SPECIFICATIONS AND CONTRACT DOCUMENTS

For the Construction of

GRAND JUNCTION ODOR CONTROL IMPROVEMENTS

GRAND JUNCTION, COLORADO

Garver Project No. 20W23045

Technical Specifications
Division 01 – Division 44

Prepared For:

City of Grand Junction

August 2021

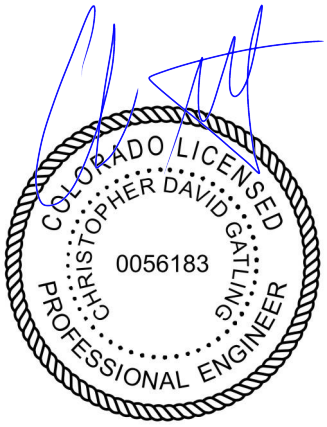
GARVER
GarverUSA.com

GRAND JUNCTION ODOR CONTROL IMPROVEMENTS
GARVER PROJECT NO. 20W23045

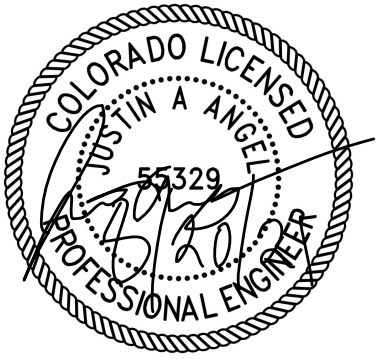
I hereby certify that the applicable portions of this project plans and specifications were prepared by me or under my direct supervision and that I am a duly Licensed Engineer under the laws of the State of Colorado.

SEAL AND SIGNATURE	APPLICABLE DIVISION OR PROJECT RESPONSIBILITY
City of Grand Junction	Division 00
Richard G. Huggins, P.E.  Digitally Signed: August 20, 2021	Division 01 Division 09 Section 09 96 40 Division 40 except for Sections 40 05 36.13, 40 61 13, 40 63 43, and 40 67 23
Kipp A. Martin, P.E.  Digitally Signed: August 20, 2021	Division 03 Division 05 Division 06

CERTIFICATIONS

SEAL AND SIGNATURE	APPLICABLE DIVISION OR PROJECT RESPONSIBILITY
Jonathan C. White, P.E.  Digitally Signed: August 20, 2021	Division 26 Division 40 Sections 40 61 13, 40 63 43, and 40 67 23
Christopher D. Gatling, P.E.  Digitally Signed: August 20, 2021	Division 31 Division 32 Division 33

CERTIFICATIONS

Justin Angel, P.E.  Digitally Signed: August 20, 2021	Division 09 Section 09 90 00 Division 13 Division 40 Section 40 05 36.13 Division 43 Division 44

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DIVISION 1

GENERAL REQUIREMENTS

SECTION 01 11 00 - SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

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

B. Work covered by Contract Documents: The completed Work will provide Owner with various odor control improvements. More specifically, the Project includes, but is not limited to, construction of the following:
   1. A biotrickling filter at the Persigo Wastewater Treatment Plant for the mitigation of odorous air upstream of the Headworks Facility.
   2. Concrete coating and installation of an air curtain at the Parshall Flume upstream of the Headworks Facility.
   3. An air jumper connection at the Persigo Wash to connect headspaces between two existing siphon structures in the collection system.
   4. A biotrickling filter in the collection system near South 4th Street, known as Dos Rios, for the mitigation of odorous air.
   5. All associated piping, site improvements, and electrical and instrumentation improvements to deliver complete and operational systems.

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

D. Secure and pay for all permits including all City of Grand Junction permits, OSHA excavation permits, Department of Transportation permits, and any other government fees and licenses.
   1. It is the Contractor's responsibility to maintain the required controls and record keeping to comply with the SWPPP and associated stormwater permit.

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

1.2 ACTIVITIES BY OTHERS

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

B. Cooperate with others to minimize interference and delays.
   1. When cooperation fails, submit recommendations and perform Work in coordination with work of others as directed.

C. Other on-going and potential projects that parallel the schedule of this project:
   1. Flow Equalization Basin Rehab Project

1.3 COORDINATION OF WORK

A. Maintain overall coordination of the Work.

B. Obtain construction schedules from each subcontractor, and require each subcontractor to maintain schedules and coordinate modifications.

C. Alternates: Alternates, if included, are specified in detail in the Bid Form and only those alternates that were selected by the Owner, as evidenced in the Agreement, are made a part of this Contract.

1.4 PROVISIONS FOR FUTURE WORK

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

1.5 LOCATION OF WORK

A. The Project is located at three locations listed below:
   1. Persigo Wastewater Treatment Plant, 2145 River Road, Grand Junction, CO 81505
   2. Persigo Wash near the River Road Bridge (Approximately: 39° 6'44.79"N, 108°39'324"W)
   3. Dos Rios near South 4th Street on Parcel 2945-232-00-088 (Approximately: 39° 3'29.70"N, 108°33'53.03"W)

1.6 OWNER FURNISHED EQUIPMENT

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 11 60 – PROJECT MANUAL LANGUAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes description and requirements of:
   1. Explanation of Project Manual arrangement.
   2. Explanation of Project Manual language.
   3. Reference standards.
   4. Method of resolving conflicts of referenced standards between Contract Documents.

B. Related Documents and Sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

1.2 REFERENCES

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

1.3 PROJECT MANUAL ARRANGEMENT

A. Document and Section numbers used in Project Manual, and Project Manual arrangement are in accordance with CSI MasterFormat™, except where departures have been deemed necessary.

B. Sections are written in accordance with CSI SectionFormat™, Three-Part Section Format, except where departures have been deemed necessary.

C. Page format for Sections in the Project Manual is in accordance with CSI Page Format, except where departures have been deemed necessary.

1.4 PROJECT MANUAL LANGUAGE

A. Specification Section Paragraphs entitled "Section Includes" summarizes briefly what is generally included in the section. Requirements of Contract Documents are not limited by "Section Includes" paragraphs. Specifications have been partially streamlined by intentionally omitting words and phrases, such as "the CONTRACTOR shall," "in conformity therewith," "shall be" following "as indicated," "a," "an," "the" and "all". Assume missing portions by inference.

B. Phrase "by ENGINEER" modifies words such as "accepted," "directed," "selected," "inspected," and "permitted," when they are unmodified.

C. Phrase "to ENGINEER" modifies words such as "submit," "report," and "satisfactory," when they are unmodified.

D. Colons (:) are used to introduce a list of particulars, an appositive, an amplification, or an illustrative quotation:
   1. When used as an appositive after designation of product, colons are used in place of words "shall be."

E. Word "provide" means to manufacture, fabricate, deliver, furnish, install, complete, assemble, erect in place, test, render ready for use or operation, including necessary related material, labor, appurtenances, services, and incidentals.

F. Words "CONTRACTOR shall" are implied when direction is stated in imperative mood.

G. Term "products" includes materials and equipment as specified in Section 01 60 00.

1.5 REFERENCE STANDARDS

A. Use only applicable portions of referenced standards, ignoring payment stipulations and other provisions which change the duties of the ENGINEER or OWNER.

B. Equate terms relating to designer to "ENGINEER."

C. Notify ENGINEER when referenced standard, code, or specification conflicts with Contract Documents.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 14 00 – WORK RESTRICTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes description and requirements of:
   1. General constraints for sequencing and scheduling the Work.
   2. Interruption of Treatment Processes.
   3. Compliance with Colorado Department of Health and Environment Permit.
   4. Work affected by existing site and facility.
   5. Work restrictions and coordination between construction operations and plant operations, including:
      a. Access to site.
      b. Use of site and premises.
      c. Utilities.
      d. Work by Others.
      e. Work Sequence.
      f. Temporary Services, Materials and Equipment.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
   3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
      a. Section 01 11 00 - Summary of Work.
      b. Section 01 26 00 - Contract Modification Procedures.
      c. Section 01 50 00 - Temporary Facilities and Controls.
      d. Section 09 90 00 – Painting and Protective Coatings

1.2 GENERAL CONSTRAINTS ON SEQUENCE AND SCHEDULING OF WORK

A. Wastewater Projects:
   1. The existing Persigo Wastewater Treatment Plant is the City of Grand Junction's only means of treating domestic and industrial wastewater prior to discharging to the Colorado River. Impairing the operational capabilities of this treatment plant will result in serious environmental damage and monetary fines.
   2. Conduct work in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of raw wastewater to the water quality limitations specified in the discharge permit.
   3. The status of the new treatment plant shall be defined as "operational" when it is capable of treating the entire quantity of wastewater received to the water quality limits specified in the discharge permit.

B. Work Sequence and Constraints:
   1. Utilize description of critical events in work sequence in this Section as a guideline for scheduling and undertaking the Work.
   2. Work sequence and constraints presented do not include all items affecting completion of the Work, but are intended to describe critical events necessary to minimize disruption of

the existing facilities and to ensure compliance with Colorado Department of Health and Environment (CDPHE) permit requirements.

1.3 INTERRUPTION OF TREATMENT PROCESSES

A. Execute the Work while the existing facility is in operation as specified in Section 01 35 00.

B. Indicate required shutdowns of existing facilities or interruptions of existing operations on Progress Schedule. Shutdowns will be permitted to the extent that existing operation of the plant will not be jeopardized and identified constraints are satisfied.

C. Submit written notification of required shutdowns of existing facilities at least 14 days prior to the planned date of shutdown.

D. The Engineer and the Plant Personnel will evaluate the request based on the plant's ability to reliably meet capacity demands.

E. Do not begin alterations until Engineer’s written permission has been received.

F. Minimize shutdown times by thorough advanced planning. Have required equipment, materials, and labor on hand at time of shutdown.

G. Where required to minimize treatment process interruptions while complying with specified sequencing constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.

1.4 COMPLIANCE WITH WATER QUALITY STANDARDS AS MANDATED BY THE COLORADO DEPARTMENT OF HEALTH AND ENVIRONMENT

A. The existing facility is operating under the terms of a discharge permit issued by the CDPHE. This permit specifies the water quality limits that the plant must meet prior to discharge of effluent. A copy of the existing permit is on file for review at the City of Grand Junction’s Wastewater Services offices.

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

C. Bear the cost of penalties imposed on the Owner for discharge violations caused by actions of the Contractor.

1.5 REQUIREMENTS FOR OPERATION OF PLANT AND MAINTAINING CONTINUOUS OPERATION OF EXISTING FACILITIES

A. Facilities or conditions required to keep the existing plant operational include, but are not limited to, the following:
   1. Electrical power, including transformers, distribution wiring, and motor control centers.
   2. Existing Headworks facility and flow measurement instrumentation and recording.
   3. Piping for conveyance of raw wastewater, partially treated wastewater, potable & non-potable water, and final effluent between treatment units, temporary on-site storage, and the outfall.
   4. All existing primary clarifiers, aeration basins, final clarifiers, and solids handling facilities, including digesters, thickening facilities, and dewatering facilities.
   5. Chemical storage, metering, conveyance, and control facilities. These are provided with existing storage tanks for gaseous chlorine; chemical metering pumps; chlorine residual

analyzers; chemical solution piping at various locations in the plant. Plant potable water and reclaimed water is required at all times to permit chlorination.
   a. Continuous addition of chemicals is required during plant operations.
   b. The ability to continuously apply chlorine following treatment is required.
6. Plant Water: Existing reuse water pumps
7. Sludge Transfer: Existing lines convey sludge from the primary clarifiers and final clarifiers to and from the Solids Handling Facilities.
8. Fencing and gates.
9. Lighting.
10. Heating, ventilation, and air conditioning equipment.
11. Instrumentation, meters, controls, and telemetry equipment.
12. Safety equipment and features.
13. Parking for City employees and vehicles required for operation and maintenance of the existing Persigo Wastewater Treatment Plant.
14. Telephone system.
15. Storm drainage.
16. Roadways to provide access route for solids hauling trucks and chemical deliveries.
17. Other incidentals necessary to continually operate the facilities.

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

C. Do not remove or demolish existing facilities required to keep the existing plant operational at the capacities specified until the existing facilities are replaced by temporary, or new facilities equipment. The replacement facilities shall have been tested and demonstrated to be operational prior to removing or demolishing existing facilities.

1.6 OPERATIONS AND MAINTENANCE ACCESS

A. Provide safe, continuous access to process control equipment for plant operations personnel.

1.7 SHUTDOWN CONSTRAINTS

A. Comply with Shutdown Constraints Described in General Terms as Follows:
   1. Include the following work sequences in the Progress Schedule.
   2. This Section identifies several construction constraints that must be reflected in the Contractor project coordination. An overall outline is presented in this Section for the Construction coordination, demolition, and seasonal/process constraints that shall be considered during construction. The sequence of Work for this Project must reflect the constraints identified herein.

B. Definitions:
   1. Dry weather periods shall, in general, be from June 15 through October 1. Actual dry weather periods shall be as determined by the Owner based on weather, flows entering plant, and plant operation requirements.
   2. Wet weather periods shall be any time period which is not within the defined dry weather periods.
   3. Low flow period shall be from 2:00 a.m. to 6:00 a.m.
   4. Minor Shutdown: Any shutdown requiring less than 4 hours.
   5. Major Shutdown: Any shutdown other than a minor shutdown.

C. Shutdown of Plant Operations:
   1. Provide 14 days advance notice to Engineer and Owner of need for a minor shutdown.
   2. Provide 30 days advance notice to Engineer and Owner of need for a major shutdown.
   3. Contractor shall schedule a shutdown coordination meeting with Owner and Engineer one week prior to each shutdown.

4. Do not proceed with work affecting a facility's operation without obtaining Owner and Engineer advance approval of the need for, and duration of, such work. The Owner will endeavor to grant Contractor requests where possible. However, because Owner's primary responsibility is to treat wastewater, the requested timing may not be possible.
5. Any and all plant shutdowns shall require a shutdown plan, including detailed schedule, backup tools and equipment, personnel involved, contingency plan, and any procedures involved in restarting the process or facility. Owner's approval of the Shutdown Plan is required prior to any shutdowns.
6. Shutdowns will be allowed but shall only be allowed in dry weather periods and with at least one flow equalization basin in operation. Shutdowns may be limited to low flow periods.
7. No minor or major shutdowns allowed within 7 days of a previous shutdown.

1.8 FACILITY OPERATIONS

A. Continuous operation of Owner's facilities is of critical importance. Schedule and conduct activities to enable existing facilities to operate continuously, unless otherwise specified, and to minimize the number of shutdowns of the plant and existing unit processes.

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

C. Conduct Work outside regular working hours on prior written consent of Owner to meet Project schedule and avoid undesirable conditions.

D. Be responsible for planning, designing, and providing various temporary services, utilities, connections, temporary piping, bypass facilities and temporary connections, and similar items to maintain continuous operations of Owner's facility. Sequences other than those specified will be considered upon written request to Owner and Engineer, provided they afford equivalent continuity of operations.

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

F. Any tanks or pipelines requiring drainage prior to construction will be drained by the Owner's staff to the maximum extent possible utilizing existing piping and drains where they exist. Contractor shall provide temporary pumping and effort to complete drainage of tank or pipeline as required. Provide minimum 7 days' notice to Engineer and Owner of need to drain a facility, unless otherwise specified.

G. Power outages will be considered upon 48 hours written request to Owner and Engineer. Describe the reason, anticipated length of time, and areas affected by the outage in the written request. Provide temporary provisions for continuous power supply to critical existing facility components, is requested by Owner.

H. Coordinate proposed work with Engineer and Owner before implementing unit shutdowns. Under no circumstances shall Work end if such actions may inadvertently cause a cessation of any facility operation. In such cases, remain onsite until necessary repairs are complete and facility is brought back online.

I. I. Relocation of Existing Facilities:
1. During construction, it is expected that minor relocations of Work will be necessary.

2. Provide complete relocation of existing structures and Underground Facilities, including piping, utilities, equipment and structures, electrical conduit wiring, electrical duct bank, and other necessary items.
3. Use only new materials for relocated facility. Match materials of existing facility, unless otherwise shown or specified.
4. Perform relocations to minimize downtime of existing facilities.
5. Install new portions of existing facilities in their relocate.

1.9 UTILITIES

A. Provide advance notice to and utilize services of Colorado One-Call System for location and marking of underground utilities operated by utility agencies other than the OWNER. Contact information: Colorado 811 One Call System, Inc., 16361 Table Mountain Pkwy, Golden, CO 80403, phone number 303-232-1991, website: https://www.colorado811.org/

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

1.10 WORK BY OTHERS

A. The Owner will continue to use the existing facilities during the Project and the Owner will conduct operational and maintenance work items to maintain system operations.

B. Remove and deliver to Owner the following items:
1. Instrumentation and controls items removed from cabinets, including HMIs, PLCs, network switches, etc.

1.11 WORK SEQUENCE

A. This possible sequence is included for informational purposes only. It is intended that Construction be performed in multiple phases as follows:

1. Persigo WWTP: Biotrickling Filter and Raw Water Parshall Flume
   a. Construct temporary facilities and lines required to perform construction.
   b. Construct equipment pads for the biotrickling filter and equipment.
   c. Perform installation of odor control equipment near the Headworks facility upstream of the existing Parshall Flume.
   d. Perform installation of piping for the odor control unit, and coordinate routing of the lines to avoid existing equipment/facilities and maintain operator access points.
   e. Bury odor control lines as required and provide proper supports in elevated areas.
   f. Maintain slope of odor control lines for proper drainage; provide sump access at all low points in the lines for moisture removal as required.
   g. Perform required testing to put the biotrickling filter and odor control units into service.
   h. Provide and install temporary pumping facilities. The bypass pumping will need to be engaged and functional. Influent flow measurement must be accurately maintained by temporary bypass lines and reported back to plant SCADA.
   i. Engage temporary pumping facilities. The Contractor shall be required to provide and operate temporary pumping to transfer the peak flow to the Headworks facility above the existing screens. The required bypass pumping would draw flow from the existing diversion structure upstream of Manhole No. 1.
   j. Drain, clean, and repair existing Manhole and Parshall flume structures.
   k. Apply protective coatings in all identified areas.
   l. Perform installation of odor control equipment at Parshall flume structure.
   m. Complete Startup and Commissioning efforts for each of the odor control units.

n. Complete all work, including facility tie-in, grading, coatings, paving and fencing to create completed facilities to achieve requirements for Persigo WWTP odor control improvements.

2. Persigo Wash: Foul Air Jumper Connection
   a. Construct temporary facilities and lines required to perform construction.
   b. Construct and perform installation of fabricated bridge structure.
   c. Perform installation of piping for the air jumper unit, coordinate routing of the lines to maintain operator access points.
   d. Construct air jumper pipe connection to the existing siphon boxes.
   e. Apply protective coatings in all identified areas.
   f. Perform required testing to put the air jumper into service.
   g. Complete Startup and Commissioning efforts for the air jumper unit.
   h. Complete all work, including facility tie-in, grading, coatings, paving and fencing to create completed facilities to achieve requirements for Persigo Wash odor control improvements.

3. Dos Rios: Biotrickling Filter
   a. Construct temporary facilities and lines required to perform construction.
   b. Construct equipment pads for the biotrickling filter and equipment.
   c. Perform installation of odor control equipment near Parcel #2945-232-00-088.
   d. Perform installation of piping for the odor control unit, and coordinate routing of the lines to avoid existing equipment/facilities and maintain operator access points.
   e. Bury odor control lines as required and provide proper supports in elevated areas.
   f. Maintain slope of odor control lines for proper drainage; provide sump access at all low points in the lines for moisture removal as required.
   g. Perform required testing to put the biotrickling filter and odor control units into service.
   h. Construct new manhole connection near the on-ramp from Riverside Pkwy to Highway 50.
   i. Perform bore and installation of piping under Riverside Parkway off-ramp. Connect piping to odor control units and manhole.
   j. Apply protective coatings in all identified areas.
   k. Coordinate with Owner to provide and install temporary pumping facilities. The bypass pumping will need to be engaged and functional.
   l. The existing 24” Interceptor will need to be connected to the new manhole. A majority of flow may be diverted near the intersection of S 15th Street and Winters Ave. Plug the 24” Interceptor to divert flow south of Winters Ave.
   m. Engage temporary pumping facilities as required. The contractor will be required to provide and operate temporary pumping to transfer the peak flow further downstream in the collection system. The required bypass pumping could draw flow from the manhole near Parcel #2945-232-03-019 and be pumped downstream to the manhole near Parcel #2945-232-00-077.
   n. Perform manhole and Interceptor connection construction.
   o. Complete Startup and Commissioning efforts for the odor control units.
   p. Complete all work, including facility tie-in, grading, coatings, paving and fencing to create completed facilities to achieve requirements for the Dos Rios odor control improvements.

1.12 PERMITS

A. Furnish necessary permits for construction of Work. Portions of this project may be subject to review and acceptance by various agencies. The Engineer shall submit a summary transmittal letter to the Colorado Department of Public Health an Environment (CDPHE) and submit plans and specifications to CDPHE if required for approval prior to construction.

B. The Contractor shall pick up permits, pay and be reimbursed the actual amount at the time of construction. However, if additional permits are required, the Contractor shall obtain them, pay, and be reimbursed the actual amount. The agencies for this project that may require coordination include but are not limited to the following:
   1. City of Grand Junction
   2. Colorado Department of Public Health and Environment.

1.13 TEMPORARY SERVICES, MATERIALS, AND EQUIPMENT

A. Locate temporary facilities in a manner that minimizes interference to Owner's operation and maintenance personnel.

B. Unless otherwise specified, install temporary pipelines of the same size as its connection to the existing facility at the downstream end of the pipeline.

C. Provide piping of suitable material for the material being conveyed.

D. Provide submittals on proposed temporary electrical and instrumentation components necessary to maintain existing facilities.

E. Dewater and promptly clean basins and channels temporarily removed from service.

F. Dimensions for all existing structures, piping, paving, and other nonstructural items are approximate. The Contractor shall field verify all dimensions and conditions and report any discrepancies to the Engineer a minimum of 14 days in advance of any construction in the area.

G. Discrepancies between coordinates, bearings and lengths, and stationing shall be resolved in the following order of precedence:
   1. Coordinates.
   2. Bearings and lengths.
   3. Stationing.

PART 2 - PRODUCTS (NOT USED)
PART 3 - EXECUTION (NOT USED)
END OF SECTION

SECTION 01 26 00 – CONTRACT MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes description and requirements of:
   1. Proposal Requests.
   2. Claims.
   3. Change Orders and Written Amendments.
   4. Field Order Procedures.

1.2 PROPOSAL REQUEST

A. Owner may, in anticipation of ordering an addition, deletion, or revision to the Work, request Contractor to prepare a detailed proposal of cost and times to perform contemplated change.

B. Proposal request will include reference number for tracking purposes and detailed description of and reason for proposed change, and such additional information as appropriate and as may be required for Contractor to accurately estimate cost and time impact on the Project.

C. Proposal request is for information only; Contractor is neither authorized to execute proposed change nor to stop Work in progress as result of such request.

D. Contractor's written proposal shall be transmitted to Engineer promptly, but not later than 14 days after Contractor's receipt of Owner's written request. Proposal shall remain firm for a maximum period of 45 days after receipt by Engineer.

E. Owner's request for proposal or Contractor's failure to submit such proposal within the required time period will not justify a claim for an adjustment in Contract Price or Contract Times (or Milestones).

1.3 CLAIMS

A. Include, at a minimum:
   1. Specific references including:
      a. Drawing numbers.
      b. Specification section and article/paragraph number.
      c. Submittal type, Submittal number, date reviewed, Engineer's comment, as applicable, with appropriate attachments.
   2. Stipulated facts and pertinent documents, including photographs and statements.
   3. Interpretations relied upon.
   4. Description of:
      a. Nature and extent of claim.
      b. Who or what caused the situation.
      c. Impact to the Work and work of others.
      d. Discussion of claimant's justification for requesting a change to price or times or both.
   5. Estimated adjustment in price claimant believes it is entitled to with documentation and justification.
   6. Requested Change in Contract Times: Include at least;
      a. Progress schedule documentation showing logic diagram for request.
      b. Documentation that float times available for Work have been used.
      c. Revised activity logic with durations including sub-network logic revisions, duration changes, and other interrelated schedule impacts, as appropriate.

7. Documentation as may be necessary as set forth below for Work Change Directive, and as Engineer may otherwise require.

1.4 WORK CHANGE DIRECTIVES

A. Procedures:
1. Upon completion of Work covered by the Work Change Directive or when final Contract Times and Contract Price is determined, Contractor shall submit documentation for inclusion in a Change Order via the ***Info Exchange*** project website.
2. Engineer will:
   a. Initiate, including a description of the Work involved and any attachments.
   b. Affix signature, demonstrating Engineer's recommendation.
   c. Engineer will update Owner monthly on the status of the Work Change Directives.
3. Owner will:
   a. Affix signature, demonstrating approval of the changes involved.
   b. Return one electronic copy to Engineer. Engineer will retain one electronic copy, send one electronic copy to the Resident Project Representative or other field representative, and forward one electronic copy to Contractor.
4. Contractor's documentation shall include but not be limited to:
   a. Appropriately detailed records of Work performed to enable determination of value of the Work.
   b. Full information required to substantiate resulting change in Contract Times and Contract Price for Work. On request of Engineer, provide additional data necessary to support documentation.
   c. Support data for Work performed on a unit price or Cost of the Work basis with additional information such as:
      1). Dates Work was performed, and by whom.
      2). Time records, wage rates paid, and equipment rental rates.
      3). Invoices and receipts for materials, equipment, and subcontracts, all similarly documented.
   d. Claim for additional cost must be made within 10 days of the directive by the Engineer. Claims on work made after 10 days will not be considered.

B. Effective Date of Work Change Directive: Date of signature by Owner, unless otherwise indicated thereon.

1.5 CHANGE ORDERS OR WRITTEN AMENDMENTS

A. Procedure:
1. Engineer will prepare the proposed Change Order or Written Amendment and transmit an electronic copy of such with Engineer's written recommendation (Change Order only) and request to Contractor for signature.
2. Contractor shall, upon receipt, either:
   a. Promptly execute the document, retaining one electronic copy for its file, and return one electronic copy via the ***Info Exchange*** project website to Engineer for Owner's signature, or
   b. Return unsigned one electronic copy with written justification via ***Info Exchange*** project website for not executing Change Order or Written Amendment.
3. Engineer will, upon receipt of Contractor-executed copy, promptly forward Engineer's written recommendation and partially executed copy for Owner's signature, or if Contractor fails to execute the Change Order or Written Amendment, Engineer will promptly so notify Owner and transmit Contractor's justification to Owner.
4. Upon receipt of Contractor-executed Change Order or Written Amendment, Owner will promptly either:
   a. Execute Change Order or Written Amendment, retaining one copy for its file and returning one electronic copy to Engineer, or

b. Return to Engineer unsigned copy with written justification for not executing Change Order or Written Amendment.

5. Upon receipt of Owner-executed Change Order or Written Amendment, Engineer will transmit one electronic copy to Contractor, one copy to Resident Project Representative or other field representative, and retain one electronic copy, or if Owner fails to execute the Change Order or Written Amendment, Engineer will promptly so notify Contractor and transmit Owner's justification to Contractor.
6. Upon receipt of Owner-executed Change Order, Contractor shall:
   a. Perform Work covered by Change Order or Written Amendment.
   b. Revise Schedule of Values to adjust Contract Price and submit with next Application for Payment.
   c. Revise progress schedule to reflect changes in Contract Times, if any, and to adjust times for other items of Work affected by change.
   d. Enter changes in Project record documents after completion of change related Work.

B. In signing a Change Order or Written Amendment, Owner and Contractor acknowledge and agree that:
1. Stipulated compensation (Contract Price or Contract Times, or both) set forth includes payment for:
   a. The Cost of the Work covered by the Change Order or Written Amendment.
   b. Contractor's fee for overhead and profit.
   c. Interruption of progress schedule.
   d. Delay and impact, including cumulative impact, on other Work under the Contract Documents, and
   e. Extended overheads.
2. Change Order or Written Amendment constitutes full mutual accord and satisfaction for the change to the Work.
3. Unless otherwise stated in the Change Order or Written Amendment, all requirements of the original Contract Documents apply to the Work covered by the Change Order or Written Amendment.

1.6 FIELD ORDER PROCEDURES

A. Engineer will issue Field Orders, with one electronic copy to Contractor.

B. Effective date of the Field Order shall be the date of signature by Engineer, unless otherwise indicated thereon.

C. Contractor shall acknowledge receipt by signing and returning one electronic copy to Engineer.

D. Field Orders will be incorporated into subsequent Change Orders, as a no-cost change to the Contract.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 29 00 – PAYMENT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes description and requirements of:
   1. Submittals Related to Payment Procedures.
   2. Cash Allowances.
   3. Schedule of Values.
   4. Schedule of Estimated Progress Payments.
   5. Payment.
   6. Nonpayment for Rejected or Unused Products.
   7. Partial Payment for Stored Materials and Equipment.
   8. Partial Payment for Undelivered, Project Specific Manufactured or Fabrication Equipment.

B. Related sections:
   1. Section 01 50 00 – Temporary Facilities and Controls.

1.2 SUBMITTALS

A. Informational Submittals:
   1. Schedule of Values: Submit on Contractor's standard form.
   2. Schedule of Estimated Progress Payments:
      a. Submit with initially acceptable Schedule of Values.
      b. Submit adjustments thereto with Application for Payment.
   3. Application for Payment.
   4. Final Application for Payment.

1.3 CASH ALLOWANCES

A. Consult with Engineer in selection of products or services. Obtain proposals from Suppliers and installers and offer recommendations.

B. Cash allowances will be administered in accordance with the General Conditions and as specified herein.

C. Contractor Agrees:
   1. The Lump Sum Work includes the allowances specified and includes all Work to perform such items covered by the Cash Allowance as approved by Owner and Engineer.
   2. The Allowances include the cost of material and equipment required by the allowances to be delivered to the Site and applicable taxes.
   3. Contractor's cost for unloading, handling, labor, installation cost, overhead, profit, and other expenses for the allowance have been included in the Lump Sum Work and not in the allowance.
   4. Accept payment equal to the amount of the actual invoices for services and products without markup.

D. Expenditure of any portion of Cash Allowances shall only be done with authorization by Owner and Engineer. Cash Allowances are estimated amounts and final payment shall be based on actual costs as authorized by Change Order and the Contract Price shall be correspondingly adjusted. The Cash Allowances are specifically for the purpose of the following items:

E. Independent Testing Cash Allowance: This allowance is to cover costs of specified Quality Assurance testing to provided by an independent testing laboratory, agency, and special inspectors retained by the Owner. Contractor shall hire independent testing laboratory, agency, and special inspectors as acceptable to the Owner. Authorization will only be given for independent testing services performed as part of field quality assurance specified to be provided by the Owner. Any re-testing or other testing desired or specified by the Contractor shall be the responsibility of the Contractor.

F. Submit, with application for payment, invoice showing date of purchase, from which the purchase was made, the date of delivery of the product or service, and the price, including delivery to the Site and applicable taxes.

1.4 SCHEDULE OF VALUES

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

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

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

D. Lump Sum Work:
1. Reflect Schedule of Values format included in conformed Bid Form, specified allowances, alternates, and equipment selected by Owner, as applicable.
2. List bonds and insurance premiums, mobilization, demobilization, preliminary and detailed progress schedule preparation, facility startup, and contract closeout separately.
3. Break down by Division 2 through 44 with appropriate subdivision of each Specification for each Project facility. The apparent “low bidder” is required to deliver a Bid breakdown by specification within 2 working days after Bid opening.

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

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

G. Submit Schedule of Values in a spreadsheet format compatible with latest version of Excel.

1.5 SCHEDULE OF ESTIMATED PROGRESS PAYMENTS

A. Show estimated payment requests throughout Contract Times aggregating initial Contract Price.

B. Base estimated progress payments on initially acceptable progress schedule. Adjust to reflect subsequent adjustments in progress schedule and Contract Price as reflected by modifications to the Contract Documents.

1.6 APPLICATION FOR PAYMENT

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

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

C. Provide separate form for each schedule as applicable.

D. Include accepted Schedule of Values for each schedule or portion of Work, the unit price breakdown for the Work to be paid on unit price basis, a listing of Owner-selected equipment, if applicable, and allowances, as appropriate.

E. Preparation:
   1. Round values to nearest dollar.
   2. List each Change Order executed prior to date of submission as separate line item. The totals will equal those shown on the Transmittal Summary Form for each schedule as applicable.
   3. Submit Application for Payment, including a Transmittal Summary Form and detailed Application for Payment Form(s) for each schedule as applicable, a listing of materials on hand for each schedule as applicable, and such supporting data as may be requested by Engineer.
   4. Prior to submitting each request for progress payment, request Engineer's review and approval of current status of record documents as required by SC-7.11.B. Failure to properly maintain, update, and submit record documents may result in a deferral by Engineer to recommend whole or any part of Contractor's Application for Payment, either partial or final.

1.7 PAYMENT

A. General:
   1. Progress payments will be made monthly.
   2. The date for Contractor's submission of monthly Application for Payment shall be established at the Preconstruction Conference.
   3. Progress payment is contingent upon applications and Contractor progress, which is subject to withholdings by Owner.

B. Payment for all the Work shown or specified in Contract Documents is included in the Contract Price. No measurement or payment will be made for individual items.

C. Payment for Lump Sum Work covers all Work specified or shown in the Contract Documents.

1.8 NONPAYMENT FOR REJECTED OR UNUSED PRODUCTS

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

1.9 PARTIAL PAYMENT FOR STORED MATERIALS AND EQUIPMENT

A. Partial Payment: No partial payments will be made for materials and equipment delivered or stored unless Shop Drawings and preliminary operation and maintenance manuals are accepted by Engineer. Thereafter, partial payment for materials and equipment delivered and stored, but not yet incorporated in work, shall not exceed 90% of the equipment or material value.

B. Final Payment: Will be made only for products incorporated in Work and following approval of final operations and maintenance manuals; remaining products, for which partial payments have

been made, shall revert to Contractor unless otherwise agreed, and partial payments made for those items will be deducted from final payment.

1.10 PARTIAL PAYMENT FOR UNDELIVERED, PROJECT-SPECIFIC MANUFACTURED OR FABRICATED EQUIPMENT

A. Notwithstanding above provisions, partial payments for undelivered (not yet delivered to Site or not stored in the vicinity of Site) products specifically manufactured for this Project, excluding off the shelf or catalog items, will be made for products listed below when all following conditions exist:
   1. Partial payment request is supported by written acknowledgment from Suppliers that invoice requirements have been met.
   2. Equipment is adequately insured, maintained, stored, and protected by appropriate security measures.
   3. Each equipment item is clearly marked and segregated from other items to permit inventory and accountability.
   4. Authorization has been provided for access to storage Site for Engineer and Owner.
   5. Equipment meets applicable Specifications of these Contract Documents.

B. Applicable Items:

Specification Section	Specific Product
None identified for this project	None identified for this project

C. Payment shall not exceed 15% of the equipment value, not including shipping and handling charges for undelivered, Project-specific manufactured equipment and will only be made following Shop Drawing approval.

D. Failure of Contractor to continue compliance with above requirements shall give cause for Owner to withhold payments made for such equipment from future partial payments.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 31 00 – PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes description and requirements of:
   1. Submittals Related to Project Management and Coordination.
   2. Utility Notification and Coordination.
   3. Work Sequencing /Constraints.
   4. Facility Operations.
   5. Adjacent Facilities and Properties.
   6. Owner's Occupancy.
   7. Partial Utilization by the Owner.
   8. Physical Conditions.
   9. Construction Photographs.
   10. Audio-Video Recordings.
   11. Cutting, Fitting and Patching.

B. Related sections:
   1. Section 01 32 00 – Construction Progress Documentation.

1.2 SUBMITTALS

A. Informational:
   1. Statement of Qualification (SOQ) for land surveyor or civil engineer.
   2. Photographs and other records of examination.
   3. Video Recordings: Submit one copy, including updated copy of project video log, within 5 days of being taken.

1.3 UTILITY NOTIFICATION AND COORDINATION

A. Coordinate the Work with various utilities within Project limits. Notify applicable utilities prior to commencing Work, if damage occurs, or if conflicts or emergencies arise during Work.
   1. Electric Company: Xcel Energy, 970-270-1953
   2. Public Works Department: City of Grand Junction, 970-256-4180

B. Before excavation, contact Colorado 811, 3 days prior to digging, drilling, excavating, and to arrange for field location of known utilities.

1.4 WORK SEQUENCING/CONSTRAINTS

A. Include the following work sequences in the Progress Schedule required under Section 01 32 00, CONSTRUCTION PROGRESS DOCUMENTATION.

B. This Section identifies several construction constraints that must be reflected in the Contractor project coordination. An overall outline is presented in this Section for the Construction coordination, demolition, and seasonal/process constraints that shall be considered during construction. The sequence of Work for this Project must reflect the constraints identified herein.

C. Definitions:
   1. Dry weather periods shall, in general, be from June 15 through October 1. Actual dry weather periods shall be as determined by the Owner based on weather, flows entering plant, and plant operation requirements.

2. Wet weather periods shall be any time period which is not within the defined dry weather periods.
3. Low flow period shall be from 2:00 a.m. to 6:00 a.m.
4. Minor Shutdown: Any shutdown requiring less than 8 hours.
5. Major Shutdown: Any shutdown other than a minor shutdown.

D. Shutdown of Plant Operations:
1. Provide 14 days advance notice to Engineer and Owner of need for a minor shutdown.
2. Provide 30 days advance notice to Engineer and Owner of need for a major shutdown.
3. Contractor shall schedule a shutdown coordination meeting with Owner and Engineer one week prior to each shutdown.
4. Do not proceed with work affecting a facility's operation without obtaining Owner and Engineer advance approval of the need for, and duration of, such work. The Owner will endeavor to grant Contractor requests where possible. However, because Owner's primary responsibility is to treat wastewater, the requested timing may not be possible.
5. Any and all plant shutdowns shall require a shutdown plan, including detailed schedule, backup tools and equipment, personnel involved, contingency plan, and any procedures involved in restarting the process or facility. Owner's approval of the Shutdown Plan is required prior to any shutdowns.
6. Shutdowns will be allowed but shall only be allowed in dry weather periods and with at least one flow equalization basin in operation. Shutdowns may be limited to low flow periods.
7. No minor or major shutdowns allowed within 7 days of a previous shutdown.

E. Incorporate the Following Construction Constraints into the Work:
1. Wet Weather Flows: This time period is anticipated to be during wet weather periods. It is anticipated that temporary plant shutdown would be limited to minor shutdowns during low flow periods.
2. Dry Weather Flows: This time period is anticipated to be during dry weather periods. It is anticipated that temporary plant shutdowns could occur for up to 24 hours during this time period. Minor and major shutdowns are allowed. Bypass pumping shall be used in the event plant shutdowns last longer than 24 hours and must be coordinated and approved by the Owner.

1.5 FACILITY OPERATIONS

A. Continuous operation of Owner's facilities is of critical importance. Schedule and conduct activities to enable existing facilities to operate continuously, unless otherwise specified, and to minimize the number of shutdowns of the plant and existing unit processes.

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

C. Conduct Work outside regular working hours on prior written consent of Owner to meet Project schedule and avoid undesirable conditions.

D. Be responsible for planning, designing, and providing various temporary services, utilities, connections, temporary piping, bypass facilities and temporary connections, and similar items to maintain continuous operations of Owner's facility. Sequences other than those specified will be considered upon written request to Owner and Engineer, provided they afford equivalent continuity of operations.

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

F. Any tanks or pipelines requiring drainage prior to construction will be drained by the Owner's staff to the maximum extent possible utilizing existing piping and drains where they exist. Contractor shall provide temporary pumping and effort to complete drainage of tank or pipeline as required. Provide minimum 7 days' notice to Engineer and Owner of need to drain a facility, unless otherwise specified.

G. Power outages will be considered upon 48 hours written request to Owner and Engineer. Describe the reason, anticipated length of time, and areas affected by the outage in the written request. Provide temporary provisions for continuous power supply to critical existing facility components, is requested by Owner.

H. Coordinate proposed work with Engineer and Owner before implementing unit shutdowns. Under no circumstances shall Work end if such actions may inadvertently cause a cessation of any facility operation. In such cases, remain onsite until necessary repairs are complete and facility is brought back online.

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

1.6 ADJACENT FACILITIES AND PROPERTIES

A. Examination:
   1. After Effective Date of the Agreement and before Work at Site is started Contractor, Engineer, and affected property owners and utility owners shall make a thorough examination of pre-existing conditions including existing buildings, structures, and other improvements in vicinity of Work, as applicable, which could be damaged by construction operations.
   2. Periodic reexamination shall be jointly performed to include, but not limited to, cracks in structures, settlement, leakage, and similar conditions.

B. Documentation:
   1. Record and submit documentation of observations made on examination inspections for signature of Engineer and Contractor and in accordance with paragraph Construction Photographs and Audio-Video Recordings.
   2. Upon receipt, Engineer will review, sign, and return one record copy of documentation to Contractor to be kept on file in field office. Such documentation shall be used as indisputable evidence in ascertaining whether and to what extent damage occurred as a result of Contractor's operations, and is for the protection of adjacent property owners, Contractor, and Owner.

1.7 OWNER'S OCCUPANCY

A. Owner will occupy the premises during the period of construction for the conduct of its normal operations. Cooperate with Owner in all construction operations to minimize conflict and to facilitate Owner usage.

1.8 PARTIAL UTILIZATION BY THE OWNER

A. Schedule operations for completion of portions of the Work, as designated under Work Sequence/Constraints, herein, for Owner's occupancy or separate operation prior to Substantial Completion of the entire Work.

B. Unless agreed in writing prior to Owner's use, the following conditions shall apply:
   1. Contractor's Responsibilities:
      a. Allow access for Owner's personnel.
      b. Allow operation of ventilation and electrical systems.
      c. All other responsibilities as specified in the General Conditions.
   2. Owner's Responsibilities:
      a. Operate ventilating systems and pay cost of same.
      b. Assume responsibility of power requirements.
      c. Assume responsibility for security and fire protection in utilized areas, but not extending to Contractor's materials and equipment in utilized areas.
      d. Assume responsibility for property insurance of utilized areas.
   3. Other Conditions of Owner's Use: The correction period for the occupied or separately operated portion of Work shall commence at the date of Substantial Completion for that separate part.

1.9 PHYSICAL CONDITIONS

A. Exercise reasonable care to verify locations of existing subsurface facilities and utilities.

B. Areas immediate and adjacent to planned excavations shall be thoroughly checked by means of visual examination and with electronic metal and pipe detection equipment for indications of underground utilities and facilities.

C. Make exploratory excavation where existing underground facilities or utilities may potentially conflict with proposed excavations and facilities or where there is reasonable cause to verify the presence or absence of, or to obtain physical information regarding underground facilities or utilities. Conduct exploratory excavations as acceptable to and in the presence of Engineer prior to proceeding with major excavation in the area and sufficiently in advance of construction to avoid possible delays to Contractor's Work. Promptly take measurements, photographs, and obtain survey data.

1.10 CONSTRUCTION PHOTOGRAPHS

A. Photographically document all phases of the project including preconstruction, construction progress, and post-construction.

B. Engineer shall have the right to select the subject matter and vantage point from which photographs are to be taken.

C. Photograph Format: Reference Section 01 34 00 for photograph requirements.

D. Preconstruction and Post-Construction:
   1. After Effective Date of the Agreement and before Work at Site is started, and again upon issuance of Substantial Completion, take photographs of all areas of the Construction Site and property adjacent to perimeter of Construction Site.
   2. Particular emphasis shall be directed to structures both inside and outside the Site.

E. Construction Progress Photos:
   1. Photographically demonstrate progress of construction, showing every aspect of Site and adjacent properties as well as interior and exterior of new or impacted structures.
   2. Take photos as frequent as required to document all major aspects of construction. Coordinate with Engineer.

1.11 AUDIO-VIDEO RECORDINGS

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

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

C. Particular emphasis shall be directed to physical condition of existing vegetation, structures, and pavements within Construction Site and areas adjacent to and within the right-of-way or easement, and on Contractor storage and staging areas.

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

E. Video Format and Quality:
   1. Video:
      a. Produce bright, sharp, and clear images with accurate colors, free of distortion and other forms of picture imperfections. Make sure sound is clear and free of distortion.
      b. Electronically, and accurately display the month, day, year, and time of day of the recording.
   2. Audio:
      a. Audio documentation shall be done clearly, precisely, and at a moderate pace.
      b. Indicate date, project name, and a brief description of the location of taping, including:
         1). Facility name.
         2). Street names or easements.
         3). Addresses of private property.
         4). Direction of coverage, including engineering stationing, if applicable.
   3. Documentation:
      a. Electronic File Name:
         1). Date of coverage in year-month-day-time format followed by a short description of video coverage.
   4. Transmission of Files:
      a. Transmit electronic files via Info Exchange, or;
      b. Place electronic files on flash drive with enough storage size to hold all videos being transmitted and deliver to Engineer via acceptable method to Engineer.
   5. Project Video Log: Maintain an ongoing log that incorporates above noted information for videos on Project.
   6. Reference specification Section 01 34 00 for additional requirements.

1.12 REFERENCE POINTS AND SURVEYS

A. Location and elevation of benchmarks are shown on Drawings.

B. Dimensions for lines and elevations for grades of structures, appurtenances, and utilities are indicated on the Drawings, together with the other pertinent information required for laying out Work. If conditions vary from those indicated, immediately notify Engineer.

C. Any existing survey points or other control markers destroyed without proper authorization will be replaced by Owner of the survey points or control markers at the Contractor's expense.

D. Contractor's Responsibilities:
   1. Provide additional survey and layout required to layout the Work.
   2. Locate and protect reference points prior to stating site preparation.
   3. Check and establish exact location of existing facilities prior to construction of new facilities and any connections thereto.
   4. In event of discrepancy in data or staking provided by Owner, request clarification before proceeding with Work.
   5. Retain professional land surveyor or civil engineer registered in state of Project who shall perform or supervise engineering surveying necessary for additional construction staking and layout.
   6. Maintain complete accurate log of survey Work as it progresses as a Record Document.
   7. On request of Engineer, submit documentation.
   8. Provide competent employee(s), tools, stakes, and other equipment and materials as Engineer may require to:
      a. Establish control points, lines, and easement boundaries.
      b. Check layout, survey, and measurement Work performed by others.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CUTTING, FITTING, AND PATCHING

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

B. Obtain prior written authorization of Engineer and Owner before commencing work to cut or otherwise alter:
   1. Structural or reinforcing steel, structural column or beam, elevated slab, trusses, or other structural member.
   2. Weather- or moisture-resistant elements.
   3. Efficiency, maintenance, or safety of element.
   4. Work of others.

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

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

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

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

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

END OF SECTION

SECTION 01 31 19 - PROJECT MEETINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Requirements for conducting conferences and meetings for the purposes of addressing issues related to the Work, reviewing and coordinating progress of the Work and other matters of common interest, and includes the following:
   1. General Requirements.
   2. Qualifications of Meeting Participants.
   3. Preconstruction Conference.
   4. Progress Meetings.
   5. Pre-Installation Meetings.
   6. Post Construction Meeting.

1.2 GENERAL REQUIREMENTS

A. Contractor will schedule physical arrangements for meetings throughout progress of Work, prepare meeting agenda with regular participant input and distribute with written notice of each meeting, preside at meetings, record minutes to include significant proceedings and decisions, and reproduce and distribute copies of minutes within 5 days after each meeting to participants and parties affected by meeting decisions.

1.3 QUALIFICATIONS OF MEETING PARTICIPANTS

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

1.4 PRECONSTRUCTION CONFERENCE

A. Contractor shall be prepared to discuss the following subjects, as a minimum:
   1. Required schedules.
   2. Status of Bonds and insurance.
   3. Sequencing of critical path work items.
   4. Progress payment procedures.
   5. Project changes and clarification procedures.
   6. Use of site, access, office and storage areas, security and temporary facilities.
   7. Major product delivery and priorities.
   8. Contractor’s safety plan and representative.

