all certification and submittal requirements specified herein before.

B. Labeling:

1. Geosynthetic materials shall be supplied by the manufacturer(s) in rolls wrapped in relatively impermeable and opaque protective covers.
2. Geosynthetics and their protective covers shall be marked or tagged by the manufacturer(s) and/or fabricator(s) with the following information:
   a. manufacturer's name
   b. product identification
   c. date of manufacture
   d. lot number
   e. roll number
   f. roll dimensions
   g. thickness of material (if applicable)

C. Transportation:

1. Transportation of the geosynthetic materials shall be the responsibility of the Contractor. The Contractor shall be liable for any and all damages to these materials prior to and/or during transportation to the site.

D. Handling and Storage:

1. Handling, storage, and care of the geosynthetics prior to, during, and following installation at the site shall be the responsibility of the Contractor. The Contractor shall be liable for any and all damages to these materials prior to final acceptance of the geosynthetics system by the Owner's Representative.
2. Each geosynthetic material shall be protected, in accordance with its manufacturer's recommendations, from moisture, excessive heat or cold, puncture, or other potentially damaging or deleterious conditions. All geosynthetics shall be stored off the ground and out of direct sunlight. Any additional storage procedures recommended by the manufacturer(s) shall be the obligation of Contractor.

2.02 60-MIL HDPE AND 40-MIL LLDPE GEOMEMBRANES

A. The geomembranes shall be 60-mil textured HDPE products manufactured for industrial applications and which has been satisfactorily demonstrated by prior use to be suitable and durable for use as a landfill liner.

B. Reclaimed polymer shall not be added to the resin; however, the use of polymer recycled during the manufacturing process shall be permitted if performed with appropriate deadlines and if the recycled polymer does not exceed 2 percent by the weight of the total polymer weight. The geomembrane shall be manufactured from new, first-quality polyethylene resin, and shall be designed and manufactured specifically for use in geomembranes.

C. The Geomembrane Manufacturer and/or Fabricator shall furnish geomembranes having properties that comply with the following property values.

Geomembrane Property Value Requirements (Textured)

Property	Test Method	Required Values	
		60-mil HDPE	40-mil LLDPE
Thickness, mil (min. average)	ASTM D5994	60 nominal (-5%)	40 nominal (-5%)
• Lowest individual for 8 of 10 values		-10%	-10%
• Lowest individual for any of the 10 values		-15%	-15%
Asperity Height, mil (min. ave.)	GM 12	10	10
Sheet Density, g/cm^3 (min.)	ASTM D792 or ASTM D1505	0.940	0.939
Min. Tensile Properties (each direction)	ASTM D6693 Type IV		
	Strength at Yield (lb/in)	126	--
	Elongational Yield (%)	12	--
	Strength at Break (lb/in)	90	60
	Elongational Break (%)	100	250
Tear Resistance, lbs. (min.)	ASTM D1004	42	22
Puncture Resistance, lbs (min.).	ASTM D4833	90	44
Carbon Black Content (allowable range in %)	ASTM D1603	2.0-3.0	2.0-3.0
Carbon Black Dispersion	ASTM D5596	9 views in categories 1 or 2 and	1 view in category 3
Hot Wedge Seams			
• Seam Peel Strength lb/in (min)	ASTM 6392	91	50
• Seam Shear Strength lb/in (min)	ASTM 6392	120	60
Extrusion Fillet Seams			
• Seam Peel Strength lb/in (min)	ASTM 6392	78	44
• Seam Shear Strength lb/in (min)	ASTM 6392	120	60

Note: Alternate test methods may be used at the discretion of the Geosynthetics Quality Assurance Manager.

D. Contractor shall provide geomembrane QC pre-shipment testing results to the Geosynthetics Quality Assurance Manager at the frequencies specified below:

Required Quality Control Pre-Shipment Testing of Textured Geomembrane Liner

Property	Test Method	Frequency
Thickness	ASTM D5994	Each Roll
Asperity Height	GM 12	Every 2nd roll
Density	ASTM D792 or ASTM D1505	Every 200,000 lbs of resin
Tensile Properties	ASTM D6693	Every 20,000 lbs
Tear Resistance	ASTM D1004	Every 45,000 lbs
Puncture Resistance	ASTM D4833	Every 45,000 lbs
Carbon Black Content	ASTM D1603	Every 45,000 lbs
Carbon Black Dispersion	ASTM D5596	Every 45,000 lbs

Note: Alternate test methods may be used at the discretion of the Geosynthetics Quality Assurance Manager.

E. In addition to the properties listed above, the geomembrane shall:
   1. Contain a maximum of 0 percent by weight of additives, fillers, or extenders (not including carbon black).
   2. Not have striations, pinholes, or bubbles on the surface or interior.
   3. Be free of holes, blisters, modules, undispersed raw materials, or any sign of contamination by foreign materials.
   4. Be manufactured in a single layer (thinner layers shall not be welded together to produce the required thickness).

F. Manufacturing:
   1. Geomembrane shall be manufactured following the QC requirements of paragraph 2.01.
   2. The Geomembrane Manufacturer and/or Fabricator shall sample and test the resin to demonstrate that the resin complies with this specification. The Geomembrane Manufacturer and/or Fabricator shall certify in writing that the resin does meet the specifications and shall be held liable for any non-compliance. Any geomembrane manufactured from non-complying resin shall be rejected.
   3. The Geomembrane Manufacturer and/or Fabricator shall continuously monitor geomembranes during the manufacturing process for inclusions, bubbles, or other defects.
   4. The Geomembrane Manufacturer and/or Fabricator shall continuously monitor the geomembrane thickness during the manufacturing process.

G. Acceptable Manufacturers/Fabricators
   1. GSE Lining Technology Inc.
   2. PolyFlex
   3. Agru America
   4. Engineer approved equal.

2.03 GEOCOMPOSITE DRAINAGE LAYER PROPERTIES

A. The Geocomposite Drainage Layer (GDL) shall be a high capacity double-sided geonet designed for landfill liner applications. The GDL required shall have the property values shown in the following table. The GDL Manufacturer and/or Fabricator shall provide results of tests performed using the procedures listed on the following Table, as well as certification that the materials meet or exceed the specified values:

GDL PROPERTY VALUE REQUIREMENTS

Properties	Test Method	Units	Qualifier	Specified Value
Geonet:				
• Resin Density	ASTM D 1505	g/cm^3	Minimum	0.93
• Carbon Black content	ASTM D 4218	%	Minimum	2.0-3.0
• Thickness	ASTM D 5199	Mil	Minimum	200
Geotextile:				
• Fabric Weight	ASTM D 3776	oz/sy	MARV*	8
• Grab Strength	ASTM D 4632	Lbs	MARV*	160
• Tear Strength	ASTM D 4533	Lbs	MARV*	65

GDL PROPERTY VALUE REQUIREMENTS

Properties	Test Method	Units	Qualifier	Specified Value
• Puncture Strength	ASTM D 4833	Lbs	MARV*	90
• Water Flow Rate	ASTM D 4491	gpm/sf	MARV*	110
• Permittivity	ASTM D 4491	1/sec	MARV*	1.3
• AOS	ASTM D 4751	US Sieve	MARV*	70
Geocomposite:				
• Peel Strength (2)	ASTM F 904	Lbs/inch	typical	1.0
Transmissivity:				
• @100 hr seat	ASTM D4716	(x10-4m^2/sec	minimum	m^2/sec (3)(4)(5)
i = 0.02				3.4

**MARV = Minimum Average Roll Values*

Note:

1. *Alternate test methods may be used at the discretion of the Geosynthetics Quality Assurance Manager.*
2. *Ply Adhesion tested by manufacturer every 40,000 square feet of product per ASTM F904 with a 2 in. wide 10-inch long strip where the geotextile bonded to one side of the geonet is pulled apart at a speed of 12.0 in/min. The value reported is the average peak value of 5 tested samples.*
3. *Transmissivity is calculated as the flow rate per unit width divided by the hydraulic gradient as defined in ASTM D4716. Transmissivity values shown above are based on a normal stress = 10,000 psf for the GDL.*
4. *Boundary conditions for the transmissivities shown above are as follows: Steel plate/geocomposite/60 mil HDPE steel plate, and a seating time of 100 hours.*
5. *Transmissivity values are approximate.*

B. The GDL system described by this Specification consists of: a composite drainage net and with a double-sided nonwoven polypropylene geotextile thermally bonded to each side of the geonet.

C. In addition to the property values listed in Table above, the GDL shall:
   1. Retain its structure during handling, placement, and long-term service.
   2. Be capable of withstanding outdoor exposure for a minimum of 30 days with no measurable deterioration.
   3. Geotextiles will be thermally bonded to geonet components of GDL rather than chemically bonded.

D. Manufacturing Quality Control
   1. At a minimum, the following manufacturing quality control tests shall be performed:

GDL Component	Test	Procedure
• Geonet Component	Specific gravity	ASTM D 1505
	Carbon black	ASTM D 4218
	Thickness	ASTM D 5199
• Geotextile Component	Mass per unit area	ASTM D 5261
	AOS	ASTM D 4751
	Permittivity	ASTM D 4491
	Puncture Strength	ASTM D 4833

GDL Component	Test	Procedure
	Grab Strength	ASTM D 4632
	Trapezoidal Tear Strength	ASTM D 4533
• Geotextile/Geonet/Composite	Peel Strength	ASTM F 904

Note: Alternate test methods may be used at the discretion of the Geosynthetics Quality Assurance Manager.

2. The hydraulic transmissivity test (ASTM D 4716) specified in paragraph 2.01 Manufacturing Quality Control need not be performed at a frequency of one per 20,000 square feet. However, the GDL Manufacturer and/or Fabricator shall certify that this test has been performed on a sample of GDL identical to the product that will be delivered to the site. The GDL Manufacturer and/or Fabricator shall provide test results to the Owner's Representative demonstrating that the GDL Manufacturer and/or Fabricator performed the tests and that acceptable results were obtained.
3. The GDL Manufacturer and/or Fabricator shall comply with the certification and submittal requirements as well as the QC requirements in paragraph 2.01 of this specification.

E. Acceptable Manufacturers/Fabricators:
1. Tenax Corporation
2. GSE
3. Engineer Approved Equal

2.04 GEOTEXTILE PROPERTIES (NONWOVEN)

A. Geotextiles (exclusive of the GDL) shall be polypropylene, needlepunched, non-woven geotextiles manufactured from continuous filaments, or Owner's Representative approved equal, and having properties that comply with the required following property values:

Geotextile Property Value Requirements

Properties	Test Method	Units	Qualifier	Specified Value
Mass/unit area	ASTM D 5261	oz/yd^2	MARV	8
Apparent Opening Size	ASTM D 4751	MM	MARV	0.21
Hydraulic Conductivity	ASTM D 4491	Cm/sec	MARV	$\geq$0.1
Puncture Strength	ASTM D 4833	Lbs	MARV	100
Tensile Strength	ASTM D 4632	Lbs	MARV	215

B. The Geotextile Manufacturer and/or Fabricator shall furnish materials whose "Minimum Average Roll Values", meet or exceed the properties specified in paragraph 2.04 Geotextile Properties (Nonwoven), as well as a certification that the material properties meet or exceed the specified values. The geotextiles shall be stock products. The Geotextile Manufacturer and/or Fabricator shall not furnish products specifically manufactured to meet the specifications of this project unless authorized by the Owner's Representative.

C. In addition to the property values specified in paragraph 2.04 Geotextile Properties (Nonwoven), the geotextiles shall:
   1. Retain their structure during handling, placement, and long-term service.
   2. Be capable of withstanding direct exposure to sunlight for a minimum of 30 days with no measurable deterioration.

D. Manufacturing Quality Control
   1. Quality control testing shall be performed as specified in paragraph 2.01 of this section.

E. Acceptable Manufacturers/Fabricators:
   1. Synthetic Industries
   2. Amoco Fabrics & Fibers Company
   3. Engineer Approved Equal

2.05 GEOTEXTILE PROPERTIES (WOVEN)

A. Geotextiles to be installed for separation/stabilization of the access road shall be woven geotextiles having properties that comply with the required following property values:

Properties	Test Method	Units	Qualifier	Specified Value
Apparent Opening Size	ASTM D 4751	Mm	MARV	0.425
Puncture Strength	ASTM D 4833	Lbs	MARV	100
Tensile Strength	ASTM D 4595	lb/in	MARV	120
Mullen Burst	ASTM D 3786	Psi	MARV	450

B. The Geotextile Manufacturer and/or Fabricator shall furnish materials whose "Minimum Average Roll Values", meet or exceed the properties specified in paragraph 2.05 Geotextile Properties (Woven), as well as a certification that the material properties meet or exceed the specified values. The geotextiles shall be stock products. The Geotextile Manufacturer and/or Fabricator shall not furnish products specifically manufactured to meet the specifications of this project unless authorized by the Owner's Representative.

C. In addition to the property values specified in paragraph 2.05 Geotextile Properties (Woven), the geotextiles shall:
   1. Retain their structure during handling, placement, and long-term service.
   2. Be capable of withstanding direct exposure to sunlight for a minimum of 30 days with no measurable deterioration.

D. Manufacturing Quality Control:
   1. Quality control testing shall be performed as specified in paragraph 2.01 of this section.

E. Acceptable Manufacturers/Fabricators:
   1. Synthetic Industries
   2. Engineer Approved Equal

2.06 GEOSYNTHETIC CLAY LINER

A. The geosynthetic clay liner (GCL) shall consist of a layer of sodium bentonite clay between two non-woven polypropylene geotextiles which are needlepunched together.

B. The GCL Manufacturer shall furnish GCLs having the following property values:

GCL Property Value Requirements

Properties	Test Method	Units	Qualifier	Specified Value
Clay Mass per Area	ASTM D 3776	Psf	MARV	0.75 (at 0% moisture)
Grab Strength	ASTM D 4632	lbs	MARV	90
Permeability	ASTM D 5084	cm/sec	Nominal	5×10^{-9}

C. The GCL shall be manufactured by mechanically bonding the geotextiles using a continuous needlepunching process to punch fibers from the geotextiles through the bentonite clay layer to integrate then into the adjoining geotextile.

D. Acceptable Manufacturers/Fabricators:
   1. Colloid Environmental Technologies Company
   2. Bentofix Technologies, Inc.
   3. Engineer Approved Equal

PART 3 EXECUTION

3.01 INSTALLATION OF GEOSYNTHETICS

A. Familiarization
   1. Prior to implementing any of the work described in this Section, the Geosynthetic Installer and Contractor, if other than installer, shall become thoroughly familiar with all portions of the work falling within this section and related sections.

B. Inspection:
   1. Prior to implementing any of the work in this Section, the Geosynthetic Installer(s) and Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse impact.
   2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he shall notify the Contractor and the Owner's Representative in writing prior to the start of the work of this Section. Failure to inform the Contractor and the Owner's Representative in writing will be construed as the Geosynthetics Installer's acceptance of the related work of all other Sections.
   3. If the Geosynthetic Installer intends to install geosynthetics between one hour before sunset and one hour after sunrise, he shall request approval from the Owner's Representative in writing prior to the start of the work. The Geosynthetic Installer shall indicate additional precautions which shall be taken during these installation hours.

3.02 EARTHWORK

A. Surface Preparation:

1. The surface of the subgrade layer/cushion soil layer shall be smooth, firm, unyielding, and free of vegetation, construction debris, sticks, sharp rocks, void spaces, abrupt elevation changes, and standing water. Immediately prior to GCL deployment, the subgrade shall be final graded to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the or GCL. At the completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions extending more than one-half inch from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor.
2. The Geosynthetic Installer shall provide continuous certification in writing that the surface on which the geosynthetics is being installed is acceptable and in accordance with the Drawings and Specifications. This certification of acceptance shall be given to the Contractor and the Owner's Representative prior to commencement of geosynthetics installation in the area under consideration.
3. Special care shall be taken to maintain the prepared soil surface throughout the geosynthetic installation work.
4. No geosynthetics shall be placed onto an area which has been softened by precipitation and/or condensation or which has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the soil surface.
5. Any damage to the soil surface caused by installation activities shall be repaired at the Contractor's expense.

3.03 QUALITY ASSURANCE TESTING BY OWNER'S REPRESENTATIVE

A. Geomembrane

1. Samples of the Geomembrane will be selected by the Owner's Representative and sent to a Geomembrane Construction Quality Assurance (CQA) Laboratory selected by the Owner's Representative for the minimum testing as specified in the Construction Quality Assurance Plan (CQAP) to ensure conformance with the requirements of this Section. This testing will be carried out prior to the start of the work of this Section.
2. Samples will be selected by the Owner's Representative.
3. The Owner's Representative may increase the frequency of sampling in the event that test results do not comply with the requirements of paragraph 2.02 of this Section. The additional testing shall be performed at the expense of the Geomembrane Manufacturer and/or Fabricator.
4. At a minimum, tests listed in paragraph 2.02 60-Mil HDPE and 40-Mil LLDPE Geomembranes shall be performed to establish the thickness, specific gravity, and tensile properties of the geomembrane.
5. Any geomembranes that are not certified in accordance with paragraph 1.06 of this Section, or that conformance testing indicates do not comply with paragraph 2.02 60-Mil HDPE and 40-Mil LLDPE Geomembranes of this Section, will not be approved for use by the Owner's Representative. The Geomembrane Manufacturer shall replace the rejected material with new material, at no additional cost to the Owner.

B. Other Geosynthetic Materials:
   1. Samples of the geocomposite will be selected by the Owner's Representative and sent to a geosynthetics CQA Laboratory selected by the Owner's Representative for testing to ensure conformance with the requirements of this Section. Samples of the delivered geocomposite will be selected by the Owner's Representative. This testing will be carried out prior to the start of the work of this Section.
   2. Samples will be selected by the Owner's Representative. Samples will be taken at a minimum frequency of one sample per 200,000 square feet.
   3. The Owner's Representative may increase the frequency of sampling in the event that test results do not comply with the requirements of paragraph 2.04 of this Section. The additional testing shall be performed at the expense of the Geosynthetics Manufacturer and/or Fabricator.
   4. As a minimum, tests listed in paragraph 2.04 Geotextile Properties (Nonwoven) of this section shall be performed on the geocomposite. The following conformance tests, at a minimum, shall be performed on geotextile materials:
      a. Mass per unit area, grab strength, tear strength,
      b. puncture strength, Apparent Opening Size (AOS),
      c. and transmissivity tests, as listed in paragraph 2.04 Geotextile Properties (Nonwoven)
   5. Any geosynthetics that are not certified in accordance with paragraph 1.06 of this Section, or that conformance testing indicates do not comply with the associated parts of this Section, will not be approved for use by the Owner's Representative. The Geosynthetic Manufacturer and/or Fabricator shall replace the rejected material with new material, at no additional cost to the Owner.

3.04 GEOMEMBRANE INSTALLATION

A. General
   1. Layout Drawings:
      a. The Geosynthetics Installer shall produce layout drawings as specified in paragraph 1.06 of the section.
   2. Field Panel Identification:
      a. Each field panel must be given an identification code/number. This identification code/number shall be agreed upon by the Owner's Representative and Geosynthetics Installer and shall be shown on the panel layout drawing.
   3. Field Panel Placement:
      a. Field panels shall be installed as approved or modified at the location and positions indicated on the Drawings.
      b. Field panels shall be placed one at a time, and each field panel shall be seamed by the end of each day.
      c. Geomembranes shall not be placed when the ambient temperature is below 32°F, unless otherwise authorized by the Owner's Representative.
      d. Geomembranes shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.
      e. The Contractor and Geosynthetics Installer shall employ placement methods which ensure that:

1) No vehicular traffic shall be allowed on the geomembrane.
2) Equipment used shall not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or other means.
3) Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane.
4) The method used to unroll/unfold the panels shall not scratch or crimp the geomembrane and shall not damage the supporting soil.
5) The prepared surface underlying the geomembrane shall not be allowed to deteriorate after acceptance, and shall remain acceptable up to the time of geomembrane placement.
6) The method used to place the panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).
7) Temporary loads and/or anchors (e.g., sand bags), not likely to damage the geomembrane, shall be placed on the geomembrane to prevent uplift by wind (in high winds, continuous loading is recommended along panel edges to minimize the risk of wind flow under the panels).
8) The geomembrane shall be especially protected from damage in heavily trafficked areas.

f. Any field panel or portion thereof which becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material at no cost to the Owner's Representative. Less serious damage may be repaired at the Owner's Representative's option and at no cost to the Owner. Damaged panels or portions of damaged panels which have been rejected shall be removed from the work area.

g. All panels shall be placed to keep wrinkles to a practical minimum. Wrinkles left in place as a consequence of method of panel deployment, where such wrinkles can be removed, shall not be acceptable.

B. Field Seaming:

1. Seam Layout
   a. To the greatest extent practicable, seams shall be oriented parallel to the line of maximum slope; i.e., oriented down, not across the slope.
   b. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized.
   c. No horizontal seam shall be located on a slope steeper than 5 percent or within 5 feet of its crest or toe, except with the written approval of the Owner's Representative.
   d. No seam shall be located in an area of potential stress concentration; e.g., at the invert of swales or channels, near anchor trenches, or similar.
2. Seaming Personnel
   a. All personnel performing seaming operations shall be qualified as indicated in paragraph 1.04 of this Section. No seaming shall be performed unless a "master seamer" is present.
3. Trial Seams
   a. Trial seams shall be fabricated from pieces of the actual geomembrane material to verify that seaming conditions are adequate for production seaming. Trial seams shall be identical to and made under the same conditions as actual

seams. Trial welds shall be at least three-feet (extrusion welds) to ten-feet (double-track welds) long and one (1) foot wide (after seaming) with the seam centered lengthwise on the sample.

b. Trial seams shall be made at the beginning of each seaming period and at least once each four (4) to six (6) hours for each production seaming apparatus used that day.

c. Each seamer shall make at least one trial seam each day.

d. The Contractor shall sample and test each trial seam (5 peel and 3 shear) in accordance with methods for destructive tests presented in ASTM D6392. Seams shall be tested using a field tensiometer to be supplied by the Contractor.

e. Test results which meet or exceed the performance criteria specified in paragraph 2.02 60-Mil HDPE and 40-Mil LLDPE Geomembranes are considered to be indicative of acceptable seams. Test results that do not meet the specified performance criteria are considered to be indicative of failed seams. Failure of one or more test specimens from a given trial seam constitutes a failure of that seam.

f. Formal results for each test shall be reported in the format described in ASTM D4437 on the working day following completion of each of the tests. Test results which indicate a failure of a trial seam(s) shall be orally reported to the Owner's Representative immediately.

g. In the event that a test specimens fails in the seam, a new trial seam and new test specimens shall be prepared and tested. This procedure shall be repeated, until the seaming deficiencies are corrected and two consecutive successful trial seam tests are achieved.

h. The tensiometer used to test the trial seams shall be capable of maintaining a constant jaw separation rate and shall be adjustable to operate in the range from 2 to 20 inches per minute.

i. After completion of the above described tests, any remaining portions of the trial seam sample(s) may be discarded.

4. Overlapping and Temporary Bonding:

a. Geomembrane panels shall be overlapped in accordance with the recommendations of the manufacturer of the specific product(s) selected by the Contractor. In any event, overlap shall be sufficient to enable sampling and peel testing to be performed on each seam.

b. Procedures used to temporarily bond adjacent panels together, if such techniques are employed, shall be in accordance with the recommendations of the manufacturer of the specific product(s) selected by the Contractor, but also shall not damage the geomembrane.

5. Seam Preparation:

a. Seam areas shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material which may adversely affect the formation of the seam.

b. Prior to initiation of seaming operations in any given area, the Contractor shall notify the Owner's Representative that the area is ready for seaming. Seaming is not to proceed until the area has been checked by the Owner's Representative and approved for seaming.

c. If seam overlap grinding is required, according to the geomembrane manufacturer recommendations, the process shall be completed within one hour prior to the seaming operation. The grind depth shall not exceed ten (10) percent

of the geomembrane thickness. Grinding marks shall not appear beyond 0.25 inch of the extrude after it is placed.

6. Field Seaming Process:
    a. As a minimum, materials, equipment and processes for field seaming shall comply with the specifications and recommendations of the manufacturer(s) or fabricator(s) of the specific geomembrane material(s) selected by the Contractor. Requirements for submission of such specifications and recommendations for all geosynthetic materials are covered in paragraph 1.06 of this Section. In addition:
        1) The Contractor shall maintain at least one spare operable seaming apparatus on site at all times.
        2) Seaming apparatus shall be equipped with fully operational controls, gauges, and monitoring devises applicable to all functions which regulate or affect the seaming process or quality.
        3) Any electric power generating equipment required for the seaming operations shall be placed outside the membrane area or mounted on pneumatic tires which distribute the equipment load such that no damage to the geomembrane or its subgrade may result. Electric power generating equipment shall be properly grounded at all times during use.
    b. Any repairs to the geomembrane shall be effected using identical geomembrane material. Such repair patches shall extend at least six (6) inches beyond the edge of the defect and all corners of the patch shall be rounded to a radius of approximately three (3) inches.
    c. Any geomembrane surfaces showing injury due to scuffing, penetration by foreign objects, or distress from other causes, shall be replaced or repaired, as directed by Owner's Representative, at no additional cost to the Owner.
    d. Field seams shall be visually inspected and manually tested by the Contractor immediately after completion of that seam. The Contractor shall carefully observe each seam for any visible evidence of defects. Manual testing each seam shall be performed by pulling the seam in a shear mode. Any seam with visible defects or which fails the manual test shall be reseamed and retested. These quality assurance tests and reworking of unacceptable seams shall be at no additional cost to the Owner.

C. Non-Destructive Testing:
    1. The Contractor shall evaluate the integrity of all field seams over their full lengths using equipment and procedures for non-destructive test methods as described in GRI GM6. Equipment and methods for this testing are to be identified in advance as discussed in paragraph 1.06 of this Section.
    2. Non-destructive testing shall be carried out on a continuing basis as the seaming work progresses To the greatest extent practicable, seams are to be tested on the day formed. At the latest, seams shall be tested on the workday following the day of formation.
    3. The Contractor shall repair any and all defects in the seams in accordance with the manufacturer's or fabricator's recommendations and the specifications.
    4. The Contractor shall employ the following procedures with respect to locations where seams cannot be non-destructively tested:
        a. If such seam is accessible to test equipment prior to its final installation, the seam shall be non-destructively tested before final installation.

b. If such seam cannot be tested prior to final installation, the Contractor shall notify the Owner's Representative at least one working day in advance of the formation of this seam, and the Owner's Representative must be present during formation of this seam.

D. Destructive Seam Strength Testing
   1. Locations and Frequency:
      a. The Geomembrane Installer shall cut a minimum of one 1-inch specimen at the end of each production seam, and test it in peel to document consistency of the welding. A film tear bond is required to continue welding.
      b. The Geosynthetics Quality Assurance Monitor will select the locations where seam samples are to be cut for laboratory testing. The sampling should be established as follows:
         1) A minimum frequency of one test location per 500 feet of field seam length. At least one sample shall be taken for each seaming crew for each day of welding.
         2) Additional test locations may be selected during seaming at the discretion of the Geosynthetics Quality Assurance Manager. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of inadequate welding.
      c. The Geomembrane Installer will not be informed in advance of the locations where the seam samples will be taken.
   2. Sampling Procedures:
      a. Samples will be cut by the Geomembrane Installer as the seaming progresses in order to have laboratory test results before completion of liner installation. The Geosynthetics Quality Assurance Monitor will:
         1) Observe sample cutting;
         2) Assign a number to each sample and mark it accordingly;
         3) Record the sample location on a layout drawing; and,
         4) Observe field tensiometer testing performed by the Geomembrane Installer and record test data.
      b. Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired by the Geomembrane. The continuity of the new seams in the repaired area will be non-destructively tested .
   3. Size of Samples:
      a. The samples will be a minimum of 12 inches wide by about 48 inches long with the seam centered lengthwise. One 1-inch wide strip will be cut from each end of the sample and these will be tested by the Installer in the field for peel and shear using the tensiometer, and should not fail in the seam. The remaining sample will be cut into three parts and distributed as follows:
         1) One portion to the Geomembrane Installer for laboratory testing, 12 in. x 18 in.;
         2) One portion for Geosynthetics Quality Assurance Consultant for possible laboratory testing, 12 in. x 18 in.; and,
         3) One portion to the Owner for archive storage, 12 in. x 12. in.
      b. Samples will be cut by the Geomembrane Installer at the locations designated by, and under the observation of, the Geosynthetics Quality Assurance Monitor as

the seaming progresses in order to obtain laboratory test results prior to completion of liner installation.

c. The Geosynthetics Quality Assurance Monitor will witness field tests and mark samples with their number. The Geosynthetics Quality Assurance Monitor will also log the date, name of seamer, number of seaming unit, and pass or fail description.

4. Testing Requirements:
   a. Laboratory testing of seams will commence as soon as possible after the field seam samples (FSS) are received. A minimum of five specimens should be tested each for shear and peel, for a total of ten destructive tests per FSS. The shear and peel testing of the seams should be conducted according to ASTM D-6392.
   b. All five tests from each FSS should fail outside of the seamed area to be considered an acceptable seam. If one of the shear or peel tests fails, an additional specimen from the same FSS will be tested in the mode by which the specimen failed. If the retest specimen passes then the FSS is acceptable. If the retest specimen fails then the FSS is unacceptable.
5. Definition of Pass/Fail Criteria:
   a. Fusion Weld
      1) A passing seam produced by the fusion weld will be achieved in peel when no greater than 25% of the seam width (defined as the extent of the knurl marks from the pinch rollers) peels (separates) at any point. From this point, a Film Tear Bond (FTB) with a peel strength listed in the Geomembrane Property Value Requirements (Textured) Table in paragraph 2.02 will result in a passing sample.
   b. Extrusion Weld
      1) A passing seam produced by the extrusion weld will be achieved in peel when no greater than a 1/8-inch separation occurs. From this point, a FTB shall occur with a peel strength listed in paragraph 2.02.
      2) A passing seam in shear will fail by FTB, with a minimum tensile strength listed in paragraph 2.02. Yield strain shall be at least 10% and break strain shall be at least 50%.
6. Procedures for Destructive Test Failure:
   a. The following procedures will apply whenever a sample fails the field destructive test. The Geomembrane Installer has two options:
      1) The Geomembrane Installer can cap strip the seam between the failed location and two passed laboratory test locations, or the beginning or end of that day's seaming. Cap-stripping involves applying a strip of geomembrane, a minimum distance of six inches on all sides of the defective seams, and seaming it to the sheet material by extrusion welding.
      2) The Geomembrane Installer can retrace the welding path to an intermediate location on both sides of the failed test location (10 ft. minimum from the location of the failed test) and take a minimum of two 8-in. x 12 in. samples for additional field tests. If these additional samples pass the test, then specimens shall be laboratory tested for confirmation and the seam should be reconstructed between the passing lab test locations. If either of these samples fail, then the entire seam will be reconstructed between passing laboratory test locations.

b. In any case, all acceptable reconstructed seams must be bounded by two passing laboratory test locations, (i.e., the above procedure should be followed in both directions from the original failed location), and one laboratory test must be taken within the reconstructed area if the failed length exceeds 200 feet.

c. In the event that a sample fails a laboratory destructive test (whether it is conducted by the independent laboratory or by the Geomembrane Installer's laboratory), then the above procedures should be followed, considering laboratory tests exclusively. Since the final seam must be bounded by two laboratory passed test locations, it may then be necessary to take one or more new samples for laboratory testing in addition to the one required in the reconstructed seam area.

d. The Geosynthetics Quality Assurance Monitor will observe and note actions taken in conjunction with destructive test failures.

E. Defects and Repairs:

1. The geomembrane will be checked by the Owner's Representative after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
2. The geomembrane surface in the area to be checked shall be swept or wiped by the Contractor if the surface condition may, in the opinion of the Owner's Representative, inhibit observation of the membrane.
3. After seaming of a geomembrane, or a portion of a large geomembrane, is completed, but prior to placing overlying materials, the Contractor shall notify the Owner's Representative that the subject area is ready for checking. Upon checking the area, the Owner's Representative will identify to the Contractor areas of observed, unacceptable wrinkles in the geomembrane. The Contractor shall cut and reseam all wrinkles so-identified. The seams thus produced shall be tested in the manner and at the frequency of the other seams.
4. Repair Procedures:
   a. Any portion of the geomembrane, including seams, exhibiting a flaw, or failing a test, shall be repaired by the Contractor, at no additional cost to the Owner. More than one suitable procedure may be applicable to a given repair. The Contractor shall submit a recommendation for each repair to the Owner's Representative for approval. In the event that the method of repair cannot be agreed between the Contractor and Owner's Representative, the Contractor shall make the repair as directed by the Owner's Representative.
   b. All repairs shall be subject to the same performance criteria and QA/QC monitoring and testing requirements as the original geomembrane installation.
   c. Repairs which fail to meet the QA/QC test requirements shall be redone and retested until a compliant repair is achieved.
5. Repair Records Verification
   a. The Contractor shall number, log, and test each and every repair. Repairs shall be laid out, dimensioned, and numbered on the appropriate panel drawing(s).
   b. The log shall identify the nature of the defect, describe the repair effected, and list the results of tests performed to verify the conformance of the repair with these specifications.

F. Materials in Contact with the Geomembrane
   1. The Contractor shall take all reasonable and appropriate precautions to avoid damage to the geomembrane during its installation, during the installation of other components of the cap system, or resulting from other construction activities.
   2. Equipment shall not be driven directly on the geomembrane or overlying components of the geosynthetics layer. Unless otherwise directed in writing by the Owner's Representative, all equipment used to spread and compact the cover soil shall comply with the following requirements:

Maximum Allowable Equipment Ground Pressure (psi)	Initial Lift Thickness of Overlying Compacted Fill (ft)
<5	1.0
<10 but >5	1.5
<20 but >10	2.0
>20	3.0

   3. In heavily trafficked areas such as access ramps, and in areas trafficked by rubber tire vehicles, the Contractor shall maintain a minimum thickness of compacted structural fill overlying the membrane of 3 feet.

G. Geomembrane Acceptance:
   1. The Contractor shall retain all ownership and responsibility for the geomembrane until accepted by the Owner.
   2. Acceptance of the geomembrane by the Owner will occur when:
      a. The installation is completed;
      b. All documentation related to the installation is completed, including the Owner's Representative's final report;
      c. Verification of the adequacy of all field seams and repairs is completed; and
      d. Written certification documents, sealed by the Owner's Representative, and including record drawings, prepared and sealed by the Contractor, have been received by the Owner.

3.05 GEOTEXTILE INSTALLATION

A. General:
   1. Geotextiles shall be handled in such a manner as to ensure they are not damaged in any way.
   2. Precautions shall be taken to prevent damage to underlying layers during placement of the geotextile.
   3. After unwrapping the geotextile from its opaque cover, the geotextile shall not be left exposed for a period in excess of 30 days unless a longer exposure period is approved by the Owner's Representative, based on a formal demonstration from the Contractor that the geotextile is stabilized against UV degradation for a period in excess of 30 days.
   4. If white-colored geotextile is used, precautions shall be taken against "snow blindness" of personnel.
   5. Care shall be taken during placement of geotextiles not to entrap stones, excessive dust, or moisture in the geotextile during placement.

6. In the presence of wind, all geotextiles shall be weighted with sand bags or the equivalent. Such sand bags shall be installed during placement and shall remain until replaced with protective soil cover or other components of the cover system.
7. The Contractor and Geosynthetics Installer shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Such foreign objects shall be removed and damaged geotextile shall be replaced.

B. Seams and Overlaps:
1. Geotextiles shall be continuously sewn (i.e., spot sewing is not allowed). Geotextiles shall be overlapped a minimum of 6 inches prior to seaming. No horizontal seams shall be allowed on slopes steeper than 10 horizontal to 1 vertical (i.e., seams shall be along, not across, the slopes). Note: Seams may be continuously heat bonded at the discretion of the design engineer.
2. Polymeric thread shall be used for all sewing. The seams shall be sewn using Stitch Type 401 (i.e., double chain stitch). The seam type shall be Federal Standard Type SSa-1 (i.e., prayer-type seam).

C. Repair:
1. Any holes or tears in the geotextile shall be repaired as follows:
a. On slopes steeper than 10 horizontal to 1 vertical, a patch made from the same geotextile shall be double seamed into place (with each seam 0.5 inches apart and no closer than 1 inch from any edge). Should any tear exceed 10 percent of the width of the roll, that roll shall be removed from the slope and replaced with new material.
b. On slopes flatter than 10 horizontal to 1 vertical, a patch made from the same geotextile shall be spot-seamed in place with a minimum of 2 feet overlap in all directions.
2. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile.

3.06 GCL INSTALLATION

A. The Contractor shall handle GCL materials/rolls in such a manner as to ensure they are not damaged in any way. Contractor shall install GCL in accordance with Manufacture's recommendations.

B. All required cuts in GCLs shall be made using a utility knife with a sharp blade. Blades shall be changed frequently to maintain suitable sharpness for cutting. Care shall be exercised to prevent alteration or damage to any underlying material during cutting.

C. During placement, care shall be taken not to entrap stones, other potentially damaging objects, or moisture under the GCL.

D. Under no circumstance shall equipment or other potentially damaging objects be dragged across exposed surfaces of the GCL.

E. Any GCL roll, panel, or portion thereof which is damaged by stones or other objects, or installation activities shall be replaced by the Contractor at no additional cost to the Owner's Representative.

F. The Contractor shall not install GCL material on a saturated subgrade or on standing water. The GCL shall be installed in a way that prevents hydration prior to covering with soil.

G. The GCL shall not be installed during precipitation or other conditions that may cause hydration of the GCL.

H. Any and all GCL which becomes hydrated, as determined by the Owner's Representative, shall be replaced by the Contractor at no additional cost to the Owner's Representative.

I. All GCL that is placed during one day shall be covered with soil or geosynthetics before the Contractor leaves the site at the end of that day.

J. Seams in GCL Panels:
   1. Horizontal seams shall not be constructed on slopes steeper than 10 percent.
   2. Seams shall be overlapped per manufacturer's recommendations or a minimum of 6 inches along the sides of adjacent panels and at least 1-foot at the ends. Accessory clay material to be obtained from the GCL Manufacturer, shall be used along all seams in accordance with the Manufacturer's recommendation.
   3. Edges of GCLs shall be pulled taught to remove any wrinkles or creases in the seam areas.
   4. Seams/overlaps shall not be nailed or stapled to the subgrade.
   5. Horizontal seams shall be overlapped such that the upgradient GCL is placed over the downgradient GCL.

K. Repair:
   1. Holes, tears, or hydrated areas in the GCL shall be repaired by closing or removing the damaged portion and placing a GCL patch over the hole. Such patch shall overlap all edges of the damaged area by 1 foot. Accessory clay material, to be obtained from the GCL manufacturer, shall be placed between the patch and the repaired area of the GCL.
   2. Prior to installation of any patch, the Contractor shall remove any soil or other material which potentially may adversely affect the bond between the patch and the underlying GCL.
   3. All repairs shall be made at no additional cost to the Owner's Representative.
   4. Patch materials shall not be nailed or stapled to the subgrade.

3.07 PLACEMENT OF SOIL AND EARTHEN MATERIALS

A. The Contractor or Geosynthetics Installer shall place all soil and earthen materials in such a manner as to ensure that:
   1. The final grades, elevation, and surface preparation are acceptable to the Engineer and the geosynthetics manufacturer and installer;
   2. The GDL and geotextile(s) and underlying cover materials are not damaged;
   3. Minimal slippage occurs between the GDL and geotextile(s) and underlying geosynthetics layers; and
   4. Excess tensile stresses are not produced in the GDL, geomembrane or GCL.

B. Equipment shall not be driven directly on the GDL. Unless otherwise specified by the Owner's Representative, all equipment operating on soil material overlying the GDL shall comply with the requirements specified in paragraph 3.04 Materials in Contact with the Geomembrane of this section.

C. Protective soil placement on the sideslopes shall occur from the bottom up. Alternate methods for placing the protective soil material shall not be allowed unless approved by the Owner's Representative. Soil placement in these areas shall provide a supporting buttress on which the uphill soil is supported as placement progresses up the slope.

3.08 PRODUCT PROTECTION

A. Use all means necessary to protect all prior work and materials and completed work of other Sections.

B. In the event of damage, the Contractor shall make all repairs and replacements necessary, to the approval of the Owner's Representative and at no additional cost to the Owner.

END OF SECTION

SECTION 31 23 00

EXCAVATION AND FILL

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies earthwork which consists of excavation, filling, grading, and disposal of excess material.
   2. This section serves to supplement the City of Newton General Construction Details included in the Drawings.

B. Definitions:
   1. Compaction: The degree of compaction is specified as percent compaction. Maximum or relative densities refer to dry soil densities obtainable at optimum moisture content.
   2. Excavation Slope: Excavation slope shall be defined as an inclined surface formed by removing material from below existing grade.
   3. Embankment Slope: Embankment slope shall be defined as an inclined surface formed by placement of material above existing grade.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM C136	Standard Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D1556	Test Method for Density of Soil in Place by the Sand-Cone Method
ASTM D1557	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.5-kg) Rammer and 18-in. (457-mm) Drop
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate

Reference	Title
ASTM D3017	Test Method for Moisture Content of Soil and Soil- Aggregate in Place by Nuclear Methods (Shallow Depth)

B. Tests:

1. The Construction Manager will take samples and perform moisture content, gradation, compaction, and density tests during placement of backfill materials to check compliance with these specifications. The Contractor shall remove surface material at locations designated by the Construction Manager and provide such assistance as necessary for sampling and testing. The Construction Manager may direct the Contractor to construct inspection trenches in compacted or consolidated backfill to determine that the Contractor has complied with these specifications. Payment for inspection trenches shall be as specified in the General Conditions of the Contract Documents .
2. Tests will be made by the Construction Manager in accordance with the following:

Test	Standard Procedure
Moisture content	ASTM D3017
Gradation	ASTM C136
Density in-place	ASTM D1556
Moisture-density relationships	ASTM D1557

1.03 SUBMITTALS

A. Samples of fill materials to be used shall be submitted 2 weeks in advance of use. Samples shall consist of 0.5 cubic feet of each type of material.

PART 2 PRODUCTS

2.01 FILL MATERIALS

A. Type A:

1. Type A material shall be a clean gravel-sand mixture free from organic matter and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
3/4 inch	100
3/8 inch	70-100
No. 4	55-100
No. 10	35-95
No. 20	20-80
No. 40	0-55
No. 100	0-2

B. Type B:

1. Type B material shall be a select granular material free from organic matter and of such size and gradation that the specified compaction can be readily attained.

Material shall have a sand equivalent value determined in accordance with ASTM D2419 of not less than 20 and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
3 inch	100
No. 4	35-100
No. 30	20-100

2. The coefficient of uniformity shall be 3 or greater.
3. The material may be an imported quarry waste, clean natural sand or gravel, select trench excavation or a mixture thereof.

C. Type C:

1. Type C material shall be unclassified material which is free from peat, wood, roots, bark, debris, garbage, rubbish or other extraneous material. The maximum size of stone shall not exceed 6 inches. If the material excavated from the site meets these requirements, it may be classified as Type C.

D. Type D:

1. Type D material shall be granular material commonly known as pea gravel and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
1/4 inch	100
No. 8	0-5

E. Type E:

1. Type E material shall be crushed rock commonly known as drain rock and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
1-1/2 inch	100
3/4 inch	30-75
1/2 inch	15-55
1/4 inch	0-5

2. Type E material shall be composed of hard, durable, sound pieces having a specific gravity of not less than 2.65

F. Type F:

1. Type F material shall be crushed rock and shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
1-1/2 inch	87-100
3/4 inch	45-90
No. 4	20-50
No. 30	6-29
No. 200	0-12

2. Type F material shall be composed of hard, durable, sound pieces having a specific gravity of not less than 2.65.

G. Type G:

1. Type G material shall be pervious backfill. Pervious backfill material shall conform to the following gradation:

U.S. standard sieve size	Percent by weight passing
2 inch	100
No. 50	0-100
No. 100	0-8
No. 200	0-4

H. Type H:

1. Type H material shall be 6-inch riprap. Riprap shall be graded rock having a range of individual rock weights as follows:

Weight of stone	Percent smaller by weight
10 pounds	100
5 pounds	80-100
2 pounds	45-80
1 pound	15-45
1/2 pound	5-15
Below 1/2 pound	0-5

2. Specific gravity shall be between 2.5 and 2.82.

I. Type I:

1. Type I material shall be 12-inch riprap. Riprap shall be graded rock having a range of individual rock weights as follows:

Weight of stone	Percent smaller by weight
160 pounds	100
100 pounds	80-100
50 pounds	45-80
20 pounds	15-45
5 pounds	5-15
1 pound	0-5

2. Specific gravity shall be between 2.5 and 2.82.

J. Type J:

1. Type J material shall be unclassified material and may be obtained from excavation on site. The material may contain extraneous material such as demolition waste, unsuitable material excavated from beneath structures, and clearing and grubbing debris up to 50 percent by volume. Extraneous material shall be thoroughly mixed and the maximum size of organic particles shall be 6 inches.

PART 3 EXECUTION

3.01 GENERAL

A. Control of Water:

1. The Contractor shall keep excavations reasonably free from water during construction. The static water level shall be drawn down a minimum of 1 foot below the bottom of excavations to maintain the undisturbed state of natural soils and allow the placement of any fill to the specified density. Disposal of water shall not damage property or create a public nuisance. The Contractor shall have on hand pumping equipment and machinery in good working condition for emergencies and shall have workmen available for its operation. Dewatering systems shall operate continuously until backfill has been completed to 1 foot above the normal static groundwater level.
2. Groundwater shall be controlled to prevent softening of the bottom of excavations, or formation of "quick" conditions. Dewatering systems shall not remove natural soils. The Contractor shall control surface runoff to prevent entry or collection of water in excavations.
3. Release of groundwater to its static level shall be controlled to prevent disturbance of the natural foundation soils or compacted fill and to prevent flotation or movement of structures or pipelines.

B. Overexcavation:

1. Where the undisturbed condition of natural soils is inadequate for support of the planned construction, the Construction Manager will direct the Contractor to overexcavate to adequate supporting soils. The excavated space shall be filled to the specified elevation with backfill. The overexcavated space under footings may be filled with concrete. The quantity and placement of such material will be paid for as extra work.

C. Surplus Material:

1. Unless otherwise specified, surplus excavated material shall be disposed of off site in accordance with applicable ordinances and environmental requirements.
2. If the quantity of surplus material is specified, the quantity specified is approximate. The Contractor shall satisfy himself that there is sufficient material available for the completion of the embankments before disposing of any material inside or outside the site. Shortage of material, caused by premature disposal of any material by the Contractor, shall be replaced by the Contractor.
3. Material shall not be stockpiled to a depth greater than 5 feet above finished grade within 25 feet of any excavation or structure except for those areas designated to be preconsolidated. For these areas, the depth of stockpiled material shall be as specified. The Contractor shall maintain stability of the soil adjacent to any excavation.

D. Borrow Material:

1. If the quantity of acceptable material from excavation is not sufficient to construct the embankments required by the work, the quantity of material needed to complete the embankments shall consist of imported borrow conforming to specified requirements.

E. Hauling:
   1. When hauling is done over highways or city streets, the loads shall be trimmed and the vehicle shelf areas shall be cleaned after each loading. The loads shall be watered after trimming to eliminate dust.

F. Finish Grading:
   1. Finished surfaces shall be smooth, compacted and free from irregularities. The degree of finish shall be that normally obtainable with a blade-grader.
   2. Finished grade shall be as specified by the contours plus or minus 0.10 foot except where a local change in elevation is required to match sidewalks, curbs, manholes and catch basins, or to ensure proper drainage. Allowance for topsoil and grass cover, and subbase and pavement thickness shall be made so that the specified thickness of topsoil can be applied to attain the finished grade.
   3. When the work is an intermediate stage of completion, the lines and grades shall be as specified plus or minus 0.5 foot to provide adequate drainage.
   4. If the soil is to be cultivated or straw is to be incorporated into the surface, rocks larger than 2-1/2 inches in maximum dimension, roots and other debris on the surface of the slope shall be removed and disposed of prior to cultivation or placement of straw.

G. Control Of Erosion:
   1. The Contractor shall maintain earthwork surfaces true and smooth and protected from erosion. Where erosion occurs, the Contractor shall provide fill or shall excavate as necessary to return earthwork surfaces to the grade and finish specified.

3.02 CLASSIFICATION OF FILL

A. Fill material shall be placed in horizontal layers and compacted with power-operated tampers, rollers, idlers, or vibratory equipment. Material type, maximum layer depth, relative compaction, and general application are specified in Table A. Unless otherwise specified, fill classes shall be used where specified in Table A under general application.

Table A, Fill Classifications

Fill class	Material type	Maximum uncompressed layer depth, inches	Minimum relative compaction, percent	General application
A1	A	8	95	Bedding for pipe, initial pipeline backfill; slabs on grade (other than specified for Class E1)
A2	A	48	95	Initial and subsequent pipeline backfill when ponded or jetted
B1	B	8	95	Structure and subsequent pipeline backfill
B2	B	8	90	Site fill
C1	C	8	90-95	Subsequent pipeline backfill; compaction as specified
C2	C	8	90	Site fill, embankments and dikes
D1	D	-	95	Bedding for tanks and pipe, initial and subsequent tank and pipeline backfill
E1[a]	E	8	-	Fill under slabs for structures and tank slabs with pressure relief valves

Table A, Fill Classifications

Fill class	Material type	Maximum uncompressed layer depth, inches	Minimum relative compaction, percent	General application
F1[b]	F	12	95	Structure backfill, pipeline bedding, initial and subsequent pipeline backfill
G1	G	8	95	Bedding for plastic pipe, initial and subsequent pipeline backfill
H1[c]	H	-	-	Embankment slope face, channel slope face
I1[c]	I	-	-	Embankment slope face, channel slope face
J1[d]	J	8	90	Excess fill

a. Compaction of layers shall be accomplished in two passes of equipment with complete coverage across the width of the field.

b. Material shall not be used for bedding or initial backfill for plastic pipe.

c. Fill material shall be grouted as specified in paragraph 3.08.

d. Asphalt and concrete slabs from demolition may be placed at the bottom of the fill side by side to form a continuous pad. Clearing and grubbing is not required unless shrubs are taller than 3 feet. Mucking of the subgrade and keying or benching of adjoining embankments is not required.

3.03 EARTHWORK FOR STRUCTURES

A. Structure Excavation:

1. The bottom shall not be more than 0.15 foot above or below the lines and grades specified. If the elevation of structure excavation is not specified, the excavation shall be not more than 0.15 foot above or below the elevation specified for fill material below the structure. Slopes shall vary no more than 0.5 foot from specified grade unless the excavation is in rock where the maximum variation shall be 2 feet.
2. Should the excavation be carried below the lines and grades specified on the drawings or should the bottom of the excavation be disturbed because of the Contractor's operations and require overexcavation and backfill, the Contractor shall refill such excavated space to the proper elevation in accordance with the procedure specified for backfill. The cost of such work shall be borne by the Contractor.
3. Unless otherwise specified, excavations shall extend a sufficient distance from walls and footings to allow for placing and removal of forms, installation of services, and for inspection, except where concrete is specified to be placed directly against excavated surfaces.

B. Foundation Treatment:

1. Rock foundations for concrete or masonry footings shall be excavated to sound material. The rock shall be roughly leveled or cut to steps and shall be roughened. Seams in the rock shall be grouted under pressure as directed by the Construction Manager and paid for as extra work.
2. Whenever any structure excavation is substantially completed to grade, the Contractor shall notify the Construction Manager who will make an inspection of the foundation. No concrete or masonry shall be placed until the foundation has been inspected by the Construction Manager. The Contractor shall, if directed by the Construction Manager, dig test pits and make test borings and foundation bearing tests. If the material tested is undisturbed soil, the cost thereof will be paid for as extra work. If the material tested is backfill material, the cost thereof will be paid as specified in the General Conditions of the Contract Documents.

C. Structure Backfill:
   1. Unless otherwise specified, structure backfill shall be Class B1.
   2. After completion of construction below the elevation of the final grade, and prior to backfilling, forms shall be removed and the excavation shall be cleaned of debris.
   3. Structure backfill shall not be placed until the subgrade portions of the structure have been inspected by the Construction Manager. No backfill material shall be deposited against concrete structures until the concrete has developed a strength of not less than 2500 pounds per square inch in compression, or until the concrete has been in place for 28 days, whichever occurs first.
   4. Backfill material shall be placed in uniform layers and shall be brought up uniformly on all sides of the structure. When compaction is done by ponding and jetting, thickness of uncompacted layers shall not exceed 4 feet.
   5. Compaction of structure backfill may be performed by ponding and jetting if the backfill material is of such character that it will be self-draining when compacted and that foundation materials will not be damaged by the applied water and no damage from hydrostatic pressure will result to the structure. Ponding and jetting shall not be used within 4 feet of finished grade and shall be performed in such a manner that water will not be impounded.
   6. Unless otherwise specified, backfill around and above pipelines within the excavation line of any structure shall be the same as that specified for structures.

3.04 EARTHWORK FOR PIPELINES AND CONDUITS

A. General:
   1. Earthwork for pipelines and conduits is specified in Table A; in the standard details; and in the following paragraphs.

B. Pipeline Excavation:
   1. The bottom of the trench shall be carried to the specified lines and grades with proper allowance for pipe thickness and for bedding as specified.

C. Pipeline Backfill:
   1. Bedding: The Contractor shall not proceed with backfill placement in excavated areas until the subgrade has been inspected by the Construction Manager. All pipe shall have a minimum thickness of bedding material below the barrel of the pipe as specified. Bedding material shall be placed in the bottom of the trench, leveled and compacted. Bell holes shall be excavated at each pipe joint to permit proper inspection and uniform bearing of pipe on bedding material.
      a. After the pipe has been laid to alignment and grade, unless otherwise specified, additional bedding material shall be placed in layers the full width of the trench and compacted up to the specified level. Bedding shall be placed simultaneously on both sides of the pipe, keeping the level of backfill the same on each side. The material shall be carefully placed and compacted around the pipe to ensure that the pipe barrel is completely supported and that no voids or uncompacted areas are left beneath the pipe. Contractor shall use particular care in placing material on the underside of the pipe to prevent lateral movement during backfilling.
   2. Initial Backfill: After pipe has been properly bedded, Contractor shall place and compact initial backfill as specified. Initial backfill, where specified below the

springline of the pipe, shall be placed and compacted in accordance with paragraph 3.04 Pipeline Backfill for additional bedding material.

3. Subsequent Backfill:
    a. General: Backfill material, placement and compaction above the pipe zone shall be as specified. Backfill above the pipe zone shall not commence until pipe zone backfill has been inspected and accepted by the Construction Manager.
    b. Improved Areas: Unless otherwise specified, select granular backfill (Class B1) shall be used under all paved and unpaved roadways and paved and unpaved roadway shoulders, roadway embankments, and in all public right-of-ways and easements. The trench shall be backfilled to an elevation which will permit the placement of the specified surface or paving. Paving shall be as specified in Section 32 12 16. Other surfaces shall be restored, including compaction, to the condition existing prior to construction including restoration of yard areas.
    c. Unimproved Areas: Class C1 backfill shall be used for all trenches in pastureland, cultivated land, undeveloped land, and for other unimproved areas where specified. Class C1 backfill shall not be used in any public right-of-way. Trench excavation which meets the requirements of Type C material may be used. The Contractor shall maximize the use of fine-grained materials (e.g., sand, silty sand, sandy silt) as Class C1 backfill.
        1) For Class C1 backfill, the trench above the pipe zone shall be backfilled to within 12 inches of original ground surface. The top 12 inches of soil shall be removed and stored in such a manner that it will not become mixed with unsatisfactory soils. After the trench has been backfilled, the stored topsoil shall be replaced at a uniform depth in its original area compacted to its original condition. The Contractor shall leave the backfilled trench neatly mounded not more than 6 inches above existing grade for the full width of the Class C1 backfill area.

3.05 SUBGRADE FOR PAVEMENT

A. The prepared subgrade shall be scarified to a depth of at least 12 inches and recompacted to at least 95 percent of the maximum density.

3.06 SITE FILL

A. Unless otherwise specified, site fill shall be Class C2 fill. If the existing slope in an area to be filled is greater than 5:1, the Contractor shall bench the area prior to filling.

END OF SECTION

SECTION 31 41 00

SHORING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies requirements for sheeting, shoring, and bracing of trenches greater than 5 feet in depth.

B. Design Requirements:
   1. The Contractor shall design sheeting, shoring, and bracing in accordance with OSHA.
   2. Horizontal strutting below the barrel of a pipe and the use of pipe as support are not acceptable.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall submit as product data to the Owner information required by State Labor Code. Information shall be provided in accordance with Section 01 33 00 of this project manual.

PART 3 EXECUTION

3.01 GENERAL

A. The construction of sheeting, shoring, and bracing shall not disturb the state of soil adjacent to the trench and below the excavation bottom.

B. Trench sheeting below the top of a pipe shall be left in place.

3.02 SEQUENCE

A. Trench excavation shall not be started until the design for trench support has been accepted by the Owner.

END OF SECTION

SECTION 32 12 16

ASPHALT PAVING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies paving consisting of aggregate base, asphaltic concrete, and associated materials.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D1557	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.5-kg) Rammer and 18-in (457-mm) Drop

B. Testing:

1. Testing will be conducted by the Construction Manager to determine compliance with the specified degree of compaction and moisture content.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aggregate Base:

1. Aggregate base shall be 6” Minimum (or match existing depth, whichever is greater), dense graded crushed stone conforming to Massachusetts Department of Transportation Standard Specifications (MassDOT) M2.01.7.

B. Liquid Asphalt:
   1. Liquid asphalt for tack coats and treatment of aggregate base shall be Grade MC 250 and shall comply with the City General Construction Details and MassDOT Section 400 and M3: Asphaltic Materials.

C. Asphalt - Bituminous Concrete:
   1. Surface and binder course shall comply with City General Construction Details, MassDOT Section 460 and M3: Asphaltic Materials.

D. Traffic Line Paint:
   1. Traffic line paint shall be a white latex traffic paint 21209 by Glidden, Vin-L-Stripe acrylic epoxy traffic paint W-801 by Dunn-Edwards, or equal.

PART 3 EXECUTION

3.01 GENERAL

A. Construction shall conform to the details, dimensions and grades specified. Maximum variations in finished grade of paving shall be plus or minus 0.05 feet.

3.02 AGGREGATE BASE PLACEMENT

A. Subgrade:
   1. Areas to be paved shall be graded and compacted in accordance with Section 31 23 00-3.06.

B. Aggregate Base:
   1. Placing of aggregate base shall comply with MassDOT Section 402. Relative compaction shall be a minimum of 95 percent as determined using methods set forth in ASTM D1557.

3.03 ASPHALT – BITUMINOUS CONCRETE PAVEMENT

A. Asphalt Concrete:
   1. Placement of asphalt concrete pavement shall comply with MassDOT Section 460. Berms shall be shaped and compacted with an extrusion machine.

B. Tack Coat:
   1. tack coat shall be applied to all vertical surfaces of existing pavement; to curbs, gutters, and construction joints against which asphalt concrete will be placed; to pavements to be surfaced; and where specified at the approximate rate of 0.05 gallons per square yard. Application shall comply with MassDOT Section 460. Immediately prior to placing asphalt concrete, additional tack coat shall be applied to areas where the tack coat has been damaged.
   2. Immediately prior to construction of asphalt concrete berms, a continuous tack coat shall be applied to the pavement surface. Application of the tack coat shall not cause a slip or weakened plane between the two joined surfaces.

C. Traffic Line Painting:

1. Traffic lines shall be painted on pavement surfaces where specified. Surfaces are to be free of contaminants that may interfere with adhesion. Thinning and coverage shall be as recommended by the manufacturer, but coverage shall not exceed 400 square feet per gallon. Traffic lines shall be of uniform width with the edges straight and even. Traffic shall be restricted from the area until the paint has dried.

END OF SECTION

SECTION 32 90 00

PLANTING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope: The work of this section consists of providing all necessary equipment and labor to install trees and shrubs as shown on the Construction Drawings and specified in this section. The work includes: soil preparation; installation of trees; planting mixes; mulch; and planting accessories. A complete list of plants, including a schedule of quantities, and sizes, is shown on the Construction Drawings.