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

C. Upon issuance of Notice to Proceed, or earlier when mutually agreeable, Engineer will arrange a preconstruction conference in a convenient place for most persons invited, in accordance with the General Conditions.

D. Attending Preconstruction Conference: Contractor’s superintendent, Owner, Engineer, representatives of utilities, major subcontractors and others involved in performance of the Work, and others necessary to agenda.

E. Engineer will preside at conference.

F. Purpose of conference: To establish working understanding between parties and to discuss Construction Schedule, shop drawing and other submittals, cost breakdown of major lump sum items, processing of submittals and applications for payment, and other subjects pertinent to execution of the Work.

G. Agenda will include:
   1. Adequacy of distribution of Contract Documents.
   2. Distribution and discussion of list of major subcontractors and suppliers.
   3. Proposed progress schedules and critical construction sequencing.
   4. Major equipment deliveries and priorities.
   5. Project coordination.
   6. Designation of responsible personnel.
   7. Procedures and processing of:
      a. Field decisions.
      b. Proposal requests.
      c. Submittals.
      d. Change Orders.
      e. Applications for Payment.
      f. Record Documents.
   8. Use of premises:
      a. Office, construction, and storage areas.
      b. Owner's requirements.
   9. Construction facilities, controls, and construction aids.
   10. Shoring requirements and submittal of Contractor’s geotechnical report.
   11. Temporary utilities.
   12. Safety and first aid procedures.
   13. Security procedures.
   14. Housekeeping procedures.

H. Engineer will record minutes of meeting and distribute copies of minutes within 5 days of meeting to participants and interested parties.

1.5 PROGRESS MEETINGS

A. Contractor will schedule regular progress meetings at site, conducted weekly, to review the Work progress, progress schedule, Shop Drawing and Sample submissions schedule, Application for Payment, contract modifications, and other matters needing discussion and resolution. At one meeting each month the Contractor’s updated narrative progress report and overall schedule will be a topic of discussion.

B. Attendees will include:
   1. Owner’s representative(s), as appropriate.
   2. Contractor, Subcontractors, and Suppliers, as appropriate.
   3. Engineer’s representative(s).
   4. Others as appropriate.

C. Contractor shall:
   1. Conduct progress meetings at least once every week in Contractor's field office, Engineer's field office, or other mutually agreed upon place.

2. Distribute to each anticipated participant written notice and agenda of each meeting at least 2 days before meeting.
3. Require attendance of Contractor's superintendent and subcontractors who are or are proximate to be actively involved in the Work, or who are necessary to agenda.
4. Invite Owner, Engineer, utility companies when the Work affects their interests, and others necessary to agenda.
5. Complete and bring Application for Payment and Progress Schedule to progress meeting.
6. Prepare and distribute agenda.

D. Engineer will preside at meetings.

E. Purpose of progress meetings:
1. To expedite work of subcontractors or other organizations that are not meeting scheduled progress, resolve conflicts, and coordinate and expedite execution of the Work.
2. Review progress of the Work, Progress Schedule, narrative report, Application for Payment, record documents, and additional items of current interest that are pertinent to execution of the Work.
3. Verify:
   a. Actual start and finish dates of completed activities since last progress meeting.
   b. Durations and progress of activities not completed.
   c. Reason, time, and cost data for Change Order Work that will be incorporated into Progress Schedule and application for payment.
   d. Percentage completion of items on Application for Payment.
   e. Reasons for required revisions to Progress Schedule and their effect on Contract Time and Contract Price.

F. Discuss potential problems that may impede scheduled progress and corrective measures.

G. Contractor will record minutes of meeting and distribute copies of minutes within 7 days of meeting to participants and interested parties.

1.6 QUALITY CONTROL AND COORDINATION MEETINGS

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

B. Attendees will include:
1. Contractor.
2. Contractor’s designated quality control representative.
3. Subcontractors and Suppliers, as necessary.
4. Engineer’s representatives.

1.7 PRE-INSTALLATION MEETINGS

A. General: Scheduled by Contractor on regular basis and as necessary to coordinate with manufacturers and installers. Meet with manufacturers and installers of major units of construction that require coordination between subcontractors. Major units of construction which require pre-installation meetings include:
1. Specification Section 44 31 31 - Odor Control Biotrickling Filter Equipment.

B. Contractor shall:
1. Distribute to each anticipated participant written notice and agenda of each meeting at least 4 days before meeting.
2. Schedule meeting at least 7 days in advance of installation.

3. Conduct meetings in Contractor's field office or other mutually agreed upon place.
4. Require attendance of Superintendent, appropriate manufacturers and installers of major units of constructions, and affected subcontractors.
5. Invite Owner and Engineer.
6. Preside at meetings.
7. Record minutes of meeting and distribute copies of minutes within 3 days of meeting to participants and interested parties.

1.8 FACILITY STARTUP MEETINGS

A. Schedule and attend a minimum of 5 facility startup meetings. The first of such meetings shall be held prior to submitting the Facility Startup Plan, as specified in Section 01 79 00, DEMONSTRATION AND TRAINING, and shall include preliminary discussions regarding such plan.

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

C. Attendees will include:
1. Contractor.
2. Contractor’s designated quality control representative.
3. Subcontractors and equipment Manufacturer’s representatives whom Contractor deems to be directly involved in facility startup.
4. Engineer’s representatives.
5. Owner’s operations personnel.
6. Others as required by Contract Documents or as deemed necessary by Contractor.

1.9 POST CONSTRUCTION MEETING

A. Meet with and inspect the Work at 11 months after date of Substantial Completion with Owner and Engineer.

B. Arrange meeting at least 7 days before meeting.

C. Meet in Owner’s office or other mutually agreed upon place.

D. Inspect the Work and draft list of items to be completed or corrected.

E. Review service and maintenance contracts, and take appropriate corrective action when necessary.

F. Complete or correct defective work and extend correction period accordingly.

G. Require attendance of Superintendent, appropriate manufacturers and installers of major units of constructions, and affected subcontractors.

1.10 OTHER MEETINGS

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 32 00 – CONSTRUCTION PROGRESS DOCUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Preparation, submittal, and maintenance of computerized progress schedule and reports, contract time adjustments, and payment requests, including the following:
   1. Preliminary Schedule.
   2. Detailed Progress Schedule.
   3. Schedule Updates.
   4. Schedule Revisions.

1.2 SUBMITTALS

A. Informational Submittals:
   1. Preliminary Progress Schedule: Submit at least 7 days prior to preconstruction conference.
   2. Detailed Progress Schedule:
      a. Submit initial Detailed Progress Schedule within 45 days after Effective Date of the Agreement.
      b. Submit an Updated Progress Schedule at each update, in accordance with Article Detailed Progress Schedule.
   3. Submit with Each Progress Schedule Submission:
      a. Contractor's certification that Progress Schedule submission is actual schedule being utilized for execution of the Work.
      b. Electronic files compatible with latest version of the Contractor's selected software, or compatible with Microsoft Project, or compatible with Microsoft Excel.
      c. Progress Schedule: Legible copies.
      d. Narrative Progress Report: Same number of copies as specified for Progress Schedule.
   4. Prior to final payment, submit a final Updated Progress Schedule.

1.3 PRELIMINARY PROGRESS SCHEDULE

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

B. Show activities including, but not limited to the following:
   1. Notice to Proceed.
   2. Permits.
   3. Submittals, with review time. Contractor may use Schedule of Submittals specified in Section 01 33 00, SUBMITTAL PROCEDURES.
   4. Early procurement activities for long lead equipment and materials.
   5. Initial Site work.
   6. Earthwork.
   7. Specified Work sequences and construction constraints.
   8. Contract Milestone and Completion Dates.
   9. Owner-furnished products delivery dates or ranges of dates.
   10. Major structural, mechanical, equipment, electrical, architectural, and instrumentation and control Work.
   11. System startup summary.
   12. Project close-out summary.
   13. Demobilization summary.

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

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

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

1.4 DETAILED PROGRESS SCHEDULE

A. General: Comprehensive computer-generated schedule using a “Critical Path Method” (CPM), generally as outlined in Associated General Contractors of America (AGC) 580, “Construction Project Planning and Scheduling Guidelines.” If a conflict occurs between the AGC publication and this Specification, this Specification shall govern. Adjust or confirm schedules in accordance with General Conditions on a monthly basis and submit to Engineer.

B. Contents:
1. Schedule shall begin with the date of Notice to Proceed and conclude with the date of Final Completion.
2. Identify Work calendar basis using days as a unit of measure.
3. Show complete interdependence and sequence of construction and Project-related activities reasonably required to complete the Work.
4. Identify the Work of separate stages and other logically grouped activities, and clearly identify critical path of activities.
5. Reflect sequences of the Work, restraints, delivery windows, review times, Contract Times and Project Milestones set forth in the Agreement and Section 01 31 00, PROJECT MANAGEMENT AND COORDINATION.
6. Include as applicable, at a minimum:
    a. Obtaining permits, submittals for early product procurement, and long lead time items.
    b. Mobilization and other preliminary activities.
    c. Initial Site work.
    d. Specified Work sequences, constraints, and Milestones, including
    e. Substantial Completion date(s) Subcontract Work.
    f. Major equipment design, fabrication, factory testing, and delivery dates.
    g. Delivery dates for Owner-furnished products, as specified in Section 01 11 00, SUMMARY OF WORK.
    h. Site work.
    i. Concrete Work.
    j. Structural steel Work.
    k. Architectural features Work.
    l. Conveying systems Work.
    m. Equipment Work.
    n. Mechanical Work.
    o. Electrical Work.
    p. Instrumentation and control Work.
    q. Interfaces with Owner-furnished equipment.
    r. Other important Work for each major facility.
    s. Equipment and system startup and test activities.
    t. Project closeout and cleanup.
    u. Demobilization.
7. No activity duration exclusive of those for Submittals review and product fabrication/delivery, shall be less than 1 day and not more than 14 days, unless otherwise approved.
8. Activity duration for Submittal review shall not be less than review time specified unless clearly identified and prior written acceptance has been obtained from Engineer.

9. If Contractor provides an accepted schedule with an early completion date, Owner reserves the right to reduce Contract Times to match the early completion date by issuing a deductive Change Order at no change in Contract Price.

C. Network Graphical Display:
   1. Plot or print on paper not greater than 30" x 42" or smaller than 22" x 34", unless otherwise approved.
   2. Title Block: Show name of Project, Owner, date submitted, revision or update number, and the name of the scheduler. Updated schedules shall indicate data date.
   3. Identify horizontally across top of schedule the time frame by year, month, and day.
   4. Identify each activity with a unique number and a brief description of the Work associated with that activity.
   5. Indicate the critical path.
   6. Show, at a minimum, the controlling relationships between activities.
   7. Plot activities on a time-scaled basis, with the length of each activity proportional to the current estimate of the duration.
   8. Plot activities on an early start basis unless otherwise requested by Engineer.
   9. Provide a legend to describe standard and special symbols used.

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

E. Cost -Loading:
   1. Note the estimated cost to perform each Work activity, with the exception of Submittals or Submittal reviews, in the network in a tabular listing.
   2. The sum of all activity costs shall equal the Contract Price. An unbalanced or front-end-loaded schedule will not be acceptable.
   3. The accepted cost-loaded Progress Schedule shall constitute the Schedule of Values specified in Section 01 29 00, PAYMENT PROCEDURES.

1.5 PROGRESS OF THE WORK

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

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

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

D. Owner may order Contractor to increase plant, equipment, labor force or working hours if Contractor fails to:
   1. Complete an activity by its completion date.
   2. Satisfactorily execute Work as necessary to prevent delay to overall completion of Project, at no additional cost to Owner.

1.6 SCHEDULE ACCEPTANCE

A. Engineer's acceptance will demonstrate agreement that:
   1. Proposed schedule is accepted with respect to:
      a. Contract Times, including Final Completion are within the specified times.
      b. Specified Work sequences and constraints are shown as specified.
      c. Access restrictions are accurately reflected.
      d. Startup and testing times are as specified.
      e. Submittal review times are as specified.
      f. Startup testing duration is as specified and timing is acceptable.

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

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

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

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

1.7 ADJUSTMENT OF CONTRACT TIMES

A. Reference the General Conditions and Section 01 26 00, CONTRACT MODIFICATION PROCEDURES.

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

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

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 32 90 – SAFETY PLAN

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 REFERENCES

A. OSHA.

1.3 CONSTRUCTION SAFETY PLAN

A. Detail the Methods and Procedures to comply with Federal, and Local Health and Safety Laws, Rules and Requirements for the duration of the Contract Times. Include the following:
   1. Identification of the Certified or Licensed Safety Consultant, who will prepare, initiate, maintain and supervise safety programs, and procedures.
   2. Procedures for providing workers with an awareness of safety and health hazards expected to be encountered in the course of construction.
   3. Safety equipment appropriate to the safety and health hazards expected to be encountered during construction. Include warning devices, barricades, safety equipment in public right-of-way and protected areas, and safety equipment used in multi-level structures.
   4. Methods for minimizing employees' exposure to safety and health hazards expected during construction.
   5. Procedures for reporting safety or health hazards.
   6. Procedures to follow to correct a recognized safety and health hazard.
   7. Procedures for investigation of accidents, injuries, illnesses and unusual events that have occurred at the construction site.
   8. Periodic and scheduled inspections of general work areas and specific work stations.
   9. Training for employees and workers at the jobsite.
   10. Methods of communication of safe working conditions, work practices and required personal protection equipment.

B. Assume responsibility for every aspect of Health and Safety on the jobsite, including the health and safety of subcontractors, suppliers, and other persons on the jobsite:
   1. Forward available information and reports to the Safety Consultant who shall make the necessary recommendations concerning worker health and safety at the jobsite.
   2. Employ additional health and safety measures specified by the Safety Consultant, as necessary, for workers in accordance with OSHA guidelines.

C. Transmit to OWNER and ENGINEER copies of reports and other documents related to accidents or injuries encountered during construction.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 33 00 – SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes description and requirements of:
   1. Submittals Related to Project Submittals as related to:
      a. Action Submittals
      b. Informational Submittals

B. Related sections:
   1. 01 29 00 – Payment Procedures.
   2. 01 31 00 – Project Management and Coordination.
   3. 01 32 00 – Construction Progress Documentation.
   4. 01 77 00 – Closeout Procedures.
   5. 01 78 23 – Operation and Maintenance Data.
   6. 01 79 00 – Demonstration and Training.

1.2 DEFINITIONS

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

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

1.3 PROCEDURES

A. Direct Submittals to Engineer.

B. Contractor will submit all submittals electronically using the ***Info Exchange*** project website to facilitate the transfer of submittals and related files.

C. Transmittal of Submittal:
   1. Contractor shall:
      a. Review each submittal and check for compliance with Contract Documents.
      b. Stamp each submittal with uniform approval stamp before submitting to Engineer.
         1). Stamp to include Project name, submittal number, Specification number, Contractor's reviewer name, date of Contractor's approval and statement certifying that submittal has been reviewed, checked, and approved for compliance with Contract Documents.
         2). Engineer will not review submittals that do not bear Contractor's approval stamp and will return them without action.
   2. Complete, sign, and transmit with each submittal package, one Transmittal of Contractor's Submittal form. A blank Transmittal of Contractor's Submittal form may be provided by Engineer.
   3. Identify Each Submittal with the Following:
      a. Numbering and Tracking System:
         1) Submittal No. 8300-001, etc.
      b. Sequentially number each submittal.
      c. Resubmission of submittal shall have original number with sequential alphabetic suffix (ie: Resubmittal No. 8300-001-A).
         1). Specification section and paragraph to which submittal applies.
         2). Project title and Engineer's project number.

3). Date of transmittal.
4). Names of Contractor, subcontractor or Supplier and Manufacturer as appropriate.

4. Identify and describe each deviation or variation from Contract Documents.

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

E. Timeliness: Schedule and submit in accordance Schedule of Submittals, and requirements of individual Specification sections.

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

G. Re-submittals: Clearly identify each correction or change made.

H. Incomplete Submittals:
1. Engineer will return entire submittal for Contractor's revision if preliminary review deems it incomplete.
2. When any of the following are missing, submittal will be deemed incomplete:
a. Contractor's review stamp completed and signed.
b. Transmittal of Contractor's Submittal completed and signed.
3. Submittals not required by Contract Documents will not be reviewed and will be returned stamped "Not Reviewed."
4. Engineer will keep one electronic copy and return one electronic copy to Contractor.

I. Coordination with Project:
1. It is the Contractor's responsibility to coordinate all equipment furnished with project elevations and dimensions. Approval of the submittal does not relieve the Contractor of the responsibility.
2. Contractor shall be responsible for coordinating all project aspects and project changes with all submittals.

1.4 ACTION SUBMITTALS

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

B. Contractor will submit all submittals electronically using the ***Info Exchange*** project website to facilitate the transfer of submittals and related files.

C. Shop Drawings:
1. Identify and Indicate:

a. Applicable Contract Drawing and Detail number, products, units and assemblies, and system or equipment identification or tag numbers.
b. Equipment and Component Title: Identical to title shown on Drawings.
c. Critical field dimensions and relationships to other critical features of Work. Note dimensions established by field measurement.
d. Project-specific information drawn accurately to scale.

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

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

E. Action Submittal Dispositions: Engineer will review, mark, and stamp as appropriate, and distribute marked-up copies as noted:
1. Furnish as Submitted:
   a. Contractor may incorporate product(s) or implement Work covered by submittal.
   b. Distribution
      1). One electronic copy furnished to Resident Project Representative.
      2). One electronic copy retained in Engineer's file.
      3). One electronic copy returned to Contractor appropriately annotated.
2. Furnish as Corrected or Noted:
   a. Contractor may incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
   b. Distribution:
      1). One electronic copy furnished to Resident Project Representative.
      2). One electronic copy retained in Engineer's file.
      3). One electronic copy to Contractor appropriately annotated.
3. Revise and Resubmit:
   a. Make corrections or obtain missing portions, and resubmit.
   b. Except for portions indicated, Contractor may begin to incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
   c. Distribution:
      1). One electronic copy furnished to Resident Project Representative.
      2). One electronic copy retained in Engineer's file.
      3). One electronic copy to Contractor appropriately annotated.
4. Rejected:

a. Contractor may not incorporate product(s) or implement Work covered by submittal.
b. Distribution:
1). One electronic copy furnished to Resident Project Representative.
2). One electronic copy retained in Engineer's file.
3). One electronic copy returned to Contractor appropriately annotated.

1.5 INFORMATIONAL SUBMITTALS

A. General:
1. Contractor will submit all submittals electronically using the ***Info Exchange*** project website to facilitate the transfer of submittals and related files.
2. Refer to individual Specification sections for specific submittal requirements.
3. Engineer will review each submittal. If submittal meets conditions of the Contract, Engineer will forward electronic copies to appropriate parties. If Engineer determines submittal does not meet conditions of the Contract and is therefore considered unacceptable, Engineer will retain one electronic copy and return one electronic copy with review comments to Contractor, and require that submittal be corrected and resubmitted.
4. Application for Payment: In accordance with Section 01 29 00, PAYMENT PROCEDURES.
5. Certificates:
a. General:
1). Provide notarized statement that includes signature of entity responsible for preparing certification.
2). Signed by officer or other individual authorized to sign documents on behalf of that entity.
6. Welding: In accordance with individual Specification sections.
7. Installer: Prepare written statements on Manufacturer's letterhead certifying that installer complies with requirements as specified in individual Specification sections.
8. Material Test: Prepared by qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements.
9. Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in individual Specification sections.
10. Manufacturer's Certificate of Compliance: In accordance with Section 01 79 00, DEMONSTRATION AND TRAINING.
11. Manufacturer's Certificate of Proper Installation: In accordance with Section 01 79 00, DEMONSTRATION AND TRAINING.

B. Construction Photographs and Video: In accordance with Section 01 31 00, PROJECT MANAGEMENT AND COORDINATION, and as may otherwise be required in Contract Documents.

C. Contract Closeout Submittals: In accordance with Section 01 77 00, CLOSEOUT PROCEDURES.

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

E. Manufacturer's Instructions: Written or published information that documents Manufacturer's recommendations, guidelines, and procedures in accordance with individual Specification sections.

F. Operation and Maintenance Data: As required in Section 01 78 23, OPERATION AND MAINTENANCE DATA.

G. Schedules:
   1. Schedule of Submittals: Prepare separately or in combination with Progress Schedule as specified in Section 01 32 00, CONSTRUCTION PROGRESS DOCUMENTATION.
      a. Show for Each, at a Minimum, the Following:
         1). Specification section number.
         2). Identification by numbering and tracking system as specified under Paragraph "Transmittal of Submittal".
         3). Estimated date of submission to Engineer, including reviewing and processing time.
      b. On a monthly basis, submit updated schedule to Engineer if changes have occurred or re-submittals are required.
   2. Schedule of Values: In accordance with Section 01 29 00, PAYMENT PROCEDURES.
   3. Schedule of Estimated Progress Payments: In accordance with Section 01 32 00, CONSTRUCTION PROGRESS DOCUMENTATION.
   4. Progress Schedules: In accordance with Section 01 32 00, CONSTRUCTION PROGRESS DOCUMENTATION.

H. Special Guarantee: Supplier's written guarantee as required in individual Specification sections.

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

J. Submittals Required by Laws, Regulations, and Governing Agencies:
   1. Submit promptly notifications, reports, certifications, payrolls, and otherwise as may be required, directly to the applicable Federal, State, or local governing agency or their representative.
   2. Transmit to Engineer for Owner's records one electronic copy of correspondence and transmittals (to include enclosures and attachments) between Contractor and governing agency.

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

e. Type and location of test, Sample, or inspection, including referenced standard or code.
f. Date issued, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
g. If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
h. Provide interpretation of test results, when requested by Engineer.
i. Other items as identified in individual Specification sections.

4. Testing and Startup Data: In accordance with Section 01 79 00, DEMONSTRATION AND TRAINING.
5. Training Data: In accordance with Section 01 79 00, DEMONSTRATION AND TRAINING.

1.6 FINAL SUBMITTALS

A. Submit final copy of all submitted information to OWNER as component of Final Close Out. Prepare final data in electronic media format.

B. Organizational Format:
1. Identify electronic files with title “FINAL PROJECT SUBMITTALS” and list each submittal with the following information on each file’s cover sheet:
a. Project title.
b. Designate applicable system, equipment, material, or finish.
c. Identity of separate structure as applicable.
d. Identity of general subject matter covered in manual.
e. Identity of equipment number and Specification section.
2. Provide Title Page file with the following:
a. Contractor name, address, and telephone number.
b. Subcontractor, Supplier, installer, or maintenance contractor’s name, address, and telephone number, as appropriate.
1) Identify area of responsibility of each.
2) Provide name and telephone number of local source of supply for parts and replacement.
3. Provide electronic searchable Table of Contents for all files:
a. Arranged in systematic order with consecutive page numbers.
b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
4. Text: Manufacturer’s printed data, or neatly identified
5. Material shall be suitable for reproduction, with quality equal to original.
6. All drawings and oversized figures shall be presented electronically in 11x 17 format.

C. Electronic Media Format:
1. Portable Document Format (PDF):
a. After all preliminary data has been found to be acceptable to Engineer, submit Operation and Maintenance data in PDF format on CD.
b. Files to be exact duplicates of Engineer-accepted preliminary data. Arrange by specification number and name.
c. Files to be fully functional, fully viewable and fully searchable in most recent version of Adobe Acrobat.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 34 00 – PHOTOGRAPHIC AND VIDEOGRAPHIC DOCUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes Requirements for:
   1. Pre-construction photographs.
   2. Pre-construction videos.
   3. Post-construction photographs.
   4. Post-construction videos.

B. The purpose of the photographs and videos is to document the condition of the facilities prior to the CONTRACTOR beginning work at the Project site and after Substantial Completion of the Work.

C. Areas to be photographed and videoed shall include the site of the Work and all existing facilities either on or adjoining the Project site, including the interior of existing structures, that could be damaged as a result of the CONTRACTOR's Work.

D. The scope of the photographic and videographic documentation shall be the sole responsibility of the CONTRACTOR, but shall be acceptable to the ENGINEER.

E. Related sections:
   1. Section 01 31 00 – Project Management and Coordination
   2. Section 01 31 19 – Project Meetings.
   3. Section 01 33 00 – Submittal Procedures.
   4. Section 01 77 00 – Closeout Procedures.

1.2 SUBMITTALS

A. Key Plan: Submit key plan of Project site with notation of vantage points marked for location and direction of each photograph. Include the same label information as the corresponding set of photographs.

B. Photographs:
   1. Digital Media:
      a. Provide photos as individual, indexed JPG files with the following characteristics:
         1) Compression shall be set to preserve quality over file size.
         2) Highest resolution JPG images shall be submitted. Resizing to a smaller size when high resolution JPGs are available shall not be permitted.
         3) JPG image resolution shall be 4000 by 3000 or higher.
         4) Images shall have rectangular clean images. Artistic borders, beveling, drop shadows, etc. are not permitted.

C. Videos:
   1. Submit 4 copies of each video within 7 days of recording.
   2. Videos shall be submitted in a digital color video format on a DVD suitable for playback on a standard DVD player.
   3. Identification: On each copy provide a label with the following information:
      a. Name of project.
      b. Date video was recorded.

D. Pre-Construction Photographs and Videos: Submit prior to beginning work at the Project site or prior to the Preconstruction Conference specified in Section 01 31 19, whichever occurs earlier. Reference Section 01 31 00 for additional requirements.

E. Post-Construction Photographs and Videos: Submit with project closeout documents as specified in Section 01 77 00. Reference Section 01 31 00 for additional requirements.

PART 2 - PRODUCTS

2.1 MEDIA

A. Paper Media:
   1. Commercial grade, glossy surface, acid-free photographic paper.

B. Digital Media:
   1. One hundred and twenty millimeters, 700-MB, 80-minute CD compatible with latest version of Microsoft Windows.

C. Videos:
   1. One hundred and twenty millimeters, DVD compatible with standard DVD players.

PART 3 - EXECUTION

3.1 GENERAL

A. Photographs (Paper and Digital Media):
   1. Date Stamp: Unless otherwise indicated, date and time stamp each photograph as it is being taken so stamp is integral to photograph.

B. Videos:
   1. Display continuous running time.
   2. At start of each video recording, record weather conditions from local newspaper or television and the actual temperature reading at Project Site.

END OF SECTION

SECTION 01 35 00 – SPECIAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Special procedures for locating and verifying concealed existing facilities.

1.2 CONCEALED EXISTING FACILITIES

A. Verify locations of utilities and facilities which may exist by consulting with the OWNER, utility companies, and Colorado One-Call System (phone number 303-232-1991, website: https://www.colorado811.org/) or other service available in area of Project (see dig/call information on the Drawings):
   1. Abide by easement and right-of-way restrictions.

B. Notify the OWNER, owners of facilities when the Work will be in progress. Make arrangements for potential emergency repairs in accordance with requirements of owners of utility facilities, including individual or residential facilities.

C. Assume responsibility for repair of facilities damaged by performance of the Work.

D. Expose sanitary and storm sewers, water, gas, electric, telephone utility lines, and other underground facilities indicated to permit survey location prior to commencement of Work in affected area:
   1. Expose in ample time to permit relocation of interfering utilities with minimum delaying effect on contract time.

E. Work required for raising, lowering, or relocating utilities not indicated will be performed by affected utility owners or as part of the Work at option of affected owners of utilities:
   1. When part of the Work, perform work in accordance with standards of affected utility owner, and adjustment to Contract Price and Contract Times will be made as stipulated in conditions of contract.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 41 00 – REGULATORY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Regulatory requirements:
   1. Building code.
   2. Electrical code.
   3. Energy code.
   4. Fire code.
   5. Mechanical code.
   6. Plumbing code.

1.2 REFERENCES

A. International Code Council (ICC):
   1. International Building Code (IBC), 2018.
   2. International Existing Building Code (IEBC), 2018.
   3. International Energy Conservation Code (IECC), 2018.
   4. International Fire Code (IFC), 2018.
   5. International Mechanical Code (IMC), 2018.
   6. International Plumbing Code (IPC), 2018.

B. National Fire Protection Association (NFPA):
   1. NFPA 70: National Electrical Code, 2017.

C. National Electric Code Council:
   1. National Electric Code (NEC), NFPA 70, 2017

1.3 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Building code:
      a. International Building Code.
   2. Electrical code:
      a. NFPA 70: National Electric Code.
   3. Energy conservation code:
      a. International Energy Conservation Code.
   4. Fire code:
      a. International Fire Prevention Code.
   5. Mechanical codes:
      a. International Mechanical Code.
   6. Plumbing code:
      a. International Plumbing Code.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 42 00 - REFERENCES

PART 1 - GENERAL

1.1 REFERENCE TO STANDARDS AND SPECIFICATIONS OF TECHNICAL SOCIETIES

A. Reference to standards and specifications of technical societies and reporting and resolving discrepancies associated therewith shall be as provided in the General Conditions, and as may otherwise be required herein and in the individual Specification sections.

B. Work specified by reference to published standard or specification of government agency, technical association or trade association, professional society or institute, testing agency, or other organization shall meet requirements or surpass minimum standards of quality for materials and workmanship established by designated standard or specification.

C. Where so specified, products or workmanship shall also meet or exceed additional prescriptive or performance requirements included within Contract Documents to establish a higher or more stringent standard of quality than required by referenced standard.

D. Where two or more standards are specified to establish quality, product and workmanship shall meet or exceed requirements of most stringent.

E. Where both a standard and a brand name are specified for a product in Contract Documents, proprietary product named shall meet or exceed requirements of specified reference standard.

F. Copies of Standards and Specifications of Technical Societies:
   1. Copies of applicable referenced standards have not been bound in these Contract Documents.
   2. Where copies of standards are needed by Contractor, obtain a copy or copies directly from publication source and maintain in an orderly manner at the Site as Work Site records, available to Contractor's personnel, Subcontractors, Owner, and Engineer.

1.2 ABBREVIATIONS

A. Abbreviations for trade organizations and government agencies: Following is a list of construction industry organizations and government agencies to which references may be made in the Contract Documents, with abbreviations used.

1.	AA	Aluminum Association
2.	AABC	Associated Air Balance Council
3.	AAMA	American Architectural Manufacturers Association
4.	AASHTO	American Association of State Highway and Transportation Officials
5.	ABMA	American Bearing Manufacturers' Association
6.	ACI	American Concrete Institute
7.	AEIC	Association of Edison Illuminating Companies
8.	AGA	American Gas Association
9.	AGMA	American Gear Manufacturers' Association
10.	AI	Asphalt Institute
11.	AISC	American Institute of Steel Construction
12.	AISI	American Iron and Steel Institute
13.	AITC	American Institute of Timber Construction
14.	ALS	American Lumber Standards
15.	AMCA	Air Movement and Control Association
16.	ANSI	American National Standards Institute
17.	APA	The Engineered Wood Association
18.	API	American Petroleum Institute

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

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 42 40 – ABBREVIATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Abbreviations and meanings.

1.2 INTERPRETATIONS

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

1.3 ABBREVIATIONS

A. Abbreviations Used to Identify Reference Standards:

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

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

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

B. B. Abbreviations Used in Specifications:

1.	a	year or years (metric unit)
2.	A	ampere or amperes
3.	am	ante meridian (before noon)
4.	ac	alternating current
5.	ac-ft	acre-foot or acre-feet
6.	atm	atmosphere
7.	AWG	American Wire Gauge
8.	bbl	barrel or barrels
9.	bd	board
10.	bhp	brake horsepower
11.	bil gal	billion gallons
12.	BOD	biochemical oxygen demand
13.	Btu	British thermal unit or units
14.	Btuh	British thermal units per hour
15.	bu	bushel or bushels
16.	C	degrees Celsius
17.	cal	calorie or calories
18.	cap	capita
19.	cd	candela or candelas
20.	cfm	cubic feet per minute
21.	Ci	curie or curies
22.	cm	centimeter or centimeters
23.	cmu	concrete masonry unit
24.	CO	carbon monoxide
25.	Co.	Company
26.	CO2	carbon dioxide
27.	COD	chemical oxygen demand
28.	Corp.	Corporation
29.	counts/min	counts per minute
30.	cu	cubic
31.	cu cm	cubic centimeter or centimeters
32.	cu ft	cubic foot or feet
33.	cu ft/day	cubic feet per day
34.	cu ft/hr	cubic feet per hour
35.	cu ft/min	cubic feet per minute
36.	cu ft/sec	cubic feet per second
37.	cu in	cubic inch or inches
38.	cu m	cubic meter or meters
39.	cu yd	cubic yard or yards
40.	d	day (metric units)
41.	day	day (English units)

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

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

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

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

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 45 00 – QUALITY CONTROL

PART 1 - GENERAL

1.1 SUMMARY

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

B. Related sections:
   1. Section 01 45 24 - Special Tests and Inspections.

1.2 QUALITY CONTROL AND CONTROL OF INSTALLATION

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

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

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

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

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

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

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

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

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

1.3 TOLERANCES

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

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

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

1.4 REFERENCES

A. American Society for Testing and Materials (ASTM): E 329 - Standard for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.

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

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

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

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

1.5 MOCK-UP REQUIREMENTS

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

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

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

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

1.6 AUTHORITY AND DUTIES OF OWNER'S REPRESENTATIVE OR INSPECTOR

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

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

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

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

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

1.7 SAMPLING AND TESTING

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

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

C. Testing:
   1. Owner will employ and pay for services of independent testing laboratory to perform routine tests of materials to confirm compliance with requirements of Contract Documents:
      a. Mill tests, soil compaction test, and other specified tests shall be paid for by Contractor.

   2. When protesting failed tests of material in place or to be used, take additional specimens and have specimens tested:
      a. When original test proves to have been in error, file claim for reimbursement of direct costs for sampling and testing.

D. Test standards:
   1. Perform sampling, specimen preparation, and testing of materials in accordance with specified standards, and when no standard is specified, in accordance with standard of nationally recognized technical organization.
   2. Physical characteristics of materials not particularly specified shall conform to standards published by ASTM, where applicable.
   3. Standards and publication references in Contract Documents shall be edition or revision in effect on date stipulated in the Contract Documents.

1.8 TESTING AND INSPECTION SERVICES

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

B. Owner will employ and pay for specified services of an "Owner's independent testing firm" to perform testing and inspection as required in the technical specifications for various work and

materials or stipulated in Section 01 45 24 to confirm Contractor's compliance with Contract Documents. If Engineer or Owner's independent testing firm is not properly certified to perform specialty inspections required by the building department, Owner will employ and pay for a quality specialty inspection firm to perform required testing and inspection.

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

D. The qualifications of laboratory that will perform the testing, contracted by the Owner or by the Contractor, shall be as follows:
   1. Has authorization to operate in the state where the project is located.
   2. Meets "Recommended Requirements for Independent Laboratory Qualification," published by American Council of Independent Laboratories.
   3. Meets requirements of ASTM E 329.
   4. Laboratory Staff: Maintain full time specialist on staff to review services.
   5. Testing Equipment: Calibrated at reasonable intervals with devices of accuracy traceable to National Bureau of Standards (NBS) or accepted values of natural physical constants.
   6. Will submit copy of report of inspection of facilities made by Materials Reference Laboratory of NBS during most recent tour of inspection, with memorandum of remedies of deficiencies reported by inspection.

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

F. Reports will be submitted by Contractor's independent testing firm and by Owner's independent testing firm to Engineer, Contractor, and Owner in triplicate, indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents. Each report shall include:
   1. Date issued.
   2. Project title and number.
   3. Testing laboratory name, address, and telephone number.
   4. Name and signature of laboratory inspector.
   5. Date and time of sampling or inspection.
   6. Record of temperature and weather conditions.
   7. Date of test.
   8. Identification of product and specification section.
   9. Location of sample or test in Project.
   10. Type of inspection or test.
   11. Results of tests and compliance with Contract Documents.
   12. Interpretation of test results, when requested by Engineer.

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

H. Limitations of authority of testing Laboratory: Owner's independent testing firm or Laboratory is not authorized to:
   1. Agency or laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.
   2. Agency or laboratory may not approve or accept any portion of the Work.
   3. Agency or laboratory may not assume duties of Contractor.

4. Agency or laboratory has no authority to stop the Work.

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

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

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

L. Owner's independent testing firm individual test reports: After each test, Owner's independent testing firm will promptly submit electronically and three hard copies of report to Engineer and to Contractor. When requested by Engineer, the Owner's independent testing firm will provide interpretation of test results. Include the following:
1. Date issued.
2. Project title and number.
3. Name of inspector.
4. Date and time of sampling or inspection.
5. Identification of product and specifications section.
6. Location in Project.
7. Type of inspection or test.
8. Date of test.
9. Certified test results stamped and signed by a registered Engineer in the state that the project is located.
10. Summary of conformance with Contract Documents.

M. Owner's independent testing firm will provide monthly report of certification to identify all work performed for special inspections and other contract requirements on this project. The following certified monthly report at a minimum will include but not limited to:
1. Results of testing.
2. Testing logs.
3. Outstanding deficiencies.
4. Various statistical data.
5. Testing curves (up to 4 types) as required by the Engineer.

1.9 CONTRACTOR'S RESPONSIBILITIES

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

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

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

D. Furnish electronically and 5 hard copies of product test reports.

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

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 45 24 – SPECIAL TESTS AND INSPECTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: This Section describes the requirements for providing special tests and inspections.

B. Related sections:
   1. Section 01 45 00 - Quality Control.

1.2 REFERENCES

A. ASTM International (ASTM):
   1. ASTM C140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   2. ASTM C270, Standard Specification for Mortar for Unit Masonry.
   3. ASTM C780, Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry.
   4. ASTM C1019, Standard Test Method for Sampling and Testing Grout.
   5. ASTM C1314, Standard Test Method for Compressive Strength of Masonry Prisms.

B. International Building Code (IBC).

1.3 DESCRIPTION

A. This Section describes special tests and inspections of structural assemblies and components to be performed in compliance with IBC.

B. These special tests and inspections are in addition to the requirements specified in Section 01 45 00, and by the individual Sections.

C. The OWNER will employ one or more inspectors who will provide special inspections during construction.

1.4 INSPECTION

A. Duties of Special Inspector:
   1. General: Required duties of the Special Inspector are described in IBC.

1.5 TESTS

A. Selection of the material required to be tested shall be by the OWNER's Testing Laboratory and not the CONTRACTOR.

1.6 SPECIAL TESTING AND INSPECTIONS

A. Testing laboratory: Special tests will be performed by the OWNER's testing laboratory as specified in Section 01 45 00.

B. OWNER reserves the right to positive material identification tests.
   1. Contractor must make materials available for testing.

C. The following types of work require special inspection as described in IBC. Refer to the following verification, testing and inspection schedules.
   1. Appendix A, Cast-In-Place Concrete Special Inspection Schedule.
   2. Appendix B, Essential Architectural, Mechanical and Electrical Inspection Schedule.
   3. Appendix C, Essential Masonry Special Inspection Schedule.
   4. Appendix D, Soils Verification And Inspection Schedule.
   5. Appendix E, Structural Steel Special Inspection Schedule.
   6. Appendix F. Other Special Inspection.

1.7 OTHER SPECIFIC TESTS

A. Masonry shall be tested in accordance with IBC.
   1. Minimum strength of units shall be tested in accordance with ASTM C140.
   2. Minimum strength of grout shall be tested in accordance with ASTM C1019.
   3. Prior to construction, obtain samples of the aggregates, additives, and water; mix and test in laboratory in accordance with ASTM C270.
   4. During construction, sample and test masonry for consistency prior to use on each structure in accordance with ASTM C780.
   5. When approved by the building official, if installed masonry does not meet requirements, conduct prism tests in accordance with ASTM C1314.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SCHEDULE

A. The CONTRACTOR shall allow time necessary for Special Inspections as listed above.

B. Sufficient notice shall be given so that the Special Inspections can be performed. This includes time for off-site Special Inspectors to plan the inspection and travel to site.

3.2 PROCEDURE

A. The Special Inspector will immediately notify the ENGINEER of any corrections required and follow notification with appropriate documentation.

B. The CONTRACTOR shall not proceed until the work is satisfactory to the ENGINEER.

END OF SECTION

APPENDIX A
CAST-IN-PLACE CONCRETE SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection	
		Continuous During Task Listed	Periodic During Task Listed
1. Inspection of reinforcing steel, including pre-stressing tendons, and placement.		–	X
2. Inspection of reinforcing steel welding.	IBC Table 1704.3, Item 5B	X	–
3. Inspect bolts to be installed in concrete prior to and during placement of concrete.		X	–
4. Verifying use of required design mix.		–	X
5. At the time fresh concrete is sampled to fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.		X	–
6. Inspection of concrete and shotcrete placement for proper application techniques.		X	–
7. Inspection for maintenance of specified curing temperature and techniques.		–	X

APPENDIX B
ESSENTIAL ARCHITECTURAL, MECHANICAL AND ELECTRICAL
INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection	
		Continuous During Task Listed	Periodic During Task Listed
1. Suspended ceiling system including anchorage.		–	X
2. Anchorage of electrical equipment for emergency standby power.		–	X
3. Anchorage of other electrical or mechanical equipment on floors or roofs.		–	X
4. Anchorage of ducts.		–	X
5. Anchorage of pipes.		–	X
6. Steel storage racks supporting pipelines.		–	X
7. Elevator installation.		–	X

APPENDIX C
ESSENTIAL MASONRY SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection	
		Continuous During Task Listed	Periodic During Task Listed
1. From the beginning of masonry construction, the following shall be verified for compliance:			
a. Proportions of site-prepared mortar and grout.		–	X
b. Placement of masonry units and construction of mortar joints.		–	X
c. Placement of reinforcement and connectors.		–	X
d. Grout space prior to grouting.		X	–
e. Placement of grout.		X	–
2. The inspection program shall verify:			
a. Size and location of structural elements.		–	X
b. Type, size and location of anchors, including other details of anchorage of masonry to structural members, frames or other construction.		X	–
c. Specified size, grade and type of reinforcement.			X
d. Welding of reinforcing couplers.		X	–
e. Protection of masonry during cold weather (temperature below 40° F) or hot weather (temperature above 90° F).		–	X
3. Preparation of any required grout specimens, mortar specimens and/or prisms shall be observed.		X	–
4. Compliance with required inspection provisions of the construction documents and the approved submittals shall be verified.		–	X

APPENDIX D
SOILS VERIFICATION AND INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection	
		Continuous During Task Listed	Periodic During Task Listed
1. Verify materials below footings are adequate to achieve the design bearing capacity.		–	X
2. Verify excavations are extended to proper depth and have reached proper material.		–	X
3. Perform classification and testing of controlled fill materials.		–	X
4. Verify use of proper materials, densities, and lift thicknesses during placement and compaction of controlled fill.		X	–
5. Prior to placement of controlled fill, observe subgrade and verify that site has been prepared properly.		–	X

APPENDIX E
STRUCTURAL STEEL SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection	
		Continuous During Task Listed	Periodic During Task Listed
1. Material verification of high-strength bolts, nuts and washers:			
a. Identification markings to conform to ASTM standards specified in the approved construction documents.		–	X
b. Manufacturer's certificate of compliance required.		–	X
2. Inspection of high-strength bolting:			
a. Bearing-type connections.		–	X
b. Slip-critical connections.		X	X
3. Material verification of structural steel:			
a. Identification markings to conform to ASTM standards specified in the approved construction documents.		–	X
b. Manufacturers' certified mill test reports.		X	–
4. Material verification of weld filler materials:			
a. Identification markings to conform to AWS specification in the approved construction documents.		–	X
b. Manufacturer's certificate of compliance required.		–	X
5. Inspection of welding:			
a. Structural steel:		–	–
1) Complete and partial penetration groove welds.		X	–
2) Multi-pass fillet welds.		X	–
3) Single-pass fillet welds > 5/16".		X	–
4) Single-pass fillet welds ≤ 5/16".		–	X
5) Floor and deck welds.		–	X
b. Reinforcing steel:		–	–
1) Verification of weldability of reinforcing steel other than ASTM A706.		–	X
2) Reinforcing steel-resisting flexural and axial forces in boundary elements of special reinforced concrete shear walls and shear reinforcement.		X	–
3) Shear reinforcement.		X	–
4) "Form Saver" (reinforcing couplers).		X	–
6. Inspection of steel frame joint details for compliance with approved construction documents:			X
a. Details such as bracing and stiffening.		X	–
b. Member locations.		X	–
c. Application of joint details at each connection.		X	
7. Seismic force resisting systems identified on structural plans.		X	–

APPENDIX F
OTHER SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection	
		Continuous During Task Listed	Periodic During Task Listed
1. Shoring of Excavations.		–	X
2. Reinforced gypsum concrete.		–	X
3. Shotcrete.		–	X
4. Smoke control system.		–	X
5. Special grading, excavating, and filling.		–	X
6. Spray applied fire resistive material.		–	X
7. Special seismic resistance details.		–	X

SECTION 01 50 00 - TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Furnishing, maintaining, and removing construction facilities and temporary controls, including temporary utilities, construction aids, barriers and enclosures, security, access roads, temporary controls, project sign, field offices and sheds, and removal after construction.

B. Related sections:
   1. Section 01 14 00 – Work Restrictions.
   2. Section 01 32 00 – Construction Progress Documentation
   3. Section 01 33 00 – Submittal Procedures
   4. Section 01 34 00 – Photographic and Videographic Documentation

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Association of Nurserymen: American Standards for Nursery Stock.
   2. Federal Emergency Management Agency.
   3. NFPA, National Fire Prevention Standard for Safeguarding Building Construction Operations.
   4. Telecommunications Industry Association (TIA); Electronic Industries Alliance (EIA): 568B, Commercial Building Telecommunications Cabling Standard.
   5. U.S. Department of Agriculture: Urban Hydrology for Small Watersheds.
   6. U.S. Weather Bureau: Rainfall-Frequency Atlas of the U.S. for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years.

1.3 SUBMITTALS

A. Informational Submittals:
   1. General: For products specified to be furnished under this Section, submit product data in accordance with Section 01 33 00.
   2. For Temporary Piping Systems:
      a. Submit layout drawings showing proposed routing of piping, including proposed pipe support and pipe restraint locations.
      b. Submit product data for piping, fittings, appurtenances, restraints, supports, and all other components of the temporary piping system.
      c. Submit all information at least 28 days prior to when each temporary piping system is scheduled to be installed and allow 14 days for review and comment by Engineer and Owner.
   3. For Temporary Pumping Systems:
      a. Submit pump data, performance curves, and other operating information as specified in Section 01 32 00.
      b. Submit sketches showing layout of temporary pumping system, including pump quantity, configuration in wet well, and proposed piping layout specified in Paragraph 1.02 B.
      c. Submit piping headloss calculations based on proposed temporary piping system layout.
      d. Submit all information at least 28 days prior to when the temporary pumping system is scheduled to be installed and allow 14 days for review and comment by Engineer and Owner.

4. Copies of permits and approvals for construction as required by Laws and Regulations and governing agencies.
5. Temporary Utility Submittals:
    a. Electric power supply and distribution plans.
    b. Water supply and distribution plans.
    c. Drainage plans.
    d. Sanitary sewer.
6. Temporary Construction Submittals:
    a. Access Roads: Routes, cross-sections, and drainage facilities.
    b. Parking area plans.
    c. Contractor's field office, storage yard, and storage building plans, including gravel surfaced area.
    d. Fencing and protective barrier locations and details.
    e. Staging area location plan.
    f. Traffic and Pedestrian Control and Routing Plans: As specified herein, and proposed revisions thereto.
7. Temporary Control Submittals:
    a. Noise control plan.
    b. Plan for disposal of waste materials and intended haul routes.

1.4 MOBILIZATION

A. Mobilization shall Include, but Not be Limited to, these Principal Items:
    1. Obtaining required permits.
    2. Moving Contractor's field office and equipment required for first month operations onto Site.
    3. Installing temporary construction power, wiring, and lighting facilities.
    4. Providing onsite communication facilities, including telephones.
    5. Providing onsite sanitary facilities and potable water facilities as specified and as required by Laws and Regulations, and governing agencies.
    6. Arrange for and erection of Contractor's work and storage yard.
    7. Posting OSHA required notices and establishing safety programs and procedures.
    8. Have Contractor's superintendent at Site full time.

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

1.5 PROTECTION OF WORK AND PROPERTY

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

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

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

1.6 VEHICULAR TRAFFIC

A. Traffic Routing Plan: Show sequences of construction affecting use of roadways, time required for each phase of the Work, provisions for decking over excavations and phasing of operations to provide necessary access, and plans for signing, barricading, and striping to provide passages for pedestrians and vehicles.

1.7 TEMPORARY UTILITIES

A. Temporary Electrical Power:
    1. Arrange with local utility to provide adequate temporary electrical service.

2. Provide and maintain adequate jobsite power distribution facilities conforming to applicable Laws and Regulations.
3. Provide, maintain, and pay for electrical power for performance of the Work except for power required for the final 7-day operational test:
    a. When using permanent facilities, provide separate meter and reimburse Owner for power used in connection with performance of the Work.

B. Temporary Electrical Lighting:
1. In work areas, provide temporary lighting sufficient to maintain lighting levels during working hours not less than lighting levels required by Occupational Safety and Hath Administration (OSA) and state agency which administers OSHA regulations where Project is located.
2. When available, permanent lighting facilities may be used in lieu of temporary facilities:
    a. Prior to Substantial Completion of the Work, replace bulbs, lamps, or tubes used by Contractor for lighting.

C. Temporary Heating, Cooling, and Ventilating:
1. Heat and ventilate work areas to protect the Work and damage by freezing, high temperatures, weather, and to provide safe environment for workers.
2. Permanent heating system may be utilized when sufficiently completed to allow safe operation.

D. Temporary Water:
1. Pay for and construct facilities necessary to furnish potable water for human consumption and non-potable water for use during construction.
2. Remove temporary piping and connections and restore affected portions of the facility to original conditions before Substantial Completion.
3. Pay for water used for construction prior to Substantial Completion. Owner will provide water for 7-day final test.
4. Development of Non-Potable Water Supply:
    a. Non-potable water is available from hydrants or hose valves within plant without cost. When combined demand of the Work and plant exceeds plant supply capacity, provide additional temporary supply capacity.
    b. Post ample signs throughout the work area warning that plant water is not potable.

E. Temporary Sanitary Facilities:
1. Provide suitable and adequate sanitary facilities that are in compliance with applicable Laws and Regulations.
2. At completion of the Work, remove sanitary facilities and leave site in neat and sanitary condition.

F. Temporary Fire Protection: Provide sufficient number of fire extinguishers of type and capacity required to protect the Work and ancillary facilities.

G. First Aid: Post first aid facilities and information posters conforming to requirements of OSHA and other applicable Laws and Regulations in readily accessible locations.

H. Utilities in Existing Facilities: See Section 01 14 00, WORK RESTRICTIONS.

1.8 CONSTRUCTION AIDS

A. Provide railings, kick plates, enclosures, safety devices, and controls required by Laws and Regulations and as required for adequate protection of life and property.

B. Use construction hoists, elevators, scaffolds, stages, shoring, and similar temporary facilities of ample size and capacity to adequately support and move loads.

C. Design temporary supports with adequate safety factor to assure adequate load bearing capability:
   1. When requested, submit design calculations by professional registered engineer prior to application of loads.
   2. Submitted design calculations are for information and record purposes only.

D. Accident Prevention:
   1. Exercise precautions throughout construction for protection of persons and property.
   2. Observe safety provisions of applicable Laws and Regulations.
   3. Guard machinery and equipment, and eliminate other hazards.
   4. Make reports required by authorities having jurisdiction, and permit safety inspections of the Work.
   5. Before commencing construction work, take necessary action to comply with provisions for safety and accident prevention.

E. Barricades:
   1. Place barriers at ends of excavations and along excavations to warn pedestrian and vehicular traffic of excavations.
   2. Provide barriers with flashing lights after dark.
   3. Keep barriers in place until excavations are entirely backfilled and compacted.
   4. Barricade excavations to prevent persons from entering excavated areas in streets, roadways, parking lots, treatment plants, or other public or private areas.

F. Warning Devices and Barricades: Adequately identify and guard hazardous areas and conditions by visual warning devices and, where necessary, physical barriers:
   1. Devices shall conform to minimum requirements of OSHA and State agency which administers OSHA regulations where Project is located.

G. Hazards in Public Right-of-Way:
   1. Mark at reasonable intervals, trenches and other continuous excavations in public right-of-way, running parallel to general flow of traffic, with traffic cones, barricades, or other suitable visual markers during daylight hours:
      a. During hours of darkness, provide markers with torches, flashers, or other adequate lights.
   2. At intersections or for pits and similar excavations, where traffic may reasonably be expected to approach head on, protect excavations by continuous barricades:
      a. During hours of darkness, provide warning lights at close intervals.

H. Hazards in Protected Areas: Mark or guard excavations in areas from which public is excluded, in manner appropriate for hazard.

I. Above Grade Protection: On multi-level structures, provide safety protection that meets requirements of OSHA and State agency which administers OSHA regulations where Project is located.

J. Protect existing structures, trees, shrubs, and other items to be preserved on Project site from injury, damage or destruction by vehicles, equipment, worker or other agents with substantial barricades or other devices commensurate with hazards.

K. Fences:
   1. Enclose site of the Work with fence adequate to protect the Work against acts of theft violence and vandalism.

2. Enclose temporary offices and storage areas with fence adequate to protect temporary facilities against acts of theft, violence, and vandalism.
3. When entire or part of site is to permanently fenced, permanent fence may be built to serve for both permanent and temporary protection of the work site, provided that damaged or defaced fencing is replaced prior to Substantial Completion.
4. Protect temporary and permanent openings and close openings in existing fences to prevent intrusion by unauthorized persons. Bear responsibility for protection of plant and material on site of the Work when openings in existing fences are not closed.
5. During night hours, weekends, holidays, and other times when no work is performed at the site, provide temporary closures, or enlist services of security guards to protect temporary openings.
6. Fence temporary openings when openings are no longer necessary.

1.9 SECURITY

A. Make adequate provision for protection of the work area against fire, theft, and vandalism, and for protection of public against exposure to injury.

1.10 ACCESS ROADS

A. General:
1. Build and maintain access roads to and on site of the Work to provide for delivery of material and for access to existing and operating plant facilities on site.
2. Build and maintain dust free roads which are suitable for travel at 20 miles per hour.

B. Off-Site Access Roads:
1. Build and maintain graded earth roads.
2. Build roads only in public right-of-way or easements obtained by Owner.
3. Obtain rights-of-way or easements when electing to build along other alignment.

C. On-Site Access Roads:
1. Maintain access roads to storage areas and other areas to which frequent access is required.
2. Maintain similar roads to existing facilities on site of the Work to provide access for maintenance and operation.
3. Protect buried vulnerable utilities under temporary roads with steel plates, wood planking, or bridges.
4. Maintain on-site access roads free of mud. Under no circumstances shall vehicles leaving the site track mud off the site onto the public right-of-way.

1.11 TEMPORARY PARKING
1. Build and maintain compacted gravel and stone parking areas at these points in the project site:
   a. Contractor’s Field Office; Provide Contractor’s needs plus 5 additional spaces for visitors.
   b. WWTP Plant Parking Area: Provide minimum 20 parking spaces to allow demolition of Plant’s existing parking spaces.
   c. Environmental Services Parking: Provide minimum 5 parking spaces to allow demolition of Environmental Services Parking.
2. Provide proper drainage for all temporary parking areas
3. Provide appropriate temporary lighting at each temporary parking area.

1.12 TEMPORARY CONTROLS

A. Dust Control:

1. Prevent dust nuisance caused by operations, unpaved roads, excavation, backfilling, demolition, or other activities.
2. Control dust by sprinkling with water, use of dust palliatives, modification of operations, or other means acceptable to agencies having jurisdiction.

B. Noise Control:
1. In inhabited areas, particularly residential, perform operations in manner to minimize noise.
2. In residential areas, take special measures to suppress noise during night hours.

C. Mud Control:
1. Prevent mud nuisance caused by construction operations, unpaved roads, excavation, backfilling, demolition, or other activities.

1.13 PROJECT SIGN

A. Provide and maintain Project identification sign consisting of painted 8 foot wide by 4 foot high exterior grade plywood and minimum 10 foot long 4 by 4 lumber posts, set in ground at least 3 feet, with exhibit lettering by professional sign painter using no more than 5 sign colors:
1. List at least the title of the Project, and names of the Owner, Engineer, and Contractor.

B. Erect Project identification sign where directed.

1.14 REMOVAL

A. Remove temporary buildings and furnishings before inspection for Substantial Completion or when directed.

B. Clean and repair damage caused by installation or use of temporary facilities.

C. Remove underground installations to minimum depth of 24 inches and grade to match surrounding conditions.

D. Restore existing facilities used during construction to specified or original condition.

1.15 TEMPORARY PROCESS PIPING

A. Contractor shall provide all piping, appurtenances, and other materials as required to provide temporary piping systems as specified herein, as indicated on the Drawings, and as needed to perform the Work.

B. Contractor shall field route piping as needed and as field conditions dictate, unless otherwise indicated on the Drawings, and determine appropriate lengths of piping and quantity/type of pipe fittings needed to construct temporary piping system. Do not block access points such as stairs, doors, and walkways to existing facilities unless approved in writing by the Owner.

C. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
1. When piping is buried, use concrete thrust block or mechanical restraints.
2. When piping is exposed or under water, use mechanical or structural restraints.
3. Determine thrust forces by multiplying the nominal cross sectional area of the piping by the operating pressure of the piping.

D. Temporary piping systems shall be installed in a manner that will not damage existing or new facilities.

E. Unless indicated otherwise, piping material, including gaskets, shall be suitable for the process fluid requiring temporary piping.

F. Temporary Piping Includes, but is not limited to, the following Piping Services:
   1. Headworks Area:
      a. HDPE from Diversion Structure upstream of Manhole No. 1 to upstream wet well above the existing screens in the Headworks facility. Pipe velocities shall not exceed 7 fps at peak flow conditions.
      b. All other temporary piping required to bypass Manhole No. 1 and the Parshall Flume to perform the work.
      c. All temporary piping required to implement required temporary pumping to accomplish the work. This piping includes all suction and discharge piping associated with the temporary pumping operations. This piping will be removed from the project site following the completion of the work.
   2. Influent Flow Measurement:
      a. Install temporary bypass pipeline to divert flows to allow construction of new biotrickling filter and Parshall Flume improvements. Provide and maintain accurate flow measurement during bypass pumping and report back to plant SCADA.
   3. Dos Rios Area:
      a. As required: HDPE from the manhole near Parcel #2945-232-03-019 downstream to the manhole near Parcel #2945-232-00-077. Pipe velocities shall not exceed 7 fps at peak flow conditions.
      b. All other temporary piping required to bypass the manhole near the on-ramp from Riverside Pkwy to Highway 50 to perform the work.
      c. All temporary piping required to implement required temporary pumping to accomplish the work. This piping includes all suction and discharge piping associated with the temporary pumping operations. This piping will be removed from the project site following the completion of the work.

G. After Temporary Piping System is no longer required:
   1. Remove temporary piping system.
   2. Clean and repair damage caused by installation or use of temporary piping system.
   3. Restore existing facilities to original condition.

1.16 TEMPORARY PROCESS PUMPING

A. Contractor shall provide temporary pumping system to pump flow from structure/manhole to facility/manhole as the existing piping is relocated, as new piping is interconnected and existing piping is rehabilitated.
   1. Anticipated pressure will vary based on headlosses developed and the final length of installed temporary piping. Contractor shall calculate headlosses and provide pump with sufficient pressure to meet flow requirements. Calculations shall be sealed and signed by a professional engineer registered in the State of Colorado.
   2. Pump(s) shall be capable of passing a solid with a sphere size of 3 inches.
   3. Temporary pumps shall be capable of matching plant flow rates through the use of variable flow rate pumping. The use of cycled pumping (i.e, on/off) is not acceptable. Provide all wiring and controls necessary to match plant flow rate based on 4-20 mA signal.
   4. Provide and pay for all power required to operate temporary pumps.
   5. All electrical and instrumentation components will comply with applicable code requirements for the area where the temporary pump is located.
   6. Temporary pumping will be required 24 hours per day during the time period when pumping is required and is critical to the proper operation of the Owner's treatment facility. Provide 24-hour on-site supervision of pumps to ensure that pumps are always operational and performing as required. Notify the Owner immediately if temporary pumping cannot be provided.

7. Contractor shall be responsible for repairing any damage or reimbursing the Owner for any regulatory fines or additional plant staff time resulting from the Contractor's failure to maintain temporary pumping.
8. Provide 100 percent backup (a.k.a., standby, redundant, etc.) pumping capacity equal to the required process flow rate. Backup system shall be capable of providing required pumping capacity immediately upon failure of primary pumping system.
9. All necessary spare equipment and appurtenances shall be available on-site to allow immediate repair and/or replacement of any pumping system component that is not functioning properly.

B. Temporary Pumping Includes, but is not limited to, the following Pumping Services:
1. Headworks Area: Total plant flow for the installation of odor control units near the Headworks facility and at the Parshall Flume.
2. Influent Flow Measurement: Total plant flow for interconnection of temporary bypassing piping.
3. Dos Rios Area: Total interceptor peak flow for the installation of odor control units near Parcel #2945-232-00-088.

C. Provide temporary piping systems as specified in Paragraph 1.15.

D. Temporary pumping of other process flows is not allowed unless approved in writing by the Owner.

E. After Temporary Process Pumping System is no Longer Required:
1. Remove temporary process pumping system and associated piping.
2. Clean and repair damage caused by installation or use of temporary process pumping system.
3. Restore existing facilities to original condition.

PART 2 - PRODUCTS

2.1 FIELD OFFICES AND SHEDS

A. Contractor's Field Office:
1. Maintain on Project Site weathertight space in which to keep copies of Contract Documents, progress schedule, shop drawings, and other relevant documents.
2. Provide field office with adequate space to examine documents, and provide lighting and telephone service in that space.

PART 3 - EXECUTION

3.1 TEMPORARY UTILITIES

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

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

C. Heating, Cooling, and Ventilating:

1. Provide as required to maintain adequate environmental conditions to facilitate progress of the Work, to meet specified minimum conditions for installation of materials, and to protect materials, equipment, and finishes from damage due to temperature or humidity. Costs for temporary heat shall be borne by Contractor.
2. Provide adequate forced air ventilation of enclosed areas to cure installed materials, to dispense humidity, and to prevent hazardous accumulations of dust, fumes, vapors, or gases.
3. Pay all costs of installation, maintenance, operation, removal, and fuel consumed.
4. Provide portable unit heaters, complete with controls, oil- or gas-fired, and suitably vented to outside as required for protection of health and property.

D. Water:
1. Potable water is available at the site. Secure written permission for connection and use from Owner and meet requirements for use. Contractor shall pay cost to connect water during construction. Owner shall pay cost to for water used during construction.
2. Include costs to connect and transport water to construction areas in Contract Price.
3. Provide a means to prevent water used for testing from flowing back into source pipeline.

E. Sanitary and Personnel Facilities:
1. Provide and maintain facilities for Contractor's employees, Subcontractors, and all other onsite employers' employees. Service, clean, and maintain facilities and enclosures.

F. Telephone Service:
1. Contractor: Arrange and provide onsite telephone service for use during construction by Contractor. Pay costs of installation and monthly bills.
2. Engineer: Arrange and provide onsite telephone system for use during construction. Pay for all installation and basic monthly billing charges.
3. No incoming calls allowed to Owner's plant telephone system.

G. Fire Protection: Furnish and maintain on Site adequate firefighting equipment capable of extinguishing incipient fires. Comply with applicable parts of National Fire Prevention Standard for Safeguarding Building Construction Operations (NFPA No. 241).

3.2 PROTECTION OF WORK AND PROPERTY

A. General:
1. Perform Work within right-of-way and easements in a systematic manner that minimizes inconvenience to property owners and the public.
2. Schedule the Work so construction will not interfere with irrigation of cultivated lands or pasturelands. Construction may proceed during irrigation season, provided Contractor constructs temporary irrigation ditches, turnouts, and miscellaneous structures acceptable to property owners.
3. Provide continuous access for livestock through farm areas. Do not cut off ready access to portions of farmlands in which livestock are pastured. Maintain existing fences required to restrain livestock. Keep gates closed and secure.
4. Maintain in continuous service all existing oil and gas pipelines, underground power, telephone or communication cable, water mains, irrigation lines, sewers, poles and overhead power, and all other utilities encountered along line of the Work, unless other arrangements satisfactory to owners of said utilities have been made.
5. Where completion of the Work requires temporary or permanent removal or relocation of existing utility, coordinate all activities with owner of said utility and perform all work to their satisfaction.
6. Protect, shore, brace, support, and maintain underground pipes, conduits, drains, and other underground utility construction uncovered or otherwise affected by construction operations.

7. In areas where Contractor's operations are adjacent to or near a utility, such as gas, telephone, television, electric power, water, sewer, or irrigation system, and such operations may cause damage or inconvenience, suspend operations until arrangements necessary for protection have been made by Contractor.
8. Notify property owners and utility offices that may be affected by construction operation at least 2 days in advance: Before exposing a utility, obtain utility owner's permission. Should service of a utility become interrupted due to Contractor's operation, notify proper authority immediately. Cooperate with said authority in restoring service as promptly as possible and bear costs incurred.
9. Do not impair operation of existing sewer system. Prevent construction material, pavement, concrete, earth, volatile and corrosive wastes, and other debris from entering sewers, pump stations, or other sewer structures.
10. Maintain original Site drainage wherever possible.

B. Site Security:
1. Erect a temporary security fence for protection of existing facilities. Maintain fence throughout construction period. Obtain Engineer's written permission before removal of temporary security fencing.
2. Provide and maintain additional temporary security fences as necessary to protect the Work and Contractor-furnished products not yet installed.

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

D. Trees and Plantings:
1. Protect from damage and preserve trees, shrubs, and other plants outside limits of the Work and within limits of the Work, which are designated on the Drawings to remain undisturbed.

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

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

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

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

3.3 TEMPORARY CONTROLS

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

B. Noise Control:
   1. Noise Control Plan: Propose plan to mitigate construction noise and to comply with noise control ordinances, including method of construction, equipment to be used, and acoustical treatments.

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

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

3.4 STORAGE YARDS AND BUILDINGS

A. Coordinate requirements with Section 01 60 00, PRODUCT REQUIREMENTS.

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

C. Temporary Storage Buildings:
   1. Provide environmental control systems that meet recommendations of manufacturers of equipment and materials stored.
   2. Arrange or partition to provide security of contents and ready access for inspection and inventory.
   3. Store combustible materials (paints, solvents, fuels) in a well-ventilated and remote building meeting safety standards.
   4. Provide, at a minimum, one temporary storage building or storage trailer to house specified spare part during the duration of construction and until spare parts are accepted by Owner and Engineer.

3.5 ACCESS ROADS

A. Construct access roads as required and within easements, rights-of-way, or Project limits. Obtain Engineer's approval of access roads.

B. Maintain drainage ways. Install and maintain culverts to allow water to flow beneath access roads. Provide corrosion-resistant culvert pipe of adequate strength to resist construction loads.

C. Provide gravel, crushed rock, or other stabilization material to permit access by all motor vehicles at all times.

D. Maintain road grade and crown to eliminate potholes, rutting, and other irregularities that restrict access.

E. Coordinate with Engineer detours and other operations affecting traffic and access. Provide at least 72 hours notice to Engineer of operations that will alter access to the Site.

F. Where access road crosses existing fences, install and maintain gates.

G. Upon completion of construction, restore ground surface disturbed by access road construction to original grade. Replace damaged or broken culverts with new culvert pipe of same diameter and material.

3.6 PARKING AREAS

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

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

3.7 VEHICULAR TRAFFIC

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

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

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

D. Coordinate traffic routing with that of others working in same or adjacent areas.

3.8 CLEANING DURING CONSTRUCTION

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

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

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

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

END OF SECTION

SECTION 01 60 00 – PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 DEFINITIONS

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

1.2 DESIGN REQUIREMENTS

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

1.3 ENVIRONMENTAL REQUIREMENTS

A. Altitude: Provide materials and equipment suitable for installation and operation under rated conditions at elevations shown on Drawings.

B. Provide equipment and devices installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 0 °F to 104 °F.

1.4 PREPARATION FOR SHIPMENT

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

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

C. Extra Materials, Special Tools, Test Equipment, and Expendables:
   1. Furnish as Required by Individual Specifications.
   2. Schedule:
      a. Ensure that shipment and delivery occur concurrently with shipment of associated equipment.
      b. Transfer to Owner shall occur immediately subsequent to Contractor's acceptance of equipment from Supplier.
   3. Packaging and Shipment:
      a. Package and ship extra materials and special tools to avoid damage during long term storage in original cartons insofar as possible, or in appropriately sized, hinged-cover, wood, plastic, or metal box.
      b. Prominently Displayed on Each Package, the Following:

1). Manufacturer's part nomenclature and number, consistent with Operation and Maintenance Manual identification system.
2). Applicable equipment description.
3). Quantity of parts in package.
4). Equipment manufacturer.

4. Deliver materials to the site.
5. Notify Engineer upon arrival for transfer of materials.
6. Replace extra materials and special tools found to be damaged or otherwise inoperable at time of transfer to Owner.

D. Request a minimum 7-day advance notice of shipment from manufacturer. Upon receipt of Manufacturer's advance notice of shipment, promptly notify Engineer of anticipated date of equipment arrival.

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

1.5 DELIVERY AND INSPECTION

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

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

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

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

1.6 HANDLING, STORAGE, AND PROTECTION

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

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

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

D. Store fabricated products above ground on blocking or skids, prevent soiling or staining, and store loose granular materials in well-drained area on solid surface to prevent mixing with foreign matter. Cover products that are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.

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

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

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

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide the Manufacturers standard materials suitable for service conditions unless otherwise specified in the individual Specifications.

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

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

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

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

F. Equipment, components, systems, sub-systems: Design and manufacture with due regard for health and safety of operation, maintenance, and accessibility, durability of parts, and shall comply with applicable OSHA, State, and local health and safety regulations.

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

H. Safety Guards: Provide for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Cover rotating part on all sides. Design for easy installation and removal. Use 16-gauge or heavier; galvanized steel, aluminum coated steel, or galvanized or aluminum coated ½" mesh expanded steel. Provide galvanized steel accessories and supports, including bolts. For outdoors application, prevent entrance of rain and dripping water.

I. Authority Having Jurisdiction (AHJ):
   1. Provide the Work in accordance with the Colorado Fire Code that incorporates the 2021 or latest International Building Code [with Colorado Amendments]. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing

laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

J. Equipment Finish:
   1. Provide Manufacturer's standard finish and color, except where specific color is indicated.
   2. If Manufacturer has no standard color, provide equipment with gray finish as approved by Engineer.

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

L. Lubricant: Provide initial lubricant recommended by equipment Manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by Owner.

2.2 FABRICATION AND MANUFACTURE

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

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

2.3 SOURCE QUALITY CONTROL

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

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

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

PART 3 - EXECUTION

3.1 INSPECTION

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

3.2 INSTALLATION

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

B. No shimming between machined surfaces is allowed.

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

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

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

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

G. For material and equipment specifically indicated or specified to be reused in the Work:
   1. Use special care in removal, handling, storage, and reinstallation to assure proper function in the completed Work.
   2. Arrange for transportation, storage, and handling of products that require offsite storage, restoration, or renovation. Include costs for such Work in the Contract Price.

3.3 FIELD FINISHING

A. In accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS and individual Specification sections.

3.4 ADJUSTMENT AND CLEANING

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

3.5 LUBRICANTS

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

END OF SECTION

SECTION 01 72 20 – FIELD ENGINEERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes description and requirements of the required closeout procedures for the project:
   1. Providing and delivering informational submittals.
   2. Preparing, maintaining, providing and delivering Record Documents.
   3. Furnishing Releases from Agreements.
   4. Furnishing Evidence of Compliance with Requirements of Governing Authorities.
   5. Providing Warranties and Bonds.
   6. Providing Certificate of Final Completion.

B. Related sections:
   1. Section 01 77 00 – Closeout Procedures.

1.2 QUALITY ASSURANCE

A. Qualifications of Surveyor or Engineer: Registered civil engineer or land surveyor in state where Project is located.

B. Accuracy of stakes, alignments, and grades may be checked randomly by ENGINEER:
   1. Notice of when checking will be conducted will be given.
   2. When notice of checking is given, postpone parts of the Work affected by stakes, alignments or grades to be checked until checked.
   3. Do not assume that ENGINEER's check substitutes or complements required field quality control procedures.

1.3 CONSTRUCTION STAKES, LINES, AND GRADES

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

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

1.4 SURVEY REFERENCE POINTS

A. Basic reference line, a beginning point on basic reference line, and a benchmark will be provided, by OWNER.

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

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

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

1.5 PROJECT SURVEY REQUIREMENTS

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

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

C. Assume responsibility for accuracy of stakes, alignments, and grades by performing verifications and checking in accordance with standard surveying practice.

1.6 RECORD DOCUMENTS

A. Prepare and submit Record Documents as specified in Section 01 77 00.

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

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 73 20 – CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Cutting and patching existing and new construction.

B. Related sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 01 60 00 – Product Requirements.

1.2 SUBMITTALS

A. Submit in accordance with Section 01 33 00.

B. Cutting and Patching Plan:
   1. Submit details of proposed construction before cutting and patching construction commences affecting:
      a. Work of OWNER or of others.
      b. Structural integrity of element of Project.
   2. Cutting and Patching Plan shall Include the Following:
      a. Identification of Work.
      b. Description of affected construction.
      c. Necessity for cutting, patching, alteration, or excavation.
      d. Description of proposed construction.
      e. Scope of cutting, patching, alteration, or excavation. Verify locations of utilities and facilities which may exist by consulting with the OWNER, utility companies, and the Colorado One-Call System or other service available in area of Project (see dig/call information on the Drawings):

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with specifications and standards for products involved.

PART 3 - EXECUTION

3.1 PREPARATION

A. Provide adequate temporary support as necessary to ensure structural integrity of affected portion of Work.

B. Provide devices and methods to protect other portions of Project from damage and persons from injury.

C. Provide protection from elements for that portion of Project which may be exposed by cutting and patching and maintain excavations free from water.

3.2 CUTTING AND PATCHING

A. Cut, Fit, and Patch when Required to:
   1. Make its several parts fit together properly.
   2. Remove and replace construction not conforming to Contract Documents.

3. Remove samples of installed construction as specified for testing.
4. Provide routine penetrations of nonstructural surfaces for installation of piping and electrical conduit.

B. Execute cutting and demolition by methods which will prevent damage and will provide proper surfaces to receive installation of repairs.

C. Openings in Existing Concrete and Masonry:
1. Create Openings by:
   a. Saw cutting completely through concrete or masonry, or
   b. Scoring edges of opening with saw to at least 1 inch depth on both surfaces (when accessible) and removing concrete or masonry by chipping.
2. Do not allow saw cuts to extend beyond limits of opening.
3. Make corners square and true by combination of core drilling and grinding or chipping.
4. Prevent debris from falling into adjacent tanks or channels in service or from damaging existing equipment and other facilities.

D. Sizing of Openings in Existing Concrete or Masonry:
1. Make openings sufficiently large to permit final alignment of pipe and fittings without deflections.
2. Allow adequate space for packing around pipes and conduit to ensure watertightness.

E. Grouting Pipes in Place:
1. Sandblast concrete surfaces and thoroughly clean sand and other foreign material from surfaces prior to placing grout.
2. Grout pipes, sleeves, castings, and conduits in place by pouring grout under a head of at least 4 inches. Vibrate grout into place. Completely fill the spaces occupied by pipes, sleeves, castings, and conduits.
3. Water cure the grout.

F. Connections to Existing Pipes:
1. Cut existing pipe square.
2. Properly prepare the ends for the connection indicated on the Drawings.
3. Repair any damage to existing lining and coating.

G. Rehabilitate all areas affected by removal of existing equipment, equipment pads and bases, piping, supports, electrical panels, electric devices, and conduits such that little or no evidence of the previous installation remains:
1. Fill areas in existing floors, walls, and ceilings from removed piping, conduit and fasteners with non-shrink grout and finish smooth.
2. Remove Concrete Bases for Equipment and Supports by:
   a. Saw cutting clean, straight lines with a depth equal to the concrete cover over reinforcement minus 1/2 inch below finished surface. Do not cut existing reinforcement on floors.
   b. Chip concrete within scored lines and cut exposed reinforcing steel and anchor bolts.
   c. Patch with non-shrink grout to match adjacent grade and finish.
3. Terminate abandoned piping and conduits with blind flanges, caps, or plugs.

H. Treat Existing Concrete Reinforcement as Follows:
1. Where existing reinforcement is to remain, protect, clean, and extend into new concrete.
2. Where Existing Reinforcement is not to be Retained, Cut Off as Follows:
   a. Where new concrete joins existing concrete at the removal line, cut reinforcement flush with concrete surface at the removal line.

b. Where concrete surface at the removal line is the finished surface, cut reinforcement 2 inches below the surface, paint ends with epoxy, and patch holes with dry pack mortar.

END OF SECTION

SECTION 01 73 40 – WORK WITHIN PUBLIC RIGHT-OF-WAY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for maintenance, support, protection, relocation, reconstruction and adjusting-to-grade, restoration, construction of temporary and new facilities, and abandonment of existing utilities affected by construction work within the public right-of-way.

1.2 REFERENCES

A. State of Colorado, Department of Transportation (CDOT):
   1. Standard Specifications.

1.3 DEFINITIONS

A. Utility: For purpose of this Section, utility means any public or private service, such as electric light and power systems; gas distribution systems; telephone, telegraph, cable television and other communication services; water distribution; storm drain and sanitary sewer services; police and fire communication systems; street lighting and traffic signs and signals; parking meters; and steam distribution systems.

B. For Trenching:
   1. Open Trench:
      a. General: Includes excavation, pipe laying, backfilling, and pavement replacement.
   2. Any excavated areas shall be considered as "open trench" until all pavement replacement has been made, or until all trenches outside of pavement replacement areas have been backfilled and compacted in accordance with these Contract Documents.

1.4 DESIGN REQUIREMENTS

A. Trenching:
   1. Except where otherwise specified, indicated on the Drawings, or accepted in writing by the ENGINEER, the maximum length of open trench, where construction is in any stage of completion, shall not exceed the linear footage as set forth below. Descriptions under following area designations are general in nature and may be amended in writing by the ENGINEER due to particular or peculiar field conditions:
      a. Business District Areas C 100 Linear Feet: Store front areas.
      b. Commercial Areas C 400 Linear Feet: Industrial, shopping centers, churches, schools, hotels, motels, markets, gas stations, government and private office buildings, hospitals, fire and police stations, and nursing homes.
      c. Residential Areas C 1 Block or 600 Linear Feet, Whichever is the Least: Single and multi-family residences, apartments, and condominiums.
      d. Undeveloped Areas C 1,000 Linear Feet: Parks, golf courses, farms, undeveloped subdivided land.
   2. Completely backfill trenches across streets and install temporary or permanent pavement as soon as possible after pipe laying.

B. Site Conditions:
   1. Use substantial steel plates with adequate trench bracing to bridge across trenches at street and alley crossings, commercial driveways, and residential driveways where trench backfill and temporary patch have not been completed during regular working hours.
   2. Provide safe and convenient passage for pedestrians.
   3. Maintain access to fire stations, fire hydrant, and hospitals at all times.

4. Provide traffic control devices, barricades and signage as required by the regulating agency.

1.5 SUBMITTALS

A. Traffic Control Plan: Submit detailed traffic control plan for acceptance by jurisdictional agency.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 75 60 – TESTING, TRAINING, AND FACILITY START-UP

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for equipment and system testing and facility start up, including the following:
   1. Start-Up Plan.
   2. Performance Testing.
   3. General Start-Up and Testing Procedures.
   4. Functional Testing.
   5. Clean Water Testing.
   6. Operational Testing.
   7. Certificate of Proper Installation.
   8. Services of manufacturer's representatives.
   9. Training of OWNER's personnel.
   10. Final testing requirements for the complete facility.

B. Related sections:
   1. Section 01 32 00 – Construction Progress Documentation.
   2. Division 26 Electrical Sections.

1.2 GENERAL TESTING, TRAINING, AND START-UP REQUIREMENTS

A. Contract Requirements: Testing, training, and start-up are requisite to the satisfactory completion of the Contract.

B. Perform clean water testing on all constructed facilities.

C. Complete testing, training, and start-up within the Contract Times.

D. Allow realistic durations in the Progress Schedule for testing, training, and start-up activities.

E. Furnish labor, power, chemicals, tools, equipment, instruments, and services required for and incidental to completing functional testing, performance testing, and operational testing.

F. Provide competent, experienced technical representatives of equipment manufacturers for assembly, installation and testing guidance, and operator training.

1.3 START-UP PLAN

A. Submit start-up plan for each piece of equipment and each system not less than 3 weeks prior to planned initial start-up of equipment or system.

B. Provide detailed sub-network of Progress Schedule with the following activities identified:
   1. Manufacturer's services.
   2. Installation certifications.
   3. Operator training.
   4. Submission of Operation and Maintenance Manual.
   5. Functional testing.
   6. Performance testing.
   7. Operational testing.

C. Provide testing plan with test logs for each item of equipment and each system when specified. Include testing of alarms, control circuits, capacities, speeds, flows, pressures, vibrations, sound levels, and other parameters.

D. Provide summary of shutdown requirements for existing systems which are necessary to complete start-up of new equipment and systems.

E. Revise and update start-up plan based upon review comments, actual progress, or to accommodate changes in the sequence of activities.

1.4 PERFORMANCE TESTING

A. Test equipment for proper performance at point of manufacture or assembly when specified.

B. When Source Quality Control Testing is Specified:
1. Demonstrate equipment meets specified performance requirements.
2. Provide certified copies of test results.
3. Do not ship equipment until certified copies have received written acceptance from ENGINEER. Written acceptance does not constitute final acceptance.
4. Perform testing as specified in the equipment specification sections.

C. Include costs associated with witnessing performance tests in the bid price. Include costs for one (1) OWNER's representative for travel, lodging, transportation to and from lodging, and $50 (50 Dollars) for meal allowance per person per day.

1.5 GENERAL START-UP AND TESTING PROCEDURES

A. Mechanical Systems: As specified in the individual equipment specification sections:
1. Remove rust preventatives and oils applied to protect equipment during construction.
2. Flush lubrication systems and dispose of flushing oils. Recharge lubrication system with lubricant recommended by manufacturer.
3. Flush fuel system and provide fuel for testing and start-up.
4. Install and adjust packing, mechanical seals, O-rings, and other seals. Replace defective seals.
5. Remove temporary supports, bracing, or other foreign objects installed to prevent damage during shipment, storage, and erection.
6. Check rotating machinery for correct direction of rotation and for freedom of moving parts before connecting driver.
7. Perform cold alignment and hot alignment to manufacturer's tolerances.
8. Adjust V-belt tension and variable pitch sheaves.
9. Inspect hand and motorized valves for proper adjustment. Tighten packing glands to insure no leakage, but permit valve stems to rotate without galling. Verify valve seats are positioned for proper flow direction.
10. Tighten leaking flanges or replace flange gasket. Inspect screwed joints for leakage.
11. Install gratings, safety chains, handrails, shaft guards, and sidewalks prior to operational testing.

B. Electrical Systems: As specified in Division 26 and the individual equipment specification sections:
1. Perform insulation resistance tests on wiring except 120 volt lighting, wiring, and control wiring inside electrical panels.
2. Perform continuity tests on grounding systems.
3. Test and set switchgear and circuit breaker relays for proper operation.
4. Perform direct current high potential tests on all cables that will operate at more than 2,000 volts. Obtain services of independent testing lab to perform tests.

5. Check motors for actual full load amperage draw. Compare to nameplate value.

C. Instrumentation Systems: As specified in Division 26 and the individual equipment specification sections:
   1. Bench or field calibrate instruments and make required adjustments and control point settings.
   2. Leak test pneumatic controls and instrument air piping.
   3. Energize transmitting and control signal systems, verify proper operation, ranges and settings.

1.6 FUNCTIONAL TESTING

A. Perform checkout and performance testing as specified in the individual equipment specification sections.

B. Functionally test mechanical and electrical equipment, and instrumentation and controls systems for proper operation after general start-up and testing tasks have been completed.

C. Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration. Perform initial checks in the presence of and with the assistance of the manufacturer's representative.

D. Demonstrate proper operation of each instrument loop function including alarms, local and remote controls, instrumentation and other equipment functions. Generate signals with test equipment to simulate operating conditions in each control mode.

E. Conduct continuous 8-hour test under full load conditions. Replace parts which operate improperly.

1.7 CLEAN WATER TESTING

A. Perform checkout and performance testing as specified in the individual equipment specification sections.

B. Fill all facilities with clean water or secondary effluent.
   1. Contractor shall coordinate with Owner for availability of water source. Generally, this water shall be available at the plant’s effluent. Contractor shall be responsible for transporting clean water from the plant’s effluent to the facility to be tested.
   2. Contractor shall be responsible for providing all temporary piping, hoses, pumps and temporary power to pump clean water to the facility to be tested.

C. Operate facilities successfully for 72 hours (3 days) continuously.

D. Contractor shall be responsible for providing, installing, and removing all temporary piping and valving required to perform Clean Water Testing for each facility.

E. Functionally test mechanical and electrical equipment, and instrumentation and controls systems for proper operation after general start-up and testing tasks have been completed.

F. Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration. Perform initial checks in the presence of and with the assistance of the manufacturer's representative.

G. Demonstrate proper operation of each instrument loop function including alarms, local and remote controls, instrumentation, and other equipment functions. Generate signals with test equipment to simulate operating conditions in each control mode.

H. Conduct continuous 24-hour test under full load conditions. Replace parts which operate improperly.

I. Following successful testing, Contractor shall coordinate removal of test water from tested facilities with Owner, develop a mutually acceptable schedule to bleed the test water in the existing plant stream. Contractor shall provide and operate all equipment and piping required to remove the test water from the tested facilities. Contractor shall not direct test water to the plant's process stream without the Owner's authorization. Contractor shall not direct test water to the plant's process stream in such a manner to provide an upset, an overloading or disruption to the plant's operations without the Owner's authorization.

1.8 OPERATIONAL TESTING

A. After completion of operator training, conduct operational test of the entire facility. Demonstrate satisfactory operation of equipment and systems in actual operation.

B. Conduct operational test for continuous 7-day period.

C. OWNER will provide operations personnel, power, fuel, and other consumables for duration of each specified test.

D. Immediately correct defects in material, workmanship, or equipment which became evident during operational test.

E. Repeat operational test when malfunctions or deficiencies cause shutdown or partial operation of the facility or results in performance that is less than specified.

1.9 CERTIFICATE OF PROPER INSTALLATION

A. At completion of Functional Testing, furnish written report prepared and signed by manufacturer's authorized representative, certifying equipment:
   1. Has been properly installed, adjusted, aligned, and lubricated.
   2. Is free of any stresses imposed by connecting piping or anchor bolts.
   3. Is suitable for satisfactory full-time operation under full load conditions.
   4. Operates within the allowable limits for vibration.
   5. Controls, protective devices, instrumentation, and control panels furnished as part of the equipment package are properly installed, calibrated, and functioning.
   6. Control logic for start-up, shutdown, sequencing, interlocks, and emergency shutdown have been tested and are properly functioning.

B. Furnish written report prepared and signed by the electrical and/or instrumentation subcontractor certifying:
   1. Motor control logic that resides in motor control centers, control panels, and circuit boards furnished by the electrical and/or instrumentation subcontractor has been calibrated and tested and is properly operating.
   2. Control logic for equipment start-up, shutdown, sequencing, interlocks and emergency shutdown has been tested and is properly operating.
   3. Co-sign the reports along with the manufacturer's representative and subcontractors.

1.10 TRAINING OF OWNER'S PERSONNEL

A. Provide operations and maintenance training for items of mechanical, electrical and instrumentation equipment. Utilize manufacturer's representatives to conduct training sessions.

B. Coordinate training sessions to prevent overlapping sessions. Arrange sessions so that individual operators and maintenance technicians do not attend more than 2 sessions per week.

C. Provide Operation and Maintenance Manual for specific pieces of equipment or systems 1 month prior to training session for that piece of equipment or system.

D. Satisfactorily complete functional testing before beginning operator training.

E. Provide training sessions for each work shift listed below during the time periods shown. Pooling of shifts will not be permitted unless accepted by OWNER.

Shift		
Day	Tuesday, 7 a.m.-11 a.m.	Thursday, 7 a.m.-11 a.m.
Swing	Wednesday, 3 p.m.-7 p.m.	Thursday, 3 p.m.-7 p.m.
Graveyard	Not required	Not required

F. Training Sessions: Provide training sessions for equipment as specified in the individual equipment specification sections.

G. The CONTRACTOR shall video all training sessions and provide a copy for the OWNER.

H. The CONTRACTOR shall designate and provide one or more persons to be responsible for coordinating and expediting his/her training duties. The person or persons so designated shall be present at all training coordination meetings with the OWNER.

I. The CONTRACTOR's coordinator shall coordinate the training periods with OWNER personnel and manufacturer's representatives, and shall submit a training schedule for each piece of equipment or system for which training is to be provided. Such training schedule shall be submitted not less than 21 calendar days prior to the time that the associated training is to be provided and shall be based on the current plan of operation.

1.11 RECORD KEEPING

A. Maintain and submit following records generated during start-up and testing phase of Project:
   1. Daily logs of equipment testing identifying all tests conducted and outcome.
   2. Logs of time spent by manufacturer's representatives performing services on the job site.
   3. Equipment lubrication records.
   4. Electrical phase, voltage, and amperage measurements.
   5. Insulation resistance measurements.
   6. Data sheets of control loop testing including testing and calibration of instrumentation devices and setpoints.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 77 00 – CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes description and requirements of the required closeout procedures for the project:
   1. Providing and delivering informational submittals.
   2. Preparing, maintaining, providing and delivering Record Documents.
   3. Furnishing Releases from Agreements.
   4. Furnishing Evidence of Compliance with Requirements of Governing Authorities.
   5. Providing Warranties and Bonds.
   6. Providing Certificate of Final Completion.

B. Related sections:
   1. 01 29 00 – Payment Procedures.
   2. 01 32 00 – Construction Progress Documentation.
   3. 01 72 20 – Field Engineering.
   4. 01 78 23 – Operation and Maintenance Data.
   5. 01 79 00 – Demonstration and Training.

1.2 SUBMITTALS

A. Informational Submittals:
   1. Submit Prior to Application for Final Payment.
      a. Record Documents: As required in General Conditions.
      b. Approved Shop Drawings and Samples: As required in the General Conditions.
      c. Operations and Maintenance Manuals: In accordance with Section 01 78 23, and as required in individual Specification sections.
      d. Certificates of Testing and Inspection: As required in the General Conditions, these General Requirements sections, and the individual Specifications sections.
      e. Training Sessions: In accordance with Section 01 79 00, and individual Specifications sections.
      f. Certificate of Substantial Completion.
      g. Special bonds, Special Guarantees, and Service Agreements.
   2. Form of Submittal:
      a. Bind in commercial quality 8-1/2” by 11” three ring, side binders with hardback, cleanable, plastic covers.
         1). Label cover of each binder with typed or printed title Warranties and Bonds, with title of Project; name; address, and telephone number of Contractor and equipment Supplier, and name of responsible principal.
         2). Table of Contents: Neatly typed, in the sequence of the of the Project Manual, with each item identified with the number and title of the Specification section in which specified, and the name of the product or Work item.
         3). Separate each warranty or Bond with index tab sheets keyed to the Table of Contents. Provide full information, using separate typed sheets as necessary. List Subcontractor, Supplier, and Manufacturer, with name, address, and telephone number of responsible contact for service and warranty issues.
   3. Preparation of Submittal:
      a. Obtain notarized warranties and Bonds, executed in duplicate by responsible Subcontractor, Supplier, and Manufacturer, within 10 days after completion of the applicable item or Work, except for items put into use with Owner’s permission, leave date of beginning of time warranty until date of Substantial Completion is determined.
   4. Time of Submission: Submit within 10 days after the date of Date of Substantial Completion and prior to submission of Final Application of Payment.

a. Spare parts and special tools as required by individual Specification sections.
b. Consent of Surety to Final Payment: As required in General Conditions.
c. Releases or Waivers of Liens and Claims: As required in General Conditions.
d. Releases from Agreements.
e. Final Application for Payment: Submit in accordance with procedures and requirements stated in Section 01 29 00.
f. Extra Materials: As required by individual Specification sections.

1.3 RECORD DOCUMENTS

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

1.4 RELEASES FROM AGREEMENTS

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

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

1.5 EVIDENCE OF COMPLIANCE WITH REQUIREMENTS OF GOVERNING AUTHORITIES

A. Submit the Following:
1. Certificate of Occupancy.
2. Certificates of Inspection:
a. Mechanical.

b. Electrical.

1.6 WARRANTIES AND BONDS

A. Provide executed Warranty or Guaranty Form if required by Contract Documents.

B. Provide specified additional warranties, guarantees, and bonds from manufacturers and suppliers.

1.7 CERTIFICATE OF FINAL COMPLETION

A. When 7-day operational test has been successfully completed, ENGINEER will certify that new facilities are operationally complete. ENGINEER will submit a list of known items (punch list) still to be completed or corrected prior to contract completion.

B. List of items to be completed or corrected will be amended as items are resolved by CONTRACTOR.

C. When all items have been completed or corrected, submit written certification that the entire work is complete in accordance with the Contract Documents and request final inspection.

D. Upon completion of final inspection, ENGINEER will either prepare a written acceptance of the entire work or advise CONTRACTOR of work not complete. If necessary, inspection procedures will be repeated.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 MAINTENANCE OF RECORD DOCUMENTS

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

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

C. Making Entries on Drawings:
1. Use an erasable colored pencil (not ink or indelible pencil), clearly describe change by graphic line and note as required.
a. Make annotations with erasable colored pencil conforming to the following color code:

Additions:	Red
Deletions:	Green
Comments	Blue

Dimensions:	Graphite

2. Date entries.
3. Call attention to entry by “cloud” drawn around area or areas affected.
4. Legibly mark to record actual changes made during construction, including, but not limited to:
5. Depths of various elements of foundation in relation to finished first floor data if not shown or where depth differs from that shown.
6. Horizontal and vertical locations of existing and new Underground Facilities and appurtenances, and other underground structures, equipment, or Work, and Reference to at least two measurements to permanent surface improvements.
7. Location of internal utilities and appurtenances concealed in the construction referenced to visible and accessible features of the structure.
8. Locate existing facilities, piping, equipment, and items critical to the interface between existing physical conditions or construction and new construction.
9. Changes made by Addenda and Field Orders, Work Change Directive, Change Order, and Engineer’s written interpretation and clarification using consistent symbols for each and showing appropriate document tracking number.
10. Dimensions on Schematic Layouts: Show on record drawings, by dimension, the centerline of each run of items that are described in previous subparagraph above.
11. Clearly identify the item by accurate note such as “cast iron drain,” “galv. water,” and the like.
12. Show, by symbol or note, vertical location of item (“under slab,” “in ceiling plenum,” “exposed,” and the like).
13. Make identification so descriptive that it may be related reliably to Specifications.
14. Mark and record field changes and detailed information contained in submittals and change orders.
15. Record actual depths, horizontal and vertical location of underground pipes, duct banks and other buried utilities. Reference dimensions to permanent surface features.
16. Identify specific details of pipe connections, location of existing buried features located during excavation, and the final locations of piping, equipment, electrical conduits, manholes, and pull boxes.
17. Identify location of spare conduits including beginning, ending and routing through pull boxes, and manholes. Record spare conductors, including number and size, within spare conduits, and filled conduits.
18. Provide schedules, lists, layout drawings, and wiring diagrams.

D. Maintain Documents Separate From Those Used for Construction:
   1. Label documents "RECORD DOCUMENTS."

E. Keep Documents Current:
   1. Record required information at the time the material and equipment is installed and before permanently concealing.