B. Project Conditions:
   1. Schedule and coordinate work with all trades involved.
   2. Verify that the areas of work have been properly contoured prior to beginning work.
   3. Notify the Engineer of any unforeseen conditions, which will affect plant installation or growth.
   4. The results of the soil tests may indicate recommendations, which will affect the type and analysis of soil amendments.

1.02 QUALITY ASSURANCE

A. The Contractor shall provide a licensed and insured landscaper with at least three years of experience including at least two completed jobs of dollar value and scope similar to this work.

B. No plant substitutions will be permitted without the prior written approval of the Engineer.

C. The Engineer may inspect trees either at the place of growth or at the site before planting, for compliance with requirements for genus, species, variety, size and quality. The Engineer retains the right to further inspect trees and shrubs for size and conditions of balls and root systems, insects, injuries and latent defects, and to reject unsatisfactory or defective material at any item during progress of work. Any such inspection before or during planting operations however shall not be construed as final acceptance of the plants involved. Contractor shall remove rejected trees immediately from project site.

D. The Contractor should be familiar with the quality of materials available from suppliers in order to minimize the likelihood that unacceptable products will be rejected.

E. All plants shall be first-class representatives of their species. All plants shall have normal, well-developed branches and vigorous root system. They shall be sound, healthy, vigorous, and free from defects, disfiguring knots, abrasions of the bark, sunscald injuries, plant diseases, insect eggs, borers, and all other forms of infections. Trees shall have reasonably straight stems, and shall be well branched and symmetrical in accordance with their natural habits of growth. All plants shall be nursery grown.

F. Grading of plants, type, and minimum dimensions of containers shall conform to the specifications contained in the latest edition of "American Standard for Nursery Stock."

Plants shall not be cut back from larger sizes to meet sizes called for on the Construction Drawings. Large plants that have been cut back to the specified sizes will not be accepted. Plant names indicated, should comply with "Standardized Plant Names" as adopted by the latest edition of the American Joint Committee of Horticultural Nomenclature. All plants delivered shall be true to name. Plants larger than specified may be used if acceptable to the Engineer prior to planting. Use of such plants shall not increase the Contract price.

G. Plants shall have been nursery grown under climatic conditions similar to the location of this project, for at least one growing season prior to this work.

H. The greater quantity shall take precedence if discrepancies occur between the quantities designated on the materials list and those indicated on the Construction Drawings.

1.03 SUBMITTALS

A. Certificates of Inspection as required by law or governing authorities to accompany shipments.

B. Peat moss, compost, or other organic soil amendments.

C. Fertilizer materials.

D. Certificates indicating nursery source of each plant.

E. Manufacturer's product data for watering bags.

F. Soil analysis report for existing soil and proposed supply of soil, if needed. Also indicate location of source.

G. Source of mulch for approval and physical sample.

H. Proposed planting schedule, indicating dates for each type of landscape work during normal seasons for such work. Once accepted, revise dates only as approved in writing, after documentation of reasons for delays.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In preparing plants for moving, all precautions customary in good trade practice shall be taken. All plants shall be due to retain as many fibrous roots as possible. Container grown stock shall not be root-bound or with root systems hardened off. Securely attach to all plants, bundles, or packages of plants of a single species and size, or plant container, labels stating the correct plant name and size. Labels shall be durable and legible in weather resistant ink. Cover plants transported on open vehicle with a protective covering to prevent windburn.

B. Schedule delivery of plant material to avoid storage on site. If planting does not occur on same day as delivery, store in a location protected from sun, weather, and vandalism. Protect balls or roots from drying by covering at all times with moist saw dust, wood chips, shredded bark, peat moss, or other similar mulching material.

C. Deliver fertilizer materials in original, unopened and undamaged containers showing weight, analysis, and name of manufacturer. Store in manner to prevent wetting and deterioration.

D. Products shall be packed and shipped in a manner, which will not damage them. Damaged products will be rejected upon delivery and promptly removed from the site.

E. Products, which must be stored prior to installation, shall be protected from sun, water, theft, and any other damage.

PART 2 PRODUCTS

2.01 CONTAINER GROWN PLANTS

A. Container grown plants shall be healthy, vigorous, well-rooted, and shall have become established in the container in which they are delivered. These plants shall have been in the established container long enough for the fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container. No plants shall be loose in the container and shall not be pot bound. The container shall be a minimum #3 container or larger, sufficiently rigid to firmly hold the soil protecting the root during transporting, handling, and planting.

2.02 BACKFILL SOIL MIX

A. All tree and shrub planting pits shall be backfilled with a backfill soil mix consisting of the following proportions by volume:
   - 5 parts approved topsoil
   - 2 parts peat
   - 1 part manure.

B. The backfill soil mix shall be thoroughly rotary mixed prior to installation. If so directed by the Engineer, ground limestone shall be added to the mix at a rate of 2½ pounds per cubic yard for each one full point rise in pH desired.

2.03 TOPSOIL

A. Refer to Section 32 91 19.15 for Topsoil requirements.

2.04 PEAT MOSS

A. Brown to black in color, weed and seed free granulated raw peat or baled peat, containing not more than 9% mineral on a dry basis.

2.05 MANURE

A. Manure shall be aged, commercially composted horse or cow manure subject to approval by the Engineer.

2.06 LIMESTONE

A. Limestone, if necessary as a soil additive, shall be a pulverized limestone having a calcium carbonate content of not less than 85 percent by weight. Agricultural limestone shall be crushed so that at least 85 percent of the material will pass a No. 10 mesh screen and 50 percent will pass a No. 40 mesh screen.

2.07 FERTILIZER TABLETS

A. Agriform Planting Tablets 20-15-5, or approved equal, for woody and riparian plant material.

2.08 MULCH FOR PLANTS

A. Hardwood bark: Shredded long fibers, free of extraneous and harmful matter.

2.09 HERBICIDES

A. To protect waterways and riparian buffers use “Rodeo”, or equal if it is determined an herbicide is required. Apply herbicide according to manufacturer’s directions.

2.10 WATER

A. Water shall be clean, clear water free from any objectionable or harmful chemical qualities or organisms capable of inhibiting vigorous growth of plants. Water shall be furnished by the Contractor.

2.11 WATERING BAGS

A. If used, plastic tree watering bags shall hold a minimum of 15 gallons of water with a slow drip hole(s) water release system, specifically designed to water establishing trees. Water should release over a several days period, not within a few hours.

B. Watering bags shall be:
   1. Treegator Irrigation Bags sized to the appropriate model for the requirements of the plant, manufactured by Spectrum Products, Inc., Youngsville, NC 27596.
   2. Ooze Tube sized to the appropriate model for the requirements of the plant, manufactured by Engineered Water Solutions, Atlanta, GA.
   3. Or approved equal.

C. Submit manufacturer's product data for approval.

2.12 STAKES FOR GUYING

A. Hardwood, 2” x 2” x 24” long.

2.13 GUYING WIRE

A. 12- or 14-gauge galvanized wire.

2.14 STAKING AND GUYING RUBBER HOSE

A. Two-ply, reinforced garden hose not less than ½" inside diameter. Shall be uniform in color.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine proposed planting areas and conditions before installation. Do not start planting work until unsatisfactory conditions are corrected.

3.02 PREPARATION

A. Do not work soils that are muddy or saturated.

B. Planting shall be performed only by experienced workers familiar with planting procedures under the supervision of a qualified supervisor.

C. Locate plants as indicated on Construction Drawings. If obstructions are encountered that are not shown on the Construction Drawings, do not proceed with planting operations until Engineer has selected alternate plant locations.

D. Excavate circular plant pits with vertical sides for container material so that width of pit is two-times diameter of root ball. Scarify bottom of the pit. Remove excess excavated materials from the site. Provide planting soil mix for use around the balls and roots of the plants.

3.03 INSTALLATION

A. Planting of low and high marsh plants shall occur in the spring. Contractor shall coordinate the timing of all other plantings with the City and Engineer.

B. Set container plant material in the planting pit to proper grade and alignment. If fabric is used in container plants, remove first before setting in pit. Set plants upright, plum, and no lower than the finished grade or 2-3 inches above finished grade. Add backfill soil mix to fill approximately half of the pit and add two fertilizer tablets to each pit per the manufacturer's recommendations. Fill rest of pit with backfill soil mix and bring to finished grade. Lightly compact fill around root ball and be sure to fill all voids. No filling will be permitted around trunks or stems.

C. Watering: Thoroughly water each plant immediately after planting to pull soils against root ball and settle air pockets. Additional backfill soil may be needed, water again to ensure complete compaction. Trees shall stand plumb and uniform after watering.

D. Mulching: After planting has been satisfactorily completed, two (2) inches of mulch for woody plants shall be placed on the finished grade around all plants. The boundaries of mulch shall extend to the edge of the planting hole.

E. Pruning and Repair: Remove or cut back broken, damaged, and asymmetrical growth of new wood. Unless otherwise directed, prune evergreens only to remove broken or damaged branches.

F. Clean-Up and Safety: Take special care to keep access roads and sidewalks cleared of mud and debris tracked by site vehicles. After planting operations are finished, clean all paved areas which may have been strewn with soil or other material by washing. The Contractor shall not leave any plant hole open or unattended without proper protective signals, barriers, etc., or in any manner present a hazard to pedestrians or vehicles on the site.

3.04 WATERING FOR PLANTS

A. The Contractor shall provide watering. All plants shall be watered by the Contractor immediately prior to planting and through the warranty period. Thoroughly water plants immediately after planting to thorough saturation of all backfill in the pits and beds during the same day of planting.

B. Watering requirements during the initial shock period (first 30 days after planting) shall be every day for the first 3 days; every other day for 10 days; twice per week for 2 weeks. Rain substitutes for a scheduled watering when at least 1-inch of rainfall at the site has been verified.

C. If the Contractor elects to use watering bags, the Contractor shall install at a minimum 15-gallon watering bags for each tree to be maintained and used for tree watering during the warranty period. The watering bags will remain the property of the Contractor and shall be removed from the site after final acceptance.

D. The Contractor is responsible for providing sufficient water to all plants for survival throughout the one (1) year warranty period.

3.05 CLEAN-UP

A. During installation, keep the site free of trash, pavements reasonably clean and work area in an orderly condition at the end of each day. Remove trash and debris in containers from the site no less than once a week.
   1. Immediately clean up any spilled or tracked soil, fuel, oil, trash or debris deposited by the Contractor from all surfaces within the project or on public right of ways and neighboring property.

B. Once installation is complete, wash all soil from pavements and other structures. Ensure that mulch is confined to planting beds and that all tags and flagging tape are removed from the site.

C. Make all repairs to grades, ruts, and damage by the plant installer to the work or other work at the site.

D. Remove and dispose of all excess planting soil, subsoil, mulch, plants, packaging, and other material brought to the site by the Contractor.

3.06 PROTECTION DURING CONSTRUCTION

A. The Contractor shall protect planting and related work and other site work from damage due to planting operations, operations by other Contractors or trespassers. Maintain protection during installation until Substantial Completion Acceptance. Treat, repair or replace damaged work immediately.

B. Damage done by the Contractor, or any of their sub-contractors to existing or installed plants, or any other parts of the work or existing features to remain, including roots, trunk or branches of large existing trees, soil, paving, utilities, lighting, irrigation, other finished work and surfaces including those on adjacent property, shall be cleaned, repaired or replaced by the Contractor at no expense to the Owner. The Engineer shall determine when such cleaning, replacement or repair is satisfactory.

3.07 MAINTENANCE

A. The Contractor is responsible for maintenance of plants until final acceptance. This includes, but is not limited to all necessary watering, fertilization based on planting season, weed control, and the appropriate applications of fungicides and insecticides necessary to maintain plants free of damaging pests.

3.08 FINAL ACCEPTANCE

A. Upon completion of all planting operations, including cleanup, the Contractor shall notify the Engineer and Owner, at least 10 days before the anticipated date, to schedule an inspection of the planting. Any items found to be unsatisfactory shall be corrected prior to approval for final acceptance. The one (1) year warranty period shall begin on the date of final acceptance.

3.09 MAINTENANCE DURING WARRANTY PERIOD

A. The Contractor is responsible for maintenance of plants throughout the warranty period. This includes, but is not limited to all necessary watering, fertilization based on planting season, weed control, and the appropriate applications of fungicides and insecticides necessary to maintain plants free of damaging pests.

B. The Contractor shall monitor the project site to note dead or unacceptable plant materials by: quantities, varieties, and project locations. Any plant that is dead or not in satisfactory growth, as determined by the Owner or Engineer, shall be immediately removed from the site if requested. These and any missing plants shall be replaced as soon as conditions permit, but preferably during the normal planting season. Replacement material shall be installed per the following schedule:
   1. During Planting Season: When plant material is identified for replacement during the planting season, the material shall be replaced within 10 working days of notification.
   2. During Non-planting Season: When plant material is identified for replacement during non-planting months, the material shall be replaced within the first 30 calendar days of the earliest available planting season.

C. If the Contractor disturbs infrastructure, including but not limited to curbs, sidewalks, pavement, signage, plant material, backfilled and/or mulched areas, through the watering operations or any other maintenance or installation operation, the damage shall be fixed immediately at no cost to the Owner.

D. The Contractor shall be responsible for traffic control through the life of the project and warranty period.

3.10 WARRANTY AND REPLACEMENT

A. The Contractor shall guarantee all trees and other planted materials and workmanship for a period of one (1) year from the date of final acceptance by the Engineer and Owner. The Contractor shall replace any tree or plant that has more than 1/3 crown dieback, dieback of the central leader of a tree, or dieback of any portion of the tree that interferes with satisfactory growth or health. The Contractor shall replace any portion of the project that fails due to faulty materials or workmanship. All plants shall be insect and/or disease free. Plants damaged by pest activity through the warranty period shall be replaced.

B. A six (6) month and 11-month inspection will be held during the warranty period. Damage that occurs prior to final acceptance shall be the responsibility of the Contractor.

C. At the end of the one (1) year warranty period, trees and plantings shall meet 100 percent survival.

D. Plant replacements shall be the same species as specified in the plant list on the Construction Drawings. Replacement tree sizes shall be the same as other existing trees of the same species on the project. Trees, backfill soil mix, fertilizer, and mulch etc., shall be replaced as originally specified. Replacement trees shall meet the requirements of this specification.

E. Through the life of the warranty period any tree that is dead or not in satisfactory growth, as determined by the Engineer or Owner, shall be immediately removed from the site. These and any missing trees or shrubs shall be replaced as soon as conditions permit, but during the normal planting season.

F. Any tree and other items repaired or replaced shall have an extended warranty period of 12 months from the date of acceptance of the repaired or replaced item.

G. During and by the end of the warranty period, remove all ties and guying unless agreed to by the Owner or Engineer to remain in place. All trees that do not have sufficient caliper to remain upright, or those requiring additional anchorage in windy locations, shall be staked or remain staked, if required by the Owner or Engineer.

END OF SECTION

SECTION 32 91 19.15

TOPSOIL AND SEEDING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. The Contractor shall furnish all labor, equipment and material required to place topsoil, seed, commercial fertilizer, limestone and mulch material, including seedbed preparation, harrowing, compacting and other placement operations on graded earthen areas as described herein or shown on the Construction Drawings.
   2. Seeding operations shall be conducted on all newly graded earthen areas not covered by structures, pavement or sidewalks; all cleared or grubbed areas which are to remain as finish grade surfaces; and on all existing turf areas which are disturbed by construction operations and which are to remain as finish grade surfaces. Areas disturbed by borrow activities shall also be seeded according to this section.
   3. The Work shall include temporary seeding operations to stabilize earthen surfaces during construction or inclement weather and to minimize erosion. Temporary seeding shall be performed at the times and locations as directed by the Engineer.

1.02 SUBMITTALS

A. Seed
   1. Prior to seeding operations, the Contractor shall furnish to the Engineer labels or certified laboratory reports from an accredited commercial seed laboratory or a state seed laboratory showing the analysis and germination of the seed to be furnished. Acceptance of the seed test reports shall not relieve the Contractor of any responsibility or liability for furnishing seed meeting the requirements of this Section.

B. Topsoil
   1. Prior to topsoil operations, the Contractor shall obtain representative samples (0.5 cubic foot minimum) and furnish soil test certificates including textural, pH, and organic ignition analysis from a certified testing laboratory.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver seed and fertilizer materials in original unopened containers showing weight, analysis, and name of manufacturer.

B. Store materials in a manner to prevent wetting and deterioration.

C. Do not deliver topsoil in frozen or muddy condition.

PART 2 PRODUCTS

2.01 TOPSOIL

A. The Contractor shall utilize designated stockpiles or borrow areas on-site for topsoil before importing. If sufficient quantities of topsoil material are not available onsite to

construct the required elements of the project, then the Contractor shall import topsoil material to the project site. Imported topsoil shall be approved by the Engineer and shall include a soil test certificate. Imported topsoil shall meet the requirements of this specification. Sources of topsoil shall be approved by the Engineer prior to disturbance.

B. Topsoil shall be a friable loam containing a large amount of humus and shall be original surface solid of good rich, uniform quality, free from any material such as hard clods, stiff clay, hardpan, partially disintegrated stone, pebbles larger than 1/2-inch in any dimension, lime, cement, bricks, ashes, cinders, slag, concrete, bitumen or its residue, boards, stocks, chips or other undesirable material harmful or unnecessary to plant growth. Topsoil shall be reasonably free from perennial weeds and shall not contain objectionable plant material, toxic amounts of either acid or alkaline elements or vegetable debris undesirable or harmful to plant life.

C. Topsoil shall be natural topsoil without admixture of subsoil material, and shall be classifiable as loam, silt loam, clay loam, sandy loam or a combination thereof. The pH shall range from 5.5 to 7.0. Topsoil shall contain not less than 5 percent or more than 20 percent by weight organic matter as determined by loss on ignition of oven-dried samples to 65 degrees C.

2.02 SEED

A. Seed shall be delivered in new bags or bags that are sound and labeled and meet all applicable state and federal regulations. Labeling must indicate the supplier, formulation, germination rates and harvest date.

B. All seed shall be from the last crop available at time of purchase and shall not be moldy, wet or otherwise damaged in transit or storage. Species, rate of seeding, and other requirements are shown on the Construction Drawings.

C. Seed shall bear the growers analysis testing percent for purity and percent for germination. Native Upland seed shall test to 90 percent for purity and 85 percent for germination. Permanent Turfgrass seed shall test to 98 percent for purity and 90 percent for germination. At the discretion of the Engineer, samples of seed may be taken for check against the grower's analysis.

D. Turfgrass seed (Bermudagrass) shall be hulled if applied from May through October and unhulled if applied from November through April.

2.03 LIME

A. Refer to Section 32 90 00 for lime requirements.

2.04 FERTILIZER

A. Conforming to state and federal standards, dry, free flowing, granular or pellet form commercial product. Ratio indicates N-P-K requirements.

B. Starter fertilizer containing 10-10-10, or similar approved composition.

2.05 STRAW MULCH

A. Straw mulch shall be clean oat or wheat straw well-seasoned before bailing, free from mature seed-bearing stalks or roots of prohibited or noxious weeds and free of rot and mildew. All mulch materials shall be air-dried and reasonably free of noxious weeds and weed seeds or other materials detrimental to plant growth. Mulch shall be as specified herein and shall be suitable for spreading with standard mulch blowing equipment.

2.06 WATER

A. Water shall be clean, clear water free from any objectionable or harmful chemical qualities or organisms capable of inhibiting vigorous growth of plants. Water shall be furnished by the Contractor.

PART 3 EXECUTION

3.01 GENERAL

A. Area of Seeding: Areas to be seeded shall conform to the limits shown on the Construction Drawings and Contract Documents. Areas disturbed outside the contract limits approved for seeding shall be seeded by the Contractor at no additional compensation.

B. Watering: Water as necessary to achieve required results within the guarantee period specified.

3.02 SEEDING DATES

A. Seeding dates for Permanent Turfgrass mix shall be as noted on the Construction Drawings.

B. Temporary seed mix seeding dates for warm season grass is May 1 to August 31 and September 1 to April 30 for cool season grass.

C. Upland seed mix seeding dates shall be from September 1 to March 30.

D. At the option and at the full responsibility of the Contractor, seeding operations may be conducted under unseasonable conditions. The final results shall be as specified and guaranteed without additional compensation should the seeded areas require reseeding.

3.03 SECURING AND PLACING TOPSOIL

A. Topsoil shall be secured from areas of which topsoil has not been previously removed, either by erosion or mechanical methods. Topsoil shall not be removed to a depth in excess of the depth approved by the Engineer.

B. The area or areas from which topsoil is secured shall possess such uniformity of soil depth, color, texture, drainage and other characteristics as to offer assurance that, when removed the product will be homogeneous in nature and will conform to the requirements of this section.

C. All areas from which topsoil is to be secured, shall be cleaned of all sticks, boards, stone, lime, cement, ashes, cinders, slag, concrete, bitumen or its residue and any other refuse which will hinder or prevent growth.

D. In securing topsoil from a designated pit, or elsewhere, should strata or seams of material occur which do not come under the requirements for topsoil, such material shall be removed from the topsoil or if required by the Engineer, the pit shall be abandoned.

E. Before placing or depositing topsoil upon any areas, all improvement within the area shall be completed, unless otherwise approved by the Engineer. The areas in which topsoil is to be placed or incorporated shall be scarified to a depth of not less than two (2) inches before securing topsoil for use.

F. The Contractor shall place a minimum of three (3) inches of topsoil over all areas to be seeded as shown on the Construction Drawings.

3.04 SEEDBED PREPARATION

A. Before liming, fertilizing, and seeding; the topsoil surfaces shall be graded, spread evenly, and free from roots and stones larger than 1/2 inch in any dimension.

B. Not earlier than 24 hours before the seed is to be sown, the soil surface to be seeded shall be thoroughly cultivated to a depth of not less than two (2) inches with a weighted disc, tiller, pulvimixer or other equipment until the surface is in a condition acceptable to the Engineer. If the prepared surface becomes eroded as a result of rain or for any other reason, or becomes crusted before the seed is sown, the surface shall again be cultivated for seeding.

C. Ground preparation operations shall be performed only when the ground is in a tillable and workable condition, as determined by the Engineer.

3.05 FERTILIZING AND LIMING

A. Following seedbed preparation, fertilizer shall be applied to all areas to be seeded so as to achieve the application rates recommended in the soil test report. Fertilizer shall be spread evenly over the seedbed and shall be lightly harrowed, raked, or otherwise incorporated into the soil.

B. Limestone shall be thoroughly mixed into the soil according to the rates recommended in the soil test report. The specified rate of limestone application may be reduced by the Engineer if pH tests indicate this to be desirable. It is the responsibility of the Contractor to obtain such tests and submit the results to the Engineer for adjustment in rates.

C. It is the responsibility of the Contractor to make one application of a maintenance fertilizer on areas of lawn seeding according to the recommendations listed in the soil test report.

3.06 SEEDING

A. Seed of the specified group listed below, and as shown on the Construction Drawings, shall be sown as soon as preparation of the seedbed has been completed.

1. Upland Seed Mix - shall be applied to all naturalized areas as designated on the Construction Drawings.
2. Permanent Turfgrass Mix - shall be applied to all areas where mowing currently occurs and will continue to occur as designated on the Construction Drawings.

B. No seed shall be sown during high winds, nor until the surface is suitable for working and is in a proper condition. Seeding shall be performed during the dates shown on the Construction Drawings unless otherwise approved by the Engineer. Temporary and permanent seed mixtures may be sown together, except for the Permanent Turfgrass Mix, provided they are kept in a thoroughly mixed condition during the seeding operation.

C. Seed shall be uniformly sown by any approved mechanical method suitable for the slope and size of the areas to be seeded, preferably with a broadcast type seeder, windmill hand seeder or approved mechanical power drawn seed drills. Hydro-seeding and hydro-mulching may be used on steep embankments, provided full coverage is obtained. Care shall be taken to adjust the seeder for seedings at the proper rate before seeding operations are started and to maintain their adjustment during seeding. Seed in hoppers shall be agitated to prevent segregation of the various seeds in a seeding mixture.

D. Immediately after sowing, the seeds shall be covered and compacted to a depth of 1/8 to 3/8 inch by a cultipacker or suitable roller.

3.07 MULCHING

A. The following mulch shall be spread evenly over the seeded areas at the following application rates:
   1. Straw: 2,000-4,000 pounds per acre

B. These rates may be adjusted at the discretion of the Engineer at no additional cost to the Owner, depending on the texture and condition of the mulch material and the characteristics of the seeded area.

C. Where stabilization matting is to be applied, straw mulch shall be placed after seed has been covered and compacted. In these areas, approximately 25 percent of the ground shall be visible through the mulch blanket. Stabilization matting shall be placed over straw mulch on areas shown on the Construction Drawings.

D. All seeded areas where there is no stabilization matting shall be uniformly mulched, approximately 95 percent coverage, in a continuous blanket immediately after seeding. The straw mulch shall be applied so as to permit some sunlight to penetrate and the air to circulate and, at the same time, shade the grounds, reduce erosion and conserve soil moisture.

E. The straw mulch shall be crimped to hold mulch in place on all areas where stabilization matting is not installed.

3.08 WATERING

A. The Contractor shall be responsible for maintaining the proper moisture content of the soil to ensure adequate plant growth until a satisfactory stand is obtained. When watering, follow the guidelines below:

1. Immediately after seeding:
    a. Keep the soil moist but not excessively wet until the seed has germinated;
    b. Water a minimum of three (3) days a week for two (2) weeks preferably watering two (2) or three (3) times a day in small quantities;
    c. Use fine spray and low pressure to avoid soil wash and to prevent uncovering buried seeds.
2. After emergence:
    a. Apply one (1) inch of water per irrigation event. (Note: 1-acre-inch = 27,154 gallons. This is the volume of water necessary to cover one (1) acre, one (1) inch deep.);
    b. During summer, water two (2) to three (3) days per week;
    c. During winter, water once every ten (10) to fourteen (14) days;
    d. If rainfall occurs, suspend watering according to rainfall amount;
    e. Never apply at a rate faster than can be absorbed by the soil;
    f. When applicable, water during early morning hours or early evening hours;
    g. Do not water when rain is forecasted for the area.

B. Watering shall be accomplished by hoses, tank truck or sprinklers in such a way to prevent erosion, excessive runoff and overwatered spots.

3.09 MAINTENANCE/ESTABLISHMENT

A. The Contractor shall be responsible for all maintenance of grass and facilities until final acceptance. This includes all necessary watering, application of appropriate fertilizer (based on planting season), and the appropriate application of fungicides and insecticides necessary to maintain turf free from disease and insect activity.

B. Maintenance of seeded areas shall consist of fertilization, erosion repair, reseeding and incidental operations as necessary to establish a vigorous, health, and uniform stand of specified grass. All areas that fail to show a uniform stand of grass for any reason shall be treated properly until a uniform stand of at least 90% coverage for Permanent Turfgrass and 75-percent coverage for Upland seed is attained.

C. Grass mowing operations shall be performed by the Contractor until final acceptance of the work. Trash and debris shall be removed prior to mowing. Mowing shall be performed only when the grass is dry. No more than 1/3 leaf blade shall be removed at each mowing. Maintained turf (bermudagrass) shall be maintained at a height of 1.5 to 2 inches. All maintenance performed prior to acceptance shall be considered incidental to the project and no separate payment shall be made.

D. It shall be the responsibility of the Contractor to apply water per this specification.

E. Follow-up fertilization shall be done per the manufacturer's recommendations.

3.10 FINAL ACCEPTANCE

A. Upon completion of all seeding operations, including cleanup, the Contractor shall notify the Engineer and Owner, at least 10 days before the anticipated date, to schedule an inspection of the seeded areas. Any items found to be unsatisfactory shall be corrected

prior to the approval for final acceptance. The one (1) year warranty period shall begin at the date of the final acceptance.

3.11 WARRANTY PERIOD AND REPLACEMENT

A. The Contractor shall guarantee all seeded areas for a period of one (1) year from the date of final acceptance by the Engineer and Owner. The Contractor shall over-seed or re-establish, at the discretion of the Engineer and Owner, any seeded areas that do not have living plants producing ground coverage of 90% or more of the Permanent Turfgrass and 75% or more of the Upland grass or planted species or combination of species to be established.

B. Any time during the one (1) year warranty period that the Engineer or Owner determines that the seeding work has not met specifications or is not meeting the requirements of these standards, the Contractor shall take action within 30 days, or at the next planting season, to replace or reseed these under-performing areas.

END OF SECTION

SECTION 33 01 30.50

SEWER BYPASSING AND DEWATERING

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope: This section describes the existing conditions for temporary bypassing and dewatering of sewers during internal television inspection (CCTV), cleaning operations, rehabilitation, and inspection of the project pipelines and of service laterals during the rehabilitation prior to reconnection to the rehabilitated pipeline.

B. Requirements:

1. Contractor shall provide labor, materials, and supervision to temporarily bypass flow around the Contractor's work in accordance with the specific needs of the rehabilitation method being utilized and dewater the pipelines in preparation for cleaning and rehabilitation. All references to the bypass pumping and/or bypass pumping system include, but are not limited to, all pumps, piping, valves and other equipment needed to move the intended flow from one location to another.
2. The actual design of the bypass arrangement and alignment shall be prepared by the Contractor, and shall be submitted to the Engineer to determine conformance to project objectives. Means and methods of accomplishing the bypassing shall be the responsibility of the Contractor.
3. Sanitary sewer mains shall remain in service at all times throughout the duration of the project. Contractor shall be responsible for diverting flow away from the limits of construction through the use of bypass pumping, flow diversions, or vactor truck with prior written approval by the Engineer.
4. Service to laterals shall be disrupted for a period of no more than 8 hours. Laterals within residential areas shall only be out of service between the hours of 8:00 am to 5:00 pm, Monday through Friday. Laterals within business areas shall be addressed on a case by case basis. If Contractor feels that it is necessary to disrupt lateral services for a period longer than 8 hours, Contractor shall provide alternate means of service without disrupting use of the service by the owner/resident.
5. Contractor shall maintain pedestrian and vehicular traffic and comply with ADA regulations for access to all residential and commercial property unless written approval is otherwise obtained from the property owner allowing for reduced access.
6. It is the Contractor's responsibility to arrange all necessary access and temporary construction agreements with all affected parties for the location of the bypass pumping system.
7. The bypass pumping system shall be designed to normally maintain the wastewater flow below the top of the pipe, without surcharging.
8. The Contractor shall have the complete bypassing system in place and successfully pressure tested at 1.5 times the maximum operating pressure of the system before bypassing any sewage.
9. The Contractor shall notify the Engineer 48 hours prior to shutting down or bypassing the pipeline.
10. The bypassed flow shall be continuously monitored.

11. Contractor is responsible for immediate and proper cleanup should any spill occur, regardless of amount.

C. Experience: Contractor shall utilize staff and/or a subcontractor that has been directly responsible for completion of a previous project that required the bypass pumping of sewage flows in excess of (insert project upper limit) mgd.

1.02 SUBMITTALS

A. At the Preconstruction Conference the Contractor shall submit, in accordance with Section 01 33 00, drawings and complete design data showing methods and equipment he proposes to utilize in sewer bypassing for approval by the Engineer. The submittal shall include the following information:
   1. Drawings indicating the scheme and location of temporary sewer plugs and bypass discharge lines. The drawings shall also show the method and location for discharging the bypass lines.
   2. Capacities of pumps, prime movers, vactor trucks and standby equipment.
   3. Design calculations proving adequacy of the system and selected equipment.
   4. Standby power source.
   5. Staffing plan.
   6. Show suction and discharge points with elevations & stationing on the design plans.
   7. Provide pump performance curves.
   8. Submit calculations to verify suction lift of pumps has not been exceeded.
   9. Contractor shall submit proposed noise control and exhaust control plans for pumping equipment.
   10. Contractor shall submit a proposed plan for disruption of sewer service laterals.
   11. Contractor shall submit bypass piping inspection plan.

B. The actual design of the bypass arrangement shall be prepared by the Contractor or Subcontractor performing the work, and shall be submitted to the Engineer to determine conformance to project objectives. The Contractor shall be responsible for any Subcontractors design (if used) on this Project. Means and methods of accomplishing the bypassing shall be the responsibility of the Contractor.

C. Approval of submitted plans for sewer connection and temporary rerouting shall in no way relieve the Contractor of their responsibility for the protection of adjacent properties, downstream drainage systems and water tributaries against sewage spill. Any litigation, claims, fines, etc. associated with any sewage spill shall be the responsibility of the Contractor.

1.03 JOB CONDITIONS

A. Available Flow Data:
   1. Available flow data for the sewers to be rehabilitated at the project site is located in paragraph 3.01 of this section. Flow data for the service laterals is not available. The Contractor shall determine the flow in the service laterals.

B. Protection:

1. In areas where flows are bypassed, all bypass flows shall be discharged as approved by the Engineer. No bypassing to the ground surface, receiving waters, storm drains, or bypassing which results in soil or groundwater contamination or any potential health hazards shall be permitted.

C. Scheduling:

1. The bypassing system shall not be shut down between shifts, on holidays or weekends, or during work stoppages without written permission from the Engineer. The bypass system will have an attendant around the clock whose only duty is to maintain the bypass pumping system until the bypassing of that specific pipeline is no longer required.

PART 2 PRODUCTS

2.01 PUMPING SYSTEMS

A. Bypass Pumping System with flows equal to or less than 2.5 MGD

1. Contractor shall maintain on site, the following minimum requirements for all bypass pumping systems:
   a. Sufficient equipment and materials to ensure continuous and successful operation of the bypass and dewatering systems. The COMPLETE bypass system, including all piping, shall be continuously monitored by Contractor personnel.
   b. A system of pumps and piping operating on site to maintain a minimum 50% over capacity of the anticipated maximum flow (as determined by the Contractor). In addition, the Contractor shall have a standby pump, equal in capacity to the largest pump in the system, piped, plumbed and ready for operation. Standby pumps shall be fueled and operational at all times.
   c. The Contractor shall maintain on site a sufficient number of valves, tees, elbows, connections, tools, sewer plugs, piping, hoses and other parts of system hardware to ensure immediate repair or modification of any part of the system as necessary.

B. Standby Vactor Trucks

1. The Contractor may utilize vactor trucks as a means to control flows at Hamlet Street and Grayson Lane Pump Stations during periods of low flow.
2. Contractor must present a written plan stating proposed number of trucks, capacity, and discharge point for review and approval.

PART 3 EXECUTION

3.01 ESTIMATED FLOWS AND SEWER CAPACITY PROJECT PIPELINE

A. Daily Flow Data

1. The following paragraph provides observed daily flow information for the project pipeline. The information was obtained from the data provided by the City of Newton. For additional information contact the City of Newton, during normal business hours. Use of this flow data in no way relieves the Contractor from his responsibilities for

design, construction and operation of an adequate and properly functioning bypass system. Any additional monitoring or gathering of flow data is the responsibility of the Contractor.

2. The peak flows are based on the size of the existing pumps

Peak Sewage Flows

Location	Peak Flow (gpm)
Hamlet St PS	100
Grayson Lane PS	100
Oldham Road	300

Abbreviations: gpm – gallons per minute

B. Flow Conditions:

1. The Contractor is responsible for obtaining current flow condition information at the time of construction. The Owner is not responsible for any deviations in quantity of sewage flow at any time during the construction period. Higher flows may be encountered depending on weather and other upstream conditions.

3.02 INSPECTION

A. The Contractor shall inspect the entire bypass pumping and piping system for leaks for spills on an hourly basis. The Contractor shall also create an inspection log and shall enter the time of the inspections and the condition of the piping and the name of the inspector into the log for review by the Engineer.

3.03 DAMAGES

A. The Contractor shall repair, without cost to the owner, any damage that may result from his negligence, inadequate or improper installation, maintenance and operation of bypassing system, including mechanical or electrical failures.

END OF SECTION

SECTION 33 05 13.16

PRECAST MANHOLES, FRAMES AND COVERS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials and equipment required to install precast concrete manholes, grade rings, frames and covers, and appurtenances as shown on the Drawings and as specified herein.

1.02 REFERENCES

A. This section contains references to the following standard specifications. They are part of this section as specified and modified. In the event of a conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM A48-83	Gray Iron Castings
ASTM C478	Precast - Reinforced Concrete Manhole Sections
ASTM C891	Installation of Underground Precast Concrete Utility Structures
MassDOT 201	Basins, Manholes and Inlets

1.03 SUBMITTALS

A. Shop drawings, product data, materials of construction, and details of installation shall be submitted in accordance with Section 01 33 00. Submittals shall include the following:
   1. Design calculations, sealed by a Professional Engineer licensed in the State of Massachusetts, indicating adequate strength to resist the vertical and lateral loadings including “H-20" wheel loadings, and buoyancy forces.
   2. Base sections, riser sections, eccentric and concentric conical top sections, flat slab tops, grade rings with notarized certificate indicating compliance with ASTM C478.
   3. Concrete mix design.
   4. Detail of pipe connection(s) to manhole.
   5. Manhole frame and cover style and finish with notarized certificate indicating compliance with ASTM A48, Class 30.

B. Design data for precast concrete structures: sectional plan(s) and elevations showing dimensions, reinforcing steel placement, manhole covers, steps, baffle plates, and accessories.

C. Test reports for precast concrete structures: concrete test cylinder reports from an approved testing laboratory certifying conformance with specifications.

1.04 REFERENCE STANDARDS

A. New and replacement manholes shall be constructed and installed per MassDOT or City Specifications and the Contract Drawings.

B. Occupational Safety and Health Administration (OSHA).

1.05 QUALITY ASSURANCE

A. All material shall be new and unused.

B. Materials' quality, manufacturing process and finished sections are subject to inspection and approval by OWNER or other OWNER'S representative. Inspection may be made at place of manufacture, at work site following delivery, or both.

C. Materials will be examined for compliance with ASTM specifications, these Specifications and approved manufacturer's drawings. Additional inspection criteria shall include: appearance, dimensions(s), blisters, cracks and soundness.

D. Materials shall be rejected for failure to meet any Specification requirement. Rejection may occur at place of manufacture, at work site, or following installation. Mark for identification rejected materials and remove from work site immediately. Rejected materials shall be replaced at no cost to OWNER.

E. Repair minor damage to precast concrete sections by approved method, if repair is authorized by OWNER.

1.06 WARRANTY

A. All materials supplied under this section shall be warranted for a period of 2-years by the manufacturer and the CONTRACTOR. Warranty period shall commence upon formal acceptance of the project by the OWNER.

B. The materials shall be warranted to be free from defects in workmanship, design and materials. If the materials should fail during the warranty period, it shall be replaced or restored to service at no expense to the OWNER.

C. The manufacturer's warranty period shall run concurrently with the Contractor's warranty period. No exception to this provision shall be allowed.

PART 2 PRODUCTS

2.01 GENERAL

A. Reference to a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Like items of materials/equipment shall be the end products of one manufacturer in order to provide standardization for appearance, operation, maintenance, spare parts and manufacturer's service.

C. Provide lifting lugs or holes in each precast section for proper handling.

2.02 PRECAST CONCRETE MANHOLE SECTIONS

A. Precast concrete base sections, riser sections, transition top sections, flat slab tops and grade rings shall conform to ASTM C478, MassDOT, City Details and meet the following requirements:

1. Bottom slab thickness shall equal the riser wall thickness or flat slab top thickness, whichever is greater.
2. Unless otherwise specified, top section shall be eccentric cone where cover over pipe exceeds 4 feet; top section shall be flat slab where cover over top of pipe is 4 feet or less, or where shown.
3. Base, riser and transition top sections shall have tongue and groove joints.
4. Sections shall be cured by an approved method.
5. Ship precast concrete only after concrete has attained 3,000 psi compressive strength.
6. Design precast concrete base, riser, transition top, flat slab top and grade ring for a minimum H-20 loading plus earth load. Calculate earth load with a unit weight of 130 pcf. Calculate buoyancy forces based on groundwater depth 1-foot below the ground surface.
7. Mark date of manufacture, name and trademark of manufacturer on the inside of each precast section.
8. Construct and install precast concrete base as shown on the Drawings.
9. Portland cement shall be ASTM C150, Type II.

2.03 MANHOLE FRAME AND COVER

A. Manhole frames and covers shall be of good quality, strong, tough, even grained cast iron, smooth, free from scale, lumps, blisters, sand holes and defects of any kind which render them unfit for the service for which they are intended. Manhole covers and frame seats shall be machined to a true surface. Castings shall be thoroughly cleaned and subject to hammer inspection. Cast iron shall conform to ASTM A48, Class 30, and MassDOT.

B. Manhole covers shall be frames shall be as detailed on the Drawings.

2.04 JOINTING PRECAST MANHOLE SECTIONS AND STRUCTURES

A. Seal tongue and groove joints of precast manhole and structure sections with either rubber "O"-ring gasket or preformed flexible joint sealant. "O"-ring gasket shall conform to ASTM C443. Preformed flexible joint sealant shall be Kent Seal No. 2 as manufactured by Hamilton-Kent; Ram-Nek as manufactured by K.T. Snyder Company or equal.

B. Completed joint shall withstand 15 psi internal water pressure without leakage or displacement of gasket or sealant.

2.05 PIPE CONNECTIONS TO MANHOLE

A. Connect pipe to manhole in the following ways:
   1. Precast manhole connections shall be watertight in accordance with ASTM C-923.
   2. Flexible Sleeve
      a. Integrally cast sleeve in precast manhole section or install sleeve in a formed or cored opening. Fasten pipe in sleeve with stainless steel clamp(s). Coat stainless steel clamp(s) with bituminous material to protect from corrosion. Flexible sleeve shall be Lock Joint Flexible Manhole Sleeve; Kor-N-Seal connector; PSX Press-Seal Gasket or equal.

3. Compression Gasket
    a. Integrally cast compression gasket in precast manhole section. Insert pipe into compression gasket. Compression gasket shall be A-Lok, or equal.

PART 3 EXECUTION

3.01 GENERAL

A. All excavation, temporary shaft supports, sheeting and shoring, foundation cushion, concrete and grout required to support the walls of shafts and necessary to construct the manholes as shown on the Contract Drawings shall be provided.

B. All sheeting and shoring inclusive of liner plates shall be cut off 2 feet below ground surface and left in place.

C. Excavated materials shall be disposed of by the contractor as described in Section 31 23 00 of the specifications and the cost of which shall be included in the various lump sum prices stipulated in the bid.

3.02 PRECAST MANHOLES

A. Precast concrete manhole riser sections shall be installed plumb and true on the precast concrete base sections as shown on the Contract Drawing. Before placing the O-ring gasket in the spigot groove, the gasket and all bearing surfaces of the tongue and groove shall be wiped clean, and a lubricant as recommended by the manufacturer shall be applied to the gasket and the inside bell surface. Care shall be taken when lowering any precast unit into the trench that no dirt gets on the gasket or into the joint. Top sections of precast manholes shall be flat slab-type or eccentric cone sections cast to the proper dimensions to receive the manhole casting shown on the Contract Drawings.

B. All manhole riser section joints more than 20 feet below the manhole rim shall be provided with an exterior joint collar and be installed according to the manufacturer's recommendations. After removing the protective paper, the band shall be placed around the manhole riser, mastic side to the riser and spanning the joint. The steel straps shall be secured with the proper tools. The closing flap shall cover all remaining exposed strap.

C. The top of the wall of all manholes shall be properly leveled off with mortar so as to form a flat surface upon which the manhole rim is to rest, and manholes shall be carried to such height above the sewer as shown, as necessary to meet grade or as ordered, but shall not be left in a depression to act as an area drain.

D. When there is not enough room for a full length of precast concrete riser section to be installed under the manhole frame, precast reinforced concrete grade rings and mortar shall be used for sanitary manholes. The use of brick masonry on manholes is prohibited.

E. In order to allow for a future adjustment of roadway grade or widening of existing roadway, shorter lengths of riser sections when used should be installed immediately below the cone section. Also, a minimum of one precast concrete grade ring will be required on top of the cone or flat slab top section to effect the proper elevation for the manhole rim. The total height of precast concrete grade rings and mortar shall not exceed 12 inches.

F. Precast bottom sections with integral bases when used shall be set plumb on a firm foundation in the trench. Height of the bottom section shall be provided to admit the various pipes at the elevations shown on the drawings and still contain sufficient material for structural integrity across the top of these openings. Pipe openings shall be cast into the unit at the time of manufacture. All pipe connections to precast concrete manholes shall be made with resilient connectors conforming to ASTM C923.

G. Cast-in-place non-reinforced concrete manhole bottom sections shall be built in accordance with the dimensions indicated on the Contract Drawings. Forming and finishing shall be done per MassDOT Standard Specifications.

H. Manholes shall have steps (rungs) built into the precast and cast-in-place concrete manhole sections and shall be securely embedded in the precast concrete manhole wall at the time of manufacture. Steps shall be placed as shown on the Contract Drawings. The CONTRACTOR shall arrange the various components that will become part of the manhole so that the vertical step spacing is consistent and the frame and cover is situated as oriented in plan on the Contract Drawings.

I. The manhole frames shall be properly set in place in a full bed of mortar and so adjusted as to make the top of the rim a few inches higher than the surrounding ground so as not to act as a surface drain, or flush with paved surfaces.

3.03 CLEANING

A. Thoroughly clean all new manholes of all silt, debris and foreign matter of any kind, prior to final inspections.

3.04 LEAKAGE TESTING

A. Hydrostatic Testing for Shallow Sanitary Sewer Manholes (Less Than 20 Feet Deep)
   1. When, in the Engineer's opinion, the groundwater table is too low to permit visual detection of leaks, up to 20 percent but in no case less than 10 percent of the total all manholes shall be hydrostatically tested. The test shall consist of plugging all inlets and outlets and filling the manhole with water to a height determined by the Engineer. Leakage in each manhole shall not exceed 0.2 gallon per hour per foot of head above the invert. A manhole may be filled 24 hours prior to time of testing, if desired, to permit normal absorption into the pipe walls to take place. Repair all manholes that do not meet the leakage test, or are unsatisfactory from visual inspection, to conform to the requirements herein.

END OF SECTION

SECTION 33 05 31

PVC SEWER PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies PVC solid wall pipe for the use of gravity sewer (non-pressure-rated) application.
   2. This section specifies PVC solid wall pipe for the use of pressure pipe in a gravity sewer application.

B. Pipe Designations:
   1. Polyvinyl Chloride designation shall be as follows:

Designation	Definition
PVC	Polyvinyl Chloride

C. Definitions:
   1. Pipe Joint: The area approximately 12 inches each way from the centerline of the visible gap between pipe lengths.
   2. Pipe Length: The pipe between two joints; part of a pipe section.
   3. Pipe Section: The reach of pipeline between two successive manholes.

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D1748	Specification for Rigid Polyvinyl Chloride (PVC) compounds and Chlorinated Polyvinyl Chloride (CPVC) compounds.
ASTM D2321	Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe.
ASTM D3034	Type PSC Polyvinyl Chloride PVC Sewer Pipe and Fittings.
ASTM D3139	Specification for Joints for Plastic Pressure Pipes using Flexible Elastomeric Seals.
ASTM D3212	Joints for Drains and Sewer Plastic Pipes using Flexible Elastometric Seals.
ASTM F477	Specification for Electrometric Seals (Gaskets) for Joining Plastic Pipe.
ASTM F679	Polyvinyl Chloride (PVC) Large Diameter Plastic Gravity Sewer Pipe and Fittings.
AWWA M23	PVC Pipe Design and Installation.
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems.
AWWA C110	Standard for Ductile Iron and Gray Iron Fittings, 3 in. Through 48 in., for Water and Other Liquids.
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in., For Water Distribution
AWWA C905	Polyvinyl Chloride (PVC) Pressure Pipe, 14 in. Through 48 in., For Water Transmission and Distribution.

1.03 SUBMITTALS

A. Shop drawings, product data, materials of construction, and details of installation shall be submitted in accordance with Section 01 33 00. Submittals shall include the following:
   1. Specifications, Details
   2. Pipe Length
   3. Joint Detail/Gasket Material
   4. Data on accessories

PART 2 PRODUCTS

2.01 PIPE MATERIALS

A. PVC pipe, fittings, and accessories shall be handled in accordance with Chapter 6 of AWWA Manual M23, to ensure installation in sound, undamaged condition. Pipe shall not be stored uncovered in direct sunlight.

B. Pipe:
   1. Gravity (non-pressure-rated) Pipe:
      a. Unless otherwise specified, pipe shall conform to the following specifications:
         1) Direct burial - Four-inch to fifteen-inch diameter: Consistent with ASTM D3034, SDR as shown on drawings, Cell Class 12454.
   2. Pressure Rate Pipe:
      a. Unless otherwise specified, pipe shall conform to the following specifications:
         1) Conforming to AWWA C-900
         2) Dimension Ratio (DR) as shown on the drawings.
         3) Working Pressure (PSI) as shown on the drawings.

C. Joints:
   1. Bell and Spigot Joints consistent with ASTM D3212, integral bell push-on type with elastomeric gasket joints.
      a. Gaskets consistent with ASTM F477, synthetic rubber.
      b. Provide 'home' mask on spigot end to indicate proper insertion depth.
      c. Make joints in conformance with manufacturer's recommendations.
      d. Field-cut Joints shall be provided with stainless steel shear rings.

PART 3 EXECUTION

3.01 GENERAL

A. Verify size, pipe condition, and pipe class prior to installation of pipe.

B. Pipe and joints shall be carefully examined for cracks and other defects immediately before installation.

C. Remove foreign matter and dirt from inside of pipe and fittings and keep clean during and after laying. Wash ends of section clean with wet brush prior to joining sections of pipe.

D. Install and handle pipe sections in accordance with Manufacture’s recommendations.

E. Install flexible pipe consistent with the provisions of ASTM D2321.

F. Provide tracer wire for non-metallic sewer mains and service laterals within public right-of-way. Tracer wire to be extended to terminal points of all laterals and main piping. Terminal points are at the end of the new piping which includes connection points to existing.
   1. Access points shall be at manholes and access boxes. Access box locations are as shown on the drawings and/or as determined by the Owner.
   2. Ground all underground wire ends with 1 pound magnesium alloy anode ground.
   3. Tape wire directly to mainline pipes at a minimum of three points per pipe length.
   4. Extend wire up to the surface at access points.
   5. Install tracer wire into manhole between the upper most adjusting ring and the manhole frame and casting by cutting a groove in the top of the concrete adjusting ring and laying the tracer wire in the groove before setting the frame and casting. A minimum of 10 feet of tracer wire should be coiled and left inside the manhole.
   6. At each splice, use direct bury rated, mechanical splice kit to make connection per the manufacturers requirements.

3.02 ALIGNMENT

A. Install pipe in conformance with established lines and grades. Tolerances measured along pipe centerlines or invert as follows:
   1. Horizontal: Within 0.50 feet of alignment shown.
   2. Vertical: Zero plus and 0.08 feet minus grade shown with no intermediate high points, level sections, or reverse invert slope.

3. Joint deflection: No more than 75% of the maximum allowable, as recommended by manufacturers of pipe and joint material.
4. Maintain reference line and grade with laser equipment or other equipment approved by the city. Periodically check equipment for adjustment and accuracy. Correct deficiencies in equipment, reference line and reference grade. Take precautions to prevent deflections in reference line and grade.
5. Non - conforming pipe installation: Remove and reinstall.

3.03 LAYING AND JOINTING

A. Lay pipe upgrade with bell ends pointing in direction of laying.

B. Pipe shall not be laid in water or under unsuitable weather or trench conditions.

C. Place sufficient pipe bedding material to secure pipe from movement before next joint is installed.

D. When laying operations are not in progress, block open end of last laid section of pipe to prevent entry of foreign material or creep of gasketed joints.

E. Install

F. Jointing
1. In conformance with recommendations of manufacturers of pipe and joint material.
2. All joint surfaces shall be lubricated with manufacture's recommended lubrication immediately before the joint is completed. Each spigot end shall be suitably beveled to facility assembly.
3. Use suitable equipment and end protection to push or pull the pipes together.
4. Do not exceed forces recommended by the manufacturer for coupling pipe.
5. Provide watertight joints.
6. Hand fill and compact all bell depressions with granular bedding materials to prevent joints from sagging or movement.

3.04 PIPELINE ACCEPTANCE

A. Sewer Televising
1. Televise all sanitary sewers after final cleaning. The camera shall stop at all possible defects and tilt to fully view. Complete all televising in accordance with NASSCO standards.
2. Provide two copies of inspection report prepared by the televisor for Engineer acceptance.

END OF SECTION

SECTION 40 05 01

PIPING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the general requirements for design, selection, and supply of pipe materials, fittings, appurtenances, expansion control, supports, and seismic restraints for process, mechanical, plumbing, utility, odor control ducts, and HVAC piping systems. Installation, inspection, and testing are also specified in this Section.

B. Use the general requirements specified in this section with the more specific requirements listed in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99) and other referenced sections. Except where referenced specification sections specify alternate provisions, the requirements of this Section apply to all piping systems listed in Section 40 05 02.

C. Provide professional engineering services for a piping system design engineer (hereinafter and in all related and referenced sections the "Design Professional") for the design and inspection of piping systems work. For the scope of the work, defined herein as the “Design Professional’s Scope of Responsibility,” the Design Professional provides the design, final inspection, and certification for the piping supports, seismic restraints, and expansion control as specified in this Section and referenced sections.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 61 45 – Area Exposure Designations
   3. Section 01 66 00 – Product Storage and Handling Requirements
   4. Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
   5. Section 03 30 00 – Cast-in-Place Concrete
   6. Section 31 23 00 – Excavation and Fill
   7. Section 40 05 02 – Piping System Schedules
   8. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping
   9. Section 40 05 07 – Hangers and Supports for Process Piping

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ANSI B16.21	Nonmetallic Flat Gaskets for Pipe Flanges
ANSI B31.1	Power Piping
ANSI B31.3	Process Piping
ANSI B31.9	Building Services Piping
ANSI Z223.1	National Fuel Gas Code
ANSI/ISA-S70.01	Quality Standard for Instrument Air
ASME B1.1	Unified Inch Screw Threads
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Requirements
ASTM F37	Sealability of Gasket Materials
ASTM F104	Nonmetallic Gasket Materials
ASTM F152	Tension Testing of Nonmetallic Gasket Materials
AWWA C651	Disinfecting Water Mains
CAN/CGA B149.6	Code for Digester Gas and Landfill Gas Installations
EJMA	Expansion Joint Manufacturer's Association
UPC	Uniform Plumbing Code

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Maximum pressure: The greatest continual pressure at which the piping system is designed to operate.
   2. Test pressure: The hydrostatic, air, or gas pressure used to determine system compliance.
   3. Take down coupling: Pipe couplings that facilitate disassembly of piping systems without damage or demolition of piping system components.
   4. Embedded/Encased piping: Piping enveloped in reinforced concrete, typically under structures and under roadways, where specified on the drawings.
   5. Exposed: All area exposures specified in Section 01 61 45 other than buried, submerged, or encased/embedded.

B. Piping System Identification
   1. Process, mechanical, plumbing, utility, odor control, and HVAC piping system piping is identified by a two component alpha-numeric code, (Line Label) as follows:
      a. The first component of the code indicates the nominal line size.
      b. The second component of the code identifies the process Service or fluid being conveyed in the Piping System.
   2. Process Service identifiers for pipelines are specified on the drawings. The Process Service is defined for each Process Service Identifier in Section 40 05 02.
   3. Detailed specifications for each Process Service are scheduled in Section 40 05 02.00 through 40 05 02.99.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Pipe Sleeves: Coordinate placement of sleeves and penetrations in cast-in-place concrete with raceway, duct, and pipe penetrations prior to concrete placement. Coordinate placement of sleeves and wall penetration prior to construction of masonry building elements.
   2. Coordination required with the design of piping supports (hangers, guides, anchors, structural attachments, etc.), expansion joints, and expansion control and seismic restraints. Refer to section 40 05 07.
   3. Refer to paragraph 1.09 Piping System Design for additional coordination requirements.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. Qualifications of the Design Professional charged with inspection and certification of pipe hangers and supports and related scope of work; provide educational background, proof of registration, and proof of insurance and previous experience in performing this type of work. No further submittals under this or any related section will be considered until the Design Professional's qualifications have been reviewed and accepted by the Construction Manager.
   3. A copy of this specification section, along with Sections 01 73 24 and 40 05 07 with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. For each piping system (refer to Piping System Schedules in Section 40 05 02.00 through 40 05 02.99), submit document listing pipe, fittings, linings, coatings, valves, flexible connectors, expansion joints, couplings, bolts, gaskets, restraints, and other items provided for each applicable pipe size and category.

5. Welding: Prior to commencing any welding of steel or stainless steel pipe, supports, and/or structural attachments, provide a written description of welding techniques, including, but not limited to, materials, methods, and quality control. Identify differences in shop and field techniques. Indicate in the submittal that the welding technique has been reviewed for each piping service and certify that the technique is acceptable for the intended service condition (piping service defined in Section 40 05 02 and area exposure designation specified in Section 01 61 45). Written procedures to be stamped and sealed by a Professional Engineer registered in the State of Massachusetts and qualified for welding design.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Pre-Construction Data:
      a. Design drawings and calculations for pipe supports, anchorage, seismic restraints, and expansion control systems as specified in Section 40 05 07. Drawings and calculations sealed and submitted by the Design Professional specified in this Section. The Design Professional shall affirm that loads on structures are within any stipulated load limits that may be noted on the contract documents.
      b. Submit piping layout drawings for all piping systems, including raceway, duct and other specified systems support. Indicate assembly details, location and placement of field welds, unions and flanges, fittings, valves, flushing connections, drains, sample taps, cathodic protection, seismic restraint system, expansion joints, guides, anchors, hangers, supports, and the provisions for thrust restraint, as well as any other pertinent details and appurtenances for all piping, including wall and floor penetrations, where applicable, in that area. Indicate location and clearances from structures and other utilities (ductwork, conduit, electrical tray, etc.). Include details of connections to new and existing equipment, piping and structures. Submit original layouts by the Contractor; photocopies of Contract Drawings are not acceptable. Identify the invert elevation of buried pipe at changes in slope, pipe crossings, and connections to structures on piping layout drawings in addition to providing coordinates for locating changes in horizontal alignment of buried pipe.
      c. Product Samples: Where specified or when directed by the Construction Manager, provide mill test results or product samples.
      d. Prior to the commencement of welding, submit current and complete documentation of the welder's qualifications.
      e. Safety plans for pneumatic pressure testing.
   3. Post-Construction Data: Inspection reports, authored, sealed, and signed by the Design Professional retained under the provisions of this Section submitted to the Construction Manager. The Design Professional's final report shall be submitted to the Construction Manager before beneficial occupancy by the Owner.

1.07 QUALITY ASSURANCE

1. Review the drawings prior to installation of piping, conduit services, and fixtures. Identify any conflicts and cooperate with the Construction Manager to determine the adjustments necessary to resolve conflicts.
2. Confirm the routing of each section of pipeline with other services prior to commencement of installation. Advise the Construction Manager of any conflicts

with existing services or services yet to be installed. Where necessary, amend the routing of pipework to avoid conflict and confirm with the Construction Manager.

3. Refer to paragraph 1.09 Piping System Design for additional quality assurance requirements.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Requirements:

1. Deliver pipe, fittings, and specials to site using loading methods which do not damage pipe or linings, or coatings.
2. Piping materials delivered to site will be clearly marked to indicate size, type, class/schedule and coatings.
3. Until ready for incorporation in the work, store on site as recommended by the piping materials manufacturer to prevent damage, undue stresses, or weathering.
4. Store materials at least 8 inches above ground. Provide sufficient supports to prevent undue bending.
5. Protect non-UV light inhibited plastic from sunlight.
6. Maintain refrigerant piping factory seals until ready for incorporation into the Work.
7. Cover openings in piping, and temporarily seal to protect from contamination.
8. Protect materials and equipment from damage due to environmental conditions. Use protective cover, and protect from surface water by elevating above floor or surrounding grade.
9. Protect unfinished work at end of each workday from damage, contamination and moisture by use of plugs, caps or covers.
10. Protect piping and valves from damage pending performance of system tests.
11. Use proper implements, tools, and facilities for the proper protection of the pipe. Exercise care in the installation so as to avoid damage to pipe, linings, and coatings.
12. Inspect each pipe and fitting prior to installation. Do not install damaged pipe or pipe with damaged protective coatings or linings.
13. Prevent entry of foreign matter during handling, assembling, and installation. Use compressed air, wire brush, solvent and other acceptable means to remove all foreign matter from inside of pipe prior to installation. Remove residual scale, dirt and other foreign matter from interior of piping before final connections are made.