F. Deliver record documents with transmittal letter containing date, Project title, CONTRACTOR's name and address, list of documents, and signature of CONTRACTOR.

G. During progress meetings, record documents will be reviewed to ascertain that changes have been recorded.

H. Final Schedule Submittal in accordance with Section 01 32 00.

3.2 FINAL CLEANING

A. At completion of the Work or of a part thereof and immediately prior to Contractor's request for certificate of Substantial Completion; or if no certificate is issued, immediately prior to Contractor's notice of completion, clean entire Site or parts thereof, as applicable.
   1. Leave the Work and adjacent areas affected in a cleaned condition satisfactory to Owner.
   2. Remove grease, dirt, dust, paint or plaster splatter, stains, labels, fingerprints, and other foreign materials from exposed surfaces.
   3. Repair, patch, and touch up marred surfaces to specified finish and match adjacent surfaces.
   4. Clean all windows.
   5. Clean and wax wood, vinyl, or painted floors.
   6. Broom clean exterior paved driveways and parking areas.
   7. Hose clean sidewalks, loading areas, and others contiguous with principal structures.
   8. Rake and clean all other surfaces.
   9. Remove snow and ice from access to buildings.
   10. Replace air-handling filters and clean ducts, blowers, and coils of ventilation units operated during construction.
   11. Leave water courses, gutters, and ditches open and clean.
   12. Perform final cleaning prior to inspections for Final Acceptance.
   13. Employ skilled workers who are experienced in cleaning operations.
   14. Use cleaning materials which are recommended by manufacturers of surfaces to be cleaned.
   15. Prevent scratching, discoloring, and otherwise damaging surfaces being cleaned.
   16. Clean roofs, gutters, downspouts, and drainage systems.
   17. Broom clean exterior paved surfaces and rake clean other surfaces of site work:
       a. Police yards and grounds to keep clean.
   18. Remove dust, cobwebs, and traces of insects and dirt.
   19. Clean grease, mastic, adhesives, dust, dirt, stains, fingerprints, paint, blemishes, sealants, plaster, concrete, and other foreign materials from sight-exposed surfaces, and fixtures and equipment.
   20. Remove non-permanent protection and labels.
   21. Polish waxed woodwork and finish hardware.
   22. Wash tile.
   23. Wax and buff hard floors, as applicable.
   24. Wash and polish glass, inside and outside.
   25. Wash and shine mirrors.
   26. Polish glossy surfaces to clear shine.
   27. Vacuum carpeted and soft surfaces.
   28. Clean permanent filters and replace disposable filters when heating, ventilation, and air conditioning units were operated during construction.
   29. Clean ducts, blowers and coils when units were operated without filters during construction.
   30. Clean light fixtures and replace burned-out or dim lamps.

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

3.3 WASTE DISPOSAL

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

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

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

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

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

3.4 TOUCH-UP AND REPAIR

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

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

3.5 FINAL CLEANING AND DISINFECTION OF SYSTEMS OF PLANT FACILITIES

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

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

C. Disinfect piping intended to carry potable water as follows or in accordance with American Water Works Association Standards.

D. Provide ample sampling outlets in pipe for testing.

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

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

3.6 FINAL CLEANING AND DISINFECTION OF SYSTEMS OF POTABLE WATER MAINS

A. Clean interior of pipe and fittings.

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

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

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

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

3.7 CLOSEOUT DOCUMENTS

A. Submit following Closeout Submittals upon completion of the Work and at least 7 days prior to submitting Application for Final Payment:
   1. Evidence of Compliance with Requirements of Governing Authorities.
   2. Project Record Documents.
   3. Operation and Maintenance Manuals.
   4. Warranties and Bonds.
   5. Keys and Keying Schedule.

6. Evidence of Payment and Release of Stop Payment Notices as outlined in Conditions of the Contract.
7. Release of claims as outlined in Conditions of the Contract.
8. Survey Record Documents as specified in Section 01 72 20.
9. Certificate of Final Completion.

END OF SECTION

SECTION 01 78 23 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

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

B. Related sections:
   1. Section 01 77 00 – Closeout Procedures.

1.2 DEFINITIONS

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

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

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

1.3 SEQUENCING AND SCHEDULING

A. Equipment and System Data:
   1. Preliminary Data:
      a. Do not submit until Shop Drawing for equipment or system has been reviewed and approved by Engineer.
      b. Submit prior to shipment date.
   2. Final Data:
      a. Submit Instructional Manual Formatted data not less than 30 days prior to equipment or system field functional testing.

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

1.4 DATA FORMAT

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

B. Instructional Manual Format:
   1. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.
   2. Size: 8-1/2" x 11" minimum.
   3. Cover: Identify manual with typed or printed title "OPERATION AND MAINTENANCE DATA" and list:
      a. Project title.
      b. Designate applicable system, equipment, material, or finish.
      c. Identity of separate structure as applicable.
      d. Identity of general subject matter covered in manual.
      e. Identity of equipment number and Specification section.
   4. Title Page:

a. Contractor name, address, and telephone number.
b. Subcontractor, Supplier, installer, or maintenance contractor's name, address, and telephone number, as appropriate.
1). Identify area of responsibility of each.
2). Provide name and telephone number of local source of supply for parts and replacement.

5. Table of Contents:
a. Neatly typewritten and arranged in systematic order with consecutive page numbers.
b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.

6. Paper: 20-pound minimum, white for typed pages.
7. Text: Manufacturer's printed data, or neatly typewritten.
8. Three-hole punched data for binding and composition; arrange printing so that punched holes do not obliterate data.
9. Material shall be suitable for reproduction, with quality equal to original. Photocopying of material will be acceptable, except for material containing photographs.

C. Electronic Media Format:
1. Portable Document Format (PDF):
a. After all preliminary data has been found to be acceptable to Engineer, submit Operation and Maintenance data in PDF format on CD.
b. Files to be exact duplicates of Engineer-accepted preliminary data. Arrange by specification number and name.
c. Files to be fully functional and viewable in most recent version of Adobe Acrobat.

1.5 SUBMITTALS

A. Procedures of Submittal
1. Contractor shall:
a. Submit all submittals electronically using the ***Info Exchange*** project website to facilitate the transfer of submittals and related files.
b. Submit all required final hard copies and required electronic copies as specified herein.

B. Informational:
1. Data Outline: Submit one electronic copy via the ***Info Exchange*** website of a detailed outline of proposed organization and contents of Final Data prior to preparation of Preliminary Data.
2. Preliminary Data:
a. Submit one electronic copy for Engineer's review.
b. If data meets conditions of the Contract:
1). One electronic copy will be returned to Contractor.
2). One electronic copy will be forwarded to Resident Project Representative.
3). One electronic copy will be retained in Engineer's file
c. If data does not meet conditions of the Contract:
1). One electronic copy will be returned to Contractor with Engineer's comments (on separate document) for revision.
2). Engineer's comments will be retained in Engineer's file.
3). One electronic copy will be retained in Engineer's file.
4). Re-submit one electronic copy revised in accordance with Engineer's comments.
3. Final Data: Submit two hard copies and one electronic copy in each format specified herein.

1.6 DATA FOR EQUIPMENT AND SYSTEMS

A. Content for Each Unit (or Common Units) and System:
   1. Product Data:
      a. Include only those sheets that are pertinent to specific product.
      b. Clearly annotate each sheet to:
         1). Identify specific product or part installed.
         2). Identify data applicable to installation.
         3). Delete references to inapplicable information.
      c. Function, normal operating characteristics, and limiting conditions.
      d. Performance curves, engineering data, nameplate data, and tests.
      e. Complete nomenclature and commercial number of replaceable parts.
      f. Original Manufacturer's parts list, illustrations, detailed assembly drawings showing each part with part numbers and sequentially numbered parts list, and diagrams required for maintenance.
      g. Spare parts ordering instructions.
      h. Where applicable, identify installed spares and other provisions for future work (e.g., reserved panel space, unused components, wiring, and terminals).
   2. As-installed, color-coded piping diagrams.
   3. Charts of valve tag numbers, with the location and function of each valve.
   4. Drawings: Supplement product data with Drawings as necessary to clearly illustrate:
      a. Format:
         1). Provide reinforced, punched, binder tab; bind in with text.
         2). Reduced to 8-1/2" x 11", or 11" x 17" folded to 8-1/2" x 11".
         3). Where reduction is impractical, fold and place in 8-1/2" x 11" envelopes bound in text.
         4). Identify Specification section and product on Drawings and envelopes.
      b. Relations of component parts of equipment and systems.
      c. Control and flow diagrams.
      d. Coordinate drawings with Project record documents to assure correct illustration of completed installation.
   5. Instructions and Procedures: Within text, as required to supplement product data.
      a. Format:
         1). Organize in consistent format under separate heading for each different procedure.
         2). Provide logical sequence of instructions for each procedure.
         3). Provide information sheet for Owner's personnel, including:
            a). Proper procedures in event of failure.
            b). Instances that might affect validity of guarantee or Bond.
      b. Installation Instructions: Including alignment, adjusting, calibrating, and checking.
      c. Operating Procedures:
         1). Startup, break-in, routine, and normal operating instructions.
         2). Test procedures and results of factory tests where required.
         3). Regulation, control, stopping, and emergency instructions.
         4). Description of operation sequence by control Manufacturer.
         5). Shutdown instructions for both short and extended duration.
         6). Summer and winter operating instructions, as applicable.
         7). Safety precautions.
         8). Special operating instructions.
      d. Maintenance and Overhaul Procedures:
         1). Routine maintenance.
         2). Guide to troubleshooting.
         3). Disassembly, removal, repair, reinstallation, and re-assembly.
   6. Guarantee, Bond, and Service Agreement: In accordance with Section 01 77 00, CLOSEOUT PROCEDURES.

B. Content for Each Electric or Electronic Item or System:
   1. Description of Unit and Component Parts:
      a. Function, normal operating characteristics, and limiting conditions.
      b. Performance curves, engineering data, nameplate data, and tests.
      c. Complete nomenclature and commercial number of replaceable parts.
      d. Interconnection wiring diagrams, including control and lighting systems.
   2. Circuit Directories of Panelboards:
      a. Electrical service.
      b. Controls.
      c. Communications.
   3. List of electrical relay settings, and control and alarm contact settings.
   4. Electrical interconnection wiring diagram, including control and lighting systems.
   5. As-installed control diagrams by control Manufacturer.
   6. Operating Procedures:
      a. Routine and normal operating instructions.
      b. Sequences required.
      c. Safety precautions.
      d. Special operating instructions.
   7. Maintenance Procedures:
      a. Routine maintenance.
      b. Guide to troubleshooting.
      c. Adjustment and checking.
      d. List of relay settings, control and alarm contact settings.
   8. Manufacturer's printed operating and maintenance instructions.
   9. List of original Manufacturer's spare parts, Manufacturer's current prices, and recommended quantities to be maintained in storage.

C. Maintenance Summary:
   1. Compile individual Maintenance Summary for each applicable equipment item, respective unit or system, and for components or sub-units.
   2. Format: Use only 8-1/2" x 11" size paper.
   3. Include detailed lubrication instructions and diagrams showing points to be greased or oiled; recommend type, grade, and temperature range of lubricants and frequency of lubrication.
   4. Recommended Spare Parts:
      a. Data to be consistent with Manufacturer's Bill of Materials/Parts List furnished in O&M manuals.
      b. "Unit" is the unit of measure for ordering the part.
      c. "Quantity" is the number of units recommended.
      d. "Unit Cost" is the current purchase price.

1.7 DATA FOR MATERIALS AND FINISHES

A. Content for Architectural Products, Applied Materials, and Finishes:
   1. Manufacturer's data, giving full information on products:
      a. Catalog number, size, and composition.
      b. Color and texture designations.
      c. Information required for reordering special-manufactured products.
   2. Instructions for Care and Maintenance:
      a. Manufacturer's recommendation for types of cleaning agents and methods.
      b. Cautions against cleaning agents and methods that are detrimental to product.
      c. Recommended schedule for cleaning and maintenance.
   3. Content for Moisture Protection and Weather Exposed Products:
   4. Manufacturer's data, giving full information on products:
      a. Applicable standards.
      b. Chemical composition.

c. Details of installation.

5. Instructions for inspection, maintenance, and repair.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 79 00 – DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes description and requirements of the required demonstration and training for the project:
   1. Providing and delivering informational submittals.
   2. Submitting required qualifications of Manufacturer's Representative.
   3. Preparing, maintaining, providing and delivering Manufacturer's Certificate of Compliance and Manufacturer's Certificate of Proper Installation.
   4. Furnishing required Training.
   5. Furnishing required Equipment Testing, Unit Process and Facility Performance Demonstration.

B. Related Sections
   1. Section 01 31 19 – Project Meetings.
   2. Section 01 32 00 – Construction Progress Documentation.
   3. Section 01 78 23 – Operation and Maintenance Data.

1.2 DEFINITIONS

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

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

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

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

E. Unit Process: As used in this Section, a unit process is a portion of the facility that performs a specific process function, such as, but not limited to:
   1. Persigo Wastewater Treatment Plant Biotrickling Filter
   2. Persigo Wastewater Treatment Plant Parshall Flume
   3. Persigo Wash Air Jumper
   4. Dos Rios Biotrickling Filter
   5. Dos Rios Carbon Absorption Unit
   6. Dos Rios Sump Pump Station

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

1.3 SUBMITTALS

A. Informational Submittals:
   1. Training Schedule: Submit not less than 21 days prior to start of equipment installation and revise as necessary for acceptance.
   2. Lesson Plan: Submit proposed lesson plan not less than 21 days prior to scheduled training and revise as necessary for acceptance.
   3. Training Session Tapes: Furnish Owner with two complete sets of DVDs fully indexed and cataloged with printed label stating session and date taped.
   4. Facility Startup and Performance Demonstration Plan.
   5. Functional and performance test results.
   6. Completed Unit Process Startup Form for each unit process.
   7. Completed Facility Performance Demonstration/Certification Form.

1.4 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

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

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

1.5 FACILITY STARTUP AND PERFORMANCE DEMONSTRATION PLAN

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

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

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

C. Schedule Manufacturer's services to avoid conflict with other onsite testing or other Manufacturer's onsite services.

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

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

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

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

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

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

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

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

3.2 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

A. When specified in individual Specification section, submit prior to shipment of product or material.

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

C. Signed by product Manufacturer certifying that product or material specified conforms to or exceeds specified. Attach supporting reference data, affidavits, and certifications as appropriate.

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

3.3 MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

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

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

3.4 TRAINING

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

B. Training Schedule:
   1. List specified equipment and systems that require training services and show:
      a. Respective Manufacturer.
      b. Estimated dates for installation completion.
      c. Estimated training dates.
   2. Allow for multiple sessions when several shifts are involved.
   3. Adjust schedule to ensure training of appropriate personnel as deemed necessary by Owner, and to allow full participation by Manufacturer's representatives. Adjust schedule for interruptions in operability of equipment.
   4. Coordinate with Section 01 32 00, CONSTRUCTION PROGRESS DOCUMENTATION.

C. Lesson Plan: When Manufacturer or vendor training of Owner personnel is specified, prepare for each required course, containing the following minimum information:
   1. Title and objectives.
   2. Recommended types of attendees (e.g., managers, engineers, operators, maintenance).

3. Course description and outline of course content.
4. Format (e.g., lecture, self-study, demonstration, hands-on).
5. Instruction materials and equipment requirements.
6. Resumes of instructors providing the training.

D. Pre-startup Training:
1. Coordinate training sessions with Owner's operating personnel and Manufacturer's representatives, and with submission of operation and maintenance manuals in accordance with Section 01 78 23, OPERATIONS AND MAINTENANCE DATA.
2. Complete at least 14 days prior to beginning of facility startup.

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

F. Taping of Training Sessions:
1. Furnish audio and color video taping of all instruction sessions, including Manufacturer's representatives, hands-on equipment instruction and classroom sessions.
2. Video training DVDs shall be produced by a qualified, professional video specialist approved by Owner.
3. Use DVD format, suitable for playback on standard equipment available commercially in the United States.

3.5 EQUIPMENT TESTING

A. Preparation:
1. Complete installation before testing.
2. Furnish qualified Manufacturer's representatives, when required by individual Specification sections.
3. Obtain and submit from equipment Manufacturer's representative Manufacturer's Certificate of Proper Installation Form when required by individual Specification sections.
4. Equipment Test Report Form: Provide written test report for each item of equipment to be tested, to include the minimum information:
   a. Owner/Project Name.
   b. Equipment or item tested.
   c. Date and time of test.
   d. Type of test performed (Functional or Performance).
   e. Test method.
   f. Test conditions.
   g. Test results.
   h. Signature spaces for Contractor and Engineer as witness.
5. Cleaning and Checking: Prior to beginning functional testing:
   a. Calibrate testing equipment in accordance with Manufacturer's instructions.
   b. Inspect and clean equipment, devices, connected piping, and structures to ensure they are free of foreign material.
   c. Lubricate equipment in accordance with Manufacturer's instructions.
   d. Turn rotating equipment by hand when possible to confirm that equipment is not bound.
   e. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
   f. Check power supply to electric-powered equipment for correct voltage.
   g. Adjust clearances and torque.
   h. Test piping for leaks.
6. Ready-to-test determination will be by Engineer-based at least on the following:
   a. Acceptable Operation and Maintenance Data.
   b. Notification by Contractor of equipment readiness for testing.
   c. Receipt of Manufacturer's Certificate of Proper Installation, if so specified.

d. Adequate completion of work adjacent to, or interfacing with, equipment to be tested.
e. Availability and acceptability of Manufacturer's representative, when specified, to assist in testing of respective equipment.
f. Satisfactory fulfillment of other specified Manufacturer's responsibilities.
g. Equipment and electrical tagging complete.
h. Delivery of all spare parts and special tools.

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

C. Performance Testing:
1. Conduct as specified in individual Specification sections.
2. Notify Engineer and Owner in writing at least 10 days prior to scheduled date of test.
3. Performance testing shall not commence until equipment has been accepted by Engineer as having satisfied functional test requirements specified.
4. Type of fluid, gas, or solid for testing shall be as specified.
5. Unless otherwise indicated, furnish labor, materials, and supplies for conducting the test and taking samples and performance measurements.
6. Prepare Equipment Test Report summarizing test method and results.
7. When, in Engineer's opinion, equipment meets performance requirements specified, such equipment will be accepted as to conforming to Contract requirements. Such acceptance will be evidenced by Engineer's signature on Equipment Test Report.

3.6 STARTUP OF UNIT PROCESSES

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

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

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

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

E. Significant Interruption: May include any of the following events:
1. Failure of Contractor to provide and maintain qualified onsite startup personnel as scheduled.
2. Failure to meet specified functional operation for more than 2 consecutive hours.
3. Failure of any critical equipment or unit process that is not satisfactorily corrected within 5 hours after failure.
4. Failure of any non-critical equipment or unit process that is not satisfactorily corrected within 8 hours after failure.
5. As determined by Engineer.

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

3.7 FACILITY PERFORMANCE DEMONSTRATION

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

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

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

D. Document, as defined in Facility Startup and Performance Demonstration Plan, the performance of the facility.

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

3.8 SUPPLEMENTS

A. Supplements listed below, following “End of Section”, are a part of this Specification:
   1. Manufacturer’s Certificate of Proper Installation Form.
   2. Unit Process Startup Form.
   3. Facility Performance Demonstration/Certification Form.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

OWNER: _____ EQUIP. SERIAL NO: _____

EQUIP. TAG NO: _____ EQUIP. SYSTEM: _____

PROJECT NO: _____ SPEC. SECTION: _____

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

(Check Applicable)

	Installed in accordance with Manufacturer's recommendations.
	Inspected, checked, and adjusted.
	Serviced wit proper initial lubricants.
	Electrical and mechanical connections meet quality and safety standards.
	All applicable safety equipment has been properly installed.
	Functional tests.
	System has been performance tested, and meets or exceeds specified performance requirements. (When complete system of one manufacturer)

Note: Attach any performance test documentation from manufacturer.

Comments:

_____
_____
_____
_____
_____
_____

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

Date: _____, 20___.

Manufacturer: _____

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

UNIT PROCESS STARTUP FORM

OWNER: _____ PROJECT: _____

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

_____

_____

_____

_____

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

_____

_____

_____

_____

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

_____

_____

_____

Evaluation Comments:

_____

_____

_____

_____

FACILITY PERFORMANCE DEMONSTRATION/CERTIFICATION FORM

OWNER: _____ PROJECT: _____

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

_____

_____

_____

_____

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

_____

_____

_____

_____

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

Contractor: _____ Date: _____, 20 ___

Engineer: _____ Date: _____, 20 ___

SECTION 01 80 01 – COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Responsibilities of the OWNER, ENGINEER, and CONTRACTOR during the Commissioning Phase of the Project.

B. Related sections:
   1. Section 01 75 60 – Testing, Training, and Facility Start-Up.

1.2 DEFINITIONS

A. Commissioning: The sequential process in which a newly constructed facility, comprised of concrete basins interconnected with hydraulic conveyance structures and equipped with miscellaneous process oriented equipment, is put into successful operation.

B. Automatic/SCADA Operational Mode: The definition of the automatic/SCADA operational mode centers around the designed remote control and monitoring capability of the control system.

C. Facility Start-Up.

D. Manual Operational Mode: This operational mode represents the lowest level of control philosophy utilized in the plant instrumentation and control design. For all practical purposes, this means that an operational control decision requiring equipment or process monitoring and/or control will require an individual to physically go to the local control for the associated task in order to operate the facility. Normal prestart-up activities of exercising of the equipment is traditionally accomplished in this mode. In the manual operational mode, the focus will be on verifying that the equipment and processes function correctly, independent of the instrumentation system and control system.

E. Successful Operation: The resultant operation of all the processes and related controls in a manner that is consistent with the design intent and treatment objectives.

1.3 SUBMITTALS

A. Preventive and Unscheduled Maintenance Plan: Submit detailed plan prior to start of 7-day test for providing all preventive and unscheduled maintenance of all equipment and facilities in the plant throughout the entire commissioning phase of the project prior to start of 7-day test.

B. OWNER’s Personnel Training Schedule and Plan: Submit detailed plan and schedule for training OWNER's personnel in accordance with Section 01 75 60, Testing, Training and Facility Start-Up.

1.4 REQUIREMENTS

A. Commissioning Process will commence after successful completion of 7-day test and issuance of Substantial Completion to CONTRACTOR.

B. Commissioning Process will be 30 days in duration.

C. During the course of the Commissioning Process, the ENGINEER and OWNER will evaluate design related issues and recommend design modifications which shall be implemented by the CONTRACTOR through the Change Order process.

1.5 RESPONSIBILITIES

A. Responsibilities listed do not relieve the CONTRACTOR from all other responsibilities and duties associated with project closeout as defined in the OWNER's agreement with the CONTRACTOR and DIVISION 01 of the Specifications.
   1. CONTRACTOR's Responsibilities During the Commissioning Process:
      a. All Change Order work resulting from the evaluation of design-related issues by the ENGINEER and OWNER.
   2. All preventive and unscheduled maintenance of all equipment and facilities in the plant. This shall include, but not be limited to the following:
      a. Providing all lubricants.
      b. Lubrication of all equipment in accordance with manufacturer's recommendations.
      c. Perform all manufacturer recommended preventive maintenance.
      d. Exercise all equipment not in use during Commissioning phase.
      e. Repair all failed equipment.
      f. Periodic check of all equipment alignment, vibration, and noise levels in accordance with Specifications.
      g. Provide all parts required for equipment repair.
      h. Provide all tools and miscellaneous equipment required for equipment repair.
      i. Administration/logging/documentation of all preventive maintenance and repair work.
      j. Cleanup associated with equipment failure and repair.
      k. Daily cleanup of buildings.
      l. Landscaping maintenance.
      m. Roadway cleanup and maintenance.
      n. Replacement of all HVAC filters.
   3. Warranty related issues/items.
   4. OWNER's personnel training required after successful completion of the 7-day testing.
   5. Assist in transition to Automatic/SCADA operational mode.
   6. Other contractual requirements including, but not limited to, incomplete work list.

B. OWNER's Responsibilities During the Commissioning Process:
   1. Provide all chemicals required for plant operations, including scheduling and securing of chemical deliveries to the plant and respective storage tanks.
   2. Perform all laboratory analysis required for plant operations.
   3. Review training schedules and plans, and schedule personnel training.
   4. Assisting ENGINEER in the evaluation of design related issues and recommendations of modifications to be implemented by the CONTRACTOR through the change order process.
   5. Provide staff for Commissioning.
   6. Operation of facilities.

C. ENGINEER's Responsibilities During Commissioning Process:
   1. Provide OWNER with programming support during the Commissioning Process.
   2. Provide liaison and coordination between CONTRACTOR and OWNER's activities.
   3. Administer Change Order work performed by CONTRACTOR.
   4. Provide coordination of all other project closeout related issues/items.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 81 00 – PROJECT DESIGN CRITERIA

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Project design criteria such as temperature and site elevation.

1.2 PROJECT DESIGN CRITERIA

A. All equipment and materials for the project are to be suitable for performance in the wastewater treatment plant environment and under following conditions:
   1. Design temperatures are:
      a. Outdoor temperatures: 15 to 95 degrees Fahrenheit.
      b. Indoor temperatures for the following buildings:
         1) Process areas: 65 to 85 degrees Fahrenheit.
         2) Electrical rooms: 75 to 85 degrees Fahrenheit.
   2. Design 100-year flood elevations are:
      a. Persigo WWTP: 4517.25
      b. Persigo Wash: 4518.50
      c. Dos Rios: 4566.00
   3. Frost line is assumed 40 inches below grade.
   4. Moisture conditions: Defined in individual equipment sections.
   5. Site elevation generally ranges from:
      a. Persigo WWTP: 4521 feet above mean sea level.
      b. Persigo Wash: 4519 feet above mean sea level.
      c. Dos Rios: 4572 feet above mean sea level.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 81 02 – SEISMIC DESIGN CRITERIA

PART 1 - GENERAL

1.1 SUMMARY

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

B. Related sections:
   1. Section 01 41 00 – Regulatory Requirements.

1.2 REFERENCES

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

1.3 SYSTEM DESCRIPTION

A. Design requirements:
   1. Design in accordance with the requirements of the building code as specified in Section 01 41 00:
      a. Soil Site Class: D
      b. Design spectral acceleration at short period, S_{DS}: 0.251g for Persigo WWTP site, 0.253g for Dos Rios site.
      c. Design spectral acceleration at short period, S_{D1}: 0.105g for the Persigo WWTP site, 0.105g for the Dos Rios site.
      d. Seismic Design Category: B
      e. Importance Factor, I: 1.25
      f. Component amplification factor, a_p: In accordance with ASCE 7-16, Tables 13.5 1 and 13.6-1.
      g. Component response modification factor, R_p: In accordance with ASCE 7-16 Tables 13.5-1 and 13.6-1.
      h. Component importance factor, I_p: 1.50.
   2. Do not use friction to resist sliding due to seismic forces.
   3. Do not use more than 60 percent of the weight of the mechanical and electrical equipment for designing anchors for resisting overturning due to seismic forces.
   4. Do not use more than 60 percent of the weight of the tank for resisting overturning due to seismic forces.
   5. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic forces. Anchor bolts used to resist seismic forces shall have a standard hex bolt head embedded in the concrete. Do not use anchor bolts fabricated from rod stock with an L or J shape.
   6. Do not use chemical anchors, concrete anchors, flush shells, powder actuated fasteners, sleeve anchors, or other types of anchors unless indicated on the Drawings or accepted in writing by the ENGINEER.
   7. Seismic forces must be resisted by direct bearing on the fasteners used to resist seismic forces. Do not use connections that use friction to resist seismic forces.

1.4 SUBMITTALS

A. Shop drawings and calculations: Complete shop drawings and seismic calculations.

B. Calculations shall be signed and stamped by a civil or structural engineer licensed in the state where the Project is located.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

SECTION 01 81 04 – WIND DESIGN CRITERIA

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Wind design criteria.

B. Related sections:
   1. Section 01 41 00 – Regulatory Requirements.

1.2 SYSTEM DESCRIPTION

A. Design requirements:
   1. Building code criteria: Design for wind in accordance with building code as specified in Section 01 41 00:
      a. Occupancy category: III.
      b. Basic wind speed: 109 miles per hour.
      c. Exposure category: C.
      d. Topographic factor, K_{zt}: 1.0.
      e. Wind importance factor, I_w: 1.15.
   2. Use anchor bolts, bolts, or welded studs for anchors for resisting wind forces. Anchor bolts used to resist wind forces shall have a standard hex bolt head embedded in the concrete. Do not use anchor bolts fabricated from rod stock with an L or J shape:
      a. Do not use concrete anchors, sleeve anchors, flush shells, chemical anchors, powder actuated fasteners, or other types of anchor unless indicated on the Drawings or accepted in writing by the ENGINEER.
      b. Wind forces must be resisted by direct bearing on the anchors used to resist wind forces. Do not use connections which use friction to resist wind forces.

1.3 SUBMITTALS

A. Shop drawings and calculations: Complete shop drawings and seismic calculations.

B. Calculations shall be signed and stamped by a civil or structural engineer licensed in the state where the Project is located.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

DIVISION 3

CONCRETE

SECTION 03 01 00 - CONCRETE SURFACE REPAIR SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Resurfacing of concrete surfaces in preparation for finish materials.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. T277, Standard Method of Test for Rapid Determination of the Chloride Permeability of Concrete.
   2. ASTM International (ASTM):
      a. A 82, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
      b. A 185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
      c. C 78, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
      d. C 109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.
      e. C 309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
      f. C 348, Standard Test Method for Flexural Strength of Hydraulic Cement Mortars.
      g. C 469, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
      h. C 496, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
      i. C 596, Standard Test Method for Drying Shrinkage of Mortar Containing Portland Cement.
      j. C 666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
      k. C 672, Standard Test Method for Scaling Resistance for Concrete Surfaces Exposed to Deicing Chemicals.
      l. C 779, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.
      m. C 882, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
      n. C 928, Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repair.
      o. C 1012, Standard Test Method for Length Change of Hydraulic Cement Mortars Exposed to a Sulfate Solution.
      p. C 1202, Standard Test Method for Electrical Induction of Concrete's Ability to Resist Chloride Ion Penetration.
      q. E 699, Criteria for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating Building Components in Accordance with Test Methods Promulgated by ASTM Committee.

1.3 DEFINITIONS

A. Low Pressure Spray Mortar: Mortar designated by "S" before the product number, applied by low pressure spraying, or in small areas by hand troweling.

B. Surface Repair Areas: Areas that are deemed to be defective and not meeting the density or surface specified in Section 03 30 00, CAST-IN-PLACE CONCRETE, regardless of depth of the defective area.

1.4 SUBMITTAL

A. Information Submittals:
   1. Mortar System:
      a. Manufacturer's installation bulletin.
      b. Manufacturer's recommended fabric size for mesh reinforcement.
   2. Written description of equipment proposed for hydro-demolition surface preparation.
   3. Certificates:
      a. Certificate of Compliance that proposed product systems meet or exceed specified performance criteria when tested in accordance with Article FIELD QUALITY CONTROL.
      b. Mortar system Manufacturer's Certificate of Proper Installation.
   4. Statements of Qualification:
      a. Independent testing laboratory.
      b. Mortar system Manufacturer's representative.
   5. Mortar system Manufacturer's proposed modified test procedures for ASTM C 109 and ASTM C 882 test methods.
   6. Independent testing laboratory test report.

1.5 QUALITY ASSURANCE

A. Qualifications:
   1. Independent Testing Laboratory: Based on evaluation of laboratory submitted criteria in accordance with ASTM E 699.
   2. Mortar System Applicator: For low pressure spray mortar system in lieu of endorsement, complete mortar system manufacturer's demonstration in accordance with Article MANUFACTURER'S SERVICES.

PART 2 - PRODUCTS

2.1 LOW PRESSURE SPRAY MORTAR SYSTEM (FOR VERTICAL AND OVERHEAD REPAIRS)

A. Mortar:
   1. One component, rheoplastic, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.
   2. Cured materials mixed to a flow of 70%, at five drops shall conform to the following criteria:
      a. Minimum Slant Shear Bond Strength: 3,000 psi in 28 days in accordance with "modified" ASTM C 882 test method.
      b. Minimum Compressive Strength: 11,000 psi at 28 days in accordance with ASTM C 109.
      c. Minimum Direct Shear Bond Strength: 650 psi in 28 days in accordance with Michigan DOT.
      d. Minimum Tensile Bond Strength (MBT In-House Test): 300 psi. in 28 days.
      e. Minimum Flexural Properties: 1,250 psi in 28 days in accordance with ASTM C 348.
      f. Modulus of Elasticity: 4.1 to 4.5 by 106 psi in accordance with ASTM C 469.
      g. Maximum Permeability: 1,000 coulombs in accordance with AASHTO T 277.
      h. System shall not produce a vapor barrier.

B. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only the addition of water.

C. Free of chlorides and other chemicals causing corrosion.

D. Manufacturer and Product:
   1. Master Builders Technologies Co., Cleveland, OH; EMACO S88CA with Concresive liquid (LPL) bonding agent for hand applied areas.
   2. Sika Corp., Lyndhurst, NJ; SikaRepair 224.

2.2 POLYMER-MODIFIED REPAIR MORTAR (HORIZONTAL SURFACE REPAIR)

A. Mortar: One component, polymer-modified, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar conforming to the following properties:
   1. Bond strength in accordance with ASTM C 1042 Test Method at 7 days: Minimum 1,750 psi.
   2. Modules of Elasticity: ASTM C469, minimum 2.0 by 10^6 psi.
   3. Compressive Strength:
      a. ASTM C 109 at 1 day: minimum 2,500 psi.
      b. ASTM C 109 at 28 days: minimum 7,500 psi.
   4. Flexural Properties, ASTM C 348 at 28 days: minimum 1,200 psi.
   5. Permeability, AASHTO T 277: 800 coulombs maximum.
   6. Splitting Tensile Strength: ASTM C 496 at 7 days, minimum 450 psi.
   7. Drying Shrinkage, ASTM C 596 at 28 days: -0.090%.
   8. Freeze Thaw Resistance, ASTM C 666, at 300 cycles: 95% RDF.
   9. Abrasion Resistance: ASTM C 799, 60 minutes, 0.0165”.

B. Manufacturers and Products:
   1. Master Builders Technologies Co., Cleveland, OH; EMACO R 310
   2. Or approved equal.

2.3 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards.

2.4 ACCESSORIES

A. Finishing Aid Manufacturer and Product: Master Builders Inc., Cleveland, OH; CONFILM.

B. Flexible Cementitious Rebar Coating Manufacturer and Product: Master Builders Inc., Cleveland, OH; EMACO P22.

PART 3 - EXECUTION

3.1 GENERAL

A. Where required because of deficiencies, concrete surface repair system shall be low pressure spray mortar for structural repairs.

3.2 PREPARATION

A. Remove unsound and deteriorated concrete from Work by high pressure water blasting machines capable of scoring concrete surfaces to minimum amplitude roughness of 3/16” or as shown. Remove to provide for maximum thickness specified for mortar.

B. High pressure water blasting machines with 16,000 to 20,000 psi minimum.

C. Collect and dispose of water from removal operations in manner and location acceptable to Owner.

D. Do not use power-driven jackhammers and chipping hammers, unless water blasting is prohibited due to potential damage to installed equipment.

E. Remove concrete minimum of 1" clearance around rebar for application and bonding of new mortar to entire periphery of exposed rebar if the following surface conditions exist:
   1. 50% or more of periphery around rebar is exposed during removal of concrete.
   2. 25% or more of periphery around rebar is exposed during removal of concrete and corrosion has eventuated to the extent that loss of section has occurred.
   3. Bond between existing concrete and reinforcement has deteriorated.

F. Clean exposed reinforcing bars of rust and concrete, and coat with flexible cementitious rebar coating.

G. Maintain surface areas free of slurry where concrete has been removed. Remove slurry from prepared areas before new mortar is applied.

H. Clean surface areas to be filled with new mortar of laitance and contamination by high pressure water blasting not more than 24 hours before applying bonding agent, Saturated Surface Dry (SSD) existing concrete at time of application of mortar.

3.3 LOW PRESSURE SPRAY MORTAR APPLICATION

A. Mix mortar in mortar-concrete mixer attached to pump-spray equipment for spray application. Mix with a slow speed drill and jiffler type paddle or small mortar type mixer for hand trowel application.

B. Apply mortar by low pressure spraying with a machine such as Moynotype, MEYCO DEQUNA Model 20.

C. Finish mortar with a hand float application to smooth even surface matching adjacent concrete. Provide finishing aid at full strength.

D. Bonding Agent:
   1. Hand apply bonding agent within 20 minutes of troweling on mortar. Prevent bonding agent from drying by reapplying bonding agent to maintain surface tackiness of coat.
   2. Work mortar firmly and quickly into area and compact with firm trowel stroke. Finish smooth with finishing aid at full strength.

3.4 POLYMER-MODIFIED REPAIR MORTAR APPLICATION FOR REPAIR OF HORIZONTAL SURFACES

A. Mix mortar in mortar-concrete mixer.

B. Hand Troweling: Apply (scrub in) a bond coat slurry of the repair mortar to the SSD prepared substrate before application of the mortar. Do not apply more of the bond coat than can be covered with mortar before the bond coat dries. Do not re-temper this bond coat.

C. Place mortar into prepared area from one side to the other.

D. Work material firmly into the side and bottom of patch to assure a good bond. Level repair mortar and screed to elevation of existing concrete.

E. Finish to same texture as existing concrete around patch.

F. Use self-leveling mixture where appropriate to obtain uniform or plane surface.

3.5 CURING

A. Water fog nozzle all of the mortar systems prior to curing in accordance with mortar system Manufacturer's instructions.

B. Commence water curing after mortar system application and when curing will not cause erosion of mortar.

C. Continuously cure mortar system for a period of 7 days.

D. Do not membrane cure, unless method is part of mortar system Manufacturer's instructions and approval has been obtained.

E. Cure intermediate layers of mortar in accordance with manufacturer's instructions.

3.6 FIELD QUALITY CONTROL

A. Independent testing laboratory shall perform the following:
   1. Secure production samples of mixed materials during construction and test for compliance with the Specifications.
   2. Obtain actual core samples from the completed repair Work and test.
   3. Perform "modified" ASTM C 109 and ASTM C 882 test methods in accordance with manufacturer's approved modifications of testing procedures.

B. Construction Testing:
   1. Production Samples:
      a. Obtain mixed mortar material from shotcrete or spray equipment and produce samples, and cure samples prior to testing.
      b. Provide minimum of three samples each test for each 1,000 square feet or portion thereof of mortar repair to be installed.
   2. Core Samples of In-Place Repair:
      a. Obtain two core samples and test samples for each 2,000 square feet or portion thereof for actual repair Work:
      b. Cores shall be either 2-1/2" or 3" in diameter and shall be cored through cured mortar repair and into base concrete to total depth equal to at least 2.5 times repair mortar thickness.
      c. Sawcut the cores after removal to trim base concrete thickness to same thickness as mortar so that bond line is at center of repaired sample.
      d. Samples shall be epoxy bonded to steel plates at each end using a bonding agent to prevent failure in bond to steel plates.
      e. Sustain bond line without failure or movement with a minimum of 300 psi in direct tension. The tension test shall use eyebolts or threaded connectors tapped and threaded into base plate so that tension load is concentric with center of core sample.

C. Repair and fill holes where core samples have been removed using same mortar used in repair.

3.7 MANUFACTURER'S SERVICES

A. Provide mortar system manufacturer's representative at site for installation assistance, inspection and certification of proper installation, and training of mortar system applicators.

B. Mortar System Manufacturer's Demonstration:
   1. Schedule a time for Manufacturer's demonstration of repair system proposed for the Project. Prepare mortar, to specified consistency, for testing and placement. Initiate curing on portions of each type of surface to be repaired to include overhead and vertical applications.
   2. Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.
   3. Demonstrate:
      a. Mixing and application equipment capabilities and procedures, including the flow of material from nozzle or sprayer.
      b. Nozzle operator and person in charge of low pressure sprayer, capabilities and ability to follow prescribed application procedures and properly operate equipment and apply surface repair materials.
   4. Make compression test samples during demonstration and deliver to an independent testing laboratory for testing at 1, 7, and 28 days. Take a core of the demonstration placement and test for tensile bond at 1 day.

3.8 PROTECTION

A. Protect adjacent surfaces, and equipment, from being damaged by overshooting of low pressure spray mortar.

3.9 CLEANING

A. Remove overshot mortar and deposited rebound materials as Work proceeds. Remove from Work, waste materials, unsound material from concrete surfaces, material chipped from walls, water used in preparation of application and finishing.

END OF SECTION

SECTION 03 11 00 - CONCRETE FORMWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete formwork.

B. Related sections:
   1. Section 03 30 00 – Cast-In-Place Concrete.
   2. Section 03 60 00 – Grout.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Concrete Institute (ACI):
      a. 117, Standard Specifications for Tolerances for Concrete Construction and Materials.
      b. 318/318R, Building Code Requirements for Reinforced Concrete.
      c. 347, Formwork for Concrete.

1.3 DESIGN REQUIREMENTS

A. Design, erect, shore, brace, and maintain formwork in accordance with ACI 301, ACI 347, and ACI 318 to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads. Provide concrete finishes specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
   1. Formwork shop drawings shall be prepared by or under the supervision of a qualified professional engineer licensed in the state of the work.

B. When high range water reducer (superplasticizer) is used in concrete mix, forms shall be designed for full hydrostatic pressure per ACI 347.

C. Make joints in forms watertight.

D. Limit panel deflection to 1/360th of each component span to achieve tolerances specified.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Form Ties-Tapered Through-Bolts: Proposed method of sealing form tie hole; coordinate with details shown.
   2. Manufacturer’s Data for the Following Product: Form release agent.

B. Samples: One each as follows:
   1. Form ties.

C. Information Submittals: Statement of qualification for formwork designer.

1.5 QUALIFICATIONS

A. Formwork Designer: Formwork, falsework, and shoring design shall be by an Engineer licensed in the State of the project site.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

A. Wall Forms and Underside of Slabs:
   1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particle board, or steel in “new and undamaged” condition, of sufficient strength and surface smoothness to produce specified finish.
   2. Circular Structures:
      a. Conform forms to circular shape of structure.
      b. Straight panels may be substituted for circular forms provided panels do not exceed 2’ in horizontal width and angular deflection is no greater than 3-1/2° per joint.

B. Painted Surface Forms: High density overlay plywood for flat concrete surfaces to be painted.

C. All Other Forms: Materials as specified for wall forms.

D. Form Release Agent:
   1. Material: Release agent shall not bond with, stain, or adversely affect concrete surfaces, and shall not impair subsequent treatments of concrete surfaces when applied to forms. A “ready to use” water based material formulated to reduce or eliminate surface imperfections, containing no mineral oil or organic solvents. Environmentally safe, meeting local, state, and federal regulations and can be used in potable water facilities.
   2. Manufacturers and Products:
      a. Master Builders, Inc.; Rheofinish 211.
      b. Cresset Chemical Company; Crete-Lease 20-VOC.
      c. US Mix Products Company; US SPEC Slickote.

E. Rustication Grooves and Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

F. Form Ties:
   1. Material: Steel
   2. Spreader Inserts:
      a. Conical or spherical type.
      b. Design to maintain positive contact with forming material.
      c. Furnish units that will leave no metal closer than 1” to concrete surface when forms, inserts, and tie ends are removed.
   3. Wire ties not permitted.
   4. Flat bar ties for panel forms furnish plastic or rubber inserts with minimum 1” depth and sufficient dimensions to permit patching of tie hole.
   5. Water Stop Ties: For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
      a. Integral steel water stop 0.103” thick and 0.625” in diameter tightly and continuously welded to tie.
      b. Neoprene water stop 3/16” thick and 15/16” diameter whose center hole is 1/2-diameter of tie, or molded plastic water stop of comparable size.
      c. Orient water stop perpendicular to tie and symmetrical about center of tie.
      d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.
   6. Through-Bolts: Tapered minimum 1” diameter at smallest end.
   7. Elastic Vinyl Plug:
      a. Design and size of plug to allow insertion with tool to enable plug to elongate and return to original length, and diameter upon removal forming watertight seal.

b. Manufacturer and Product: Dayton/Richmond Co., Miamisburg, OH; A58 Sure Plug.
c. Recess plug 1” minimum and grout over hole. See Section 03 60 00 GROUT.

PART 3 - EXECUTION

3.1 FORM SURFACE PREPARATION

A. Thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants prior to coating surface.

B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by the manufacturer.

C. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.

3.2 ERECTION

A. General: Unless specified otherwise, follow applicable recommendations of ACI347.

B. Beveled Edges (Chamfer):
1. Form 3/4” bevels at concrete edges, unless otherwise shown.
2. Where beveled edges on existing adjacent structures are other than 3/4”, obtain Engineer’s approval of size prior to placement of beveled edge.

C. Wall Forms:
1. Do not reuse forms with damaged surfaces.
2. Locate form ties and joints in an uninterrupted uniform pattern.
3. Inspect form surfaces prior to installation to assure conformance with specified tolerances.

D. Forms for Curbs and Sidewalks:
1. Provide standard steel or wood forms.
2. Set forms to true lines and grades, and securely stake in position.

E. Form Tolerances: Provide forms in accordance with ACI 117, 347 and 318 and the following tolerances for finishes specified:
1. Wall Tolerances:
a. Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.
b. Wall Type W-A:
1). Plumb within 1/4” in 10’ or within 1” from top to bottom for walls over 40 feet high.
2). Depressions in Wall Surface: Maximum 5/16” when 10’ straightedge is placed on high points in all directions.
c. Wall Type W-B:
1). Plumb within 1/8” in 10’ or within 1/2” from top to bottom for walls over 40’ high.
2). Depressions in Wall Surface: Maximum 1/8” when 10’ straightedge is placed on high points in all directions.
2. Thickness: Maximum -1/4” or +1/2” from dimension shown.
3. Form Offset: Between adjacent pieces of form work, facing material shall not exceed 1/8” where exposed to public view and 1/4” maximum for all other conditions.

3.3 ADDITIONAL REQUIREMENTS

A. Construct forms tight enough to prevent loss of concrete mortar.

B. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
   1. Install keyways, reglets, recesses and the like for easy removal.
   2. Do not use rust-stained steel form-facing material.
   3. Use only form or form-tying methods which do not cause spalling of the concrete upon form stripping or tie removal.

C. Set edge forms, bulkheads and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

D. Provide temporary 12 inch wide x 18 inch high openings for cleanouts and inspection ports every 7 feet at the bottom of each lift form and where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations, where possible.

E. Chamfer exterior corners and edges of permanently exposed concrete.

F. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds and bulkheads required in the Work.
   1. Determine sizes and locations from trades providing such items.
   2. Openings shall be of sufficient size to permit final alignment of pipes or other items without deflection or offsets of any kind. Allow space for packing where items pass through the wall to ensure watertightness. Provide openings with continuous keyways and waterstops. Provide a slight flare to facilitate grouting and the escape of entrained air during grouting. Provide formed openings with reinforcement as indicated in the typical structural details. Reinforcing shall be at least 2 inches clear from the opening surfaces and encased items.

G. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt and other debris just before placing concrete.

H. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

I. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions before placing reinforcement.

J. Embedded Items.
   1. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.
      a. Install anchor bolts/rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
      b. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles and other conditions.

c. Check special castings, channels or other metal parts that are to be embedded in the concrete prior to and again after placing the concrete.
d. Check nailing blocks, plugs and strips necessary for the attachment of trim, finish and similar work prior to placing the concrete.

K. Pipes and wall spools cast in concrete.
1. Install wall spools, wall flanges, and wall anchors before placing concrete. Do not weld, tie or otherwise connect the wall spools or anchors to the reinforcing steel.
2. Support pipe and fabricated fittings to be encased in concrete on concrete piers or pedestals. Carry concrete supports to firm foundations so that no settlement will occur during construction.
3. Pipes or spools located below operating water level shall have waterstop ring collars and shall be cast in place. Do not block out such piping and grout after the concrete section is cast. Pipes fitted with thrust rings shall be cast in place.