1.09 PIPING SYSTEM DESIGN

A. Design Professional:

1. Provide professional engineering services (“Design Professional”) for the design and inspection of piping systems work. The Design Professional must have not less than ten years’ experience in the type of piping support, seismic restraint, and expansion control design work required for this project.
2. The Design Profession shall be a professional engineer currently licensed to practice in the State of Massachusetts.
3. The Design Professional must obtain and maintain professional liability insurance in the amount of $1,000,000 aggregate, to be in effect for the duration of this project plus one year.

4. The requirements for the Design Professional shall not be construed as relieving the Contractor of overall responsibility for this portion of the work.

B. Piping System Design and Inspection:
   1. The Design Professional shall provide the design, inspection, and certification for piping supports (hangers, guides, anchors, structural attachments, etc.), expansion control and seismic restraints as specified in this Section and referenced Sections.
   2. The work of the Design Professional is complementary to the design elements specified in the Contract Documents and intended to provide complete piping system designs. The Design Professional's inspection responsibilities also complement inspections by the Construction Manager. The division of responsibility for work is shown in the following table:

Piping System Element (Specification)	Contractor's Design Professional's Responsibility	Engineer's Responsibility
Pipe material and thickness, test pressures and other properties (Section 40 05 02.00 through 40 05 02.99)	(NA)	All piping
Contractor layout drawings (Section 40 05 01)	All piping	(NA)
Support design (Section 40 05 07 and Section 01 73 23, and related sections)	All piping supports not specified on the drawings.	Pipe supports specified on the drawings
Inspection – General. For design and specification conformance (Section 40 05 01 and related sections)	All piping	(NA)

   3. Acceptable types of supports, guides, saddles, expansion joints, flexible couplings, hangers and structure attachments for general piping support are specified in Section 40 05 07.
   4. Pipe support and seismic restraint placement is subordinate to the function of anchorage, flexibility, and expansion control provisions. Do not interfere with the function of anchorage, flexibility, and expansion control provisions specified on the drawings.
   5. Where pipe anchors are specified, they have been designed for longitudinal (axial) seismic loading, in addition to other longitudinal forces associated with expansion control, and pipe thrust for the associated piping. Rely on the specified anchors for longitudinal seismic bracing of the pipe in these instances.
   6. There may be situations where the Construction Manager wants to control where certain anchors are located, the level of forces that can be transmitted to structures, the direction that expansion growth is allowed, or requires use of particular piping elements. In such cases these elements will be specified on the drawings and incorporated into the Design Professional's design. Mandatory anchorage locations identified on the drawings and maximum limitations, if any, for structure loads from the anchor will be as indicated on the drawings, identifying location and the maximum force that can be imposed on the structure. Where structural load would be exceeded, provide piping flexibility or expansion joints to reduce the maximum loading imposed on the structure.
   7. For general understanding of intent and bidding purposes, general support locations, arrangements, types and means of attachment may be shown on the drawings. Some of the elements may be specifically designed and detailed. If a particular type

of support, anchor, seismic restraint or expansion element is detailed on the drawings, then incorporate those elements into the Contractor's design. Include all elements of the piping system in Piping submittals by the Contractor, including those portions directed by the Construction Manager and complete piping runs.

8. Calculate the structural reaction loads for all fixed supports and indicate the calculated reaction loads on the submitted layout drawings. Notify the Construction Manager if any elements specified on the Drawings are incompatible with the overall piping system and its function.
9. Include consideration of and provisions for:
    a. Support and restrain pipe independent of support or restraint provided by equipment or without equipment supported loads exceeding equipment manufacturer's nozzle loading recommendations. Obtain maximum nozzle loads from the equipment manufacturer.
    b. Routing of pipe to provide access aisles free of obstruction and worker hazards. Unless otherwise specified or approved by the Construction Manager, the minimum clear space between equipment is 36 inches horizontally. Minimum vertical clearance is 7 ft above the floor or local grade at pedestrian access aisles and egress paths. Minimum clearance for equipment access aisles in galleries, tunnels and utilidors is 10 ft by 10 ft.
    c. Electrical bonding for all gas, fuel, and pneumatic conveyance systems.
    d. Dielectric separation, as specified.
10. Include all elements of piping systems required for fabrication and construction in the piping layout submittals. Depict couplings, support, restraint, anchorage, expansion control measures and other elements of the piping system.
11. Depict fitting angles and vertical and horizontal pipe locations, as determined by the Contractor, on piping layout drawings.
12. Do not interfere with maintenance functions and access around equipment, including monorails and hoists.

PART 2 PRODUCTS

2.01 PIPE MATERIALS - GENERAL

A. All pipe materials to be new, free from defects and conforming to the requirements and standards identified in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99) and related sections.

B. New and existing piping is designated by process service rather than pipe material. Existing pipe material types may not be the same as material types specified for new piping. Investigate connections to existing piping and provide suitable connections, including electrical isolation, as necessary.

C. Fittings and Coupling Compatibility: To assure uniformity and compatibility of piping components, furnish fittings and couplings for grooved-end or shouldered-end piping systems from the same manufacturer.

D. Buried Piping: Size temporary and/or permanent thrust restraints. Design restraint systems to allow complete piping system disassembly without destruction of any portion of the piping system.

2.02 MATERIAL FOR PIPING SUPPORT, SEISMIC RESTRAINTS AND PIPE ANCHORS

A. This paragraph specifies materials for pipe supports specified in Section 40 05 07 and all associated appurtenances. Section 01 61 45 defines environmental exposures by physical location. Pipe Support, Seismic Bracing, and Pipe Anchor materials are specified based on the environmental exposure specified in Section 01 61 45. Provide Pipe Support, Seismic Bracing and Pipe Anchor components fabricated from materials as specified in the following table:

Environmental Exposure or Pipe Material	Materials [1]	Nuts, bolts, washers, and fasteners
Outdoor	Steel, hot dip galvanized after fabrication	Type 304/316 stainless steel
Indoor, Dry	Steel, hot dip galvanized after fabrication	Steel, Zinc plated or hot-dip galvanized after fabrication
Indoor, Wet	Type 316 stainless steel or FRP	Type 316 stainless steel
Chemical Corrosive	Fiberglass (FRP)	Type 316 stainless steel
Head Space	Type 316 stainless steel or FRP	Type 316 stainless steel
Submerged	Type 316 stainless steel or FRP	Type 316 stainless steel
Undefined	Type 316 stainless steel or FRP	Type 316 stainless steel
Stainless steel piping	Same type of stainless steel as the pipe or FRP	(per area as defined in this table)

Notes:

1. *Where materials as designated in drawing details or indicated in other specification sections, those requirements govern over the provisions of this table.*

2.03 PIPE AND VALVE COMPATIBILITY

A. Coordinate the selection of pipe materials, linings, and end connections so that valves operate properly over their entire range (e.g., sufficient disk clearance for butterfly valves). Support wafer style valves or spectacle flanges between flanges of equal inside diameter.

2.04 BONDING JUMPERS

A. Provide plated, flexible copper braid jumpers with unplated copper ferrules for attachment to pipe flanges, rated for a 100 amp minimum. Provide Burndy Electrical, Type B series, or Approved Equal, and sufficient conductive, anti-oxidant compound (Burndy Electrical Penetrox series or Approved Equal) to protect ferrules.

2.05 JOINTS – GENERAL

A. Provide joints for disassembly within 3.0 ft of any connection to equipment, on both sides of structural penetrations, and within 2.0 ft of all threaded end valves.

B. Unless otherwise specified on the drawings or in equipment specifications, adapt all equipment connections to a flanged connection compatible with the connected piping system.

C. Flexible Joints at Structural Joint Crossings: Provide a flexible joint (or joints) on all piping crossing structural joints.

2.06 FLANGES AND OTHER COUPLINGS

A. Pipe connections are specified in the Piping System Schedules in Sections 40 05 02.00 through 40 05 02.99

B. General requirements for flanges are as follows:
   1. Where raised-face and flat flanges are provided for connection, reface the raised-face flanges. Flange face to be flush with flat-faced companion flanges on flat-faced valve or equipment flanges.
   2. Provide flat-faced flanges on each side of butterfly valves.
   3. For steel piping, provide weld neck flanges on both sides of wafer or lug body valves.

C. Slip-on flanges that are attached to a pipe by means of set screws and gaskets (uni-flange, etc.) are not acceptable.

2.07 FITTINGS – GENERAL

A. Fittings are specified in the Piping System Schedules.

B. Provide eccentric reducers in horizontal lines with the flat side on top, unless specified otherwise on the drawings (e.g., flow meters in horizontal runs requiring submergence).

C. Provide concentric reducers in vertical lines, unless otherwise specified on the drawings.

D. Provide reducers upstream and downstream of flow measurement devices to adapt line size to the specified flow measurement device dimension. Coordinate with the specific instrument requirements.

E. Provide long radius (greater than or equal to 1.5 x nominal diameter) elbows unless otherwise specified on the drawings.

2.08 GASKET MATERIALS

A. For flat faced flanges, use full-face gaskets. For raised-face flanges, use ring type gaskets. Conform to ANSI B16.21.

B. Refer to the Piping System Schedule for the specified gasket material. Material designations used in the detailed pipe specification sheets are as follows:
   1. EPDM: ethylene-propylene-diene-terpolymer 70 durometer
   2. Neoprene: neoprene (black) 70 durometer
   3. Nitrile: nitrile (Buna N)
   4. SBR: Styrene-butadiene (red)
   5. Natural rubber: natural rubber
   6. Compressed synthetic fibers (Kevlar): ASTM F104 (F712400), and neoprene binder: 1.7 MPa (ASTM F152), 0.2 mL/h Leakage Fuel A (ASTM F37)
   7. Compressed synthetic fibers (Kevlar): ASTM F104 (F712400) and SBR binder: 1.7 MPa (ASTM F152), 0.1 mL/h Leakage Fuel A (ASTM F37)
   8. Gylon - Type 1: Garlock Style 3500: 1.35 MPa (ASTM F152), 0.22 mL/h Leakage Fuel A (ASTM F37)

9. Gylon - Type 2: Garlock Style 3510: 1.35 MPa (ASTM F152), 0.04 mL/h Leakage Fuel A (ASTM F37)
10. CPE - Chlorinated Polyethylene
11. Spiral-wound: per ASME B16.20, rated to 1200 degree Fahrenheit Flexitallic SS316L or approved equal
12. PTFE bonded EPDM, full-face gaskets
13. Viton/FKM – Fluoroelastomer, 75 Durometer

2.09 DISSIMILAR METAL CONNECTIONS

A. Where dissimilar metals are to be connected, provide dielectric fittings and/or isolating flanges, including bolt sleeves and washers, according to Section 40 05 06.

2.10 CATHODIC PROTECTION

A. Provide cathodic protection of piping, pipe fittings, and appurtenances where specified on the drawings.

2.11 STRUCTURAL ELEMENT PENETRATIONS

A. Penetrations through structural elements are referenced to a custom detail or Standard Detail. Where a penetration detail is not specified, conform to the Standard Detail relevant to the type of structure, exposure, and type of pipe.

B. Provide pipe sleeves capable of supporting the loads applied during placement of concrete or during block work erection.

PART 3 EXECUTION

3.01 PREPARATION

A. Prior to installation, inspect, and field measure to ensure that previous work is not prejudicial to the proper installation of piping.

B. Pothole existing pipe at connections to new pipe to confirm material and joints prior to submittal of pipe layout drawings.

C. The Drawings are, in part, diagrammatic, make all minor modifications to suit installed equipment and structural element locations and elevations and coordinate with electrical construction.

D. Provide details of connections to new and existing equipment, piping, and structures in piping layout drawing submittals. Unless otherwise specified on Drawings, piping fitting angles and vertical and horizontal pipe locations shall be determined by Contractor.

E. Piping arrangements indicated on the drawings have been estimated from the approximate configuration of the type of equipment listed in the equipment specifications. If the equipment to be provided does not have the same configuration, modify the piping arrangement as necessary. Include any piping modifications in shop drawings submitted prior to fabrication or installation.

3.02 PIPE SUPPORT, ANCHORAGE, AND SEISMIC BRACING

A. Support piping with anchor brackets, guides, saddles, or hangers. Pipe movement due to thermal expansion and internal pressure and dynamic forces shall be accommodated by pipe springing, anchors, expansion joints, and guides selected for the specific purpose by the Design Professional retained under the provisions of this Section. Provide supports on each run at each change of direction.

B. Provide seismic bracing as required to resist seismic loads.

C. Do not use existing pipes and supports to support new piping. Existing tunnel pipe support racks can be used for new pipe if the Design Professional determines that the existing rack components are adequate to support the additional load.

D. Install expansion loops, anchors, expansion joints, and guides where specified on the drawings.

3.03 PIPING CONNECTIONS TO MACHINES

A. Align piping at machine connections in all planes to permit insertion of bolts at bolted connections or coupling screwed connections without using jacks, come-a-longs or other mechanical means to align field piping with the connections at the machines.

B. Do not force bolts into mating flange bolt holes. Align flange bolt holes to permit insertion of bolts by hand (without tools, hammering, or prying).

C. Use of 'dutchmen' mitered sections or similar specials to achieve the required alignment with machine connections are strictly prohibited.

D. Provide equipment connection fittings per Section 40 05 06 as specified on the drawings.

3.04 JOINT AND COUPLING OPTIONS

A. Provide pipe connection (joint and coupling) options as specified in the Piping System Schedule.

B. If a Piping System Schedule lists several connection options, then any of the listed options may be used for a particular pipe material, but the selected option shall be used consistently. For example, if flanged or grooved connections are specified and grooved are represented on the Drawings, then flanged may be installed in lieu of the grooved couplings specified on the drawings.

C. Connecting straight runs of pipe by welding is acceptable only where the individual Piping System Schedule allows welding as a connection option.

D. Where connections other than those indicated on the Piping System Schedule are specified on the Drawings, locate the connection specified on the drawing at the specific location indicated on the drawing.

E. Provide rigid, non-rotating connections at all valves and equipment.

3.05 SMALL BORE UTILITY PIPING

A. Field route small bore (generally less than 3-inch) diameter branch piping for utility services.

B. In general, small bore utility branch piping is not specified on the Drawings unless a specific pipe routing or configuration is to be provided or where necessary to show valves or instrumentation requiring electrical connections.

C. Distribution lines for small bore utility piping are specified on the Drawings along with service connection routes to locations that require utility service piping.

D. Install small bore utility piping that must be drained to provide freeze protection with a continuous slope down to the drain.

3.06 SEWER AND DRAIN PIPING

A. Run horizontal drainage piping as straight as practicable and at uniform pitch.

B. Install pipe 3-inch or less in diameter with slope of not less than two percent, unless otherwise specified on the Drawings.

C. Install pipe larger than 3-inch diameter with slope of not less than one percent, unless otherwise specified on the Drawings or required by the Plumbing Code.

3.07 SLEEVES

A. Unless otherwise noted in the specified pipe penetration details or otherwise approved by the Construction Manager, provide sleeves where piping passes through a wall, floor, or ceiling.

B. Locate and place sleeves prior to construction of cast-in-place elements and prior to the construction of concrete and masonry building elements.

3.08 PIPE JOINTS AND CONNECTIONS

A. Field cuts for glass-lined pipe are not permitted.

B. Cut pipe with appropriate tool and deburr.

C. Make joints tight. Test and remake leaking joints with new materials. Do not use thread cement or caulking to remake joints.

D. Do not use sharp toothed wrench in making up brass pipe, or chrome plated items.

E. Provide thread forms and length in accordance with ASME standards. Use lubricant or sealant on male threads suitable for proposed pipe service.

F. Clean joints before soldering. Use flux and alloy appropriate for specified operating temperature and pressure.

G. Welding procedures, welder certification/qualification, and weld testing per ASME Section IX, Boiler and Pressure Vessel Code. Make welds per the specified standard when ASME B31.1 or ASME B31.3 are specified for a Piping System in the Piping System Schedules (Sections 40 05 02.00 through 40 05 02.99).

H. Coat gasket with gasket manufacturer's recommended lubricant between flange faces.

3.09 TAKEDOWN COUPLINGS

A. Takedown Couplings: Provide takedown couplings at the locations specified on the Drawings in accordance with this Section.

B. Provide takedown couplings at changes in piping direction and where specified in the Drawings on straight runs of pipe.

C. Provide screw unions, flanged or grooved end coupling type joints as takedown couplings.

D. Use flanged or grooved end joints on pipelines 1.5-inch diameter and larger.

E. Where piping passes through walls provide takedown couplings within 40 inches of the wall.

F. Provide a union or flanged connection within 24 inches of each threaded end valve.

3.10 INSTALLATION OF BURIED PIPE AND PIPE BELOW STRUCTURES

A. Trenching and backfill for buried pipe: conform to Section 31 23 00.

B. Pipe laying and bedding: conform to Section 31 23 00.

C. Restrain all plugs, caps, tees and bends in buried pressure piping systems by means of restrained joints as specified in the respective Piping System Schedule.

D. In accordance with Section 40 05 06, and where specified on the Drawings, provide flexibility per specified details where buried pipe passes under, through, or is connected to structures. Provide restrained joint connections or provide restraints across each un-restrained joints.

E. Install pipe in straight alignment. Do not exceed 3/8-inch variance over 30 ft from the true alignment in any direction.

F. Slope gravity lines uniformly from point of origin to discharge.

G. Ensure the pipe alignment stays true during and after placement of concrete encasement.

H. Ensure that the method used to prevent pipe uplift during placement of concrete encasement results in an invert and crown true to intended grade.

I. Maintain circular cross section of pipe.

J. Provide lean concrete below the underside of the slab or footing for backfill over pipe laid below structures when pipe is less than 6 inches below the underside of the slab or footing, unless specified otherwise. Place concrete in accordance with Section 03 30 00.

K. Provide Heat-Shrinkable Cross-Linked Polyolefin Coating or Tape Wrap coating on all flanged, grooved, and welded joints that are buried or below structures.

L. Provide Petrolatum Tape wrap on all valves and mechanical pipe couplings that are buried or below structures. Install per manufacturer's recommendations. Candidate Manufacturers:
   1. Denso Densyl Tape
   2. #1 Wax Tape
   3. Approved Equal

M. Use anti-seize compound with all stainless steel nuts and bolts.

3.11 EXPOSED INSTALLATION

A. Fabricate and install domestic hot and cold water piping, sanitary piping and storm drainage piping in accordance with the Plumbing Code.

B. Provide pipe system layout in accordance with the following criteria:
   1. Drawings show general layout of piping. Exact dimensions determined by Contractor.
   2. Maintain minimum clear areas through tunnels and principal access aisles as specified in this Section.
   3. Expanding or swaging of tubing to fit IPS (Iron Pipe Size) fitting sockets is not permitted.
   4. Use reducing fittings where change in pipe size occurs.
   5. Use couplings only where pipe runs are longer than standard supplied pipe lengths.
   6. Make exposed polished or enameled connections to fixtures or equipment with special care to avoid damage to finished surfaces.
   7. Make changes in direction only with fittings.
   8. Install piping with not less than minimum slope to ensure adequate drainage and venting.
   9. Maintain clear areas around equipment to allow adequate access for maintenance as specified in this Section.
   10. Ensure valve operators are accessible from floor level. Provide chain wheel operators for valves with centerline elevations of 7 feet or above.
   11. Ensure piping ancillaries and in-pipe instrumentation is installed in accessible locations which do not create problems for traffic in the clear areas.

C. Make adequate provision in piping and pipe support systems for expansion, contraction, slope, and anchorage.

D. Install pipe support system to adequately secure the pipe and to prevent undue vibration, sag or stress.

E. Install expansion joints where specified on the Drawings or where required by the Design Professional, to allow for piping expansion and contraction.

F. Install expansion loops or bends where specified, or required by the Design Professional, to allow for proper pipe expansion. Construct expansion loops with long radius welded bends.

G. Provide temporary supports as necessary during construction to prevent overstressing of equipment, valves or pipe.

H. Accurately cut all piping for fabrication to field measurements.

I. Install pipes in straight alignment and parallel to wall. Do not exceed 3/8-in variance over 30 ft from the true alignment, in any direction.

J. Fabricate and assemble pipe runs so that the pipework is not stressed to achieve the desired alignment and that no stresses are transferred to equipment or equipment flanges. Unless stipulated by the Design Professional to address significant thermal strain, and accepted by the Construction Manager, the "springing" of pipe and fittings to ensure alignment is not permitted. Undo and subsequently remake all pipework connections where so instructed by the Construction Manager to ensure that unintended springing does not occur. Take care not to damage equipment, valves, or flanges.

K. Slope instrument air piping to condensate traps.

L. Do not cut or weaken the building structure to facilitate installation of piping.

M. In parallel pipe runs, offset flanges and/or grooved joint fittings by a minimum of 8 inches longitudinally to allow for proper access.

N. In vertical pipe runs of pipe diameter greater than 10 inches, provide 8-inch long spool piece on lower side of each valve.

O. Do not install water piping over electric switchboards, transformers, cable tray or electric motor starters.

P. Provide pipe markers for all exposed pipe.

3.12 THREADED JOINTS

A. Conform to the requirement of ANSI B31.1.

B. Ream the end of all pipes to remove all burrs and cuttings when fabricating threaded joints.

C. Clean out pipe and repair linings and coatings prior to joining.

D. Apply Teflon tape to male threads and join pipe. Use both Teflon tape and Teflon sealing compound on stainless steel pipe threads. Do not apply extra tape to make up for slack in the joint.

3.13 FLANGED JOINTS

A. Maintain consistent flange bolt hole positions along the entire length or run of the pipe.

B. For pipe installed with a horizontal axis, position flange bolt holes so that the vertical centerline of the flange face bisects the arc between flange bolt holes (“Two-Holed”).

C. For pipe installed with a vertical axis, position flange bolt holes so that the horizontal centerline of the flange face bisects the arc between flange bolt holes and is perpendicular to the closest structural wall (“Two-Holed”).

D. Clean flanges and gaskets prior to connection.

E. Lubricate gaskets with gasket manufacturer’s recommended lubricant and apply anti-seize compound to all bolts.

F. Bring flanges into close parallel and lateral alignment.

G. Tighten bolts progressively. Proceed from side to side of the flange.

H. Use proper length bolts for each size flange on flanged connections. Washers may not be used to take up excess bolt length. Provide approximately two full threads bolt projection beyond nuts. Bolts with excessive length of exposed threads will not be permitted. All-thread rod is not acceptable for bolting flanges.

I. When joining steel to cast iron flanges, take care to avoid damage to the cast iron flange. Ensure both flanges are flat-faced and use full face gaskets.

J. Align flanges which connect piping to mechanical equipment to close parallel and lateral alignment prior to tightening bolts. Do not place strain on the equipment.

K. Allow a minimum of 6 inches’ clearance to face or 8 inches to edge of flange to wall, floor, or ceiling unless otherwise specified.

3.14 FLEXIBLE HOSE CONNECTORS

A. Accurately align pipelines to receive flexible connectors before installing the connectors. Do not stretch, compress, misalign or offset the connectors.

B. Align and install each flexible connector in accordance with the manufacturer's instructions.

C. Support, anchor and guide the piping so that the flexible hose connectors are not required to absorb any axial compression or elongation.

D. Do not torque or twist the flexible connectors.

E. Check bolt tightness and tighten where necessary, a maximum of one week after commissioning and periodically thereafter.

3.15 EXPANSION JOINTS

A. Accurately align pipelines to receive expansion joints before installing the joint. Do not stretch, compress or offset the joint to fit the piping. Install expansion joints in accordance with manufacturer's instructions prior to releasing preload.

B. Align and install each expansion joint in accordance with EJMA standards and with the manufacturer's written instruction; properly guide and anchor all expansion joints. No lateral movement is permitted on compensator type expansion joints.

C. On rubber expansion joints, check bolt tightness, and tighten where necessary one week after Commissioning is completed.

3.16 REPAIR/RESTORATION

A. Repair pipe with damaged shop-applied protective linings in accordance in accordance with specified standard (e.g. AWWA C210) or accordance with the lining manufacturer's directions, if no standard is cited.

B. Damaged glass lining cannot be repaired. Replace piping with damaged glass lining.

C. Patching inserts, overlays, or pounding out of dents is not to be permitted.

D. Repair pipe with damaged protective coatings and holdback areas for welding and other field fabrication, as follows:
   1. For shop-applied coatings, not subject to Section 09 90 00 requirements, in accordance with specified standard (e.g. AWWA C210) or in accordance with the coating manufacturer's directions, if no standard is cited.
   2. For coatings applied pursuant to Section 09 90 00 requirements, apply repair coatings in conformance with the applicable Section 09 90 00 coating system, including thickness and stipulated preparation of the lowest full thickness coating layer (i.e. exposed metal would require full profile preparation and specified multi-layer coating restoration).
   3. Prepare areas to be repaired not less than 2-inches beyond damaged areas and feather repair coating into adjacent areas.
   4. Repair to provide equivalent protection to undamaged coatings and a uniform appearance when judged from 4 feet away.

E. Other requirements may be stipulated in related piping sections.

3.17 FIELD QUALITY CONTROL

A. Inspections:
   1. Inspect and provide reports as specified in Section 40 05 07.
   2. Submit the Design Professional's final report before beneficial occupancy by the Owner.

3.18 TESTING

A. Provide 24 hours notice prior to testing.

B. Do not insulate or conceal work until piping systems are tested and have met all required criteria.

C. Complete any required weld tests.

D. Supply all water, air, and inert gases required for pressure testing.

E. Supply all pumps, compressors, gauges, etc. required for testing.

F. Install air threadolets, air relief valves, and line fitting valves as necessary to complete testing. Remove after testing and plug threadolets.

G. Cap or plug all lines which are normally open ended. Remove on completion of testing.

H. Provide all temporary thrust restraints necessary for testing. Remove upon completion of testing.

I. Test all underground lines prior to backfilling. Do not place concrete encasement until lines are tested and have met all required criteria.

J. Test all existing piping where it connects to new piping to the first valve in the existing piping. Repair any failures in existing piping which occur as a result of the test after informing the Construction Manager of such failure.

K. Isolate all pumps and low pressure equipment and appurtenances during testing so as not to place any excess pressure or thrust forces on the equipment.

L. Where defective material or equipment is identified, repair or replace using new material.

M. Flush and drain liquid pipes after pressure tests. Purge all gas pipes after pressure tests using inert gas.

N. Dispose of flushing water in manner approved by the Construction Manager, which causes no damage to buildings or siteworks.

3.19 HYDROSTATIC PRESSURE TESTING OF LIQUID LINES

A. Hydrostatically test all lines normally used for the conveyance of liquids using water as the test medium, unless otherwise specified in this Section.

B. Test pressures and durations as specified in the Piping System Schedules.

C. Ensure all lines are filled with water. Bleed air from all high spots using the taps provided specifically for that purpose.

D. Lined pipelines: Allow filled pipeline or section thereof to stand under a slight pressure for at least 8 hours (24 hours for cement mortar lining) to allow the lining to absorb water and to allow the escape of air from air pockets.

E. Zero leakage is permitted throughout the specified test period for all exposed piping, buried insulated piping, and any liquid chemical lines.

F. Show evidence of leakage rates below 0.02 gal per hour per inch pipe diameter per 100 ft of pipe length for buried piping, unless otherwise specified.

G. Test drains in accordance with the Plumbing Code.

H. For hydraulic and lube oil systems, test using the medium of service. Provide zero loss of pressure throughout the specified test period.

3.20 PNEUMATIC PRESSURE TESTING

A. Use nitrogen gas or oil free dry air to test piping systems where nitrogen or air is the specified testing medium in the Piping System Schedule.

B. Submit a testing plan and a safety plan for each piping system that will be pressure tested with nitrogen gas or oil free dry air. Do not perform pressure testing with air or nitrogen until a favorable review of the safety plan and testing plan for the piping system has been returned from the Construction Manager. Comply with all workplace safety and pressure vessel safety codes and guidelines.

C. Provide a separate pressure relief valve for pneumatic pressure testing.

D. Locate pressure relief valve within visual range of the test gauge and with exhaust to a safe location.

E. Set relief valve at not more than full test pressure plus 10 percent.

F. Continuously monitor and control testing to assure personnel safety and piping integrity.

G. Remove all personnel from areas where piping will be subjected to pressure tests and prevent entry into testing areas until test pressure has been relieved.

H. Protect installed work from potential damage from pressure testing failures. The Contractor is responsible for any damage or injury resulting from failed pressure testing with air or nitrogen.

I. When using nitrogen or air to test steel or stainless steel pipelines, gradually introduce the test gas up to a pressure of 45 psig or 1/3 of specified test pressure, whichever is less.

J. While maintaining this pressure, test lines for leaks using soapy water.

K. When the line is free from leaks at this pressure, increase by increments of 50 psig or 1/3 of specified test pressure (whichever is less) to the specified test pressure.

L. After each increment, retest using soapy water; take corrective action as necessary.

M. When the system is free from leaks at the test pressure, depressurize the system slowly.

N. To prevent the entrance of water or moisture into the medium source, disconnect the test source from the system and cap.

O. Where specified, maintain nitrogen pad after testing until the line is put into service. Label any piping for which a pad is provided and maintained.

P. Provide high purity nitrogen gas used for testing, in cylinders fitted with pressure regulators for 0 to 300 psig and all necessary fittings and adaptors necessary to complete the connection between the source and the system header. Provide self-relieving type pressure regulator that vents to the atmosphere and include a throttling valve.

Q. Provide oil free air with a relative humidity of zero for testing. Provide all fittings, adaptors, accessories, and the pressure regulator and throttling valve that are suitable for pressure testing with air and rated for 300 psig service.

3.21 PRESSURE TESTING OF AIR AND VAPOR LINES

A. Hydrostatically or pneumatically pressure test, as specified in the Piping System Schedules, all lines normally used for the conveyance of gas, air, and/or vapor in accordance with ASME procedures for testing pressure piping and CAN/CGA B149.6 for buried digester gas piping. Pneumatically test all instrument air lines in accordance with ISA-S7.0.01 and digester gas piping in accordance with CAN/CGA B149.6.

B. Test pressures are identified in the Piping System Schedule.

C. Zero leakage rate is required at the specified test pressure through the test period. Prior to commencing test using air, ensure air will be at ambient temperature and specified test pressure.

D. Do not exceed the maximum specified leakage rate during the test period for all other systems tested with air.

E. Remake all joints which display leakage and retest.

3.22 CLEANING AND FLUSHING

A. After installation and prior to testing, perform initial cleaning of process and utility lines. Clean piping greater than 6 inches and less than 24 inches by passing a tightly fitting cleaning ball or swab through the pipeline, unless specified otherwise. Lines greater than 24 inches may be cleaned manually or with a cleaning ball or swab. Give lines smaller or equal to 6 inches an initial flush or purge.

B. After initial cleaning, connect the piping systems to related process and mechanical equipment. Insert temporary screens, provided with visible locator tabs, in the suction of pumps and compressors in accordance with the following table:

Suction size, in.	Maximum screen opening, in.
0 – 1	1/16
1-1/4 – 3	1/4
3-1/2 – 6	1/2
Over 6	1

C. Maintain the screens during testing, flushing/purging, initial startup, and the initial operating phases of the commissioning process. In special cases and with the Construction Manager's acceptance, screens may be removed for performance tests. Install screens for clear water testing and initial operation on liquid systems handling solids. Initial operation on solids systems following clear water testing may be without screens.

D. Unless specified otherwise, flush liquid systems after testing, with clean water and screens in place. Maintain flushing for a minimum period of 15 minutes and until no debris is collected in the screens.

E. Remove the screens and make the final connections after the screens have remained clean for a minimum of 24 consecutive hours of operation. Keep screens in place for 24 hours of clean water operation on solids handling systems; remove prior to placing the system into solids handling service.

F. In air or gas systems with pipe sizes less than or equal to 6 inches, purge with air and/or inert gases before testing. Upon completion of testing and cleaning, drain and dry the piping with a dry air stream. Satisfy ANSI/ISA-S7.0.01 standards for instrument air systems.

G. Clean and flush piping connecting to HVAC equipment in accordance with Division 23.

3.23 DISINFECTION

A. Flush and disinfect lines intended for potable water service after testing in accordance with AWWA C651.

END OF SECTION

Schedule 40 05 02.05 – Piping System Schedule, Service Air

Process Service	Service Air
Process Service Identifier	SA

General Requirements

A. **Testing Requirements: Pressure: 200 psig. Duration: 120 min. Medium: Air**

B. Comply with the provisions of Section 40 05 01 in addition to the requirements specified herein. Refer to Section 40 05 02 for definitions of abbreviations and acronyms used in this schedule.

C. Full-Faced flanges mated with raised face flanges are not permitted.

D. Mating flanges for pipe shall be of the same Standard, Class, and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.

E. Pipe threads per ASME B1.20.1.

F. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)

G. Provide dielectric couplings at material transitions. Provide threaded adapters at material transitions.

H. Provide unions or flanges as shown on Drawings to allow for pipe disassembly. Spacing between unions provided for piping disassembly: not less than 60 ft.

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Flange Bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Apply anti-seize to stainless steel bolts before turning nut on flange bolts.
3. Provide long radius elbows.
4. Provide weld neck flanges on both sides of wafer, lug body, or flanged valves.
5. Hard, drawn, furnished in straight lengths.
6. Provide annealed tube for flared fittings. Furnished in straight lengths or coils.
7. Furnish threaded adapters at connections to valves.
8. Provide stem extension and valve box.

Schedule 40 05 02.05 – Piping System Schedule, Service Air

Process Service	Service Air
Process Service Identifier	SA

Area Exposure Types: Headspace, Process Corrosive, Chemical Corrosive, and Submerged (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	1/4 thru 2	Stainless Steel: ASTM A312-TP316L, SML, Dim. Per ASME B36.19	Sch 40S	THD	40 05 23	
Lining for Pipe & Fittings	All	None	—	—	—	
External Coating	All	None	—	—	—	
	Valves	Shop Coat: Manufacturer's standard primer or primer and finish coat Field Coat: Finish coat per Specification	—	—	09 90 00	
Fittings	1/4 thru 2	Forged Stainless Steel: ASTM A182-F316L, Dim. per ASME B16.11	Class 3000	SW, THD	40 05 23	3
		Cast Stainless Steel: ASTM A351-CF8M, Dim. per ASME B16.3	Class 150	SW, THD	40 05 23	3
Taps	1/4 thru 2	Forged Stainless Steel Tee: ASTM A182-F316L, Dim. per ASME B16.11	Class 3000	THD, SW	40 05 23	
Grooved Coupling	All	None	—	—	—	
Flanges	2-1/2 thru 6	Welded Forged Stainless Steel: ASTM A182-F316L, FF, Dim. per ASME B16.5	Class 150	LWN, WN, SO, SW	40 05 23	4
FLG Bolts, nuts, and hardware	All	Stainless steel bolts: ASTM A193 B8M Bolts, AISI 316 Stainless steel nuts: ASTM A194 Grade 8M Heavy Hex Nuts	—	—	—	1, 2
Flange gaskets	2-1/2 thru 6	Viton/FKM	1/16 in	FLG	40 05 01	
Mechanical Coupling Gaskets	All	None	—	—	—	
Compression and Push-On Gasket	All	None	—	—	—	
Valves	1/4 thru 2	Ball: 316 Stainless Steel Body, 40 05 63.03	—	THD	40 05 60	7
Insulation	All	None	—	—	---	

END OF SECTION

Schedule 40 05 02.43 – Pressurized Wastewater, Drainage, and Vent

Process Service	Raw Sewage	Vent
Process Service Identifier	RS	V

Test Conditions

Pressure (psig)	Duration (min.)	Medium
200	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Pipe Threads per ASME B1.20.1.
4. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)
5. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Install lining and coating prior to welding Threadolet or Half Coupling.
5. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
6. Bolts and nuts with metallurgy specified in AWWA C111.
7. Install plug valve with seat at the inlet or upstream connection to piping.
8. Provide rigid couplings except for pipe installed on pipe racks in below pipe/utility tunnels or chases.

Schedule 40 05 02.43 – Pressurized Wastewater, Drainage, and Vent

Process Service	Raw Sewage	Vent
Process Service Identifier	RS	V

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	4 thru 48	Ductile Iron: AWWA C151	Thk. Class 53	FLG, RMJ	40 05 19	
Lining for Pipe & Fittings	1/8 thru 2-1/2	—	—	None	—	
	Ductile Iron, All	Cement Mortar: AWWA C104, NSF 61 certified, Factory Applied	Thk, per Std.	—	40 05 19	
External Coating	Ductile Iron, All	Manufacturer's Standard, Factory Applied	8 mils DFT	—	40 05 19	
	Valves	Epoxy: Manufacturer's standard, primer and finish coat, Factory Applied	—	—	—	
Fittings	4 thru 48	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	150 psi	FLG	40 05 19	2
Taps	Ductile Iron, All	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	Sch. 40	THD	40 05 19	

Schedule 40 05 02.43 – Pressurized Wastewater, Drainage, and Vent

Process Service	Raw Sewage	Vent
Process Service Identifier	RS	V

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Flanges	Ductile Iron, All	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1-Class 125	250 psi	FLG	40 05 19	
FLG Bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	3 thru 72	—	—	Nitrile or Neoprene	40 05 01	
Valve	3 thru 60		FLG	Plug: AWWA C517, Standard Port, 40 05 62.01	40 05 60	7
				Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16 Duckbill Valve: Slip on style check valve with cuff clamps, elastomer construction.	40 05 65.16 40 05 62.05	
Insulation	3/8 thru 8	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 72	1 in. Thk	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	

Schedule 40 05 02.43 – Pressurized Wastewater, Drainage, and Vent

Process Service	Raw Sewage	Vent
Process Service Identifier	RS	V

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/2 thru 3	Sch. 80	THD, FLG, SLV	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	40 05 31.13	
	4 thru 12	Pr. Class 350	RMJ, FLG	Ductile Iron: AWWA C151	40 05 19	
Lining for Pipe & Fittings	1/2 thru 3	—	—	None	—	
	Ductile Iron, All			Cement Mortar: AWWA C104, NSF 61 certified, Factory Applied	40 05 19	
External Coating	1/2 thru 3	—	—	None	—	
	Ductile Iron, All	Polyamidoamine Epoxy Primer: Manufacturer's Standard, Factory Applied	8 mils DFT	—	40 05 19	
		—	—	V-Bio Enhanced Polyethylene Encasement: Per Specification, Field Installed		
	Valves	—	—	Coating System M-1: Per specification, Field Applied	09 90 00	
Fittings	1/2 thru 3	Sch. 80	THD, FLG, SLV	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2467	40 05 31.13	
	4 thru 12	350 psi	CGRV	Ductile Iron: ASTM A536-Gr 65/45/12, Dim. per AWWA C110 or AWWA C153	40 05 19	2
Taps	1/2 thru 3	Sch. 80 IPS SDR 17	SLV FLG, FSW, EFSW, BFW, HPEG, HGRV	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2467 Molded HDPE Tee: ASTM D 3350-445574C/PE 4710, NSF 61 certified, Dim. per ASTM D3261, with reducers and HDPE to 316 Stainless Steel MNPT transition	40 05 31.13 40 05 33.13	
	Ductile Iron, All	Sch. 40	THD	Steel Short Nipple: ASTM A53, seamless-Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 19	
Flanges	1/2 thru 3	Class 150	SLV x FLG	PVC: ASTM A1784-Class 12454-B, FF, Dim. per ASME B16.5	40 05 31.13	
	Ductile Iron, All	250 psig	FLG	Ductile iron: AWWA C115 for pipe, AWWA C110 for fittings, Dim. per ASME B16.1-Class 125	40 05 19	
FLG Bolts, nuts and hardware	All	—	—	Non Corrosive, High-Strength, Low-Alloy Steel Bolts: ASTM A 449- Gr 3, Class C or Class D with	—	1, 6
				Carbon Steel Nuts: ASTM A563-Gr C3, Class C or Class D		1
				Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal with		1
				Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal		1

Schedule 40 05 02.43 – Pressurized Wastewater, Drainage, and Vent

Process Service	Raw Sewage	Vent
Process Service Identifier	RS	V

Buried (Includes Embedded and Encased)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Flange gaskets	1/2 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	4 thru 72	—	CGRV	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gasket	4 thru 54	—	RMJ, RPO, RBAS	Neoprene or Nitrile	40 05 01	
Valves	1/2 thru 3	—	THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	
	4 thru 60	—	FLG	Plug: AWWA C517, Standard Port, 40 05 62.01	40 05 60	7
Insulation	All	—	—	None	—	

Schedule 40 05 02.89 – Drainage

Piping Service	Drain
Piping Service Abbreviation	D

Test Conditions

Pressure (psig)	Duration (min.)	Medium
5.0	15	Water

General Requirements

1. Minimum test conditions specified above.
2. Sleeve drain, waste and vent piping through structural concrete and masonry.
3. Provide copper tube for Outdoor HVAC equipment condensate drains.
4. Pipe Threads per ASME B1.20.1.

Notes:

1. Provide long radius elbows.
2. Provide magnetic tracer tape,
3. Pipe Tape Wrap is not required for pipe installed in Indoor Dry, Indoor Wet, and Outdoor Area Exposures.
4. PVC lining is not required for D, RWP, and STD service.
5. Fabricated (miter cut pipe) PVC fittings are not acceptable.
6. Unreinforced Precast Concrete Manholes: 6 inch minimum wall thickness. Reinforced Precast Concrete Manholes: 4 inch minimum wall thickness. Provide Rubber gasket joints or mastic sealant joints between Precast Concrete Manhole Sections.
7. Bolts and nuts with metallurgy specified in AWWA C111.

Schedule 40 05 02.89 – Drainage

Piping Service	Drain
Piping Service Abbreviation	D

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, and Headspace – Exposed and Buried (Includes Embedded and Encased) Under Buildings and Within 5 feet of Building Perimeter

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/4 thru 1-1/2	Sch. 40	THD	Steel: ASTM A53, galvanized, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	
	1-1/4 thru 12	Sch. 40	SLV	PVC: ASTM D1784-Class 12454-B or ASTM D2665-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	40 05 31.13	
Lining for Pipe & Fittings	1/4 thru 1-1/2	—	—	None	—	
	PVC, All	—	—	None	—	
External Coating	1/4 thru 1-1/2	2 wraps / layers	—	Pipe Wrap Tape: Polyethylene or PVC tape, Field Applied on Installed Pipe	—	
	PVC, All	—	—	None	—	
	Valves	—	—	None	—	
Fittings	1/4 thru 1-1/2	Class 3000	THD	Forged Steel: ASTM A105, galvanized, Dim. per ASME B16.11		
	PVC, All	Sch. 40	SLV	PVC: ASTM D2665-Class 12454-B, NSF 61 certified, Dim. Per ASTM D3311	40 05 31.13	1
Taps	All	—	—	None		
Grooved Coupling	All	—	—	None	—	
Flanges	All	—	—	None	—	
FLG Bolts, nuts, and hardware	All	—	—	None	—	
Flange gaskets	All	—	—	None	—	
Mechanical Coupling Gaskets	All	—	—	None	—	
Compression and Push-On Gasket	All	—	—	None	—	
Valves	All	—	—	None	—	
Insulation	½ thru 36	1 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium-Temperature Range, Condensation Control, Aluminum Jacket/Covers		

Schedule 40 05 02.89 – Drainage

Piping Service	Drain
Piping Service Abbreviation	D

Buried (Includes Encased and Embedded)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1-1/4 thru 12	Sch. 40	SLV	PVC: ASTM D1784-Class 12454-B or ASTM D2665-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	40 05 31.13	2
	3 thru 15	DR 35	PO	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D3034	40 05 31.13	2
Lining for Pipe & Fittings	PVC, All	—	—	None	—	
External Coating	PVC, All	—	—	None	—	
Fittings	1-1/4 thru 12	Sch. 40	SLV	PVC: ASTM D2665-Class 12454-B, NSF 61 certified, Dim. Per ASTM D3311	40 05 31.13	1
	PVC, 3 thru 15	SDR 35	PO	Molded PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D3034	40 05 31.13	1
Taps	All	—	—	None	—	
Grooved Coupling	All	—	—	None	—	
Flanges	All	—	—	None	—	
FLG Bolts, nuts, and hardware	All	—	—	None	—	
Flange gaskets	All	—	—	None	—	
Mechanical Coupling Gaskets	All	—		None	—	
Compression and Push-On Gasket	PVC, All	—	PO	Oil Resistant gasket: ASTM F477	—	
Valves	All	—	—	None	—	
Insulation	All	—	—	None	—	

SECTION 40 05 02

PIPING SYSTEM SCHEDULES

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies a Piping System Schedule for each Process Service. Each Piping System Schedule specifies piping system materials for groups of similar process piping services.

B. The following table lists process services and the corresponding Piping System Schedule that specifies piping system material requirements for the associated process piping service. See Part 4 for Piping System Schedules that define materials for piping services.

C. Piping System Schedule assignments are listed in the following table:

Process Service Identifier	Process Service	Piping System Schedule	Fluid Category	Pipe Marker Background Color
D	Drainage	40 05 02.89	Drain/Vent	Green
RW	Raw Sewage	40 05 02.43	Wastewater	Grey
SA	Service Air	40 05 02.05	Compressed Air	Blue
FA	Foul Air	40 05 31.13	Foul Air	Beige
V	Vent	40 05 02.43	Air	Beige

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ASME B1.20.1	Pipe Threads, General Purpose
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250
ASME B16.3	Malleable Iron Threaded Fittings Class 150 and 300
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory-Made Wrought Steel Butt Welding Fittings
ASME B16.11	Forged Steel Fittings, Socket Welding and Threaded
ASME B16.12	Cast Iron Threaded Drainage Fittings
ASME B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	Cast Copper Alloy Fittings for Flared Copper Tubes

Reference	Title
ASME B31.1	Power Piping
ASME B31.3	Process Piping
ASME B31.9	Building Services Piping
ASME B32	Solder Metal
ASME B36.10	Welded and Seamless Wrought Steel Pipe
ASME B36.19	Stainless Steel Pipe
ASME B1.1	Unified Inch Screw Threads
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Requirements
ASTM A47	Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot Dipped, Zinc Coated Welded and Seamless
ASTM A74	Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106	Seamless Carbon Steel Pipe for High Temperature Service
ASTM A126	Grey-Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A135	Electric-Resistance-Welded Steel Pipe
ASTM A139	Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and Over)
ASTM A167	Stainless Steel and Heat-Resisting Chromium-Nickel Steel Plate
ASTM A181/181M	Forgings, Carbon Steel, for General Purpose Piping
ASTM A182/182M	Forged or Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/193M	Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service High Pressure Service and Other Special Purpose Applications
ASTM A194/194M	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service or High Temperature Service, or Both
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A240	Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
ASTM A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A307	Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
ASTM A312/312M	Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A320/320M	Alloy Steel Bolting Materials for Low-Temperature Service
ASTM A403/A403M	Wrought Austenitic Stainless Steel Piping Fittings
ASTM A409/A409M	Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service
ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A536	Ductile Iron Castings
ASTM A563	Carbon and Alloy Steel Nuts
ASTM A774/A774M	As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures
ASTM A778	Welded, Unannealed Austenitic Stainless Steel Tubular Products

Reference	Title
ASTM A1011/A1011M	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B75	Seamless Copper Tube
ASTM B88	Seamless Copper Water Tube
ASTM B584	Copper Alloy Sand Castings for General Applications
ASTM C76	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C564	Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C361	Reinforced Concrete Low-Head Pressure Pipe
ASTM C443	Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	Circular Precast Reinforced Concrete Manhole Sections
ASTM D638	Test Method for Tensile Properties of Plastics
ASTM D792	Test Method for Specific Gravity and Density of Plastics by Displacement
ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2513	Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2996	Filament-Wound Reinforced Thermosetting Resin Pipe
ASTM D3034	Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals
ASTM D3261	Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Fittings
ASTM D3350	Polyethylene Plastics Pipe and Fittings Materials
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM D4174	Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems
ASTM D4894	Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials
ASTM D4895	Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F894	Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
AWWA C104	Cement–Mortar Lining for Ductile-Iron Pipe and Fittings
AWWA C105	Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids
AWWA C110	Ductile-Iron and Grey-Iron Fittings, 3 Inch Through 48 Inch, for Water and Other Liquids
AWWA C111	Rubber-Gasket Joints for Ductile-Iron and Grey-Iron Pipe and Fittings
AWWA C115	Flanged Ductile-Iron and Grey-Iron Pipe with Threaded Flanges
AWWA C150	Thickness Design of Ductile-Iron Pipe

Reference	Title
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water and Other Liquids
AWWA C153	Ductile-Iron Compact Fittings
AWWA C200	Steel Water Pipe, 6 Inches and Larger
AWWA C203	Coal Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inches through 144 Inches
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services - Sizes 4 Inch Through 144 Inch
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings
AWWA C301	Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
AWWA C303	Reinforced Concrete Pressure Pipe - Steel Cylinder Type, Pretensioned, for Water and Other Liquids
AWWA C600	Installation of Ductile-Iron Water Mains and their Appurtenances
AWWA C606	Grooved and Shouldered Joints
AWWA C651	Disinfecting Water Mains
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Through 12 Inches, for Water
AWWA M11	Steel Pipe - A Guide for Design and Installation
CISPI 301	Specification Data for Hubless Cast Iron Sanitary System with No-Hub Pipe and Fittings
EJMA STDS	Standards of Expansion Joint Manufacturers' Association, Edition No. 6
FSA	Fluid Sealing Association Technical Handbook, Rubber Expansion Joint Division
FEDSPEC, L-C-530B(1)	Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy
MIL-H-13528B	Hydrochloric Acid, Inhibited, Rust Removing
MIL-S-8660C	Silicone Compound
MIL-STD-810C	Environmental Test Methods
MSS SP-25	Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-43	Wrought Stainless Steel Butt Welding Fittings
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded, and Buttwelding Ends
MSS SP-114	Corrosion Resistant Pipe Fittings Threaded and Socket Welding Class 150 and 1000
NSF/ANSI 61:	Drinking Water System Components – Health Effects
SSPC	Society for Protective Coatings
SAE J1227	Assessing Cleanliness of Hydraulic Fluid Power Components and Systems

1.03 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:

B. Pipe Connections and Joints:
   1. BABS – Bell and Ball Spigot
   2. BAS – Bell and Spigot
   3. BFW – Butt Fusion Weld
   4. BSS – Bolted Split Sleeve Coupling
   5. BW – Butt Weld
   6. BSW – Butt-Strap Weld
   7. CGRV – Cut (or Cast) Grooved End Coupling
   8. CPLG – Coupling
   9. CPO – Compression Type Push-On
   10. CPRSN – Compression
   11. DLW – Double Lap Weld (Bell and Spigot)
   12. EFSW - Electro-Fusion Socket Weld
   13. FLG – Flanged
   14. FLRD – Flared
   15. FP – Full Penetration
   16. FSW – Fusion Socket Weld
   17. HAS – Hub and Spigot, Compression (Cast Iron Soil Pipe)
   18. HBLS - Shielded Hubless (Cast Iron Soil Pipe)
   19. HGRV – HDPE Groove Coupling
   20. HLF CPLG – Half Coupling
   21. HPEG – HDPE Plain End with Gripping Teeth
   22. HXGT - HDPE by Grooved End Transition
   23. LR ELL – Long Radius Elbow
   24. MJ – Mechanical Joint
   25. PGRV - Proprietary Groove Coupling
   26. PO – Push-on
   27. RBAS – Restrained (Lap Welded) Bell and Spigot with O-ring rubber gasket
   28. RGRV – Rolled Grooved End Coupling
   29. RJC – Ring Joint Coupling
   30. RMJ – Restrained Mechanical Joint
   31. RPO – Restrained Push-On joint
   32. SLV – Solvent Weld
   33. SLDR – Solder or Brazing
   34. SLW – Single Lap Weld (Bell and Spigot)
   35. SR ELL – Short Radius Elbow
   36. SW – Socket Weld
   37. THD – Threaded

38. UN – Union

C. Flanges:
   1. FF – Full Face
   2. LF – Loose Flange
   3. LJ – Lap Joint
   4. LWN – Long Weld Neck
   5. RF – Raised Face
   6. SO – Slip-On
   7. THD – Threaded
   8. WN – Weld Neck

D. Materials:
   1. DI – Ductile Iron
   2. RCP – Reinforced Concrete Pipe
   3. RCP-LHP – Reinforced Concrete Low Head Pressure Pipe
   4. SS – Stainless Steel
   5. SV – Service (Cast Iron Soil Pipe available with SV rating or XH, extra heavy, rating)

E. Welding:
   1. FP – Full Penetration
   2. SML – Seamless
   3. WLD – Welded

F. Other:
   1. CFT - Cured Film Thickness
   2. DFT – Dry Film Thickness
   3. Dim – Dimensions
   4. M or E Pipe – Matches or exceeds rating of connecting pipe
   5. Thk – Thickness
   6. Sch – Schedule
   7. Std – Standard
   8. STD – Standard Weight or Standard

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe size (nominal diameter) and the Process Service Identifier for the contents of the pipeline are specified in pipe line labels on the drawings.

B. Provide piping system materials and components per the Piping System Schedule assigned for the specified process service and pipe size.

C. The Rating column in the Piping System Schedule specifies the minimum acceptable pressure rating or wall thickness for the component of the piping system.

PART 3 NOT USED

PART 4 SCHEDULES

4.01 DETAILED PIPING SPECIFICATION SHEETS.

A. Piping System Schedules follow this Section. Piping System Schedules are assigned a Section number in the range from 40 05 02.00 through 40 05 02.99.

END OF SECTION

SECTION 40 05 06

SPECIALTY COUPLINGS AND ADAPTERS FOR PROCESS PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes specialty couplings and adapters to provide electrical isolation, connect misaligned pipe, provide pipeline flexibility, provide disconnection/dismantling capabilities, and other specialty functions in pipelines.

B. Connections, couplings, and joints used to connect pipe segments and fittings that are not specifically designed to provide the capabilities of a specialty coupling are specified with the pipe materials.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 40 05 01 – Piping Systems
   2. Section 40 05 02 – Piping System Schedules

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.
   1. ASME B31.1 – Power Piping
   2. ASME Section IX – Boiler and Pressure Vessel Code; Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Qualifications
   3. ASTM A36 – Standard Specification for Carbon Structural Steel
   4. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   5. ASTM A193 – Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
   6. ASTM A194 – Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
   7. ASTM A536 – Standard Specification for Ductile Iron Castings
   8. ASTM F593 – Stainless Steel Bolts, Hex Cap Screws, and Studs
   9. ASTM F594 – Standard Specification for Stainless Steel Nuts
   10. AWWA C105 – Polyethylene Encasement for Ductile-Iron Pipe Systems
   11. AWWA C111 – Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
   12. AWWA C116 – Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings
   13. AWWA C153 – Ductile-Iron Compact Fittings

14. AWWA C206 – Field Welding of Steel Water Pipe
15. AWWA C213 - Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
16. AWWA C219 – Bolted, Sleeve-Type Couplings for Plain-End Pipe
17. AWWA C550 – Protective Epoxy Coatings for Valves and Hydrants
18. AWWA C606 – Grooved and Shouldered Joints
19. AWWA M11 – Steel Pipe-A Guide for Design and Installation
20. NSF 61 – Drinking Water System Components - Health Effects

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   3. Manufacturers' product data, catalog cuts, typical installation details, and dimensions for each size and type of specialty coupling or adapter furnished for the project.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide new specialty pipe couplings and adapters, free from defects and conforming to the requirements and standards specified in this Section.

B. Provide specialty couplings and adapters at locations indicated on drawings.

2.02 MECHANICAL COUPLINGS

A. Sleeve-Type Couplings:
   1. Candidate manufacturer:
      a. Sleeve-type mechanical pipe couplings:
         1) Smith-Blair 411.
         2) Dresser Style 38.
         3) Romac 501
         4) Approved equal, with the stop removed from the middle ring.
      b. Restrained mechanical pipe couplings:
         1) Romac Alpa
         2) Smith-Blair 471
         3) Approved equal.
      c. Sleeve-type Flanged Coupling Adapters:
         1) Romac FCA 501.
         2) Smith-Blair 912.
         3) Dresser Style 128.
         4) Approved equal.

d. Gaskets: Match gasket material specified for Mechanical Coupling Gaskets in the Piping System Schedule for the associated Process Service.

e. Coat and line all metal portions of the fittings, with the exception of 316 stainless steel components, with fusion bonded epoxy conforming to AWWA C550 and NSF 61.

B. Dismantling Joints:

1. Dismantling joints may be used as takedown couplings in accordance with this Specification.

a. Dismantling joints: fully restrained double flange fittings consisting of a flange coupling adapter and flanged spool piece that allows for longitudinal adjustment.

b. Provide thrust restraint by means of all threaded rod spanning between flanges and secured to the flanges with a minimum of two flange bolts.

c. Design Dismantling Joints in accordance with AWWA C219.

d. Provide schedule 40 ASTM A53 Grade B pipe sleeves with ASTM A536 Grade 65-45-12 or ASTM A36 flange bodies and end rings. The pressure ratings of the flange adapters are to meet or exceed the pressure rating of the mating flanges. Coat and line all metal portions of the fittings, with the exception of 316 stainless steel components, with fusion bonded epoxy conforming to AWWA C550 and NSF 61.

e. Candidate manufacturers:

1) Romac DJ-400

2) Smith Blair 975

3) Viking Johnson Dismantling Joint

4) Approved equal

2.03 UNIONS

A. 2-inch and Smaller: Ground joint screwed pattern unions.

B. 2 1/2-inch and Larger: Ground joint flange unions.

C. Dielectric Unions: Match the pipe material except bronze may be used with copper piping. Dielectric unions shall be EPCO, Capitol Manufacturing, or approved equal.

2.04 INSULATING FLANGES, COUPLINGS, AND UNIONS

A. Flange Insulating Kits: 2-1/2 inches and larger:

1. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.

2. In accordance with applicable piping material specified in Piping System Schedules (Section 40 05 02.00 through 40 05 02.99). Provide insulating flange assemblies per ASME B31.9 or B31.1. Flange assembly pressure/temperature rating equal to or greater than pipeline rating.

3. Galvanically compatible with piping.

4. Gaskets: Full-face, Type E, with elastomeric sealing element. Sealing element retained in a groove within retainer portion of gasket.

5. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA G-10 grade).

6. Insulating Washers: Fiberglass reinforced epoxy (NEMA G-10 grade).

7. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
8. Manufacturers:
    a. Pipeline Seal and Insulator, Houston, TX
    b. Advance Products and Systems, Lafayette, LA
    c. Approved equal

B. Insulating Sleeve Couplings:
1. Smith-Blair 416.
2. Dresser Style 39.
3. Approved equal.

C. Flexible Insulated Couplings:
1. Baker Coupling Company, Inc.; Series 216.
2. Approved equal

D. Insulating Unions: Union Type, 2 inches and Smaller:
1. Screwed or solder-joint.
2. O-ring sealed with molded and bonded insulation to body.
3. O-ring sealed with molded and bonded insulating bushing to union body, as manufactured by Central Plastics Co., Shawnee, OK.
4. Approved equal

E. Force Balanced Double Ball and Single Ball Expansion Joints
1. Install ball expansion joints in the locations specified on the Drawings.
2. Provide foundry certification of material upon request. Materials as follows:
    a. Ductile iron joints conforming to the material requirements of ASTM A536 and AWWA C153.
    b. Type 410 stainless steel lock rings.
    c. EPDM molded watertight construction for ring gasket, casing, ball and cover.
3. Pressure test each expansion joint prior to shipment to a minimum of 250 PSI.
4. Flexible expansion joints consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint, providing a minimum deflection of: 25 degrees per ball for 4-inch through 8-inch expansion joints; 20 degrees per ball for 10-inch and 12-inch expansion joints, and 15 degrees per ball for 14-inch and larger expansion joints. Two ball and socket joints required for each Double Ball Expansion Joint.
5. Provide 10 inches minimum axial elongation capability with each single or double ball expansion joint. Furnish additional expansion sections as necessary to provide the specified minimum axial elongation capability.
6. Provide force balance ball expansion joint fittings that do not expand or exert an axial thrust under internal water pressure.
7. Line all metal surfaces, including the stainless steel lock rings, with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of AWWA C213. Provide EPDM sealing gaskets. Provide NSF 61 compliant coatings and gaskets.

8. Coat exterior surfaces with a minimum of 6 mils of fusion bonded epoxy conforming to AWWA C116.
9. For buried installations, install polyethylene sleeve, meeting per AWWA C105, in accordance with the manufacturer's instructions.
10. Candidate manufacturers:
    a. Romac FJ Restraint
    b. Starflex Series 5000
    c. EBAA Iron, Flex-Tend
    d. Approved equal

2.05 COATINGS

A. Field coat mechanical couplings in Buried exposure areas with System M-1 as specified in Section 09 90 00.

PART 3 EXECUTION

3.01 FLEXIBILITY

A. Unless otherwise specified, pipe passing from concrete to earth shall be provided with two pipe couplings or flexible joints (or a double ball expansion joint) as specified on the Drawings. Locate pipe couplings within 24 inches of the structure for 2-inch through 6-inch diameter pipe; within 40 inches of the structure for 8-inch through 24-inch pipe; and within one and one-half pipe diameters of the structure for pipe larger than 24-inch. Where required for resistance to pressure, restrain mechanical couplings in accordance with Chapter 13 of AWWA M11, including Tables 13-4, 13-5 and 13-5A, and Figure 13-20.

B. Install Single and Double Ball Expansion Joints with ¼ inch elongation/extension of the of the minimum axial elongation capability specified in this Section.

3.02 DIELECTRIC CONNECTIONS

A. Provide an insulating section of rubber or plastic pipe where a copper pipe is connected to steel or cast iron pipe. The insulating section shall have a minimum length of 12 pipe diameters.

B. Dielectric unions as specified in this Section may be used instead of the specified insulating sections.

END OF SECTION

SECTION 40 05 06.16

PIPING CONNECTIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the following methods of connecting metallic piping: flanges, threading, mechanical couplings, equipment connection fittings, dielectric unions, and welding.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI BI.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI BI.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B18.2.1	Square and Hex Bolts and Screws Inch Series
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ANSI B31.1	Power Piping
ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Qualifications
ASTM B98	Copper-Silicon Alloy Rod, Bar and Shapes
ASTM F37	Standard Test Methods for Sealability of Gasket Materials
ASTM F104	Standard Classification System for Nonmetallic Gasket Materials
ASTM F152	Standard Test Methods for Tension Testing of Nonmetallic Gasket Materials
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C206	Field Welding of Steel Water Pipe

Reference	Title
AWWA C207	Steel Pipe Flanges for Waterworks Service-Size 4 in. through 144 in.
AWWA C219	Bolted, Sleeve-Type Couplings for Plain-End Pipe
AWWA C550	Protective Epoxy Coatings for Valves and Hydrants
AWWA C606	Grooved and Shouldered Joints
AWWA M11	Steel Pipe-A Guide for Design and Installation
NSF 61	Drinking Water System Components - Health Effects

1.03 SUBMITTALS

A. In addition to the material listed in the detailed specification, the following submittals shall be provided in accordance with Section 01 33 00:
   1. For Equipment Connection Fittings used in pumping applications submit thrust rod stretch calculations in accordance with paragraph 2.02 Equipment Connection Fittings. and dimensional layout data.

PART 2 PRODUCTS

2.01 FLANGE ASSEMBLIES

A. Flanges:
   1. General: Flanges shall either be flat flanges or convoluted ring flanges as specified in the following paragraphs.
   2. Flat Flanges: Cast iron flanges shall be faced in accordance with ANSI B16.1. Where companion flanges are used, the flanges on pipe shall be refaced to be flush with the companion flange face. Class 150 and Class 300 forged steel flanges shall be raised face conforming to ANSI B16.5. Lightweight slip-on flanges shall be plain face conforming to AWWA C207, Class B and ANSI B16.5. Unless otherwise specified, steel flanges shall be ANSI B16.5, Class 150 or AWWA C207, Class D. Class E AWWA flanges shall be provided where test pressure exceeds 175 psi. Plain faced flanges shall not be bolted to raised face flanges.
   3. Convoluted Ring Flanges: Convoluted ring flanges shall be ductile iron, forged steel or cast stainless steel, designed to bear on hubs welded to the pipe and shall be as manufactured by Improved Piping Products. The Construction Manager knows of no equal. The flange joints shall be rated for not less than 150 percent of the test pressures listed in Section 40 05 01 and shall conform to the requirements of ANSI B 16.5 and AWWA C207. The flange manufacturer shall be prepared to demonstrate, by certified pressure test that the flanges will meet these requirements.

B. Gaskets:
   1. Gasket material shall be as specified in paragraph 2.03.
   2. Gaskets for plain faced flanges shall be the full face type. Thickness shall be 1/16 inch for pipe 10 inches and less in. Unless otherwise specified, gaskets for raised face flanges shall match the raised face and shall be 1/16 inch thick for pipe 3-1/2 inches and less in diameter and 1/8 inch thick for pipe 4 inches and larger.

C. Bolts:
   1. Flange assembly bolts shall be ANSI B18.2.1 standard square or hexagon head bolts with ANSI B18.2.2 standard hexagon nuts. Threads shall be ANSI Bl.1, standard

coarse thread series; bolts shall be Class 2A, nuts shall be Class 2B. Bolt length shall conform to ANSI B16.5.

2. Unless otherwise specified, bolts shall be carbon steel machined bolts with hot pressed hexagon nuts. Bolts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04 or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.

2.02 MECHANICAL COUPLINGS

A. Sleeve-Type Couplings:

1. Unless otherwise specified, sleeve-type mechanical pipe couplings shall be Smith-Blair Type 411, Dresser Style 38, or equal, with the stop removed from the middle ring. Reducing couplings shall be Smith-Blair Type 415, Dresser Style 62, or equal. Sleeve-type flanged coupling adapters shall be Smith-Blair Type 913, Dresser Style 128, or equal.
2. Bolts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM F593, marking F593F. Nuts for submerged service shall be made of copper-silicon alloy bronze conforming to ASTM B98, alloy C65100, designation H04, or alloy C65500, designation H04. Bolts and nuts for buried service shall be made of noncorrosive high-strength, low-alloy steel having the characteristics specified in ANSI/AWWA C111/A21, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.
3. Gaskets shall be as specified in paragraph 2.03 and AWWA C111.

B. Restrained Plain End Couplings:

1. Restrained Plain end pipe couplings for pipe sizes 6 inches and smaller shall be 304 stainless steel Romac Armor Lock or approved equal. Unless otherwise specified, bolts and nuts shall comply with AWWA C606.
2. Gaskets shall be EPDM as specified in paragraph 2.03 and AWWA C 606

C. Dismantling Joints:

1. Dismantling joints may be used as takedown couplings in accordance with paragraph 3.03. Dismantling joints shall fully restrained double flange fittings consisting of a flange coupling adapter and flanged spool piece that allows for longitudinal adjustment. Thrust restraint shall be provided by means of all threaded rod spanning between flanges and secured to the flanges with a minimum of two flange bolts. Design of equipment connection fittings shall conform to AWWA C219. Sleeves shall be carbon steel or as specified for the specific piping system. Pressure rating of flange adapters shall equal or exceed the pressure rating of mating flanges. All metal portions of equipment connection fittings, with the exception of 316 stainless steel components, shall be coated and lined with fusion bonded epoxy conforming to AWWA C550 and NSF 61. Dismantling joints shall be Romac DJ-400, Smith Blair 975, or Crane-Viking Johnson Dismantling Joint.

D. Sleeve Band Couplings:
   1. Sleeve band couplings for liquid service, unless otherwise noted, shall be Style 232 fully restrained, shouldered high deflection couplings with standard width band. Couplings shall comply with AWWA C-219Sleeve band couplings are acceptable wherever sleeve type couplings are used (paragraph 2.02 Sleeve Type Coupling).

2.03 GASKETS

A. Gaskets designated in Section 40 05 01 shall be as follows:
   1. EPDM: ethylene-propylene-diene-terpolymer.
   2. Neoprene: neoprene.
   3. Nitrile: nitrile (Buna N).
   4. Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder; ASTM F104 (F712400), 2500 psi (ASTM F152), 0.2 ML/HR LEAKAGE FUEL A (ASTM F37).
   5. Compressed gasketing consisting of organic fibers (Kevlar) and SBR binder; ASTM F104 (F712400), 2500 PSI (ASTM F152), 0.1 ml/hr leakage Fuel A (ASTM F37).
   6. Gylon gasketing, Garlock Style 3500, 2000 psi (ASTM F152), 0.22 ml/hr Fuel A (ASTM F37).
   7. Gylon gasketing, Garlock Style 3510, 2000 psi (ASTM F152), 0.04 ml/hr Fuel A (ASTM F37).
   8. Gylon gasketing, Garlock Style 3504, 2000 psi (ASTM F152), 0.12 ml/hr Fuel A (ASTM F37).
   9. TFE: noncreeping tetrafluoroethylene (TFE) with insert filler.
   10. PTFE bonded EPDM: PTFE bonded to EPDM in full-face gasket having concentric-convex molded rings; Garlock Stress Saver 370 or equal.

2.04 THREAD

A. Pipe thread dimensions and size limits shall conform to ANSI BI.20.1.

2.05 DIELECTRIC UNIONS

A. Dielectric unions shall be EPCO, Capitol Manufacturing, or equal.

2.06 COATINGS

A. Unless otherwise specified, flange assemblies and mechanical type couplings for buried installation shall be field coated with System M-1 as specified in Section 09 90 00.

2.07 PRODUCT DATA

A. In accordance with Section 01 33 00, the Contractor shall provide for each welder, a welder qualification certificate indicating the welder is certified for pipe welding in accordance with ASME Boiler and Pressure Vessel, Section IX. Each welder's certificate shall be provided to the Construction Manager prior to that welder working on the job.

PART 3 EXECUTION

3.01 PIPE CUTTING, THREADING AND JOINTING

A. Pipe cutting, threading and jointing shall conform to the requirements of ANSI B31.1.

3.02 PIPE WELDING

A. Pipe shall be welded by ASME-certified welders using shielded metal arc, gas shielded arc or submerged arc welding methods. Welds shall be made in accordance with the requirements of ANSI B31.1 for piping Systems 8, 26, and 28 specified in Section 40 05 01. Welds shall be made in accordance with the requirements of ANSI B31.3 for piping System 20 specified in Section 40 05 01.

B. Welds for piping systems not specified above shall be made in accordance with AWWA C206.

3.03 FLEXIBILITY

A. Unless otherwise specified, piping passing from concrete to earth shall be provided with two pipe couplings or flexible joints as specified on the buried pipe within 2 feet of the structure for 2-inch through 6-inch diameter pipe; within 3 feet of the structure for 8-inch through 24-inch diameter pipe; and within one and one-half pipe diameters of the structure for larger pipe. Where required for resistance to pressure, mechanical couplings shall be restrained in accordance with Chapter 13 of AWWA M11, including Tables 13-4, 13-5 and 13-5A, and Figure 13-20.

END OF SECTION

SECTION 40 05 07

HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies hangers and supports for all exposed piping systems specified in Section 40 05 01. This section does not include pipe supports for fire sprinkler systems or seismic restraints.

B. Scope Of Contractor Design: The Contractor shall provide the services of a "Design Professional" as specified in Section 40 05 01 to conduct all necessary piping and support design for exposed piping.
   1. Whether a design or general arrangement is shown or not, Contractor's Design Professional shall design all pipe supports, anchorage, restraints and expansion control, as specified. Where a conflict arises, Contractor's Design Professional shall present any conflict to Construction Manager for resolution.
   2. The Design Professional's work shall incorporate design criteria and other conditions as specified herein, in related sections and as shown on the drawings.
   3. Additional requirements are specified in related sections.
   4. Bidding: For purposes of bidding supports within Design Professional's Scope of Responsibility, Contractor may use the support and seismic restraint tables presented in Appendix A of this Section and information shown on the Drawings.
      a. Additional supports are required for concentrated loads, changes in direction and disassembly.
      b. Support frequency shall be determined based upon hanger load capacity, with minimum indicated factor of safety specified. Rod hanger support frequency indicated in Table A (Appendix A) shall not be represented as being sufficient to address seismic loads.
      c. Notwithstanding the Mechanical Standard Details and direction as shown on the Drawings, the full scope of supports, specified and shown, including those within the Design Professional's Scope of Responsibility is required work and differences between bid quantities and actual requirements will not be considered as extra work subject to adjustment by change order.

C. Scope Of Work By Design Engineer: Design Engineer has undertaken design details for supports and anchors as specified in Section 40 05 01 1.09. Contractor's Design Professional shall incorporate these features into the Contractor's design.
   1. Where shown, Design Engineer has also provided guidance in the form of general arrangements that may include specific types of supports or anchorage details. In addition, allowable anchor points and load capacities for potential support structures are shown or otherwise described herein.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures

2. Section 01 61 45 – Area Exposure Designations
3. Section 01 66 00 – Product Storage and Handling Requirements
4. Section 01 73 24 – Design Requirements for Non-Structural Components and Non-Building Structures
5. Section 03 30 00 – Cast-in-Place Concrete
6. Section 05 05 20 – Anchor Bolts
7. Section 40 05 01 – Piping Systems
8. Section 40 05 02 – Piping System Schedules
9. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
AISC Manual of Steel Construction	American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design - 9th Ed.
FEDSPEC WW-H-171e-78	Hangers and Supports, Pipe
MFMA-2-91	Metal Framing Standards Publication
MSS SP-69-91	Pipe Hangers and Supports - Selection and Application
MSS SP-58-93	Pipe Hangers and Supports - Materials, Design and Manufacture

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordination required with the design of piping systems, expansion joints, and expansion control and seismic restraints.
   2. Refer to Section 40 05 01 for additional coordination requirements.
   3. Refer to paragraph 1.09 Hanger and Supports Selection and Design for additional coordination requirements.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with addenda updates, and all referenced sections with each paragraph check marked to show specification compliance or marked to show deviations.
   3. Hanger and support locations and components shall be indicated on the piping layout drawings required by Section 40 05 01.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.

2. Design Professional's reports as specified in paragraph 3.05.

1.06 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

B. Refer to paragraph 1.09 Pipe Hanger and Support Selection and Design for additional quality assurance requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01.

1.08 PIPE HANGER AND SUPPORT SELECTION AND DESIGN

A. Hanger And Support Selection:
   1. The Contractor shall cause the pipe hangers and supports to be designed and selected by the Design Professional retained under the provisions of Section 40 05 01. This provision, however, shall not relieve the Contractor of overall responsibility for this portion of the work. Hanger and support selection shall be based on the following:
      a. The Contractor shall select pipe hangers and supports as specified in the project manual. Selections shall be based upon the pipe support classifications specified in MSS-SP 69 and any special requirements which may be specified in the project manual.
      b. The Contractor shall review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the type of support to be used at each hanger point.
      c. Where a particular pipe support arrangement is shown, a design incorporating that arrangement shall be used.
      d. Where a particular pipe support design is shown, that design shall be used.
      e. Pipe supports shall be spaced such that pipe span deflections do not exceed 0.1-inch.
      f. Pipe support design shall incorporate applicable criteria of ASME or other recognized standard.
      g. Hangers and supports shall withstand all static and specified dynamic conditions of loading to which the piping and associated equipment may be subjected. As a minimum, consideration shall be given to the following conditions:
         1) Weights of pipe, valves, fittings, insulating materials, suspended hanger components, and normal fluid contents.
         2) Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid contents are lighter.
         3) Reaction forces due to test and operational conditions.
         4) Reaction forces due to the operation of safety, relief, or other valves.
         5) Wind, snow or ice loadings on outdoor piping.

6) Supports shall be designed to prevent transfer of the weight of piping, valves and piping appurtenances to equipment piping connections. All supports adjacent at equipment connections to piping systems shall have provisions for vertical and horizontal adjustment. Two flexible piping connections not less than one pipe diameter apart shall be provided between piping supports and any equipment piping connection.

h. Hangers and supports shall be sized to fit the outside diameter of pipe, tubing, or, where specified, the outside diameter of insulation.

i. Where negligible movement occurs at hanger locations, rod hangers shall be used for suspended lines, wherever practical. For piping supported from below, bases, brackets or structural cross members shall be used.

j. Hangers for the suspension of size 2 1/2 inches and larger pipe and tubing shall be capable of vertical hanger component adjustment under load.

k. The supporting systems shall provide for and control the free or intended movement of the piping including its movement in relation to that of connected equipment.

l. Where there is horizontal movement at a suspended type hanger location, hanger components shall be selected to allow for swing. The vertical angle of the hanger rod shall not, at any time, exceed 4 degrees.

m. There shall be no contact between a pipe and hanger or support component of dissimilar metals. Prevent contact between dissimilar metals when supporting copper tubing by use of copper-plated, rubber, plastic or vinyl coated, or stainless steel hanger and support components.

n. Stock hanger and support components shall be used wherever practical.

o. Fiberglass framing channel shall be provided where specified.

B. The following structural criteria shall also be applied:

1. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.
2. Unless otherwise specified, pipe support components shall not be attached to pressure vessels.
3. Where critical support load requirements have been identified, limiting structural load requirements are shown.
4. Pipe support hangers, brackets etc. shall be of suitable capacity and shall be appropriate to the individual structural member that is used to support the pipe.
5. The structural integrity of existing and new members shall in no way be impacted by the placement of connections for pipe supports. For example, the tension reinforcement in reinforced concrete members shall not be impacted in any way by the placement of fasteners for pipe supports.
6. Spacing and arrangement of hangers supporting pipe shall be provided in such a manner that the loads from the pipes on existing and new structural members shall be quasi-uniform. These quasi-uniform loads shall not exceed the allowable design loads for mechanical equipment as shown on existing (not necessarily contract) drawings and as listed under Design Live Loads in the General Notes.
7. For new construction, unless otherwise shown, pipe may be supported from nearest structural element (floor, ceiling, or wall). The Design Loads for mechanical equipment, as listed in the General Notes sheet of the Structural drawings shall not be exceeded.

8. The loads and specific attachment requirements for pipe supports on new concrete Tees shall be coordinated with the Tee manufacturer and incorporated into the design of the Tees.
9. Unless otherwise specified, pipe supports from existing Tees or other roof types shall not be constructed without an evaluation of capacity and appropriate design from Contractor's Design Professional.

C. The following, project-specific criterion shall also be applied:
1. The spacing for pipe hangers shall not be less than 5 feet and shall not exceed 375 lbs of load for all existing pre-cast, Double Tee roof elements. For hangers off flanges of existing Tees, a washer shall be provided having minimum dimensions of 1/4 inch thick by 4 inch long and 4 inch wide. The design and projection of those hangers above the roof shall be coordinated with the architectural roofing system.

PART 2 PRODUCTS

2.01 PERFORMANCE/ DESIGN CRITERIA

A. Service Conditions:
1. The hangers and supports specified in this section are provided to resist pipe loads occurring primarily in the downward (gravity) direction. For the purpose of pipe hanger and support selection, this section establishes pipe support classifications based on the operating temperatures of the piping contents. Pipe support classifications are as follows:
a. Ambient Systems
1) B. 60 degrees F to 119 degrees F

2.02 MATERIALS

A. Standard pipe supports and components shall be manufactured by B-Line, Carpenter & Patterson, Kin-Line, Grinnell, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or equal. Pipe support components shall conform to the requirements of MSS SP-69 and FEDSPEC WW-H-171e.

B. Pipe support materials shall conform to the requirements of MSS SP-58. Metal framing system components shall conform to the metal framing manufacturers' Association Standard MFMA-2.

2.03 CONFIGURATION, COMPONENTS, FEATURES

A. General:
1. Unless otherwise specified, pipe hangers and supports, structural attachments, fittings and accessories shall be hot-dip or mechanically galvanized after fabrication. Nuts, bolts and washers may be zinc-plated except for those subject to moisture or corrosive atmosphere, as specified in Section 26 05 00-1.05 Corrosive Areas as shown on the drawings, which shall be type FRP or 304 stainless steel.

B. Pipe Hangers And Supports:
   1. Pipe hangers and supports of dissimilar metals than pipe shall be insulated. Pipe hangers and supports shall support pipe in the manner recommended by the pipe manufacturer and/or applicable building or piping codes.

C. Rack And Trapeze Supports:
   1. Unless otherwise specified, trapeze and pipe rack components shall have a minimum steel thickness of 12 gage, with a maximum deflection 1/240 of the span.

D. Structural Attachments:
   1. Type A - Malleable Iron Concrete Insert: Concrete inserts shall be malleable iron and comply with MSS and FEDSPEC Type 18. Grinnell Fig. 282, Carpenter & Patterson Fig. 108, or equal.
   2. Type B - Side Beam Bracket: Bracket shall be malleable iron and comply with MSS Type 34 and FEDSPEC Type 35. Grinnell Fig. 202, B-Line B3062, or equal.
   3. Type C - Malleable Beam Clamp With Extension Piece: Clamp and extension piece shall be malleable iron, tie rod shall be steel. Beam clamp shall comply with MSS and FEDSPEC Type 30. Grinnell Fig. 218 with Fig. 157 extension piece, B-Line B3054, or equal.
   4. Type D - Steel Beam Clamp With Eye Nut: Beam clamp and eye nut shall be forged steel. Configuration and components shall comply with MSS and FEDSPEC Type 28. Grinnell Fig. 292, Carpenter & Patterson Fig. 297, or equal.
   5. Type E - Framing Channel Post Base: Post bases shall be carbon steel, of standard design manufactured by framing channel manufacturer. Single channel: Unistrut P2072A, B-Line B280, or equal. Double channel: Unistrut P2073A, B-Line B281, or equal.
   6. Type F - Welded Beam Attachment: Beam attachment shall be carbon steel and comply with MSS and FEDSPEC Type 22. B-Line B3083, Grinnell Fig. 66, or equal.
   7. Type G - Welded Steel Bracket: Bracket shall be carbon steel and comply with MSS Type 32 and FEDSPEC Type 33 for medium welded bracket. Heavy welded bracket shall comply with MSS Type 33 and FEDSPEC Type 34.
   8. Type H - Cast Iron Bracket: Bracket shall be cast iron, Carpenter & Patterson Fig. 340, or equal.
   9. Type J - Adjustable Beam Attachment: Beam attachment shall be carbon steel, Carpenter & Patterson Fig. 151, B-Line B3082, or equal.
   10. Type K - Double Channel Bracket: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel. Cantilever bracket shall be a carbon steel double framing channel assembly, Unistrut P2542 through P2546, B-Line B297-12 through B297-36, or equal.
   11. Type L - Single Channel Bracket: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel. Cantilever bracket shall be a carbon steel single framing channel assembly, Unistrut P2231 through P2234, B-Line B198-6, B198-12, B196-18 and B196-24, or equal.
   12. Type M - Wall Mounted Channel: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel.
   13. Type N - Pipe Stanchion Floor Attachment: Baseplate shall be carbon steel with 1/2 inch minimum thickness. Anchor bolt holes shall be 1/16 inch larger than the anchor

bolt diameter. The space between the baseplate and the floor shall be filled with nonshrink grout.

14. Type Q - Continuous Concrete Inserts: shall be 1 5/8 by 1 3/8 Channel, cold formed 12 Ga. steel conforming to ASTM A 1001, stainless steel GR 33 or ASTM GR 33 A., hot dip galvanized conforming to ASTM A123 or A153, UNISTRUT P3200 Series, or approved equal.

E. Accessories:

1. Hanger Rods: Rods shall be carbon steel, threaded on both ends or continuous threaded and sized as specified.
2. Weldless Eye Nut: Eye nut shall be forged steel and shall comply with MSS and FEDSPEC Type 17. Eye nut shall be Grinnell Fig. 290, B-Line B3200, or equal.
3. Welded Eye Rod: Eye rod shall be carbon steel with eye welded closed. Inside diameter of eye shall accommodate a bolt diameter 1/8 inch larger than the rod diameter. Eye rod shall be Grinnell Fig. 278, B-Line B3211, or equal.
4. Turnbuckle: Turnbuckle shall be forged steel and shall comply with MSS and FEDSPEC Type 13. Turnbuckle shall be Grinnell Fig. 230, B-Line B3202, or equal.
5. Framing Channel: Framing channel shall be 1 5/8 inches square, roll formed, 12-gage carbon steel. Channel shall have a continuous slot along one side with in-turned clamping ridges. Single channel: Unistrut P1000, B-Line B22, or equal. Double channel: Unistrut P1001, B-Line B22A, or equal. Triple channel: Unistrut P1004A, B-Line B22X, or equal.

PART 3 EXECUTION

3.01 HANGER AND SUPPORT LOCATIONS

A. Locate hangers and supports as near as possible to concentrated loads such as valves, flanges, etc. Locate hangers, supports and accessories within the maximum span lengths specified in the project manual to support continuous pipeline runs unaffected by concentrated loads.

B. Locate at least one hanger or support within 2 feet from a pipe change in direction.

C. Locate hangers and supports to ensure that connections to equipment, tanks, etc., are substantially free from loads transmitted by the piping.

D. Where piping is connected to equipment, a valve, piping assembly, etc., that will require removal for maintenance, support the piping in such a manner that temporary supports shall not be necessary for this procedure.

E. Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.

3.02 INSTALLATION

A. Weld and bolt attachments to the building structural steel shall be in accordance with the requirements of the AISC Manual of Steel Construction. Unless otherwise specified, there shall be no drilling or burning of holes in the building structural steel.

B. Hanger components shall not be used for purposes other than for which they were designed. They shall not be used for rigging and erection purposes.

C. Install items to be embedded before concrete is poured. Fasten embedded items securely to prevent movement when concrete is poured.

D. Embedded anchor bolts shall be used instead of concrete inserts for support installations in areas below water surface or normally subject to submerging.

E. Install thermal pipe hanger shields on insulated piping at required locations during hanger and support installation. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

F. Hanger and support components in contact with plastic pipe shall be free of burrs and sharp edges.

G. Rollers shall roll freely without binding.

H. Finished floor beneath Type N structural attachments and framing channel post bases shall be roughed prior to grouting. Grout between base plate and floor shall be free of voids and foreign material.

I. Baseplates shall be cut and drilled to specified dimensions prior to welding stanchions or other attachments and prior to setting anchor bolts.

J. Plastic or rubber end caps shall be provided at the exposed ends of all framing channels that are located up to 7 feet above the floor.

3.03 ADJUSTMENTS

A. Adjust hangers and supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used. Stanchions shall be adjusted prior to grouting their baseplates.

3.04 ANCHOR BOLTS

A. Anchor bolts in new concrete shall be cast in place. Refer to Section 05 05 20.

3.05 INSPECTION AND CERTIFICATION

A. The Design Professional retained by the Contractor under the provisions of Section 40 05 01 shall inspect the pipe hangers, support and restraint systems at not less than bi-weekly intervals during construction and furnish the Construction Manager with monthly reports. The Design Professional shall inspect the completed pipe hanger, support and restraint system before the Owner assumes beneficial occupancy and provide written certification, without any qualification statements, that the installation conforms to the design professional’s design and the Contract Document requirements as may be described in other Sections or on the drawings. All reports shall bear the Design Professional's seal and signature in accordance with the laws, rules and regulations of the state.

APPENDIX A: PIPE HANGERS AND SUPPORTS TABLES

TABLE A - SUPPORT SPACING AND ALLOWABLE ROD LOADS

NOMINAL PIPE SIZE (INCHES)	SUPPORT ROD SIZE AND MAXIMUM LOAD PER ROD - SEE NOTES 1 AND 2		MAXIMUM SUPPORT SPACING (FEET)				
	ROD SIZE (INCHES)	MAX LOAD (POUNDS)	STEEL	COPPER	PLASTIC SEE NOTE 4	CAST IRON SEE NOTE 5
3/8 TO 3/4	3/8	610	5	5	CONTINUOUS	---
1	3/8	610	5	5	5	---
1-1/4	3/8	610	5	5	5	---
1-1/2	3/8	610	5	5	5	---
2	3/8	610	10	5	5	
2-1/2	3/8	610	10	10	5	
3	3/8	610	10	20	5	
4	1/2	1130	10	20	5	
6	5/8	1810	15	20	5	
8	3/4	2710	15	20	5	
10	3/4	2710	20	---	5	
12	1	4960	20	---	10	
14	1	4960	20	---	---	
16	1	4960	20	---	---	
18	1	4960	20	---	---	
20	1-1/4	8000	20	---	---	
24	1-1/4	8000	20	---	---	
30	1-1/2	11630	20	---	---	

12 FEET FOR PRESSURE PIPE
10 FEET FOR SOIL PIPE

TABLE A NOTES:

1. DESIGN WEIGHT SHALL BE TWICE THE WEIGHT OF THE PIPE FULL OF WATER PLUS THE WEIGHTS OF VALVES, FITTINGS, INSULATING MATERIALS AND SUSPENDED HANGER COMPONENTS ON THE RUN OF PIPE BEING SUPPORTED.
2. ROD SIZES SHOWN ARE FOR THE SUPPORT OF A SINGLE PIPE. WHEN SUPPORTING MORE THAN ONE PIPE, ROD SHALL BE SIZED USING DESIGN WEIGHTS (SEE NOTE 1) TO DETERMINE THE TOTAL DESIGN LOAD. THE TOTAL DESIGN LOAD SHALL NOT EXCEED THE MAXIMUM LOADS IN THE TABLE ABOVE.
3. PIPE SHALL NOT HAVE POCKETS FORMED IN THE SPAN DUE TO SAGGING OF THE PIPE BETWEEN SUPPORTS CAUSED BY THE WEIGHT OF THE PIPE, MEDIUM IN THE PIPE, INSULATION, VALVES AND FITTINGS.
4. SPAN SHOWN IS FOR SCHEDULE 80 PVC PIPE AT 100°F. SPANS FOR OTHER PLASTICS, OTHER PVC PIPE SCHEDULES AND PIPES AT HIGHER TEMPERATURES SHALL BE SHORT- ENED IN ACCORDANCE WITH THE PIPE MANUFACTURER'S RECOMMENDATIONS. "CONTINUOUS" MEANS PIPE SHALL BE IN UNISTRUT OR SIMILAR CHANNEL.
5. PROVIDE A MINIMUM OF ONE HANGER PER PIPE LENGTH, WITHIN 4-INCHES OF THE BELL.
6. PIPE HANGER AND SUPPORT SELECTION SHALL BE IN ACCORDANCE WITH TABLE B (M2302) AND SPECIFICATION SECTION 15096.

TABLE B HANGER AND SUPPORT SELECTIONS

SYSTEM TEMP RANGE DEG F	INSULATION NOTE 1	PIPE ATTACHMENTS								BUILDING STRUCTURAL ATTACHMENTS			
		HORIZONTAL							VERTICAL	STEEL AND/OR MALL. IRON			
		STEEL STRAPS	STEEL BANDS	STEEL CLAMPS	CAST IRON HANGING ROLLS	CAST IRON SUPPORTING ROLLS	STEEL TRAPEZES AND RACKS	THERMAL HANGER SHIELDS	STEEL OR CAST IRON STANCHIONS	STEEL RISER CLAMPS	INSERTS	BEAM CLAMPS	WELDED AND BOLTED ATTACHMENTS	BRACKETS
HOT A-1 120 TO 450	COVERED	13	1, 2	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	6, 7 13	1, 2	3	4, 5	8	20, 21	NONE	10					
HOT A-2 451 TO 750	COVERED	13	1	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	NONE	NONE	3	NONE	NONE	20, 21	NONE	NONE					
HOT A-3 OVER 750	COVERED	13	1	3 (ALLOY)	4, 5	8	20, 21	SEE SPEC	10	11, 12	NONE	C, D	F, J, M	B, G, H, K, L
	BARE	13	NONE	3 (ALLOY)	NONE	NONE	20, 21	NONE	NONE					
AMBIENT B 60 TO 119	COVERED	13	1, 2	3	4, 5	8	20, 21	SEE SPEC	9,10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	6, 7 13	1, 2	3	4, 5	8	20, 21	NONE	9,10					
COLD C-1 33 TO 59	COVERED	13	1, 2, 3	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	6, 7 13	1, 2, 3	3	4, 5	8	20, 21	NONE	10					
COLD C-2 -2 TO 32	COVERED	13	1, 2, 3	3	4, 5	8	20, 21	SEE SPEC	10	11, 12	A	C, D	F, J, M	B, G, H, K, L
	BARE	NONE	1, 2, 3	3	4, 5	8	20, 21	NONE	10					

TABLE B NOTES:

1. HANGERS ON INSULATED SYSTEMS SHALL INCORPORATE THERMAL HANGER SHIELDS.
2. HANGER AND SUPPORT SPACING SHALL BE IN ACCORDANCE WITH TABLE A (M2301).

TABLE C
SEISMIC RESTRAINT SPACING

NOM. PIPE SIZE	MAXIMUM SPAN BETWEEN BRACES		BRACE TYPE	MAXIMUM BRACE LENGTH
	LATERAL BRACE (FEET)	LONGITUDINAL BRACE (FEET)		
2	40	80	A1	9'-4"
2-1/2	40	80	A1	9'-4"
3	40	80	A1	9'-4"
4	40	80	A1	9'-4"
6	40	80	A1	9'-4"
8	40	40	A1	9'-4"
10	40	40	A1	9'-4"
12	40	40	A2	10'-0"
14	30	30	A2	10'-0"
16	25	25	A2	10'-0"
18	20	20	A2	10'-0"
20	16	16	A2	10'-0"
24	10	10	A2	10'-0"

(S) - STANDARD WALL

END OF SECTION

SECTION 40 05 19

DUCTILE IRON PIPE

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies ductile iron pipe and fittings.

1.02 RELATED SECTIONS

A. Section 01 33 00 – Submittal Procedures

B. Section 01 66 00 – Product Storage and Handling Requirements

C. Section 40 05 01 – Piping Systems

D. Section 40 05 02 – Piping System Schedules

E. Section 40 05 06 – Specialty Couplings and Adaptor for Process Piping

F. Section 40 05 06.16 – Piping Connections

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, and 250
ASME B16.5	Pipe Flanges and Flanged Fittings
ASTM C150	Portland Cement
ASTM A716	Standard Specification for Ductile Iron Culvert Pipe
AWWA C104	Cement-Mortar Lining for Ductile- Iron and Gray-Iron Pipe
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings
AWWA C111	Rubber-Gasket Joints for Ductile- Iron and Gray-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges
AWWA C116	Protective Fusion-Bonded-Epoxy Coating for the Interior and Exterior Surfaces for Ductile-Iron and Gray-Iron Fittings.
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast
AWWA C153	Ductile-Iron Compact Fittings
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances.
AWWA C606	Grooved and Shouldered Type Joints
ISO 8179-1	Ductile Iron Pipes – Externa Zinc-based Coating - Part 1: Metallic Zinc with Finishing Layer

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager is the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Manufacturer's product data, catalog cuts, dimensions and materials. Indicate each Piping System Schedule where the product will be used.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Certifications indicated in the following documents:
      a. ASTM A716, sworn statement of inspection and certification.
      b. AWWA C110, certification of inspection and testing.
      c. AWWA C111, record of specified tests.
      d. AWWA C115, affidavit of compliance.
      e. AWWA C151, manufacturer's statement and affidavit of compliance.
      f. AWWA C606, affidavit of compliance.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00 for shipment and storage.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe system materials to be new, free from defects and conforming to the requirements and standards identified in Section 40 05 02 and related sections.

B. Pipe.
   1. Provide increased wall thickness where specified on the Drawings.

2.02 PIPE LINING

A. Provide pipe and fittings with lining as specified in Piping System Schedules in Section 40 05 02.00 through 40 05 02.99. Requirements for each lining type are specified in this Section.
   1. Cement Mortar Lining.
      a. Factory applied.
      b. Line pipe and fittings with cement mortar as specified in AWWA C104.
      c. Cement shall be ASTM C150, Type II or V, low alkali, containing less than 0.60 percent alkalis
      d. Patch field welds, cuts, connections, and damaged lining in accordance with AWWA C104.

2.03 PIPE COATING

A. Provide pipe with coating as specified in Piping System Specification Sheets in Section 40 05 02. Requirements for each coating type are specified in this Section.
   1. V-Bio Enhanced Polyethylene Encasement
      a. Field installed
      b. Encase pipe and fittings in polyethylene tubing as specified in AWWA C105.
      c. Three layer, co-extruded, linear low density polyethylene wrap.
      d. 8 mils minimum wrap thickness
      e. Inner surface of polyethylene wrap infused with anti-microbial biocide and corrosion inhibitor.
      f. Candidate Manufacturers:
         1) V-Bio
         2) Approved Equal
   2. Epoxy Primer.
      a. Factory or shop applied.
      b. Coat pipe and fittings with Amide or Polyamide cured epoxy, 4 to 6 mils DFT

2.04 FUSION-BONDED EPOXY LINING AND COATING FOR FITTINGS

A. Factory or shop applied.

B. Fusion Bonded Epoxy lining and coating per AWWA C116.

2.05 JOINTS, AND COUPLINGS

A. Mechanical Joints (MJ) and Restrained Mechanical Joints (RMJ) per section 40 05 06 and 40 05 06.16

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Follow piping routes specified on the drawings as closely as possible. Submit proposed deviations in accordance with Section 01 33 00.
   2. Install pipe in accordance with AWWA C600.
   3. Make connections to existing structures and manholes so that the finished work will conform as nearly as practicable to the requirements specified for new manholes, including necessary concrete work, cutting and shaping. Shape concrete mortar within any structure and manhole as specified.

B. Insulating Sections: Where a metallic nonferrous pipe/appurtenance connects to ferrous pipe/appurtenance, provide an insulating section per Section 40 05 06.16.

C. Anchorage: Provide as specified on the Drawings.

3.02 REPAIR/RESTORATION

A. Per Section 40 05 01.

3.03 COMPONENT TEST PHASE

A. Buried Piping: Test hydrostatic pressure in accordance with Section 5 of AWWA C600, using the test pressures and allowable leakage specified in Section 40 05 01.

B. Exposed and Concrete Encased Piping: Conduct hydrostatic pressure tests in accordance with Section 40 05 01.

3.04 POLYETHYLENE ENCASEMENT

A. Install polyethylene as specified in AWWA C105 and within this Section.

B. Potable Water Pipe: Single wrap, 4-mil high density polyethylene.

C. Wrapping:
   1. Wrap buried pipe, fittings, valves, and couplings.
   2. Prior to the placing of concrete, wrap fittings that require concrete backing.
   3. Wrap the polyethylene tube seams and overlaps and hold in place by means of a 2-inch-wide plastic backed adhesive tape.
   4. The tape shall be such that the adhesive shall bond securely to both metal surfaces and polyethylene film.
   5. Bedding and initial backfill for polyethylene wrapped pipe shall be a well-graded granular material to avoid cutting or damaging the polyethylene tube during placement and backfilling.

END OF SECTION

SECTION 40 05 23

STAINLESS STEEL PROCESS PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies stainless steel pipe and fittings.

1.02 RELATED SECTIONS

A. Section 40 05 01 – Piping Systems

B. Section 40 05 02 –Piping System Schedules

1.03 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B31.3	Process Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Requirements
ASTM A480	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
AWWA M11	Steel Pipe-A Guide for Design and Installation
AWWA C227	Bolted, Split-Sleeve Restrained and Non-Restrained Couplings for Plain-End Pipe
AWWA C606	Grooved and Shouldered Joints
CSA W48.3	Low Alloy Steel Covered Electrodes for Shielded Metal Arc Welding

1.04 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.

2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The CITY shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. Piping layout drawings as specified in Section 40 05 01.
4. Manufacturers' product data, catalog cuts, typical installation details, and dimensions. Indicate on the submittal each piping system where the product will be used.
5. Pipe wall thickness calculations for pipe fabricated per AWWA C220. Demonstrate the maximum permissible internal design pressure in the pipe based on the wall/shell thickness specified in the Piping System Schedule for the associated Process Service and pipe size and the support and/or bedding conditions specified on the Drawings. Steel pipe design calculations conform to AWWA M11.
6. Pipe wall thickness and reinforcement calculations for fittings fabricated per AWWA C226. Demonstrate that the maximum permissible internal design pressure for fabricated fittings matches or exceeds the maximum permissible internal design pressure in the connecting pipe for the support and/or bedding conditions specified on the Drawings. Fabricated steel pipe fitting design calculations conform to AWWA M11.
7. Calculations for any pipe and fittings that are not fabricated per one of the components standards listed in the specified ASME B31 code.
8. Submit calculations for engineered flange face rings in accordance with Appendix D of ASME Section VIII Division 1.

B. Informational Submittals:
1. Procedures: Section 01 33 00.
2. Manufacturers' certificates of compliance with specified industry standards.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00 for Shipment and Storage.

B. Deliver pipe and fittings with end protectors in place. Do not remove protectors until materials are about to be installed.

C. Prevent carbon steel contamination of stainless steel pipe and fittings during storage, handling, fabrication, and installation.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe system materials to be new, free from defects and conforming to the requirements and standards specified in Piping System Schedules (Section 40 05 02.00 through Section 40 05 02.99) and this Section.

B. Pipe.
   1. Use pickled and annealed sheet or plate for manufacture of fabricated stainless steel pipe.
   2. Finish.
      a. 8-gage through 16-gage material: No. 1 or 2B per ASTM A480.
      b. 3/16-inch and heavier plate material: No. 1 mill finish per ASTM A480, "Hot-Rolled or Cold-Rolled, and Annealed or Heat Treated, and Blast Cleaned or Pickled."

C. Shop-fabricated stainless steel pipe and fittings.
   1. Furnished by a single manufacturer who is experienced and qualified in the manufacture and fabrication of the items to be provided.
   2. Manufacture using Weld Procedure Specifications (WPS) that have been qualified under ASME Section IX. Document qualifications in Procedure Qualification Reports (PQR). Use only certified welders who have successfully completed performance qualification tests per ASME Section IX for manufacture of stainless steel pipe.

D. Stub ends.
   1. Wall thickness equal to or greater than pipe or fitting to which it is welded.
   2. Lap face/gasket mating surfaces clean, free of debris, with welds ground flush and surface roughness between 3.18 and 12.7 microns RMS.

E. Fittings.
   1. Double ferrule compression fittings capable of holding the full bursting pressure of connected tubing.
   2. Candidate manufacturers for double ferrule compression fittings.
      a. Swagelok.
      b. Gyrolok.
      c. Approved Equal.
   3. Provide straight tapered reducers. Flanged & flued reducers and bushing type adapters are not permitted.
   4. Pressure rating and thickness of elbows, tees, crosses, and wyes equal to or greater than connecting pipe.

2.02 SHOP FABRICATION

A. Metal forming processes.
   1. Use pinch rolls with a hard chrome finish to form cylinders. Thoroughly clean the rolls using Avesta BlueOneTM 130 Pickling Paste or approved equal, prior to roll forming

the pipe. Alternatively, provide a protective barrier between the stainless steel plate/sheet and the plate rolls during the forming process.

2. Provide a protective barrier between pipe welding rollers and the stainless steel pipe cylinder. Alternately, new rollers or rollers that have been turned down on a lathe to provide a new and clean working face may be used.

B. All saws, drills, files, wire brushes, grinding wheels, etc. will be free of carbon contamination and designated for stainless steel use only.

C. Provide nonferrous, stainless steel, or rubber-lined pipe storage and fabrication racks.

D. Use nylon slings or straps for handling stainless steel piping.

E. Preparation of surfaces to be welded.
   1. Surfaces of joints to be welded are to be free from mill scale, slag, grease, oil, paint, rust, and other foreign material.
   2. Use only stainless wire wheels and grinding wheels that have not come into contact with carbon steel.
   3. Flame cutting or any use of oxy-acetylene gas cutting tools is prohibited. Use plasma arc torch with a nitrogen or argon-hydrogen carrier gas, laser or waterjet processes for cutting and plate beveling.
   4. Air arc and gas backgouging are prohibited. Use grinding and plasma gouging methods to achieve full penetration welds.

F. Welding.
   1. Welding and production processes are to conform to ASME B31.3.
   2. Use of Solar Flux is prohibited.
   3. Use of FCAW welding is prohibited.
   4. Pipe and fittings with wall thickness up to 11-gage (1/8-inch): weld using the GTAW process.
   5. Pipe and fittings with wall thicknesses greater than 1/4-inch may be welded using an automated SAW process.
   6. Pipe and fittings with wall thickness greater than 11-gage (1/8-inch): Bevel and complete root pass using the GTAW process, followed by subsequent passes with the GTAW, GMAW, or Metallic Arc SMAW process.
   7. Filler material:
      a. Add only ELC wire grades to provide a cross section at the weld equal to or greater than the parent metal.
      b. SMAW electrodes to conform to CSA W48.3.
   8. Make weld deposit smooth and evenly distributed and with a crown of no more than 1/16-inch on the I.D. and 3/32-inch on the O.D. of the piping. Concavity, undercut, cracks, or crevices are not permitted.
   9. Full penetration butt welds: provide inert gas shielding to the interior and exterior of the joint.
   10. Lap joints: provide full thickness seal welds on both joints.

G. Remove excessive weld deposits, slag, spatter, and projections by grinding. Grind welds smooth on gasket surfaces. Tack welds, clips, and other attachments.

1. Repair nicks, gouges, notches, and depressions in the base metal in the area before the joint weld is made.
2. Remove tack welds, clips, and other attachments and repair defects, except where the tack welds occur within the weld area and these tack welds do not exceed the size of the completed weld. Remove cracked tack welds.
3. Grind those areas to be repaired down to clean metal and then repair by building up with weld metal. Grind the repaired areas smooth to form a plane surface with the base metal.

H. Defects and repairs.
1. Remove welds with cracks, slag inclusions, porosity, undercutting, incomplete penetration, or which are otherwise deficient in quality or made contrary to any provisions of these specifications, by chipping or grinding throughout their depth to clean base metal.
2. Do not perform calking or peening of welds to correct defects.
3. Enlarge welds found deficient in dimension but not in quality by additional welding after thoroughly cleaning the surface of previously deposited metal and the adjoining plate.
4. Remove weld deposits, slag, weld spatter, and projections into the interior of the pipe by grinding.

I. Finish.
1. Treat all welded joints with Avesta BlueOne™ 130 Pickling Paste or approved equal and rinse with clean water.
2. If rusting of embedded iron occurs, pickle the affected surface with Avesta BlueOne™ 130 Pickling Paste or approved equal.
3. Rinse clean using Avesta FinishOne Passivator 630 or approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. Field Installation Weather conditions.
1. Perform welding only when the surfaces are clean and completely free of any moisture or mineral deposits. Protect pipe and fittings from salt water spray or deposition or clean and protect pipe and fitting joints prior to welding.
2. Do not weld the pipe during periods of high winds or rain unless the areas being welded are properly shielded.

B. Field welding.
1. Use couplings and prefabrication of pipe systems at the factory to minimize field welding to the greatest extent possible. Pipe butt welds may be performed at the job site, providing the butt welds are performed only with an inert gas shielded process and that the welding requirements of this Section are rigidly adhered to.
2. On the interior and exterior of the pipe, remove all residue, oxide, and heat stain from any type of field weld and the affected areas adjacent by the use of stainless steel wire brushes, followed by cleaning with an agent such as Avesta BlueOne™ 130 or approved equal, followed by complete removal of the agent.

C. Use wooden scaffolding and/or ladders if possible to gain access to work areas. If metal scaffolding and/or ladders must be used, tape or otherwise shield the contact points between scaffolding/ladders and the stainless steel.

D. After installation, wash and rinse all foreign matter from the piping surface. Adhere to the passivation manufacturer's recommendations and local regulations for safety and disposal of any waste chemicals.

3.02 REPAIR/RESTORATION

A. Per Section 40 05 01 and as specified herein.

B. Paint all steel or iron flanges, couplings, and appurtenances in accordance with Section 09 90 00. Painting of the stainless steel pipe is not required.

C. Restore areas damaged or discolored by field welding or handling, iron contamination or soiled to a uniform surface finish and consistently clean surface with methods specified for shop fabrication.

D. Identifying spool piece marks shall be removed with paint thinner or solvents and the entire stainless steel surface shall be washed with detergent and hot water and rinsed clean.

3.03 COMPONENT TEST PHASE

A. Per Section 40 05 01.

END OF SECTION

SECTION 40 05 24

STEEL PROCESS PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies steel pipe and fittings.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI B16.3	Malleable Iron Threaded Fittings, Class 150 and 300
ANSI B16.9	Factory-Made Wrought Steel Buttwelding Fittings
ANSI B16.11	Forged Steel Fittings, Socket-Welding and Threaded
ASTM A36/A36M	Structural Steel
ASTM A47	Ferritic Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106 REV A	Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A283/A283M REV A	Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars
ASTM A536	Ductile Iron Castings
ASTM A570/A570M	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
ASTM A572/A572M REV B	High Strength Low Alloy Columbium-Vanadium Steels of Structural Quality
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe--4 In. and Larger-- Shop Applied

Reference	Title
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services--Sizes 4 In. Through 144 In.
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA M11	Steel Pipe--A Guide for Design and Installation
SSPC-SP10	Near-White Blast Cleaning

B. Testing:
   1. Factory testing shall conform to the requirements of ASTM A53, ASTM A106, or AWWA C200 as applicable.

PART 2 PRODUCTS

2.01 PIPE MATERIALS

A. Steel pipe and fittings shall be provided in accordance with ASTM A53, ASTM A106, or AWWA C200 as specified in Section 40 05 01.

B. Steel for pipe fabricated to meet requirements of AWWA C200 shall conform to the requirements of ASTM A36, ASTM A572, Grade 42, ASTM A570, Grades 33 and 36, or ASTM A283, Grade D. Steel for ASTM A53 and ASTM A106 pipe shall be Grade B.

2.02 PIPE MANUFACTURE

A. Unless otherwise specified, ASTM A53 pipe shall be Type E, electric resistance welded or Type S, seamless pipe as specified in Section 40 05 01. The minimum wall thickness for ASTM A53 or ASTM A106 pipe shall be Schedule 40 for pipe 10 inch diameter and less.

B. AWWA C200 pipe shall be straight or spiral seam. The minimum wall thickness shall be 7 gage for pipe 6 inch through 24 inch diameter.

2.03 CONNECTIONS

A. Connections shall be as specified in Section 40 05 01 and shall conform to Section 40 05 06.89. Coating for buried connections shall be as specified in Section 40 05 06.89.

2.04 FITTINGS AND APPURTENANCES

A. Malleable iron threaded fittings and appurtenances shall conform to the requirements of ASTM A47 or ASTM A197, ANSI B16.3.

B. Unless otherwise specified, steel fittings and appurtenances shall conform to the requirements of ASTM A234, ASTM A105, or ANSI B16.11; and fabricated steel fittings and appurtenances shall conform to AWWA C208.

C. Cast fittings shall be cast of ductile iron conforming to ASTM A536 or malleable iron conforming to ASTM A47. Standard steel fittings, including large size elbows, shall be forged steel conforming to ASTM A106. Standard segmentally welded fittings shall be fabricated of Schedule 40 carbon steel pipe.

D. Unless otherwise specified, all fittings shall be rated for pressure and loadings equal to the pipe.

2.05 PIPE COATING

A. Polyethylene Tape:
   1. Where specified, pipe and fittings shall be coated and wrapped with prefabricated multilayer cold applied polyethylene tape coating in accordance with AWWA C214. The coating application shall be a continuous step operation in conformance with AWWA C214, Section 3. The total coating thickness shall be not less than 50 mils for pipe 24 inches and smaller and not less than 80 mils for pipe 26 inches and larger.

2.06 JOINT GASKETS

A. Joint gaskets shall be as specified in Section 40 05 01 and 40 05 02.89.

2.07 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Affidavits of Compliance with AWWA C200, ASTM A53, or ASTM A106 as applicable.
   2. Contractor's layout drawings as specified in Section 40 05 01-2.04.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Pipe shall be installed in accordance with AWWA M11, Chapter 16. Welded joints shall be in accordance with AWWA C206.
   2. Sleeve-type mechanical pipe couplings shall be provided in accordance with AWWA M11 and Section 40 05 06.
   3. Pipe coatings at field joints shall be applied as specified in paragraphs 2.05.
   4. Unless otherwise specified, buried mechanical couplings and valves shall be field coated as specified in Section 40 05 06.

B. Anchorage:
   1. Anchorage shall be provided as specified. Calculations and drawings for proposed alternative anchorage shall be submitted in accordance with Section 01 33 00.

3.02 TESTING

A. Per Section 40 05 01.

END OF SECTION

SECTION 40 05 31.13

PVC AND CPVC DUCT

PART 1 PART 1 GENERAL

1.01 SUMMARY

A. Scope

1. This Section specifies Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) duct and fittings with solvent cement welded or threaded connections/joints.

B. Definitions

1. Terminology used in this Section conforms to the following definitions
   a. PVC: Polyvinylchloride
   b. CPVC: Chlorinated Polyvinylchloride

1.02 QUALITY ASSURANCE

A. Reference Codes and Standards

1. This Section contains references to the following documents. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there was no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. In all cases, the effective version of the Georgia Building Code (GBC) at the time of Advertisement for Bids or Invitation to Bid shall be considered the building code in effect.

Reference	Title
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2464	Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings

Reference	Title
ASTM D2657	Heat-Joining Polyolefin Pipe and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D3034	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM F402	Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings
ASTM F437	Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F1498	Taper Pipe Threads 60 Degrees for Thermoplastic Pipe and Fittings

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment in this Section shall be subjected to environmental conditions in accordance with Section 01 11 80 – Environmental Conditions.

1.04 SUBMITTALS

A. Preconstruction/Action Submittals: The following minimum submittals shall be submitted prior to construction of this element of the Work in accordance with Section 01 33 00 - Submittals.
   1. A copy of this Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements or those parts which are to be provided by the Contractor or others shall be provided. Check marks (✓) shall denote full compliance with a paragraph as a whole.
   2. If deviations from the Specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations.
   3. The remaining portions of the paragraph not underlined shall signify compliance with the Specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the requirements of the Specification shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.
   4. Duct layout drawings.

5. Supplier's product data, catalog cuts, typical installation details, and dimensions. Indicate each Piping System Schedule where the product will be used.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose. If alternatives are proposed, the proposals shall be accompanied with documentation supporting the claimed superiority of the proposed substitutions. The Engineer shall be the sole decider in the equivalency of alternative materials of construction.

B. All materials to be new and free from defects.

C. The following materials shall be used for the foul air duct in this project:
   1. CPVC - SCH 80, ASTM D1784-CLASS 23447-B, NSF 61 CERTIFIED, DIM. PER ASTM F441

2.02 LINING

A. No Lining shall be provided.

2.03 COATING

A. Provide pipe coatings types in accordance with the following requirements
   1. Exposed – No coating shall be provided.
   2. Buried - No coating shall be provided.

2.04 JOINTS

A. Size 1/4 to 24-inch
   1. Pipe joints shall be solvent-welded with solvent cement in accordance with ASTM F 493 - Solvent Cements for CPVC Plastic Pipe and Fittings, and with primer compatible with the solvent cement.
   2. Threaded joints which are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape.
   3. Flanged joints shall be made with solvent-welded CPVC flanges, drilled to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated.

2.05 FITTINGS

A. Solvent-welded fittings shall be Schedule 80 CPVC fittings in accordance with ASTM F 439 - Socket-Type CPVC Fittings, Schedule 80.

B. Flanged fittings shall be Schedule 80 fabricated CPVC fittings with Class 150 flanges to ASME B 16.5 – Pipe Flanges and Flanged Fittings, Class 150.

2.06 DAMPERS

A. Round dampers shall be butterfly dampers suitable for balancing and shut-off.

B. Dampers blades and all internal parts shall have sch. 80 CPVC, ASTM D1784-Class 23447. Damper bearings shall be permanently lubricated and of material impervious to attack by acids and caustics. Damper frames shall be fabricated to match connecting ductwork. Flanges shall be pre-punched and shall match duct flanges and bolt patterns.

C. Dampers shall be furnished with a locking quadrant system to allow for permanently positioning the damper in place once the odor control system has been balanced.

D. Dampers shall allow for less than 5% air flow restriction when open and minimum 95% seal when fully closed.

E. Dampers shall withstand temperatures of up to 200°F.

2.07 TAPS

Taps shall be sch. 80 sleeve CPVC Tee: ASTM D1784-Class 23447-B, Dim. Per ASTM F439, Reducing bushings as necessary.

2.08 FLG BOLTS, NUTS AND HARDWARE

A. Use Stainless steel bolts ASTM A320-B8M and Stainless-steel nuts ASTM A194-8M.

PART 3 EXECUTION

3.01 SHIPMENT AND STORAGE

A. Product shall be shipped and stored in accordance with Section 01 66 00 – Shipment, Protection and Storage.

B. Supplier shall provide Contractor with detailed recommendations and instructions for product storage.

3.02 SUPPLIER'S FIELD SERVICES

A. Supplier shall provide field services as required within this Section.

B. Supplier shall provide assistance during product installation as required by the Contractor.

3.03 INSTALLATION

A. The Supplier shall provide the Contractor with detailed recommendations and instructions for installation of the product specified in this Section.

B. Supplier shall provide assistance during equipment installation as required by the Contractor.

C. The product shall be aligned, connected, and installed at the locations shown and in accordance with the recommendations of the Supplier.

D. Join by means of socket fittings and solvent cement welding in conformance with ASTM D2564 and ASTM F402.

E. Make solvent-cemented joints in strict compliance with the Supplier's/supplier's instructions and recommended procedures.

F. Connections
   1. Connect to different pipe materials by means of flanges, specified adapters, or transition fittings.
   2. Provide threaded by solvent-welded socket joint adapters at connections to equipment and appurtenances with threaded connections.
   3. Foreign material to be removed from the duct interior prior to assembly.

G. Plastic pipe installation personnel trained to ASME B31.3.

3.04 FIELD TESTING AND COMMISSIONING

A. Field Testing and Commissioning shall be in accordance with the requirements of Section 01 45 20 – Equipment and System Performance and Operational Testing.

B. The Supplier shall provide detailed procedures for Field Testing and Commissioning for the equipment specified in this Section.

C. Field Testing and Commissioning shall be performed under the direction of experienced and qualified personnel provided by the Supplier.

END OF SECTION

SECTION 40 05 57.13

MANUAL ACTUATORS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies manual operators for valves and gates, and operator appurtenances.

1.02 REFERENCES

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AWWA C500	Gate Valves 3 through 48 inch NPS, for Water and Sewage Systems

PART 2 PRODUCTS

2.01 GENERAL

A. Except as specified in valve and gate specification sections, manual operators shall be as specified herein. Operators shall be mounted on the valve or gate and provided as a unit. Each valve body or operator shall have cast thereon the word "OPEN," an arrow indicating the direction to open, and flow direction arrows.

2.02 OPERATORS

A. General:
   1. Manual operators shall have operating torques less than 80 foot-pounds. Unless specified otherwise, each manual operator shall be provided with an operating wheel. Unless specified otherwise, the direction of rotation of the operator shall be counterclockwise for opening.

B. Wrench Nuts:
   1. Wrench nuts shall comply with Section 3.15 of AWWA C500. A minimum of two operating keys shall be provided for operation of the wrench nut operated valves.

2.03 PRODUCT DATA

A. Manufacturer's catalog information and other data confirming conformance to design and material requirements shall be provided in accordance with Section 01 33 00.

PART 3 EXECUTION

3.01 GENERAL

A. Installation shall be as specified herein. Valve operators shall be located so that they are readily accessible for operation and maintenance. Valve operators shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Valve operators shall not be mounted where shock or vibration will impair their operation. Support systems shall not be attached to handrails, process piping, or mechanical equipment.

3.02 OPERATORS

A. General:
   1. Valves and gates shall be provided with manual operators, unless specified otherwise. Where possible, manual operators shall be located between 48 inches and 60 inches above the floor or a permanent work platform.

END OF SECTION

SECTION 40 05 59.23

FABRICATED STAINLESS STEEL SLIDE GATES

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the minimum requirements for corrosion-resistant fabricated slide gates (gates) for control of wastewater flow as shown on the Drawings and specified herein. Gates shall be all 316L stainless steel construction. The scope of supply shall include gate frames, slides, seals, stems, stem guides, operators, floor stands, gate enclosures where specified, and all other appurtenances, in-place and complete.

B. Equipment List: Equipment provided under this section is listed in paragraph 1.04, Service Requirements.

1.02 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this Section and the listed documents, the requirements of the Contract Specifications shall prevail.

Reference	Title
ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM D2000	Standard Classification System for Rubber Products in Automotive Applications
AWWA C561-12	Fabricated Stainless Steel Slide Gates
ASTM A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

B. Unit Responsibility: Unit responsibility, as specified in Section 43 05 11, is assigned to the gate manufacturer (Manufacturer) for the gates and appurtenances specified in this Section

C. All gates for this project shall be supplied by the same Manufacturer, who shall be fully experienced, reputable and qualified in the manufacturing of the equipment furnished and who has been fabricating gates and appurtenances for a minimum period of 10 years.

1.03 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00.