L. Removing and reusing forms.
1. General: Do not remove forms from concrete which has been placed with outside temperature below 50°F without first determining and verifying with Engineer if the concrete has properly set without regard for time. Do not apply loading on green concrete. Immediately after forms are removed, the surface of the concrete shall be carefully examined and any irregularities in the surface shall be repaired and finished as specified.
a. Leave formwork for beam soffits, joists, structural slabs, beams, girders and other structural elements that support weight of concrete in place until concrete has achieved 100 percent its 28-day design compressive strength.
b. Formwork for sides of beams, walls, columns and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50°F (10 deg C) for 48 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
c. Leave bracing for walls until the top or roof slab concrete reaches 100% of its 28-day design compressive strength.
d. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
2. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
3. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces.

M. Aluminum surfaces in contact with concrete.
1. Aluminum surfaces in contact with concrete or grout or dissimilar metals shall be protected with a Mylar isolator, bituminous paint or other material approved by Engineer.

N. Shores and reshores.
1. Comply with ACI 318 (ACI 318M) and ACI 301 for design, installation and removal of shoring and reshoring.
a. Do not remove shoring or reshoring until measurement of slab tolerances is complete.
2. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.
3. For multi-storied structures, the shoring and reshoring diagrams and procedures shall be signed and sealed by a Registered Professional Engineer in the state where the

construction is being undertaken. These diagrams and procedures shall take into account the effect of the loads on the uncured concrete and the construction load on each floor.

4. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

END OF SECTION

SECTION 03 15 00 – CONCRETE ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Waterstops.
   2. Joint fillers.

1.2 REFERENCES

A. ASTM International (ASTM):
   1. ASTM D570 - Standard Test Method for Water Absorption of Plastics.
   2. ASTM D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
   3. ASTM D638 - Standard Test Method for Tensile Properties of Plastics.
   4. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
   5. ASTM D747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
   6. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   7. ASTM D2240 - Standard Test Method for Rubber Property – Durometer Hardness.

B. American National Standards Institute (ANSI):
   1. ANSI A135.4 - Basic Hardboard.

C. U. S. Army Corps of Engineers (USACE):
   1. CRD-C-572, Specification for Polyvinyl Chloride Waterstop.

1.3 SUBMITTALS

A. Product Data:
   1. Polyvinyl chloride waterstops: Complete physical characteristics.
   2. Preformed expansion joint material: Sufficient information on each type of material for review to determine conformance of material to requirements specified.

B. Samples:
   1. Polyvinyl chloride waterstop.

C. Laboratory test reports: Indicating that average properties of polyvinyl chloride waterstops material and finish conform to requirements specified in this Section.

D. Quality control submittals:
   1. Certificates of Compliance:
      a. Written certificates that polyvinyl chloride waterstops supplied on this Project meet or exceed physical property in accordance with USACE CRD-C-572 and the requirements of this Section.
   2. Manufacturer's instructions: For materials specified in this Section that are specified to be installed with such instructions.

1.4 QUALITY ASSURANCE

A. Mock-ups:

1. Welding demonstration:
    a. Demonstrate ability to weld acceptable joints in polyvinyl chloride waterstops before installing waterstop in forms.

B. Field joints:
1. Polyvinyl chloride waterstops field joints: Shall be free of misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects which would reduce the potential resistance of the material to water pressure at any point. Replace defective joints. Remove faulty material from the site and disposed of by the CONTRACTOR at its own expense.

C. Inspections:
1. Quality of welded joints will be subject to acceptance of the ENGINEER.
2. Polyvinyl chloride waterstop: The following defects that represent a partial list that will be grounds for rejection:
    a. Offsets at joints greater than 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
    b. Exterior crack at joint, due to incomplete bond, which is deeper than 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
    c. Any combination of offset or crack which will result in a net reduction in the cross section of the waterstop in excess of 1/16 inch or 15 percent of the material thickness, at any point, whichever is less.
    d. Misalignment of the joint, which will result in misalignment of the waterstop in excess of 1/2 inch in 10 feet.
    e. Porosity in the welded joint as evidenced by visual inspection.
    f. Bubbles or inadequate bonding.

PART 2 - PRODUCTS

2.1 WATERSTOPS

A. Waterstops - Polyvinyl chloride (PVC):
1. Manufacturers: One of the following or equal:
    a. Vinylex Corporation.
    b. Greenstreak Plastic Products Company, Inc.
2. Type: Ribbed waterstop:
    a. Construction joints: 6-inch wide ribbed type. Vinylex R638, Greenstreak 679, or equal.
    b. Construction joints for slab to wall intersections: 4-inch wide ribbed type. Vinylex R4316T, Greenstreak 781, or equal.
    c. Expansion joint for wall penetrations for concrete encased electrical duct banks: 6-inch ribbed type with hollow center bulb. Vinylex RB638H, Greenstreak 732, or equal.
    d. Expansion joints: 9-inch wide ribbed type with hollow center bulb or tear web. Vinylex RB938H, Greenstreak 735, or equal for expansion joints 1 inch and narrower, Vinylex TWB938, Greenstreak 739 or equal for expansion joints wider than 1 inch.
3. Dumbbell type waterstop will not be allowed unless otherwise specified or indicated on the Drawings.
4. Provide polyvinyl chloride waterstops complying with following requirements:
    a. Manufactured from prime virgin polyvinyl chloride plastic compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements of this Section.
    b. No scrap or reclaimed material shall be used.
5. Properties as indicated in the following table:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D 792	Not less than 1.3.
Hardness	ASTM D 2240	70 to 90 Type A15 Shore durometer.
Tensile Strength	ASTM D 638	Not less than 2,000 pounds per square inch.
Ultimate Elongation	ASTM D 638	Not less than 300 percent
Alkali Extraction	CRD-C-572	7 day weight change between minus 0.1 percent and plus 0.25 percent. Hardness change within 5 points.
Low Temperature Brittle Point	ASTM D 746	No sign of cracking or chipping at -35 degrees Fahrenheit minimum.
Water Absorption	ASTM D 570	Not more than 0.15 percent after 24 hours.
Accelerated Extraction Tensile	CRD-C-572	Not less than 1,600 pounds per square inch.
Stiffness in Flexure	ASTM D 747	Not less than 600 pounds per square inch.
Tear Resistance	ASTM D 624	Not less than 225 pounds per inch.
Thickness	–	3/8 inch
Center Bulb		
6 inch Waterstops	–	7/8 inch or 1-inch nominal outside diameter.
9 inch Waterstops	–	1-inch nominal outside diameter. For expansion joints 1 inch and narrower and 2 inches for expansion joints wider than 1 inch.
Allowable Tolerances		
Width	–	Plus or minus 3/16 inch.
Thickness	–	Plus or minus 1/32 inch.

2.2 JOINT FILLERS

A. Hardboard: 1/8-inch minimum thickness, in accordance with ANSI A135.4 Class 2.

B. Preformed expansion joint materials:
   1. General:
      a. Use specific type in applications as indicated on the Drawings.
      b. No scrap or recycled material shall be used.
   2. Bituminous fiber expansion joint material:
      a. Manufacturers: One of The following or equal:
         1). Tamms Industries, a division of Euclid Chemical Company: Hornboard/fiber.
         2). Approved equal.
   3. Synthetic sponge rubber expansion joint material:
      a. Manufacturers: One of the following or equal:
         1). Tamms Industries, a division of Euclid Chemical Company: Cementone.
         2). Approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Waterstops - General:

1. Waterstops shall be stored so as to permit free circulation of air around the waterstop material and to prevent direct exposure to sunlight.
2. Install waterstops in concrete joints where indicated on the Drawings.
3. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.
4. In water-bearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.
5. Provide waterstops that are continuous and in longest lengths practical.
6. Set waterstops accurately to position and line as indicated on the Drawings.
7. Hold and securely fix edges in position at intervals of not more than 24 inches so that they do not move during placing of concrete.
8. Position the waterstop so that symmetrical halves of the waterstop are equally divided between the concrete pours. The center axis of the waterstop shall be coincident with the centerline of the joint.
9. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.
10. Use wires at not more than 24 inches on centers near outer edge of the waterstop to tie waterstops into position.
11. Special clips may be used in lieu of wires, at contractor's option.
12. Terminate waterstops 3 inches from top of finish surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
13. When any waterstop is installed in the concrete on one side of a joint, while the other half or portion of the waterstop remains exposed to the atmosphere for more than 2 days, suitable precautions shall be taken to shade and protect the exposed waterstop from direct rays of sunlight during the entire exposure and until the exposed portion is embedded in concrete.
14. When placing concrete at waterstops in slabs, lift the edge of the waterstop while placing concrete below the waterstop. Manually force the waterstop against and into the concrete. Then cover the waterstop with fresh concrete.

B. Polyvinyl chloride waterstops:
   1. Install waterstops so that joints are watertight.
   2. Weld joints such as unions, crosses, ells, and tees, with thermostatically controlled equipment recommended by waterstop manufacturer:
      a. The material shall not be damaged by heat sealing.
      b. Make joints by overlapping then simultaneously cut the ends of the sections to be spliced so they will form a smooth even joint. Heat the cut ends with the splicing tool until the plastic melts. Press the 2 ends together until the plastic cools.
      c. The continuity of the waterstop ribs and tubular center axis shall be maintained.
      d. The splices shall have a tensile strength of not less than 60 percent of the unspliced materials tensile strength.
   3. Butt joints of the ends of 2 identical waterstop sections may be made while the material is in the forms.
   4. Joints for crosses and tees shall be factory prefabricated by the manufacturer.

C. Joints:
   1. Construct construction, and expansion joints as indicated on the Drawings.
   2. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

D. Hardboard:
   1. When indicated on the Drawings, face surface of joint filler with hardboard.
   2. Other facing materials may be used provided they furnish equivalent protection and the material is acceptable to ENGINEER.

3. Hold boards in place by nails, waterproof adhesive, or other means acceptable to the ENGINEER.

END OF SECTION

SECTION 03 20 00 - CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Reinforcing steel and related items required for cast-in-place concrete.

B. Related Sections:
   1. Section 03 11 00 – Concrete Formwork.
   2. Section 03 30 00 – Cast-In-Place Concrete.

1.2 SUPERVISION

A. Workmanship: Provide qualified supervision at all times reinforcing work is in progress. Workmen shall be experienced iron workers.

B. Codes: Reinforcement placement and detailing shall comply with practice specified in the "Manual of Standard Practice for Detailing Reinforced Concrete Structures" publication ACI 315- latest edition of the American Concrete Institute or its latest revision, unless otherwise specified herein.

1.3 SUBMITTALS

A. Shop drawings: Shop drawings shall be prepared for all reinforcement required by the project. Shop drawings shall be logically and legibly prepared to permit reasonable ease of sorting, selecting, placing reinforcement as well as checking drawings. Preparer and fabricator shall be identified on the drawings.
   1. Reinforcement shall not be fabricated until the shop drawings have been processed, approved and returned.
   2. Check all shop drawings to verify reinforcement dimensions required by drawings are satisfied.
   3. Provide bar sizes, bar lengths, bar material, bar grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and lap lengths, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

B. Reinforcement shop drawings:
   1. Review of reinforcement shop drawings by the Engineer will be limited to general compliance with the Contract Documents.
   2. Submit reinforcement shop drawings in a complete package for each specific structure. Partial submittals will be rejected.

C. Changes to reinforcing steel contract drawing requirements:
   1. Indicate in separate letter submitted with shop drawings any changes of requirements indicated on the Drawings for reinforcing steel.
   2. Such changes will not be acceptable unless the Engineer has accepted such changes in writing.

1.4 PRODUCT HANDLING

A. Protection:
   1. Use all means necessary to protect reinforcement from dirt and other foreign substances before and after placing.
   2. Store in a neat manner in logical order, bundled, tagged, off the ground, and in an area adequately isolated.

3. Re-bundle to maintain identification when placing is interrupted.

B. Replacement: All damaged or improperly fabricated bars shall be replaced at the Contractor's expense.

PART 2 - PRODUCTS

2.1 CONCRETE REINFORCEMENT

A. General: All reinforcement shall be free from rust, loose mill scale, and other contaminants.

B. All bars shall be billet steel bars for concrete reinforcement ASTM A 615 Grade 60.

C. Wire bar supports located between reinforcing bars and face of concrete:
1. Stainless steel. Type 304 stainless steel bar supports.
2. Support reinforcing for concrete placed on ground using bar support chairs with Type 304 stainless steel plates for resting on ground welded to the chairs.

D. Concrete bar supports located between reinforcing bars and face of concrete:
1. Manufactured expressly for supporting reinforcing bars.
2. Manufactured with two annealed steel wires to securely tie concrete bar support to reinforcing steel.
3. Manufactured with minimum f'_c = 5,000 psi concrete.

2.2 WELDED WIRE REINFORCEMENT (WWR):

A. In accordance with ASTM A 185.

B. WWR may not be used in place of reinforcing bars unless accepted in writing by the Engineer.

C. Provide WWR in flat sheet form.

D. If WWR is used, provide WWR having cross-sectional area per linear foot of not less than cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.

2.3 ACCESSORIES:

A. General: Accessories shall be subject to Engineer's approval.
1. Tie wire - 18 gauge annealed steel wire.
2. Number of chairs shall be adequate to prevent sag during steel and concrete placement.
3. Wall layer spacers shall be 1/4 inch round "Z" bar.
4. Horizontal layer spacers shall be wire bar supports or reinforcing bars bent to support top layer.
5. Dowel bar splicer:
   a. Dowel bar splicer shall be Richmond or approved equal, manufactured from standard specified rebar material, with NC threads and shop fabricated to specified dowel configurations.
6. Mechanical Connectors:
   a. Approved Manufacturers: Dayton Superior, Erico, or approved equal.
   b. The mechanical connection shall meet the code requirements of developing in tension and compression as required by the referenced codes. Install per the manufacturer’s approved procedures.

PART 3 - EXECUTION

3.1 GENERAL

A. Reinforcing bars and welded wire fabric reinforcement: Verify that reinforcement is new stock free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings which adversely affect bonding capacity when placed in the work.

B. Other trades: Coordinate all work of other trades to avoid conflict with reinforcement.

C. Shop drawings: Check all shop drawings to verify dimensions required.

3.2 FABRICATING

A. General: Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice." Reinforcement shall be shop fabricated except where straight bars No. 5 or smaller are required.

B. Bending: All bending shall be by using bending jigs and mandrels. All bars shall be bent cold.

C. Cutting: Bars shall be cut by cold shearing. Torch cutting in the field may be permitted in special situations.

3.3 PREPARATION

A. Surface Preparation:
   1. Reinforcing bars: Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean any bars having rust scale, loose mill scale, or thick rust coat.
   2. Cleaning of reinforcement materials: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placement.

3.4 PLACING

A. General:
   1. Accurately place all bars to meet tolerances as outlined in ACI 318 and tie in place before placing concrete, include dowels. Tie with 18 gauge steel wire.
   2. Corner bars required for horizontal reinforcing. Unless otherwise noted on plans corner bars shall be same size and spacing as horizontal bar.
   3. No field bending of bars will be allowed.

B. Clearance:
   1. Preserve clearance between bars of 1 inch minimum, not less than one bar diameter or 1-1/3 times large aggregate, whichever is larger.
   2. Provide following concrete coverage over reinforcing steel unless otherwise indicated on plans:
      a. Three inches above subgrade - in excavation.
      b. Two inches above subgrade - slab on fill.
      c. Two inches from form - walls exposed to water or earth and for slab over water.
      d. One and one-half inches from form - normal cover interior walls, beams, columns, etc.
      e. Three-fourths inch on top steel - interior slabs.
      f. One and one-half inches on top and bottom - exterior slab.
   3. Lap all reinforcing bars as required by ACI 318-latest edition Class B as indicated on the drawings except where otherwise required by ACI.

4. Stagger splices except where otherwise shown.
5. Lap welded wire reinforcement a minimum of two spaces.

C. Dowels: All dowels shall be placed and securely anchored before placing concrete

D. Supports:
1. Provide a sufficient number to prevent sagging, to prevent shifting, and to support loads during construction; but in no case less than quantities and at locations as indicated in ACI 315.
2. Do not use brick, broken concrete masonry units, spalls, rocks, wood or similar materials for supporting reinforcing steel.
3. Do not use reinforcing bars that have less cover than required by the Contract Documents. Do not adjust location of reinforcement required by the Contract Documents to provide cover to these bars.
4. Wire chairs will not be accepted to hold reinforcing clearance on walls.

E. Tying of bar reinforcement:
1. Fasten bars securely in place with wire ties.
2. Tie bars sufficiently often to prevent shifting.
3. Provide at least 3 ties in each bar length.
4. Do not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity.
5. Tie slab bars at every intersection around periphery of slab.
6. Tie wall bars and slab bar intersections other than around periphery at not less than every fourth intersection, but at not greater than following maximum spacings:

Bar Size	Slab Bar Spacing Inches	Wall Bar Spacing Inches
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

7. After tying wire ties, bend ends of wire ties in towards the center of the concrete section.
   a. The cover for wire ties shall be the same as the cover requirements for reinforcing bars.

F. Openings and obstructions:
1. Place additional reinforcing around openings as shown on the drawings and standard details.
2. Bend reinforcing around obstructions. Place extra reinforcing where cutting is authorized. Engineer's approval required before cutting steel.
3. Consult Engineer on special situations.

G. Welded Wire Reinforcement:
1. Install necessary wiring, spacing chairs, or supports to keep welded wire fabric in place while concrete is being placed.
2. Bend fabric as indicated on the Drawings or required to fit work.
3. Unroll or otherwise straighten fabric to make flat sheet before placing in the Work.
4. Lap splice welded wire fabric as indicated on the Drawings.
5. If lap splice length is not indicated on the Drawings, splice fabric in accordance with ACI 318 and ACI 350.

H. Certification: Certify material and type of deformation.

I. Condition: All reinforcement shall be free from loose rust, dirt coating, oil, paint, or any foreign substance.

END OF SECTION

SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cast-in-place concrete, including concrete materials, concrete accessories, concrete mixture designs, placement procedures, and finishes, for the following:
   1. Footings.
   2. Foundation walls.
   3. Slabs-on-grade.
   4. Suspended slabs.
   5. Concrete toppings.
   6. Building frame members.
   7. Building walls.
   8. Hydraulic (liquid containing) structures.

B. Related Sections:
   1. Section 03 01 00 - Concrete Surface Repair
   2. Section 03 11 00 - Concrete Formwork
   3. Section 03 15 00 - Concrete Accessories
   4. Section 03 20 00 - Concrete Reinforcement
   5. Section 03 41 00 - Precast Concrete
   6. Section 03 60 00 - Grout
   7. Section 03 64 00 - Concrete Repair Crack Injection

1.2 REFERENCES

A. American Concrete Institute (ACI):
   1. ACI 301 – Specifications for Structural Concrete
   2. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials
   3. ACI 305 - Hot Weather Concreting Standard
   4. ACI 306 - Cold Weather Concreting Standard
   5. ACI 318 - Building Code Requirements for Structural Concrete and Commentary
   6. ACI 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary
   7. ACI 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
   8. ACI 302.1R – Guide for Concrete Floor and Slab Construction
   9. ACI 308.1 – Standard Specification for Curing Concrete
   10. Manual of Concrete Practice

B. ASTM International (ASTM):
   1. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
   2. ASTM C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. ASTM C33 - Standard Specification for Concrete Aggregates
   4. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
   5. ASTM C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
   6. ASTM C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
   7. ASTM C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

8. ASTM C94 - Standard Specification for Ready-Mixed Concrete
9. ASTM C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement
10. ASTM C117 - Standard Test Method for Materials Finer that 75-m (No. 200) Sieve in Mineral Aggregates by Washing
11. ASTM C123 - Standard Test Method for Lightweight Particles in Aggregate
12. ASTM C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
13. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
14. ASTM C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate
15. ASTM C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete
16. ASTM C150 - Standard Specification for Portland Cement
17. ASTM C156 - Standard Test Method for Water Loss [from a Mortar Specimen] Through Liquid Membrane-Forming Curing Compounds for Concrete
18. ASTM C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
19. ASTM C171 - Standard Specifications for Sheet Materials for Curing Concrete
20. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete
21. ASTM C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
22. ASTM C192 – Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
23. ASTM C231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
24. ASTM C260 – Standard Specification for Air-Entraining Admixtures for Concrete
25. ASTM C295 – Standard Guide for Petrographic Examination of Aggregates for Concrete
26. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
27. ASTM C494 – Standard Specification for Chemical Admixtures for Concrete
28. ASTM C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
29. ASTM C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
30. ASTM C1064 – Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
31. ASTM C1059 – Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
32. ASTM C1077 – Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
33. ASTM C1116 – Standard Specification for Fiber-Reinforced Concrete
34. ASTM C1315 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
35. ASTM D448 – Standard Classification for Sizes of Aggregate for Road and Bridge Construction
36. ASTM D1751 – Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
37. ASTM D2240 – Standard Test Method for Rubber Property – Durometer Hardness
38. ASTM E329 – Standard Specification for Agencies Engages in Construction Inspection, Testing, or Special Inspection
39. ASTM E1155 – Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers
40. ASTM E1643 – Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs
41. ASTM E1745 – Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

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

C. Hydraulic Structures: Liquid containing basins.

D. Defective Areas: Surface defects that include honeycomb, rock pockets, indentations greater than 3/16", cracks 0.005" wide and larger as well as any crack that leaks for liquid containing basins and below grade habitable spaces; cracks 0.010" wide and larger in non-fluid holding structures, spalls, chips, air bubbles greater than ¾" in diameter, pinholes, bug holes, embedded debris, lift lines, sand lines, bleed lines, leakage from form joints, fins and other projections, form pop-outs, texture irregularities, and stains and other color variations that cannot be removed by cleaning.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Concrete Mixture Designs: For each concrete mixture.
1. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
2. Indicate amounts of mixing water to be withheld for later addition at Project site.
3. Submit Shrinkage Test Results for design mixtures. See 3.14 FIELD QUALITY CONTROL, E. Shrinkage Tests - 3 for shrinkage test requirements and limitations. Any Mix Design submitted without a Shrinkage Test will not be reviewed and will be returned to the Contractor as "Rejected".

C. Welding certificates.

D. Qualification Data: For manufacturer, testing agency.

E. Material Certificates: For each of the following, signed by manufacturers:
1. Cementitious materials.
2. Admixtures.
3. Curing compounds.
4. Floor and slab treatments.
5. Bonding agents.
6. Adhesives.
7. Vapor retarders.
8. Semi-rigid joint filler.
9. Joint-filler strips.

F. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.

G. Field quality-control test and inspection reports.

H. Course Aggregate Gradation.

I. Fine Aggregate Gradation.

J. One copy of each 30 consecutive strength test results and mix design used from a record of past performance or one copy of the laboratory trial mix design and results and one copy of the mix design proposed for each mixture and use under this contract. If the 30 consecutive strength tests are used, the test shall have been made within the 12 month period prior to this submittal.

K. Material Test Reports: for the following, from a testing agency acceptable to the ENGINEER, indicating compliance with requirements:
   1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

L. Ready-Mix concrete.
   1. Provide delivery tickets for ready-mix concrete or weigh-masters certificate per ASTM C94 including weights of cement and each size aggregate and amount of water added at the plant and record of pours. Record the amount of water added on the job on the delivery ticket. Water added at the plant shall account for moisture in both coarse and fine aggregate. If water is added on the job the total water content shall not exceed the water content of the approved design mix.
   2. Keep record showing time and place of each pour (placement) of concrete, together with transit-mix delivery slips certifying the contents of the pour (placement).
   3. Furnish records to Engineer upon request.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Manufacturer Qualifications: A firm with a minimum of 5 years' experience in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
   2. The criteria hereinafter set out are solely for the purpose of establishing required mixture proportions and do not constitute a basis for confirming the adequacy of concrete strength.
      a. Required Average Strength above Specified Compressive Strength: Proportions, including water-cement ratio, shall be established on the basis either of laboratory trial batches or of field experience with the materials to be employed. The proportions shall be selected to produce an average strength of 28 days exceeding the specified compressive strength by the amount indicated below, when both air content and slump are the maximums permitted by the Specifications.
      b. Determination of the required average strength shall be in accordance with ACI 318 "Building Code Requirements for Reinforced Concrete," except that if suitable data from trial batches or field experience cannot be obtained, permission will not be granted to base concrete proportions on the water-cement ratio limits set out in the above referenced code.
         1). Past Plant Performance: Proportions may be established on the actual field performance of the ready-mix producer. Where the concrete production facility has a record, based on at least 30 consecutive strength tests taken within the prior 12 months representing similar materials and conditions to those expected, the strength used as the basis for selecting proportions shall exceed the required f'c by at least:
            a). 400 psi if the standard deviation is less than 300 psi;
            b). 500 psi if the standard deviation is 300 to 400 psi;
            c). 700 psi if the standard deviation is 400 to 500 psi;
            d). 900 psi if the standard deviation is 500 to 600 psi;

e). 1,200 psi if the standard deviation is above 600 psi or unknown.

2). Strength data for determining standard deviation shall be considered to comply with the foregoing stipulations if they represent either a group of at least 30 consecutive tests or the statistical average of two groups totaling 30 or more tests. The tests used to establish standard deviation shall represent concrete produced to meet a specified strength or strengths within 1,000 psi of that specified for the proposed work. Changes in materials and proportions within the population of background tests shall not have been more closely restricted than they will be for the proposed work.

3). Strength data for determining standard deviation shall be considered to comply with the foregoing stipulations if they represent either a group of at least 30 consecutive tests or the statistical average of two groups totaling 30 or more tests. The tests used to establish standard deviation shall represent concrete produced to meet a specified strength or strengths within 1,000 psi of that specified for the proposed work. Changes in materials and proportions within the population of background tests shall not have been more closely restricted than they will be for the proposed work.

4). Laboratory Trial Batches: When the ready-mix producer does not have a record of past performance, the combination of materials and the proportions selected shall be determined from trial mixes having proportions and consistencies suitable for the work based on ACI 211.1-77.

a) When laboratory trial batches are used as the basis for selecting concrete proportions, strength tests shall be made in accordance with "Method of Test for Compressive Strength of Molded Concrete Cylinders" (ASTM C39) on specimens prepared in accordance with "Method of Making and Curing Test Specimens in the Laboratory" (ASTM C192). A curve shall be established showing the relationship between water-cement ratio (or cement content) and compressive strength. The curve shall be based on at least three points representing batches which produce strengths above and below that required. Each point shall represent the average of at least three specimens tested at 28 days or the earlier age designation.

b) The average strength required shall exceed the specified compressive strength by 1,200 psi.

c) The maximum permissible water-cement ratio (or minimum cement content) for the concrete to be used in the structure shall be that shown by the curve to produce the average strength indicated, but in no case shall the water-cement ratio exceed 0.42 by weight.

C. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

E. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301, "Specifications for Structural Concrete."
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

3. ACI 350 “Code Requirements for Environmental Engineering Concrete Structures.”
4. ACI 318 “Building Code Requirements for Reinforced Concrete.”

F. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

G. Sequence of concrete placing: Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements.

H. Pre-installation Conference: Conduct conference at Project site.
1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
   a. Contractor's superintendent.
   b. Independent testing agency responsible for concrete design mixtures.
   c. Ready-mix concrete manufacturer.
   d. Concrete subcontractor.
2. Review special inspection and testing and inspecting agency procedure for field quality control, concrete finishes and finishing, cold and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints and joint-filler strips, semi-rigid joint fillers, forms and form removal limitations, shoring and re-shoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures and concrete protection.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Products: Subject to compliance with requirements products that may be incorporated into the work include, but are not limited to products specified.
2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 FORM-FACING MATERIALS

A. See Section 03 11 00 CONCRETE FORMWORK for additional requirements.

B. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints. Furnish on exposed surfaces and interior surfaces.

C. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit. Permitted to furnish on below grade exterior surfaces

D. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

E. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

F. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

G. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.

H. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

I. Form-Release Agent: As specified in Section 03 11 00 CONCRETE FORMWORK.

2.3 REINFORCEMENT ACCESSORIES

A. Expansion Joint Dowel Bars: ASTM A615/A615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.
   1. All dowels shall be placed and securely anchored before placing concrete. All dowels shall be parallel with each other and perpendicular to the joint.

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
   1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
   2. Secure all reinforcement in place using steel chairs, supports, “A” bars and any other ACI approved product. Supports shall be spaced adequately to support the steel firmly in place.
   3. Charis will not be accepted to hold reinforcing clearance on walls.

C. General:
   1. Accessories shall be subject to Engineer’s approval.
   2. Tie wire- 18 gauge steel wire. Ends of wire shall be bent towards the interior part of the wall.
   3. Support above forms with fabricated steel chairs. Number of chairs shall be adequate to prevent sag during steel and concrete placement.
   4. Wall layer spacers shall be 1/4” ROUND “Z” BAR.
   5. Horizontal layer spacers shall be stand.
   6. Mechanical Connectors:
      a. Approved Manufactures: Dayton Superior, Erico, or approved equal.
      b. The mechanical connection shall meet the code requirements of developing in tension and compression as required by the referenced codes. Install per the manufacture’s approved procedures.

2.4 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
   1. Portland Cement (Non-hydraulic Above Grade Structures): ASTM C150, Type I or II, or combination of Type I with fly ash.
   2. Portland Cement (Hydraulic and/or Below Grade Structures): ASTM C150 type II or combination of Type I with fly ash.
   3. Fly Ash: ASTM C618, Class C or F fly ash shall not exceed 15 percent of the cementitious materials, unless written approval is given by the Engineer.

B. Normal-Weight Aggregates: ASTM C33, Class 3S coarse aggregate or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1" nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
3. Fine aggregate:
   a. Provide fine aggregate for concrete or mortar consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.
   b. Do not provide aggregate having deleterious substances in excess of following percentages by weight of contaminating substances.
   c. In no case shall total exceed percent listed.

Item	**Test Method**	**Percent**
Removed by decantation (dirt, silt, etc.)	ASTM C117	3
Shale or Chert	ASTM C123 ASTM C295*	1 1
Clay Lumps	ASTM C142	1

* Test Method C123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C295 is used to identify which of the lightweight particles are shale or chert. If the results of Test Method C123 are less than 1 percent, Test Method C295 is not required.

   d. Except as otherwise specified, grade fine aggregate from coarse to fine in accordance with ASTM C33.
4. Coarse aggregate:
   a. Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances.
   b. Not exceeding 15 percent by weight, of thin or elongated pieces having length greater than 5 times average thickness.
   c. Deleterious substances: Not in excess of following percentages by weight, and in no case having total of all deleterious substances exceeding 2 percent.
   d. Coarse aggregate shall be washed prior to combining in concrete mix.

Item	**Test Method**	**Percent**
Shale or chert	ASTM C123 ASTM C295**	1.25 1
Coal and lignite	ASTM C123	1/4
Clay lumps and friable particles	ASTM C142	1/4
Materials finer than Number 200 sieve	ASTM C117	1/2*

*	Except when material finer than Number 200 sieve consists of crusher dust, maximum amount shall be 1 percent.
**	Test Method C 123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C 295 is used to identify which of the lightweight particles are shale, chert, coal, or lignite. If the results of Test Method C 123 are less than 1.25 percent (the minimum combined percentage of shale, chert, coal and lignite), Test Method C 295 is not required.

5. Grading:
    a. Aggregate for building elements and hydraulic structures: In accordance with ASTM C33, Size Number 57, except as otherwise specified or authorized in writing by the ENGINEER.

C. Water: ASTM C94 and potable (not recycled water).

2.5 ADMIXTURES

A. Air-Entraining Admixture: ASTM C260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
2. Retarding Admixture: ASTM C494/C494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
    a. Bayer Corporation.
    b. ChemMasters.
    c. Conspec Marketing & Manufacturing Co., Inc.; a Dayton Superior Company.
    d. Davis Colors.
    e. Elementis Pigments, Inc.

2.6 VAPOR RETARDERS

A. Plastic Vapor Retarder: ASTM E1745, Class B. Include manufacturers' recommended adhesive or pressure-sensitive tape.
1. Products:
    a. Fortifiber Corporation: Moistop Ultra.
    b. Revan Industries Inc.; Vapor Block 10.
    c. Stego Industries, LLC; Stego Wrap, 15 mils.

B. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D448, Size 57, with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

2.7 FLOOR AND SLAB TREATMENTS

A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.
1. Products:
    a. Burke by Edoco; Titan Hard.
    b. ChemMasters; Chemisil Plus.
    c. ChemTec international; ChemTec One.

d. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company
e. Curecrete Distribution Inc.; Ashford Formula.
f. Dayton Superior Corporation; Day-Chem sure Hard.
g. Euclid Chemical Company (The); Euco Diamond Hard.
h. Kaufman Products, Inc.; SureHard.
i. L&M Construction Chemicals, Inc.; Seal Hard.
j. Meadows, W. R., Inc.; Liqui-Hard.
k. Metalcrete Industries; Floorsaver.
l. Nox-Crete Products Group, Kinsman Corporation; Duranox.
m. Symons Corporation, a Dayton Superior Company; buff Hard.
n. US Mix Products Company; US Spec Industraseal.
o. Vexcon Chemicals, Inc.; Vexcon StarSeal PS.

2.8 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
1. Products:
a. Axim Concrete Technologies; Cimfilm.
b. Burke by Edoco; BurkeFilm.
c. ChemMasters; Spray-Film.
d. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior company; Aquafilm.
e. Dayton Superior Corporation; Sure Film.
f. Euclid Chemical Company (The); Eucobar.
g. Kaufman Products, Inc.; Vapor Aid.
h. Lambert Corporation; Lambco Skin.
i. L&M Construction Chemicals, Inc.; E-Con.
j. MBT Protection and Repair, Div., of ChemRex; Confilm.
k. Meadows, W. R., Inc; Sealtight Evapre.
l. Metalcrete Industries; Waterhold.
m. Nox-Crete Products Group, Kinsman Corporation; Monofilm.
n. Sika Corporation, Inc.; SikaFilm.
o. Symons Corporation, a Dayton Superior Company; Finishing Aid.
p. Unitex; Pro-Film.
q. US Mix Products Company; US Spec Monofilm ER.
r. Vexcon Chemicals, Inc.; Certi-Vex EnvioAssist.

B. Absorptive Cover: AASHTO M182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

C. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, dissipating.
1. Products:
a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.
b. Burke by Edoco; Aqua Resin cure.
c. ChemMasters; Safe-Cure Clear.
d. Conspec Marketing & Manufacturing co., Inc., a Dayton Superior Company; W.B. Resin cure.
e. Dayton Superior Corporation; Day Chem Rez cure (J-11-W).
f. Euclid Chemical Company (The); Kurez DR VOX.
g. Kaufman Products, Inc.; Thinfilm 420.

h. Lambert Corporation; Aqua Kure-Clear.
i. L&M Construction Chemicals, Inc.; L&M Cure R.
j. Meadows, W. R., Inc.; 100 Clear.
k. Nox-Crete Products Group, Kinsman Corporation; Resom Cire E/
l. Sykkmons Corporation, a Dayton Superior Company; Resi-Chem Clear Cure.
m. Tamms Industries, Inc., Horncure WB 30.
n. Unitex; Hydro cure 309.
o. US Mix Products Company; US Spec Maxcure Resin Clear.
p. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.

F. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C1315, Type 1, Class A. Compatible with penetrating liquid floor treatment for surfaces specified to receive penetrating liquid floor treatment.
1. Products:
a. Burke by Edoco; Cureseal 1315 WB.
b. ChemMasters; Polyseal WB.
c. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; Sealcure 1315 WB
d. Euclid Chemical Company (The); Super Diamond Clear VOX.
e. Kaufman Products, Inc.; Sure Cure 25 Emulsion.
f. Lambert Corporation; UV Safe Seal.
g. L&M Construction Chemicals, Inc.; Lumiseal WB Plus.
h. Meadows, W. R., Inc.; Vocomp-30.
i. Metalcrete Industries; Metcure 30.
j. Symons Corporation, a Dayton Superior Company; Cure 7 Seal 31 Percent E.
k. Tamms Industries, Inc.; LusterSeal WB 300.
l. Unitex; Hydro Seal 25.
m. US Mix Products Company; US Spec Radiance UV-25.
n. Vexcon Chemicals, Inc.; Vexcon Starseal 1315.

2.9 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber.

B. Semi-rigid Joint Filler: Two-component, semi-rigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 per ASTM D2240.

C. Bonding Agent: ASTM C1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
1. Types IV and V, load bearing for bonding hardened or freshly mixed concrete to hardened concrete.

2.10 REPAIR MATERIALS

A. See Sections 03 01 00, CONCRETE SURFACE REPAIR SYSTEMS.

2.11 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Cementitious Materials: Limit percentage by weight of cementitious materials other than Portland cement in concrete as follows:
   1. Fly Ash: 15 percent of cementitious materials maximum, unless written approval is given by the Engineer.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement for non-hydraulic structures and 0.10 percent by weight of cement for hydraulic structures.

D. Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing or high-range water-reducing admixture in concrete, as required, for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
   3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

2.12 CONCRETE MIXTURES

A. Proportion normal-weight concrete mixture as follows for all structural elements:
   1. Minimum Compressive Strength: 4,000 psi at 28 days.
   2. Maximum Water-Cementitious Materials Ratio: 0.42.
   3. Slump Limit: 8-inches Max for concrete with verified slump of 2 to 4-inches before adding high range water-reducing admixture or plasticizing admixture per ACI 301.
   4. Air content: 5 1/2%, ±1.5% at point of delivery.

B. Proportion normal-weight concrete mixture as follows for all non-structural elements:
   1. Minimum Compressive Strength: 3,000 psi at 28 days.
   2. Maximum Water-Cementitious Materials Ratio: 0.45.
   3. Slump Limit: 8 inch for concrete with verified slump of 2” to 4”: before adding high-range water-reducing admixture or plasticizing admixture per ACI 301.
   4. Air content: 5 1/2%, ±1.5% at point of delivery.

2.13 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M and ASTM C1116, and furnish batch ticket information.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
   1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
   2. For mixer capacity larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd.
   3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 PLACING CONCRETE

A. Place no concrete without prior authorization of the Engineer.

B. Do not place concrete until:
   1. Reinforcement is secure and properly fastened in its correct position and loose form ties at construction joints have been retightened.
   2. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
   3. Forms have been cleaned and oiled as specified.

C. Do not place concrete in which initial set has occurred, or that has been retempered.

D. Do not place concrete during rainstorms or high velocity winds.

E. Protect concrete placed immediately before rain to prevent water from coming in contact with such concrete or winds causing excessive drying.

F. Keep sufficient protective covering on hand at all times for protection of concrete.

G. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested and accepted by the Engineer.

H. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the work:
   1. Provide this notification in such time in advance of operations, as the Engineer deems necessary to make final inspection of preparations at location of proposed concrete placing.
   2. Place forms, reinforcement, screeds, anchors, ties, and inserts in place before notification of readiness is given to the Engineer.
   3. Depositing concrete:
      a. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
      b. Do not deposit concrete in large quantities in one place and work along forms with vibrator or by other methods.
      c. Do not drop concrete freely into place from height greater than 5 feet.
      d. Use tremies for placing concrete where drop is over 5 feet.
      e. Commence placement of concrete on slopes, starting at bottom of slope.

I. Place concrete in approximately horizontal layers not to exceed 24 inches in depth and bring up evenly in all parts of forms.

J. Continue concrete placement without avoidable interruption, in continuous operation, until end of placement is reached.

K. After concrete placement begins, continue concrete placement without significant interruption. Plan and implement precautions to prevent any delay, between layers being placed, from exceeding 20 minutes.

L. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout not less than 1/2 inch in thickness nor more than 1 inch in thickness over surface before placing additional concrete.

M. Placement of concrete for slabs, beams, or walkways:
   1. If cast monolithically with walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
   2. Allow set time of not less than 1 hour for shrinkage.

3.2 FORMWORK: See Section 03 11 00, CONCRETE FORMWORK.

3.3 VAPOR RETARDERS

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E1643 and manufacturer's written instructions.
   1. Lap joints 6 inches and seal with manufacturers' recommended tape.

3.4 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer/Owner
   1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
   2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
   3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
   4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
   5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
   6. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one fourth of concrete thickness as follows:
   1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
   2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
   1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.
   2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants, specified in Division 07 Section "Joint Sealants," are indicated.
   3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

E. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by the Engineer.

C. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.
   1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
   1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
   2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
   3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
   1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
   2. Maintain reinforcement in position on chairs during concrete placement.
   3. Screed slab surfaces with a straightedge and strike off to correct elevations.
   4. Slope surfaces uniformly to drains where required.
   5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

F. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
   1. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
   2. All embedded items such as wall pipes, embed frames, steel guide rails, channels, etc. (not including conduit and reinforcing) shall be considered “massive embedments” and are required to be kept above 32 deg F during placement and for the first 48 hours after placement. Contractor shall take the necessary measures; including insulated blankets, heated blankets, and heaters; to insure items are kept above 32 deg F. All other methods shall be submitted to the Engineer for approval.
   3. Do not use frozen materials or materials containing ice or snow.
   4. Do not place concrete on frozen subgrade or on subgrade containing frozen materials. Top 12-inches of subgrade shall be thawed prior to concrete placement. Contractor is

responsible for verifying that the temperature for the top 12-inches of subgrade is above 32 deg F.

5. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

G. Hot-Weather Placement: Comply with ACI 305 and as follows:
   1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is included in total amount of mixing water. Using liquid nitrogen to cool concrete is contractor's option, but liquid nitrogen should not replace water.
   2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.
   3. All other methods shall be submitted to the Engineer for approval.

3.6 CONCRETE WALL FINISHES

A. Type W-1 (Ordinary Wall Finish or Coating):
   1. Patch tie holes.
   2. Knock off projections.
   3. Patch defective areas.

B. Type W-2 (Smooth Wall Finish):
   1. Patch tie holes.
   2. Grind off projections, fins, and rough spots.
   3. Patch defective areas and repair rough spots resulting from form release agent failure or other reasons to provide smooth uniform appearance.

C. Type W-5 (Finish for Painting):
   1. Patch tie holes.
   2. Grind off projections, fins, and rough spots.
   3. Patch and repair defective areas as specified for Type W-2.
   4. Apply paint or coating system as specified in Section 09 90 00 Painting and Protective Coatings.

3.7 CONCRETE SLAB FINISHES

A. General:
   1. Finish slab concrete per the requirements of ACI 302.1R
   2. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
   3. Do not use “Jitterbugs” or other special tools designed for the purpose of forcing coarse aggregate away from the surface and allowing a layer of mortar, which will be weak and cause surface cracks or de-lamination, to accumulate.
   4. Do not dust surface with dry materials.
   5. Use evaporation retardant.
   6. Round off edges of slabs with a steel edging tool, except where a cove finish is shown. Steel edging tool radius shall be 1/4” for slabs subject to wheeled traffic.

B. Type S-1 (Steel Troweled Finish):
   1. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation, use evaporation retardant.
   2. While concrete is still green, but sufficiently hardened to bear a person’s weight without deep imprint, wood float to true, even plane with no coarse aggregate visible.
   3. Use sufficient pressure on wood floats to bring moisture to surface.
   4. After surface moisture has disappeared, hand trowel concrete to produce smooth, impervious surface, free from trowel marks.

5. Burnish surface with an additional troweling. Final troweling shall produce a ringing sound from trowel.
6. Do not use dry cement or additional water during troweling, nor will excessive troweling be permitted.
7. Power Finishing:
    a. An approved power machine may be used in lieu of hand finishing in accordance with directions of machine manufacturer.
    b. Do not use power machine when concrete has not attained the necessary set to allow finishing without introducing high and low spots in slab.
    c. Do first steel troweling for slab S-1 finish by hand.

C. Type S-2 (Wood Float Finish):
1. Finish slabs to receive fill and mortar setting beds by screeding with straight edges to bring surface to required finish plane.
2. Wood float finish to compact and seal surface.
3. Remove laitance and leave surface clean.
4. Coordinate with other finish procedures.

D. Type S-5 (Broomed Finish):
1. Finish as specified for Type S-1 floor finish, except omit final troweling and finish surface by drawing a fine-hair broom lightly across the surface.
2. Broom in same direction and parallel to expansion joints, or, in the case of inclined slabs, perpendicular to scope, except for round roof slab, broom surface in radial direction.

E. Type S-6 (Sidewalk Finish):
1. Slope walks down 1/4” per foot away from structures, unless otherwise shown.
2. Strike off surface by means of strike board and float with wood or cork float to a true plane, then flat steel trowel before brooming.
3. Broom surface at right angles to direction of traffic or as shown.
4. Lay out sidewalk surfaces in blocks, as shown or as directed by Engineer, with a grooving tool.

F. Type S-7: The top surfaces of basins in which raking mechanisms are to be installed
1. Slabs shall be finished by sweeping in cement grout with the mechanism. The cement grout to be used shall be composed of one part Portland cement and two parts sand.
2. The sweeping-in process shall be performed under the supervision of a factory representative of the equipment manufacturer.
3. The slab upon which the grout is to be applied shall receive a Type S-5 finish except that after leveling and floating, it shall be raked in such a manner as to provide a good bond for the grout. Raking shall develop a pattern with a depth of 1/4” every 2”. Before grout is deposited on the slab, it shall be thoroughly cleaned, wet down with clean water and lightly dusted with neat cement immediately prior to placement of the grout.

3.8 SCHEDULE OF CONCRETE FINISHES

A. Form Tolerances: As specified in Section 03 11 00, CONCRETE FORMWORK.

B. Provide concrete finishes as scheduled:

Area	Type of Finish	Required Form Tolerances
EXTERIOR WALL SURFACES		
Above grade/exposed (above a point 12” below finish grade)	W-2	W-B
Backfilled (below a point 12” below final grade)	W-1	W-A

INTERIOR WALL SURFACES		
Hydraulic Structures including tanks, pump stations, flow channels, junction boxes, and basins	W-5	W-A
Buildings, pipe galleries, and other dry areas	W-5	W-B
EXTERIOR SLABS		
Exposed Roof slab or Slab-on-grade for non-hydraulic structures (includes slabs under open canopies)	S-5	
Roof slab or Top of Wall for Hydraulic Structures	S-1	
Other water holding tanks and basins	S-1	
Stairs and landings	S-5	
Sidewalks	S-6	
Other exterior slabs/pads	S-6	
Top surfaces of basins in which raking mechanisms are to be installed	S-7	
INTERIOR SLABS		
Non-Hydraulic areas such as pipe galleries and slabs-on-grade	S-1	
Hydraulic channels / Water Holding Structures	S-1	
Underside of elevated slabs	S-3	
Slabs to receive fill and mortar setting beds	S-2	

3.9 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel finish concrete surfaces.

3.10 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 305.1 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
   1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
      a. Water.
      b. Continuous water-fog spray.
      c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
   2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
      a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
      b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
      c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.
   3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
      a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.
   4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.11 LIQUID FLOOR TREATMENTS

A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.
   1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
   2. Do not apply to concrete that is less than 28 days' old.
   3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.

B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

3.12 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.
   1. Defer joint filling until concrete has aged at least one month. Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

C. Install semi-rigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.13 REPAIRING CONCRETE

A. General:
   1. Any areas deemed as having excessive defects or considered to have a negative effect on the structural performance of the structure shall be removed to the extents approved by the Engineer. The Engineer has the option of calling for the removal of the entire section if the damage is such that a repair will not be a suitable option. All work required to correct the defect will be the responsibility of the Contractor and will be paid for by the Contractor.
   2. Inject cracks as defined in 1.3.D Defective Areas with crack repair epoxy as specified in Section 03 64 00, CONCRETE REPAIR CRACK INJECTION.
   3. Repair concrete surfaces defects as defined in 1.3.D Defective Areas using one of the materials specified in Section 03 01 00, CONCRETE SURFACE REPAIR SYSTEMS. Select system, submit for review, and obtain approval from Engineer prior to use.
   4. Prior to starting the repair work, obtain quantities of color-matched repair material and manufacturer’s detailed instructions for use to provide a structural repair with finish to match adjacent surface.
   5. Develop repair techniques with material manufacturer.
   6. Dress surface of repair that will remain exposed to view to match color and texture of adjacent surfaces. Repair of concrete shall provide a structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to Engineer.