2. Product information, calculations, charts and graphs demonstrating compliance with the requirements of this Section and the Drawings.
3. Plans, elevations, sections, and details showing dimensions and mounting requirements for each gate specified.
4. Manufacturer's data including materials of construction, construction details of equipment, and weight of equipment.
5. Manufacturer's product literature.
6. Certificate of unit responsibility attesting that unit responsibility has been assigned as specified in this Section and Section 43 05 11. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements. The Contractor shall ensure that all gate assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified.
7. Results of factory testing including leak testing per AWWA C-561, Section 5.22.
8. Certification attesting that all gate components have been cleaned, passivated and tested in accordance with the procedures described in this section
9. Manufacturer's operation and maintenance manual defining maintenance requirements.

1.04 SERVICE REQUIREMENTS

A. Performance Requirements
1. Gates are intended to isolate channels and pipes or to control water surface elevations.
2. Gates shall be designed for the Design Head specified. The Design Head is defined as the maximum head that will be applied to the gate. The Design Head is measured from the maximum water surface elevation to the bottom of the gate.
3. Slides and frames shall have a safety factor of 5 with regard to ultimate tensile, compressive and shear strength; calculations shall be submitted to show conformance.
4. Gates shall comply with field leakage tests as defined in AWWA C561.
5. Gates shall not require exercise at a frequency of more than once per year to meet the extended warranty requirements described in this section.
6. Gates shall be passivated prior to shipping in accordance with the requirements of this section.
7. See the Gate Schedule for specific dimensional and design requirements.

Gate Schedule

Pump Station	Equiq. Number	Gate Type[a]	Size W X H[b] (inches)	Frame Type[c]	Frame Mounting[d]	Design Head[e], feet		Operator Type[f]	Operator Mount[g]	Special Feature[h]
						Seating	Unseating			
Quinobequin	QUIN SG01	C	36 X 36	NSC	e	3	NA	MH	SP	EN
Elliot Street	ELI SG01	C	48 X 48	NSC	e	3	NA	MH	SP	EN
Elliot Street	ELI SG02	C	36 X 48	SC	4	3	NA	MH	YTT	EN
Elliot Street	ELI SG03	C	42 X 48	SC	2	3	NA	MH	YTT	EN
Elliot Street	ELI SG04	C	36 X 48	SC	4	3	NA	MH	YTT	EN

a. C = channel, S = Sluice, W = weir
b. Nominal size of opening (aperture style gates) or channel width x slide height (channel and weir gates). See Drawings for additional dimensional requirements.
c. SC = self contained, NSC = non self contained
d. 1 = embedded frame/sill, 2 = wall mounted with embedded sill, 3 = upper section of frame wall mounted with sill and lower portion of frame embedded (e.g., sluice style gate mounted in channelized structure), 4 = combination frame mounting, wall and embedded frame, e = flange mounted
e. Design Head is the maximum water surface elevation minus the invert elevation of the gate.
f. MH = manual hand wheel, MFN = manual 2" floor nut, E = electric motor
g. YTT = yoke-mounted torque tube, SP = structure-mounted pedestal, YA = yoke-mounted actuator, WB = wall bracket
h. RB = radius bottom, DS = dual stem, EN = stainless steel enclosure.
i. The unseating head indicated would be an unusual condition resulting from a closed gate on a pressurized forcemain. For this condition, the gate would not need to seal the pipe to AWWA standards but the gate would need to withstand the resulting force without damage to the gate or seals.

1.05 COMPONENT SIZING

A. Operating forces used for determining the strength of gate components (yokes, frames, slides, stems, slide nut pockets, and other load-bearing members) shall be based on the sum of the guide friction force (computed using an opening breakaway friction factor of 0.2) and the weight of slide and stem.

B. When the gate is in motion, the operating forces shall be based on the sum of the frictional force (using a guide friction factor of 0.25) and the weight of slide and stem.

1.06 PICKLING AND PASSIVATION OF STAINLESS STEEL

A. General:
   1. Equipment specified under this section shall be cleaned, descaled and passivated in accordance with methods defined in ASTM A380 – Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, and the specific requirements of this section.
   2. For purposes of this section, passivation is defined as the removal of exogenous iron or iron compounds from the surface of stainless steel by means of treatment with an acid solution that will remove the surface contamination but will not significantly affect the stainless steel itself.
   3. Equipment components that bolt together shall be disassembled prior to passivation treatment to allow for effective circulation and removal of cleaning solutions.
   4. All fasteners and anchor bolts required for assembly and mounting of equipment shall be passivated as described in this section, then dried and sealed in plastic bags and labeled. Fasteners shall conform to the requirements of Section 43 05 11.
   5. The use of "fabricator's crayons" shall be prohibited during fabrication of equipment as these marks may prevent proper passivation.

B. Passivation Process Requirements:
   1. The processes required for proper passivation shall include precleaning, chemical descaling, neutralization, and post-cleaning protection as defined below.
      a. Precleaning – Precleaning required for the removal of all grease, oil, paint, soil, grit and other gross contaminants preparatory to the fabrication process shall be accomplished by vapor degreasing, immersion or spray application of alkaline or emulsion cleaners, steam, or high pressure water jetting.

b. Chemical Descaling –Chemical descaling (pickling) shall be accomplished by immersion bath or spray application of a citric acid solution to produce a matt white, pristine appearance. The acid solution and process used shall conform to Code B, Table A1.1, ASTM A380.

c. Neutralization – The chemical reactions of the pickling media shall be stopped by rinsing of the part with a 10 percent soda ash solution for a minimum of 30-minutes followed by a water bath using high pressure water jetting. The pH of the wetted part surface shall be same as the water used for rinsing.

d. Post Cleaning Inspection – Post treatment inspection of the chemically pickled and neutralized part shall exhibit a clean surface with no signs of etching, pitting, or frosting resulting from the pickling procedure.

e. Testing – The passivated part shall be tested for the presence or absence of free iron with a solution of potassium ferricyanide as defined in Verification Test Practice E, ASTM A967. The test solution shall be mixed and used within 24-hours or less and applied with sterile cotton swabs. The test result shall indicate an absence of free iron on the surface of the part.

f. Protection – Protection shall be provided by applying shrink wrap to all parts of the equipment sufficient to prevent exposure of passivated surfaces to contaminants during handling, shipping and installation. Protected equipment shall be tagged with highly visible warning signs stating the equipment has been passivated and shall only be opened by authorized personnel. Equipment arriving at the project site without proper protection will require retesting for the presence of free iron and re-passivation if free iron is detected.

C. Assembly of equipment following passivation – If assembly of bolted parts is required following passivation, it shall be done at the manufacturing facility under clean conditions such that the parts will not be contaminated with exogenous iron or iron compounds. Following assembly, retest for the presence of free iron per ASTM A967 and treat any contaminated areas with citric acid solution. Equipment requiring assembly shall be re-shrink wrapped sufficient to prevent exposure of passivated surfaces to contaminants during handling, shipping and installation.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Gates shall be all stainless steel construction. Acceptable manufacturers include the following:
   1. Stainless steel slide gate manufacturers:
      a. Whipps, Inc. Athol, Massachusetts
      b. Fontaine International Corporation, Quebec, Canada
      c. Golden Harvest, Burlington, Washington
      d. Approved equal

B. The manufacturer's standard models or products may require modifications to conform to specified requirements.

2.02 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Slide	ASTM A240 Type 316L stainless steel
Frame	ASTM A276 Type 316L stainless steel
Slide Seats	ASTM D4020 UHMW Polyethylene
Seating faces or seals	ASTM D4020 UHMW PE
Stem and supports	ASTM A276 Type 316 stainless steel
Fasteners, adjusting hardware, and anchors	ASTM A276 Type 316 stainless steel
Yoke	ASTM A276 Type 316L stainless steel
Flush bottom seal	Resilient synthetic rubber bonded to frame or ASTM D2000 neoprene
Pedestal/Torque Tube	ASTM A276 Type 316L stainless steel
Enclosure	ASTM A276 Type 316L stainless steel

2.03 FEATURES

A. General:
   1. Mounting requirements as shown on the Drawings and specified in this section.
   2. Unless otherwise indicated, provide gates with rising stems with clear, graduated plastic covers in accordance with AWWA C561.
   3. Stainless Steel Passivation: All stainless steel components to be cleaned, descaled, and passivated after fabrication in accordance with ASTM A380 and the specific requirements of this section.

B. Slide:
   1. Slides shall consist of steel plate reinforced with steel members welded to the plate. Minimum thickness of the steel plate shall be ¼".
   2. Slides shall be reinforced with horizontal stiffeners welded to vertical stiffeners. Slides shall not deflect more than 1/1000 of the span of the gate under the design head.
   3. Gates with an opening width x design head of 80' or greater shall incorporate a 3" minimum structural edge extended into the guide grove or design equivalent.
   4. The slide manufacturer shall submit drawings and comprehensive design criteria to substantiate that the maximum deflection for each slide has not exceeded 1/1000 of the span regardless of the type used. Comprehensive safety factor calculations shall include bending moments, buckling stress, and bonding stress with thermal expansion factors. Safety factors shall be calculated for the slide under the maximum head indicated in this section, and for shear at the slide/seal interface.

C. Frame:
   1. Guide frames extending above operating floors or slabs shall be self-contained and sufficiently strong so that no further support or reinforcement is required. Frames for self-contained gates shall be designed for maximum loads imposed by gate operators

in the stalled condition plus the weight of the slide, stem, torque tube or pedestal, and operator.

2. The yoke shall be formed by two structural members welded at the top of the guides to provide a one-piece rigid frame and configured to enable slide removal without removing the yoke. The yoke shall be designed to support the maximum stall force applied by the operator in addition to the weight of the stem, torque tube or pedestal, and operator where this equipment is being supported at the yoke.
3. The frame shall be designed with a minimum factor of safety of 4 with regard to ultimate tensile, compressive, and shear strength.
4. Wall-mounted frames shall be the flanged type. Guides for wall mounted frames shall be formed from one plate with wrap around gussets if required for unseating head.
5. Embedded frame gates shall be installed in block-out recesses formed in the channel walls and floor.
6. Thimble-mounted gates shall be drilled to match the wall thimble. Wall thimbles shall conform to AWWA C561.

D. Seals:
1. Gates shall incorporate factory-set self-adjusting seals utilizing a sealing surface of UHMW PE to achieve the leakage rates specified. Self adjusting seals shall not require adjustment and shall be replaceable without removing the guide frame.
2. All moving contact surfaces shall be incompatible to each other thereby minimizing sticking or jamming.

E. Stems:
1. All stems shall be of the rising type unless otherwise specified.
2. Provide stem diameter to withstand at least twice the rated output of the electric operator or the manual operator at 40-pounds pull.
3. Stem guides shall be provided at intervals necessary to maintain a slenderness ratio (L/R) of the unsupported stem length of less than 200, where R is the radius of gyration of the stem.
4. Stems shall be designed to withstand tensile and compressive loads that occur under maximum operating conditions. Design for compressive loading shall meet AISC code where K=1 with a minimum safety Factor of 2 to 1.
5. Stem sections shall be joined together by solid couplings, threaded and keyed to the stems. All couplings of the same size shall be interchangeable.
6. The threaded portion of the stem shall have dual lead, machine rolled, full depth ACME type threading with a 16 micro-inch finish or better. Stub threads are not acceptable.
7. Stems shall be fixed to the slide by a threaded and keyed assembly into a lifting nut attached to the disc in a lifting bracket, which is bolted to the disc. The bolts securing the bracket shall be in tension and not shear.
8. Yoke-supported stems shall be provided with a torque between the top of the yoke and the operator constructed of 316L SS. The torque tube shall have appropriate flanges at the top and bottom for mounting to the operator and yoke, and be sized and constructed to provide lateral support to the stem between the yoke and the operator. Torque tubes shall be provided with UHMW stem guides at appropriate intervals to provide lateral support to the stem. Torque tubes shall be equipped with tabs for bolting lateral supports; the dimensions and location of the tabs shall be determined by the manufacturer and coordinated during the submittal review process.

F. Operators:
   1. See Gate Schedule for operator requirements.
   2. Unless otherwise indicated, manual operators shall meet requirements of AWWA C561 as appropriate.
   3. Yoke-supported operators shall be provided with 316 SS pedestals between the top of the yoke and the operator. See drawings for length requirements.
   4. Unless otherwise indicated and whenever possible, operator base shall be set 42" above the walking surface.
   5. Manual operators are specified in Section 40 05 57.13.

2.04 FACTORY TESTING

A. Conduct shop performance test per AWWA C561 as applicable. All gates to be field leak tested following installation. Submit written report of results.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install gates and appurtenances in accordance with manufacturer's instruction and as shown on the Drawings.

B. For embedded gates, fill blockouts along guide frames and gate sill with grout following installation.

C. Provide all 316 SS anchors; size anchors in accordance with the design requirements specified in this section and in accordance with Sections 01 73 24 and 43 05 11.

3.02 FIELD SERVICE AND TESTING

A. Operation and Leakage Tests: In accordance with AWWA C561 as appropriate.

B. Leakage rates shall not exceed 0.05 gpm per linear foot of seating perimeter.

3.03 CONTRACTOR EQUIPMENT ACCEPTANCE

A. Adjust, repair, modify, or replace components failing to perform as specified in the re-inspect.

B. Make final adjustments to equipment under direction of the manufacturer.

C. Furnish manufacturers certificate of proper installation attesting that equipment has been properly installed and is ready for startup and testing.

END OF SECTION

SECTION 40 05 60

VALVES

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies the supply, installation and testing of valves. Materials and performance requirements for valves are specified in Detailed Valve Specifications. Detailed Valve Specifications are provided in Sections 40 05 62.01 through 40 05 65.16. Additional Detailed Valve Specifications for some valves used for HVAC service are provided in Division 23.

B. Determining Valve Type:
   1. Drawings specify valve types (gate, plug, butterfly, check, globe, etc.) used in each pipeline. Process fluids that will be conveyed in pipelines are identified by the Process Service Identifiers shown on the Drawings.
   2. Piping System Schedules (Sections 40 05 02.01 through 40 05 02.99) specify piping system materials and components, including valve requirements, based on the Process Service Identifier specified on the Drawings for the pipeline or piping system. Piping System Schedules reference Detailed Valve Specifications that specify requirements for each valve type used in the pipeline or piping system.
   3. Provide valves conforming to the Detailed Valve Specifications listed in the Piping System Schedule for the valve/line size, process service, and valve type specified on the Drawings. Example: The Drawings specify a ball valve on a 1-inch line. The Piping System Schedule for the process service specified on the Drawings refers to Section 40 05 63.01 for 1/2 through 2 1/2 inch ball valves. For this example, provide the subject ball valve per the requirements specified in 40 05 63.01.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 78 23 – Operation and Maintenance Manual
   2. Section 40 05 02 – Detailed Piping Specification Sheets

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI 16.10	Face-to-Face and End-to-End Dimensions of Valves
ANSI B1.20.1	Pipe Threads, General Purpose
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, and 250
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.34	Valves—Flanged, Threaded, and Welding End
API 607	Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats
ASTM A48	Gray Iron Castings
ASTM A108	Steel Bars, Carbon, Cold-Finished, Standard Quality
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A216/A216M	Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A276	Stainless and Heat Resisting Steel Bars and Shapes
ASTM A351	Castings, Austenitic, for Pressure-Containing Parts
ASTM A516	Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A536	Ductile Iron Castings
ASTM A571	Austenitic Ductile Iron Castings
ASTM A995/A995M-13	Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts
ASTM B124	Copper and Copper Alloy Forging Rod, Bar, and Shapes
ASTM B148	Aluminum-Bronze Sand Castings
ASTM C283	Resistance of Porcelain Enameled Utensils to Boiling Acid
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D5162	Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
AWWA C500	Metal-Seated Gate Valves for Water Supply Service
AWWA C504	Rubber-Seated Butterfly Valves
AWWA C507	Standard for Ball Valves
AWWA C508	Swing Check Valves for Waterworks Service, 2 – 24 Inches NPS
AWWA C517	Resilient-Seated Cast Iron Eccentric Plug Valves
AWWA C550	Protective Interior Coatings for Valves and Hydrants
MSS SP-70	Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	Bronze Gate, Globe, Angle and Check Valves
MSS SP-81	Stainless Steel, Bonnetless, Flanged, Knife Gate Valves
MSS SP-110	Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
NSF 61	Drinking Water System Components - Health Effects
UL 429	Electrically Operated Valves
UL 1002	Electrically Operated Valves for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00

2. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote with a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal will be sufficient cause for rejection of the entire submittal with no further consideration.
3. Catalog cuts and/or shop drawings for each type of valve indicating the valve type (Detailed Valve Specification Section Number), materials of construction, dimensions, operating torque, valve end connection configuration, pressure rating, and operating temperature range.
4. An amended Detailed Valve Specification for all valve types provided for this contract. Indicate with check marks where the valve supplied meets the requirements specified and with written amendments where the product differs from the specification.
5. Factory Acceptance Test results and/or Certified Statement of Proof-of-Design testing results when specified in Detailed Valve Specifications.
6. Action Submittal Items listed on Detailed Valve Specifications

B. Informational Submittals:
1. Affidavits and registration numbers as specified.
2. Operating and Maintenance data for incorporation in operation and maintenance manual, as specified in Section 01 78 23. Include complete description of operation together with detailed drawings, a complete list of replacement and repair parts, and parts manufacturer's identifying numbers.
3. Informational Submittal Items listed on Detailed Valve Specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Deliver valves to site in accordance with Section 01 66 00 and using loading methods which do not damage any valve components or coatings.

C. Tag loose valves as specified in Section 01 66 00, stating size, type, coatings and mating parts shipped loose or separate.

D. Store on site until ready for incorporation in the work using methods recommended by the manufacturer to prevent damage, undue stresses, or weathering.

1.06 WARRANTY

A. Where a warranty duration is specified by the Detailed Valve Specification, provide a special warranty valid for the specified duration.

B. Where no special warranty requirements are specified in the Detailed Valve Specification, provide manufacturer’s standard warranty.

PART 2 PRODUCTS

2.01 VALVE CONFIGURATION REQUIREMENTS

A. General
   1. Provide valves of the same type, size range and service from a single manufacturer.
   2. Provide new, unused valves for the work.
   3. Provide valve materials free from defects or flaws, with true alignment and bores.
   4. Provide valves that open by turning the valve shaft to rotate counter-clockwise unless otherwise specified in the Detailed Valve Specification Section.

B. Provide padlockable lockout feature on all valves.

C. Manual Operators
   1. Provide valves with manual operators as specified in the Detailed Valve Specification.
   2. Provide 6 (total) eight-point operating wrenches for use on all valves with square nut operators.

D. Valve Stem Extensions and Wrench Nuts
   1. Wrench nuts shall comply with AWWA C500. A minimum of two operating keys, but no less than one key per every ten valves, shall be provided for operation of wrench nut operated valves.

2.02 VALVE IDENTIFICATION TAGS

A. Provide valve identification tags for all valves with an identification tag number on the drawings (Mechanical and PI&D drawings).

B. Match tag numbers shown on the drawings.

C. Type 316 stainless steel tags, minimum 2.5-inches x 0.75 inches, with 0.1875 inch numbers and letters. Complete tag number shall be embossed on the tag. Tags shall be attached using stainless steel wire.

PART 3 EXECUTION

3.01 PREPARATION

A. The valve and piping arrangement indicated on the Drawings is based on typical dimensions for valves of the specified type. Make the necessary modifications in the piping to allow for discrepancies between the valve dimensions shown and those supplied for the Work.

B. Prior to installation of valves, field measure and check all equipment locations, pipe alignments, and structural installations. Ensure that the valve location and orientation provides suitable access to manual operators and that sufficient space and accessibility is available for hydraulic, pneumatic, and electric power actuators.

C. Where conflicts are identified, inform the Owner.

3.02 INSTALLATION

A. Install valves in conjunction with the piping specified in the Piping System Schedules (Sections 40 05 02.01 through 40 05 02.99).

B. In horizontal pipe runs, other than in locations where space does not permit, install all valves (except for butterfly valves, eccentric plug valves, and trunnion ball valves) with a vertical operating shaft with the actuator at the top. In no case install a valve with the operator below the valve.

C. Unless otherwise specified on the drawings, install butterfly valves, eccentric plug valves, and trunnion ball valves with the shaft in a horizontal orientation. Install eccentric plug valves with the plug above the valve shaft centreline when the valve is full open.

D. When joining valves to pipe or fittings, do not over torque bolts to correct for misalignment.

E. Support valves in position using temporary supports until valves are fixed in place.

F. Permanently support valves to prevent transmission of loads to adjacent pipework and/or equipment.

G. Where valves are installed in plastic pipelines (PVC, CPVC, HDPE, polypropylene etc.) greater than 4-inch diameter, support valves independent of the piping and brace valves against operating loads and torque to prevent transmission of stresses to the adjacent pipework.

H. Install valves which are bubble tight in one direction to provide bubble tight seal of flow in normal direction of flow unless otherwise noted or directed by the Owner.

I. Unless otherwise specified, install single seated valves with the seat downstream. Install valves at tank connections with seat away from tank. Install valves on pump discharge and suction lines with seat end towards the pump.

J. Install all valves in accordance with the manufacturer's recommendations.

K. Protect valves installed below grade with a shrink sleeve or polyethylene sheath attached to the pipe with tape wrap.

3.03 FIELD QUALITY CONTROL

A. Field or Site Tests and Inspections per Detailed Valve Specifications.

B. Pressure test all valves in conjunction with the pipes in which the valves are installed at test pressures specified in the applicable Piping System Schedule.

END OF SECTION

40 05 62.01

PLUG VALVE, AWWA C517 STANDARD PORT

GENERAL

1. Line Size: 3 through 12 inches
2. Rated Limits: Pressure 175 psi; Temperature 125 °F

VALVE MATERIALS

1. Body: Cast Iron
2. Plug: Cast Iron or Ductile Iron
3. Plug Facing: Neoprene or Buna-N
4. Seating: Ni or Stainless Steel
5. Packing: Buna V-flex or TFE
6. Bearings: Stainless Steel
7. Grit Excluder: PTFE or Buna-N

VALVE CONFIGURATION

1. Valve End/Connections: ANSI B16.1 Class 125# Flange
   a. Flange connections per AWWA C115 for pipe, AWWA C110 for fittings, Dim. Per ASME B16.1-Class 125.
2. Pattern: One-piece, Standard Port; provide 100% minimum port area of adjacent pipe for valves 4 inches and less, provide 80 to 85% port area of adjacent pipe for valves 6 to 24 inches.
3. Reference Standard: AWWA C517
4. Installation: Install in accordance with the manufacturer's written recommendations.
   a. Unless otherwise indicated, provide valves with seat downstream away from flow or direct pressure source (seating force on plug).
5. Operator: Stem and standard AWWA nut
6. Special: upper and lower journal bearings shall be replaceable, sleeve-type, corrosion resistant, and permanently lubricated; packing shall be self-adjusting chevron type replaceable without disassembling the valve

SUBMITTALS

1. Action Submittals:
   a. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   b. Manufacturer's catalog information including dimensions, cross sectional views, and details for construction.
   c. Furnish three certified copies of a report from an independent testing laboratory certifying successful completion of proof-of-design testing conducted in accordance with AWWA C517, Section 5.2. In lieu of testing the valves at an independent testing laboratory, proof-of-design testing may be performed at the valve manufacturer's laboratory, but must be witnessed by a representative of a qualified independent testing laboratory, and all test reports must be certified by the laboratory representative. Proof-of-design testing shall have been performed on not less than three 6-inch diameter valves, with all three test units demonstrating full compliance with the test standards. Failure to satisfactorily complete the test shall be deemed sufficient evidence to reject all valves of the proposed make or manufacturer's model number.
2. Information Submittals:
   a. Affidavits of compliance with AWWA C517.

3. Closeout Submittals: a. Operation and maintenance information
CANDIDATE MANUFACTURERS
1. DeZurik Style PEC 2. Val Matic, Cam-Centric 3. GA Industries, ECO-Centric 4. Approved equal

END OF SECTION

40 05 62.05

DUCKBILL VALVE

GENERAL

1. Line Size: 3 through 12 inches
2. Cracking pressure: 2” head (0.07 psi) or less

VALVE MATERIALS

1. Body: EPDM
2. Compression Clamps: 316 stainless steel, furnished by manufacturer

VALVE CONFIGURATION

1. Body: Single piece construction
2. Cuff: Slip on style with full round bore
3. Installation: Install in accordance with the manufacturer’s written recommendations.

SUBMITTALS

1. Action Submittals:
   a. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   b. Manufacturer’s catalog information including dimensions, cross sectional views, and details for construction.
2. Closeout Submittals:
   a. Operation and maintenance information

CANDIDATE MANUFACTURERS

1. Tideflex Series TF-1
2. Cla-Val RD-DBF
3. Proco Proflex 710
4. Approved equal

END OF SECTION

40 05 65.16

CHECK VALVE, LEVER ARM AND SPRING, TRANSIENT SERVICE, 150 psi

GENERAL

1. Line Size: 2 through 12 inches
2. Rated Limits: Pressure 175 psi; Temperature 100 °F

VALVE MATERIALS

1. Body: Cast Iron, ASTM A126, Grade B or Ductile Iron, ASTM A536; body permits mounting external lever and springs on either side of the valve, clear opening size equal to or greater than connecting pipe
2. Disc: Ductile Iron, ASTM A536; pivot arm secured to disc with twin bolted connections or a pinned nut, disc and lever arm keyed to the shaft and retained by bushings or pins
3. Body Seat: Aluminum Bronze or Stainless Steel
4. Disc Seal: Nitrile (Buna-N/BR)
5. Hinge Pin/Shaft: Stainless Steel; provided with stuffing box and packing or O-ring seal at each shaft penetration through valve body, minimum shaft diameters as follows:

Valve Inlet Size, Inches	3	4	6	8	10	12
Shaft Diameter Inches	0.75	0.825	1.00	1.75	2.00	2.50

6. Shaft Bushings: Bronze

VALVE CONFIGURATION

1. Valve End/Connections: Flanged, ASME B16.1 Class 125
2. Check Mechanism: Swing
3. Closure Control: Lever Arm and Spring; capable of closing within 0.05 seconds of pump stoppage with fluid moving at 8 feet/second, adjustable spring tension
4. Lining: Epoxy, 12 mils

SUBMITTALS

1. Action Submittals:
   a. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate request deviations.
   b. Manufacturer's catalog information including dimensions, cross-section views, details of construction and materials list.
2. Information Submittals:
   a. Affidavit of compliance with AWWA C508.
3. Closeout Submittals:
   a. Operation and maintenance information.

CANDIDATE MANUFACTURERS

1. Golden Anderson Series 220
2. DeZurik/Apco Series 6000

END OF SECTION

SECTION 40 06 70

SCHEDULES FOR INSTRUMENTATION OF PROCESS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Instrument Index for instruments furnished or installed under Sections 40 61 13 through 40 76 00.

B. Related sections:
   1. Section 40 61 13 – General Requirements for Instrumentation and Control
   2. Section 40 61 21 – Process Control System Testing

1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. PICS submittal requirements: Section 40 61 13.

C. Action Submittal:
   1. Submit updated schedule with field instrumentation submittal to match equipment being provided.

PART 2 NOT USED

PART 3 EXECUTION

3.01 EXAMINATION

A. Instruments furnished by others or existing.
   1. Listed equipment, furnished under other contracts, is an integral part of the instrumentation systems specified under this contract and listed in the Instrument Index.
   2. Inspect items to verify operation and integration requirements.
   3. Provide wiring, testing, and commissioning services for the listed equipment. Notify the Construction Manager where equipment fails to provide the required function.

3.02 INSTALLATION

A. Refer to Section 40 61 13 for requirements.

3.03 FIELD QUALITY CONTROL

A. Refer to Section 40 61 21 for requirements.

B. Maintain a copy of the complete Instrument Index with modifications during construction in Excel format. Provide a copy of the latest version to the [Engineer] [Construction Manager] upon request.

3.04 ATTACHMENTS

A. 40 06 70 Attachment A: INSTRUMENT INDEX

1. Description of headings in Instrument Index.

Instrument Field or Heading	Example	Comment or Description
Tag No. Function Abbreviation	PDIT	See P&ID sheet legend.
Tag No. Area	01	See P&ID sheet legend.
Tag No. Loop #	23	See P&ID sheet legend.
Tag No. Suffix 1	A	See P&ID sheet legend.
Tag No. Suffix 2	1	See P&ID sheet legend.
INSTRUMENT TAG	PDIT-0123A1	Combined function abbreviation, area, loop number, and suffixes
DWG Number	I-10-101	Primary drawing that shows the instrument
Device Function	Primary sludge Pump 1 Discharge flow	Provides the functional description of the instrument, analyzer, or device.
LINE/CONNECTION SIZE	4" flange	Provides the application data relative to sizing the instrument; flow tube diameter, probe length, associated pipe sizes, etc. 4-inch, 6-inch flange, 3/4-inch tap
CONNECTION TYPE	Diaphragm	Provides the connection type to the instrument
Operating Range	25–65 PSIG	25 to 65, -10 to 90, etc.
CALIBRATED RANGE	0-100 PSIG	Provides the range that the instrument should be calibrated for
Units	mgd	mgd, kW, psi, etc.
Signal Type	4-20 mA	4-20 mA, Ethernet, DeviceNet, etc., discrete contact, etc.
Power Requirements	120 V	None, loop, 120-volt, 24-volt, internal battery, etc.
Device Type	Differential pressure transmitter	
INSTRUSPEC TYPE	FM	Instruspec type or other name in specification listed below
Specification #	40 71 00	Specification under which device is provided or specified.
	I-20-101	P&ID sheet number
Installation Detail Number		Installation detail number if provided.
REMARKS	Class 1 Div 2 Area, Owner-supplied for installation by contractor. Provide grounding ring to match instrument.	Provides the features, interlocks, and information applicable to the instrument, analyzer, or device. Describes special installation instructions, area classifications, modifiers to standard instrument specs, Owner-supplied, existing, accessories, signal surge protection, options, etc.

END OF SECTION

FUNCTION ABBREVIATION	AREA	LOOP #	SUFFIX 1	SUFFIX 2	INSTRUMENT TAG	DWG NUMBER	DEVICE FUNCTION	LINE/ CONNECTION SIZE	CONNECTION TYPE	Operating Range	CALIBRATED RANGE	Units	SIGNAL TYPE	POWER REQUIREMENTS (Loop, 120 VAC, 24 VDC, etc.)	DEVICE TYPE	INSTRUSPEC TYPE	SPECIFICATION #	INSTALLATION DETAIL	REMARKS
AIT	10	00	A		AIT-1000A	I-10-101	QUIN - COMBUSTIBLE GAS DETECTOR-ROOM 104	NA	NA	0-100 %	0-100 %	LEL	Vendor dependent. Must be rated for classified area	Fed from Vendor Control Panel	Combustible Gas Detector	MI	407600		
AIT	10	00	B		AIT-1000B	I-10-101	QUIN - COMBUSTIBLE GAS DETECTOR-ROOM 106	NA	NA	0-100 %	0-100 %	LEL	Vendor dependent. Must be rated for classified area	Fed from Vendor Control Panel	Combustible Gas Detector	MI	407600		
AIC	10	00			AIC-1000	I-10-101	QUIN - GAS ANALYZER CONTROLLER	NA	NA	NA	NA	NA	Dry Contacts	120 V AC	Gas Analyzer Controller	MI	407600		
FSL	10	10	A		FSL-1010A	I-10-101	QUIN - INLET AIR LOW FLOW	18"X24"	1.5" NPT	0-4000	2500 and falling	SCFM	Dry Contact		Flow Switch	FVS	407100		
FSL	10	10	B		FSL-1010B	I-10-101	QUIN - EXHAUST AIR LOW FLOW	18"X24"	1.5" NPT	0-4000	3000 and falling	SCFM	Dry Contact		Flow Switch	FVS	407100		
FSL	10	10	C		FSL-1010C	I-10-101	QUIN - EXHAUST AIR LOW FLOW	8"	1.5" NPT	0-1000	450 and falling	SCFM	Dry Contact		Flow Switch	FVS	407100		
AIT	20	00	A		AIT-2000A	I-20-101	ELLIOT- COMBUSTIBLE GAS DETECTOR -EXHAUST FAN 2 AREA	NA	NA	0-100 %	0-100 %	LEL	Vendor dependent. Must be rated for classified area	Fed from Vendor Control Panel	Combustible Gas Detector	MI	407600		
AIT	20	00	B		AIT-2000B	I-20-101	ELLIOT - COMBUSTIBLE GAS DETECTOR-COMMINUTOR ROOM	NA	NA	0-100 %	0-100 %	LEL	Vendor dependent. Must be rated for classified area	Fed from Vendor Control Panel	Combustible Gas Detector	MI	407600		
AIC	20	00			AIC-2000	I-20-101	ELLIOT - GAS ANALYZER CONTROLLER	NA	NA	NA	NA	NA	Dry Contacts	120 V AC	Gas Analyzer Controller	MI	407600		
FSL	20	10	A		FSL-2010A	I-20-101	ELLIOT- EXHAUST AIR LOW FLOW	16"X 16"	1.5" NPT	0-4000	3200 and falling	SCFM	Dry Contact		Flow Switch	FVS	407100		
FSL	20	10	B		FSL-2010B	I-20-101	ELLIOT- EXHAUST AIR LOW FLOW	16"x16"	1.5" NPT	0-1000	500 and falling	SCFM	Dry Contact		Flow Switch	FVS	407100		
FSL	20	10	C		FSL-2010C	I-20-101	ELLIOT-INLET AIR LOW FLOW	12"x12"	1.5" NPT	0-4000	3150 and falling	SCFM	Dry Contact		Flow Switch	FVS	407100		
LT	70	01			LT-7001	I-70-101	OLDHAM WET WELL LEVEL	.	Submerged in still	0-80"	0-80"	inches	4-20 mA	Loop Powered	Submersible Level Transducer	LST	407200		
LSHH	70	02	A		LSHH-7002A	I-70-101	OLDHAM WET WELL HI HI LEVEL	NA	NA	73.34"	NA	inches	Dry Contact		Float Switch	LSS	407200		High Level Alarm
LSH	70	02	B		LSH-7002B	I-70-101	OLDHAM WET WELL START PUMP	NA	NA	72.84"	NA	inches	Dry Contact		Float Switch	LSS	407200		Pump On
LSL	70	02	C		LSL-7002C	I-70-101	OLDHAM WET WELL STOP PUMP	NA	NA	71.65"	NA	inches	Dry Contact		Float Switch	LSS	407200		Pump Off
LSLL	70	02	D		LSLL-7002D	I-70-101	OLDHAM WET WELL LO LO LEVEL	NA	NA	71.15"	NA	inches	Dry Contact		Float Switch	LSS	407200		Low Level Alarm
ME	70	11			ME-7011	I-70-101	OLDHAM PUMP 7011 - MOISTURE DETECTED	NA	NA	Vendor Supplied	Vendor Supplied	NA	Dry Contact	Vendor Supplied with Pump Motor	Vendor Supplied in Pump Motor	NA		NA	Vendor Supplied in Pump Motor
TE	70	11			TE-7011	I-70-101	OLDHAM PUMP 7011 - HIGH MOTOR TEMPERATURE	NA	NA	Vendor Supplied	Vendor Supplied	DEG F	Dry Contact	Vendor Supplied with Pump Motor	Vendor Supplied in Pump Motor	NA		NA	Vendor Supplied in Pump Motor
PIT	70	11			PIT-7011	I-70-101	OLDHAM PUMP 7011 - DISCHARGE PRESSURE	4"	Diaphragm	0-30 psig	0-30 psig	psig	4-20 mA	Loop Powered	Pressure Transmitter	PGT	407300		
ME	70	12			ME-7012	I-70-101	OLDHAM PUMP 7012 - MOISTURE DETECTED	NA	NA	Vendor Supplied	Vendor Supplied	NA	Dry Contact	Vendor Supplied with Pump Motor	Vendor Supplied in Pump Motor	NA		NA	Vendor Supplied in Pump Motor
TE	70	12			TE-7012	I-70-101	OLDHAM PUMP 7012 - HIGH MOTOR TEMPERATURE	NA	NA	Vendor Supplied	Vendor Supplied	DEG F	Dry Contact	Vendor Supplied with Pump Motor	Vendor Supplied in Pump Motor	NA		NA	Vendor Supplied in Pump Motor
PIT	70	12			PIT-7012	I-70-101	OLDHAM PUMP 7012 - DISCHARGE PRESSURE	4"	Diaphragm	0-30 psig	0-30 psig	psig	4-20 mA	Loop Powered	Pressure Transmitter	PGT	407300		

AREA	site
10	QUIN
20	Elliot
30	hamlet
40	grayson
50	edgewater
60	islington
70	oldham

SECTION 40 61 13

PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies general requirements applicable to Sections 40 06 70 through 40 76 00 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a single Systems Integrator (SI) meeting the qualifications section of this specification.

B. System overview. Detailed requirements are in individual related specification sections.
   1. Field Instrumentation:
      a. New field instruments at Oldham Road, Quinobequin, and Elliot pumping stations.
   2. Process Control Hardware:
      a. Replacement of an existing control system PLC, Pump Control Panel, Instrumentation, and Main Control Panel at Oldham Road.
      b. Modification of existing control panels and addition of new instrumentation at Quinobequin, and Elliot pumping stations
   3. Process Control Software, Programming, and Integration:
      a. Replacement of the existing PLC, instrumentation, main control panel, and pump control panel at Oldham Road pumping station.
      b. Coordinated programming and testing responsibilities between supplier and Owner.
      c. Integration with new packaged gas monitoring systems and instrumentation at Quinobequin and Elliot pump stations.
      d. Integration with existing SCADA System historian and reporting system network and communication system.
   4. Communications and Networking
      a. Integrate the new PLC installed at Oldham Road pumping station with the existing radio communication network.

1.02 RELATED SECTIONS:

A. The requirements of this section are applicable to work specified in Sections 40 06 70 through 40 76 00 these specifications.

B. Section 40 06 70 – Schedules for Instrumentation of Process Systems.

1.03 REFERENCES

A. Reference Standards:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under

this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

2. Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
3. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
4. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
IEEE 100	Standard Dictionary of Electrical and Electronics Terms
ISA 5.4	Instrument Loop Diagrams
ISA 20	Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
ISA 51.1	Process Instrumentation Terminology
ISA TR20.00.01	Specification Forms for Process Measurement and Control Instruments Part 1: General Considerations
NEMA ICS 1	General Standards for Industrial Control and Systems

1.04 DEFINITIONS

A. Abbreviations:
   1. dBm: decibel-milliwatts
   2. HMI: human-machine interface
   3. OIT: operator interface terminal
   4. PICS: Process and Instrumentation Control System
   5. PLC: programmable logic controller
   6. SCADA: supervisory control and data acquisition
   7. SI: Systems Integrator

B. Definitions General:
   1. General: Definitions of terminology related to Instrumentation and Industrial Electronic Systems used in the specifications as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.
   2. Data sheets: Data sheets refer to ISA 20 or ISA TR20.00.01, as referenced within ISA-20-1981 specification.
   3. Two-wire transmitter: A transducer that derives operating power supply from the signal transmission circuit and requires no separate power supply connections. A two-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a 24-volt direct current (VDC) driving potential and a maximum circuit resistance of 600 ohms.

4. Four-wire transmitter: A transducer that derives operating power from separate power supply connections. A four-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a maximum circuit resistance of 600 ohms. Four-wire transmitters typically require 120-volt alternating current (VAC) or 24VDC input power supply.
5. Galvanic isolation: An electrical node having no direct current path to another electrical node. Galvanic isolation refers to a device with electrical inputs and/or outputs that are isolated from ground, the device case, the process fluid, and separate power supply terminals. Inputs and/or outputs may be externally grounded without affecting the characteristics of the devices or providing a path for circulation of ground currents.
6. Panel: An instrument support system that may be a flat surface, partial enclosure, or complete enclosure for instruments and other devices used in process control systems including consoles, cabinets, and racks. Panels provide mechanical protection, electrical isolation, and environmental protection from dust, dirt, moisture, and chemical contaminants that may be present in the atmosphere.
7. Systems Integrator: A firm engaged in the business of detailed control system design and engineering, instrumentation component purchase, system and panel assembly, control device programming, and implementing of the specified process control and industrial automation systems.

C. Definitions—Signal Types:
1. Analog, low level: Signal with full output level of 100 millivolts or less including thermocouples and resistance temperature detectors.
2. Analog, high level: Signals with full output level greater than 100 millivolts but less than 30 volts, including 4 to 20 mA transmission.
3. Audio signals, high level: Audio signals exceeding plus 4 dBm, including loudspeaker circuits.
4. Digital code: Coded information from the output of an analog-to-digital converter or digital transmission terminal.
5. Discrete control or events: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits.
6. Discrete control or events, low voltage: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits operating at less than 30 volts and 250 milliamperes.
7. Modulated signals: Signals from modems or low-level audio signals. Normal signal level: plus 4 dBm to minus 22 dBm. Frequency range is 300 to 10,000 hertz.
8. Pulse frequency: Counting pulses emitted from speed or flow transmitters.
9. Radio frequency (RF) signals: Continuous wave alternating current signals with fundamental frequency greater in a range of 310 kilohertz to 300 gigahertz.

D. Definition—Drawing Types:
1. Elementary or schematic diagram:
    a. Use graphic symbols to indicate the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing of the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.

b. Indicate connections to internal and external components connected to the panel. Note which devices are external to the panel.
c. Depicted in ladder logic format.
d. Indicates contact arrangement of internal and external devices such that circuits are complete and match equipment furnished.
e. Indicates equipment designations/tag numbers to match contract drawings and P&IDs.

2. Block diagram: A diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
3. Network block diagram:
   a. A diagram of the overall control system, containing annotated boxes showing the primary network components (controllers, hubs, routers, switches, computers, displays).
   b. Include annotated interconnecting lines showing the system communication media and communication protocols.
   c. Indicate manufacturer and model of the primary network components and software.
   d. Indicates functions performed by each device (e.g., Historical Data Server, Field controller, Database Server, Operator workstation, etc.)
4. Connection diagram:
   a. Purpose is to show wiring requirements between internal panel components.
   b. Show components of a control panel in an arrangement similar to the actual panel layout.
   c. Indicate internal wiring between components.
   d. Show terminal blocks used for internal wiring and field wiring, with identification as such.
   e. Indicate insulation color code, signal polarities, wire numbers, and terminal block numbers.
5. Interconnection diagram:
   a. Purpose is to show wiring requirements between panels, standalone devices, components, and instruments.
   b. Indicate wire numbers, cable numbers, raceway numbers, terminal box numbers, terminal block numbers, panel numbers, and field device tag numbers.
   c. Show external connections between terminals of equipment and outside points, such as motors and auxiliary devices.
   d. Indicate references to connection diagrams that interface to the interconnection diagrams.
   e. Interconnection diagrams are to be of the continuous line type. Show bundled wires as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable.
   f. Show termination of each cable. Clearly mark each termination point. Show each wire's identification as actually installed. The wire identification for each end of the same wire shall be identical. Identify devices and equipment.
   g. Depict terminal blocks as actually installed and identified in the equipment with individual terminal identification.
   h. Indicate external jumpers, shielding, and grounding terminations.

i. Indicate polarities for signal and DC circuit.
j. Depict spare wires and cables installed or slated for installation.

6. Arrangement, layout, or outline drawings:
   a. Show the physical space and mounting requirements of a piece of equipment.
   b. Indicate ventilation requirements and space provided for connections or the location to which connections are to be made.
   c. Indicate clearance requirements for ventilation and access.
   d. Show the dimensioned external and interior control panel views with components and Bill of Material.
7. Loop diagrams:
   a. Prepared per ISA 5.4 – Loop Diagrams using the sample Loop Diagrams on the drawings attached to this section.
   b. Show device element wiring of the system. Indicate device terminations, with terminal numbers.
   c. Show circuits for hardwired device interlocks.
   d. Show circuit cable and wire cable numbers, signal polarities, and terminal block numbers.
   e. Show connection to power supplies. Include alternating current (AC) and direct current (DC) power supplies and circuit information for instruments furnished under this contract.
   f. Indicate controller or I/O card address/node, rack, slot, and point wiring terminals.
   g. Show power supplies for signal loops. Indicate in which panel components reside and power originates with circuit numbering/name. Where new/modified loops connect to an existing power supply, show the existing power supply name, location, and circuit.
   h. Indicate surge protection type, manufacturer, and model number (i.e., types include floating ground reference or grounded reference).
   i. Show new and modified terminal blocks with numbering in new and existing panels.
   j. Indicate signal loop grounding terminations.
   k. Indicate loop numbers, wire numbers, and cable numbers used in field wiring and panel wiring.
   l. Indicate field element being controlled or monitored (i.e., normally open contact from relay CR17, or FIT 365).

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the process and instrumentation control system for proper operation with related equipment and systems specified in other Divisions.
   2. Integrate equipment in conformance with the drawings, specifications, and recommendations of the equipment manufacturer and the related processes equipment manufacturers.

3. Obtain manufacturer's technical information for items of equipment not provided with, but connected to, the control system. Provide the necessary coordination and components for correct signal interfaces between equipment and the control system.
4. Coordinate interface requirements and schedule with other project subcontractors and equipment suppliers.
5. Present to the Construction Manager conflicts between the plans, specifications, manufacturer/vendor drawings, and installation instructions, etc. for resolution before proceeding.

1.06 SUBMITTALS

A. General:
   1. Procedures: Section 01 33 00.
   2. This article indicates general requirements applicable to all PICS submittals. Additional information to be submitted with each section will be listed under Action Submittals or Closeout Submittals in this and each related section.
      a. Submit all information for sections covered by a submittal as a complete package in one submittal. Partial submittals of a section from multiple vendors showing contractor's division of equipment, labor, or portions of the work are not acceptable.
      b. Include a table of contents in each submittal divided by specification section and content of each section such as drawings and components. Clearly indicate the article or paragraph to which each table of content item applies.
      c. Related sections indicate additional detail for each submittal.
      d. Bookmark PDF submittals to match the table of contents of each submittal. Submitted information is to conform to the following:
      e. Shop Drawings: Prepare drawings in AutoCAD version 2019with borders and title blocks identifying the project, system, revisions to the drawing, and type of drawing. Include a date and description for each revision of a drawing including the date and description of the revisions. Drawing prints shall be 11" by 17" with a minimum lettering size of 1/8". Generate drawings using Owner-furnished drawing borders and title blocks, and in adherence to Owner's drawing standards.
      f. Product Literature: Provide manufacturer's specifications, data sheets, and catalog literature for the equipment and components that clearly and unambiguously show what is being provided and that it meets the requirements specified. Indicate provided and available options, materials of construction, environmental characteristics, electrical characteristics, and connection requirements. Include only applicable information.
      g. Conformance with Contract Documents:
         1) Provide a copy of sections applicable to the submittal group with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. .
         2) Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote them with a number in the margin to the right of the identified paragraph. Paragraph portions not underlined signify specification compliance. Include a detailed, written justification for each

deviation. Show conformance with all paragraphs in a section. Failure to include a copy of the marked-up specification sections and justification(s) for requested deviations is cause for rejection of the entire submittal with no further consideration.

3) Mark a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings "no changes required." Failure to include copies of the relevant drawings with the submittal is cause for rejection of the entire submittal with no further review. Contract drawings would include the following:
   a) Network system block diagrams
   b) Cabinet and panel arrangement drawings
   c) Control single-line diagrams
   d) Process and instrumentation diagrams
   e) Loop diagrams
   f) Equipment installation details
4) Show conformance across suppliers and vendors in one submittal. Partial submittals from multiple vendors showing contractor's division of labor or portions of the work are not acceptable.
5) Provide a detailed written request and explanation for each deviation. Failure to include a copy of the marked-up specification sections and drawings, along with justification(s) for requested deviations to the contract requirements, with the submittal, is cause for rejection of the entire submittal with no further consideration.

B. Closeout submittal general requirements.
   1. Procedures: Section 01 78 23.
   2. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.
   3. Include the following in each operation and maintenance manual:
      a. Final reviewed submittals, including revised as-built record drawings.
      b. Manufacturer's operation and maintenance instructions, edited for this project.
      c. Written record of menu configuration, jumpers, switch settings, and other configurable parameters for each instrument.
      d. Final application software configurations, in the software native format. Include a comprehensive report print-out from each controller CPU in full color. Provide in Adobe PDF format on compact disc media.
      e. Final network equipment software configurations.
   4. Markup of existing O&M documentation that show modifications to existing panels, communications, and loops/wiring.
   5. Maintenance Material Submittals
      a. Provide one listing of spare parts that is divided by specification section.
      b. Include list prices for spare parts, expendable supplies, and tools.

c. Indicate spare parts packaging and storage methods.
d. Indicate spare parts or components that could be deleted or reduced based on manufacturer's recommendations.
e. Indicate where manufacturer's recommendations exceed the spare parts specified.
f. Obtain spare parts from the equipment manufacturer. Do not provide third-party equivalent replacements.
g. Packaging, Testing, and Storage:
    1) Provide protective toolboxes for special tools.
    2) Test spare boards, circuit cards, power supplies, and similar spare electronic assemblies on site prior to acceptance.
    3) Carefully repackage operable parts. Immediately remove inoperable parts from the site and order replacement parts. Test replacement parts prior to acceptance.
    4) Package spare parts for protection against dirt and moisture. Label each package as to its contents with a description and part number.
    5) Do not place spare parts for different equipment items in the same package.

C. Action Submittals
1. Quality Assurance (within 30 days of contract Notice to Proceed):
    a. Systems Integrator qualifications per paragraph 1.08, Quality Assurance.
    b. Project personnel qualifications per paragraph 1.08, Quality Assurance.
2. System Overview
    a. Network block diagram
    b. System description
3. Interconnection Diagrams per paragraph 1.02.
    a. Between all System Integrator furnished equipment and all other connected equipment. Include terminal numbers for all other connected equipment.

D. Closeout Submittals
1. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.

1.07 QUALITY ASSURANCE

A. All work covered by Sections 40 06 70 through 40 76 00 shall be the responsibility of a single Systems Integrator as defined within this article.

B. The instrumentation and control system functions are shown on the drawings and specified in subsequent sections of Division 40. The Systems Integrator drawings and integration practices shall be as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.

C. Demonstrate the overall system performance to the Owner for acceptance.

D. Systems Integrator qualifications:
   1. The following Systems Integrators are pre-qualified to perform the work specified in Division 40 without the need to provide Evidence of Experience:
      a. Woodard and Curran, Canton, MA.
      b. Only the firms above will be allowed to provide this work.

E. Systems Integrator Personnel Qualifications: Provide qualified personnel to complete the work specified for this project. Demonstrate by including the following:
   1. Organization chart and resumes for proposed project personnel showing experience for the proposed roles on this project.
   2. Training and certification information. Completion of the following training courses or appropriate portions thereof or possession of the following certifications included with the Systems Integrator's personnel experience requirements described above:
      a. Project manager: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or Project Management Professional (PMP) certification.
      b. Systems engineer: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or completion of the relevant core courses in the Engineering Skills Training program as certified by ISA.
      c. Programmer: Certified by the software/hardware manufacturer for the software and hardware being used on the project, or Control System Engineer (CSE), or Professional Engineer (PE) registration.
      d. Field instrument technician: Certified Control Systems Technician (CCST) registration or completion of the relevant core courses in the Technical Skills Training program as certified by ISA.

1.08 ENVIRONMENTAL CONDITIONS

A. Ambient conditions: Per Section 01 11 80

B. Corrosive locations: Per Division 26.

C. Hazardous (Classified) areas: Per Division 26 and on the contract drawings.

PART 2 PRODUCTS

2.01 EQUIPMENT/MATERIALS

A. General requirements:
   1. New.
   2. Free from defects.
   3. Rated for the installed environment.

B. Similar control system components, instrument, instrument accessory, and devices used throughout the work shall be manufactured by one firm, where possible.

C. The components, modules, devices, and control system equipment shall be recognized industrial-quality products. Recognized commercial- or office-grade products are prohibited.

D. Use electronic equipment of solid-state construction with printed or etched circuit boards of glass epoxy of sufficient thickness to prevent warping.

E. Equipment supports: hot-dip galvanized after fabrication or shall be 316L stainless steel, as shown or specified.

2.02 SOFTWARE

A. Software packages are to be latest versions available or compatible with existing software currently in use.

2.03 ENCLOSURES

A. Table A specifies the instrument and control panel enclosure material and minimum NEMA rating for the location and application where not identified in other specification sections.

TABLE A

Location	Enclosure Material and NEMA Rating
Indoor: architecturally finished area	NEMA 12: mild steel
Indoor: electrical room	NEMA 12: mild steel
Indoor: process areas	NEMA 4X: 316 stainless steel
Indoor: corrosive area	NEMA 4X: 316 stainless steel
Outdoor: corrosive area	NEMA 4X: 316 stainless steel
Outdoor: non-corrosive areas	NEMA 4X: non-metallic, UV-resistant
Corrosive area (hypochlorite)	NEMA 4X: non-metallic
Hazardous area	NEMA 7: galvanized malleable iron or aluminum or NEMA 4X and UL listed or FM approved for the hazardous area. Where no such enclosure is available, enclosure ratings shall be for the indoor or outdoor area and shall be made intrinsically safe.
Hazardous and corrosive area	NEMA 7: iron or aluminum with factory-applied corrosion-resistant coating or NEMA 4X and UL listed or FM approved for the hazardous area. Where no such enclosure is available, enclosure ratings shall be for the indoor or outdoor area and shall be made intrinsically safe.

2.04 NAMEPLATES

A. Provide nameplates for field-mounted instrument, analyzer, or equipment covered by this section with the following requirements:
   1. Include the equipment or instrument loop title and the instrument or equipment tag number, where nameplate engraving is not specified or shown.
   2. machine engraved white phenolic with black with 3/32-inch-high lettering, as minimum, unless otherwise specified or shown.

B. Nameplate wording may be changed without additional cost or time, if changes are made prior to commencement of engraving.

C. Attach nameplates to support hardware with a minimum of two self-tapping type 316 stainless steel screws in a readily visible location so the nameplate will remain to identify

the service when the device is removed. Attach field instrument nameplates with braided stainless steel straps where not stand-mounted.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify field measurements prior to fabrication.

3.02 INSTALLATION

A. General:
   1. Install equipment in locations that are accessible for operation and maintenance services.
   2. Installation, calibration, settings, and testing procedures are specified in Section 40 61 13, Section 40 06 70-3.03, and subsequent sections of Divisions 26 and 40.

B. Field Equipment:
   1. Space instruments and cabinets from concrete walls by 5/8 inch with framing channel between instrument or cabinet and wall. Add supports to block wall to avoid damage to the wall.
   2. Design support systems, including panels, in accordance with Section 01 73 24 to prevent deformation greater than 1/8 inch in any direction under the attached equipment load and under an external load of 200 pounds.
   3. In wet or outdoor areas, make conduit penetrations into instrument housing or panels through the bottom (preferred) or side of enclosures to minimize water entry from around or from inside of conduits. Provide conduit hubs for connections and waterproof mastic for moisture sealant.
   4. Provide nameplates for field-mounted equipment. Attach nameplates in a readily visible location, but such that if the field device is replaced, the nameplate will remain to identify the service.

3.03 FIELD QUALITY CONTROL

A. Delivery Inspection:
   1. Notify the Owner's Representative upon arrival of material or equipment to be incorporated into the work. Remove protective covers or otherwise provide access in order that the Owner's Representative may inspect such items.

B. Inspection and Installed Tests:
   1. Refer to Section 40 61 21.

3.04 CLEANING

A. Execute final cleaning prior to final project assessment.

B. Clean surfaces exposed to view, remove temporary labels, stains, and foreign substances.

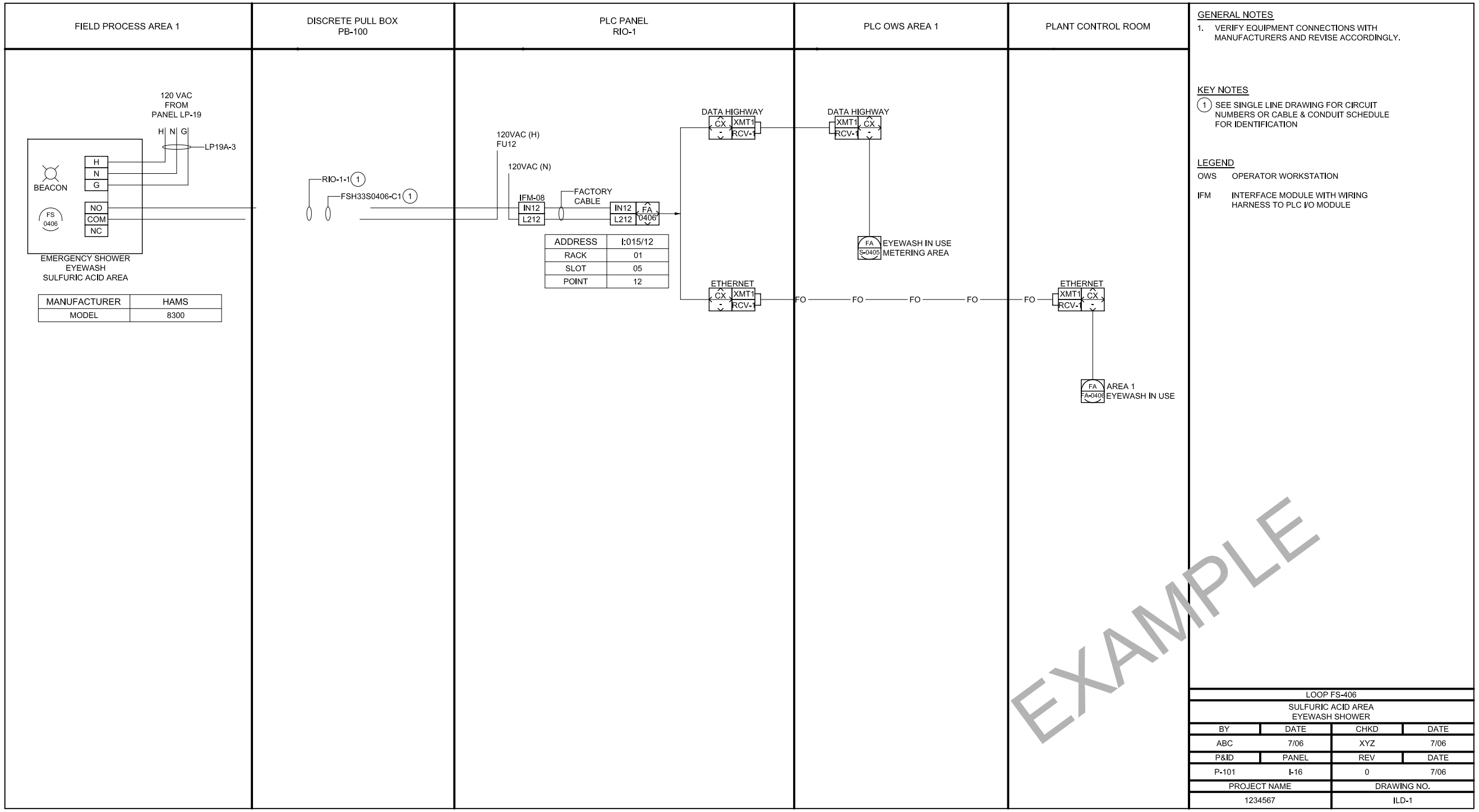
C. Replace filters of operating equipment.