B. Tie Holes:
   1. Fill with nonshrink grout as specified in Section 03 60 00, GROUT.
   2. Match color of adjacent concrete.
   3. Compact grout using steel hammer and steel tool to drive grout to high density. Cure grout with water.

C. Alternate Form Ties-Through-Bolts:
   1. Seal through-bolt hole by sandblasting or mechanically cleaning and roughening entire interior surface of hole, coating roughened surface with bonding agent and driving elastic vinyl plug and then dry packing entire hole on each side of plug with nonshrink grout, as specified in Section 03 60 00, GROUT. Use only enough water to dry pack grout. Dry pack while bonding agent is still tacky or remove bonding agent by mechanical means and reapply new bonding agent.
   2. Compact grout using steel hammer and steel tool to drive grout to high density. Cure grout with water.

D. Exposed Metal Objects:
   1. Metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, shall be removed by chipping back concrete to depth of 1 inch and then cutting or removing metal object.
   2. Repair areas of chipped-out concrete per requirements of Section 03 01 00 CONCRETE SURFACE REPAIR SYSTEMS.

E. Blockouts at Pipes or Other Penetrations:
   1. Meet details shown or submit proposed blockouts for review.
   2. Use nonshrink, nonmetallic grout, Category I or II as specified in Section 03 60 00, GROUT.

3.14 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports. Payment of the testing and inspection agency shall be by the Contractor from the contract allowance for independent testing in accordance with Section 01 29 00, PAYMENT PROCEDURES.

B. Inspections:
   1. Steel reinforcement placement.
   2. Headed bolts and studs.
   3. Verification of use of required design mixture.
   4. Concrete placement, including conveying and depositing.
   5. Curing procedures and maintenance of curing temperature.
   6. Verification of concrete strength before removal of shores and forms from beams and slabs.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd. plus one set for each additional 50 cu. yd. or fraction thereof.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
   4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
   5. Compression Test Specimens: ASTM C31/C31M.
      a. Cast and laboratory cure two sets of three standard cylinder specimens for each composite sample.
      b. Cast and field cure two sets of three standard cylinder specimens for each composite sample.
   6. Compressive-Strength Tests: ASTM C39/C39M; test one set of three laboratory-cured specimens at 7 days and one set of three specimens at 28 days.
      a. Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days. The third cylinder will be retained for subsequent testing if required by the Engineer.
      b. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
   7. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
   8. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive

strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

9. Test results shall be reported in writing to Engineer, Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
10. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.
11. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by the Engineer. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Engineer.
12. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
13. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

D. Measure floor and slab flatness and levelness according to ASTM E 1155 48 hours after finishing. Specified overall values of flatness F(f)=25; and levelness F(L)=20; with minimum local values, F(f)=17 and F(L)=15.
   1. F(L) value only applies to elevated slabs after shoring has been removed.

E. Shrinkage Tests:
   1. Drying shrinkage tests shall be performed for the trial batch indicated in Paragraph CONCRETE MIXTURES FOR HYDRAULIC ELEMENTS for the first placement of each class of concrete for all structures noted in paragraph CONCRETE MIXTURES FOR HYDRAULIC ELEMENTS, and during construction to insure continued compliance with these Specifications. Number of field test to be determined by Engineer or Engineer's Field Representative.
   2. Drying shrinkage specimens shall be 4" by 4" by 11" prisms with an effective gauge length of 10"; fabricated, cured, dried, and measured in accordance with ASTM C157 modified as follows: specimens shall be removed from molds at an age of 23 ±1 hours after trial batching, shall be placed immediately in water at 70 °F ±3 °F for at least 30 minutes, and shall be measured within 30 minutes thereafter to determine original length and then submerged in saturated lime water at 73 °F ± 3 °F. Measurement to determine expansion expressed as a percentage of original length shall be made at age 7 days. This length at age 7 days shall be the base length for drying shrinkage calculations ("0" days drying age). Specimens then shall be stored immediately in a humidity control room maintained at 73 °F ±3 °F and 50% ±4% relative humidity for the remainder of the test. Measurements to determine shrinkage expressed as percentage of base length shall be made and reported separately for 7, 14, 21, and 28 days of drying after 7 days of moist curing.
   3. The drying shrinkage deformation of each specimen shall be computed as the difference between the base length (at "0" days drying age) and the length after drying at each test age. The average drying shrinkage deformation of the specimens shall be computed to the nearest 0.0001" at each test age. If the drying shrinkage of any specimen departs from the average of that test age by more than 0.0004", the results obtained from that specimen shall be discarded. Results of the shrinkage test shall be reported in graphical form Length Change (in) vs. Age (days) and Length Change (%) vs. Age (days) to the nearest 0.001% of shrinkage. Compression test specimens shall be taken in each case from the same concrete used for preparing drying shrinkage specimens. These tests

shall be considered a part of the normal compression tests for the project. Allowable shrinkage limitations shall be as indicated below.

a. Shrinkage Limitation: The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-day drying age or at 28-day drying age shall be 0.036% or 0.042%, respectively. The Contractor shall only use a mix design for construction that has first met the trial batch shrinkage requirements.
b. The maximum concrete shrinkage for specimens cast in the field shall not exceed the trial batch maximum shrinkage requirement by more than 25%.
c. If the required shrinkage limitation is not met during construction, the Contractor shall take any or all of the following actions at no additional cost to the Owner, for securing the specified shrinkage requirements. These actions may include changing the source of aggregates, cement and/or admixtures; reducing water content; washing of aggregate to reduce fines; increasing the number of construction joints; modifying the curing requirements; or other actions designed to minimize shrinkage or the effects of shrinkage

F. Water Leakage Tests: In accordance with ACI 350.1.
1. Purpose: Determine integrity and water tightness of finished concrete surfaces. Contractor shall perform and pay for all costs associated with water leakage tests. Report all test results to the Engineer.
2. All water-holding Structures:
a. Perform leakage tests after concrete structure is complete and capable of resisting the hydrostatic pressure of the water test. The concrete shall have achieved its full design strength.
b. Perform leakage test before backfill, brick facing, or other work that will cover concrete wall surfaces is begun.
c. Install all temporary bulkheads, cofferdams, and pipe blind flanges, and close all valves. Inspect each to see that it provides a complete seal.
d. Fill with water to test level shown, or maximum liquid level if no test level is given. Maintain this level for 72 hours prior to the start of the test to allow water absorption, structural deflection, and temperature to stabilize.
e. Measure evaporation and precipitation by floating a partially filled, transparent, calibrated, open top container.
f. Measure the water surface at two points 180° apart, when possible where attachments such as ladders exist, at 24-hour intervals. Using a sharp pointed hook gauge and fixed metal measure capable of reading to 1/100 of an inch. Continue the test for a period of time sufficient to produce at least 1/2” drop in the water surface based on the assumption that leakage would occur at the maximum allowable rate specified or for 72 hours whichever is the lesser time.

G. Acceptance Criteria:
1. Volume loss shall not exceed 0.075% of contained liquid volume in a 24-hour period, correcting for evaporation, precipitation, and settlement.
2. No damp spots or seepage visible on exterior surfaces. A damp spot is defined as sufficient moisture to be transferred to a dry hand upon touching.

H. Repairs When Test Fails: Dewater the structure; fill leaking cracks with crack repair epoxy as specified in Section 03 64 00 CONCRETE REPAIR CRACK INJECTION. Patch areas of damp spots previously recorded, and repeat water leakage test in its entirety until the structure successfully passes the test.

END OF SECTION

SECTION 03 60 00 - GROUT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Non-shrink grout.
   2. Topping grout.
   3. Concrete Fill.
   4. Cement grout for pipe invert fill.
   5. Construction joint mortar.

B. Related Sections:
   1. Section 03 11 00 – Concrete Formwork.
   2. Section 03 30 00 – Cast-In-Place Concrete.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. ASTM International (ASTM):
      a. C 230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
      b. C 1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

B. Cement Grout (Non-shrink).
   1. Corps of Engineers (COE):
      a. CRD-C 611, Flow of Grout for Prep laced Aggregate Concrete.
      b. CRD-C 621, Specification for Non-shrink Grout

1.3 SUBMITTALS

A. Product data for each type of product indicated.

B. Certified test results verifying compliance with compressive strength, shrinkage and expansion requirements and manufacturer’s literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of non-shrink and epoxy grout.

C. Fine aggregate gradation.

D. One copy of each 30 consecutive strength test results and mix design used from a record of past performance, or one copy of laboratory trial mix and design and results, and one copy of the mix design proposed for each cementitious mixture and use under this contract.

E. Qualification for testing agency.

F. Material test reports: For the following from a qualified testing agency, indicating compliance with requirements:
   1. Aggregates: Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
   2. Non-shrink grout.
   3. Epoxy grout.

G. Material certificates: For each of the following, signed by manufacturers:
   1. Cementitious materials.

2. Non-shrink grout.
3. Epoxy grout.

H. Field quality-control tests and observation reports.

I. Ready mix concrete (Cement Grout)
1. Provide delivery tickets for ready-mix concrete (cement grout) or weigh master's certificate per ASTM C 94, include weights of cement and each size aggregate and amount of water added at the plant and a record of placements. Record the amount of water added at the job site on the delivery ticket. Water added at the plant shall account for the moisture in aggregate. If water is added at the job site, then the total water content shall not exceed the water content of the approved design mix.
2. Keep records showing time and place of each placement of concrete, joint mortar bed material or cement grout, together with transit delivery slips certifying the contents of the placement. Furnish records to Engineer.

J. Joint Mortar Bed: Provide material analysis and certification for each placement.

K. Shop Drawings:
1. Product data of grouts.
2. Curing method for grout.
3. Mix design of cement-sand grout mixture for pipe invert/structure fill.
4. Mix design of Joint Mortar Bed.

L. Information Submittals:
1. Manufacturer's written instructions for mixing of grout.
2. Manufacturer's Certificate of Compliance: Grout free from chlorides and other corrosion-causing chemicals.
3. Manufacturer's Certificate of Proper Installation.
4. Statements of Qualification: Non-shrink grout manufacturer's representative.
5. Test Reports: Test report for 24-hour evaluation of non-shrink grout.

1.4 QUALIFICATIONS

A. Manufacturer's qualifications for cement grout and joint mortar bed: A firm experienced in manufacturing ready-mixed concrete products and a firm that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician – Grade I, Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician – Grade II.

C. Source limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source and obtain admixtures through one source from a single manufacturer.

D. Non-shrink Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer, with minimum of 1 year experience that has resulted in successful installation of grouts similar to those for this Project.

E. For grout suppliers not listed herein, provide completed 24-hour Evaluation of Non-shrink Grout Test Form, attached at the end of this section. Independent testing laboratory to certify that testing was conducted within last 18 months.

1.5 GUARANTEE

A. Manufacturer's guarantee shall not contain disclaimer on the product data sheet, grout bag, or container limiting responsibility to only the purchase price of products and materials furnished.

B. Manufacturer guarantees participation with Contractor in replacing or repairing grout found defective due to faulty materials, as determined by industry standard test methods.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand and source throughout project:
   1. Portland Cement: ASTM C 150, Type I or II or combination of Type I with fly ash.
   2. Fly Ash: ASTM C 618.

B. Fine aggregates: ASTM C 33, Class 4S or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials. Aggregates shall be free of materials with deleterious reactivity to alkali in cement. Aggregates for cement grout and/or mortar bed shall be provided from the same source as aggregate for the cast-in-place concrete.

C. Water: ASTM C 94 and potable.

2.2 ADMIXTURES

A. Comply with Section 03 30 00 Cast-In-Place Concrete.

2.3 NONSHRINK GROUT SCHEDULE

A. Furnish non-shrink grout for applications in grout category in the following schedule:

Application	Temperature Range 40 to 100 °F	Max. Placing Time 20 min	Max. Placing Time Greater than 20 min
Filling tie hole	I	I	I
Machine bases 25 hp or less	II	II	II
Through-bolt openings	II	II	II
Patching Concrete Walls	II	II	II
Machine bases 26 hp and up	III	III	III
Base plates and/or soleplates with vibration, thermal movement, etc.	III	III	III
Other applications not listed	II	II	II

2.4 NONSHRINK GROUT

A. Category I:
   1. Nonmetallic and non gas-liberating.

2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Test in accordance with ASTM C1107:
    a. Flowable consistency 140%, five drops in 30 seconds, in accordance with ASTM C 230.
    b. Flowable for 15 minutes.
4. Grout shall not bleed at maximum allowed water.
5. Minimum strength of flowable grout, 3,000 psi at 3 days, 5,000 psi at 7 days, and 7,000 psi at 28 days.
6. Manufacturers and Products:
    a. Chemrex, Inc., Shakopee, MN; Set Grout.
    b. Euclid Chemical Co., Cleveland, OH; NS Grout.
    c. Dayton Superior Corp., Miamisburg, OH; 1107 Advantage Grout.
    d. US MIX Products, Denver, CO; US Spec Multi-Purpose Grout.
    e. L & M Construction Chemicals, Inc., Omaha, NE; Duragrout.
    f. Master Builders.

B. Category II:
1. Nonmetallic, non gas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency - at specified times or temperatures.
4. Test in accordance with COE CRD-C 621 and ASTM C 1107, Grade B:
    a. Fluid consistency 20 to 30 seconds in accordance with COE CRD-C 611.
    b. Temperatures of 40, 80, and 100 °F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
7. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready- mix truck.
8. Manufacturers and Products:
    a. Chemrex, Inc., Shakopee, MN; Master Flow 928.
    b. Five Star Products Inc., Fairfield, CT; Five Star 100.
    c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
    d. Dayton Superior Corp., Miamisburg, OH; Sure Grip High Performance Grout.
    e. L & M Construction Chemicals, Inc., Omaha, NE; Crystex.
    f. Master Builders.

C. Category III
1. Metallic and nongas-liberating flowable fluid.
2. Prepackaged aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with CRD-C 621 and ASTM C 1107, Grade B:
    a. Fluid consistency 20 to 30 seconds in accordance with CRD-C 611.
    b. Temperatures of 40 and 100 °F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of grout, 4,000 psi at 1 day, 5,000 psi at 3 days, and 9,000 psi at 28 days.
7. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready-mix truck.
8. Manufacturers and Products: Chemrex, Inc., Shakopee, MN; EMBECO 885.

2.5 TOPPING GROUT AND CONCRETE/GROUT FILL

A. Where fill is thicker than 3-inches, structural concrete 03 30 00, CAST-IN-PLACE CONCRETE, may be used when accepted by the Engineer.

B. Grout for topping of slabs and concrete/grout fill for built-up surfaces of tank, channel and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water and admixtures proportioned and be mixed as indicated. Bonding Agent shall be used to enhance adhesion to basin concrete. Materials and procedures indicated for normal concrete in Section 03 30 00, CAST-IN-PLACE CONCRETE, shall apply unless indicated otherwise.

C. Topping grout and concrete/grout fill shall contain a minimum of 564 pounds of cement per cubic yard with a maximum water cement ratio of 0.45.

D. Aggregate shall be graded as follows:

U.S. STANDARD SIEVE SIZE	PERCENT BY WEIGHT PASSING
1/2 inch	100
3/8 inch	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 30	0

E. Final mix design shall be as determined by trial mix design as indicated in Section 03 30 00, except that drying shrinkage tests are not required.

F. Topping grout and concrete grout/fill shall contain air-entraining agent per Section 03 30 00.

G. Strength: Minimum compressive strength of topping grout and concrete/grout fill at 28 days shall be 4,000 psi.

H. Topping grout used in clarifiers shall contain fiber reinforcing. Fiber shall be 100 percent virgin polypropylene fibrillated fibers specifically manufactured in a blended gradation for use as concrete secondary reinforcement. Fibers shall be added at a rate of 1.5 pounds per cubic yard of concrete. Fibers shall conform to ASTM C 1116 – Fiber Reinforced Concrete and Shotcrete. Type III.

2.6 NON-SHRINK EPOXY GROUT

A. Manufacturers: One of the following or equal:
1. Five Star Products, Inc., Fairfield, CT, Five Star Epoxy Grout.
2. BASF Construction Chemicals, Shakopee, MN, Masterflow 648 CP Plus.
3. L&M Construction Chemicals, Inc., EPOGROUT.

B. Non-shrink epoxy grout shall be a 100 percent solid, premeasured, prepackaged system containing a 2-component thermosetting epoxy resin and inert aggregate.

C. Maintain a flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.

D. Shrinkage or expansion (less than 0.0006 inches/inch) when tested in accordance with ASTM C 531.

E. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C 579, Method B.

F. Compressive creep: Not exceed 0.0027 inches/inch when tested under a 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C 1181.

G. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C 531, Method B.

2.7 CEMENT-GROUT (CEMENT-SAND GROUT) MIXTURE FOR PIPE INVERT/STRUCTURE FILL

A. Prepare design mixture proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301. Submit proposed mixture design to Engineer for review. Comply with Section 03 30 00 Cast-In-Place Concrete and as follows.
   1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based upon laboratory trial mixtures.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete and cement grout as follows:
   1. Fly Ash: 15 percent maximum unless approved in writing by the Engineer.

C. Admixtures: All materials other than Portland cement, water and aggregates that are added to the concrete or cement grout, shall be subject to the approval of the Engineer. If so approved, use admixtures according to manufacturer's written instructions.
   1. Use water reducing, high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
   3. Use water-reducing admixture in pumped concrete, concrete for heavy-use slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

D. Minimum compressive strength: 2,000 psi at 28 days.

E. Air content: ASTM C 94, 5 percent, plus or minus 1.0 percent at point of delivery.

F. Aggregate shall be sand, three parts sand to one part cementitious material by volume. The sand gradation shall be such that 100% shall pass the No. 16 sieve and not more than 30% shall be retained on a No. 30 sieve.

G. Water – cementitious material ratio. The Contractor shall submit a proposed mix design to the Engineer for review. The amount of water shall be the minimum amount of water necessary to make a workable mixture.

H. Slump: Maximum of 4 inches.

2.8 JOINT MORTAR BED

A. Joint Mortar Bed: Mortar placed on horizontal construction joints shall be a mixture of cement, sand and water in the same proportions used in the approved 4,500 psi cast-in-place concrete mix design and/but with the coarse aggregate omitted.

PART 3 - EXECUTION

3.1 NONSHRINK GROUT

A. General: Mix, place, and cure non-shrink grout in accordance with grout Manufacturer's representative's training instructions.

B. Form Tie or Through-Bolt Holes: Provide non-shrink grout, Category I and II, fill space with dry pack dense grout hammered in with steel tool and hammer. Through-bolt holes; coordinate dry

pack dense grout application with vinyl plug in Section 03 11 00, CONCRETE FORMWORK, and bonding agent in Section 03 30 00, CAST-IN-PLACE CONCRETE.

C. Grouting Machinery Foundations:
   1. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material.
   2. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts.
   3. Form with watertight forms at least 2” higher than bottom of plate.
   4. Fill space between bottom of machinery base and original concrete in accordance with Manufacturer’s representative’s training instructions.

3.2 CEMENT GROUT

A. Place cement grout topping over concrete slabs where indicated on the drawings. Place in accordance with the procedures of this section and the manufacturer’s or suppliers of equipment recommendations. The finish surface of the grout topping shall be similar to a steel trowel finish and which will facilitate the proper operation of the mechanical equipment. The finish of the structural slab below the cement grout topping shall be a heavy broom finish.

B. Where cement grout is to be placed without mechanical equipment, the fresh surface of the cement grout shall be a smooth trowel finish. Placement procedure of cement grout at areas with mechanical equipment includes:
   1. Notify Project Representative or Engineer a minimum of 48 hours in advance of placement.
   2. Make a trial cement grout batch of not less than 1/2 cubic yard to allow time for adjustment in mix design if required.
   3. Clean the exposed structural slab by sandblasting and washing clean.
   4. Thoroughly broom a neat cement paste containing an epoxy binder into the concrete slab surface immediately ahead of placing the cement grout topping.
   5. Where applicable, install level and trial operate mechanical screed equipment over the floor slab to provide a minimum thickness of 2 inches +/- 1/4 inch. In areas where the distance between the mechanical screed and the structural slab is less than the above clearances, grind surface as directed by Engineer to provide such clearance. The mechanical screed shall operate at a speed acceptable to the cement grout topping placement procedures. Screeding procedures shall account for the effects of differential temperatures on the mechanical screed equipment.
   6. Place cement grout topping in a continuous operation. If grouting operations are interrupted, clean the edge of the previously placed topping by water jetting and add a coat of cement paste to provide a bond to the fresh topping.
   7. Temporarily equip the mechanical screed mechanism on at least two arms with a 2-inch by 10 inch continuous wood plate with light gauge metal angles and surface plates or channels. The bottom of the screed plates or steel plates shall be adjustable and set to elevations which allow the proper operation of equipment and as recommended by the equipment manufacturer or supplier.
   8. Screed the topping immediately after consolidation with vibrators or tampers and provide a steel trowel finish.
   9. Cure cement grout topping with water and cover with PVC sheeting to prevent damage from foot traffic for seven days. When/If the cement grout topping is found not to be acceptable, remove and replace. Cement grout topping not acceptable shall include, but is not limited to, poor bonding with the concrete slab, low strength, excessive cracking and unevenness in finish or elevation.

3.3 JOINT MORTAR BED

A. Joint Mortar Bed: Immediately prior to placement of fresh concrete at horizontal joints, or as indicated, place joint mortar bed to cover horizontal joint and protect water stop as applicable. Spread uniformly and work into all irregularities of the surface. The water cement ratio of the joint mortar bed shall not exceed that of the concrete being placed and the consistency of the mortar shall be suitable for placing and working. The fresh concrete shall then be immediately placed in a time and manner so that the joint mortar bed and the fresh concrete mix to form a homogenous concrete meeting all requirements.

3.4 NON-SHRINK GROUT

A. Non-Shrink grout:
   1. Used for repair of holes and defects and at locations indicated where epoxy grout is not indicated. Execution shall follow manufacturer's recommendations.
   2. Base plates and equipment where indicated. Execution shall follow manufacturer's recommendations.

3.5 EPOXY GROUT

A. Epoxy Grout: Used to embed all anchor bolts and reinforcing steel set in grout, specific machinery base plates as indicated and at other locations where indicated. Execution shall follow manufacturer's recommendations.

3.6 FIELD QUALITY CONTROL

A. Evaluation and Acceptance of Non-shrink Grout:
   1. Consistency: As specified in Article NON-SHRINK GROUT. Grout with consistencies outside range requirements shall be rejected.
   2. Segregation: As specified in Article NON-SHRINK GROUT. Grout when aggregate separates shall be rejected.

3.7 MANUFACTURER'S SERVICES

A. General: Coordinate demonstrations, training sessions, and applicable site visits with grout manufacturer's representative.

3.8 SUPPLEMENTS

A. The supplement listed below, following "END OF SECTION," is part of this Specification.
   1. 24-hour Evaluation of Non-shrink Grout Test Form and Grout Testing Procedures.

END OF SECTION

SUPPLEMENT 1

_____
(Test Lab Name)

_____
(Address)

_____
(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

OBJECTIVE: Define standard set of test procedures for an independent testing laboratory to perform and complete within a 24-hour period.

SCOPE: Utilize test procedures providing 24-hour results to duplicate field grouting demands. Intent of evaluation is to establish grout manufacturer's qualifications.

PRIOR TO TEST: Obtain five bags of each type of grout.

1. From intended grout supplier for Project.
2. Five bags of grout shall be of same lot number.

ANSWER THE FOLLOWING QUESTIONS FOR GROUT BEING TESTED FROM LITERATURE, DATA, AND PRINTING ON BAG:

A.	Product data and warranty information contained in company literature and data?	Yes_____	No_____
B.	Literature and bag information meet specified requirements?	Yes_____	No_____
C.	Manufacturer guarantees grout as specified in Article GUARANTEE?	Yes_____	No_____
D.	Guarantee extends beyond grout replacement value and allows participation with CONTRACTOR in replacing and repairing defective areas?	Yes_____	No_____
E.	Water demands and limits printed on bag?	Yes_____	No_____
F.	Mixing information printed on the bag?	Yes_____	No_____
G.	Temperature restrictions printed on bag?	Yes_____	No_____

*Rejection of a grout will occur if one or more answers are noted NO.

GROUT TESTING PROCEDURES

A. Bagged Material:

1. List lot numbers. _____

2. List expiration date. _____

3. Weigh bags and record weight. _____

ENGINEER will disqualify grout if bag weights have misstated measure plus or minus 2 pounds by more than one out of five bags. (Accuracy of weights is required to regulate amount of water used in mixing since this will affect properties.)

B. Mixing and Consistency Determination:

1. Mix full bag of grout in 10 gallon pail.

2. Use electric drill with a paddle device to mix grout (jiffy or jiffler type paddle).

3. Use maximum water allowed per water requirements listed in bag instructions.

4. Mix grout to maximum time listed on bag instructions.

5. In accordance with COE CRD-C611 (flow cone) determine time of mixed grout through the flow cone. _____ seconds

6. Add water to attain 20 to 30 second flow in accordance with COE CRD-C611.

7. Record time of grout through cone at new water demand. _____ seconds

8. Record total water needed to attain 20 to 30 second flow. _____ pounds

9. Record percent of water. _____ percent

C. When fluid grout is specified and additional water is required beyond grout manufacturer's listed maximum water, COE CRD-C621 will be run at new water per grout ratio to determine whether grout passes using actual water requirements to be fluid. Use new water per grout ratio on remaining tests.

D. Bleed Test:

1. Fill two gallon cans half full of freshly mixed grout at ambient temperatures for each category and at required consistency for each.

2. Place one can of grout in tub of ice water and leave one can at ambient temperature.

3. Cover top of both cans with glass or plastic plate preventing evaporation.

4. Maintain 38 to 42 degrees F temperature with grout placed in ice and maintain ambient temperature for second container for 1 hour.

5. Visually check for bleeding of water at 15-minute intervals for 2 hours.

6. Perform final observation at 24 hours.

7. If grout bleeds a small amount at temperatures specified, grout will be rejected.

E. Extended Flow Time and Segregation Test (for Category II and III):

1. Divide the remaining grout into two 3 gallon cans. Place the cans into the 40 °F and 100 °F containers and leave for 20, 40, and 60 minutes. Every 20 minutes remove and check for segregation or settlement of aggregate. Use a gloved hand to reach to the bottom of the can, if more than 1/4-inch of aggregate has settled to the bottom or aggregate has segregated into clumps reject the grout.

2. Right after the settlement test mix the grout with the drill mixer for 10 seconds. Take a COE CRD-C611 flow cone test of grout and record flow time. Maintain this process for 1 hour at ambient temperatures of 40 and 100 degrees F.

   a. 20 min _____, sec. @ 40 degrees F.

   b. 40 min _____, sec. @ 40 degrees F.

   c. 60 min _____, sec. @ 40 degrees F.

   d. 20 min _____, sec. @ 100 degrees F.

   e. 40 min _____, sec. @ 100 degrees F.

   f. 60 min _____, sec. @ 100 degrees F.

   All Category II and III grout that will not go through the flow cone with continuous flow after 60 minutes will be disqualified.

   _____ _____

   Qualified Disqualified

F. 24-hour Strength Test:

1. Using grout left in mixing cans in accordance with COE CRD-C621 for mixing and consistency determination test and for extended time flow test, make minimum of nine cube samples.

2. Store cubes at 70 degrees F for 24 hours.

3. Record average compressive strength of nine cubes at 24 hours.

Grout will be disqualified if 24-hour compressive strengths are under 2,500 psi for grouts claiming fluid placement capabilities.

Grouts that have not been disqualified after these tests are qualified for use on the Project for the application indicated in Nonshrink Grout Schedule.

_____ _____

Signature of Independent Testing Laboratory Date Test Conducted

SECTION 03 64 00 - CONCRETE REPAIR CRACK INJECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Epoxy injection system.

B. Related Sections:
   1. Section 03 30 00 – Cast-In-Place Concrete.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Association of State Highway and Transportation Officials (AASHTO): T 237, Standard Method for Testing Epoxy Resin Adhesive.
   2. ASTM International (ASTM):
      a. D 638, Standard Test Method for Tensile Properties of Plastics.
      b. D 648, Standard Test Method for Deflection of Plastics Under Flexural Load.
      c. D 695, Standard Test Method for Compressive Properties of Rigid Plastics.
      d. D 790, Standard Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials.

1.3 DEFINITIONS

A. Large Cracks: Wider than 0.015”.

B. Small Cracks: Width equal to 0.015” or less.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Physical and chemical properties for epoxy adhesives.
   2. Technical data for metering, mixing, and injection equipment.

B. Information Submittals:
   1. Manufacturer’s recommended surface preparation procedures and application instructions for epoxy adhesives.
   2. Installation instructions for repairing core holes with epoxy grout.
   3. Manufacturer’s Certificate of Compliance: Certified test results for each batch of epoxy adhesive.
   4. Statements of Qualification for Epoxy Adhesive:
      a. Manufacturer’s site representative.
      b. Injection applicator.
      c. Injection pump operating technician.
   5. Epoxy adhesive two component ratio and injection pressure test records for concrete crack repair work.

1.5 QUALITY ASSURANCE

A. Qualifications for Epoxy Injection Staff:
   1. Manufacturer’s Site Representative:
      a. Capable of instructing successful methods for restoring concrete structures utilizing epoxy injection process.

b. Understands and is capable of explaining technical aspects of correct material selection and use.
c. Experienced in the operation, maintenance, and troubleshooting of application equipment.

2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
   a. Licensed and certified by epoxy Manufacturer.
   b. Minimum 3 years experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection including 2,000 linear feet of wet crack injection to stop water leakage.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Package adhesive material in new sealed containers and label with following information:
   1. Manufacturer's name.
   2. Product name and lot number.
   3. ANSI Hazard Classification (formerly SPI Classification).
   4. ANSI recommended precautions for handling.
   5. Mix ratio by volume.

B. Storage and Protection: Store adhesive containers at ambient temperatures below 120 °F and above 32 °F.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Epoxy Manufacturers and Products:
   1. Sika Corp., Lyndhurst, NJ; Sikadur 35 Hi-Mod LVPL.
   2. Euclid Chemical Co., Cleveland, OH; Eucopoxy injection resin.

2.2 EPOXY ADHESIVE

A. Two-component A and B structural epoxy adhesive for injection into cracks or other voids in concrete structures for bonding or grouting.

B. Adhesive Properties: When cured for 7 days at 77, ±3 °F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

	Test Method	**Large Cracks**	**Small Cracks**
Ultimate Tensile Strength, psi	ASTM D638	8,000 min.	5,000 min.
Tensile Elongation @ Break, percent	ASTM D638	3.7 max.	3.7 max.
Flexural Strength, psi	ASTM D790	10,000 min.	10,000 min.
Flexural Modulus, psi	ASTM D790	5.5 x10^5 min.	4.5 x10^5 min.
Compressive Yield Strength, psi	ASTM D695*	15,000 min.	12,000 min.
Compressive Modulus, psi	ASTM D695*	3.8 x10^5 min.	3.8 x10^5 min.
Heat Deflection Temperature	ASTM D648*	130 °F min.	140 °F min.
Slant Shear Strength: (5,000 psi Compressive Strength Conc.)	AASHTO T 237**		
Cured 3 days @ 40 °F-Wet Concrete			3,500 psi min
Cured 1 day @ 77 °F-Dry Concrete			5,000 psi min.

	Test Method	Large Cracks	Small Cracks
Cured 3 days @ 77 °F ±3 °F			5,000 psi min.
* Cure test specimens so that peak exothermic temperature of adhesive does not exceed 100 °F			
**See referenced specifications for preparation method of test specimens			

2.3 SURFACE SEAL

A. Sufficient strength and adhesion for holding injection fittings firmly in-place, and to resist pressures preventing leakage during injection.

B. Capable of removal after injection adhesive has cured.

PART 3 - EXECUTION

3.1 GENERAL

A. Structurally repair cracks in structures as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

B. Cracks: Repair by injection of epoxy adhesive.

3.2 PREPARATION

A. Free cracks from loose matter, dirt, laitance, oil, grease, salt, and other contaminants.

B. Clean cracks in accordance with epoxy adhesive manufacturer's instructions.

C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system.

D. Do not use acids and corrosives for cleaning, unless neutralized prior to injecting epoxy.

3.3 APPLICATION

A. Sealing: Apply surface seal in accordance with Manufacturer's instructions to designated crack face prior to injection. Seal surface of crack to prevent escape of injection epoxy.

B. Entry Ports:
1. Establish openings for epoxy entry in surface seal along crack.
2. Determine space between entry ports equal to thickness of concrete member to allow epoxy to penetrate to the full thickness of the wall.
3. Provide a means to prevent concrete dusts and fines from contaminating the crack or ports when drilling.
4. Space entry ports close together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
    a. Cracks extend entirely through wall.
    b. Backfill of walls on one side.
    c. Difficult to excavate behind wall to seal both crack surfaces.
5. Core drill to verify epoxy depth where only one side of wall is exposed.

C. Epoxy Injection:
1. Store epoxy at minimum of 70 °F.
2. Start injection into each crack at lowest elevation entry port.
3. Continue injection at first port until adhesive begins to flow out of port at next highest elevation.

4. Plug first port and start injection at second port until adhesive flows from next port.
5. Inject entire crack with same sequence.

D. Finishing:
1. Cure epoxy adhesive after cracks have been completely filled to allow surface seal removal without draining or runback of epoxy material from cracks.
2. Remove surface seal from cured injection adhesive.
3. Finish crack face flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports are not acceptable.
5. Remove surface seal material and injection adhesive runs and spills from concrete surfaces.

3.4 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter and mix two adhesive components, and inject mixture into crack.

B. Discharge Pressure: Automatic pressure controls capable of discharging mixed adhesive at pressures up to 200 psi, ±5%, and able to maintain pressure.

C. Automatic Shutoff Control: Provide sensors on both Component A and B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

D. Proportioning Ratio Tolerance: Maintain epoxy adhesive Manufacturer's prescribed mix ratio within a tolerance of ±5% by volume at discharge pressure p to 160 psi.

E. Ratio/Pressure Check Device:
1. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
2. Pressure gauge capable of sensing pressure behind each valve.

3.5 FIELD QUALITY CONTROL

A. Epoxy Adhesive Two Component Ratio Tests:
1. Disconnect mixing head and pump two adhesive components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 psi for both adhesive components.
3. Simultaneously discharge both adhesive components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection workday, and when injection work has stopped for more than 1-hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:
1. Disconnect mixing head of injection equipment and connect two adhesive component delivery lines to pressure check device.
2. Pressure Check Device:
   a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
   b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.

4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
    a. Beginning and end of each injection workday.
    b. When injection work has stopped for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Crack Injection Tests:
1. Initial Cores:
    a. 4” diameter for full crack depth taken from Engineer selected locations.
    b. Take three cores in first 100 lineal feet of crack repaired and one core sample for each 500 lineal feet thereafter.
2. Provide suitable containers for storage, curing, and transportation of test specimens.
3. Methods of Testing Cores:
    a. Penetration: Visual examination.
    b. Bond Strength/Compression Test: Concrete failure prior to adhesive failure.
4. Test Requirements:
    a. Penetration: Minimum of 90% of crack shall be full of epoxy adhesive.
    b. Bond Strength/Compression Test: Concrete failure before adhesive failure, or 6,500 psi with no failure of either concrete or adhesive.
5. Evaluation and Acceptance of Tests:
    a. If initial cores pass tests as specified, epoxy adhesive injection Work at area represented by cores will be accepted.
    b. If initial cores fail either by lack of penetration or bond strength, crack repair Work shall not proceed further until areas represented by cores are re-injected or repaired and retested for acceptance.
    c. Obtain verifying core samples, number and location as selected by Engineer, after rework of areas represented by failed initial core is complete.
6. Core Hole Repair:
    a. Correct Work as result of testing upon notification from Engineer.
    b. Refill initial and verifying core holes with an epoxy grout tamped and rodded in place to form a dense fill.
    c. Finish surface to blend with adjacent concrete.

END OF SECTION

SECTION 03 64 25 – HYDROPHOBIC POLYURETHANE FOAM RESIN INJECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Polyurethane Foam injection system.

B. Related Sections:
   1. Section 03 30 00 – Cast-In-Place Concrete.

1.2 SUBMITTALS

A. Shop Drawings:
   1. Physical and chemical properties for polyurethane foam.
   2. Technical data for metering, mixing, and injection equipment.

B. Information Submittals:
   1. Manufacturer's recommended surface preparation procedures and application instructions for polyurethane foam.
   2. Manufacturer's Certificate of Compliance: Certified test results for each batch of polyurethane foam.
   3. Statements of Qualification for polyurethane foam:
      a. Manufacturer's site representative.
      b. Injection applicator.
      c. Injection pump operating technician.
   4. Polyurethane foam two component ratio and injection pressure test records for concrete crack repair work.

1.3 QUALITY ASSURANCE

A. Qualifications for Polyurethane Foam Injection Staff:
   1. Manufacturer's Site Representative:
      a. Capable of instructing successful methods for sealing concrete cracks utilizing polyurethane foam injection process.
      b. Understands and is capable of explaining technical aspects of correct material selection and use.
      c. Experienced in the operation, maintenance, and troubleshooting of application equipment.
   2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
      a. Licensed and certified by polyurethane foam manufacturer.
      b. Minimum 3 years' experience in successful polyurethane foam injection for at least 10,000 linear feet of successful crack injection including 5,000 linear feet of wet crack injection to stop water leakage.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Package adhesive material in new sealed containers and label with following information:
   1. Manufacturer's name.
   2. Product name and lot number.
   3. ANSI Hazard Classification (formerly SPI Classification).
   4. ANSI recommended precautions for handling.

5. Mix ratio by volume.

B. Storage and Protection: Store adhesive containers at ambient temperatures below 120 °F and above 32 °F.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Polyurethane Foam Manufacturers and Products:
1. Sika Corp., Lyndhurst, NJ; SikaFix HH+.
2. Grace Construction Products, Cambridge, MA; DeNeef Aqua-Tite.
3. Sauereisen, Pittsburgh, PA; Hydroactive Polyurethane Grout No. F-370

2.2 HYDROPHOBIC POLYURETHANE FOAM

A. Two-component A and B hydrophobic polyurethane foam for injection into cracks or other voids in concrete structures for sealing and prevention of water intrusion.

B. Properties: When cured for 7 days at 77, ±3 °F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

	Test Method	**Property**
Density	ASTM D1622	2.0 pcf
Viscosity	ASTM D1638	700 cps at 74ºF
Specific Gravity		>1.1
Tensile Strength	ASTM D638	15 psi
Shear Strength	ASTM C273	14 psi
Elongation	ASTM D1623	9%
Shrinkage		<1%
Solids		100%
Expansion		6 times original volume.

PART 3 - EXECUTION

3.1 GENERAL

A. Install in accordance with recommendations from polyurethane foam manufacturer.

B. Cracks: Seal by injection of polyurethane foam.

3.2 PREPARATION

A. Drill holes alongside of crack at a 45º angle. Drill holes to intersect crack midway through concrete slab thickness.

B. Spacing of holes will depend on crack size and manufacturer recommendations.

3.3 APPLICATION

A. Install injection packers in holes and tighten.

B. Flush the drilled holes with water to remove debris and drill dust from the holes and the crack.

C. Beginning at the lowest injection packer, inject polyurethane foam grout. Continue to inject grout until grout appears at the adjacent packer hole.

D. Stop pumping and install injection packer at next adjacent hole. Inject polyurethane foam grout until grout appears at the next adjacent hole.

E. Repeat process until 3 or 4 holes have been injected. Return to original packer and inject all holes a second time. Some holes may take additional grout.

F. Continue process until length of crack has been injected.

G. When entire crack has been injected, reinject each packer with water to active grout left in drill hole.

H. Polyurethane foam that has foamed from the cracks will be removed by scraping before it has cured to a solid. If foam has cured to a solid, remove with wire brush or hand held grinder.

I. Allow polyurethane foam to cure fully before removing packers. Cut packers and injection holes flush with concrete surface.

3.4 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter and mix two polyurethane foam components, and inject mixture into crack.

B. Discharge Pressure: Automatic pressure controls capable of discharging mixed polyurethane at pressures up to 2500 psi, ±5%, and able to maintain pressure.

C. Automatic Shutoff Control: Provide sensors on both Component A and B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

D. Proportioning Ratio Tolerance: Maintain polyurethane foam manufacturer's prescribed mix ratio within a tolerance of ±5% by volume at discharge pressure up to 2500 psi.

E. Ratio/Pressure Check Device:
   1. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
   2. Pressure gauge capable of sensing pressure behind each valve.

3.5 FIELD QUALITY CONTROL

A. Polyurethane Foam Two-Component Ratio Tests:
   1. Disconnect mixing head and pump two adhesive components simultaneously through ratio check device.
   2. Adjust discharge pressure to 500 psi for both adhesive components.
   3. Simultaneously discharge both adhesive components into separate calibrated containers.
   4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.

5. Complete test at 500 psi discharge pressure and repeat procedure for 1500 psi discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1 hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:
1. Disconnect mixing head of injection equipment and connect two polyurethane foam component delivery lines to pressure check device.
2. Pressure Check Device:
   a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
   b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 2000 psi.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 1875 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
   a. Beginning and end of each injection work day.
   b. When injection work has stopped for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Crack Injection Tests:
1. When required by the Engineer.
2. Initial Cores:
   a. 4” diameter for full crack depth taken from Engineer selected locations.
   b. Take three cores in first 100 lineal feet of crack repaired and one core sample for each 500 lineal feet thereafter.
3. Provide suitable containers for storage, curing, and transportation of test specimens.
4. Methods of Testing Cores:
   a. Penetration: Visual examination.
5. Test Requirements:
   a. Penetration: Minimum of 90% of crack shall be full of epoxy adhesive.
6. Evaluation and Acceptance of Tests:
   a. If initial cores pass tests as specified, polyurethane foam injection Work at area represented by cores will be accepted.
   b. If initial cores fail either by lack of penetration, crack repair Work shall not proceed further until areas represented by cores are re-injected or repaired and retested for acceptance.
   c. Obtain verifying core samples, number and location as selected by Engineer, after rework of areas represented by failed initial core is complete.
7. Core Hole Repair:
   a. Correct Work as result of testing upon notification from Engineer.
   b. Refill initial and verifying core holes with an epoxy grout tamped and rodded in-place to form a dense fill.
   c. Finish surface to blend with adjacent concrete.

END OF SECTION

DIVISION 5

METALS

SECTION 05 12 00 - STRUCTURAL STEEL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Structural steel.
   2. Grout.

B. Related sections:
   1. Section 01 45 00 - Quality Control, for independent testing agency procedures and administrative requirements.
   2. Section 05 50 00 – Metal Fabrications, for steel lintels or shelf angles not attached to structural-steel frame, miscellaneous steel fabrications, and other metal items not defined as structural steel.
   3. Section 09 90 00 - Coatings, for surface preparation and priming requirements.

1.2 DEFINITIONS

A. Structural Steel: Elements of structural-steel frame, as classified by AISC “Code of Standard Practice for Steel Buildings and Bridges,” that support design loads.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show fabrication of structural-steel components.
   1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
   2. Include embedment drawings.
   3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
   4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pre-tensioned and slip-critical high-strength bolted connections.

C. Welding certificates.

D. Qualification Data: For Installer and fabricator.

E. Mill Test Reports: Signed by Manufacturers certifying that the following products comply with requirements:
   1. Structural steel including chemical and physical properties.
   2. Bolts, nuts, and washers including mechanical properties and chemical analysis.
   3. Shop primers.
   4. Non-shrink grout.

F. Source quality-control test reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who regularly erects structural steel with scope and complexity similar to that of this project.

B. Fabricator Qualifications: A qualified fabricator who regularly fabricates structural steel with scope and complexity similar to that of this project.

C. Welding: Qualify procedures and personnel according to AWS D1.1, “Structural Welding Code--Steel.”

D. Comply with applicable provisions of the following specifications and documents:
   1. AISC “Code of Standard Practice for Steel Buildings and Bridges.”
   2. AISC “Seismic Provisions for Structural Steel Buildings” and “Supplement No.2.”
   3. AISC “Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design.”
   4. AISC “Specification for the Design of Steel Hollow Structural Sections.”
   5. AISC “Specification for Allowable Stress Design of Single-Angle Members”.
   6. RCSC “Specifications for Structural Joints Using ASTM F 3125 Bolts.

E. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00, PROJECT MANAGEMENT AND COORDINATION and Section 01 31 19, PROJECT MEETINGS.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from erosion and deterioration.
   1. Store fasteners in a protected place. Re-lubricate bolts and nuts that become dry.
   2. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
   3. Do not clean and use rusty bolts.

1.6 COORDINATION

A. Furnish anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

PART 2 - PRODUCTS

2.1 STRUCTURAL-STEEL MATERIALS

A. W-Shapes: ASTM A 992.

B. Channels, Angles, and Shapes: ASTMA A 36 unless otherwise noted.

C. Plate and Bar: ASTM A 36 unless otherwise noted.

D. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B structural tubing.

E. Steel Pipe: ASTM A53, Type E or S, Grade B.
   1. Weight Class: Standard unless otherwise indicated.
   2. Finish: Black, except where indicated to be galvanized.

F. Welding Electrodes: Comply with AWS requirements. Tensile strength should be the same or greater than base metal.

2.2 BOLTS, CONNECTORS, AND ANCHORS

A. High-Strength Bolts, Nuts, and Washers: ASTM F 3125 Type 1, heavy hex steel structural bolts; ASTM A 563 heavy hex carbon steel nuts; and ASTM F 436 hardened carbon-steel washers.
   1. Finish: Plain unless noted or indicated otherwise.

B. Un-headed Anchor Rods: ASTM F 1554, Grade 36, unless otherwise indicated.
   1. Configuration: as indicated.
   2. Nuts: ASTM A 563, heavy hex carbon steel.
   3. Plate Washers: ASTM A 36 carbon steel.
   4. Washers: ASTM F 436, hardened carbon steel.
   5. Finish: Plain, unless noted or indicated otherwise.

C. Threaded Rods: ASTM A 36.
   1. Nuts: ASTM A 563 heavy hex carbon steel.
   2. Washers: ASTM F 436 hardened carbon steel.
   3. Finish: Plain, unless noted or indicated otherwise.

D. Clevises or turnbuckles: ASTM A 108, Grade 1035, cold-finished carbon steel.

E. Eye Bolts and Nuts: ASTM A 108, Grade 1030, cold-finished carbon steel.

F. Sleeve Nuts: ASTM A 108, Grade 1018, cold-finished carbon steel.

2.3 PRIMER

A. Primer: Fabricator's standard lead and chromate free non-asphaltic rust inhibiting primer.

B. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20.

2.4 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, non-corrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time, complying with Section 03 60 00, GROUT.

2.5 FABRICATION

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC "Code of Standard Practice for Steel Buildings and Bridges" and AISC "Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design".
   1. Camber structural-steel members where indicated.
   2. Identify high-strength structural steel according to ASTM A 6 and maintain markings until structural steel has been erected.
   3. Mark and match-mark materials for field assembly.
   4. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.

B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
   1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1.

C. Bolt Holes: Cut, drill, or punch standard bolt holes perpendicular to metal surfaces.

D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 3, “Power Tool Cleaning.”

F. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural steel. Straighten as required to provide uniform, square, and true members in completed wall framing.

G. Welded Door Frames: Build up welded door frames attached to structural steel. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk, cross-recessed head machine screws, uniformly spaced not more than 10” o.c., unless otherwise indicated.

H. Holes: Provide holes required for securing other work to structural steel and for passage of other work through steel framing members.
   1. Cut, drill, or punch holes perpendicular to steel surfaces.
   2. Base-Plate Holes: Cut, drill, or punch holes perpendicular to steel surfaces.
   3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.6 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC “Specification for Structural Joints Using ASTM F 3125 Bolts” for type of bolt and type of joint specified.
   1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.
   1. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
   2. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances of AISC “Code of Standard Practice for Steel Buildings and Bridges” for mill material.