D. Remove waste and surplus materials, rubbish, and construction facilities from site.

PART 4 ATTACHMENTS

A. Attachment 40 61 13 A – Sample Loop Drawings

END OF SECTION

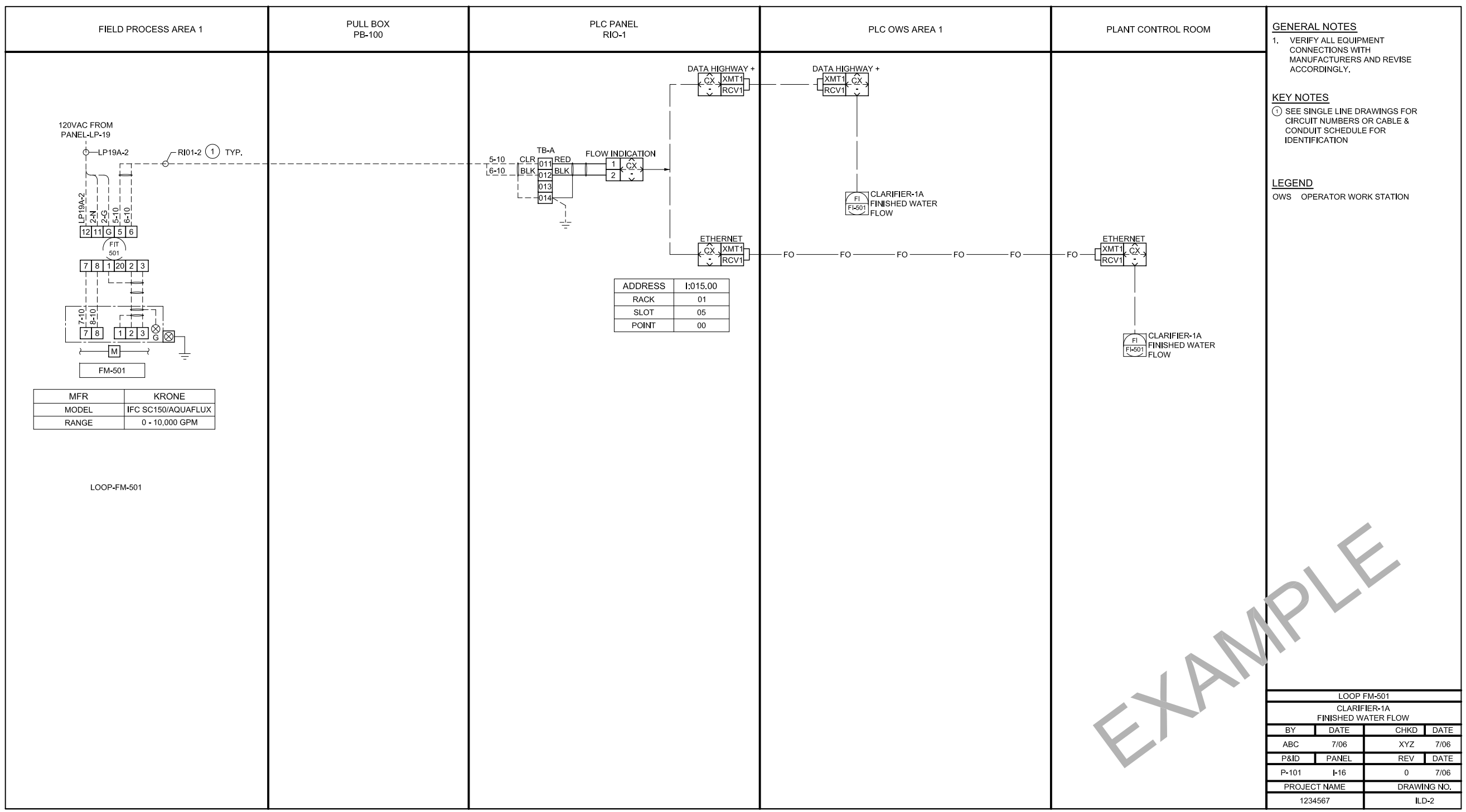


NOTES TO THE DESIGNER:
- NONE.

LOOP DIAGRAM
TYPICAL DISCRETE LOOP
DETAIL I1001

SCALE: NONE

DISCIPLINE: INSTRUMENTATION	BROWN AND CALDWELL	SUPERCATEGORY: DRAWINGS
NUMBER CATEGORY: 10		DETAIL ID AND TITLE: 01 LOOP DIAGRAM TYPICAL DISCRETE LOOP
LOOP DIAGRAM		
VER: A | GUIDE APPROVED | TSG: EPAS		APPVD: H. PACE | DATE: 11/28/2006

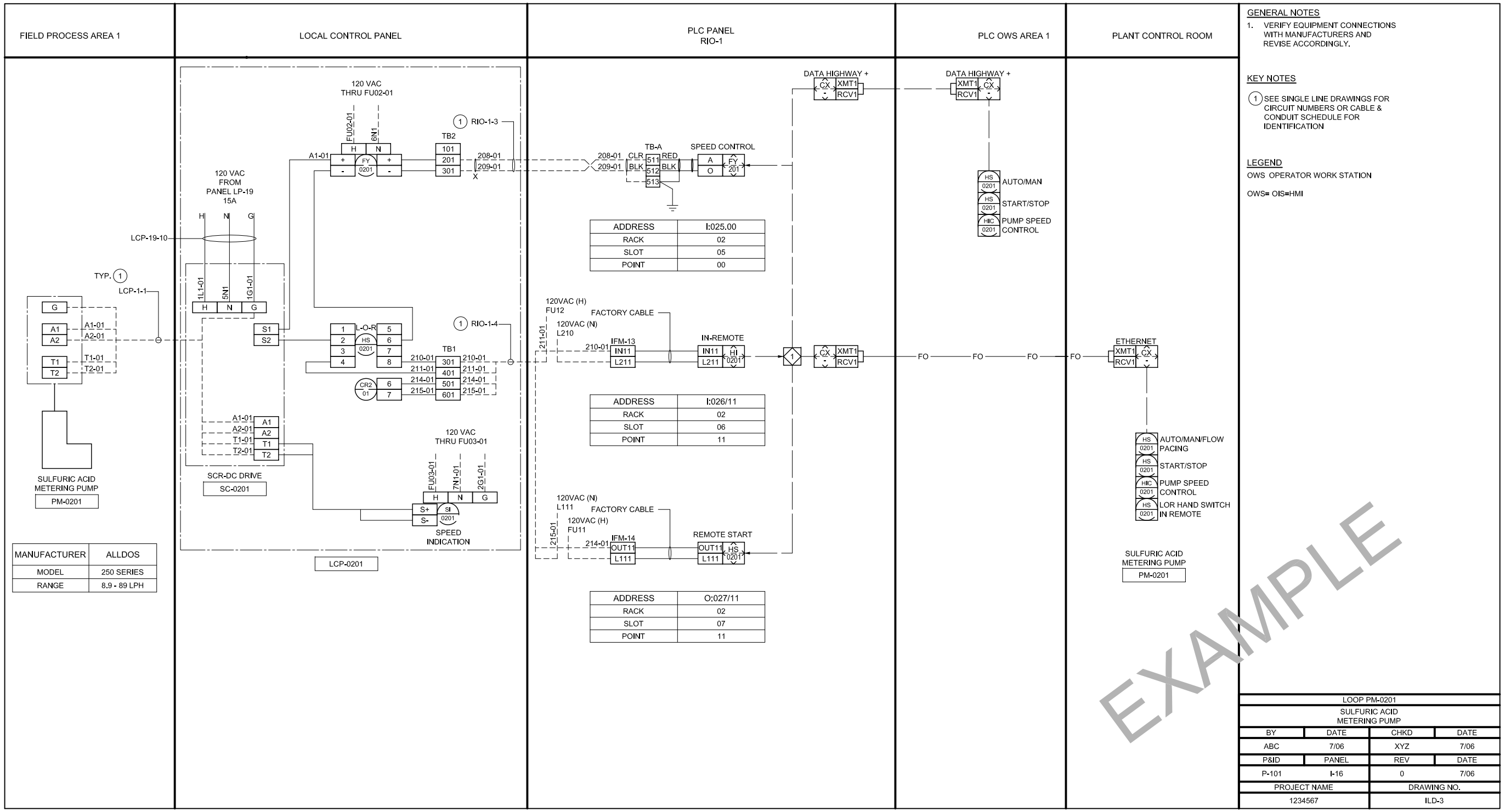


NOTES TO THE DESIGNER:
- NONE.

LOOP DIAGRAM
TYPICAL ANALOG LOOP
DETAIL I1002

SCALE: NONE

DISCIPLINE: INSTRUMENTATION			SUPERCATEGORY: DRAWINGS
NUMBER CATEGORY: 10 LOOP DIAGRAM		BROWN AND CALDWELL	DETAIL ID AND TITLE: 02 LOOP DIAGRAM TYPICAL ANALOG LOOP
VER: A	GUIDE APPROVED TSG: EPAS		APPVD: H. PACE DATE: 11/28/2006



GENERAL NOTES

1. VERIFY EQUIPMENT CONNECTIONS WITH MANUFACTURERS AND REVISE ACCORDINGLY.

KEY NOTES

(1) SEE SINGLE LINE DRAWINGS FOR CIRCUIT NUMBERS OR CABLE & CONDUIT SCHEDULE FOR IDENTIFICATION

LEGEND

OWS OPERATOR WORK STATION

OWS= OIS=HMI

LOOP PM-0201			
SULFURIC ACID METERING PUMP			
BY	DATE	CHKD	DATE
ABC	7/06	XYZ	7/06
P&ID	PANEL	REV	DATE
P-101	I-16	0	7/06
PROJECT NAME		DRAWING NO.	
1234567		ILD-3	

NOTES TO THE DESIGNER:
- NONE.

LOOP DIAGRAM
TYPICAL COMPLEX LOOP
DETAIL I1003

SCALE: NONE

DISCIPLINE: INSTRUMENTATION	BROWN AND CALDWELL	SUPERCATEGORY: DRAWINGS
NUMBER CATEGORY: 10 LOOP DIAGRAM		DETAIL ID AND TITLE: 03 LOOP DIAGRAM TYPICAL COMPLEX LOOP
VER: A | GUIDE APPROVED | TSG: EPAS		APPVD: H. PACE | DATE: 11/28/2006

SECTION 40 61 21

PROCESS CONTROL SYSTEM TESTING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies testing requirements applicable to Sections 40 06 70 through 40 76 00 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a PICS Testing Manager meeting the Qualifications section of this specification. Section includes:

1. Testing documentation.
2. Testing organization and sequencing.
3. Performance testing.
4. Loop testing.
5. Functional testing.
6. Operational testing.

B. Related sections:

1. Section 40 06 70 – Schedules for Instrumentation of Process Systems
2. Section 40 61 13 – Process Control System General Provisions
3. Section 40 61 96 – Process Control Descriptions

1.02 REFERENCES

A. Definitions:

1. The term “instrumentation” covers field and panel instruments, analyzers, primary sensing elements, transmitters, power supplies, and monitoring devices.

B. Reference Standards:

1. This section contains references to the following documents with additional references listed in Section 40 61 13.
    a. References are part of this section as specified and modified. In case of conflict between the requirements of this section and those of the referenced documents, the requirements of this section prevail.
    b. Version: Latest documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no bids) unless noted otherwise.
    c. If referenced documents have been discontinued by the issuing organization, use the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
    d. Where document dates are given in the following listing, reference to those documents means the specific document version associated with that date, whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ISA RP7.1	Pneumatic Control Circuit Pressure Test
ISA S51.1	Process Instrumentation Terminology

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate testing with Section 01 45 20.
   2. Provide notice to the Construction Manager prior to conducting a test.
   3. Provide a detailed step-by-step test procedure, between 60 and 70 days before the commencement of testing activity, complete with forms for the recording of test results, testing equipment used, and a place for identification of the individuals performing and witnessing the test.
   4. Provide detail assistance to the Contractor in generating Section 01 45 20-Form A, customized for this project. Submit detailed form prior to testing per the requirements of Section 01 45 20.
   5. Equipment and System Performance and Operational Testing: Section 01 45 20 specifies testing of the mechanical, electrical, instrumentation, and HVAC systems. Coordinate, manage, and supervise the work with the quality assurance program including:
      a. Testing plan with the sequence for the test work.
      b. Calibration program for instruments and analyzers.
      c. Documentation program that records tests results.
      d. Performance testing program systems.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Action Submittals:
   1. Quality Assurance submittal:
      a. PICS Testing Manager Qualifications.
      b. Testing Technician Qualifications.
   2. Testing submittal:
      a. Submit detailed testing plan and proposed testing documentation after review of the Quality Assurance submittal showing conformance with Part 2 of this specification. Obtain approved submittal prior to testing. Separate submittals may be provided for each test group:
         1) Control descriptions.
         2) Input/Output (I/O) interface.
         3) Testing status spreadsheets.
         4) Test procedures.
         5) Proposed test forms per this section, detailed for each test for this project.

C. List of Certified Factory Calibration Reports. Closeout Submittals

1. Final Test Report assembled in a three-ring binder and submitted at the completion of the inspection and testing activities for a process area.
    a. Label the binder cover and spine to identify the project name and process area. Include in the test report the applicable test procedures for the process area and the completed inspection and test report forms associated with the equipment and systems of that area.
    b. Organize test results by equipment item or system with individual, labeled tab dividers to identify each. The responsible testing entity is to acknowledge system deficiencies and noncompliant test results identified in the final test report as corrected.
    c. Test equipment and test equipment calibration date.
    d. Certified factory calibration reports.
    e. Performance test results.
    f. Loop test results.
    g. Functional test results.
    h. Operational test results.

1.05 QUALITY ASSURANCE

A. Appoint a startup engineer or qualified specialist as PICS Testing Manager to manage, coordinate, and supervise the testing work.

B. The quality assurance program includes:

1. Definition of process areas and systems, with testing executed on an area-by-area basis, based on the P&ID drawings.
2. Regularly updated testing status tracking by pump station and task.
3. Regularly updated separate testing documentation for each process system.

C. PICS Testing Manager Qualifications:

1. The PICS Testing Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the testing and startup of similar electrical and instrumentation control systems.

D. Testing Technician Qualifications:

1. Employ technicians who are qualified by completion and certification from training courses offered by the International Society of Automation (ISA), the instrumentation and analyzer manufacturer's training courses, or technician training courses at a recognized trade school that specializes in instrumentation calibration.

PART 2 PRODUCTS

2.01 GENERAL

A. Test forms: Conform to the requirements of Reference Forms 40 61 13-A through 40 61 13-K included in Section 01 99 90. Develop additional or detailed forms as necessary to suit complex instrumentation. Use terms on test forms that comply with ISA S51.1.

B. Project Labeling:
   1. The items specifying project labeling herein include the following as a minimum: Owner's name, facility name, project name, and project number.

2.02 TESTING DOCUMENTATION

A. Documentation Records:
   1. Develop a record-keeping system to document progress and completion for each task in each process area or system. Coordinate overall organization of areas and systems with overall testing required by Section 01 45 20, Equipment and System Performance and Operational Testing.
   2. Always keep documentation current and available for inspection on site in a location designated by the Construction Manager:
      a. PICS Testing Manager's qualifications, project startup, and testing history, including resume per paragraph 1.02 PICS Testing Manager.
      b. List of names of Contractor's and System Integrator's personnel associated with final construction and testing, and normal and emergency contact telephone numbers
      c. Testing Status spreadsheet with breakdown for each process area and process system, with percentage complete on each testing sequence task.
      d. Testing status specific to pre-loop test and loop testing status spreadsheet to include the I/O list organized by area and system and loop number. Percent complete of the PICS system will be based on percentage of I/O points tested.
      e. Test Report Volumes.

B. Test Report Volumes:
   1. Develop and maintain testing documentation for each process area or system in separate volumes. Always keep each volume current and available for inspection on site in a location designated by the Construction Manager. Include the following as a minimum:
      a. Three-ring binder with front cover and spine labeled: "Testing Documentation for (applicable) Process Area / Process System" including project labeling.
      b. Table of Contents with same labeling as the volume cover with tabs for each section:
      c. Section 1: Control Description
      d. Section 2: I/O Interface
      e. Section 3: Instrument Index
      f. Section 4: Test Procedures and Forms
      g. Section 5: Certified Factory Calibration Reports
      h. Section 6: Test Report

C. Control Description:
   1. Provide a control description outlining operation for each process area's system. The Control Description Specification Section 40 61 96 may be used as a basis.

D. I/O Interface:
   1. Provide I/O spreadsheets for each process area's system. Spreadsheets are to include the following for each new I/O point:
      a. Signal number/tag.
      b. Annotation description that may be logically abbreviated and that is subject to approval.
      c. Complete physical I/O channel designation and addressing or communication I/O register designation.
      d. True/false status designations for digital I/O.
      e. Process range; engineering units and multipliers; and raw signal range count for analog I/O.
      f. Signals: Fixed point and scaled at the controller with minimum four significant implied digits of scaling; e.g., 0 to 1,400 at controller for a pH range of 0 to 14 at operator interface.
      g. Provide operator interface scaling to display decimal digits required.
      h. Indicate pass/fail for each point for both pre-loop test and loop tests.
      i. Indicate date of tests and comment for failed points.

E. Instrument Index:
   1. Provide a detailed Instrument Index. The Instrument Index from Section 40 06 70 may be used as a basis. Indicate actual calibration ranges, set points, and deadbands.

F. Field Test Procedure Documentation:
   1. Organize and assemble test procedures for each analog and discrete loop in the process control system in separate volumes for each process area or test group. Organize by I/O point. Submit final test records in electronic form by scanning and converting the records and files to Adobe PDF format, to preserve actual signatures and signoffs.
   2. Include a detailed, step-by-step description of the required test procedure, panel and terminal block numbers for points of measurement, input test values, expected resultant values, test equipment required, process setup requirements, and safety precautions.
   3. Include test report forms for each loop, including forms for wiring, piping, and individual component tests, with the test procedure documentation. Record the actual test results on these forms and assemble them into final test reports.
   4. Preprint and populate information in the test report forms to the extent possible prior to commencing testing.
   5. Include on the test report forms:
      a. Project name.
      b. Process area associated with the equipment under test.
      c. Instrument loop description.
      d. Instrument loop identification number.
      e. Instrument nameplate data.
      f. Instrument setup and configuration parameters.
      g. Time and date of test.

h. Inspection checklist and results.
i. Reference to applicable test procedure.
j. Expected and actual test results for each test point in the loop including programmable controller data table or register values.
k. Test equipment used.
l. Space for remarks regarding test procedure or results, observations, etc.
m. Name, date, and signature of testing personnel.
n. Test witness's name and signature.

PART 3 EXECUTION

3.01 GENERAL

A. General Requirements:
1. Provide the labor, tools, material, power, and services necessary to provide the process instrumentation and control system inspection and testing specified herein.
2. Inspect materials, equipment, and construction included under this specification in accordance with this section and subsequent sections of this division. Perform testing in accordance with this and subsequent sections of this division.
3. Have a certified instrument technician qualified to calibrate the instrumentation calibrate and set up field instruments and analyzers.

B. Test Equipment and Materials:
1. Provide test equipment to conduct the specified tests that simulate inputs and read outputs with a rated accuracy at the point of measurement at least three times greater than the component under test.
2. Provide a calibration sticker on test instruments showing date of calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required. Include certified calibration reports traceable to the National Institute of Standards and Technology with the final test report.
3. Provide a documenting calibration system to conduct process instrumentation calibration activities that consist of a documenting process calibrator and an instrumentation data management software system that captures the calibration results and electronically document instrument data, date of calibration, calibration procedures, and as-found and as-left instrument calibration data.
4. Provide an instrument calibration system such as Fluke 743B with Fluke DPC/Track Instrumentation Management software or similar system. Submit calibration files with the final test report in hard-copy and electronic formats that does not require specialized equipment or software to read and print the files.
5. Provide buffer solutions and reference fluids for tests of analytical equipment.
6. Vendor software tools may document the systems where a licensed copy of the identical software including connectors, cables, keys, interface cards, and devices required for operation is submitted with the final documentation files.
7. Performance Deviation Tolerances:
8. Tolerances are specified in individual sections. Where tolerances are not specified, refer to the manufacturer's published performance specifications.

9. Calculate overall accuracy requirements for loops consisting of two or more components, by the root-summation-square (RSS) of the component accuracy specifications. Calculate and record tolerances for each required calibration point on the associated test report form.

C. Witnessing:
   1. The Construction Manager reserves the right to observe factory and field instrumentation testing and calibration procedures. Notify the Construction Manager prior to testing, as specified herein.

3.02 TESTING SEQUENCE

A. Perform tests for each area or system in the following sequence:
   1. Performance testing
   2. Loop testing
   3. Functional testing
   4. Operational testing

B. Group equipment and I/O based on the relationship of the equipment to operate safely as specified, including full automatic and manual control and monitoring through the control system. Equipment and I/O in a given area or system shall pass testing prior to proceeding to the next set of tests in the sequence above.

3.03 PERFORMANCE TESTING

A. Perform tests in the order below.

B. Wiring Tests:
   1. Verify that electrical power and signal cable ring-out and resistance testing has been performed as specified in Section 26 05 00. Conduct wiring tests after cables have been properly terminated, tagged, and inspected.
      a. Power and Control: Section 26 05 00.
      b. Signal: Section 40 61 13-Form A.

C. Network and Bus Cable Inspection and Testing:
   1. Inspected and tested by independent industrial network testing firms.
   2. Test proprietary bus systems by the manufacturer's qualified field services technician. Manufacturer's sales personnel are not considered to be qualified technicians unless qualifications are documented and certified by the manufacturer.
   3. Have a qualified independent network testing service test standardized networks and buses. The following types of cabling and networks shall be tested and certified by the independent industrial network testing firm:
      a. Ethernet system cabling.
      b. DeviceNet trunk and branch cabling.
      c. Other networks provided as a part of a packaged monitoring or control system.
   4. Test and verify control and instrumentation bus cabling using the standards that apply to the specific cable and bus type as follows:
      a. Ethernet Category 5E and Category 6: per TIA/EIA-568B standards.

b. DeviceNet: Open DeviceNet Vendors Association.

5. Pre-Active Testing: Inspect and test cables prior to energizing to verify the following:
   a. Media type and specifications.
   b. Physical routing and project-specific cable identification tagging.
   c. Correct termination installation and connection of conductors to pins at terminations.
   d. Record cable run length and compare to the manufacturer or industry standards to verify that lengths are within specifications.
   e. Locations and values of network termination resistance.
   f. Integrity and grounding of cable shields.
   g. Values of transient protection (surge) elements.
   h. Firmware revision level of network devices available prior to energization.
   i. Settings of dip switches and configuration parameters.
6. Active System Testing: After the cable or network system has been activated for testing, provide diagnostic monitoring and signal analysis for the bus network system to evaluate network and bus integrity and data transfer quality. Measure, verify, and record the following parameters:
   a. Node addressing.
   b. Signal attenuation before and after a repeater device and at the farthest point in the network.
   c. Total network trunk voltage and current loading as applicable.
   d. Baud rate, message traffic rate, percent bandwidth used, error rate, and lost packet count.
   e. Firmware revision level of the network devices.
   f. Pre-active and active testing: within the specified range of values established by the referenced standards.
   g. Correct the functionality of networks and devices connected to the network.

D. Piping Tests:
   1. Pneumatic Piping Systems: Tested for leaks in compliance with Section 40 05 01. Test pneumatic piping systems for leaks in compliance with ISA RP7.1, except performed at 10 times the normal system operating pressure. Test Section 40 61 13-Form B.
   2. Liquid Piping Systems: Tested for leaks in compliance with Section 40 05 01.

E. Instrument and Component Inspection:
   1. PICS components inspection activities include the following:
      a. Compare and validate instrument type and nameplate data with the drawings, specifications, and data sheet.
      b. Validate instrument identification tag.
      c. Confirm that instrument installation conforms to drawings, specifications, and manufacturer's instructions.
      d. Verify proper conductor termination and tagging.
      e. Visually check for physical damage, dirt accumulation, and corrosion.

f. Verify that isolation amplifiers, surge protection, and safety barriers are properly installed.

g. Report deficiencies identified within 24 hours of discovery. No instrument or system component shall be tested until deficiencies are addressed.

F. Instrumentation Calibration:

1. Calibrate instruments and final elements in accordance with the manufacturer's recommended procedures and tested in accordance with the Contractor's test procedure.
2. Complete and document instruments and component inspections to the satisfaction of the Construction Manager prior to individual component calibration and testing.
3. Calibrate analog instrument at 0, 10, 50, 90, and 100 percent of the specified full-scale range. Adjust each signal sensing trip and process sensing switch to the required setting. Verify instrument readout matches loop signal. Test data recorded on test forms as specified herein.
4. Test and adjust final element alignment to verify that each final element operates smoothly over the full range in response to the specified process control signals.
5. Enter test data on the applicable test forms at the time of testing: set alarm trips, control trips, and switches to initial values specified in Section 40 06 70 Instrument Index at this time. Check final elements for range, deadband, and speed of response.
6. Have any component repaired or replaced by the manufacturer where the component fails to meet the required tolerances. Repeat the specified tests until the component is within tolerance.
7. Install a calibration sticker on each instrument following successful calibration that indicates the date of calibration, the name of the testing company, and personnel who calibrated the instrument.
8. Test forms Section 40 61 13-Form C through K.
9. Certified Test Reports: Field test and inspection activities include verification of instrument parameter setup, verification of instrument zero, and performance at three operating points within the instrument range. Return each instrument that fails to demonstrate proper performance for recalibration or replaced as agreed depending on the impact to the project as determined by the Construction Manager.
    a. Where instrument field calibration is not feasible, certified factory calibration reports may be submitted that include the name and address of the laboratory that conducts the calibration testing. Certified factory test reports may be submitted for the following instrument types in lieu of field calibration:

G. Pre-Loop Testing:

1. Test every I/O point from the field device to the termination on the I/O card in the panel.
2. Perform tests with loop wiring complete and terminated for each point being tested between initial field device and I/O termination point.
3. For each discrete I/O point, verify and document contact status value for both the opened and closed positions of the contact.
4. For analog points, verify analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.

3.04 LOOP TESTING

A. Provide a request to perform loop testing at least 2 weeks prior to the requested loop test date. Include the following with the request:
   1. Area/system for which request is being made.
   2. Written certification that performance testing has been completed, documented, and passed for the area/system for which loop testing is being requested.
   3. Submittal numbers that define the tests and data points for the I/O to be tested. Provide updates to the I/O list or instrument calibration as an outcome of the performance testing.

B. Commence loop testing after the performance testing has been completed and documented to the satisfaction of the Construction Manager.

C. Test each instrument loop as an integrated system. Check operation from field instruments to transmitter to receiving components to the vendor panel or the Plant Control System Operator Interface Station. Inject test signals at the process impulse line connection where the measuring technique permits, and otherwise at the most primary signal access point.

D. For each discrete I/O point, verify and document field contact status value for both the opened and closed position of the contact.

E. For analog points, verify that analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.

F. Where loops are interfaced to a controller, verify the controller I/O assignment and operation of the input/output system and processor. Inspect the data table or register in the PLC memory to verify proper operation.

G. If the output control or monitoring device fails to indicate properly, make corrections to the loop circuitry or device. Repeat the test until devices and instruments operate as required.

H. Correct loop circuitry and repeat the test until the instruments operate properly.

I. Test Section 40 61 13-Form J.

3.05 FUNCTIONAL TESTING

A. Process Control Strategy/Functional Testing:
   1. Commence control strategy testing after loop testing has been completed and documented to the satisfaction of the Construction Manager.
   2. Control strategy testing, performed by the Programmer, consists of installing and debugging the PLC control logic program, verifying the interface points between the controller I/O cards and field devices and equipment, and exercising the control strategies. Perform control strategy testing on one PLC at a time.
   3. Provide qualified personnel to immediately correct deficiencies in the work that may be encountered during control strategy testing. Failure of the Contractor to provide

such personnel in a timely manner may prolong the time allotted to complete control strategy testing.

B. Control System Closed-Loop Testing:
   1. Commence closed-loop commissioning after the control strategy testing has been successfully completed and documented to the satisfaction of the Construction Manager.
   2. Demonstrate stable operation of each loop under operating conditions. Adjust loop tuning parameters as part of the test.
   3. Provide the loop response to a step disturbance for each loop. Provide two graphs for cascaded control loops, one showing the secondary loop response with its set point in manual, and the second showing overall loop response.
   4. Adjust control loops with “batch” features to provide optimum response following startup from an integral action saturation condition.
   5. Provide graph recording showing the response and made at sufficient speed and amplitude to show 1/4 amplitude damping. Label to show loop number and title, and settings of parameters and set point.
   6. Where a loop is controlled under the direction of a PLC, the Programmer will perform the necessary adjustment of loop tuning parameters and set points, record the loop response, adjusting final elements, and ensuring total integrated loop performance as specified.

C. Functional Checkout:
   1. Conduct to verify the operation of discrete and hardwired control devices, refer to Section 01 45 20. Exercise the operable devices and energize the control circuit. Operate control element, alarm device, and interlocks to verify that the specified action occurs.

3.06 OPERATIONAL TESTING

A. Perform the Operational Tests after component and subsystem tests have been completed. Perform the test of the completed system in full operation and demonstrate that functional requirements of this specification have been met. Demonstrate the following:
   1. Each component of the system operates correctly with other components of the system.
   2. Analog control loops operate in a stable manner.
   3. Hard-wired and software equipment interlocks perform correctly.
   4. Process control sequences perform correctly.
   5. Application program performs monitoring and control functions correctly.
   6. Operator interface graphics represent the monitoring and control functions correctly.

END OF SECTION

SECTION 40 61 96

PROCESS CONTROL DESCRIPTIONS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the added process monitoring and control strategies for Newton, MA 's remote pumping stations.

B. These control strategies are not intended to apportion work or responsibility for work among subcontractors, suppliers and manufacturers, but are offered as a guide for programming, startup, and checkout. They describe how the system is to operate, and do not necessarily include every component required to make the system function.

1. Control strategies describe sequential and interlocking control functions, analog control functions, color-graphic video display HMI Computers and Operator Interfaces and alarm and event logging. The System Programmer will provide all necessary software and applications programming to implement the control strategies. All control functions shall be programmed in the PLCs, the Operator Interfaces and HMI computers shall perform supervisory functions.
2. The System Integrator will configure Operator Interface and HMI computer screens for the new equipment installed at Oldham Road, Islington, Quinobequin, Edgewater, and Elliot Street pumping stations. The Systems Integrator will configure and update existing graphics for these pumping stations to include the new instrumentation and equipment and provide equipment status and alarming requirements for the abnormalities of the process and malfunctions of equipment.

C. The Contractor and Systems Integrator shall be responsible to provide all related hardware, software, system configuration, programming and modification to provide the automated functionality described herein as well as the labor and equipment to test the specified control strategies. The entire process control system application development encompasses field instruments and all controls systems provided by the major equipment suppliers. Process graphics screens, trending screens, database points, alarm points and reports shall be developed for all these systems

D. Programming of control logic for new equipment shall be developed by applying the descriptions contained herein and the Piping and Instrumentation Diagrams (P&IDs).

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below. Refer to Section 40 61 13 for additional details.

1.03 REFERENCES

A. This Section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this section prevail.

1. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ISA 5.06.01	Functional Requirements Documentation for Control Software
ANSI/ISA 101.01	Human Machine Interfaces for Process Automation

1.04 DEFINITIONS

1. Per ANSI/ISA 5.06.01:
   a. Analog Input (AI): A modulated signal received by the control system from an external device, such as a 4-20 mA or fieldbus signal from a pressure transmitter.
   b. Analog Output (AO): A modulated signal sent by the control system to an external control device, such as a 4-20 mA or fieldbus signal to a flow control valve.
   c. Discrete Input (DI): A binary signal received by the control system from an external switch, such as a 24-Vdc or fieldbus signal from a block valve's closed limit switch.
   d. Discrete Output (DO): A binary signal sent by the control system to an external on/off device, such as a 120-Vac or fieldbus signal to start a pump.
   e. Operation: A major programmed processing action or set of related actions normally consisting of one or more phases.
   f. Piping and Instrumentation Diagram (P&ID): A diagram showing the interconnection of process equipment and instrumentation used to control a process,
   g. Process Flow Diagram (PFD): A diagram showing outlines of one or more pieces of equipment and the expected flow paths for materials and utilities.
   h. Phase: The smallest element of procedural control that can accomplish a process-oriented task. A phase may be comprised of steps.
   i. Step: Sequential action of control devices within a phase.
2. Per ANSI/ISA 101.01:
   a. Control System: A system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner.
   b. Human Machine Interface (HMI): The collection of hardware and software used by the operator or other users to monitor and interact with the control system and with the process via the control system.
   c. Supervisory Control and Data Acquisition (SCADA): A system for monitoring and control of process which are geographically widespread. This includes all equipment and functions for acquiring, processing, transmitting, and displaying the necessary process information.

3. For the purposes of this section, "Existing" refers to those structures, devices, or items of equipment which were a part of the process system prior to the work done under this Contract

1.05 ADMINISTRATIVE REQUIREMENTS

A. The control strategies are not intended to apportion work or responsibility for work among subcontractors, suppliers and manufacturers, but are offered as a guide for programming, startup, and checkout. The control strategies describe how the system is to operate, and do not necessarily include every component required to make the system function.

B. Coordinate with the Programmer as specified in Section 40 61 13 for testing and commissioning.

1.06 SUBMITTALS

A. Procedures:
   1. Section 01 33 00.

B. Action Submittals:
   1. Conformance with specification per Section 40 61 13.

C. Closeout Submittals:
   1. Provide updated control strategies reflecting final programming configuration as record included in testing per Section 01 91 00.
   2. Fully documented PLC and HMI software application with updated I/O listing and CPU configuration, in native format.
   3. All operator interface screens fully documented to indicate component functionality, including color change due to alarm or event, navigation aids, process animations, and equipment descriptions. Final interface is to be approved by the Owner and Engineer.

PART 2 NOT USED

PART 3 EXECUTION

3.01 CONTROL STRATEGIES – GENERAL CONDITIONS

A. The following control strategies are included in this section and describe general control features for all systems.

Control Strategy Number	Title
1	Discrete Point Status
2	Analog Point Status
3	General Ready, Running and Failure Status
4	SCADA Inputs and Outputs Distribution and Control Requirements
5	General Recording System
6	General Contact/Logic System
7	General Process Control Function (Analog) System
8	Trend Plots

Control Strategy Number	Title
9	Color Notation for Dynamic Objects on Control Graphic Display Screens
10	Discrete Alarm System
11	Discrete Status System
12	Motor Monitoring System
13	Oldham Road Pumping Station
14	Remote Gas Detection and HVAC Upgrades for Quinebequin and Elliot Street Pumping Stations
15	Remote Gas Detection for Edgewater and Islington Pumping Stations

B. Arrangement:
   1. All logic and scaling is to be performed in the PLC, not in the HMI.
   2. The graphics shall be “MENU” driven. All operator functions shall be selected from a Master menu or submenu, including system configurations.
   3. An overview screen will be developed for the OIT at Oldham Road that will summarize the status of major systems, levels, flows, and analytical readings. Provide navigation buttons to get to more detailed graphical displays. This overview screen shall be based on the Piping and Instrumentation Diagrams. As a minimum, one graphical screen for each Piping and Instrumentation Diagram drawing in the Contract documents. Provide an alarm overview and operator setpoint entry screen for local control of the station.

C. Refer to related sections for detailed process control system descriptions.

Control Strategy 1
Discrete Point Status

A. Reference Drawings:
   1. All P&IDs.

B. System Components:
   1. In accordance with P&IDs.

C. Description:
   1. The status of each discrete input point shall be maintained in the SCADA system database. The status of each logical discrete point shall also be maintained in the SCADA system database. Logical points are points which depend upon the status of one or several discrete input points.
   2. For example, an equipment-failed logical status will result from a loss of ready status when running. Loss of ready status when NOT running will not result in a failed logical status.
   3. Coordinate inclusion of timers to moderate the effects of fluttering field devices and alarm conditions with the Owner and Engineer.

D. SCADA:
   1. Calculate and maintain the status of all discrete and logical discrete status points in the SCADA system database.

End of Control Strategy 1

Control Strategy 2
Analog Point Status

A. Reference Drawings:
   1. All P&IDs.

B. System Components:
   1. In accordance with P&IDs.

C. Description:
   1. Analog input points shall be checked for the following status conditions:
      a. Failed: Point value is less than or greater than the specified value range, typically less than 3.6 mA and greater than 21.6 mA.
      b. Low Alarm: Point value is equal to or less than a predetermined alarm value.
      c. High Alarm:Point value is equal to or greater than a predetermined alarm value.
      d. High Alarm: Point value is equal to or greater than a predetermined alarm value.
      e. Normal: Point value is within the predetermined low and high alarm values.
   2. An analog point which is in alarm status shall not be changed to normal status until the point value changes by the predetermined deadband value for the point.

D. SCADA:
   1. Failed, high alarm, low alarm, and deadband values shall be maintained in the SCADA system database. These limits may be changed via the SCADA programmer.
   2. Point status shall be maintained in the SCADA system database. Discrete alarm outputs shall be driven from the point status.

End of Control Strategy 2

Control Strategy 3
General Ready, Running and Failure System

A. Each motor-driven piece of equipment shall have a RUNNING status input to the SCADA system. If the equipment is equipped with one or more HAND-OFF-AUTO switches, the equipment shall have an input for AUTO status. If a "RUNNING" input status occurs and the "AUTO" status does not occur, the SCADA system shall identify that the motor is operating in the HAND mode.

B. The run time shall be calculated and stored for all equipment being monitored. This function shall be equivalent to a conventional elapsed time meter to include the tenth of an hour digit and shall include: Today's Total and Yesterday's total and Cumulative Total. Program a setpoint to set a flag for maintenance of equipment. Program an adjustable timer to set a flag for maintenance of equipment. A summary of equipment requiring maintenance shall be printed out upon plant operator request.

C. The failure of driven equipment shall be monitored by the SCADA system. Equipment shall be considered failed under the following conditions:
   1. The equipment is in AUTO and the SCADA system attempts to operate the equipment and it does not respond within a defined time period.
   2. The equipment is in AUTO and running and for whatever reason other than the SCADA system requesting the equipment to "STOP," the equipment stops.

D. In addition, specific equipment is required to provide "Trouble", "Fault", or other specific alarm inputs to the SCADA system. This input shall be added to the internal logic described in items 1 and 2 above so that any one of these events shall trigger a "FAIL" alarm. In addition, the following is required:
   1. DISAGREEMENT ALARM: The equipment is in AUTO and the PLC attempts to operate or maintain operation of the equipment and it does not respond within a defined time period.
   2. NOTIFICATION: The system shall notify an operator if an interlock interrupts Remote-Manual Operation.

E. All interlocking conditions will be listed and active interlocks will be identified to the operators.

F. The SCADA system shall be used to the extent that it shall facilitate sequencing of the equipment. The plant operator shall be able to bypass the sequencing and START/STOP the equipment and OPEN/CLOSE valves and gates on a "MANUAL" procedure from the hand switches when desired. Interface to the SCADA system shall be through I/O points or workstations or laptops.

End of Control Strategy 3

Control Strategy 4
SCADA Inputs and Outputs Distribution and Control Requirements

A. Reference Drawings:
   1. Various P&IDs.

B. Description:
   1. HMI / SCADA system I/O assignment shall be as shown on the P&IDs.
   2. Upon failure of a process equipment item, the SCADA system shall start the next available unit, as described in the applicable control strategy.
   3. Upon failure of a PLC input/output module, SCADA system shall skip equipment controlled by PLC input/output module and go to next process unit in the lead-lag sequence.
   4. For example, two pumps' input/outputs shall be equally distributed to two different I/O modules. If three pumps are required and only two input modules and two output modules are available, then as a minimum, two pumps shall be assigned to one set of input/output modules while the third pump shall be assigned to the second set of input/output modules.
   5. Note that "pumps" are used to describe the I/O distribution requirements. The concept shall be extended to all process equipment including, valves, gates, instruments for level, flow, pressure, etc.

End of Control Strategy 4

Control Strategy 5
General Recording System

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. HMI workstations shall generate reports based upon process variables (pressure, flow, temperature, level and analytical) and equipment status (speed, and motor current) in real-time and from recent historical data. The exact report requirements will be determined by the Owner and shall be configured by the System Programmer during the project construction period.

End of Control Strategy 5

Control Strategy 6
General Contact/Logic System

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. All discrete/logic control functions shall be provided as required and shall include but not be limited to the following:
      a. Discrete/Logic Functions: The ability to perform logic and sequencing functions shall be supported to provide control interlocks, event sequencing and other logic operations.
      b. Boolean Algebra requirements: AND gate, OR gate, NAND gate, NOR gate, XOR gate, and NXOR gate.
      c. Logic requirements: Logic switch, logic compare, bi-directional time delay, and on-off with feedback.
      d. Ladder Logic requirements: NO contact, NC contact, energize coil, latch/unlatch coil, retentive timer on/off delay, up/down counter, counter/timer reset, ladder execution control, immediate input, and immediate output.

End of Control Strategy 6

Control Strategy 7
General Process Control Function (Analog) System

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. All analog control functions shall be provided as required and shall include but not be limited to the following:
      a. Proportional-Integral-Derivative (PID) Control--Standard controller functions with balanceless, bumpless transfer from manual to automatic, manual overrides, external reset and output summing capabilities. Provision for cascade, rationing gain, bias, lead-lag, dead-time, feed forward, and feedback control shall be available.
      b. HMI display system shall have a common PID controller operator interface for all equipment utilizing PID control. Controller operator interface shall include alphanumeric and graphic indication of the following features as a minimum:
         1) ID of controlled equipment
         2) ID of process variable input
         3) Controller setpoint value
         4) Process variable value
         5) Controller output value
         6) Setpoint adjustment interface
         7) Indication if setpoint is under local or remote control
         8) Local/Manual control output adjustment interface
         9) Indication if control output is under local/manual control or under control of process controller
      c. Computational Functions: On-line mathematical functions shall be available to provide real-time computational capability of control variables for use in feed-forward and other advanced control functions.
      d. All setpoints for alarm and control shall be adjustable from password-protected HMI Computer screens. Coordinate level of security required for password protection of setpoint screens with the Owner and Engineer.
      e. Appropriate control action(s) shall be provided as needed.

End of Control Strategy 7

Control Strategy 8
Trend Plots

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. HMI workstations shall graphically plot trends of process variables (pressure, flow, temperature, level and analytical), controller setpoints and outputs, and equipment status (speed and motor current) in real-time and from historical data. The plant operator shall be able to select the plotting interval, within the limits of the actual data collection. Provide a minimum of four trends per display view.
   2. In addition to the plotted data, a trend shall include:
      a. Time
      b. Date
      c. Tag number
      d. Plotting interval
      e. Time at start
      f. Time at latest value

End of Control Strategy 8

Control Strategy 9
Color Notation for Dynamic Objects on Control Graphic Display Screens

A. Reference Drawings:
   1. All P&IDs, all control strategies.

B. Description:
   1. All dynamic objects on control graphic display screens shall be provided with multiple-color display to identify status as tabulated below:

Equipment	Status	Required color
Motor	Running	Green
Motor	Ready, Off	Red
Valve	Open position	Green
Valve	Closed position	Red
Gate	Open position	Green
Gate	Closed position	Red
All	Abnormal condition	Amber (Yellow)

End of Control Strategy 9

Control Strategy 10
Discrete Alarm System

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with P&IDs.

C. Description:
   1. All discrete input alarms shall be provided as shown on P&IDs or listed in the instrument index (Section 40 06 70) whether or not specific control strategies are provided. Whenever a P&ID is not shown with any On/Off, Start/Stop, Open/Close or analog modulation control, no specific control strategy will be written even if a discrete alarm system is shown on the drawing. For this condition, control strategies 1-15 shall be applicable. Discrete inputs can be from field instruments (level switches, HVAC related air handling units, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units). A manual reset is required at the equipment control panel; Reset from SCADA is not acceptable.
   2. On a power failure, equipment shall return to the ready state when power is returned. Given the process condition, the lead piece of equipment shall start if called for. The lag and lag-lag, etc., starting sequence shall be staggered at 15-second intervals (adjustable) depending on the process. Operations shall designate this time during startup.

End of Control Strategy 10

Control Strategy 11
Discrete Status System

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. All discrete input status shall be displayed on HMI screens as required by the reference drawings and specifications regardless whether or not specific control strategies are provided. Each discrete input shall be shown in its appropriate process screen and/or equipment status screen. Discrete inputs can be originated from field instruments (motorized actuators, HVAC related air handling units, power management related contact inputs, level switches, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units).
   2. All equipment HOA selector switch Auto mode status contact is to be monitored by the PLC. When the HOA switch is not in the Auto mode the SCADA system shall display “Not in Auto” for that respective piece of equipment.

End of Control Strategy 11

Control Strategy 12
Motor Monitoring System

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. Discrete indication shall be provided for the pump motors at Oldham Road. These relays contain information such as motor monitoring features that may be used for diagnostic information above that shown on the P&IDs. Where the relays are used this information shall be extracted from the device using an interposing relay or dry contact and displayed on the SCADA system pop-up for that device and used for alarming as is appropriate. In addition to the status and control signals shown on the P&IDs, at a minimum the following information shall be extracted from these devices:
      a. Moisture Detected
      b. Thermal Capacity
      c. Overload Status
      d. Pump Running

End of Control Strategy 12

Control Strategy 13
Oldham Road Pumping System

A. REFERENCE DRAWINGS:
   1. I-70-101

B. Process Equipment: the pumping station shall be a wetwell type with two (2) constant speed submersible pumps.

C. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

D. Description:
   1. The Oldham Road Pumping Station collects and pumps the raw sewage to the treatment plant. The station consists of a wetwell and two (2) constant-speed, submersible pumps. The pumps are designed to operate as Duty and Standby.
   2. There is a submersible transducer type level transmitter and four (4) float switches. Pumps are primarily controlled from the Main Control Panel (MCP 7000) that houses the station PLC and provides manual or automatic pump control modes. The pump station PLC communicates with Newton's SCADA system via a radio signal.
   3. The pumps can be controlled via the following four methods:
      a. Local – Hand
      b. Local – Auto
      c. Remote – Manual
      d. Remote - Auto

E. Control Descriptions:
   1. Local Hand Control:
      a. Each pump has an HOA (HAND-OFF-AUTO) switch on the pump control panel. When the HOA is placed in the HAND mode the pump starts. Placing the HOA switch in the OFF position stops the pump. This is true regardless of the position of the Local/Remote Control switch on the main control panel.
   2. Local Auto Control:
      a. With the motor starter HOA in the Auto mode and the Local/Remote switch in LOCAL, the pump is started and stopped by the float switches. The starting and stopping of the pumps shall be controlled by the level float switches START PUMP, and STOP PUMP. When the wetwell level (as measured by the level floats) reaches the "PUMP START" level float switch, the control shall start the duty pump.. Pumps will continue to operate until the wetwell level decreases to the programmed "STOP PUMP" float switch.
      b. A software alternation switch P1/P2/ ALT is used to select which pump is the Duty pump. If a pump is not in the Auto mode it will not be included in the sequencing. If the pump designated as duty fails for any reason or is not available, the standby pump in the sequence shall run in its place. When the switch is in the ALT position, the Duty pump shall be rotated automatically after each stop cycle.

3. Remote Manual Control:
    a. When the HOA for each pump is in the AUTO position and the pump station Local Remote switch is in REMOTE, the pump is controlled via the PLC/SCADA system. When the software AUTO/MANUAL switch is in the MANUAL position, the pump is started on demand and will continue to run until the switch is placed in the OFF position or an until an interlock stops the pump.
4. Remote Auto Control:
    a. When the software HOA switch is in the AUTO position, the pump is started automatically by the PLC/SCADA system. The starting and stopping of the pumps shall be controlled by operator-adjustable setpoints (entered in tenths of feet) at SCADA for START PUMP, STOP PUMP and STOP STANDBY. The wetwell level is continuously monitored via the level transmitter.

       A software alternation switch P1/P2/ ALT displayed on the OIT and the remote SCADA system is used to select which pump is the Lead. If a pump is not in the Auto mode, it will not be included in the Duty/Standby sequencing. If the duty operating pump fails for any reason or is not available, the standby pump in the sequence shall run in its place. When the switch is in the ALT position, the Duty pump shall be rotated automatically after each stop cycle.

F. Interlocks and Permissives:
    1. Refer to the P&ID, elementary diagrams, and as per the pump manufacturer.

G. Status:
    1. The following status indicators shall be included at the Main Control Panel (MCP-7000) OIT and transmitted to SCADA:
        a. PUMP 7011 RUNNING
        b. PUMP 7011 IN AUTO
        c. PUMP 7012 RUNNING
        d. PUMP 7012 IN AUTO
        e. ALTERNATOR IN AUTO
        f. LINE POWER AVAILABLE
        g. WET WELL FLOAT HI HI LEVEL ALARM
        h. WET WELL FLOAT PUMP ON
        i. WET WELL FLOAT PUMP OFF
        j. WET WELL FLOAT LOW LEVEL ALARM

H. Alarms:
    1. The following alarm conditions shall be indicated at the Main Control Panel OIT and transmitted to SCADA:
        a. LOW TEMPERATURE PLC CABINET
        b. PUMP 7011 MOTOR OVERLOAD
        c. PUMP 7011 MOISTURE DETECTED
        d. PUMP 7011 MOTOR TEMPERATURE HIGH
        e. PUMP 7012 MOTOR OVERLOAD
        f. PUMP 7012 MOISTURE DETECTED

g. PUMP 7012 MOTOR TEMPERATURE HIGH
h. HIGH HIGH WET WELL LEVEL ALARM
i. LOW LEVEL ALARM
j. CONTROL PANEL INTRUSION ALARM
k. CONTROL POWER FAIL
l. 24VDC POWER FAIL
m. STATION ON BATTERY
n. UPS BATTERY LOW
o. UPS FAIL
p. PLC GENERAL FAILURE

I. Monitoring:
1. The following parameters shall be monitored at the Main Control Panel OIT and transmitted to SCADA:
a. PUMP 7011 DISCHARGE PRESSURE
b. PUMP 7012 DISCHARGE PRESSURE
c. PUMP 7011 RUNTIME
d. PUMP 7012 RUNTIME
e. PARALLEL RUNTIME
f. WET WELL LEVEL INDICATION
g. PLC CABINET TEMPERATURE

End of Control Strategy 13

Control Strategy 14
Remote Gas Detection and HVAC Upgrades for Quinobequin and Elliot Street Pumping Stations

A. REFERENCE DRAWINGS:
   1. I-10-101
   2. I-20-101

B. Process Equipment: the existing pumping station shall be outfitted with new gas detection systems and HVAC flow switches.

C. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

D. Description:
   1. Both the Quinobequin Road and Elliot Street pumping stations are built with an electrically classified side and non-hazardous side. The hazardous side of the station above the wet wells at each station require the installation of combustible gas sensors in strategic areas with local and remote SCADA indication.
   2. Also as part of this project, both pumping stations will require upgrades to the HVAC units on the classified side. The operation of this system must be monitored for failure via flow switches that will alert the remote operators of any upset conditions.

E. Control Descriptions:
   1. Quinobequin Road Pumping Station:
      a. Three “rooms”, 104 (wet well upper level room),106 (influent channel room), 108 (wet well), at the station are classified as hazardous. Install a Gas Controller capable of aggregating the signals from the gas detectors located inside these three rooms. Locate the gas controller outside at the door to room 104 in a NEMA 4X enclosure with clear cover. This will provide visual indication for personnel visiting the station. Power this unit from the site’s local 120V panelboard.
      b. Install two gas sensors in to serve these hazardous areas:
         - One near the where the operator must replace the carbon filter in Room 104. This sensor should be accessible but not in the Operator’s way.
         - One near the middle of the Room 106 that’s accessible to personnel away from any air intake ducts.
      c. Wire the sensor heads back to the gas controller located at the entrance.
      d. Wire three discrete input NO contacts from the gas controller back to SCADA Control Panel to provide remote monitoring. Owner’s Integrator to program points. The discrete inputs will provide the following alarms to SCADA:
         - Hi Alarm
         - Hi Hi Alarm
         - Gas Controller Fault
      e. Three flow switches must be installed; one downstream of the exhaust fans QEF-2 and QOC-1,and one on the intake air downstream of QSF-2. These switches can be installed near the blower and wired back to the existing PLC panel. These flow switches will alarm to the SCADA system when the flow falls below the set point,

2. Elliot Street Pumping Station:
    a. Three “rooms” are classified as hazardous. Install a Gas Controller capable of aggregating the signals from the gas detectors located inside these three rooms. Locate the gas controller outside at the door to room 104 in a NEMA 4X enclosure with clear cover. This will provide visual indication for personnel visiting the station. Power this unit from the new panelboard.
    b. Install two gas sensors in to serve these hazardous areas:
        - One near the where the operator must replace the exhaust fan filters on the upper level of the influent channel room area. This sensor should be accessible but not in the Operator’s way.
        - One in the influent channel room that’s accessible to personnel and indicative of the atmosphere entering the exhaust air grills from the wet well.
    c. Wire the sensor heads back to the gas controller located at the entrance.
    d. Wire three discrete input NO contacts from the gas controller back to Elliot Street Wastewater Pump Station SCADA Control Panel to provide remote monitoring. Owner’s Integrator to program points. The discrete inputs will provide the following alarms to SCADA:
        - Hi Alarm
        - Hi Hi Alarm
        - Gas Controller Fault
    e. Three flow switches must be installed; one downstream of exhaust fan ELEF-2,one downstream of the intake blower ELSF-1 that serve the hazardous location, and one downstream of ELOC-1. Since these will be installed in an electrically classified area, wire them back to an ISB panel. The ISB will then be wired to the existing PLC panel. These flow switches will alarm to the SCADA system when the flow falls below the set point,

End of Control Strategy 14

Control Strategy 15
Elliot Street In-channel Grinder Controls

A. REFERENCE DRAWINGS:
   1. E-20-302

B. Process Equipment: the existing pumping station shall be outfitted with new a new in-channel grinder

C. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

D. Description:
   1. An in-channel grinder shall be installed in the eastern most influent channel at the Elliot Street pump station at the former location of a comminutor.
   2. The grinder shall be primarily controlled with a vendor supplied control panel with vendor supplied PLC. Detailed alarm messages will be logged and viewable from a local OIT supplied with the vendor control panel. Remote indication will be supplied to the existing Elliot Street Wastewater Pump Station SCADA control panel to monitor the operation of the grinder and screen as detailed below.

E. Control Descriptions:
   1. Vendor Control Panel:
      a. A local “POWER ON” indicating light will alert local personnel that power is available to operate the grinder and screen.
      b. The Vendor Control Panel shall have an “ON-OFF-REMOTE” selector switch for the grinder.
         1) When in the “ON” position, this switch will energize the grinder motor forward contactor. This will also energize a local indicating light to show that the grinder is operating.
         2) When in the “OFF” position, the switch will de-energize the grinder motor contactors and de-energize the local “GRINDER RUN” indicating light.
         3) When in the “REMOTE” position, the grinder motor forward contact will activate and deactivate based on a Run permissive interposing relay input to the vendor supplied PLC.
      c. The Vendor Control Panel shall have an “ON-OFF-REMOTE” selector switch for the screen.
         1) When in the “ON” position, this switch will energize the screen motor forward contactor. This will also energize a locating indicating light to show that the screen is operating.
         2) When in the “OFF” position, the switch will de-energize the screen motor contactors and de-energize the local “SCREEN RUN” indicating light.
         3) When in the “REMOTE” position, the screen motor forward contact will activate and deactivate based on the operation of the grinder.
      d. The Following alarms shall be displayed on the Vendor Control Panel OIT:
         1) GRINDER JAMMED
         2) GRINDER MOTOR OVERLOAD

3) GRINDER MOTOR OVERTEMP
4) GRINDER FAIL TO RUN
5) SCREEN JAMMED
6) SCREEN OVERLOAD
7) SCREEN OVERTEMP
8) SCREEN FAIL TO RUN
9) EMERGENCY STOP ACTIVATED

2. Grinder System Sequences:
   a. The grinder system shall attempt to automatically clear a jam by:
      1) When the current sensor detects a jam, the motor forward contactor will momentarily de-energize.
      2) The reverse contactor will energize for a pre-determined period of time and then de-energized.
      3) The motor forward contactor will re-energize and attempt to continue normal operation.
      4) The above sequence shall be repeated as required to clear the jam, but not more than 3 times in a given period.
      5) If the jam is not cleared during this time, an alarm condition will be set and displayed on the OIT and the Grinder Fail relay shall be energized.
   b. The screen system shall attempt to automatically clear a jam by:
      1) When the current sensor detects a jam, the motor forward contactor will momentarily de-energize.
      2) The reverse contactor will energize for a pre-determined period of time and then de-energized.
      3) The motor forward contactor will re-energize and attempt to continue normal operation.
      4) The above sequence shall be repeated as required to clear the jam, but not more than 2 times in a given period.
      5) If the jam is not cleared during this time, an alarm condition will be set and displayed on the OIT and the Grinder Fail relay shall be energized.
3. Grinder System Remote Monitoring and Control:
   a. The following discrete statuses from the grinder system shall be tied into the Elliot Street Wastewater Pump Station SCADA Control Panel:
      1) GRINDER RUN
      2) SCREEN RUN
      3) GRINDER SYSTEM FAIL RELAY
   b. A remote run permissive shall be provided by Elliot Street SCADA system to bring the grinder system online when any of the station's pumps are called to operate. This discrete status will be brought from the Elliot Street Wastewater Pump Station SCADA Control Panel and tied into the new grinder system's vendor supplied control panel.
   c. In addition to any vendor supplied emergency stop pushbuttons, a remote emergency stop pushbutton shall be installed near the grinder system and wired back to the vendor control panel.

End of Control Strategy 15

Control Strategy 16
Compressed Air Wetwell Mixer for Quinobequin Pumping Station

A. REFERENCE DRAWINGS:
   1. E-10-302

B. Process Equipment: the existing pumping station shall be outfitted with an air compressor and compressed air wet well mixing system.

C. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

D. Description:
   1. A mixer shall be installed to agitate the effluent stream at the Quinobequin Road pumping station. This system will consist of an air compressor and a vendor supplied control panel that operates a high CV electro-pneumatic valve. Pulsing the valve will allow compressed air to pass through to a bubble forming plate located in the station's wet well.

E. Control Descriptions:
   1. Air Compressor Control:
      a. The air compressor shall come with a local LCD display where output pressure can be set, maintained, and monitored.
      b. The vendor control panel shall be capable of displaying two different types of faults: shutdown conditions and warnings. A general shutdown condition fault shall be reported back to the vendor supplied control panel for the mixer.
      c. The air compressor shall be called to start when the hydro-pulse mixer is called to begin operating.
   2. Vendor Control Panel:
      a. The following discrete statuses from the mixer system vendor control panel shall be tied into the Quinobequin Road Wastewater Pump Station SCADA Control Panel:
         1) MIXER RUN
         2) MIXER FAULT
         3) COMPRESSOR RUN
         4) COMPRESSOR FAULT

End of Control Strategy 16

SECTION 40 63 43

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope

1. This Section specifies requirements for small programmable logic controllers (PLC) designed to execute discrete and continuous control logic with high reliability in industrial applications. Enclosures and components are specified in Section 40 67 00.
2. All PLCs provided for this project shall comply with the requirements of this Section. PLCs provided with equipment specified in Divisions 23, 41, 43, 44, and 46 are provided by the Equipment Manufacturer except for the PLC for Oldham Road Station. This PLC will be provided by the Systems Integrator per Section 40 61 13.

B. PLC Schedule

Panel No.	Panel Name	PLC Size	Testing	Spares
MCP-7000	Oldham Road Main Control Panel	Small	Factory Acceptance	Required
VCP-1000	Quinobequin Rd. Air Compressor Control Panel	Small	Not required	Not required
VCP-2000	Elliot Street Grinder Control Panel	Small	Not required	Not required

C. General Requirements

1. General requirements shall be as specified in Sections 40 61 13 and 40 67 00. PLC assemblies provided by Equipment Manufacturers may be provided by firms other than the Systems Integrator.

1.02 QUALITY ASSURANCE

A. References

1. This Section contains references to the following documents or documents listed in Sections 26 05 00, 40 61 13, and 40 67 00. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
3. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

4. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEC 61131-3	Programmable Controllers – Part 3: Programming Languages
NEMA IA 2.2	Programmable Controllers – Equipment Requirements and Tests
NEMA IA 2.3	Programmable Controllers – Programming Languages

B. Systems Integrator
   1. Responsibilities and qualifications shall be as specified in Section 40 61 13.

C. Factory Acceptance Tests:
   1. Factory Acceptance Tests are specified in Section 40 61 21 and scheduled in paragraph 1.01 PLC Schedule.
      a. Submit factory test forms for approval prior to tests.
      b. Provide all expenses for one Owner staff member and one Engineer staff member to witness factory testing. Travel shall be during business hours on weekdays.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Sections 01 33 00 and 40 61 13:

B. Shop Drawings:
   1. Submit under Section 40 67 00, including:
      a. A copy of this Specification Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements. A check mark shall denote full compliance with a paragraph as a whole.
      b. If deviations from the Specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
      c. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the Specifications.
      d. *Failure to include a copy of the marked-up Specification Sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*
   2. Submittal requirements per Section 40 67 00 for the equipment specified herein.
   3. PLC Input/Output (I/O) loop diagram drawings.
   4. Internal power distribution schematic diagram drawings.
   5. PLC power supply loading calculations.