2.7 SHOP PRIMING

A. Shop prime steel surfaces except the following:
   1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2”.
   2. Surfaces to be field welded.
   3. Surfaces to be high-strength bolted with slip-critical connections.
   4. Surfaces to receive sprayed fire-resistive materials.
   5. Galvanized surfaces.

B. Surface Preparation: Clean the surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
   1. SSPC-SP 3, “Power Tool Cleaning.”

C. Priming: Immediately after surface preparation, apply primer according to Manufacturer’s written instructions and at rate recommended by SSPC to provide a dry film thickness of not less than 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
   1. Stripe paint comers, crevices, bolts, welds, and sharp edges.
   2. Apply two coats of shop paint to inaccessible surfaces after assembly or erection. Change color of second coat to distinguish it from first.

D. Painting: Apply a 1-coat, non-asphaltic primer complying with SSPC-PS Guide 7.00, “Painting System Guide 7.00: Guide for Selecting One-Coat Shop Painting Systems,” to provide a dry film thickness of not less than 1.5 mils.

2.8 GALVANIZING

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123.
   1. Fill vent holes and grind smooth after galvanizing.
   2. Galvanize lintels and shelf angles attached to structural-steel frame and located in exterior walls.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedment, with steel erector present, for compliance with requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place, unless otherwise indicated.
   1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC “Code of Standard Practice for Steel Buildings and Bridges” and “Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design”.

B. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting base and bearing plates. Clean bottom surface of base and bearing plates.
   1. Set base and bearing plates for structural members on wedges, shims, or setting nuts as required.
   2. Weld plate washers to top of base plate.
   3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of base or bearing plate before packing with grout.
   4. Promptly pack grout solidly between bearing surfaces and base or bearing; plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow it to cure. Comply with Manufacturer’s written installation instructions for shrinkage-resistant grouts.

C. Maintain erection tolerances of structural steel within AISC “Code of Standard Practice for Steel Buildings and Bridges.”

D. Align and adjust various members forming part of complete frame or structure before permanently fastening. Before assembly clean bearing surfaces and other surfaces that will be

in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
1. Level and plumb individual members of structure.
2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

C. Splice members only where indicated.

D. Do not use thermal cutting during erection unless approved by Engineer. Finish thermally cut sections within smoothness limits in AWS D1.1.

E. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC “Specification for Structural Joints Using ASTM F 3125 Bolts” for type of bolt and type of joint specified.
1. Joint Type: Snug tightened, unless noted or indicated otherwise.

B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.
1. Comply with AISC “Code of Standard Practice for Steel Buildings and Bridges” and “Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design”, for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.
2. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
3. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances of AISC “Code of Standard Practice for Steel Buildings and Bridges” for mill material.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.

B. Bolted Connections: Shop-bolted connections will be tested and inspected according to RCSC “Specification for Structural Joints Using ASTM F 3125 Bolts.”

C. Welded Connections: Field welds will be visually inspected according to AWS D1.1.

D. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

3.6 REPAIRS AND PROTECTION

A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and Manufacturer’s written instructions.

B. Touchup Painting: After installation, promptly clean, prepare, and prime or re-prime field connections, rust spots, and abraded surfaces of prime-painted joists and accessories, bearing plates, and abutting structural steel.
1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.
2. Apply a compatible primer of same type as shop primer used on adjacent surfaces.

C. Touchup Painting: Cleaning and touchup painting are specified in Section 09 90 00, COATINGS.

END OF SECTION

SECTION 05 50 00 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Steel framing and supports for overhead doors.
   2. Steel framing and supports for mechanical and electrical equipment.
   3. Steel framing and supports for applications where framing and supports are not specified in other Sections.
   4. Shelf angles.
   5. Loose bearing and leveling plates.
   6. Steel welded plates and angles for casting into concrete not specified in other Sections.
   7. Miscellaneous steel trim including steel angle corner guards and steel edgings.
   8. Metal ladders.
   9. Metal bollards.
   10. Pipe guards.
   11. Metal floor plate and supports.
   12. Abrasive metal nosing, treads, and thresholds.

B. Products furnished, but not installed, under this Section include the following:
   1. Loose steel lintels.
   2. Anchor bolts, steel pipe sleeves, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.

C. Related Sections include the following:
   1. Section 03 30 00 – Cast-In-Place Concrete, for installing anchor bolts, steel pipe sleeves, wedge-type inserts and other items indicated to be cast into concrete.
   2. Section 04 22 00 – Unit Masonry Assemblies, for installing loose lintels, anchor bolts, and other items indicated to be built into unit masonry.
   3. Section 05 12 00 – Structural Steel.
   4. Section 05 51 00 – Metal Stairs.
   5. Section 05 53 00 – Metal Gratings.
   6. Section 09 90 00 – Coatings.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance of Ladders: Provide ladders capable of withstanding the effects of loads and stresses within limits and under conditions specified in ANSI A14.3.

B. Thermal Movements: Provide exterior metal fabrications that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
   1. Temperature Change (Range): 120 °F, ambient; 180 °F, material surfaces.

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Metal nosing and treads.
   2. Paint products.
   3. Grout.
   4. Fall Protection (ladder).

5. Metal Floor Plate and support.

B. Shop Drawings: Show fabrication and installation details for metal fabrications.
   1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.
   2. Provide templates for anchors and bolts specified for installation under other Sections.
   3. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Samples for Verification: For each type and finish of extruded nosing and tread.

D. Mill Certificates: Signed by Manufacturers of stainless-steel sheet certifying that products furnished comply with requirements.

E. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, “Structural Welding Code--Steel.”
   2. AWS D1.2, “Structural Welding Code--Aluminum.”
   3. AWS D1.3, “Structural Welding Code--Sheet Steel.”
   4. AWS D1.6, “Structural Welding Code--Stainless Steel.”

1.5 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication and indicate measurements on Shop Drawings.
   1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate wall and other contiguous construction to ensure that actual dimensions correspond to established dimensions.
   2. Provide allowance for trimming and fitting at site.

1.6 COORDINATION

A. Coordinate installation of anchorages for metal fabrications. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

B. Coordinate installation of steel weld plates and angles for casting into concrete that are specified in this Section but required for work of another Section. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.

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

2.2 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces, unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

2.3 FERROUS METALS

A. Steel Plates, Shapes, and Bars: ASTM A 36.

B. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304.

C. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304.

D. Steel Tubing: ASTM A 500, cold-formed steel tubing.

E. Steel Pipe: ASTM A 53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.

F. Cast Iron: ASTM A 48, Class 30, unless another class is indicated or required by structural loads.

2.4 NONFERROUS METALS

1. Aluminum Plate and Sheet: ASTM B 209, Alloy 6061-T6.
2. Aluminum Extrusions: ASTM B 221, Alloy 6063-T6.
3. Aluminum-Alloy Rolled Tread Plate: ASTM B 632, Alloy 6061-T6.
4. Aluminum Castings: ASTM B 26, Alloy 443.0-F.

2.5 FASTENERS

A. General: Unless otherwise indicated, provide Type, 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, at exterior walls. Provide stainless-steel fasteners for fastening aluminum. Select fasteners for type, grade, and class required.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A, with hex nuts, ASTM A 563; and, where indicated, flat washers.
1. Finish: Plain or Hot Dip Zinc-coated ASTM A153 Class C, as indicated.

C. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, nuts and, where indicated, flat washers; ASTM F 593, AISI Type 316, Condition CW for bolts and ASTM F 594 for AISI Type 316, Condition CW nuts.
1. All threads on stainless steel rods/bolts shall be protected with antiseize lubricant suitable for submerged stainless bolts and complying with Federal Specification MIL-A-907E.

D. Anchor Bolts: ASTM F 1554, Grade 36.
1. Provide hot-dip or mechanically deposited, zinc-coated anchor bolts where item being fastened is indicated to be galvanized.

E. Machine Screws: ASME B 18.6.3.

F. Lag Bolts: ASME B 18.2.1.

G. Wood Screws: Flat head, ASME B18.6.1.

H. Plain Washers: Round, ASME B 18.22.1.

I. Lock Washers: Helical, spring type, ASME B 18.21.1.

J. Cast-in-Place Anchors in Concrete: Anchors capable of sustaining, without failure, a load equal to four times the load imposed, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
   1. Threaded or wedge type; galvanized ferrous castings either: ASTM A 47 malleable iron or ASTM A 27, cast steel. Provide bolts, washers, and shims as needed, hot-dip galvanized per ASTM A 153.

K. Expansion Anchors: Anchor bolt and sleeve assembly with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
   1. Material for Anchors in Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B 633, Class Fe/Zn 5.
   2. Material for Anchors in Exterior Locations: ASTM F 593, AISI Type 316, Condition CW for bolts and ASTM F 594 for AISI Type 316, Condition CW nuts.
   3. Expansion anchors shall not be substituted for adhesive anchors.

L. Adhesive Anchors:
   1. Threaded Rod:
      a. ASTM F 593 stainless steel threaded rod, diameter as shown on Drawings.
      b. Length as required to provide minimum depth of embedment.
      c. Clean and fee of grease, oil, or other deleterious material.
      d. For hollow-unit masonry, provide galvanized or stainless steel wire cloth screen tube to fit threaded rod.
   2. Adhesive:
      a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments, with gray color after mixing.
      b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and environmental conditions.
      c. Nonsag, with selected viscosity based on installation temperature and overhead application where applicable.
      d. HILTI HIT HY-150 or approved equal.
   3. Packaging:
      a. Disposable, self-contained cartridge system capable of dispensing both components in the proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
      b. Cartridge Marking: Include manufacturer's name, product name, material type, batch serial number, and adhesive expiration date.
   4. Manufacturers and Products:
      a. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System, HIT HY 150 (HIT HY 20 for hollow masonry).
      b. Approved Equal.

2.6 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Shop Primers: Provide primers that comply with Division 9.

C. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79.
   1. Use primer with a VOC content of 420 g/L (3.5 lb/gal.), or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

D. Zinc-Rich Primer: Complying with SSPC-Paint 20 or SSPC-Paint 29 and compatible with topcoat.
   1. Use primer with a VOC content of 420 g/L (3.5 lb/gal.), or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Available Products:
      a. Benjamin Moore & Co.; Epoxy Zinc-Rich Primer CM18119.
      b. Carboline Company; Carbozinc 621.
      c. ICI Devoe Coatings; Catha-Coat 313.
      d. International Coatings Limited; Interzinc 315 Epoxy Zinc-Rich Primer.
      e. PPG Architectural Finishes, Inc.; Aquapon Zinc-Rich Primer 97-670.
      f. Sherwin-Williams Company (The); Corothane I GalvaPac Zinc Primer.
      g. Tnemec Company, Inc.; Tneme-Zinc 90-97.

E. Galvanizing Repair Paint: High-zinc-dust-content paint for re-galvanizing welds in steel, complying with SSPC-Paint 20.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

G. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, non-corrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by Manufacturer for interior and exterior applications and complying with Section 03 60 00 GROUT.

H. Concrete Materials and Properties: Comply with requirements in Section 03 30 00, CAST-IN-PLACE CONCRETE for normal-weight, air-entrained, ready-mix concrete with a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.

2.7 FABRICATION, GENERAL

A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32”, unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form bent-metal comers to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work true to line and level with accurate angles and surfaces and straight edges.

E. Weld comers and seams continuously to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.

4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts, unless otherwise indicated. Locate joints where least conspicuous.

G. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

I. Provide for anchorage of type indicated; coordinate with supporting structure, and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
1. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8” x 1-1/2”, with a minimum 6” embedment and 2” hook, not less than 8” from ends and corners of units and 24” o.c., unless otherwise indicated.

2.8 MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Design and provide steel framing and supports not specified in other Sections as needed to complete the Work.

B. Fabricate units from steel shapes, plates, and bars of welded construction, unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction retained by framing and supports. Cut, drill, and tap units to receive hardware, hangers, and similar items.
1. Fabricate units from slotted channel framing where indicated.
2. Furnish inserts if units are installed after concrete is placed.

C. Galvanize miscellaneous framing and supports where indicated.

D. Prime miscellaneous framing and supports with zinc-rich primer where indicated.

2.9 LOOSE STEEL LINTEL

A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Weld adjoining members together to form a single unit where indicated.

B. Size loose lintels to provide bearing length at each side of openings equal to 1/12 of clear span but not less than 8”, unless otherwise indicated.

C. Galvanize loose steel lintels located in exterior walls.

D. Prime loose steel lintels located in exterior walls with zinc-rich primer.

2.10 LOOSE BEARING AND LEVELING PLATES

A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

B. Galvanize plates after fabrication.

C. Prime plates with zinc-rich primer.

2.11 STEEL WELD PLATES AND ANGLES

A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with not less than two integrally welded steel strap anchors for embedding in concrete.

2.12 MISCELLANEOUS STEEL TRIM

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.
   1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

C. Galvanize exterior miscellaneous steel trim.

D. Prime interior miscellaneous steel trim, with zinc-rich primer.

2.13 METAL LADDERS

A. General:
   1. Comply with the more stringent requirements of OSHA and ANSI A14.3, unless indicated otherwise.
   2. Space side rails 16” clear apart, unless otherwise indicated.
   3. Support each ladder at top and bottom and not more than 60” o.c, with welded or bolted brackets, made from same metal as ladder.
   4. All ladders including ladders less than 20 feet in height shall be equipped with an integral fall protection system.

B. Design Live Loads:
   1. Side rail loads: Ladder rails shall be designed to withstand a minimum of two (2) 300 pound loads plus 30 percent impact concentrated between any two consecutive attachments.
   2. Rung loads: Ladder rungs shall be designed to withstand a minimum live load of 300 pounds plus 30 percent impact.

C. Ladder Deflection:
   1. Limit rung deflection to span divided by 360.

D. Extension (Pop-up). Every ladder that does not have an exterior hand hold shall be equipped with a pop-up extension designed by the ladder manufacturer.
   1. Pop-up extension shall be of the same material and finish as the ladder with telescoping tubular section that locks automatically when fully extended.
   2. Upward and downward movement shall be controlled by stainless steel spring balancing mechanisms.
   3. Units shall be completely assembled with fasteners for securing to the ladder rungs in accordance with the manufacturer’s recommendations.

E. Fall Prevention System (Ladder):
1. All ladders, including ladders less than 20 feet in height, shall be equipped with an integral fall prevention system. The fall prevention system at each ladder shall include a permanent metal carrier rung/rail, carrier rung/rail extension as required, sliding sleeve arresting unit, ladder rung clamps, full body harness, dismount section and all other components as necessary for complete installation and system to comply with OSHA and ANSI A14.3 standards and requirements.
   a. The fall prevention system manufacturer shall design each fall prevention system, coordinate with the ladder manufacturer and submit the fall prevention system design and detailed plans to the Engineer for approval.
   b. The carrier rung/rail shall be Type 316 stainless steel or aluminum alloy 6105-T5.
   c. Carrier rung/rail extensions shall be provided for safe ladder access and egress. The total carrier rung/rail length shall be as designed by the fall prevention system manufacturer.
   d. Available Manufacturers:
      1). Sellstorm Manufacturing
      2). North Safety Products, Ltd.
      3). Or approved equal.

F. Steel Ladders:
1. Side rails: Continuous, 1/2” x 2-1/2” steel flat bars, with eased edges.
2. Rungs: 3/4” steel bars.
3. Fit rungs in centerline of side rails; plug-weld and grind smooth on outer rail faces.
4. Rung spacing shall not exceed 12 inches on center.
5. Provide non-slip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.
6. Provide non-slip surfaces on top of each rung by coating with abrasive material metallically bonded to rung by a proprietary process.
7. Available Products:
   a. IKG Industries, a Harsco company; Mebac.
   b. W. S. Molnar Company; SlipNOT.
8. Galvanize exterior ladders and interior ladders, where indicated, including brackets and fasteners.

G. Aluminum Ladders:
1. Side rails: Continuous extruded-aluminum channels or tubes, not less than 2-1/2” deep, 3/4” wide, and 1/8” thick.
2. Rungs: Extruded-aluminum tubes, not less than 3/4” deep and not less than 1/8” thick, with ribbed tread surfaces.
3. Fit rungs in centerline of side rails; fasten by welding or with stainless-steel fasteners or brackets and aluminum rivets.
4. Rung spacing shall not exceed 12 inches on center.

2.14 ALUMINUM PLANK

A. Acceptable Manufacturers include, but are not limited to the following:
1. Ohio Gratings Inc.
2. McNichols Co.
3. Amico, a Gibraltar Industries Co.
4. Harsco Industrial IKG.
5. Or Approved equal.

B. Materials: Plank and banding are Aluminum type 6061-T6, ASTM B221.
1. Description:

a. Unpunched, Aluminum Heavy Duty Plank Grating: Six inch wide extruded aluminum plank with support bars spaced 1.2” on center, fabricated with banding into panels of standard width to fill areas shown on the drawings.
   1) Top Surface: Slip resistant
   2) Finish: Mill finished
   3) Plank Type: Unpunched
   4) Plank Depth: based on loading requirements and clear span.

2.15 METAL FLOOR PLATE

A. Also referenced as “Checkered” or “Check” Plate, with raised lugs on one side and smooth surface on other side.

B. Fabricate from roller-aluminum-alloy 6061-T6, ASTM B 632 plate of thickness indicated below Raised lug pattern shall be on top and start at 45° angle to edge of plate or tread.

C. Design and provide stainless steel or aluminum angle and/or aluminum beam supports, as indicated or required and not indicated.

D. Include stainless steel or aluminum angle stiffeners and fixed and removable sections, as indicated or required.

E. Provide flush stainless steel bar drop handles for lifting removable sections one at each end of each section.

F. Floor plate, including all support members, reinforcement ribs, stiffeners, edge members, supports and all structural requirements shall be designed by a Professional Engineer licensed in the State of the Work and provided by the manufacturer/fabricator of the floor plate.

G. Design of the floor plate, including all supports, connections and integral members shall be for the actual dead load plus a live load consisting of:
   1. The uniform live load of the adjacent floor, or
   2. A uniform live load of 200 lbf/sq. ft., whichever load produces the greater effects. Design shall use the loading and pattern loading for multiple spans which produces the greatest loading, stresses and deflection wit the floor plate system.

H. The maximum fiber stress shall not exceed that which is allowed by the Aluminum Association.

I. The maximum total load deflection shall be limited to the span divided by 180 (L/180), not to exceed 0.25 inch between supporting members.

J. Contractor shall submit sealed shop drawings complete with details and calculations to the Engineer for review prior to fabrication. Submittal data will be complete with detail and calculations to determine all components of the floor plate system, including plate, reinforcing ribs, supports, rib pattern, connections and others as necessary.

K. All ends and openings shall be banded.

L. Provide 1/4 inch neoprene gaskets for all sealed or odor control floor plate coverings as/where indicated.

M. The weight of a floor plate section shall not exceed 80 pounds.

N. Aluminum surfaces in contact with concrete, grout or dissimilar metals will be protected with a coat of bituminous paint, Mylar isolators or other protective system, as approved by the Engineer.

O. Available Manufacturers
1. Thompson Fabricating, LLC; Tarrant, AL.
2. Or approved equal.

2.16 METAL BOLLARDS

A. Fabricate metal bollards from steel shapes as indicated.

2.17 ABRASIVE METAL NOSINGS AND TREADS

A. Cast-Metal Units: Cast aluminum, with an integral abrasive finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions.
1. Manufacturers:
a. American Safety Tread Co., Inc.
b. Baleo Inc.
c. Barry Pattern & Foundry Co., Inc.
d. Granite State Casting Co.
e. Safe-T-Metal Co.
f. Wooster Products Inc.
2. Nosing: Cross-hatched units, 4” wide with 1/4” lip, for casting into concrete steps.
3. Nosing: Cross-hatched units, 1-1/2” x 1-1/2”, for casting into concrete curbs.
4. Treads: Cross-hatched units, full depth of tread with 3/4” x 3/4” nosing, for application over bent plate treads or existing stairs.

B. Extruded Units: Aluminum, with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder. Fabricate units in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions.
1. Available Manufacturers:
a. ACL Industries, Inc.
b. American Safety Tread Co., Inc.
c. Amstep Products.
d. Armstrong Products, Inc.
e. Baleo Inc.
f. Granite State Casting Co.
g. Wooster Products Inc.
2. Provide ribbed units, with abrasive filler strips projecting 1/16” above aluminum extrusion.
3. Provide solid-abrasive-type units without ribs.
4. Nosing: Square-back units, 3” wide, for casting into concrete steps.
5. Nosing: Beveled-back units, 3” wide with 1-3/8” lip, for surface mounting on existing stairs.
6. Nosing: Two-piece units, 3” wide, with sub channel for casting into concrete steps.
7. Treads: Beveled-back units, full depth of tread with 1-3/8” lip, for application over existing stairs.

C. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with Manufacturer.

D. Drill for mechanical anchors and countersink. Locate not more than 4” from ends and not more than 12” o.c., evenly spaced between ends, unless otherwise indicated. Provide closer spacing if recommended by Manufacturer.

1. Provide 2 rows of holes for units more than 5” wide, with 2 holes aligned at ends and intermediate holes staggered.

E. Apply bituminous paint, Mylar isolators or other protective system as approved by the Engineer to concealed bottoms, sides, and edges of cast-metal units set into concrete

2.18 FINISHES, GENERAL

A. Comply with NAAMM “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

B. Finish metal fabrications after assembly.

2.19 STEEL AND IRON FINISHES

A. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:
1. ASTM A 123 for galvanizing steel and iron products.
2. ASTM A 153 for galvanizing steel and iron hardware.

B. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed metal fabrications:
1. Exteriors (SSPC Zone 1B) and Items Indicated to Receive Zinc-Rich primer: SP 6/NACE No.3, “Commercial Blast Cleaning.”
2. Interiors (SSPC Zone 1A): SSPC-SP 3, “Power Tool Cleaning.”

C. Shop Priming: Apply shop primer to uncoated surfaces of metal fabrications, except those with galvanized finishes and those to be embedded in concrete, sprayed-on fireproofing, or masonry, unless otherwise indicated. Comply with SSPC-PA 1, “Paint Application Specification No.1: Shop, Field, and Maintenance Painting of Steel,” for shop painting.
1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

2.20 STAINLESS-STEEL FINISHES

A. Remove tool and die marks and stretch lines or blend into finish.

B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

C. Bright, Directional Satin Finish: No.4.

D. Dull Satin Finish: No.6.

E. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.21 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. As-Fabricated Finish: AA-M10 (Mechanical Finish: as fabricated, unspecified).

C. Class 1, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: non-specular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class 1, clear coating 0.018 mm or thicker) complying with AAMA 611.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with the following requirements:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag bolts, wood screws, and other connectors.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

F. Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Install framing and supports to comply with requirements of items being supported, including Manufacturers' written instructions and requirements indicated on Shop Drawings.

B. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in "Installing Bearing and Leveling Plates" Article.

3.3 INSTALLING BEARING AND LEVELING PLATES

A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of plates.

B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.

1. Use non-shrink grout, nonmetallic, in concealed locations where not exposed to moisture; use non shrink, nonmetallic grout in exposed locations, unless otherwise indicated.
2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.4 INSTALLING METAL BOLLARDS

A. Anchor bollards in concrete as indicated.

B. Anchor bollards in place with concrete footings. Center and align bollards in holes 3” above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.

C. Fill bollards solidly with concrete, mounding top surface to shed water.
1. Do not fill removable bollards with concrete.

3.5 INSTALLING NOSINGS, TREADS, AND THRESHOLDS

A. Center nosing on tread widths.

B. For nosing embedded in concrete steps or curbs, align nosing flush with riser faces and level with tread surfaces.

C. Seal thresholds exposed to exterior with elastomeric sealant complying with Section 07 92 00, JOINT SEALANTS to provide a watertight installation.

3.6 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
1. Apply by brush or spray to provide a minimum 2.0 mil dry film thickness.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 9 painting Sections.

C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION

SECTION 05 51 00 - METAL STAIRS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Pre-engineered industrial-type stairs with Aluminum grating treads.
   2. Aluminum railings attached to metal stairs.
   3. Aluminum handrails attached to walls adjacent to metal stairs
   4. Railing gates at the level of exit discharge.

B. Related Sections include the following:
   1. Section 03 30 00 – Cast-In-Place Concrete, for concrete fill for stair platforms.
   2. Section 05 50 00 – Metal Fabrications, for metal treads and nosings not installed in metal stairs.

1.2 PERFORMANCE REQUIREMENTS

A. Comply with the more stringent of IBC, OSHA and as follows.

B. Structural Performance of Stairs: Design and provide metal stairs capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
   1. Uniform Load: 200 lbf/sq. ft.
   2. Concentrated Load: 300 lbf applied on an area of 4 sq. in.
   3. Uniform and concentrated loads need not be assumed to act concurrently.
   4. Stair tread, 250psf for tread itself.
   5. Platform and landings: Aluminum tread with uniform live load of 200 psf or a concentrated load of 1000 lbf over one (1) sq. ft. applied at midspan, whichever produces the greater effect.
   6. Stair Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above.
   7. Limit deflection of treads, platforms, and framing members to L/360 or 1/4” whichever is less.

C. Seismic Performance: Provide metal stairs capable of withstanding the effects of earthquake motions determined according to ASCE 7, “Minimum Design Loads for Buildings and Other Structures”; Section 9, “Earthquake Loads.”

1.3 SUBMITTALS

A. Product Data: For metal stairs and the following:

B. Shop Drawings: Include sealed calculations, plans, elevations, sections, details, and attachments to other work.
   1. Provide templates for anchors and bolts specified for installation under other Sections.
   2. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation, licensed in the State where the work is located.

C. Samples for Initial Selection: For products involving selection of color, texture, or design.

D. Samples for Verification: For the following products, in Manufacturer’s standard sizes:
   1. Grating treads.

2. Abrasive nosings.

E. Welding certificates.

F. Qualification Data: For professional engineer and testing agency.

G. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for stairs and railings.
1. Test railings according ASTM E 894 and ASTM E 935.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. NAAMM Stair Standard: Comply with “Recommended Voluntary Minimum Standards for Fixed Metal Stairs” in NAAMM AMP 510, “Metal Stairs Manual,” for class of stair designated, unless more stringent requirements are indicated.
1. Industrial-Type Stairs: Industrial class.

C. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.2 “Structural Welding Code – Aluminum.”

D. Professional Engineer qualifications.

1.5 COORDINATION

A. Coordinate installation of anchorages for metal stairs. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to project site in time for installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
2. Available Manufacturers: Subject to compliance with requirements, Manufacturers offering products that may be incorporated into the Work include, but are not limited to; Manufacturers specified.

2.2 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces, unless otherwise indicated, for components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Aluminum Extrusions: ASTM B 221, Alloy 6063- T6.

C. Aluminum Castings: ASTM B 26, Alloy 443.0-F.

2.3 ABRASIVE NOSINGS

A. As specified in Section 05 50 00, METAL FABRICATIONS.

B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with Manufacturer.

C. Apply bituminous paint to concealed bottoms, sides, and edges of cast-metal units set into concrete.

D. Apply clear lacquer to concealed bottoms, sides, and edges of extruded units set into concrete.

2.4 FASTENERS

A. As specified in Section 05 50 00, METAL FABRICATIONS.

2.5 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Bituminous Paint: Cold, applied asphalt emulsion complying with ASTM D 1187.

C. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, non-corrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by Manufacturer for interior and exterior applications.

D. Concrete Materials and Properties: Comply with requirements in Section 03 30 00, Cast-in-Place Concrete for normal-weight, air-entrained, ready-mix concrete with a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.

E. Non slip-Aggregate Concrete Finish: Factory-packaged abrasive aggregate made from fused, aluminum-oxide grits or crushed emery; rustproof and non-glazing; unaffected by freezing, moisture, or cleaning materials.

F. Welded Wire Fabric: ASTM A 185, 6” X 6” W1.4 X W1.4, unless otherwise indicated.

2.6 FABRICATION, GENERAL

A. Provide complete stair assemblies, including metal framing, hangers, struts, railings, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
   1. Join components by welding, unless otherwise indicated.
   2. Use connections that maintain structural value of joined pieces.
   3. Fabricate treads and platforms of exterior stairs so finished walking surfaces slope to drain.

B. Preassembled Stairs: Assemble stairs in shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32”, unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

D. Form bent-metal comers to smallest radius possible without causing grain separation or otherwise impairing work.

E. Form exposed work true to line and level with accurate angles and surfaces and straight edges.

F. Weld connections to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Weld exposed comers and seams continuously, unless otherwise indicated.
   5. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flathead (countersunk) screws or bolts unless otherwise indicated. Locate joints where least conspicuous.

H. Fabricate joints that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

2.7 ALUMINUM-FRAMED STAIRS

A. Manufacturers:
   1. Alfab, Inc.
   2. American Stair, Inc.
   3. Sharon Companies Ltd. (The).
   4. Approved Equal.

B. Stair Framing:
   1. Fabricate stringers of Aluminum channels.
      a. Provide closures for exposed ends of channel stringers.
      b. Minimum stringer size shall be C 12x10.37.
   2. Construct platforms of Aluminum channel headers and miscellaneous framing members as needed to comply with performance requirements.
   3. Weld or bolt stringers to headers; weld or bolt framing members to stringers and headers. If using bolts, fabricate and join so bolts are not exposed on finished surfaces.
   4. Columns shall be aluminum tube as required, minimum size AL 3x3x3/16.
   5. Treads shall be aluminum from rolled aluminum alloy tread, alloy T6061-T6, ATM B632 or aluminum grating as indicated. Tread plate shall have raised lugs on the top surface. Grating for treads shall have integral corrugated nosing.
      a. Form treads with integral nosing and back edge stiffener. Form risers of same material as treads.
      b. Weld supporting brackets to stringers and weld treads to brackets.
      c. Fabricate platforms with integral nosings matching treads and weld to platform framing.
   6. Provide lateral support and bracing as required by design.

C. Metal Bar-Grating Stairs: Form treads and platforms to configurations shown from metal bar grating; fabricate to comply with NAAMM MBG 531, “Metal Bar Grating Manua1.”
   1. Fabricate treads and platforms from welded Aluminum grating with 1-1/2” by 3/16” bearing bars at 15/16” o.c. and crossbars at 4” o.c., NAAMM designation: W-15-4 (1-1/4”x 3/16”) STEEL.
   2. Surface: Serrated.

3. Fabricate grating treads with cast abrasive nosing and with steel angle or steel plate carrier at each end for stringer connections. Secure treads to stringers with bolts.
4. Fabricate grating platforms with nosing matching that on grating treads. Provide toe plates at open-sided edges of grating platforms. Weld grating to platform framing.

2.8 FINISHES

A. Comply with NAAMM “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

B. Finish metal stairs after assembly.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.

C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

E. Field Welding: Comply with the following requirements:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Place and finish concrete till for treads and platforms to comply with Section 03 30 00, CAST-IN-PLACE CONCRETE.
1. Install abrasive nosings with anchors fully embedded in concrete, center nosings on tread width.

G. Install pre-cast concrete treads with adhesive supplied by Manufacturer.

3.2 INSTALLING METAL STAIRS WITH GROUTED BASEPLATES

A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of baseplates.

B. Set stair baseplates on wedges, shims, or leveling nuts. 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.
   1. Use nonmetallic, non-shrink grout, unless otherwise indicated.
   2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

END OF SECTION

DIVISION 6

WOOD AND PLASTICS

SECTION – 06 53 00 FIBERGLASS REINFORCED PLASTIC GRATING

PART 1 - GENERAL

1.1 SCOPE

A. This section covers furnishing and installing fiberglass reinforced plastic (FRP) grating, and ladders with structural support systems and appurtenances.

1.2 COORDINATION

A. The work in this section shall be completely coordinated with the work of other sections. Verify at the site both the dimensions and work of other trades adjoining items of work in this section before fabrication and installation of items specified herein.

B. The Contractor shall provide pertinent trades with data and information for all items included under this section that are to be built into the work of other sections.

1.3 QUALITY ASSURANCE

A. Qualifications.
   1. The fiberglass reinforced plastic components manufacturers shall have at least 5 years' experience in the manufacture of items of similar size and quality and shall present proof as required to the Engineer of successful installations involving the items under conditions similar to this project.

1.4 SUBMITTALS

A. Complete specifications and drawings showing materials, properties and details of fabrication, construction and installation of items under this section shall be submitted.

B. Two sets of grating samples shall be submitted for review in representative sizes which are acceptable. Samples shall be representative of construction, workmanship, appearance and surface finish of the manufactured items which are proposed. Samples shall be from plant production.

C. The contractor shall furnish a letter from the grating manufacturer certifying that the grating has been designed in accordance with the load-bearing and deflection provisions of the specifications for each size of grating and for each span.

D. Certified test data based on tests of actual production samples of grating which demonstrate that the products conform to the stress and deflection requirements specified herein shall be submitted.

E. The Engineer may reject any item which does not meet the standards of the representative tested or submitted samples.

F. Shop Drawings:
   1. Include plans, elevations, sections, details, supports and attachment to other work.
   2. Grating: Show dimensions, weight, and size, and location of connections to adjacent grating, supports, and other Work.
   3. Grating Anchorage: Show structural calculations and details of anchorage to supports to prevent displacement from traffic impact.

4. Grating Supports: Show dimensions, weight, size, location, and anchorage to supporting structure. Design and provide calculations for supports indicated or required and not indicated.
5. Catalog information and catalog cuts.
6. Manufacturer's specifications, to include coatings.
7. Include structural analysis data signed and sealed by the qualified professional engineer licensed in the State of Colorado and responsible for their preparation.

G. Quality Control Submittals:
1. Special handling and storage requirements.
2. Installation instructions.
3. Factory test reports.
4. Manufacturer's Certification of Compliance for specified products.
5. Written Test Report that swaged crossbars, if used on grating, meet the requirements of the specified test and additional requirements of these Specifications.
6. Professional engineer's qualifications.

1.5 DELIVERY AND STORAGE

A. All materials shall be delivered to the site as required to meet the installation schedules.
1. All materials shall be stored under cover to protect them from direct sunlight.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall be as follows:

Resin	Polyester or vinyl ester resin with ultraviolet inhibition suitable for use in the specified environment.
Reinforcements	Glass fiber with a suitable coupling agent.
Stainless Steel:	
Fasteners	AISI Type 316.
Bolts	ASTM F 593, Alloy Group 1 or 2.
Nuts	ASTM F 594, Alloy Group 1 or 2.
Washers:	
Flat	ANSI B18.22.1.
Lock	ANSI B18.21.1, helical spring type.
Chain	AISI TP-316, Trade size 2/0.

Pultruded Structural Shapes and Plates:

Minimum Physical Properties

Property	Value	Test Method
Tensile Strength (ultimate)	30,000 psi	ASTM D 638
Tensile Strength (full section)	20,000 psi at 75°F	ASTM D 638
Shear Strength, Minimum	5,000 psi	ASTM D 732
Modulus of Elasticity	$2.3x10^6$ psi at 75°F; $1.8x10^6$ psi at 125°F.	ASTM D 7990
Barcol Hardness	45	ASTM D 2583
Water Absorption	0.60 percent (by weight)	ASTM D 570
Specific Gravity	1.60	ASTM D 792
Flexural Strength	30,000 psi	ASTM D 790
Flexural Modulus	$1.6x10^6$ psi	ASTM D 790
Molded Grating		
Fiberglass Properties:		
Tensile Strength	14,000 psi	ASTM D 638
Tensile Modulus	$2.0x10^6$ psi	ASTM D 638
Grating Section Properties:		
Flexural Strength, Minimum	25,000 psi at 200°F	ASTM D 790
Flexural Modulus, Minimum	$1.5x10^6$ psi at 200°F	ASTM D 790
Shear Strength	7,000 psi	ASTM D 732

2.2 GRATING

A. FRP molded grating shall be Chemgrate Corp., Fibergrate Corporation, Fowler Fiberglass Grating Inc., or equal.

B. Outer surfaces, cut edges, or any surfaces which are exposed to air during cure shall be finished so as to obtain complete cure of the resin without air inhibition. Finishing of exposed surfaces shall be done by coating the surface after initial cure with resin. Softening or tackiness of any surface under an acetone test will be considered evidence of incomplete cure.

C. The fiberglass grating shall be constructed from fire-retardant materials. The grating and stair treads shall have an ASTM E 84 rating below 25. The grating shall be suitable for use in a Midwestern environment with ambient temperatures in the range of -20°F to 110°F. The top surface shall be nonskid type, utilizing angular silica particles embedded in the upper portion of the grating or a concave profile.

D. Resin for FRP components shall be an acceptable polyester or vinyl ester, integrally resistant without applied coatings to ultraviolet radiation; and to concentrated and dilute ferric chloride.

E. Compatible and equally resistant resin acceptable for shop and field sealing of cut edges shall be provided.

F. FRP components shall have integral colors acceptable to the Engineer and Owner, selected from standard resin colors.

G. The design and depth of grating shall be determined by the manufacturer.

H. Factor of safety shall be 5, based on ultimate stress. Grating shall be a minimum of 2 inches deep, and shall have a rectangular bar shape.

I. Square shaped FRP molded grating shall be constructed of straight parallel bearing bars and cross bars composed of glass fiber and resin. No dry glass fibers shall be visible on any surface of bearing bars or cross bars. Bearing bars shall be spaced on 2 inch centers and cross bars spaced on 2 inch centers.

J. The FRP grating shall be designed to meet the following loading requirements. In addition to the dead load of the grating (and FRP plate where indicated), the grating shall be capable of supporting a uniform live load of 250 pounds per square foot while maintaining a maximum deflection of (L/300) of the grating clear span.

K. The Contractor may reduce the grating clear span by the addition of intermediate support members. Additional member size and location shall be subject to acceptance by the Engineer.

L. Structural FRP angle frames and structural support shapes shall be provided.

M. Angle frames shall be continuous around the opening in order to present an even and flat support for the grating except as otherwise indicated on the construction drawings. The angles and anchors shall be detailed on the construction drawings.

N. FRP grating shall be securely attached to supporting members and angles. Attachment to FRP supporting members shall be stainless steel with stainless steel fasteners. Each grating panel shall be attached to supporting members on the two long edges, with a minimum of two attachments each edge. All materials and incidentals required for attaching grating to angle frame and supports shall be furnished and installed under this section.

O. The layout of grating panels shall be coordinated with work of other sections to provide openings for approved mechanical equipment, actuators, gates, piping, and other items which require penetrations or openings in the grating. Grating panels shall be further subdivided and supported to provide maximum panel weight of 110 pounds.

P. Where grating is indicated over an opening, it shall cover the entire opening, unless specifically noted or detailed otherwise on the construction drawings.

Q. The top surfaces of grating sections adjacent to each other shall be in the same plane.

R. Fiberglass plates or angles shall be installed where required to fill openings at changes in elevation and at openings between equipment and grating. Angle stops shall be installed at ends of grating to prevent grating from sliding.

2.3 STRUCTURAL SHAPES

A. Pultruded structural shapes and plates shall be Extren by MMFG or Pultrex by Creative Pultrusions, Inc.

2.4 LADDERS AND HANDRAILS

A. The ladder shall be supported on and anchored to the concrete slab and bracketed to the containment basin wall as required. The ladder shall be fabricated of fiberglass reinforced plastic. Uncoated or exposed carbon steel parts or fasteners will not be acceptable. As a minimum, ladder shall be designed and constructed to conform to OSHA requirements. The ladder shall have a clear width of at least 16 inches, with rungs at least 3/4 inch in diameter and spaced not more than 12 inches apart, and a clearance of at least 7 inches between the back of the ladder and the wall.

PART 3 - EXECUTION

3.1 All components shall be installed in full accordance with the construction drawings, the final shop drawings, and manufacturer's recommendations by mechanics skilled in the installation of this type of work.

3.2 There shall be not more than 1/8 inch clearance between the ends of the grating and the inside face of the vertical leg of the shelf angles. The horizontal bearing leg of the shelf angle shall not be less than 2 inches. Ends of grating and cutouts shall be shop or field resin coated. Field coating shall conform to original manufacturer's materials and shall be in accordance with the manufacturer's recommendations. Cutouts in the grating shall be provided where required for valve actuators or stems, piping, conduit and other items.

3.3 Where an area requires more than one grating section to cover the area, adjacent grating sections shall be clamped together at the 1/4 points with acceptable fasteners.

END OF SECTION

SECTION 06 61 00 - FIBERGLASS REINFORCED PLASTICS (FRP) FABRICATIONS AND MOLDED GRATINGS SUPPORTED BY GRATING PEDESTALS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The Contractor shall furnish, fabricate (where necessary), and install all fiberglass reinforced plastic (FRP) items, with all appurtenances, accessories and incidentals necessary to produce a complete, operable and serviceable installation as shown on the Contract Drawings and as specified herein, and in accordance with the requirements of the Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 1 Specifications.

1.2 REFERENCES

A. The publications listed below (latest revision applicable) form a part of this specification to the extent referenced herein. The publications are referred to within the text by the designation only.
   1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) Test Methods:
      a. ASTM D 635 - Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
      b. ASTM D 638 - Tensile Properties of Plastics
      c. ASTM D 696 - Coefficient of Linear Thermal Expansion for Plastics
      d. ASTM D 790 - Flexural Properties of Unreinforced and Reinforced Plastics
      e. ASTM D 2344 - Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short Beam Method
      f. ASTM E 84 Surface Burning Characteristics of Building Materials
   2. THE OCCUPATIONAL HEALTH AND SAFETY ADMINISTRATION (OSHA)
      a. Code of Federal Regulations (CFR), Volume 29

1.3 CONTRACTOR SUBMITTALS

A. The Contractor shall furnish shop drawings of all fabricated structural systems and accessories in accordance with the provisions of this Section.

B. The Contractor shall furnish manufacturer's shop drawings clearly showing material sizes, types, styles, part or catalog numbers, complete details for the fabrication of and erection of components including, but not limited to, location, lengths, type and sizes of fasteners, clip angles, member sizes, and connection details.

C. The Contractor shall submit the manufacturer’s published literature including structural design data, structural properties data, corrosion resistance tables, certificates of compliance, test reports as applicable, and design calculations for systems not sized or designed in the contract documents, sealed by a Professional Engineer.

D. The Contractor may be requested to submit sample pieces of each item specified herein for acceptance by the Engineer as to quality and color. Sample pieces shall be manufactured by the method to be used in the Work.

1.4 QUALITY ASSURANCE

A. All items to be provided under this Section shall be furnished only by manufacturers having a minimum of ten (10) years experience in the design and manufacture of similar products and

systems. Additionally, if requested, a record of at least five (5) previous, separate, similar successful installations in the last five (5) years shall be provided.

B. Manufacturer shall offer a 3 year limited warranty on all FRP products against defects in materials and workmanship.

C. Manufacturer shall be certified to the ISO 9001-2000 standard.

D. Manufacturer shall provide proof of certification from at least two other quality assurance programs for its facilities or products (UL, DNV, ABS, USCG, AARR).

1.5 PRODUCT DELIVERY AND STORAGE

A. Delivery of Materials: Manufactured materials shall be delivered in original, unbroken pallets, packages, containers, or bundles bearing the label of the manufacturer. Adhesives, resins and their catalysts and hardeners shall be crated or boxed separately and noted as such to facilitate their movement to a dry indoor storage facility.

B. Storage of Products: All materials shall be carefully handled to prevent them from abrasion, cracking, chipping, twisting, and other types of damage. Store adhesives, resins and their catalysts and hardeners in dry indoor storage facilities between 70 and 85 degrees Fahrenheit (21 to 29 degrees Celsius) until they are required.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Structural shapes shall be Dynaform, molded gratings shall be Fibergrate or Chemgrate, and grating pedestals shall be Dynaform and molded components as manufactured by:
1. Fibergrate Composite Structures Inc.
5151 Belt Line Road, Suite 700
Dallas, Texas 75254-7028 USA
(800) 527-4043 (972) 250-1530 Fax

2.2 GENERAL

A. All FRP items furnished under this Section shall be composed of fiberglass reinforcement and resin in qualities, quantities, properties, arrangements and dimensions as necessary to meet the design requirements and dimensions as specified in the Contract Documents.

B. Fiberglass reinforcement shall be continuous roving in sufficient quantities as needed by the application and/or physical properties required.

C. Resin shall be Vinyl ester for all systems with chemical formulations as necessary to provide the corrosion resistance, strength and other physical properties as required.

D. All finished surfaces of FRP items and fabrications shall be smooth, resin-rich, free of voids and without dry spots, cracks, crazes or unreinforced areas. All glass fibers shall be well covered with resin to protect against their exposure due to wear or weathering.

E. All FRP products shall have a tested flame spread rating of 25 or less per ASTM E-84 Tunnel Test. Gratings shall also have tested burn time of less than 30 seconds and an extent of burn rate of less than or equal to 10 millimeters per ASTM D635.

F. All mechanical grating clips shall be manufactured of Type 316SS (stainless steel).

2.3 STRUCTURAL SHAPES

A. All structural shapes are to be manufactured by the pultrusion process with a glass content minimum of 45%, maximum of 55% by weight. The structural shapes shall be composed of fiberglass reinforcement and resin in qualities, quantities, properties, arrangements and dimensions as necessary to meet the design requirements and dimensions as specified in the Contract Documents.

B. Fiberglass reinforcement shall be a combination of continuous roving, continuous strand mat, and surfacing veil in sufficient quantities as needed by the application and/or physical properties required.

C. Resins shall be DYNAFORM VEFR, fire retardant vinyl ester with chemical formulation necessary to provide the corrosion resistance, strength and other physical properties as required.

D. Pultruded structural shapes are to have the minimum longitudinal mechanical properties listed below:

Property	**ASTM Method**	**Value**	**Units**
Tensile Strength	D 638	30,000 (206)	psi (MPa)
Tensile Modulus	D 638	2.5×10^6 (17.2)	psi (GPa)
Flexural Strength	D 790	30,000 (206)	psi (MPa)
Flexural Modulus	D 790	1.8×10^6 (12.4)	psi (GPa)
Flexural Modulus (Full Section)	N/A	2.8×10^6 (19.3)	psi (GPa)
Short Beam Shear (Transverse)	D 2344	4,500 (31)	psi (MPa)
Shear Modulus (Transverse)	N/A	4.5×10^5 (3.1)	psi (GPa)
Coefficient of Thermal Expansion	D 696	8.0×10^{-6} (1.4×10^{-6})	in/in/°F (cm/cm/°C)
Flame Spread	E 84	25 or less	N/A

2.4 FIBERGRATE OR CHEMGRATE SQUARE MESH MOLDED FRP GRATING

A. Manufacture: Grating shall be of a one piece molded construction with tops and bottoms of bearing bars and cross bars in the same plane. Grating shall have a square mesh pattern providing bidirectional strength. Grating shall be reinforced with continuous rovings of equal number of layers in each direction. Percentage of glass (by weight) shall not exceed 35% so as to achieve maximum corrosion resistance, and as required to maintain the structural requirements of the Contract.

1. After molding, no dry glass fibers shall be visible on any surface of bearing bars or cross bars. All bars shall be smooth and uniform with no evidence of fiber orientation irregularities, resin rich or resin starved areas.

B. Non–slip surfacing: Fibergrate gratings shall be manufactured with a concave, meniscus profile on the top of each bar providing maximum slip resistance. Chemgrate gratings shall be manufactured with an integral grit molded into the panels during the manufacturing process. A concave profile on the top of each bar shall also be allowed for VE-25 and FS-25 resins.

C. Fire rating: Unless Chemgrate CP-84 is specified, grating shall be fire retardant with a tested flame spread rating of 25 or less when tested in accordance with ASTM E 84. Data performed only on the resin shall not be acceptable.

D. Resin system: The resin system used in the manufacture of Fibergrate gratings shall be Vi-Corr, FGI, Corvex, ELS, XFR or Super Vi-Corr. The resin system used in the manufacture of Chemgrate gratings grating shall be Chemgrate CP-84, FS-25 or VE-25. Manufacturer may be required to submit corrosion data from tests performed on actual grating products in standard chemical environments. Corrosion resistance data of the base resin from the manufacturer is not a true indicator of grating product corrosion resistance and shall not be accepted.