6. List of spare parts to be provided.

C. Factory Acceptance Test Schedule And Forms
   1. Submit under Section 40 61 21 and per the requirements of this Section.

D. Operating and Maintenance Information:
   1. Operating and maintenance information shall be provided in accordance with Section 01 78 23, including the following for the PLC system:
      a. Manufacturer, Representative, and Supplier contact information.
      b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
         1) Safety Precautions.
         2) Environmental Conditions.
         3) Troubleshooting guides and diagnostic techniques.
         4) Component connection diagrams.
         5) Removal and replacement instructions.
      c. Warranty information.
      d. Final reviewed submittal.
      e. As-built drawings with record of switch and jumper settings for all components.
      f. List of spare parts provided.

PART 2 PRODUCTS

2.01 GENERAL

A. Manufacturer
   1. The Owner and Construction Manager require the specified Manufacturer to provide the equipment and/or products to be furnished under this Section. The Owner and Construction Manager believe the Manufacturer is capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed to mean that the named Manufacturer's standard product will comply with the requirements of this Section.
   2. Manufacturers and models shall be as specified for the purpose of compatible and efficient utilization of existing equipment, supplies, and personnel training and experience, no substitutions are permitted.

B. Materials
   1. Equipment and/or products shall be new and unused at the time of system assembly.

C. Controller conforming to NEMA IA 2.2, and with required memory and functional capacity to perform specified sequence of operation with scheduled input and output points.
   1. RFI/EMI Susceptibility: MIL STD 461B CS02.
   2. Showering Arc Test: NEMA Pub No ICS2-230.42.
   3. Surge Withstand: ANSI C37.90a.
   4. RFI Immunity: IEC 801-3.
   5. Ground Continuity: IEC 801-5.

6. Electrostatic Discharge: IEC 801-2.
7. Electromagnetic Field: IEC 61000-4-3.
8. Fast transients: IEC 61000-4-4.

2.02 PROGRAMMABLE LOGIC CONTROLLER - SMALL

A. Manufacturer:
   1. Allen-Bradley MicroLogix 1400.

B. NEMA IA 2.3 and IEC 61131-3 compliant program editor with program written in Equipment Manufacturer's standard Language. Program to be written using the same type of software as is specified below.

C. Networking Connections: Provide all communication interfaces, network cables, taps, terminators, power supplies, and accessories for a complete operating network.
   1. Ethernet/IP.
   2. RS-232/RS-485
   3. Allen-Bradley DF1 RS-232 Serial, in addition to processor port.

D. Processor:
   1. With Ethernet port and serial port dedicated solely for programming use, minimum 200k bytes (8 bit) for IEC 1131 control programs, and 24k words (16 bit) for storage of data in battery-backed RAM memory. Provide additional serial communications adapters required for other serial interfacing. Include real-time clock.

E. Input and Output Modules:
   1. Discrete Inputs: 120 Vac, 20 channel.
   2. Discrete Outputs:
      a. Relay output, 12 channel isolated.
   3. Analog Inputs:
      a. 4-20 mAdc/1-5 Vdc, isolated channel-to-channel, 4 channel.
   4. Analog Outputs:
      a. 4-20 mAdc, 2 channel.
   5. I/O module terminations:
      a. By Manufacturer to match module.
   6. I/O module interface modules:
      a. Provide as necessary including cabling to interface all I/O to processor.
   7. Spare Input/Outputs:
      a. The greater of a minimum one channel or 15 percent of each type provided per control panel.

F. Power Supplies:
   1. 24 Vdc. Refer to Section 40 67 00 for power supply.

G. Miscellaneous:
   1. Provide all cables, taps, terminators, power supplies, and accessories for a complete operating PLC system.

2.03 PROGRAMMING SOFTWARE

A. The following software shall be provided by the Systems Integrator for this project.

B. Programmable Logic Controller - Small
   1. Manufacturer:
      a. Allen-Bradley RSLogix 500.
   2. Licenses: Provide 1 License. Request Owner / City licensee information prior to ordering for registration. Provide one PC to PLC programming cable for each license.

2.04 SPARE PARTS

A. The following spare parts shall be provided, refer to Paragraph 1.01 PLC Schedule for schedule.

B. B. Programmable Logic Controller - Small
   1. One of each unique processor card.
   2. One of each unique communication card.
   3. One for each ten, minimum of one for each unique I/O card.
   4. One of each unique power supply.
   5. One of each unique pre-fabricated cable.

2.05 CONTROL PANEL FABRICATION

A. Refer to Section 40 67 00.

B. Detail shop drawings showing field connections and any terminal block jumpering required.

C. Terminate all used and spare I/O wiring to terminal blocks.

D. Create wire markers with “to-from” component name, PLC slot/base, or terminal column number and terminal number information identical at each end.

E. Provide terminal Blocks for field connections to PLC Discrete Inputs:
   1. One fused terminal with LED for each group of 8 inputs, connected to control power.
   2. Fused terminal connected to eight terminal blocks to provide power to each field input circuit.
   3. One terminal per PLC input.
   4. One common terminal for each group of 8 inputs, connected to control power common.

F. Provide terminal Blocks for field connections to PLC Discrete Outputs:
   1. One fused terminal with LED for each output, connected to control power.

2. Two terminals per PLC relay output. Provide interposing relay for each solid-state PLC output. Connect output and control power common to relay coil. Provide two terminals for relay contact, normally opened unless otherwise noted.
3. One common terminal for each output, connected to control power common.

G. Provide terminal Blocks for field connections to PLC Analog Inputs:
1. One fused terminal with LED for each input, connected to +24 Vdc.
2. Two terminals per PLC input.
3. One common terminal for each input, connected to 24 Vdc common.
4. One ground terminal for each input shield, connected to signal ground bus.
5. Two surge protecting terminals for each field mounted instrument or equipment, grounded to the frame ground bus.

H. Provide terminal Blocks for field connections to PLC Analog Outputs:
1. One fused terminal with LED for each output, connected to +24 Vdc.
2. Two terminals per PLC output.
3. One common terminal for each output, connected to 24 Vdc common.
4. One ground terminal for each output shield, connected to signal ground bus.
5. Two surge protecting terminals for field mounted equipment, grounded to the frame ground bus.

2.06 PRODUCT DATA

A. The following Product Data shall be provided in accordance with Section 01 33 00.

B. Factory Acceptance Test Results:
1. Submit under Section 40 61 21 and per the requirements of this Section.

C. Operating and Maintenance Information:
1. Operating and maintenance information shall be provided in accordance with Section 01 78 23, including the following.
a. Manufacturer, Representative, and Supplier contact information.
b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
1) Safety Precautions.
2) Environmental Conditions.
3) Troubleshooting guides and diagnostic techniques.
4) Component connection diagrams.
5) Removal and replacement instructions.
c. Warranty information.
d. Final reviewed submittal.
e. As-built drawings with record of switch and jumper settings for all components.
f. List of spare parts provided.

D. PLC Program – Equipment Manufacturer:
   1. Provide the as-built programmable controller program on a CD or jump drive, prepared using the software type specified in Part 2. Provide 2 copies. Label the CD to include:
      a. Owner's name, facility name, project name and project number as shown on the drawings.
      b. "Application Programs For (equipment and/or PLC name)".
      c. Programming software name and revision.
      d. Supplier name and program revision date.

E. PLC Program – Systems Integrator
   1. Provide the as-built programmable controller program prepared using the software type specified in Part 2. Provide 2 copies. Label the CD to include:
      a. Owner's name, facility name, project name and project number as shown on the drawings.
      b. "Application Programs For (equipment and/or PLC name)".
      c. Programming software name and revision.
      d. Supplier name and program revision date.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 40 67 00.

B. Connect input and output devices to the PLC via control panel terminal blocks, not directly to the PLC.

3.02 FIELD INSPECTION AND TESTING

A. Refer to Section 40 67 00.

B. Equipment Manufacturer and Systems Integrator: The supplier of each PLC system shall provide a qualified service representative to perform the following:
   1. Inspect the PLC installation including I/O and network systems, hardware configuration switch and jumper settings.
   2. Monitor all PLC system diagnostic indicators, both hardware and software, and certify that the PLC system performance meets or exceeds the Manufacturer's published specifications.
   3. Assist in all testing. The Systems Integrator will provide a minimum of one man-weeks on-site for each PLC I/O rack.
   4. Modify PLC programs as required.
   5. Certify in writing to the Construction Manager that the PLC system has been installed and configured in accordance with the Manufacturer's published guidelines.

C. Contractor
   1. Fault or trouble conditions shall be investigated and resolved by the Contractor to the satisfaction of the PLC supplier.

3.03 TRAINING

A. Operations and Troubleshooting

1. The Systems Integrator shall conduct application program maintenance, modification, and re-loading training conforming to the requirements of Section 01 79 00. A minimum of four man-hours on-site including training materials and expenses shall be provided for three maintenance personnel.
2. Equipment Manufacturer training is per the associated equipment Specification.

END OF SECTION

SECTION 40 67 00

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies requirements for panels, cabinets, and termination cabinets for instruments, and control equipment for the Newton Pump Station Rehabilitation Project per the Panel Schedule herein.
2. This section specifies requirements for power supply and conditioning equipment required to support the instrumentation and communication systems specified.
3. Provide the instrument, control, and monitoring features indicated on the P&ID and electrical drawings. Panels shall be arranged to separate control and instrument devices from power wiring. Panel shall be arranged for dedicated field wiring terminations rated for 600 Vac or less for power, control, and instrument signal wiring, in accordance with NEC Article 409. It shall be fabricated by a UL-508A recognized facility and shall bear the appropriate UL 508A Industrial Control Panel label. Panels for Hazardous (Classified) Locations shall bear the appropriate UL 698A label. Panels shall be labeled in accordance with Article 409 of the National Electrical Code.
4. Transmitters, Analyzers, signal conditioning modules and other equipment or devices as specified in other Division 40 sections.
5. Panels that contain programmable logic controllers (PLC) and operator interface stations (OIS) units shall be as indicated in the Panel Schedule. Specific panel devices are specified herein and in Section 26 05 00.
6. PLC and OIS shall comply with the specified in Division 40. Panels that do not comply with the specified products and specified logic method, hardwired or PLC logic, shall not be accepted. Cost to retrofit the panel as specified shall be borne by the panel supplier. Corrections or modifications to UL 508A Industrial Control Panels shall be transported to the panel supplier's facility for corrections, testing, relabeling and inspection.
7. Field modifications require a UL inspector site inspection for approval of panel corrections and to re-label the panel after the field modifications are completed.
8. Vendor and Manufacturer panels specification Sections are referenced in the Panel Schedule and specify specific requirement for these panel. Contractor custom panels are specified herein and shown on the drawings.
9. The Vendor / Manufacturer package equipment and Contractor custom field panels shall adhere to the requirements in specifications Section 26 05 00 for motor starters, controllers, and devices and the circuits shall be arranged for Fail-Safe wiring and electrical operation, as defined hereinafter.

B. Panel Design:

1. General:
   a. Panel hardware and software is specified in other Sections within Division 40.

2. Control Power Distribution:
    a. Panel containing 120-volt powered equipment shall use the din-rail power distribution method with fuses and blown fuse indication. Control Power is restricted to 120 Vac and 24 Vdc.
3. Panels containing voltages greater than 480 Vac shall be separated from the control section by physical barrier.
4. Power Supplies:
    a. Panel containing direct current powered instruments or serving as the termination point for transmission loop powered field instruments shall contain direct current power supply system as specified herein.
5. Electrical Control Devices:
    a. Pushbuttons, indicating lights, relays, and similar equipment located in panels specified in this section shall comply with the requirements of Section 26 05 00.
6. Uninterruptible Power Supplies:
    a. Panel mounted 120 Vac input and 120 Vac output are specified herein.

C. Control Panel Schedule:

	Panel No.	Spec / P&ID	Features *	Enclosure Type	Short Circuit Current Rating	Panel Title	E-Dwgs / Notes
1	MCP-7000	40 67 00 / I-70-101	C,1, 2, 5,7	NEMA-4X	22,000	Oldham Rd. Main Control Panel	to replace existing main control panel
2	VCP-7010	40 67 00/I-70-101	C,3,	NEMA-4X		Oldham Road Pump Control Panel	to integrate into existing control shelter
3	ISB-7000	40 67 00/ I-70-101	C	NEMA-7		Oldham Road Intrinsic Safety Barrier Panel	To Isolate instruments in classified areas from the equipment housed in MCP-7000
4	VCP-1000	40 67 00	V,1,2	NEMA-4X	20,000	Quinobequin Road Mixer Control Panel	Provided as part of the air powered influent mixer. Control panel to be located remotely in appropriately rated area
5	VCP-2000	40 67 00	V,1,2	NEMA-4X	25,000	Elliot Street Grinder Control Panel	Required for the addition of the new grinder and screen at Elliot Street Pump Station. Control panel to be located remotely in appropriately rated area.

**FEATURES Legend*

V - Vendor / Manufacture Panel per equipment specification requirements*

C - Contractor Custom Panel as shown*

1. *Programmable Logic Controller (PLC) or Remote I/O devices
2. *Panel mounted Operator Interface Station (OIS)
3. *Hardwired control logic required
4. *Windowed outer door and inner door for displays or devices.
5. *UPS
6. *Fans

7. *Heating
8. *Air Conditioning
9. *Sun/Rain Hood

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents that are part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
3. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
EIA RS-310C	Racks, Panels, and Associated Equipment
NEMA 250	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508A	Industrial Control Panels
UL 698A	Industrial Control Panels Relating to Hazardous (Classified) Locations
NFPA 79	Electrical Standard for Industrial Machinery
NFPA 70	National Electrical Code (NEC)
NEMA ICS 6	Industrial Control and Systems: Enclosures
ANSI/UL 497-1995	Standard for Protectors for Paired Conductor Communications Circuits
UL 1012	Power Supplies
EIA RS-310C	Racks, Panels, and Associated Equipment
UL 1449	UL Standard for Safety for Surge Protective Devices

4. This Section references other sections with associated work specified therein:
   a. Section 01 45 20 specifies Equipment and System Performance and Operational Testing with reference to Contractor's Quality Assurance Manager that is responsible for startup commissioning of system including mechanical, HVAC, electrical, and instrumentation system.
   b. Section 26 05 00 specifies raceways, conductors, and device requirements.
   c. Section 40 61 21.
   d. Section 40 61 96.

B. Listed Products:
   1. Equipment and components shall be Underwriters Laboratory (UL) listed for the purpose or UL recognized.
   2. The control panels shall have factory applied UL 508A labels. Where intrinsic safety barriers are used within a control panel, provide UL 698A factory applied label as required by UL.
   3. All panels shall be labeled in accordance with NEC Article 409.

C. Shipment, Protection, and Storage:
   1. Equipment shipment, protection and storage shall conform to the requirements specified in Section 01 66 00.

1.03 SUBMITTALS

A. General:
   1. Submittals and transmittal procedures for submittals are defined in Section 01 33 00. Submit In accordance with the procedures set forth in the General Conditions of the Contract Documents and Section 01 33 00 that include drawings, information and technical data for equipment and as required in Section 40 61 13. Submittal information shall be included in one complete submittal.
      a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
         1) A <u>check mark</u> shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
         2) The Owners Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
         3) Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
      b. A marked copy of specification Section 40 61 13.
      c. A marked copy of specification Section 40 61 21.
      d. A marked copy of specification Section 40 61 96.
      e. A marked copy of specification Section 01 45 20.
      f. A marked copy of specification Section 26 05 00.
      g. A copy of the contract document Process and Instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the

relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

h. Marked contract document Control Schematic diagrams related to the submitted equipment.

i. Marked contract document Control Single Line diagrams related to the submitted equipment.

j. Marked product literature of all the enclosure electrical devices and components mounted on or within the control panel.

k. List of miscellaneous items, cables, spare and replenishment parts, and chemicals to be provided, including MSDS information.

l. Dimensioned drawings:
   1) Exterior panel and layout
   2) Interior devices and layout
   3) Door-in-door construction devices, where required

m. Panel assembly drawings including sections showing clearances between face and rear mounted equipment.

n. Nameplate engraving schedule:
   1) Indicate engraving by line
   2) Character size
   3) Nameplate size
   4) Panel and equipment tag number and description

o. Heat load calculations for each cabinet based on the highest ambient temperature listed in Section 40 61 13 for the area in which the subject panel will be located.

p. Wiring drawings:
   1) Schematic diagrams
   2) internal wiring diagrams
   3) Connection diagrams
   4) Power and control single line diagrams to comply with NEC Article 409.

1.04 ENVIRONMENTAL CONDITIONS

A. Refer to Section 40 61 13.

PART 2 PRODUCTS

2.01 FABRICATION

A. General:
   1. Panels shall be designed for the requirements of Section 40 61 13. Structures, equipment, and devices shall be braced to prevent damage from specified forces. Equipment panels shall be capable of operation following a disturbance.
   2. Nameplates with tag number and equipment description shall identify face-mounted instruments. Instruments shall be mounted for access to components and ease of removal. Cutouts for future equipment shall be blanked off with suitable covers. Instrument tag numbers shall be identified on the panel rear.

3. Face-mounted equipment shall be flush or semi-flush with flat-black escutcheons. Face-mounted instruments that are more than 6 inches deep, weigh more than 10 pounds, or exert more than a 4 ft-lb moment force on the face of the panel shall be supported underneath at the rear by a 1-inch x 1/8-inch thick steel angle.
4. Panels less than 60 inches high shall be provided with floor stands to raise the top of the panel to 60 inches above the floor or work platform. Panels that weigh less than 100 pounds may be wall mounted.
5. Panels with specified requirements including stainless steel or aluminum mounting requirements that are indicated on the project drawings or on the project details take precedence over the panel types or panel features indicated herein.

B. Panel Layout:
1. Provide 20 percent spare contiguous sub-panel area for future expansion.
2. Provide minimum of 20 percent spare terminal blocks, with a minimum of 10 analog, discrete, power.
3. Provide minimum of 12 inches clear space from the bottom of the panel to the bottom of the subpanel.
4. Separation between the power components (over 120Vac) and the control / instrument components (120Vac and less) by locating the power components and the control / instrument components in separate sections of the cabinet enclosure.
5. Power cabinet section and the control / instrument cabinet section with separate door handles.
6. Separation between the power components and the control / instrument components using barriers.
7. External lockable circuit breaker handle for the main panel disconnect.
8. Individual power and control components with internal circuit breakers, as required.
9. Motor controllers, as required by the equipment specifications.
10. Displays with door-in-door construction accessible by opening the cabinet outer door.
11. Face-mounted equipment flush or semi-flush with flat-black escutcheons.
12. Panel tops of wall-mounted panels: mounted at the same elevation.
13. Panel inner door contains a copy of the record elementary and wiring diagrams, or reference as allowed per NEC Article 409.
14. Panel inner door contains a drawing holder.
15. Panel drawings enclosed in a transparent, protective jacket.
16. Panel functions as specified.
17. Panels with floor stands, to raise the top of the panel to 60 inches above the floor or work platform.
18. Wall mounting of panel weighs less than 100 pounds, where wall space is available,

C. ENCLOSURES
1. Panel enclosures shall comply with the requirements of NEC Article 409 and NEMA 250.
2. Manufacturer:
   a. Hoffmann Enclosures, Inc.
   b. Rittal
   c. or equal.

2.02 NOT USED

2.03 PROTECTION COATING AND FINISH

A. Panels located outdoors or located in corrosive areas shall be bottom coated with waterproof coatings.

2.04 NAMEPLATES

A. External door-mounted components and the panel description shall be identified with plastic nameplates. Machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.

B. The machine engraved laminated white phenolic nameplates with black lettering shall be provided for panel-mounted equipment. Nameplate engraving shall include the instrument tag number and description in 3/32-inch minimum size lettering.

C. The machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.

D. The nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel screws. Provide RTV sealant for nameplates for NEMA-4X stainless steel panels.

E. The nameplate wording may be changed without additional cost or time prior to commencement of engraving. Submit nameplate legend with the panel submittal.

2.05 PANEL FEATURES

A. Interconnection Wiring: Panel Interconnecting Wiring:
   1. Panel control wiring: Single conductor stranded copper NEC rated Type MTW No. 16 AWG minimum(rated 10 A per NFPA 79, Table 12.5.1), with an exception for factory supplied PLC wiring harnesses that are U.L. approved.
   2. Panel instrument wiring: Twisted No. 16 AWG shielded pair or tri conductors.
   3. Panel power wiring: Conductors specified in Division 26 and meet the NEC requirements for power including phase, grounded, and grounding conductors.
   4. Wiring shall be supported independently of terminations by lacing to panel support structure or by slotted flame retardant plastic wiring channels.
   5. Wiring channels shall comply with UL 94, Type V.
   6. Plastic wireway with covers shall be used to route groups of wires. Wireway fill shall be sized to provide 50% maximum fill.
   7. Plastic spiral wrap shall be used for exposed wires. Wires that cross door hinges shall be enclosed in plastic spiral wrap.

B. Conductor Identification:
   1. Wiring shall be tagged at every termination with machine printed plastic sleeves or pre-printed self-sticking labels as manufactured by W.H. Brady, 3M, or approved equal. No hand-written labels are permitted.
   2. Three-part wire numbers for instrument and control panel internal conductors:

a. Part-1: Prefix of the wire number shall be the instrument loop number or equipment tag number.
b. Part-2: Code letter and wire colors per the following tables.
c. Part-3: Number that identifies individual circuit conductor Terminal Number.

Code	120 Vac Conductor	Color
L	Power	Black
C	Control	Red
N	Neutral	White
PG	Ground	Green

Code	V dc Conductor	Color
PS	24 Vdc Power	Blue
PS	12 Vdc Power	Violet
S+	Signal (+)	Black
SG	Signal Ground	White
EG	Equipment Ground	Green
FV	Panel Foreign Voltage	Yellow

C. Conductor Installation And Protection:
1. Power and control wiring shall be carried in covered channels separate from low voltage signal circuits. An interior steel barrier shall be provided between AC control devices and the electronic equipment.
2. Terminal blocks shall be strap screw type rated for 600 volts. Each terminal trip shall have a unique identifying alphanumeric code at one end and a vinyl-marking strip running the entire length of the terminal strip with a unique number for each terminal. Numbers shall be machine printed and 1/8 inch high.
3. No more than two connections shall be made to one terminal.
4. Wire connectors shall be locking fork tongue or ring tongue insulated crimp type terminals.
5. Terminal blocks shall be;
   a. Buchanan 0621-1
   b. Allen-Bradley 1492-JD3 600 V 30-amperes, finger-safe terminal block.
   c. Phoenix Contact or Weidmuller, or equal products. Phoenix Contact or Weidmuller, or equal products.

D. Field Wiring:
1. Field wiring shall be connected to separate dedicated terminal blocks in a dedicated part of the panel where the field cables enter the panel. Provide a dedicated raceway on the field side of the terminal block for field wiring use only.

E. Fuse And Fuse Holders:
1. Fuses for 120 Vac circuits shall have a minimum of 12,000-amperes interrupting capacity and blown fuse indicators.
2. Fuses for 24 Vdc circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 mA loops.

3. Fuses for 24 Vdc circuits shall be 1/2 amp for the power supply to individual instruments.
4. Fuse holders shall be tip-out or draw-out type.
5. Provide Phoenix Contact or equal products.

F. Control Power:
1. 120 Vac control power source: Single power source for all control and DC power. Dual power sources, one for control power and one for DC power. Dual power sources, one for PLC and DC power and one for PLC output and input control power.
a. Provide control power transformers, as required for the load. Provide direct current power supplies, as required for the load.
b. Provide UPS for PLC and derived loop power as defined above, as required for the load.

G. Panel Power: Panel power source:
1. Provide a 120 Vac circuit for the panel light, receptacle, heating, fan, heat exchanger, or cooling load as required.

H. Accessories
1. Panels greater than 24" high x 24" wide shall include GFCI convenience receptacles and LED utility lights.
2. Receptacles and utility lights shall not be powered by the UPS, where included.
3. Print pocket.
4. External access port including GFCI 15 amp duplex 120Vac receptacle, RJ-45 network connection

I. Fail-Safe Wiring:
1. Fail-safe wiring of control relay or other on/off device or instrument provides the condition that will occur upon loss-of-power or internal failure in the device such that the relay is de-energized in the failure or loss-of-power condition such that the control relay contact operation provides for equipment failing in a safe mode.

2.06 ALARM AND TROUBLE DETECTION

A. The equipment control system shall incorporate a non-energized, open-state, output contact to activate on an alarm or trouble condition or on loss-of-power. Detection of a critical alarm or trouble condition shall cause the control system to initiate the shutdown or the operation of the equipment's controlled components to achieve a "Fail-Safe" condition.

B. Devices that signal an alarm or a trouble conditions shall latch in the alarm position and require a manual reset at the equipment control panel.

C. Alarm and trouble output shall:
1. Open an output dry-contact.
2. Remain open until manually reset.
3. Not indicate abnormal condition when the equipment shutdown manually or automatically.

4. Indicate the alarm at the equipment control panel.

D. Fail-Safe Design and Operation:
   1. Failure of part of a system shall not result in the failure of the rest of the system.
   2. Failure of equipment or process shall not propagate beyond the failing device or equipment component.
   3. Control design and operation shall prevent improper system functioning due to a circuit malfunction or operator error.
   4. Control system design shall cause the controlled equipment to operate in a safe mode in the event of loss-of-power or the failure of a control system component.

2.07 CONTROL DEVICES

A. Control devices shall comply with Section 26 05 00.

2.08 INDICATING LIGHTS

A. Red, amber, green, and blue indicating lights shall be heavy-duty full voltage 120Vac or 24Vdc push-to-test LED type with NEMA rating to match enclosure type for installation in a 30.5mm hole. Furnish with 28 chip high visibility LED. The escutcheon and lens color shall be as shown on Drawings or scheduled.

B. White indicating lights shall be as above, incandescent type lamp.

C. Manufacturer:
   1. Allen-Bradley 800H-QRTH10 series or equal for 120Vac applications with colors other than white.
   2. Allen-Bradley 800HQRTH24 series or equal for 24Vdc applications with colors other than white.
   3. Allen-Bradley 800H-QRT10 series or equal for 120Vac applications with white.
   4. Allen-Bradley 800H-QRT24 series or equal for 24Vdc applications with white.

D. Indicating Light Lens Color:

Lens Color	Typical Function	Example
Red	Danger, Running, Open	Equipment Operating, motor running, valve open, power voltage applied, cycle in automatic
Amber	Control	Equipment Failure, status abnormal
Green	Off, Closed, Ready	End of cycle; unit or head returned; motors stopped; motion stopped; contactors open; valve closed
White or Clear	Normal Condition	Normal pressure of air, water, lubrication, control power on, status okay
Blue	Advisory	Control Mode Not in Automatic

2.09 OPERATOR INTERFACE TERMINAL

A. Operator Interface Terminals (OIT's) shall be utilized as the interface to the process controller for specific subsystems or particular process, as shown on the Contract Drawings.

B. OIT's shall conform to the following requirements:
   1. Display Screen Size: 7 inches, diagonally measured.
   2. Resolution: 800 X480 color graphics.
   3. Display and keyboard type: Color TFT LCD Display and touchscreen
   4. Memory: 26 MB
   5. Storage Memory: 2 GB SD card slot
   6. Supply Voltage: 120 VAC
   7. Communications: RS-232
   8. Mounting: Unit shall be mounted on the front face of the enclosure.

C. Manufacturer and Model: C-More EA9

D. Programming of the OIT shall be by the Systems Integrator

2.10 PROCESS CONTROLLER:

A. Manufacturer:
   1. Allen Bradley MicroLogix 1400
   2. See Section 40 63 43 for detailed specifications.

2.11 POWER SUPPLY AND CONDITIONING EQUIPMENT

A. Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application.

B. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems.

C. Direct-Current Power Supplies:
   1. Redundancy step-diode isolation shall be provided for redundant direct current supply units and the power supply negative output terminal shall be grounded. Shall be Phoenix Contact, Model STEP-DIODE/5-24DC/2X5/1X10 or equal.
   2. Nominal 24-volt direct-current instrumentation and control power supply:
      a. Convection-cooled linear type or switching type.
      b. Line regulation: 0.4 percent for line variations from 105 to 132 volts
      c. Load regulation: 0.4 percent for load variations from 0 to full load.
      d. Ripple and noise: Not exceed 100 mV peak-to-peak.
      e. Hold-up time at maximum load: Not less than 16 milliseconds.
      f. Continuous duty from 0 to 50 degrees C at rated load.

g. Output electronically current limited.
h. Over-voltage crowbar shutdown.
i. Output voltage:
    1) Rated 28 Vdc
    2) Adjustable plus or minus 5 percent
    3) Set to provide 26.4 volts to the panel direct current bus.
j. Power Supply: Emerson SOLA-HD, or equal.
k. Provide dry contact for failure alarm. Dry contact to be wired as an input to the PLC

D. Uninterruptible Power System (UPS):
1. The UPS shall be on-line, computer-grade, double conversion type, with electrical isolation including output neutral. UPS shall be packaged for panel enclosure mounting using a back-panel bracket or holder:
    a. Nominal input voltage: 120Vac.
    b. Nominal output voltage: 120Vac.
2. The online UPS system shall be provided with integral sealed no maintenance batteries, sized to provide full capacity backup power for 30minute minimum at connected load with integral battery charger.
3. The UPS Shall provide continuous unity power factor with no interruption from to inverter and return. The panel supplier shall calculate the required kVA rating at 150 percent of connected load. Submit load calculations, schematic diagrams, and wiring connection diagrams. Provide battery cabling and other required cabling for a complete system.
4. The UPS shall be mounted within the panel on a pedestal or tray with stainless-steel legs to provide space for wire entry and passage.
5. The UPS shall be configured with a maintenance bypass switch to allow ease of removal from the panel; to allow the panel to operate on utility power.
6. Uninterruptible power supply systems shall be as manufactured by Eaton, American Power Conversion (APC), Falcon, or equal.

2.12 SURGE PROTECTION

A. General: Surge protection shall be provided to protect the electronic instrumentation systems from surges propagating along the signal and power supply lines. The protection systems shall be such that the protection level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, be maintenance free, and self restoring.
1. Provide lightning and surge protection devices at all antennas, as well as signal lines, communication networks, and power feeds for all lines that originate or are routed outside a building on any part of the existing or proposed circuits.
2. Lightning and surge protection devices shall provide full protection from line to line and from line to ground. Units shall be DIN-rail mounted, rated for a minimum of 10kA maximum surge current and voltage suitable for the type of circuit being protected. Reaction time shall be on the order of nanoseconds.

B. Surge protectors shall be removable without changing the impedance of the circuit. Surge protectors product manufactures shall be:
   1. AC power lines shall comply with all requirements of UL1449 3rd edition with listed devices having a minimum 18kA surge protection and RFI filtering.
      a. Phoenix Contact
      b. MTL MA30
      c. Joslyn Model 1663-08
      d. Taylor 1020FA
      e. Telematic
      f. Edco
      g. Liebert
      h. Powerware
      i. Or equal.
   2. For analog signal lines use ANSI/UL497 listed device with minimum 15kA protection Phoenix contact, or approved equal.
   3. SPD units shall be Phoenix Contact, Emerson SolaHD STC-SLAC Series, Eaton Clipper Power System or approved equal.

C. Intrinsic Safety Barriers (ISB's):
   1. Dual type to prevent grounding alarm circuit at the barrier.
   2. Acceptable manufacturers:
      a. Phoenix Contact
      b. Eaton MTL 7700,
      c. Or approved equal.

2.13 REDUCED VOLTAGE SOLID STATE MOTOR STARTERS (RVSS)

NOT USED

2.14 PANEL GROUNDING

A. Each panel shall be provided with two copper ground bars.
   1. One bar (NEC required) shall be bonded to the panel or panel frame or back-plate and to the facility grounding system.
   2. Second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the panel ground bar only at one point.

B. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar.

C. Field analog wiring shields shall only be grounded at the signal ground bar. Test to verify that single ground point at panel signal ground bar.

D. Surge protectors and separately derived AC power supplies shall be bonded to the frame ground bar.

E. Panels exceeding 36-inches width shall contain ground bars shall be 1/4- by 1-inch copper bars extending the entire length of the panel interior at the bottom of the panel.

2.15 PANEL DRAWING PROTECTION

A. Provide wiring diagrams in accordance with Section 01 33 00. Provide a panel-wiring diagram and schematic for each panel in a plastic bag or plastic container to avoid water damage and aging.

2.16 SPARE PARTS

A. The following spare parts shall be provided:
   1. Ten each of each type of light bulb used in the panels.
   2. Five each of each type and rating of fuse used in the panels.
   3. Five each of each type primary protector surge suppressor used in the panels.
   4. Two each of each type of surge protective device used in the panels.

2.17 PRODUCT DATA

A. The following data shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's operation and maintenance information as specified in Section 01 78 23. Manual shall include final reviewed submittal and separate record of all final configuration, jumper, and switch settings.
   2. Test results as specified in Section 40 61 21-2.02.
   3. Manufacturer's certification for the performance of features of the specified equipment that cannot be readily inspected.
   4. Special requirements for delivery of the information such as time, manner, place, or quantity.

PART 3 EXECUTION

3.01 GENERAL

A. Floor mounted cabinets shall be mounted and shimmed to precise alignment so doors operate without binding. Sealant shall be provided for conduit entering the panels.

B. Floor-mounted panels except in dry control rooms or electrical equipment rooms shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified. Coating shall be provided for outdoor panels in contact on concrete. Field panels and cabinets shall be mounted in compliance with Section 40 61 13-3.01 Field Equipment.

C. Provide panels with the Record As-built schematic, connection, and interconnection diagrams mounted behind plexiglass holder on the inside of the door. Place documentation in a water proof clear bag in the panel document holder.

D. Verify that all panels have been labeled with Arc Flash warning labels per NEC 110.16. Provide labels, with Arc Flash protection boundary and PPE levels, in accordance with Section 26 05 00.

3.02 MOUNTING

A. Control panels supported directly by concrete or concrete block walls shall be spaced out not less than 5/8 inch by framing channel between instrument and wall. Sills shall be leveled so panel structures will not be distorted. Panels shall be shimmed to precise alignment so doors operate without binding and mounted where shock or vibration will impair its operation.

B. Support systems shall not be attached to handrails, process piping or mechanical equipment. Control panels supported directly by concrete or concrete block walls shall be spaced out from the wall to provide for air circulation around the panels.

C. Steel used for support of equipment shall be 316 stainless steel. Support systems including panels shall be designed to prevent deformation greater than 1/8 inch under the attached equipment load and an external load of 200 pounds in any direction.

D. Floor-mounted cabinets, except in dry control rooms or electrical equipment rooms, shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified.

E. Panels shall be shimmed to precise alignment so doors operate without binding. Sealant shall be provided under panels not located in dry control or electrical equipment rooms.

F. Center-line of wall-mounted panels shall be 48 inches above the floor.

G. Panel tops of wall-mounted panels shall be mounted at the same elevation.

3.03 PANEL POWER SUPPLY

A. Power supply and conditioning equipment shall be mounted and connected in compliance with the manufacturer's instructions.

B. Line side disconnect switches shall be provided for power supply and conditioning equipment. Line and load side overcurrent protection shall be provided for power supply and conditioning equipment in compliance with NFPA 70. Disconnect switches shall comply with Section 26 05 00.

C. Small power supply and conditioning equipment may be mounted in the panel served. Larger units shall be mounted adjacent to the equipment served. Where unconditioned power is brought into control panels, it shall be enclosed in metallic raceways within the panel.

D. Power supply and conditioning equipment larger than 5 kVA load capacity supported from surfaces other than concrete shall be provided with sound isolators.

E. Final raceway connections shall be a flexible conduit in compliance with Division 26.

3.04 FACTORY TESTING

A. The control panel shall be assembled, interconnected, and functionally tested at the assembly shop prior to shipment. The Owner/Engineer shall have the option of witnessing the functional shop test. The Contractor shall notify the Owner/Engineer at least two (2) weeks in advance prior of the scheduled functional shop test.

3.05 FIELD TESTING

A. Field verify the following for Instrument and Control Panels:
   1. Control circuits grounded with one terminal of each load device connected to the grounded conductor.
   2. Control contacts installed in the ungrounded side of the circuit.
   3. Panel signal and control wiring separated and installed in separate wireways with barriers between the power wiring and the signal and control wiring.
   4. Barriers between the power wiring and the signal and control wiring.
   5. Connected to the plant grounding system, as specified.
   6. Inner door contains a copy of the Record elementary and wiring diagrams, in a protected drawing holder. Drawings shall be enclosed in a transparent, protective jacket.
   7. Panel Functions as specified.
   8. Mounted with stainless steel unistrut, fittings, and fasteners.
   9. Tested in accordance with Section 26 05 00 and Section 40 61 21.

END OF SECTION

SECTION 40 71 00

FLOW MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 40 06 70.

B. This section specifies requirements for process flow transmitters, associated indication devices, and accessories.

C. This section specifies requirements for process flow activated switches, devices, and accessories.

D. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 06 70. Application requirements are specified in the instrument schedule, Section 40 06 70.

1.02 QUALITY ASSURANCE

A. Manufacturer: Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installer: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

C. References: References are listed in Section 40 61 13 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13-1.08.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 06 70-1.02.

B. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:

   a. Section 01 79 00 – Demonstration and Training

b. Section 01 78 23 – Operating and Maintenance Data
c. Section 40 61 13 – Process Control System General Provisions
d. Section 40 06 70 – Schedules for Instrumentation of Process Systems

A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.

The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.

Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
5. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
6. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.

B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 SYSTEM EQUIPMENT

A. General:
   1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required

in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
   6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
   7. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in paragraph 2.04.
   8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
   1. Measured parameter output indicators complying with paragraph 2.03 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
   2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
   3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
   4. Transmitter output shall increase with increasing measurement.
   5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
   6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
   7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
   8. Transmitters located outdoors shall be provided with surge protectors:
      a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, or accepted equal.
      b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or accepted equal.

9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.04.
10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.05 connected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Phoenix Contact, Eaton MTL 5500 Series, Stahl Series 9000, or accepted equal.

2.05 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20madc to 4-20madc / 5.5VPL / -RF DIN rail mounted with maximum 250 ohm output impedance, or equal.

2.06 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
   1. Flow calculation for each differential-type flow element.
   2. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13-1.06. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21-2.02.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in paragraph 40 61 13-3.02.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.
   2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
   3. Root Valves: Root valves shall be provided at all process taps, except as follows:
      a. Temperature taps, where valves are unnecessary.
      b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
      c. Process taps for safety instruments.
      d. Where gauge valves are provided.
      e. Where chemical seals are used.
   4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.

C. Tubing:
   1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
   2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
   3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:

1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 TESTING

A. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
FVS	Vane Actuated Flow Switch	Flow Measurement

4.02 INSTRUMENT IDENTIFICATION: FVS

A. Instrument Function: Flow Measurement

B. Instrument Description: Vane actuated Flow Switch

C. Signal Input: Process

D. Signal Output: Contacts, in accordance with paragraph 2.02 of this section.

E. Process Connection: Female NPT

F. Product Data:
   1. Vane actuated flow switch shall consist of a vane and a magnetically actuated switch. The body of the switch divided into upper and lower sections so that the upper section is isolated from the process fluid. A stainless steel vane and a primary magnet located in the lower section.
   2. The force of the process fluid impinging on the vane shall produce movement of the primary magnet. The primary magnet shall produce movement of the secondary magnet located in the upper body section, actuating the switch.
   3. The switch shall be DPDT and enclosed in an explosion-proof housing. The switch body and vane shall be type 316 stainless steel unless otherwise specified. Minimum pressure rating of 400 psig and minimum temperature rating of 220 degrees F.

G. Execution:
   1. Installation: Install in accordance with the manufacturer's instructions, Section 40 06 70-3.01, and the specified functional requirements.
   2. Test: In accordance with Section 40 06 70-3.02.
   3. Application/Calibration: Application, calibration and set points as specified in Section 40 06 70-3.03.

H. Approved Manufacturers: W. E. Anderson model V6, McDonnell and Miller AF Series, or equal.

END OF SECTION

SECTION 40 72 00

LEVEL MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 40 06 70.

B. This section specifies requirements for process level transmitters, associated indication devices, and accessories.

C. This section specifies requirements for process level activated switches, devices, and accessories.

D. Scope:

1. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 06 70-3.03. Application requirements are specified in the instrument schedule, Section 40 06 70-3.03.

1.02 QUALITY ASSURANCE

A. Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

C. References are listed in Section 40 61 13 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13-1.08.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 06 70-1.02.

B. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:

a. Section 01 79 00 – Demonstration and Training

b. Section 01 78 23 – Operating and Maintenance Data
c. Section 40 61 13 – Process Control System General Provisions
d. Section 40 06 70 – Schedule for Instrumentation of Process Systems

A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
5. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
6. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.

B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 PRODUCT DATA

A. General:
   1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required

in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
   6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
   7. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers.
   8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
   1. Measured parameter output indicators complying with paragraph 2.02 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
   2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
   3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
   4. Transmitter output shall increase with increasing measurement.
   5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
   6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
   7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
   8. Transmitters located outdoors shall be provided with surge protectors:
      a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, , or accepted equal.
      b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or accepted equal.
   9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.04.

10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.05 connected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Phoenix Contact, Eaton MTL 5500 Series, Stahl Series 900, or Accepted equal.

2.05 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20madc to 4-20madc / 5.5VPL / -RF DIN rail mounted with maximum 250 ohm output impedance, or equal.

2.06 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
   1. Flow calculation for each differential-type flow element.
   2. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13-1.06. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21-2.02.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13-3.01.

B. Process Connections:
   1. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.
   2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
   3. Root Valves: Root valves shall be provided at all process taps, except as follows:
      a. Temperature taps, where valves are unnecessary.
      b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
      c. Process taps for safety instruments.
      d. Where gauge valves are provided.
      e. Where chemical seals are used.
   4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.

C. Tubing:
   1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
   2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
   3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:

1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 TESTING

A. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
LSS	Side-Mounted Float Switch	Level Measurement
LST2	Submerged Diaphragm Level Transmitter	Level Measurement

4.02 INSTRUMENT IDENTIFICATION: LSS

A. Instrument Function: Level Measurement

B. Instrument Description: Side-mounted float Switch

C. Power Supply: N/A

D. Signal Input: Process

E. Signal Output: Contacts, in accordance with paragraph 2.02 of this section.

F. Process Connection: 1-inch female NPT

G. Product Data:
   1. Switch stem and float shall be polypropylene unless otherwise specified. Switch shall be SPDT rated at 15A.
   2. The switch rated for use in Class I, Division 1, Groups BCD hazardous areas. The housing rated NEMA 4X. The float magnetically coupled to the switch such that no seals are required. The process temperature rating to 220 deg. F and the pressure rating of -15 to +2250 psig.

H. Execution:
   1. Installation: Install in accordance with the manufacturer's instructions, Section 40 06 70-3.01, and the specified functional requirements.
   2. Test: In accordance with Section 40 06 70-3.02.
   3. Application/Calibration: In accordance with Section 40 06 70-3.03. Switch set point and reset point adjusted as specified.

I. Approved Manufacturers: Delta Controls type 735, or equal.

4.03 INSTRUMENT IDENTIFICATION: LST2

A. Instrument Function: Level Measurement

B. Instrument Description: Submerged Level Transmitter - Wastewater

C. Power Supply: 24 Vdc Loop Powered

D. Signal Output: 4 to 20 milliamperes into 0 to 550 ohms

E. Process Connection: Submerged, suspended

F. Product Requirements:
   1. Sensor/Transmitter: Minimum 3" large diameter diaphragm with 316 Stainless Steel housing and separate suspension cable. FM Approved for Class I Division 1 when used with approved barrier. Accuracy of 0.25% of full scale and operating temperature from -25°F to 180°F. Cable is shielded and includes vent tube. Separate junction box with built-in breather assembly. Provide cable length to reach junction box without splicing.
   2. Manufacturers:
      a. Blue Ribbon Corp. Model BC001.
      b. Delta Controls Corp. Model 566Y.
      c. Siemens Model A1000i.
      d. Accepted equal.

G. Execution:
   1. Installation: Install in accordance with manufacturer's instructions.
   2. Manufacturer to provide sensor/transmitter, and full length cables.
   3. Calibration: In accordance with Section 40 06 70-3.03. Switch set point and reset point adjusted as specified.

END OF SECTION

SECTION 40 73 00

PRESSURE, STRAIN, AND FORCE MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 40 06 70.

B. This section specifies requirements for process pressure transmitters, associated indication devices, and accessories.

C. This section specifies requirements for process pressure activated switches, devices, and accessories.

D. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 06 70-3.03. Application requirements are specified in the instrument schedule, Section 40 06 70-3.03.

1.02 QUALITY ASSURANCE

A. Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

C. References are listed in Section 40 61 13 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13-1.08.

1.04 SUBMITTALS

A. Submittals shall be provided as specified in Section 40 06 70-1.02.

B. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
    a. Section 01 79 00 – Demonstration and Training
    b. Section 01 78 23 – Operating and Maintenance Data

c. Section 40 61 13 – Process Control System General Provision

d. Section 40 06 70 – Schedule for Instrumentation of Process Systems

A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.

The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.

Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
5. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
6. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.

B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 EQUIPMENT

A. General:

1. In accordance with Section 01 33 00 the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required

in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
   6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
   7. Switch contacts located in Class I, Division 1 areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers.
   8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
   1. Measured parameter output indicators complying with paragraph 2.02 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
   2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
   3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
   4. Transmitter output shall increase with increasing measurement.
   5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
   6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
   7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
   8. Transmitters located outdoors shall be provided with surge protectors:
      a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or accepted equal.
      b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or accepted equal.
   9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.04.

10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.05 connected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Phoenix Contact, Eaton MTL 5500 Series, or Stahl Series 9000], Accepted equal.

2.05 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20madc to 4-20madc / 5.5VPL / -RF DIN rail mounted with maximum 250 ohm output impedance, or equal.

2.06 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
   1. Flow calculation for each differential-type flow element.
   2. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13-1.06. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21-2.02.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13-3.02.

B. Process Connections:
   1. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.
   2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
   3. Root Valves: Root valves shall be provided at all process taps, except as follows:
      a. Temperature taps, where valves are unnecessary.
      b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
      c. Process taps for safety instruments.
      d. Where gauge valves are provided.
      e. Where chemical seals are used.
   4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.

C. Tubing:
   1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
   2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
   3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:

1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 TESTING

A. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
PGT	Gage Pressure Transmitter	Pressure Measurement

4.02 INSTRUMENT IDENTIFICATION: PGT

A. Instrument Function: Pressure Measurement

B. Instrument Description: Gage Pressure Transmitter

C. Power Supply: As specified in paragraph 2.02

D. Signal Input: Process

E. Signal Output: Analog transmission signal as specified in paragraph 2.02

F. Process Connection: 1/2-inch female NPT flange adapter

G. Product Requirements:
   1. Pressure Transmitter: Capacitance or piezoresistive type.
   2. Wetted Parts: Type 316 stainless steel or as specified in Section 40 06 70-3.03.
   3. Range: 100:1.
   4. Accuracy: 0.075 percent of calibrated span.
   5. Static Pressure Rating: 2,000 psi.
   6. Indicator: LCD display.
   7. HART standard data communication protocol
   8. Acceptable Manufacturer:
      a. Rosemount 3051C.
      b. Accepted equal.

H. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and the Engineer’s installation detail.
   2. Root valves provided at all process pressure taps.
   3. Gauge valves provided at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
   4. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording.
   5. Pressure instruments located as close as practical to the process tap and be positioned to permit observation and maintenance.

6. Pressure instruments shall not be supported from process piping.
7. Pressure instruments for use with integral seals, or remote seals and capillary tubing provided by a single manufacturer, and all components factory-assembled prior to shipping.

I. Seals:
   1. Type: Diaphragm,
   2. Process Connection: 3-1/2 inch saddle style, flush surface or inline style.
   3. Diaphragm and Wetted Parts: Type 316L stainless steel unless otherwise specified.
   4. Upper Housing and Mounting Flange: Type 316L stainless steel. Lower Housing: Type 316 stainless steel
   5. Temperature Limit, High Side: -40 to 300 degrees F
   6. Acceptable Manufacturer:
      a. Rosemount 1199.
      b. Accepted equal.

J. Capillary option:
   1. Seal Location: High pressure side of transmitter, direct mounting.
   2. Fill Fluid: DC 200 Silicone
   3. Capillary Seal Connection Material: Type 316 stainless steel armored sleeving

END OF SECTION

SECTION 40 76 00

PROCESS GAS ANALYTICAL MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for process gas analyzer indicating transmitters.

1.02 REFERENCES

A. References shall be as specified in Section 40 61 13.

1.03 SUBMITTALS

A. Submittals shall be provided as specified in Sections 01 33 00 and 40 61 13, including:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
   a. Section 01 79 00 – Demonstration and Training
   b. Section 01 78 23 – Operating and Maintenance Data
   c. Section 40 61 13 – Process Control System General Provisions
   d. Section 40 06 70 – Schedules for Instrumentation and Process Systems

   A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. *Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*
2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be *marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.*
3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. *Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.*
4. Marked product literature of all equipment and features to be provided.

5. Installation drawings for the analyzer, sensor, and mounting accessories to be provided.
6. Electrical and signal connection drawings for the analyzer and sensor to be provided.
7. List of miscellaneous items, cables, spare parts, replenishment parts, and gases that will be provided in accordance with INSTRUSPEC sheet requirements.
8. List of spare parts and calibration materials to be provided.

1.04 ENVIRONMENTAL CONDITIONS

A. Refer to Section 40 61 13.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the candidate manufacturers listed in the INSTRUSPEC sheets included in this Section are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.

2.02 GENERAL

A. Process gas analyzers shall comply with the following requirements:
   1. Measured parameter output indicators shall be calibrated in process engineering units.
   2. Two-wire, three-wire and four-wire analyzers shall provide 4 to 20 milliampere (mA) output signal. Two-wire transmitter shall derive operating power from the current output signal. Three-wire transmitter shall require an external 24 V DC power supply; the power supply common and the current output return shall share the same wire. Four-wire transmitter shall require external 24 V DC or 120 V AC power supply; there shall be no electrical connection between the current output signal and the power supply.
   3. Transmitter output signal shall support an external load of a minimum of 500 ohms.
   4. Transmitter output signal shall be galvanically isolated from the process, the analyzer case, and external power supply to prevent ground loops. If output signal is not galvanically isolated then loop-powered current signal isolator as specified in Section 40 71 00 and connected in series with the output signal shall be provided.
   5. Analyzers located outdoors shall be provided with surge protectors as specified in Section 40 71 00.
   6. Transmitter output shall linearly increase with increasing process measurement, except where specified as "reverse action" in the Instrument Index.
   7. Electrical parts of analyzer transmitter and/or primary element mechanisms shall be housed in enclosures meeting NEMA 250, Type 4X requirements.
   8. Electrical equipment and analyzer transmitters located outdoors or in areas specified as corrosive shall have enclosures meeting NEMA 250, Type 4X requirements.
   9. Transmitters located in a classified hazardous area per the NFPA and the NEC, shall be manufacturer approved and labelled for classified hazardous area installations.

Provide intrinsic safety barriers if required by the manufacturer to meet approval of installation for classified hazardous area installations, as specified in Section 40 71 00.

10. One analyzer transmitter shall be provided for each sensor, unless otherwise noted.

2.03 PRODUCT DATA

A. The following data shall be provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each analyzer.
   2. Test results as specified in Section 40 61 21.

2.04 HAZARDOUS AND COMBUSTIBLE GAS DETECTORS

A. All combustible and hazardous gas detector sensors and transmitters shall comply with the following requirements:
   1. Each sensor shall have an independent transmitter capable of locally and remotely alerting personnel to hazardous situations in the area being monitored.
   2. The transmitter shall continuously monitor and analyze the volume of toxic and/or combustible gases and display the current process variable on an integral interface. The interface shall also provide an alarm when it reaches the programmed set point. The interface shall also provide means to display transmitter diagnostics and active faults.
   3. The accuracy of the measurements shall be within 5% of full scale.
   4. Transmitter must have three dry contact outputs capable of transmitting “High Alarm”, “High High Alarm”, and “transmitter fault” conditions.
   5. Transmitters utilized for the monitoring of combustible gas conditions must have the “High Alarm” activated at no higher than 10% of the Lower Explosive Limit (LEL).
   6. Contacts must be rated for 5A at 250 Volts AC or 5A at 24 VDC.
   7. Field elements shall be suitable for the atmospheric pollution monitored; i.e., combustible gas detectors shall be explosionproof and chlorine, sulfur dioxide, and hydrogen sulfide detectors shall operate where exposed to dangerous concentrations of the monitored gas.
   8. The sensors shall be hot swappable that are rated to be replaced under power within the hazardous classified area.
   9. Transmitters located outdoors without integrated surge protection shall be provided with surge protectors.
   10. Transmitter output signal shall be galvanically isolated from the process, the analyzer case, and external power supply to prevent ground loops. If output signal is not galvanically isolated then loop-powered current signal isolator as specified in Section 40 71 00 and connected in series with the output signal shall be provided.
   11. Transmitters located in a classified hazardous area per the NFPA and the NEC, shall be manufacturer approved and labelled for classified hazardous area installations. Provide intrinsic safety barriers if required by the manufacturer to meet approval of installation for classified hazardous area installations, as specified in Section 40 71 00.

12. Provide nameplates for all devices covered by this section as required in Section 40 61 13 2.05.

2.05 GAS ANALYZERS CONTROLLERS THAT AGGREGATE SIGNALS FROM AT LEAST ONE DETECTOR

A. In installations where more than one hazardous and/or combustible gas detector is to be installed, all detectors associated with the hazardous area will be connected to a gas analyzer controller that can aggregate all of the associated detector signals.

B. The gas analyzer controller system shall be installed outside of the hazardous area being monitored. The gas analyzer system shall be situated in a way to alert and report conditions in the hazardous space to employees who could potentially be entering that space.

C. Gas Analyzer shall be provided with a NEMA 4X panel suitable for wall mounting and include all accessories for a complete installation. Panel shall display gas concentrations and alarms for all integrated signals and include an alarm horn and strobe activated by the alarms. A silence/acknowledge pushbutton shall be provided.

D. The gas analyzer system shall accept 120 VAC, 60 Hertz power.

E. All sensors associated with the analyzer system shall be powered from the gas analyzer system by a lower voltage that is suitable for the area classification that the sensors are installed.

F. In addition to passing on all alarms associated with detectors, the analyzer system shall be capable of providing local and remote alarming for at least the following fault conditions:
   1. Transmitter fault – this would alert personnel to a failure of any of the integrated detectors.
   2. Analyzer fault – this would alert personnel to a failure of the analyzer system.

G. Recommended Manufacturer must match the manufacturer chosen for the detectors listed in Section 2.02.

H. Provide nameplates for all devices covered by this section as required in Section 40 61 13 2.05.

2.06 STROBES

A. Additional strobes that are not intrinsic to a gas analyzer system shall be provided where specified on the Drawings. These visual devices have a rotating or flashing light that is activated when gas is detected in the associated area. All strobes provided under this Section shall be provided by the same manufacturer.

B. Strobes shall meet the following requirements, at a minimum:
   1. Power: 24 VDC.
   2. Color: Red and Yellow as specified on the Drawings.
   3. Flashes: 60 flashes per minute (minimum).

4. Light intensity: 165 Effective Candlepower (ECP)
5. Enclosure: NEMA 4X or explosion-proof with corrosion-resistant housing, as required by the installation environment.
6. Accessories: Provide hazardous location light wall-mounting kit and protective dome guard.
7. Where gas is monitored each horn and beacon shall include a 6-inch by 10-inch red with white letter lamacoid nameplate with the specific warning.
    a. DANGER GAS
    b. VENTILATION SYSTEM FAILURE
    c. As needed for each application.
8. Approvals:
    a. Unclassified or Class I, Division 2 locations: UL Listed or FM Approved for Class I division 2.
    b. Class I, Division 1 locations: UL Listed or FM Approved for Class I division 1.
9. Manufacturers:
    a. Federal Signal:
        1) Unclassified or Class I, Division 2 locations: Model 151XST.
        2) Class I, Division 1 locations: Model 27XL.

C. Provide nameplates for all devices covered by this section as required in Section 40 61 13 2.05.

2.07 CALIBRATION EQUIPMENT

A. Provide one set of all tubing, regulators, calibration gas cylinders, and appurtenances required to perform field verification and regular calibrations.

B. If sensors must be installed in an area where personnel cannot reasonably reach the equipment for calibration, then additional tools or means to get the calibration gas to the head must be provided to allow them to calibrate the equipment.

2.08 PRODUCT DATA

A. Provide the following product data in accordance with Section 01 33 00:
1. Final reviewed submittal, including revised as-built submittal drawings.
2. Record of all final configuration, jumper, and switch settings for each instrument.
3. Record document such as panel wiring diagrams, connection diagrams, interconnection diagrams, loop diagrams, elementary control diagrams, and data sheets as outlined in Section 40 61 13.01.
4. Manufacturer's operation and maintenance information, edited for this project, as specified in Section 40 61 13-2.03.
5. Hardcopy and electronic copy of final configuration files used for configuration and communication set up of programmable electronic based instruments. If instrument uses HART programmer, provide the most current HART configuration files.
6. Calibration forms completed with the name of company and individual responsible for calibration, location of calibration, range or set point (including deadband for reset), and date.

7. Safety Data Sheets.
8. Test results as specified in Section 40 61 21-2.02.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation requirements are specified in Section 40 61 13.

B. Install instruments and process connections in accordance with manufacturer's instructions, the recommendations of API RP 551 to the specified requirements, NFPA 820, and as shown on the Drawings.

C. Sensors:
   1. Provide sensor manufacturer fabricated or recommended cable between sensor and the remote transmitter.
   2. Location: Panel, duct, or room as specified.
      a. Panel: Locate in panel enclosure when using a sample gas pump.
      b. Duct: Provide sensor manufacturer duct mount kit, including sensor guard to protect against dirt and water while allowing gas to penetrate.
      c. Room: Locate in non-stagnated HVAC air flow area away from fresh air inlet duct.
   3. Sensors must be accessible. Efforts should be made to install them in a way where they are reachable for scheduled or unscheduled calibrations by means of readily available tools.

D. Horns: Install horns in locations that are accessible for maintenance and audible at the entries and within the affected area when gas detection is present.

E. Strobes: Install strobes in locations that are accessible for maintenance and readily viewable at the entries and within the affected area when gas detection is present.

F. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 CALIBRATION

A. Application, calibration, and set points shall be as specified in 40 06 70-3.03 or per

3.03 TESTING

A. Testing requirements are specified in Section 40 61 21.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00 and 40 61 13. Provide two training sessions, each with one hour per type of analyzer

3.05 INSTRUMENTATION SPECIFICATION (INSTRUSPEC) SHEETS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, Section 40 70 00-3.03, and/or on the drawings.

B. INSTRUSPEC sheets for the analyzers listed in the following Table A are included in this paragraph:

INSTRUSPEC Symbol	Instrument Description	Instrument Function
MI	Combustible Gas Detector	Hazardous Atmosphere Measurement

3.06 MI INSTRUMENT SPECIFICATION SHEET – INSTRUSPEC

A. Instrument Identification: MI

B. Instrument Description: A complete, factory provided unit including sensor and analyzer/transmitter that measures combustible gas concentrations (as a % of Lower Explosive Limit (LEL)) in ambient air using infrared technology. Sensor and analyzer/transmitter shall be compatible with the environmental classification(s).

C. Unless otherwise specified, combustibles (Methane) Sensors shall utilize infrared point gas detection for continuous monitoring of combustible gasses and vapors. The sensor shall continuously analyze 0-100% Lower Explosive Limit (LEL).

D. Power Supply: 8 – 30 VDC.

E. Signal Output:
   1. 4 to 20 mA or MODBUS RS-485 Communications if communicating with an analyzer that aggregates more than one signal.
   2. Two SPDT outputs rated at 5 A at 120 VAC.
   3. Output signaling that allows the transmitter to communicate with the chosen gas analyzer controller technology.

F. Product Requirements:
   1. Sensor and analyzer/transmitter shall be from the same manufacturer.
   2. Analyzer/transmitter shall have an integral LCD display.
   3. The unit assembly shall be approved by Factory Mutual.
   4. The detector shall operate on the infrared absorption principle incorporating a heated double-compensated optical bench (2 lamps, 2 detectors) with non-focusing optics design.
   5. The analyzer/transmitter shall be microprocessor controlled and shall perform self-diagnostics with error indications such as "Beam block", indicating the beam is more than 80 percent interrupted by dirt or impurities. The detection shall automatically compensate for temperature and humidity changes in the surrounding atmosphere.
   6. Performance Parameters:
      a. Range: 0 – 100% LEL.

b. Temperature Range: -40 F to 140 F.
c. Zero Drift: ±2%/year.
d. Repeatability: ±1% full scale.
e. Linearity: ±5% full scale.
f. Response Time (T90 combustible): <2 seconds.
g. Humidity: 0% - 95% RH, non-condensing.

7. Calibration Kit: Provide manufacturer's recommended calibration kit consisting of the following:
   a. Provide two cylinders of zero and span gas; one pair of zero and span gas shall be used by the Contractor for initial calibration, the second pair shall be delivered to the owner.
   b. Flow regulator(s) with tubing.
   c. Environmental guard (if needed).
   d. Carrying case.
   e. [Controller for configuration, one for all analyzers].
   f. Any tools that are required to reach remote sensors for regular calibration.
8. Provide two years of onsite calibration services including gases.

G. Manufacturers:
1. MSA Safety Ultima XIR, RKI Instruments T3A, Honeywell, or equal.

H. Execution:
1. Installation: Sensor and analyzer/transmitters shall be installed in accordance with manufacturer's recommendations. Sensor mounted near the most likely area of a leak or gas source. For methane gas, whose density is less than air, the sensor shall be mounted close to the ceiling. Remote-mounted sensors shall be mounted within the manufacturer's recommended distance(s).
2. Configure alarm contacts to open upon alarm for the following:
   a. Trouble.
   b. Gas level/concentration alarm.
3. Application/Calibration: In accordance with Section 40 06 70-3.03.

END OF SECTION

SECTION 43 05 11

GENERAL REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies general requirements which are applicable to all mechanical equipment. The Contractor is responsible for ensuring that all mechanical equipment meets the requirements of this section in addition to the specific requirements of each individual equipment specification section.

B. Equipment Lists:

1. Equipment lists, presented in these specifications and as specified on the drawings, are included for the convenience of the Construction Manager and Contractor and are not complete listings of all equipment, devices and material required to be provided under this contract. The Contractor shall prepare his own material and equipment takeoff lists as necessary to meet the requirements of this project manual.

1.02 QUALITY ASSURANCE

A. Arrangement:

1. The arrangement of equipment shown on the drawings is based upon information available to the Owner at the time of design and is not intended to show exact dimensions conforming to a specific manufacturer. The drawings are, in part, diagrammatic, and some features of the illustrated equipment installation may require revision to meet actual submitted equipment installation requirements; these may vary significantly from manufacturer to manufacturer. The contractor shall, in determining the cost of installation, include these differences as part of his bid proposal. Structural supports, foundations, connected piping, valves, and electrical conduit specified may have to be altered to accommodate the equipment actually provided. No additional payment shall be made for such revisions and alterations.

B. References:

1. This section contains references to the documents listed below. They are a part of this section as specified and modified. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that

date, regardless of whether the document has been superseded by a version with a later date, has been discontinued or has been replaced.

Reference	Title
ABMA Std 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA Std 11	Load Ratings and Fatigue Life for Roller Bearings
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Gray Iron Pipe Flanges and Flanged Fittings, (Classes 25, 125, and 250)
ANSI B18.2.1	Square and Hex Bolts and Screws (Inch Series)
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ANSI S2.19	Mechanical Vibration – Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Unbalance, Including Marine Applications

C. Unit Responsibility:
   1. The Contractor shall cause equipment assemblies made up of two or more components to be provided as a working unit by the unit responsibility manufacturer, where specified. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance requirements. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement. The requirement for unit responsibility shall in no way relieve the Contractor of his responsibility to the Owner for performance of all systems as provided in the General Conditions of the Contract Documents.

D. The Contractor shall ensure that all equipment assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Contractor to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, form and style of Form 43 05 11-C specified in Section 01 99 90, shall be signed by an officer of the unit responsibility manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.

PART 2 PRODUCTS

2.01 FLANGES AND PIPE THREADS

A. Flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.

B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise specified, flanges shall be flat faced.

C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.02 BEARINGS

A. Unless otherwise specified, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service specified. Each bearing shall be rated in accordance with the latest revisions of ABMA Methods of Evaluating Load Ratings of Ball and Roller Bearings. Unless otherwise specified, equipment bearings shall have a minimum L-10 rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.

C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.

D. All bearings accessible to touch, and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures, shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65 degrees C or less for continuous operation at bearing rated load and a 50 degrees C ambient temperature or shall be provided with appropriate shielding shall be provided that will prevent inadvertent human contact.

2.03 CAUTION SIGNS

A. Equipment with guarded moving parts which operates automatically or by remote control shall be identified by signs reading "Caution - Automatic Equipment May Start At Any Time". Signs shall be constructed of fiberglass material, minimum 1/8 inch thick, rigid, suitable for post mounting. Letters shall be white on a red background. The sign size and pattern shall be as shown on the drawings. Signs shall be installed near guarded moving parts.

2.04 GAGE TAPS, TEST PLUGS AND GAGES

A. Gage taps shall be provided on the discharge sides of pumps. Pressure and vacuum gages shall be provided where specified. Gage taps, test plugs, and gages shall be as specified in Division 40.

2.05 NAMEPLATES

A. Nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation and equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible and visible location with stainless steel screws or drive pins.

2.06 LUBRICANTS

A. The Contractor shall provide for each item of mechanical equipment a supply of the required lubricant adequate to last through the specified commissioning period. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of the Owner's current lubricant supplier. The Contractor shall limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. Not less than 90 days before the date shown in his construction schedule for starting, testing and adjusting equipment (Section 01 45 20), the Contractor shall provide the Owner with three copies of a list showing the required lubricants, after consolidation, for each item of mechanical equipment. The list shall show estimated quantity of lubricant needed for a full year's operation, assuming the equipment will be operating continuously.

2.07 ANCHOR BOLTS

A. Anchor bolts shall be designed for lateral forces for both pullout and shear in accordance with the provisions of Section 05 05 20. Unless otherwise stated in the individual equipment specifications, anchor bolt materials shall conform to the provisions of Section 05 05 20.

2.08 SPARE PARTS

A. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified by part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

PART 3 EXECUTION

3.01 GENERAL

A. Installation of equipment accessories included in this section shall be as recommended by the equipment manufacturer unless otherwise specified in the individual equipment specification section.

END OF SECTION

SECTION 43 05 21

COMMON MOTOR REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Squirrel cage type, AC induction motors, up to 500 HP, for up to 4 poles (3600 or 1800 rpm nominal), or up to 250 HP for over 6 poles (1200 rpm or slower) shall be per NEMA MG1, Small or Medium.
2. Special purpose motors with features or ratings which are not specified herein, are specified in the particular equipment specifications.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

Section 26 05 00.01

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
IEEE 112	Standard Test Procedures for Polyphase Induction Motors and Generators
IEEE 841	Standard for Petroleum and Chemical Industry- Premium-Efficiency, Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500 HP
NEMA ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA MG 1	Motors and Generators
Department of Energy	Energy Policy and Conservation Act, Final Rules EERE-2010-BT-STD-0027-0117
UL 674	Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 1004	Electric Motors

1.04 DEFINITIONS

A. Terminology used in this Section conforms with NEMA MG-1. Motors covered in this specification are those defined in NEMA MG1 as Small (Fractional) and Medium (Integral) AC induction motors.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility: Where Unit Responsibility is specified in the driven equipment sections of these specifications, the motor supplier shall coordinate with the provider of the driven equipment to verify that the motor provided under this section is fully compatible with and meets the specified performance requirements for that equipment.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
      a. Copy of this Section, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
      b. Check-marks (✓) to denote full compliance with a paragraph as a whole. Underline deviations and denote by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance. Include a detailed, written justification for each deviation.
      c. Failure to include a copy of the marked-up specification sections with justification(s) for any requested deviation will cause rejection of the entire submittal with no further consideration.
   2. Motor Data Sheets specified in this Section.
      a. Motors in conformance with IEEE 841: Manufacturers to complete IEEE Standard 841 Data Sheet for AC Induction Motors.
      b. Motor Speed-Torque curve, where specified.
   3. Routine Factory test data for polyphase motors.
      a. High-potential test.
   4. Factory test data, from required dynamometer tests, where specified.
   5. Vibration level when measured in accordance with NEMA MG 1, for all IEEE 841 motors, and where elsewhere specified.
   6. Motor heating curve, where specified,
   7. Motor mounting, outline, dimensions, and weight.
   8. Motor bearing and winding RTDs (resistance temperature detector), where specified.
   9. Motor winding thermostat or thermistor, where specified.
   10. Motor winding space heaters, where specified.
   11. Motor nameplate data.

B. Informational Submittals:
   1. Procedures: Section 01 33 00 and 01 78 23.
   2. Submittal requirements for operation and maintenance manuals as per requirements of Section 01 78 23.

1.07 QUALITY ASSURANCE

A. Factory Testing:
   1. All polyphase motors shall be factory tested in conformance with routine tests per NEMA MG1 and IEEE 112. Provide the following tests:

a. Measurement of winding resistance.
b. No-load readings of current and speed at normal voltage and frequency.
c. Current input at rated frequency with rotor at standstill.
d. High potential test.

B. Where specified for use in corrosive or hazardous locations, motor testing shall additionally be per IEEE 841. Test report shall be certified by the motor manufacturer's test personnel and submitted to the Engineer.

1.08 DELIVERY, STORAGE AND HANDLING

A. Procedures shall be in accordance with Section 01 66 00.

1.09 SPECIAL WARRANTY

A. Provide warranty in accordance with Section 01 78 36.

B. Submit warranties in writing to include 100 percent full payment coverage for parts and labor for repair or replacement of the motor (s) during the warranty period.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:
1. Baldor
2. General Electric
3. Siemens
4. US Motors
5. WEG
6. Approved Equal

2.02 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:
1. Temperature: -25-degree C to +40 degree C.
2. Altitude: 0 to 3300 feet above sea level minimum.
3. Derate motors for higher ambient temperature and for higher altitude with motor size based on brake-horsepower.

B. Design Requirements:
1. Operation: Continuous.
2. Compliance: Energy Policy Act of 1992 (EPAct), Final Rule 2014.
3. Tolerance: +/- 10-percent of rated voltage at rated frequency; +/- 5-percent of rated frequency at rated voltage.
4. Standard design: NEMA Design B.

C. Service Factor (percent of additional horsepower):
   1. 1.15 for Sine-wave motors.
   2. Dual rating: 1.15 Sine-wave and 1.0 Inverter Duty for Inverter Duty motors.

D. Motor Efficiency:
   1. NEMA Premium™ efficiency electric motor, single-speed, polyphase, 1-500 horsepower, 3600-rpm 2-pole, 1800-rpm 4-pole, and 1200-rpm 6-pole (1-250 HP), squirrel cage induction motors, NEMA Design B, continuous rated. NEMA Standards Publication MG 1 2011, in Table 12-12.

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Open Motors								
	2 Pole		4 Pole		6 Pole		8 Pole	
HP	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84	81.5	86.5	84.0	86.5	84.0	77.0	74.0
2	85.5	82.5	86.5	84.0	87.5	85.5	86.5	84.0
3	85.5	82.5	89.5	87.5	88.5	86.5	87.5	85.5
5	86.5	84.0	89.5	87.5	89.5	87.5	88.5	86.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5	89.5	87.5
10	89.5	87.5	91.7	90.2	91.7	90.2	90.2	88.5
15	90.2	88.5	93.0	91.7	91.7	90.2	90.2	88.5
20	91.0	89.5	93.0	91.7	92.4	91.0	91.0	89.5
25	91.7	90.2	93.6	92.4	93.0	91.7	91.0	89.5
30	91.7	90.2	94.1	93.0	93.6	92.4	91.7	90.2
40	92.4	91.0	94.1	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	91.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.5	95.0	94.1	94.5	93.6	93.0	91.7
75	93.6	92.4	95.0	94.1	94.5	93.6	94.1	93.0
100	93.6	92.4	95.4	94.5	95.0	94.1	94.1	93.0
125	94.1	93.0	95.4	94.5	95.0	94.1	94.1	93.0
150	94.1	93.0	95.8	95.0	95.4	94.5	94.1	93.0
200	95.0	94.1	95.8	95.0	95.4	94.5	94.1	93.0
250	95.0	94.1	95.8	95.0	95.8	95.0	95.0	94.1
300	95.4	94.5	95.8	95.0				
350	95.4	94.5	95.8	95.0				
400	95.8	95.0	95.8	95.0				
450	96.2	95.4	96.2	95.4				
500	96.2	95.4	96.2	95.4				

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Enclosed Motors								
HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5	78.5	75.5
2	85.5	82.5	86.5	84.0	88.5	86.5	84.0	81.5
3	86.5	84.0	89.5	87.5	89.5	87.5	85.5	82.5
5	88.5	86.5	89.5	87.5	89.5	87.5	86.5	84.0
7.5	89.5	87.5	91.7	90.2	91.0	89.5	86.5	84.0
10	90.2	88.5	91.7	90.2	91.0	89.5	89.5	87.5
15	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
20	91.0	89.5	93.0	91.7	91.7	90.2	90.2	88.5
25	91.7	90.2	93.6	92.4	93.0	91.7	90.2	88.5
30	91.7	90.2	93.6	92.4	93.0	91.7	91.7	90.2
40	92.5	91.0	94.2	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	94.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.5	95.0	94.1	94.5	93.6	92.4	91.0
75	93.6	92.4	95.4	94.5	94.5	93.6	93.6	92.4
100	94.1	93.0	95.4	94.5	95.0	94.1	93.6	92.4
125	95.0	94.1	95.4	94.5	95.0	94.1	94.1	93.0
150	95.0	94.1	95.8	95.0	95.8	95.0	94.1	93.0
200	95.4	94.5	96.2	95.4	95.8	95.0	94.5	93.6
250	95.8	95.0	96.2	95.4	95.8	95.0	95.0	94.1
300	95.8	95.0	96.2	95.4				
350	95.8	95.0	96.2	95.4				
400	95.8	95.0	96.2	95.4				
450	95.8	95.0	96.2	95.4				
500	95.8	95.0	96.2	95.4				

2.03 MATERIALS

A. Motor frames:
   1. TEFC motors shall be cast iron.
   2. Aluminum frame motors are not permitted.

B. Stator windings:
   1. Shall be copper with Class F minimum insulation not to exceed Class B temperature rise of 80-degree C at rated load and with Design B torque /current characteristics for all Medium (Integral) motors.

2. Small (fractional) motors shall be supplied with Class F insulation where available.

C. Rotor material shall be aluminum or copper.

D. Fans shall be non-sparking fan blades.

E. Motor leads shall be non-hygroscopic.

2.04 MOTOR TYPES

A. General Requirements for motors 1/2 horsepower through 500 horsepower:
   1. Three phase, squirrel cage, with copper windings.
   2. Rated for full voltage starting and continuous duty.
   3. Rating shall be:
      a. 460/ 230 volts, three-phase, 60-Hertz, as shown on the contract drawings.
   4. General Purpose Type motors, which may also be called Type 1 per the project equipment specifications shall be:
      a. Open Drip Proof Motors, shall be as defined per NEMA MG1, self-cooled by convection air.
   5. Severe Duty Type Motors, which may also be called Type 2 per the project equipment specifications, shall be in accordance with IEEE 841.
      a. Totally Enclosed Fan-Cooled Motors (TEFC) shall be defined per NEMA MG1.
      b. Enclosure: totally enclosed, fan cooled, with external fan blowing air to the motor frame cooling fins for cooling.
      c. Applications: severe duty and most outdoor installations.
   6. Explosion Proof Type Motors, which may also be called Type 3 per the project equipment specifications.
      a. Enclosures: UL listed explosion proof
      b. Applications: hazardous locations including Class I and Class II (Division 1 and 2), and Class III classified areas.

B. Motors Less Than 1/2 Horsepower:
   1. Type shall be:
      a. Squirrel cage, capacitor start with Class F insulation and copper windings.
      b. Fan motors rated 1/8 horsepower or less: split-phase or shaded-pole type.
   2. Rating shall be as shown on drawings.
      a. 115 Volts, single phase, 60 Hz.
      b. 208 Volts, single phase, 60 Hz.
      c. 230 Volts, single phase, 60 Hz.

2.05 COMPONENTS

A. Inverter-Fed Polyphase Motors per NEMA MG1 Part 31:
   1. Applications: variable torque or constant torque loads, for vertical or horizontal motors with variable frequency drive controllers (VFD).

2. Features shall include:
    a. Insulation design to meet 2000-Volt peak at a minimum of 0.1 micro-second rise time.
    b. Built-in motor winding protection as specified.
    c. Electrically insulated bearings or,
    d. Provide Electro Static Technology's AEGIS Shaft Grounding Ring for Bearing Protection or equal. The shaft grounding ring shall be solidly bonded per manufacturer's recommendations.

B. Vertical Motors:
    1. Features: Inverter duty or non-inverter duty with solid shaft P-base and high thrust bearing compatible with loads imposed by the driven equipment.

C. Thermal Protection:
    1. Inverter duty motors:
        a. Motors up to 50 horsepower:
            1) Protection to be NEMA Type 2 bi-metallic thermal switch (Klixon) type.
            2) Motor Nameplate: Marked "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.43.
    2. Explosion proof motors:
        a. Protection to be NEMA Type 2 bi-metallic thermal switch (Klixon) type:
            1) Constant speed motors (non-explosion proof).
        b. Motors up to 50 horsepower:
            1) Where thermal protection is specified in the driven equipment specifications, provide NEMA Type 2 bi-metallic thermal switch (Klixon) type.
            2) Motor Nameplate: Marked "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.43.

D. Motor Nameplates:
    1. Materials: Engraved or stamped stainless steel.
    2. Features shall be as follows:
        a. NEMA Standard MG 1 motor data.
        b. Permanently fastened to the motor frame.
        c. ABMA bearing identification number for motors meeting IEEE 841.
        d. NEMA nominal efficiency for all motors.
        e. NEMA nominal and minimum efficiency for motors meeting IEEE 841.
        f. UL frame temperature limit code for explosion proof motors.
        g. Space heater data.
        h. Over Temperature Protection Type Number.
        i. Temperature device rating and alarm and shutdown setpoint.
        j. Provide motor nameplates for motors with space heaters located in Class I, Division 2, Groups C, and D areas in accordance with NEC 501.125(B).

E. Conduit Boxes:
   1. Provide oversized boxes, with split construction with threaded hubs and petroleum-resistant gaskets.
   2. Conduit boxes can be rotated in order to permit installation in any of four positions 90 degrees apart.
   3. Provide grounding lug located within the conduit box for ground connection.
   4. Provide separate conduit boxes for temperature devices and space heaters.
   5. Separate terminal box for any signal leads (RTD, thermistor, vibration transmitter, etc.).

F. Bearings:
   1. Provide oil or grease lubricated ball bearings, angle contact roller bearings for axial thrust loads, and cylindrical bearings for radial-only loads.
   2. Rated for a minimum L-10 life of 50,000 hours for direct-connected loads.
   3. Cartridge type bearings will not be accepted.
   4. Fitted with lubricant fill and drain or relief fittings.
   5. Belt loads not to exceed forces calculated from NEMA MG 1 Table 14-1 and 14-1A.

G. Bearing lubrication shall be either grease or oil as per the requirements in either 1 or 2:
   1. Grease lubricated bearings:
      a. Shall be for electric motor use only.
      b. Grease shall be capable of higher temperatures associated with electric motors and shall be compatible with Polyurea-based greases.
      c. Provide grease fittings, similar to Alemite™ type (or equivalent).
      d. Shielded bearings with regreasable provisions are permissible.
   2. Provide oil lubricated bearings with externally visible sight glass to view oil level.

H. Lifting Eyes:
   1. Provide lifting eyes with a safety factor of 5.
   2. Provide one lifting eye for motors more than 50 pounds.
   3. Provide two lifting eyes for motors over 150 pounds.

I. Winding Space Heaters when specified or shown:
   1. Provide winding space heaters to prevent condensation.
   2. Rating: 120 volts, single phase, 60 Hertz.
   3. Motor nameplate to show space heater rating in watts and volts.
   4. Provide terminal block in motor conduit box for heater leads termination.

2.06 FINISHES

A. Paint Finish:
   1. Provide standard manufacturer paint finish.
   2. Provide motors with semi-gloss finish, scratch and heat resistance electric motor paint.

PART 3 EXECUTION

3.01 EXAMINATION

A. Delivery Inspection:
   1. Inspect driven equipment-motor assembly and components immediately upon delivery and unloading at the job site for damages.
   2. Take photos of damage(s) if any, to substantiate the delivery inspection report.

3.02 INSTALLATION

A. Grounding of Motors:
   1. Connect the motor feeder ground cable (green) to the grounding lug terminal in the conduit terminal box.

B. Supplemental Grounding of Motors: Provide for motors fed from VFDs, all motors above 100 horsepower, and all motors in classified areas, where feasible.
   1. Bond the motor frame to the grounding grid/electrode system to provide supplemental grounding.

3.03 FIELD QUALITY CONTROL

A. Field Testing:
   1. Measure winding insulation resistance of motors to no less than 10-megohm with a 1000-Vac megohmmeter.
   2. Perform motor phases current imbalance testing for motors 20 horsepower and larger.
   3. Test motors for proper rotation prior to connection to the driven equipment.
   4. Perform thermographic survey per NETA ATS, for motors over 100 horsepower.

B. Field Inspection:
   1. Compare equipment nameplate data with drawings and specifications.
   2. Inspect physical and mechanical condition.
   3. Inspect anchorage, alignment, and grounding.
   4. Verify the installation of breather/drain fittings as specified herein.
   5. Check for proper connections of space heaters, winding and RTDs and or thermostats.
   6. Visually check for correct phase and ground connections:

3.04 SYSTEM START UP

A. Commissioning Test: Provide where specified or shown on the drawings.
   1. Provide assistance during the commissioning test of the motor driven equipment.

3.05 CLOSEOUT ACTIVITIES

A. Operation and Maintenance:
   1. Provide the operation and maintenance manual of the motor(s). Include testing result information in the O&M manual.

END OF SECTION

SECTION 43 23 80.11

SUBMERSIBLE WASTEWATER PUMPS – CONSTANT SPEED

PART 1 GENERAL

1.01 SUMMARY

A. Scope:
   1. This section specifies submersible pumps suitable for pumping unscreened wastewater at constant speed. Pumps furnished under this specification shall have discharge nozzles from 2 through 4 inches in diameter and motors less than 7.5 horsepower.
   2. Pumps will be installed in a wet-pit configuration.
   3. Pump units shall be complete with motor, discharge fitting, guide bar and brackets, chain and cable hooks and other accessories as specified and access frame.
   4. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001. Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized.

B. Type:
   1. Pumps shall be of the submersible, vertical shaft, centrifugal nonclog type, suitable for pumping fluids containing unscreened wastewater solids. The pumps shall be designed for continuous or cyclic operation under submerged, or partially submerged without damage to the pump and motor. Special attention shall be devoted to the shaft design to limit deflection under all operating conditions, as specified in this section.

C. Equipment List:

Item	Equipment Number
Pump 1	P-7011
Pump 2	P-7012
Low Low Level float	LSL 7002 – D
Low Level float	LSL 7002 – C
High Level float	LSH 7002 – B
High High Level float	LSHH 7002 - A

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 43 05 11 General Requirements for Equipment

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to

other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
ASTM A48	Gray Iron Castings
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
UL 674	Motors and Generators, Electric, for Use in Hazardous Locations, Class I, Groups C and D, Class II, Groups E, F, and G

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. See Section 01 12 16: Work Sequence.

B. Unit Responsibility:
   1. Assign unit responsibility, as specified in Section 43 05 11, to the manufacturer of the vertical, nonclog submersible pumps provided for all equipment and accessories under this section. Have all mechanical equipment components, at least, of this entire equipment assembly furnished by the pump's manufacturer. Provide a completed, signed, and notarized Certificate of Unit Responsibility (Form 43 05 11-C, Section 01 99 90).

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this Section, addendum updates included, along with the sections listed below shall be submitted with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
      a. This Section (43 23 80.11)
      b. Section 43 05 11 – General Requirements for Equipment
      c. Section 43 05 21 – Common Motor Requirements for Equipment
   3. The specification copies shall be complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for

any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

4. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
5. Unit Responsibility Certification form (Form 43 05 11-C) attesting that unit responsibility has been assigned in accordance with the requirements of this Section and Section 43 05 11. No other submittal material will be reviewed until the certificate has been found in conformance with this requirement.
6. Performance curves for each condition point specified showing head, power, efficiency, and NPSH3 on the ordinate plotted against capacity on the abscissa. All curves shall clearly display the specified operating conditions, POR and the manufacturer's limits for the AOR.
7. Drawings showing general dimensions and confirming the size of pumps, motors, drives and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; and weight of equipment.
8. Manufacturer's data including materials of construction and equipment weight.
9. Motor Data Form 43 05 21 -A.
10. Manufacturer's operation and maintenance information in accordance with Section 01 78 23.
11. Installation Forms in accordance with Section 43 05 11.

B. Informational Submittals:
   1. Project specific shop drawings for the pump, pump base plate, and pump rail/mast mounting system.
   2. Manufacturer's written recommendations for installation.

C. Closeout Submittals:
   1. Operating and maintenance submittals:
      a. Procedures: Section 01 78 23.
   2. Spare parts:
      a. Procedures: Section 43 05 11. Provide the following spare parts for each model and size of pump furnished for this Section:
         1) One complete set of all gaskets and seals
         2) One complete sets of all bearings
         3) One complete set of mechanical seals
         4) One complete set of discharge connection sealing devices
         5) One impeller
         6) One set of fastening hardware

1.06 QUALITY ASSURANCE

A. Vibration Limits: Vibration limits for submersible pumps shall be in accordance with ANSI/HI 11.6.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00

B. Block shaft and prevent damage to bearings during shipment

1.08 WARRANTY

A. Procedures: Section 01 78 36

B. Manufacture to warrant all equipment furnished under this Section against defects in materials and workmanship for a period of 2 years.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:
   1. Wilo-EMU
   2. Xylem - Flygt
   3. Pentair
   4. KSB
   5. Approved Equal

2.02 TYPE

A. Submersible, vertical shaft, centrifugal nonclog type, suitable for pumping fluids containing unscreened wastewater solids.

2.03 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:

Description	
Equipment number	P-7011 P-7012
Area exposure	Per Section 01 61 45
Fluid type	Unscreened wastewater containing up 300 mg per liter of suspended solids consisting of organic and inorganic materials, rocks, grit, petroleum products, and grease. The pumped material will have a tendency to form long fibrous strings due to the rotation of water through the piping passageways.
Fluid temperature	40 to 75 degrees F

B. Operating Conditions:

1. The performance requirements presented in tabular form below are intended to describe the results of hydraulic calculations developed using a mathematical modeling program specifically developed for the purpose. The model was intentionally used to develop the limits of expected extremes in variation of static head, coefficients for pipeline resistance and turbulence losses through fittings and valves.
2. Equipment furnished under this section shall be fully suitable for continuous operation at any specified condition or any condition lying between the extremes of the operating conditions specified in the following table. The total head in the information below is the total system head at the operating capacity, essentially a summation of the head of a single pump at that capacity. The notes presented at the end of the table are intended to be complimentary to the information presented in the table.

C. Table of Operating Conditions:

Operating Condition	Value
Equipment number	P-7011 P-7012
Condition A [1]	
Capacity, gpm	300
Total head, feet [3]	18.5
NPSHA, feet	34
Condition B [2]	
Capacity, gpm	From pump H/Q curve
Total head, feet [3]	18.0
NPSHA, feet	33.4
High level alarm, feet [4]	3.7
Pump on level, feet [4]	3.2
Pump off level, feet [4]	2
Low level alarm, feet [4]	1.5

Notes:

1. *Condition A shall be taken as the rated, continuous-duty operating condition. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this section shall be selected to achieve Condition A performance, and also shall operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and published in the manufacturer's published application data for the specific model proposed for this application.*
2. *Condition B head is presented to indicate operating conditions when the pump is operating against minimum anticipated system head, assuming a hypothetical head-capacity curve. Condition B shall be used for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*
3. *Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 1.1 through 1.6. The pump must operate continuously within the POR without objectionable vibration or cavitation at the specified condition.*
4. Dimension referenced from invert of wet well slab.

D. Design Requirements:

Item	Value
Equipment number	P-7011 P-7012
Pump	
Rigid sphere, inches diameter (min.), capable of passing through the pump from inlet to discharge	2
Minimum efficiency at best efficiency point (BEP) at maximum speed, percent [1]	38
Piping connection size, inches, minimum	4
Pump inlet	4
Pump discharge	4
Operating speed, constant or variable	constant
Motor	
Max, Horsepower	5
Type	Submersible, explosion proof
Over temperature protection	Yes
Moisture sensors	Yes
Operating speed, rpm, maximum	1,800
Voltage/Phase	460 VAC, 3 Phase

Notes:

1. *The minimum acceptable efficiency at best efficiency point (BEP) at the speed required to achieve the performance specified under Condition Points A and B. The minimum acceptable efficiency is not necessarily required to be associated with any operating condition specified in paragraph 2.03 Operating Conditions.*

E. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

F. Provide materials of construction in accordance with the following table:

Component	Material
Pump and motor casing	Cast iron, ASTM A48, Class 30 or 35
Discharge elbow	Cast iron, ASTM A48, Class 30 or 35
Impeller	A743 Duplex stainless or ASTM A532-IIIA
Motor and pump shaft	Stainless steel, ASTM A276 Type 329, 403, 416, 420 or ASTM A479 Type 403, 431
Wearing rings	Stainless steel, ASTM A276 Series 440B or Cast duplex stainless steel, ASTM A890 Grade 1B or 5A
External bolts and nuts	Stainless steel, ASTM A276 Type 316
Guide bar brackets	Stainless steel, ASTM A276 Type 316
Anchor bolts	Stainless steel, ASTM A276 Type 316
Guide rails, lifting assemblies	Stainless steel, ASTM A276 Type 316

2.04 COMPONENTS

A. Pumps and Motor Casing:
   1. Casings shall be constructed of corrosion resistant cast iron and shall be designed to allow removal of all rotating parts from the motor end of the pumps. All mating surfaces where watertight sealing is required shall be machined and fitted with nitrile O-rings. Casing shall be fitted with moisture sensor specifically designed to detect the presence of water in the seal chamber.

B. Impellers:
   1. The impeller shall be dynamically balanced with a non-clogging design capable of passing solids, fibrous materials, heavy sludge, and other matter found in normal sewage applications through to the discharge nozzle. Impellers for pumps with discharge nozzles 4 inches in diameter and greater shall be not less than two-vane design. Fit between the impeller and the shaft shall be a sliding fit with a taper-lock bushing pressed by a screw that is threaded into the end of the shaft, or a slip fit onto the shaft and drive key and fastened to the shaft by an impeller nut having cover for protection from pumped fluid. A wearing ring system designed for abrasion resistance shall provide efficient sealing between the volute and impeller.

C. Bearings:
   1. Bearings shall be heavy-duty permanently lubricated ball type. Bearings shall be designed for an L-10 life of 50,000 hours heavy-duty service without requiring additional lubrication.

D. Shaft:
   1. The pump shaft shall be turned, ground and polished, of proportions suitable for use in the specified application. The shaft shall be of sufficient section to limit deflection at the shaft seal to not more than 4.0 mils when the pump is operating at any continuous-duty point defined by the envelope of conditions specified in this Section.

E. Mechanical Seals.
   1. Provide tandem or dual mechanical seals per the following requirements:
      a. Dual cartridge
      b. High capacity barrier fluid ports
      c. Self-centering, non-fretting
      d. Springs isolated from both process and barrier fluids
      e. Pressure Rating: 250 psig
      f. Stationary Face: silicon carbide
      g. Rotary Face: silicon carbide
      h. Metal Parts: Type 316 stainless steel
      i. Springs: Type 316 stainless steel
      j. O-Rings: fluorocarbon
      k. Candidate Product: Chesterton 255 or approved substitute

F. Motor:
   1. The motor shall be designed to be non-overloading over the entire pump curve. The motor housing shall be of submersible construction with the windings operating in a

sealed environment. Motors shall be either air or dielectric oil filled with built-in automatic reset overload protection. Motors in hazardous locations shall be UL or FM listed in accordance with UL 674 for Class I, Group D hazardous atmosphere. The motor shall be provided with motor windings thermostats, one in each winding, to protect the motor from overheating.

G. Cable:

1. Pump motor and detector cables shall be suitable for submersible pump applications. Pump motor and detector cables may be combined into one assembly or separate as standard for the pump manufacturer. Each cable shall be a heavy-duty, flexible, water-resistant portable, UL listed cable, sealed at the motor bell and of sufficient length to connect to the associated pump control panel. The cable entry into the motor shall be comprised of a singles cylinder elastomer grommet and shall prevent water from leaking into the motor due to capillary action even if cable is cut or damaged. Cables shall be watertight to a minimum depth of 65 feet.

H. Guide Rail Lifting System and Discharge Elbow:

1. The pump shall be provided with a dual guide rail system to allow easy removal of the pump without entering the wet well. The discharge connection shall be bolted to the structure as required by the pump manufacturer and shall serve as a lower attachment for the guide rails. The discharge connection shall be an elbow discharge type.
2. The pump and guide rail system shall be designed to automatically connect the pump to the discharge piping when lowered into place on the discharge connection. The design shall be non-sparking and shall conform to UL requirements for installation in a location classified in accordance with NFPA 70, Article 500 for Class 1, Group D, Division 1 locations. When in place, the connection shall form a watertight seal with the discharge fitting. The pump shall be easily removable for inspection or service, requiring no bolts, nuts, or other fastenings to be removed for this purpose. Sealing of the pumping unit to the discharge connection shall be accomplished by a simple linear downward motion of the pump with the entire weight of the pumping unit guided to and pressing tightly against the discharge connections. No portion of the pump shall bear directly on the floor of the wet well and no rotary motion of the pump shall be required for sealing. Once the pump has been positioned on its support fitting at the discharge fitting, the guide bar system shall not be required for pump support.
3. The pump shall be provided with a lifting chain, guide bars, upper guide bar brackets, intermediate guide bar brackets, cable holder assemblies, safety chain hook assemblies, discharge elbow connections, anchor bolts, and all other accessories necessary to complete the installation as specified. The lifting chain length shall equal the depth of the wet well.

I. Level Instruments:

1. Provide level instruments to meet the pump control operation requirements defined in this section. Level instruments shall meet the requirements of Section 40 06 70 with the device type meeting requirements of Section 40 72 00. Provide cable of sufficient length to reach the control panel from the wet well.

2.05 CONTROL PANEL

A. General:
   1. Panels shall be provided with instruments used for control, monitoring, and alarming. The control panel for the pumps shall be designed in accordance with Section 40 67 00, the contract P&ID drawings, and to support the specified operation.

B. Pump control panels shall be rated NEMA 4X.

C. Features:
   1. Panels shall be provided with instruments used for control, monitoring, and alarming.
   2. Control shall include HAND/OFF/AUTO mode selection, pump LEAD/LAG, motor protection, and reset button to clear motor protection alarms.
   3. Panels shall contain distribution components, power supplies, and transformers, as required, to derive power for all instruments and equipment provided as part of the pump package.
   4. Separate pump and control circuit breaker with intrinsically safe module for floats.
   5. Dry contact and panel lights for pump running, pump fail, moisture sensor, motor over temperature, and high level alarm.
   6. Suitable for service from a single 480V ac, three-phase service.
   7. Provide intrinsically safe relays for use with the level switches to meet hazardous ratings.
   8. Pump protection relay for each pump for connecting the motor leak and temperature detectors.
   9. Internal enclosure heater.
   10. Terminal strip for connection of external devices.
   11. Motor starter per Division 26.
   12. External Signal Interface: Provide dry contact closures for connection to the Control System rated 0.5 amps at 12 or 24 Vdc for the following conditions:
      a. Each pump running status.
      b. HIGH HIGH level alarm.
      c. Each pump ready status. Ready status is panel has power and pumps set to AUTO mode with no active alarms present.

D. Pump Control Operation:
   1. Provide controls for the following pump Operation per Process Control Strategy 13 presented in Section 40 61 96.

2.06 FINISHES

A. Procedures: Section 09 90 00

B. Factory prime and coat in accordance with manufacturer's standard epoxy coating.

2.07 SOURCE QUALITY CONTROL

A. Factory Tests:
   1. Factory test each pump in accordance with HI standards level 3B. Results shall be approved by engineer.

PART 3 EXECUTION

3.01 COATINGS

A. Procedures: Section 09 90 00.

B. Factory prime and finish coat in accordance with manufacturer's standard epoxy coating.

3.02 FIELD QUALITY CONTROL

A. Procedures: Section 01 45 20 and Section 01 91 00.

B. Perform the following test:
   1. Performance Test
      a. Using clean water, measure pump flow and discharge pressure. Verify pump flow and discharge pressure is within the range of specified operating conditions.
      b. Temporary flow meters and pressure gauges will be required.
      c. Throttle valve on pump discharge as necessary to achieve two additional operating points within the manufacturer provided POR.
      d. Test level controls to verify pump control system operates as specified in Section 40 61 96.

3.03 MANUFACTURER'S SERVICES

A. On-Site Inspections and Training: Provide a factory-trained manufacturer's representative at the Site for the following activities. Specified durations do not include travel time to or from the Site.
   1. Installation Inspections: Assist, supervise, and inspect the Contractor's activities during installation of submersible pumps. Provide 4 hours of installation inspection during installation of each submersible pumps.

END OF SECTION

SECTION 46 24 23

IN-CHANNEL GRINDERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope: This section specifies in-channel grinders and screens complete with electric motors, controllers, control panel, and all appurtenances.

B. Type: Equipment provided under this specification shall be in-channel type vertical grinder with vertical perforated drum screen combination design as a single unit. The unit shall have twin shaft, counter-rotating differential speed type with intermeshing cutters. The space between the rotating cutters and the cutting chamber side walls shall avoid short-circuiting of the cutting elements.

C. Equipment List:

Item	Equipment No.
Elliot Street Pump Station Channel Grinder	GDR 1000
Elliot Street Pump Station Channel Grinder Control Panel	CP 1000
Elliot Street Pump Station Local Control Station	LCS 1000

D. Design Requirements:

1. General:
    a. The grinder shall be designed to be installed as depicted in the design drawings to continuously macerate solid materials from the upstream wastewater collection system. Solids to be encountered during operation of the grinders are those typically found in wastewater and include heterogeneous mixtures of organic and inorganic material. Concentrations of solids are expected to range up to 300 mg/L. Organic solids include fecal material, vegetable parts, rubber goods, plastics, paper products, bones, small chunks of wood and semi-solid grease particles. Inorganic solids will include rocks, sand, and metal pieces of various sizes and composition. The liquid is expected to contain oil, grease, petroleum products, solvents, and water.
        1) The equipment shall be capable of operation either with or without liquid in the channel and shall operate without an external source of water for flushing seals or cutter faces.
        2) The grinder shall be provided with a dedicated controller to control operation of the machine. The controller shall have sensors designed to detect motor overload and initiate momentary reversal of cutter operation to cure the condition, and then resume normal operation. If the overload clears, normal operation shall be maintained. If the overload reoccurs, the process shall be repeated. If overload still remains after three attempts within 30 seconds, the controller shall lock out the grinder's control circuits and initiate alarm through dry contacts to an external circuit.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AGMA 6010-E	Spur, Helical, Herringbone and Bevel Enclosed Drives
AISI	Pocketbook of AISI Standard Steels
ASTM A36	Carbon Steel Plate
ASTM A48	Gray Iron Castings
ASTM A536	Ductile Iron Castings
ASTM A564	Grade 630 Condition H1150 (17-3) stainless steel
SAE	Type 660 Bearing Bronze
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)

B. Factory Tests:

1. Factory testing of this equipment is not required.

C. Unit Responsibility:

1. The Contractor shall assign unit responsibility as specified in Section 43 05 11-1.02 Unit Responsibility to the grinder manufacturer for the equipment specified in this section. A certificate of unit responsibility shall be provided.

1.03 ENVIRONMENTAL CONDITIONS

A. The grinders will be located at a wastewater pump station where frequent washdowns can be expected. Environmental conditions are as specified in Section 01 11 80.

1.04 SUBMITTALS

A. Action Submittals:

1. Submittals shall be provided as specified in Section 01 33 00 and shall include the following:
2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate

requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

3. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.

B. Information Submittals:

1. A copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
2. Project specific shop drawings for the grinder and control panel.
3. Control panel wiring diagram identifying all internal and face mounted components and connections to remote equipment.
4. Motor data Section 43 05 21-Form A as specified in Section 43 05 21-1.03.
5. Manufacturer's written recommendations for installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The in-line grinders shall be a multi-drive Channel Monster Flex model# CMF3624 as manufactured and supplied by JWC Environmental Inc.,

B. Approved equal, modified to provide the specified features and to meet the specified operating conditions.

2.02 MATERIALS

Component	Material
Casing, including cleanout cover	Cast iron, ASTM A48, Class 40
Shafts	Steel, AISI 4140, Tensile strength 170,000 psi minimum
Cutters	Alloy steel, through hardened to 45 - 53 HRC
Spacers	Alloy steel, through hardened to 34 - 38 HRC
Side rails	Cast ASTM A536 65-45-12 Ductile Iron
Screen Side Rail	Cast ASTM A536 65-45-12 Ductile Iron

Component	Material
Perforated Screen Drum	Deburred and Electropolished AISI 304 Stainless Steel
Fasteners, including bolts nuts, washers and keys	AISI 304 Stainless steel

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 PERFORMANCE CRITERIA

Item	Value
Maximum rated capacity, gpm	9,065 (13.05 mgd)
Maximum head loss at peak flow, inches [1]	20
Cutter stack and perforated drum height, inches	36
Perforated drum diameter, inches	24
Grinder motor, Horsepower	5
Solids diverter motor, Horsepower	1
Motor type	Immersible

1. Based on downstream water depth of 18-inches

2.04 EQUIPMENT

A. Channel Frame:
   1. The grinder frame shall mount to channel walls with suitable anchors supplied by contractor for installation.

B. Side Rails:
   1. Side rails shall be of high flow slotted design, evenly spaced be designed to mate with the cutting teeth and shall be bolted to the body.

C. Shafts, Cutters and Spacers:
   1. Shafts shall be minimum 2-inch hexagonal in cross-section. Equipment shall be supplied with 11-tooth serrated cam style 0.310 thick alloy steel cutters keyed to the shaft with a hexagonal inner profile. Spacers shall be smooth, 0.319 inch thick alloy steel.

D. Bearings and Seals:
   1. Equipment seals and bearing cartridges shall be incorporated into a cartridge style design requiring no external seal flush or lubricants to operate wet or dry and rated for over 6X the maximum operating depth or 15 psi. Seals and bearings shall include a secondary lip seal with grease barrier. O-rings are to be Viton (Fluorocarbon).

E. Transfer Gears:

1. Transfer gears shall be of heat treated and hardened AIS 4140 alloy steel. The number of teeth on the gears shall create a ratio of cutter tip speed on low speed shaft to cutter tip speed of high speed shaft greater than 0.90 and less than 1.00 to promote cleanout of material in cutting stack.

F. Perforated Drum Screen

1. The equipment shall be equipped with a cylindrical perforated drum screen. The drum screen shall be formed with ½ inch diameter holes with a nominal 50% open area across the surface of the screen.

G. Motor:

1. The drive motor shall have a service factor of 1.15, a minimum efficiency (at full load) of 91 percent, and conform to the requirements of Section 43 05 21. The motor shall conform to a manufacturer rating of 40 consecutive days of submergence at a maximum depth of 40 feet, require no fan cooling during operation, and utilize a ceramic shaft seal requiring no oil or lubrication.
2. Hazardous classification, Class I, Division 1.
3. Installed grinder horsepower: 5 HP
4. Installed solids diverter horsepower: 1 HP
5. Provide motors as a complete Class I, Division 1 listed assembly including cables. Provide cables of sufficient length to terminate at locations indicated.
6. Provide motors with moisture and temperature elements.

H. Extended Motor Shaft

1. The equipment shall be provided with extended motor shafts to accommodate installation of channel grating per Section 06 74 13.

I. Control Panel:

1. A control panel with motor controllers and a local control station shall be provided for each grinder. The control panel shall have a NEMA 4X enclosure. The local control station shall conform with hazardous classification, Class I, Division 1. Components required for operation of the grinder shall conform to the requirements of Section 43 05 11 and Division 26.
2. Supply voltage shall be 480 volt, 3 phase, 60 Hz. The controller shall be equipped with voltage unbalance protection, motor overload protection, and single-phase protection. The controller shall follow Process Control Strategy 15 presented in Section 40 61 96.
3. Motor starters shall be NEMA or IEC type, full voltage, reversing with adjustable overload relays, and control power transformers sized to provide 120-volt AC power from the supply.
4. The grinder shall be primarily controlled with a vendor supplied control panel with vendor supplied PLC. Detailed alarm messages will be logged and viewable from a local OIT supplied with the vendor control panel. Remote indication will be supplied to the existing Elliot Street Wastewater Pump Station SCADA control panel to monitor the operation of the grinder and screen as detailed in 40 61 96, Process Control Strategy 15.
5. A dry normally open status contact shall be provided. Contact shall close when grinder is running.

J. Identification
   1. The equipment package shall include a corrosion resistant nameplate which clearly states the manufacture's name, address, model no., serial no, capacity, max psi, weight, and manufacture date.

2.05 SPARE PARTS

A. The following spare parts shall be provided for each grinder size:
   1. 2 sets -- seal assemblies
   2. 2 sets -- bearing assemblies
   3. 4 sets -- gaskets
   4. 1 complete set of cutters and spacers
   5. 1 set -- guide rails

B. Spare parts shall be packed and boxed as specified in Section 43 05 11-2.12.

2.06 PRODUCT DATA

A. The following product data shall be provided in accordance with Section 01 33 00:
   1. Applicable operation and maintenance information as specified in Section 01 78 23.
   2. Motor data as specified in Section 43 05 21-2.05.
   3. Installation certification Section 43 05 11-Form A as specified in paragraph 3.01.
   4. Training certification Section 43 05 11-Form B as specified in paragraph 3.03.
   5. Product data for equipment control devices as specified in Section 40 67 00.

PART 3 EXECUTION

3.01 INSTALLATION

A. The equipment specified under this section shall be installed in accordance with the manufacturer's recommendations and the details shown. The installation shall be certified on Form 43 05 11-A specified in Section 01 99 90.

3.02 TESTING

A. After completion of the installation, the grinder shall be field tested to demonstrate compliance with the specified performance requirements. Field testing shall include overloading to activate the automatic stop and reverse control.

3.03 TRAINING

A. The Contractor shall cause a factory trained representative to conduct no less than 4 hours of training for Owner personnel on operation and maintenance of the equipment provided under this section. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

END OF SECTION

SECTION 46 51 21

COARSE BUBBLE MIXING SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies compressed air mixing equipment. Contract shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install the mixing equipment complete and operational.
   2. This section includes the following manufactured equipment:
      a. Compressed Air System (Compressor, Air Dryer, Air Receiver, Air / Oil Separator, Condensate Filter).
      b. Mixing Valve Control Enclosure (MVE).
      c. Bubble Forming Plates (BFPs)
      d. Air Piping from the Compressed Air System to the MVE and from the MVE to the BFPs located in the process tank. (Supplied by Contractor per Section 2.03)

1.02 QUALITY ASSURANCE

A. References:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.
      a. Underwriters Laboratories (UL).
      b. Compressed Air and Gas Institute (CAGI).
      c. American National Standards Institute (ANSI).
      d. Institute of Electrical and Electronics Engineers (IEEE).
      e. National Electrical Code (NEC).
      f. National Electrical Manufacturers Association (NEMA).
      g. American Society of Mechanical Engineers (ASME).

1.03 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 01 33 00.
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. A copy of the contract document control diagrams, wiring diagrams, and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
   3. Unit Responsibility Certification form (Form 43 05 11-C) attesting that unit responsibility has been assigned in accordance with the requirements of this Section and Section 43 05 11. No other submittal material will be reviewed until the certificate has been found in conformance with this requirement.
   4. Manufacturer's literature and catalog data confirming conformance to specified design. Information to include equipment dimensions, piping connections, construction details of equipment, materials of construction, and weight of equipment.
   5. Manufacturer’s operations and maintenance information in accordance with Section 01 78 23.
   6. Installation Forms in accordance with Section 43 05 11.

B. Informational Submittals:
   1. Manufacturer’s written recommendations for installation.
   2. Manufacturer’s Installation Certification Form 43 05 11-A per Section 01 99 90.

C. Closeout Submittals:
   1. Operating and maintenance submittals:
      a. Procedures: Section 01 78 23
   2. Spare parts:
      a. Mixing Valve Control Enclosure:
         1) One (1) Ross Valve Solenoid Kit (PN 1467B9105).
         2) One (1) Ross Valve Repair Kit (PN 2297H77).

3) Two (2) Valve Seal Kits (PN CP16NA-SK).
4) One (1) Pack of 5 Silicone Lubricants (PN G661).
5) One (1) MVE Air Filter Element, 50 micron (PN 9210157).

b. Compressed Air System
1) One (1) Annual Consumables Kit for the Compressor as recommended by the manufacturer.
2) One (1) Annual Consumables Kit for the Air Dryer as recommended by the manufacturer.

c. Storage of Spare Parts
1) Spare parts shall be packed in sturdy containers with clear indelible identification markings.
2) Spare parts shall be stored in a dry, warm location until transferred to the Owner at the conclusion of the Project.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Manufacturer qualifications:
1. The Large Bubble Compressed Air Mixing System shall be furnished by a single manufacturer who is fully experienced, reputable and qualified in the manufacture of the equipment to be furnished. The associated factory assembled compressed air system shall be manufactured by Kaeser Compressors or pre-approved equal.
2. The manufacturer shall have a minimum of five (5) years of experience designing and constructing the specified Large Bubble Compressed Air Mixing System and have a reference list with at least five (5) operating mixing systems for municipal wastewater.
3. The mixing system manufacturer shall provide a third-party CFD report that when overlaid over the BFP configuration of this project's basins will show complete vertical profile mixing coverage and not cause dead zones or solids accumulation within the wet well. The CFD report shall have been verified in a test vessel.
4. The manufacturer shall provide a third-party oxygen transfer test showing the mixing system's oxygen transfer rate is less than 0.08%.
5. The manufacturer shall provide a field test report of a tank or basin (> 80'x 20'x 10') containing wastewater that proves the proposed mixing system can achieve vertical profile mixing of Total Suspended Solids (TSS) with a Coefficient of Variation equal to or less than 0.1 while at the same time not causing dissolved oxygen values of the mixed liquid to exceed 0.2 mg/l above background values. The testing protocol for the field test shall have had at least 3 measurements taking at each test location with one measurement occurring within one foot of the tank bottom and another measurement taken within one foot of the tank's liquid surface. The test shall have been certified by the customer's consulting engineer for final acceptance.

B. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section.
1. Pulsed Hydraulics Incorporated (pHi)
2. Approved equal

2.02 MATERIALS

Component	Material
Air pulsing components	Stainless steel, ASTM A240, Type 304L
Control cabinets	Stainless steel, ASTM A240, Type 304L
Bubble forming plates	Stainless steel, Type 316
Fasteners	Stainless steel, Type 316

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.03 MIXING SYSTEM REQUIREMENTS

A. General:

1. The installed system shall mix by injecting short bursts of compressed air through a piping system to specifically spaced bubble forming plates anchored to the bottom of the pump station wet well. The bubble forming plates shall create a large bubble mass at least 24 inches in diameter after each burst is delivered. The large bubble mass shall produce a complete mixing action within the tank as it rises to the surface. Mixing systems that cannot produce bubble masses at least 24 inches in diameter consistently shall not be allowed. Mixing systems whose primary function is to strip VOCs from potable water and secondary function is to mix shall not be allowed.
2. The mixing system shall not include any components located in the wet well that pivot, rotate oscillate or otherwise move to create the mixing action.
3. The mixing system shall not require pressure or flow sensors within submerged elements or piping that are essential for proper operation of the mixing system.
4. The bursts (or pulses) of compressed air shall be created in one mixing valve control enclosure (MVE) which contains both the electronic and pneumatic components in the same weather protective enclosure. The MVE manufacturer shall be UL508A compliant. The MVE shall have a NEMA 4X enclosure rating.
5. Bubble forming Plates (BFPs) shall be anchored to the wet well floor as shown in the contract drawings.

B. Equipment Criteria

Item	Value
Number of diffusers	3
Bubble forming plate diameter, inches	8
Pressure range required at bubble forming plate, psig	40 - 90
Minimum bubble diameter, inches	24
Maximum allowable oxygen transfer rate, percent	0.08%

C. Air Distribution Piping:
   1. The piping from the MVE to each BFP per Section 40 05 02.05. Piping from the compressed air system to the MVE shall be constructed of 316 stainless steel. The internal pipe diameter for all air delivery piping to and from the MVE shall be one inch.
   2. Supply air pressures from the compressed air system to the MVE can range from 90 psig to 150 psig. Working air pressures from the MVE to the BFPs will range from 40 psig to 90 psig.

D. Supports:
   1. BFPs shall be anchored to the wet well floor with as shown in the contract drawings. Equipment anchors and supports are manufacturer provided.

E. Air Pulsing Components in the Mixing Valve Control Enclosure
   1. The pulsing valve(s) will be solenoid controlled and pilot air assisted. They shall be capable of achieving pulse durations (opening / closing cycles) at operator selectable settings between 20 milliseconds and 80 milliseconds at supply air pressures between 40 and 90 psig.
   2. An air filter with a 50-micron element and an auto-drain shall be provided to remove particulates and water to protect the regulator and pulsing valves.
   3. A manually adjustable pressure regulator with pressure gauge shall be provided. The compressed air supplied to this regulator from the air source shall not exceed 150 psig.
   4. A heater with thermostat shall be provided in the MVE.
   5. Components are pre-piped with 304 stainless steel pipe and fittings and are tested for leaks and function. Pipe unions are provided to facilitate servicing of air components.
   6. A NEMA 4X 304 SST enclosure shall house the air pulsing components. See schedule at the end of this section.
   7. The MVE shall require a 20 A, 115 Volt, single phase, 60 Hz service.

F. Bubble Forming Plates
   1. Bubble forming plate(s) shall be constructed of 316 stainless steel. A bubble forming plate consists of two disks separated approximately ½- inch apart by internal spacers. Three 3/8-inch diameter equally spaced pre-drilled holes are used for bolting the bubble forming plate to the tank bottom. BFPs shall be NSF 61 certified.
   2. BFPs shall be mounted so that they are level. Anchor bolts with leveling nuts or mounting plate assemblies shall be used when tank floors slope.

G. Compressed Air System
   1. The rotary screw compressor, refrigerated air dryer, and 70 gallon air receiver shall be mounted together in a pre-manufactured free standing NEMA 12 rated enclosure measuring 24.75” x 42.25” x 43.375” LxWxH.
   2. The compressor module shall be completely factory assembled requiring only field connection of floor mounting hardware, electrical power,, air, and moisture separator and condensate drain piping.
   3. The 7.45 HP compressor shall be equipped to receive 460 V, 3ph / 60Hz.

4. The air system shall deliver a minimum of 28.25 ACFM @ 125 psig (full load operating pressure).
5. The total package input power at rated capacity at full load operating pressure shall be 7.0 kW. Total package input power at zero flow is rated at 2.5 kW.
6. The compressed air system will include a Kaeser Model KCF-25 condensate filter which will be free standing away from the Aircenter. The filter will treat oil collected from the Aircenter's oil / water separator and condensate from the refrigerated air dryer and MVE drains. The contractor shall provide drain lines from the Aircenter and MVE to the condensate filter and a drain line from the filter to a floor drain.

2.04 CONTROL PANEL

A. Vendor package shall include main (VCP-1000) control panel and local (LCS-1000) control station. Panels shall be provided with instruments used for control, monitoring, and alarming. The control panel for the mixing system shall be designed in accordance with Section 40 67 00, the contract P&ID drawings, and to support the specified operation. The main control panel (VCP-1000) shall be mounted at the compressor skid. The local control station (LCS-1000) shall be located remotely and shall be suitable for installation on a Class 1, Group D, Division 1 location.

B. A factory programmed Unitronics Model V120 PLC shall control system operation and shall allow pulse rate, pulse duration and operation interval changes to be made by operating personnel at the control panel. The mixing system shall be able to be turned on or turned off by the PLC receiving discrete 24 Vdc signals from remote devices.

C. Control Operation:
   1. Controls for bubble mixing system shall follow the Process Control Strategy 16 presented in Section 40 61 96.

2.05 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts shall be tagged and stored as specified in Section 43 05 11-2.12.

2.06 PRODUCT DATA

A. The following product data shall be provided in accordance with Section 01 33 00:
   1. Operating and maintenance information specified in Section 01 78 23.
   2. Manufacturer's written recommendations for installation.
   3. Installation certification Section 43 05 11-Form A as specified in paragraph 3.01.
   4. Training certification Section 43 05 11-Form B as specified in paragraph 3.03.

PART 3 EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed as shown and according to the manufacturer's instructions. Recommended installation procedures shall be followed, including, but not limited to, installation of the pipe supports and leveling of the BFPs. The manufacturer shall check and approve the installation prior to operation.

B. The Contractor will provide/install the following:
   1. Compressed Air Source and all appurtenances including an all-weather enclosure if listed in the schedule at the end of this specification.
   2. Compressed air delivery piping (one-inch ID) from the compressed air source to the PHI 310 enclosure and from the PHI 310 enclosure to the bubble forming plate(s).
   3. Drain piping from the condensate ports on the PHI 310 enclosure to termination point determined by the site owner.
   4. Electrical service wiring, components and accessories.
   5. Installation and anchoring of the bubble forming plate(s) and PHI 310 control enclosure.

C. The installation of the air delivery piping shall include:
   1. One (1) shut-off ball valve per MVE to be located near to the compressed air entrance port on the MVE.
   2. The piping from the MVE to the bubble forming plates shall have an internal diameter of one inch.
   3. The pipe from the compressed air system to the MVE shall have an internal diameter of at least one inch or larger to ensure that the velocity of the compressed does not exceed 35 fps.
   4. The piping shall consist of materials suitable for the liquid and the pressure application for which it is being used.
   5. The piping should be installed so that it is located above the tank's maximum liquid level at some point so as to prevent the occurrence of back-siphoning from the tank to the air pulsing components. Check valves are not allowed on the pulsing air lines.
   6. Bubble Forming Plates (BFPs) may require shimming or mounting assemblies to ensure that they are level and are at the same elevation on the tank floor if two BFPs are "t'd" together. The contractor shall be responsible for installing BFPs in accordance with the Manufacturer's instructions.

D. The equipment shall be installed and tested under the direction of a qualified manufacturer's representative. The installation and initial operation shall be certified on Form 43 05 11-A specified in Section 01 99 90.

3.02 TESTING

A. A factory trained representative shall be provided for installation supervision, start-up and O&M personnel training. The representative shall verify that the equipment conforms to the equipment and mixing system requirements specified in Section 2.03.

B. The representative shall make a minimum of 2 visits (8 hours per visit). The first visit will be for assistance in the installation of equipment. Subsequent visits shall be for checking the completed installation, start-up, testing and training.

C. The manufacturer's representative shall complete and submit Manufacturers' Installation Certification Form, 43 05,11-A provided in 01 99 90.

3.03 TRAINING

A. The manufacturer's representative shall test the system in the presence of the Engineer and verify that the equipment conforms to the requirements. The manufacturer's representative shall revisit the site as often as necessary until the installation is satisfactory.

B. All costs, including travel, lodging, meals and incidentals for additional visits shall be at no additional cost to the Owner.

3.04 WARRANTY

A. The Large Bubble Compressed Air Mixing System manufacturer shall guarantee the performance of the mixing system, and shall guarantee the equipment for a period of twelve (12) months after start-up against defects in materials and workmanship and against problems attributable to ordinary wear under normal operation of the equipment.

B. The compressor manufacturer shall guarantee the equipment for a period of one (1) year against defects in materials and workmanship and against problems attributable to ordinary wear under normal operation of the equipment. The manufacturer shall guarantee the air end, motor and controller for a period of two (2) years from the date of start-up not to exceed 30 months from the date of shipment.

END OF SECTION