E. Color: Varies by resin - consult catalog

F. Depth: 1-1/2” or 2” with a tolerance of plus or minus 1/16".

G. Mesh Configuration: 1-1/2” or 2” square mesh with a tolerance of plus or minus 1/16" mesh centerline to centerline

H. Load/Deflection: Grating design loads shall be less than manufacturers published maximum recommended loads. Maximum recommended loads shall be determined by acoustic emission testing. Grating shall be designed for a uniform load of 50 psf or concentrated load of 300 lb. Deflection is not to exceed 0.375”.

I. Substitutions: Other products of equal strength, stiffness, corrosion resistance and overall quality may be submitted with the proper supporting data to the engineer for approval.

2.5 GRATING PEDESTAL SUPPORT SYSTEM

A. Grating pedestals shall be adjustable. Pedestal shall consist of molded bases and tops, with DYNAFORM pedestals joining the bases and tops and 316 stainless steel threaded rods for adjustability.

B. Bases and tops shall be injection molded, glass reinforced, thermoplastic polyester for maximum corrosion resistance. Tops shall be provided in a single head configuration for use in the interior of the grating panels and in a quad head configuration for use at the corners and edges of the grating panels. Pedestal tops are to be manufactured such that there is free drainage of fluids. Color shall be light gray.

C. Pedestals shall be 2-1/8" x 3/16” square tube as manufactured by the pultrusion process and in accordance with Section 2.3 - STRUCTURAL SHAPES. Adjustability shall be achieved with a 316 stainless steel all-thread component that threads into the molded fittings. Color shall be light gray.

D. Where required, stainless steel clips for holding single head pedestals to the underside of the grating are to be provided. These clips are to be constructed of 316 stainless steel and be configured to allow height adjustment of the pedestal from the walking surface of the grating.

E. Design – Pedestal floor system shall be designed for a uniform load of 50 psf or concentrated load of 300 lb. Deflection of supported grating is not to exceed 0.375”. Grating pedestals are to be laid out according to the manufacturers published literature or as indicated in the contract drawings.

F. Perimeter embedded support angle shall be DYNAFORM E-Z ANGLE. Support where embedment angle is not provided shall be DYNAFORM angle, 3” x 3” x 1/4” minimum. This ledge angle is to be anchored at a maximum of 24” on center with 3/8” diameter 316SS Hilti

Kwik Bolt II anchors or equal, installed following the anchor bolt manufacturers recommendations. Anchor bolts are to be supplied by the contractor.

G. Substitutions: Other products of equal strength, stiffness, corrosion resistance and overall quality are acceptable only with prior approval by the engineer, after review of the proper supporting data.

PART 3 - EXECUTION

3.1 INSPECTION

A. Shop inspection is authorized as required by the Owner and shall be at Owner's expense. The fabricator shall give ample notice to Contractor prior to the beginning of any fabrication work so that inspection may be provided. The grating shall be as free, as commercially possible, from visual defects such as foreign inclusions, delamination, blisters, resin burns, air bubbles and pits. The surface shall have a smooth finish (except for grit top surfaces).

3.2 INSTALLATION

A. Contractor shall install gratings, grating pedestals, and embedment/ledge angles in accordance with manufacturer’s assembly drawings. Fasten materials securely in place with fasteners as specified herein. Field cut and drill fiberglass reinforced plastic products with carbide or diamond tipped bits and blades. Seal cut or drilled surfaces in accordance with manufacturer's instructions. Follow manufacturer's instructions when cutting or drilling fiberglass products or using resin products.

END OF SECTION

DIVISION 9

FINISHES

SECTION 09 90 00 - COATINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install paint and protective coatings to all surfaces unless specifically excluded in this section or on the drawings. This section excludes concrete coating/ lining and concrete rehabilitation applications.

B. Paint and coatings shall be furnished and installed on all proposed surfaces, modified surfaces, and surfaces damaged during construction. This includes, but is not limited to:
   1. PVC pipe, fiberglass duct and pipe, and fiberglass tanks.
   2. General protective coatings and painting applications

C. Paint and coatings are not required on existing items unless shown otherwise on the drawings or unless existing items are modified or damaged during construction.

1.2 WORK INCLUDED

A. Surface preparation

B. Surface finish schedule

1.3 REFERENCES

A. References:
   1. ASTM International (ASTM)
      a. D16 - Definitions of Terms Relating to Paint, Varnish, Lacquer, and Related Products.
      b. D2016 - Test Method for Moisture Content of Wood.
      c. D4417 – Standard Test Method for Field Measurement of Surface Profile of Blast Cleaned Steel.
   2. The Society for Protective Coatings (SSPC)
      a. SSPC Painting Manual, “Good Painting Practice”
      b. SSPC Painting Manual, “Systems and Specifications”
      c. SP1 Surface Preparation Specification No. 1 - Solvent Cleaning
      d. SP3 Surface Preparation Specification No. 3 - Power Tool Cleaning
      e. SP5 Surface Preparation Specification No. 5 - White Metal Blasting
      f. SP6 Surface Preparation Specification No. 6 - Commercial Blast Cleaning
      g. SP7 Surface Preparation Specification No. 7 - Brush-Off Blast Cleaning
      h. SP10 Surface Preparation Specification No. 10 - Near-White Blast Cleaning
      i. SP12 Surface Preparation Specification No. 12 - Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating
      j. SP13 Surface Preparation Specification No. 13 - Surface Preparation of Concrete
      k. SP14 Surface Preparation Specification No. 140 - Industrial Blast Cleaning
      l. VIS 1 89 – Visual Standard for Abrasive Blast Cleaned Steel
   3. NACE International (National Association of Corrosion Engineers International)
      a. RP0287-95 “Field Measurements of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using Replica Tape”
      b. RP0188-99 “Discontinuity (Holiday) Testing of Protective Coatings”
      c. TM-01-70 “Visual Comparator for Surfaces of New Steel Airblast Cleaned with Sand Abrasive”
      d. TM-01-70 “Visual Comparator for Surfaces of New Steel Airblast Cleaned with Slag Abrasive”

e. RP0178-95 “Fabrication Details, Surface Finish Requirements, and Proper Design Considerations for Tanks and Vessels to be Lined for Immersion Service”
f. 6G186, “Surface Preparation of Contaminated Steel Surfaces”
g. RPO 178 “Weld preparation Visual Comparator.”

4. National Science Foundation (NSF)

1.4 DEFINITIONS

A. Conform to ANSI/ASTM D16 for interpretation of terms used in this Section.

B. Where the terms “exposed” surfaces are used to define painting locations and requirements it shall include all visible outside surfaces, top of walls and inside surfaces to 1’-0” below the ground level or to floor level, whichever applies.

1.5 QUALITY ASSURANCE FOR ALL COATINGS

A. Product Manufacturer: Company specializing in manufacturing quality paint and finish products with 10 years’ experience.

B. Applicator: Company specializing in industrial painting and finishing with 5 years documented experience, approved by product manufacturer.

1.6 REGULATORY REQUIREMENTS

A. Conform to applicable code for flame/fuel/smoke rating requirements for finishes.

B. Materials and coatings in contact with potable water must conform to NSF Standard 61.

1.7 SUBMITTALS

A. Submit product data under provisions of Section 01 33 00.

B. Provide product data on all coatings.

C. Submit samples or color charts illustrating range of colors and textures available for each surface-finishing product scheduled, for selection.

D. Submit manufacturer’s application instructions.

E. Submit manufacturer’s technical representative’s field reports.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and protect products in accordance with coating manufacturer’s instructions.

B. Deliver products to site in sealed and labeled containers; inspect to verify acceptance.

C. Container labeling to include manufacturer’s name, type of paint, brand name, brand code, coverage, surface preparation, drying time, cleanup, color designation, and instructions for mixing and reducing.

D. Unless otherwise required by the manufacturer, store paint materials at minimum ambient temperature of 45ºF (7ºC) and a maximum of 90ºF (32ºC), in well ventilated area, unless required otherwise by manufacturer’s instructions.

E. Take precautionary measures to prevent fire hazards and spontaneous combustion.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Provide continuous ventilation and heating facilities to maintain surface and ambient temperatures above 45ºF (7ºC) for 24 hours before, during and 48 hours after application of finishes, unless required otherwise by manufacturer's instructions.

B. No exterior coatings shall be applied during rain or snow, when the air temperature is below 45ºF (7ºC) or above 100ºF (38ºC) or when the temperature of the surface to be coated is below 45ºF (7ºF) except as allowed by the coating manufacturer. No coating shall be applied if a predicted temperature of 35ºF (1.67ºC) or lower is forecast within 24 hours of application unless the coating is enclosed and temperature controlled. No painting is to be done when the relative humidity meets or exceeds 50% or when the substrate temperature is within 5ºF (2.78ºC) of the dew point, as allowed by the manufacturer.

C. Minimum Application Temperatures for Latex Paints: 45ºF (7ºC) for interiors; 50ºF (10ºC) for exterior, unless required otherwise by manufacturer's instructions.

D. Minimum Application Temperature for Varnish and Finishes: 60ºF (16ºC) for interior or exterior, unless required otherwise by manufacturer's instructions.

E. Provide lighting level of 80-foot candles measured mid-height at substrate surface.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Coatings: Ready mixed, except field-catalyzed coatings. Process pigments to a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating.

B. Accessory Materials: Thinning of paint and all accessory type materials used shall be strictly in accordance with the manufacturer's recommendations covering material types, solvents, mix ratios, and methods.

C. CONTRACTOR shall have complete responsibility for ensuring that each coating applied is compatible with its substrate and/or its intended finish coat, and that the complete coating system is suitable for its intended service.

2.2 FINISHES

A. Colors shall be selected by OWNER from manufacturer's standard color charts.

PART 3 - EXECUTION

3.1 INSPECTION

A. Verify that surfaces are ready to receive work, including specified surface preparation and profile, as instructed by the product manufacturer.

B. Examine surfaces scheduled to be finished prior to commencement of work. Report any condition that may potentially affect proper application.

C. Measure moisture content of surfaces using an electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following maximums, unless more stringent limitations are recommended by the coating manufacturer:
   1. Plaster and Gypsum Wallboard: 12 percent.
   2. Masonry, Concrete, and Concrete Unit Masonry: 12 percent.
   3. Interior Located Wood: 15 percent, measured in accordance with ASTM D2016.

D. The following quality control tests shall be performed, with results recorded and made available to the Engineer:
   1. Compressed air quality in accordance with blotter test.
   2. Environmental conditions prior to coating application, including substrate temperature, ambient temperature, relative humidity, and dew point.
   3. Observation of surface preparation, including anchor pattern prior to coating application.
   4. Results of ratio check of plural component proportioning equipment.
   5. Wet and dry film thickness measurements.

3.2 PREPARATION

A. Surface preparation shall be as indicated in Part 3.8 or as otherwise indicated in an individual specialized equipment specification.

3.3 PROTECTION

A. Protect elements surrounding the work of this Section from damage or disfiguration.

B. Repair damage to other surfaces caused by work of this Section.

C. Furnish drop cloths, shields and protective methods to prevent spray or droppings from disfiguring other surfaces.

D. Remove empty paint containers from site and dispose of all excess materials and empty containers in full accordance with all applicable state, federal and local laws.

3.4 APPLICATION

A. Apply products in accordance with manufacturer's instruction.

B. Do not apply finishes to surfaces that are not dry.

C. Apply each coat to uniform finish.

D. Apply each coat of paint slightly darker than preceding coat unless otherwise approved.

E. Sand lightly between coats to achieve required finish.

F. Allow applied coat to cure adequately per manufacturer's instructions before next coat is applied.

G. Where clear finishes are required, tint fillers to match wood. Work fillers into the grain before set. Wipe excess from surface.

H. Prime back surfaces of interior and exterior woodwork with primer paint.

I. Prime back surfaces of interior woodwork scheduled to receive stain or varnish finish with gloss varnish reduced 25 percent with mineral spirits.

J. Paint all exterior and interior wood and metal items throughout the project except for surfaces listed below:
   1. Indoor concrete surfaces, unless specifically noted on the Plans.
   2. Concrete walkways, pavement, sidewalks, and stair treads.
   3. Inside of walls and columns one foot below the average water surface level of tanks and wet wells.
   4. Fiberglass items unless specified otherwise.
   5. Metal surfaces of anodized aluminum, stainless steel, or chromium plate.
   6. Operating parts, unless otherwise specified.
   7. Existing structures, piping or equipment, unless otherwise specified.
   8. Exposed roof decking that is factory primed and finished.

K. Repair any damage to paint on existing structures caused by construction work. Match existing colors with touch-up paint.

3.5 FINISHING MECHANICAL AND ELECTRICAL EQUIPMENT

A. Colors for equipment shall be selected by Owner during submittal process.

B. Paint shop primed equipment.

C. Remove unfinished louvers, grilles, covers and access panels on mechanical and electrical components and paint separately.

D. Prime and paint insulated and exposed pipes, conduit, boxes, insulated and exposed ducts, hangers, brackets, collars and supports.

E. Replace identification markings on mechanical or electrical equipment when painted accidentally.

F. Paint interior surfaces of air ducts, and convector and baseboard heating cabinets that are visible through grilles and louvers with one coat of flat black paint, to limit of sight line. Paint dampers exposed behind louvers, grilles and convector and baseboard cabinets to match face panels.

G. Paint exposed conduit and electrical equipment occurring in finished areas.

H. Paint both sides and edges of plywood backboards for electrical and telephone equipment before installing equipment.

I. All exposed piping, indoor and outdoor, insulated and un-insulated, except RCCP and stainless steel pipe, shall be painted.

J. Color code equipment, piping, conduit, and exposed ductwork as directed by the OWNER.

K. Replace electrical plates, hardware, light fixture trim and fittings removed prior to finishing.

3.6 CLEANING

A. As Work proceeds, promptly remove paint where spilled, splashed or spattered.

B. During progress of Work maintain premises free of unnecessary accumulation of tools, equipment, surplus materials and debris.

C. Collect cotton waste, cloths and material which may constitute a fire hazard, place in closed metal containers and remove daily from site.

D. Where existing paint is removed, collect and dispose of removed coatings in full accordance with all applicable laws and regulations.

3.7 Testing for all coatings except special concrete coating

A. Wet Film Testing – Make wet-film tests during painting operations to assure proper thicknesses of coating are being applied. After each coat has been applied, test the paint film thickness with a non-destructive, magnetic type thickness gauge.

B. Dry Film Thickness Testing – Make dry film tests after coating operations to assure proper thickness of coating has been applied. The total thickness after the final coat has been applied shall be 100 percent of the thickness specified, minimum. Apply additional coats until the specified thickness is reached or exceeded.

C. Holiday Testing
1. Test the entire surface of coated metal structures with a holiday detector.
2. For thickness between 10 and 20 mils (250 to 500 microns), a non-sudsing type wetting agent, as recommended by the holiday detector Manufacturer shall be added to the water prior to wetting the detector sponge.
3. Mark and repair pinholes in accordance with the Manufacturer's printed instructions then retest pinholes.
4. No pinholes or other irregularities shall be permitted in the final coats.
5. Areas containing holidays shall receive additional coats until test indicate no holidays.

3.8 SCHEDULE

A. All Aluminum in Contact with Dissimilar Materials:
1. Surface Preparation: Remove all foreign matter.
2. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Series 66 Hi-Build Epoxoline-2 coats, 4.0 dry mils per coat.
   b. Or approved equal.

B. Exposed, Uninsulated PVC Piping, Interior and Exterior (note: PVC pipe inside air release valve vaults does not require coating):
1. Surface Preparation: As recommended by coating manufacturer.
2. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Finish: Series 66 Hi-Build Epoxoline-1 coat, 4.0 dry mils.
   b. Or approved equal.

C. All Metal Surfaces Exposed to Temperatures Over 250ºF
1. Surface Preparation: SSPC-SP10 Near-White Blast.
2. Product and Manufacturer: Provide one of the following:
   a. Tnemec:
      1) Finish: 90E-92 Tneme-Zinc - 1 coats, 3.0 dry mils per coat, 360 square feet per gallon.
   b. Or approved equal.

D. All fiberglass items, including FRP duct, FRP odor control vessels, FRP fans, and unpigmented FRP chemical tanks, shall be coated as follows:
1. Surface Preparation:
   a. Brush off cleaning, SSPC-SP7
   b. Solvent Cleaning, SSPC SP-1
2. Products and Manufacturer:

a. Tnemec
    1) Primer: Series 66 Hibuild Epoxoline, 3.0-4.0 mils dft. Broom surface after coating has dried.
    2) Intermediate coat: Series 66 Highbuild Epoxoline, 3.0-4.0 mils dft.
    3) Finish: Series 1075 Endura Shield II, 3.0-5.0 mils dft.

b. Or equal by Carboline, Valspar, or Ameron.

3. The intent of this specification is to obtain a polyurethane top coat for UV protection and cosmetic purposes. Primer and intermediate coats, as well as initial surface preparation shall be as recommended by the coating manufacturer for proper adhesion and serviceability on the fiberglass items to be painted.

END OF SECTION

SECTION 09 96 40 – REHABILITATION OF CONCRETE WASTEWATER STRUCTURES AND MANHOLES WITH EPOXY COATING/LINING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Requirements for surface preparation, repair material application, and 100% solids, high build epoxy coating/ lining application to specified concrete surfaces.
   2. This specification covers work, materials and equipment required for protecting and/or rehabilitating concrete manholes and other underground vaults by high-build, solvent-free epoxy coating/ lining to eliminate infiltration, provide corrosion protection, repair voids and provide structural enhancement as required. Procedures for surface preparation, cleaning, infiltration control, build-back/ repair, application, testing and inspection are described herein.

B. Related sections:
   1. Section 03 01 00 - Concrete Repair.

1.2 REFERENCES

A. ASTM C109 - Compressive Strength Hydraulic Cement Mortars

B. ASTM D543 - Resistance of Plastics to Chemical Reagents

C. ASTM D638 - Tensile Properties of Plastics

D. ASTM D695 - Compressive Properties of Rigid Plastics

E. ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics

F. ASTM F2414 - Standard Practice for Sealing Sewer Manholes Using Chemical Grouting

G. ASTM D2584 - Volatile Matter Content

H. ASTM D4262 – Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces

I. ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method

J. ASTM D4414 – Standard Practice for Measurement of Wet Film Thickness by Notch Gages

K. ASTM D7234 – Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers

L. NACE SP0188 – Standard Recommended Practice, Discontinuity (Holiday) Testing of Protective Coatings

M. NACE No. 6/ SSPC SP-13 – Surface Preparation of Concrete

N. ICRI No. 310.2R-2013

O. ICRI No. 03732 - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

P. ASTM - The published standards of the American Society for Testing and Materials, West Conshohocken, PA.

Q. ICRI - The published standards of International Concrete Repair Institute, St. Paul, MN

R. NACE - The published standards of National Association of Corrosion Engineers (NACE International), Houston, TX.

S. SSPC - The published standards of the Society of Protective Coatings, Pittsburgh, PA. Steel or metallic substrates may require additional references and procedures not included in this specification. Include additional info as needed. Removal of existing coating/lining may require additional references.

1.3 SUBMITTALS

A. The following items shall be submitted:
1. Technical data sheet on each product used, including ASTM test results indicating the product conforms to and is suitable for its intended use per these specifications.
2. Material Safety Data Sheets (MSDS) for each product used.
3. Manufacturer certification that rehabilitation products to be used are compatible and manufactured by the same company.
4. Warranty certificates.
5. Manufacturer and Applicator Qualifications as identified in Section 1.5 Quality Assurance.
6. Applicable, flow management, and safety plans.

1.4 DESIGN CONDITIONS

A. The following design conditions shall be assumed for all structures being rehabilitated with the approved coating/lining system:
1. Rehabilitation systems (coatings/linings) shall be considered to be semi-structural with a minimum resurfacing thickness of ½" for cementitious type resurfacing material and minimum epoxy top coat thickness of 125 mils. Adhesion strength of coating/lining to substrate shall exceed 250 psi.

1.5 QUALITY ASSURANCE

A. Applicator shall initiate and enforce quality control procedures consistent with applicable ASTM, ICRI, NACE and SSPC standards and the protective coating/lining manufacturer's recommendations.

B. Coating/lining product(s) shall be capable of being installed and curing properly within a wastewater environment. Coating product(s) shall be resistant to all forms of chemical or microbial induced corrosion commonly found in municipal sanitary sewer systems; and, capable of adhering to the manhole structure substrates.

C. All repair/ resurfacing products used shall be fully compatible with epoxy coating/lining including ability to bond effectively, forming a composite system.

D. Manufacturer's Qualifications
1. Certified in compliance with ISO 9001/14001 Quality Standards for formulation (research and development), manufacture, and technical support.
2. Manufacturer must have a local authorized NACE certified coating inspector available for acceptance of testing data during critical phases of installation process.
3. Products shall be manufactured in the United States.

4. Manufacturer shall have a minimum of ten (10) years successful applications of the protective coatings specified herein on similar applications.
5. Manufacturer must supply upon request a list of references outlining structures and equipment coated and proof of successful application.

E. Applicator's Qualifications
1. Applicator must be qualified in this line of work and have at least ten (10) years documented experience in concrete repair/restoration.
2. Must have a minimum of ten (10) years documented experience in the application of the protective coatings specified herein.
3. Must have a minimum of ten (10) years of documented successful installations of the specified products, on structures and/or equipment similar to this project.
4. Submit upon request a list of (5) recent projects involving similar work and names and contact information of references.
5. Applicator must be Manufacturer certified for 5 years prior to bid submission.
6. Applicator must have NACE certified inspector on staff at all times to conduct all testing as required.

F. Certification: Certify that coatings to be applied are resistant to discoloration or deterioration when exposed to hydrogen sulfide and other sewage gases.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Materials are to be kept dry, protected from weather and stored under cover.

B. Contractor shall deliver materials to job site in undamaged, unopened containers bearing manufacturer's original labels. Production dates shall be clearly marked on containers.

C. Materials used shall be transported, stored, mixed and applied in accordance with written manufacturer instructions for the specified products.

D. Protective coating/lining materials are to be stored between 50 deg F and 90 deg F. Do not store near flame, heat or strong oxidants.

E. Protective coating/lining products and all repair materials shall be handled in accordance with their respective material safety data sheets (MSDS).

1.7 SITE CONDITIONS

A. Applicator shall conform with all local, state and federal regulations including those set forth by OSHA, RCRA and the EPA and any other applicable authorities.

B. Method statements and design procedures are to be provided by Owner when confined space entry, flow management, or bypass pumping is necessary in order for Applicator to perform the specified work.

1.8 SAFETY

A. The Applicator is responsible for conforming to all work safety requirements of pertinent regulatory agencies, and shall secure the site for working conditions in compliance with the same. The Applicator shall erect such signs and other devices as necessary for the safety of the work site.

B. The Applicator shall perform all of the Work in accordance with applicable OSHA safety standards. Emphasis shall be placed upon the requirements for entering confined spaces and

with the equipment being utilized for manhole rehabilitation work. Confined space, defined as any space having one or more of the following characteristics:

1. Limited openings for entry and exit.
2. Unfavorable natural ventilation.
3. Not designed for continuous worker occupancy.

C. The Applicator shall have on the job site at all times at a minimum the following safety equipment, in good operating condition:

1. 1. Gas monitor capable of testing for and detecting combustible gas, oxygen deficiency and hydrogen sulfide.
2. Confined space access and retrieval winch system.
3. Ventilating fans with large diameter ventilating hose or rip-cord fans.
4. Respirator - MSHA/NIOSH approved type [Supplied air respirator].
5. Safety harness and life lines.
6. Personal protective equipment (PPE) as applicable for project.
7. All equipment to be available for use, in sufficient quantity, by the Applicator for the duration of the project.

D. All entries into or work within confined spaces shall be conducted in accordance with the U.S. Department of Health and Human Services/National Institute for Occupational Safety and Health DHHS (NIOSH) Publication No. 87-113, A Guide to Safety in Confined Spaces.

E. The Applicator shall submit a proposed Safety Plan to the Owner, prior to beginning any work, identifying all competent persons, equipment and operating procedures. The plan shall include a description of a daily safety program and daily safety meeting for the job site and all emergency procedures to be implemented in the event of a safety incident. All work shall be conducted in accordance with the Applicator's submitted Safety Plan.

1.9 WARRANTY

A. Manufacturer and Applicator shall co-warrant all work against defects in materials and workmanship for a period of five (5) years, unless otherwise noted, from the date of final acceptance of the project. Applicator shall, within a reasonable time after receipt of written notice thereof, repair defects in materials or workmanship which may develop during said five (5) years period, and any damage to other work caused by such defects or the repairing of same, at own expense and without cost to the Owner.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS

A. Standard Portland cement or new concrete (not quick setting high strength cement) must be well cured prior to application of the protective coating or lining system. In most cases, 28 days is adequate cure time for standard Portland cementitious materials. If earlier application is desired, compressive or tensile strength of the concrete can be tested to determine if acceptable cure has occurred. (Note: Bond strength of the coating to the concrete surface is generally limited to the tensile strength of the concrete itself. Engineer may require adhesion pull tests to determine suitability of concrete for coating/ lining).

B. Remove existing coatings/linings prior to application of the new protective coating. Applicator is to maintain strict adherence to applicable NACE and SSPC recommendations with regard to proper surface preparation and compatibility with existing coatings.

2.2 MANUFACTURER

A. Only certified applicators of these rehabilitation systems will be allowed.

B. Coating/ lining products that that emit isocyanate gases within the workspace area during the application process are not allowed. Injected chemical grouting material, with minimized exposure to workspace area, may be exempted from this restriction at the discretion of the Engineer.

C. Only compatible patching, water stop, grouting, caulking and repair materials approved in writing by the epoxy manufacturer shall be allowed. The manufacturer shall provide information as to its suitability and procedures for top coating with the approved coating/lining material. Project specific submittals shall be provided including application, cure time and surface preparation procedures which permit optimum bond strength with the approved coating/lining system.

2.3 INFILTRATION CONTROL - CHEMICAL GROUTING MATERIALS

A. Chemical grouting and water stop materials utilized shall be compatible with the specified repair/ resurfacing materials and epoxy coating/lining system.

B. The Applicator shall specifically define the type of compatible chemical grout that will be furnished for the project. Acrylic, Acrylate Based Grout or Urethane Based Grout shall be furnished, depending on application. The type of grout to be used shall be in accordance with the manufacturer's recommendations for the specific application area of the project.

C. Applicator shall provide a chemical sealant solution containing principal chemical sealant constituent, initiator (trigger) and catalyst specifically recommended for the purpose of sealing leaks in manholes. Chemical sealant constituent, initiator (trigger) and catalyst shall be compatible when mixed. Solution shall have ability to tolerate dilution and react in moving water. After final reaction, it shall be a stiff, impermeable, yet flexible gel. The grout proportions shall be such that dilute aqueous solutions, when properly catalyzed will form stiff gels. Materials provided shall gel in a predetermined time period when exposed to normal groundwater pH ranges, and be capable of formula adjustments to compensate for changing conditions. Final reaction shall produce a continuous, irreversible, impermeable stiff gel and shall not be rigid or brittle.

D. The grout shall exhibit the following properties:
   1. Controllable reaction times and shrinkage through the use of chemicals supplied by the same manufacturer. The minimum set time shall be established so that adequate grout travel is achieved.
   2. Resistance to chemicals, most organic solvents, mild acids and alkali.
   3. The grout shall be non-toxic in its cured form.
   4. Sealing material shall not become rigid or brittle when subjected to a dry environment. The material shall be able to withstand freeze/thaw and moving load conditions as verified by third party testing.

E. Grout conditions may be adjusted for catalyzing the reaction, inhibiting the reaction, lowering the freezing temperature the grout solution, adding fillers, providing strength or for inhibiting root growth according to the instructions of the grout manufacturer and in the specified quantities as recommended by the grout manufacturer. Applicator shall identify any additives, if utilized.

2.4 REPAIR/ RESURFACING MATERIALS

A. Repair materials shall be used to fill voids, structurally enhance and/or rebuild surfaces, etc. as determined necessary by the Engineer and protective coating/lining Applicator. Repair materials must be compatible with the specified epoxy coating and shall be applied in accordance with the manufacturer's recommendations. If a discrepancy exists between manufacturer

recommendations and the specification, the specification shall govern unless otherwise determined by the Engineer.

B. Underlayment or build-back material: System shall be compatible with 100% solids high build epoxy product, from same manufacturer. Build-back material shall be used as required by the manufacturer or if concrete deterioration exceeds 1/4-inch.

Manufacturers:	Product:
Tnemec	Mortar Clad 218 (or equal)

C. Minimum thickness for approved cementitious type resurfacing/ build back materials shall be ½". Modified epoxy mortar or epoxy mastic build-back material may be applied at thicknesses less than ½", in accordance with manufacturer instructions and approval of Engineer.

2.5 EPOXY PROTECTIVE COATING/LINING MATERIAL

A. 100% Solids High Build Epoxy: System shall be 100% solids epoxy resin. A minimum finish thickness of 125 mils is required for the system.

Manufacturers:	Product:
Tnemec	Series 436 (or equal)

B. "OR EQUAL" products may be considered for acceptance on a case-by-case basis at the sole discretion of the ENGINEER. Material properties shall meet the following minimums to be considered:

1. ASTM D638 6,000 psi tensile
2. ASTM D695 10,000 psi compressive strength
3. ASTM D790 8,000 psi flexural strength
4. ASTM D543 minimum of 50% sulfuric acid resistant
5. Volatile Organic Content (VOC) shall be zero
6. Fast setting, isocyanate-based coating/lining products (i.e. poly-ureas and polyurethane systems) are not allowed

2.6 PROTECTIVE COATING/ LINING APPLICATION EQUIPMENT

A. Manufacturer approved heated plural component spray equipment shall be used in the application of the specified protective coating, if coating/lining product is spray applied. Trowel applied material shall be acceptable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. All structures to be rehabilitated shall be readily accessible to Applicator.

B. Compliance with local, state and federal regulatory and other applicable agencies as required with regard to environment, health and safety.

C. Active wastewater flows shall be plugged, bypassed or diverted as required to ensure that the wastewater does not come into contact with surfaces while rehabilitation work is in progress. Flows shall be totally plugged, bypassed and/or diverted when coating the invert areas. Use of flow-thru plugs is permitted. All extraneous flows into the manhole or vaults at or above the area

coated shall be plugged and/or diverted until the epoxy has adequately set in accordance with manufacturer recommendations.

D. Manhole and structure inverts shall be lined. Flow-thru plugs, flow diversions, or bypass pumping shall be utilized.

E. Establish sewage bypass or flow-through plugs as necessary to rehabilitate invert areas of channel. Bypass and emergency response plan shall be submitted and approved by Owner prior to bypass or flow management activities.

F. Installation of the protective coating/lining shall not commence until the concrete substrate and/or any build back or repair material used has properly cured in accordance with these specifications and manufacturer instructions.

G. Temperature of the surface to be coated/lined shall be maintained between 40 deg F and 100 deg F during application. Prior to and during application, care should be taken to avoid exposure of direct sunlight or other intense heat source to the structure being coated. Where varying surface temperatures do exist, care should be taken to apply the coating when the temperature is falling versus rising (ie. late afternoon into evening vs. morning into afternoon). Environmental controls (tents, heaters, etc.) may be utilized at the discretion of the Engineer.

3.2 SURFACE PREPARATION

A. Applicator and INSPECTOR shall inspect all surfaces specified to receive a protective coating/lining prior to surface preparation. Applicator shall notify Engineer of any noticeable disparity in the surfaces which may interfere with the proper preparation or application of the repair mortar/ resurfacing material and protective coating/ lining.

B. Applicator shall implement measures to prevent debris from entering active sewer line. Dispose of captured debris in accordance with local regulations.

C. All contaminants including corroded material, debris, oils, grease, incompatible existing coatings, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants shall be removed.

D. All concrete or mortar that is not sound or that has been damaged by chemical exposure shall be removed down to a sound concrete surface or replaced. All microbial contamination shall be removed.

E. Surface preparation method(s) shall be performed in accordance with NACE No. 6/ SSPC SP-13, Surface Preparation of Concrete guidelines.

F. All active infiltration shall be stopped and the substrate surfaces shall have no free water visible prior to rehabilitation product application.

G. Surfaces to receive protective coating shall be cleaned using high pressure water blasting and abrasive blasting methods to produce a sound surface with adequate profile and porosity to provide a strong bond between the protective coating/lining and the substrate. Generally, this can be achieved with a high pressure water blasting using equipment capable of 5,000 psi at 4 gpm (minimum) followed by abrasive blasting using copper slag or nickel slag blast media. After abrasive blasting is complete, clean substrate again using high pressure water blasting. Other methods such as high pressure water jetting (refer to NACE Standard No. 5/SSPC-SP12), grinding, scarifying or acid etching may also be used in conjunction with high pressure water blasting and abrasive blasting. Detergent water cleaning and hot water blasting may be necessary to remove oils, grease or other hydrocarbon residues from the concrete. Whichever

method(s) are used, they shall be performed in a manner that provides a uniform, sound clean neutralized surface that is not excessively damaged. ABRASIVE BLASTING SHALL BE REQUIRED.

H. Surfaces shall be prepared to a minimum degree of roughness designated as CSP 4 by the ICRI Guideline No 03732. Overhead surfaces shall be prepared to a minimum designation of CSP 5.

I. Infiltration shall be stopped by using a material which is compatible with the specified repair/ resurfacing material and is suitable for top coating with the specified build back material and protective coating/lining. All grouting and water stop materials utilized shall be compatible with specified epoxy coating/lining system.
   1. Mixing and handling of chemical grout, which may be toxic under certain conditions, shall be done in such a manner as to minimize any hazard to personnel and shall be in accordance with the manufacturer's recommendations. It is the responsibility of the Applicator to provide appropriate protective measures to ensure that chemicals are handled only by trained and authorized personnel. All equipment used to install the grout shall be as recommended by the manufacturer and only personnel thoroughly familiar with all aspects of the grouting material and meeting the qualification requirements specified herein, shall perform the actual grouting operation.

J. After abrasive blast and infiltration repair is performed, all surfaces shall be inspected for remaining laitance, debris, microbial residue, or corroded concrete prior to build-back and/or protective coating/lining material application. Any evidence of remaining contamination or laitance shall be removed by additional abrasive blast or other approved method.

K. All surfaces shall be inspected by the Inspector during and after preparation and before the repair/ resurfacing material is applied.

L. Pre-installation Inspection Procedures:
   1. Surface profile test using Elcometer 224 surface profile gage or equal to ANSI/NACE/ICRI standards for specified substrate.
   2. pH testing for acidification of concrete (ASTM D 4262) Utilize WTW 3310 pH meter or approved equal.
   3. Chloride testing for soluble salts using Hedon Automated Soluble Salt Meter or approved equal.
   4. Ultraviolet light testing for hydrocarbon residues shall be conducted on all surfaces to be coated.
   5. Moisture vapor transmission testing (ASTM D 4263) not to exceed 5 lbs/1000 Sq. Ft./24hrs. Must use Elcometer 7410 Moisture Meter or approved equal.

3.3 APPLICATION OF REPAIR/ RESURACING MATERIALS

A. Areas where structural steel has been exposed or removed shall be repaired and primed in accordance with manufacturer recommendations.

B. Repair and resurfacing materials shall meet the specifications herein. The materials shall be spray or trowel applied utilizing proper equipment on to specified, properly prepared surfaces. The material thickness shall be specified by the Engineer according to Owner's requirements, but at a thickness of no less than ½" for cementitious type materials. Modified epoxy mortar or epoxy mastic build-back material may be applied thinner at the discretion of the Engineer, in accordance with manufacturer instructions. Verify thickness during application of repair/ resurfacing material.

C. If using approved cementitious repair materials specified herein, such shall be trowel finished to provide a smooth surface with an average profile equivalent to a rough sandpaper to optimally

receive the protective coating. No bugholes or honeycomb surfaces shall remain after final trowel procedure of repair mortar. Broom finish is not permitted.

D. The repair materials shall be permitted to cure according to manufacturer recommendations. Curing compounds should not be used unless approved in writing for compatibility with the specified protective coating/lining material.

E. The area between the manhole and the manhole ring or grade rings (if utilized) and any other area that might exhibit movement or cracking due to expansion and contraction, shall be grouted with a compatible flexible grout, caulking or gel.

F. All surfaces shall be inspected by Engineer and Inspector after repair/ resurfacing and before the protective coating is applied.

G. Installation in-process testing and inspection procedures (daily log).

H. All testing shall be documented using Elcometer model 319 or approved equal and submitted to inspector and approved by manufacturer prior to commencing work.
   1. Surface temperature (60ºF to 100ºF)
   2. Relative humidity (ASTM F 2170) (80% or less)
   3. Ambient temperature >50ºF
   4. Dew point > 50ºF above dew point
   5. Material lot numbers and quantities shall be recorded and added to report daily

3.4 APPLICATION OF EPOXY PROTECTIVE COATING/ LINING

A. Application procedures shall conform to the recommendations and instructions of the protective coating/ lining manufacturer, including material handling, mixing, environmental controls during application, safety, and equipment.

B. Spray equipment, if utilized, shall be specifically designed to accurately ratio and apply the specified protective coating/lining materials, shall be regularly maintained and in proper working order. Trowel application shall be acceptable.

C. The protective coating/ lining material must be applied by a Certified Applicator, trained and certified by protective coating/lining manufacturer.

D. Specified surfaces including manhole invert and channel areas shall be coated/lined by application of a solvent-free, 100% solids, high build epoxy coating / lining as further described herein. 125 mil minimum thickness shall be required. Wet film gauge thickness testing performed by Contractor in accordance with ASTM D4414 shall be conducted throughout epoxy application process. Wet film gauge measurements shall be recorded throughout installation process and provided to Engineer or Inspector.

E. If subsequent topcoating, patching or additional coats of the protective coating/ lining should be necessary, additional surface preparation procedures will be required if the recoat window specified by the manufacturer is exceeded. Patching shall be conducted in accordance with manufacturer recommendations.

F. Epoxy material shall be applied in conditions where substrate is shaded and/or is cooling rather than heating to help prevent offgassing issues.

3.5 POST INSTALLATION TESTING AND INSPECTION

A. High Voltage Spark Test. After the epoxy protective coating/lining has cured, it shall be inspected with high-voltage holiday detection equipment. The spark tester shall be set at 100 volts per 1 mil (25 microns) of film thickness applied, and voltage shall be verified prior to the commencement of the inspection process for each manhole. High voltage spark testing shall be conducted in accordance with NACE SP0188. All coated/lined surfaces within each manhole shall be tested in the presence of the INSPECTOR. All detected holidays shall be marked and repaired by abrading the coating surface with grit disk paper or other hand tooling method. After abrading and cleaning, additional protective coating/lining material can be hand applied to the repair area. All touch-up/repair procedures shall follow the protective coating/lining manufacturer's recommendations.

B. Adhesion Testing. Adhesion testing shall be performed on a minimum of one or 20% of all rehabilitated structures, whichever is greater, or as shown on the Plan and/or specified in the Special Provisions. Adhesion testing shall be conducted after the coating/ liner system has cured per manufacturer instructions and in accordance with ASTM D7234 as modified herein. INSPECTOR shall select locations within the manhole where adhesion test will be performed. The adhesive used to attach the dollies to the coating/ liner shall be rapid setting with tensile strength in excess of the coating/ liner material and permitted to cure in accordance with manufacturer recommendations (typically 24 hours). The coating/ lining material and dollies shall be adequately prepared to receive the adhesive. Prior to pull test, the Contractor shall utilize a scoring device to cut through the coating until the substrate is reached, in accordance with ASTM D7234. Extreme care shall be taken while scoring to prevent micro cracking in the coating/lining or scoring too deep into the substrate since cracks may cause failures at diminished strengths. The pull tests in each area shall meet or exceed 250 psi. and shall include subbase adhered to the back of the dolly or no visual signs of coating material in the test hole. A glue failure exceeding 300 psi may be acceptable at the discretion of the Inspector. If any test fails, a minimum of two additional locations within the structure where the failure was detected shall be tested, as directed by the Inspector. If any of the retests fail, all loosely adhered or unadhered liner in the failed area, as determined by the Engineer, shall be removed and replaced at the Contractor’s expense. If a structure fails the adhesion test, one additional structure or an additional 20% of the initial number of structures selected for testing (whichever is greater) shall be tested at the discretion of the Engineer and/or as specified in the Special Provisions. Patching of coating/lining material after pull testing is complete shall be performed in accordance with manufacturer instructions.

C. Visual Inspection. A final comprehensive visual inspection shall be made by the Inspector and manufacturer's representative. Any deficiencies in the finished coating shall be marked and repaired according to the procedures set forth herein by Applicator.

END OF SECTION

DIVISION 13

SPECIAL CONSTRUCTION

SECTION 13 34 23 – PRE-ENGINEERED FIBERGLASS ENCLOSURE

PART 1 - GENERAL

1.1 WORK INCLUDED

A. BTF manufacturer to provide factory-built, pre-engineered and prefabricated fiberglass enclosures in accordance with project plans and specifications. Enclosures shall be molded fiberglass construction, factory pre-assembled to make a bonded unit with no external seams or joint covers.

B. Enclosures shall house the control panel for the Persigo WWTP and Dos Rios odor control systems, water panel, recirculation pump, nutrient tank, and other miscellaneous electrical equipment.

C. Enclosures shall be supplied with ventilation, lighting, door, and other specified equipment factory installed.

1.2 RELATED SECTIONS AND REFERENCES

A. Related Sections
   1. Section 03 30 00 – Cast-In-Place Concrete: Concrete pad.

B. References
   1. ASTM C 518 – Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   2. ASTM D 256 – Standard Test Method for Determining the Pendulum Impact Resistance of Notched Specimens of Plastics.
   3. ASTM D 618 – Standard Practice for Conditioning Plastics for Testing.
   4. ASTM D 638 – Standard Test Method for Tensile Properties of Plastics.
   5. ASTM D 732 – Standard Test Method for Shear Strength Plastics by Punch Tool.
   6. ASTM D 790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   7. ASTM D 792 – Standard Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.
   8. ASTM D 1622 – Standard Test Method for Apparent Density of Rigid Cellular Plastics.
   9. ASTM D 2583 – Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.

1.3 QUALITY ASSURANCE

A. Pre-engineered fiberglass shelter Manufacturer shall have a minimum of five (5) years experience in enclosure fabrication. In addition, the Manufacturer shall have made no less than ten (10) enclosures similar to the one on this project. Evidence must be submitted to verify that these requirements are met prior to being deemed an acceptable manufacturer.

B. The Engineer shall have the right to inspect or test any materials during fabrication in the factory. At the option of the Engineer, certified tests of materials may be accepted in lieu of field tests.

C. The enclosure shall be manufactured by
   1. Associated Fiberglass Enterprises
   2. Kenco Plastics Company
   3. Warminster Fiberglass
   4. Tracom Fiberglass Products
   5. Shelter Works

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 00.

B. Product Data: Certified independent test results of representative wall laminate.

C. Shop Drawings:
1. Critical dimensions, jointing and connections, fasteners and anchors.
2. Materials of construction.
3. Sizes, spacing, and location of structural members, connections, attachments, openings, and fasteners.
4. Color.

D. Calculations: Structural design calculations, sealed by an independent licensed Professional Engineer in the State of Colorado, including anchor design.

E. Manufacturer's installation instructions.

1.5 DESIGN CRITERIA

A. Enclosure shall be designed to withstand seismic, wind and snow loads appropriate for the project location in accordance with the Universal Building Code (UBC).

B. Enclosure shall have minimum interior dimensions as shown on the plans.

C. Enclosure shall be entirely factory assembled and shipped as a one-piece unit.

D. Roof of enclosure shall be sloped to facilitate rain runoff. Enclosure shall be equipped with rain shields over the door.

1.6 WARRANTY

A. The Manufacturer shall warrant the enclosure and its components for one year from the date of installation.

PART 2 - PRODUCTS

2.1 ENCLOSURE

A. General Construction: The shelter shall be provided with a smooth interior and exterior satin finish. The walls and roof shall be integral with smooth radii for all corners.

B. The walls and roof of the enclosure shall be integral and shall be of sandwich construction consisting of 1/8-inch thick fiberglass skins and rigid polyisocyanurate foam core. Minimum core thickness shall be 1-inch.

C. Fiberglass laminate shall consist of polyester resin sheets places over a structural frame, insulated with polyurethane foam. Minimum physical properties shall be:
1. Tensile Strength: 14,000 psi (ASTM D638)
2. Flexural Strength: 25,000 psi (ASTM D790)
3. Flexural Modulus: 1,000,000 psi (ASTM D790)
4. Shear strength: 12,000 psi (ASTM D 732)
5. Barcol hardness: 40 (ASTM D 2583)
6. Thermal conductivity maximum 0.14 BTU/hr/ft2/F/in
7. Minimum R value 10.9 with maximum U value 0.092

D. Provide a minimum three-inch wide mounting flange around the entire lower perimeter of the enclosure, predrilled for anchor bolts.

E. Provide a closed cell neoprene rubber or ConSeal base mounting gasket.

F. Provide stainless steel lifting eyes or other stainless lifting hardware.

2.2 COMPONENTS

A. Doors and Frames
   1. One single door of one-piece molded fiberglass construction.
   2. Dimensions of 78 inches high, 1-3/4 inches thick, and 36 inches wide.
   3. Door threshold shall be low-profile.
   4. Provide stainless steel cylindrical lockset with levered door handle
   5. Provide stainless steel door safety “stop” chain

B. Ventilation
   1. Provide a pre-wired fiberglass exhaust fan capable of providing a minimum of 12 air changes per hour, including shutter and fiberglass canopy with insect screen.
   2. Provide intake gravity louver opposite exhaust fan sized for exhaust fan airflow capacity, manually adjustable, with a fiberglass canopy with insect screen.
   3. Provide 1500W heater with thermostat.

C. Lighting
   1. Enclosure shall be pre-wired with interior, vapor-resistant, LED lights, including interior switches. Provide a minimum of 40 lumens of lighting per square feet.

D. Electrical
   1. All electrical items should be 120V.

2.3 PAINTING

A. Interior and exterior surfaces shall be finished in polyester gel coat, same color throughout. Owner to select color of white, tan, grey or green during submittal phase of construction.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. The enclosure shall be stored on dunnage placed at the proper locations to prevent cracking, distortion, or any other physical damage.

B. The enclosure shall be provided with stainless steel lifting eyes for setting the enclosure without incurring damage to the walls or roof.

3.2 INSTALLATION

A. Install products in a manner consistent with installation instructions and recommendations of the Manufacturer.

B. Move and position the shelter using the lifting eyes provided. Position neoprene gasket between the concrete slab and the building mounting flange. If more than one lifting eye is provided, use a spreader bar.

C. Provide anchorage necessary to fasten the enclosure to the concrete pavement and to resist appropriate wind loads.

D. Seal with sealant or grout to ensure watertightness.

E. Install and test the shelter accessories in accordance with the manufacturers' instructions.

END OF SECTION

DIVISION 26

ELECTRICAL

SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies the basic requirements for electrical installations and includes requirements common to more than one section of Division 26. It expands and supplements the requirements specified in the General and Supplementary Conditions.

B. This project consists of construction of the new building structures, associated facilities, and all related electrical systems as defined in the plans and in these specifications.

C. The work includes the installation, connection and testing of new electrical equipment, including electrical services, power distribution equipment, lighting equipment, underground electrical work, grounding systems, control systems, conduit and wiring, coordination of traffic flow, temporary power systems, special electrical systems and all appurtenances to construct and demonstrate proper operation of the completed electrical systems.

D. The Contractor shall be responsible for the coordination of power, communication, and controls for the project.

E. The electrical plans do not give exact locations, etc., and do not show all the offsets, control lines, pilot lines, and other installation details. Each contractor shall carefully lay out the work at the sites to conform to the job conditions, to conform to details of installation supplied by the manufacturers of the equipment to be installed, and thereby to provide complete operating systems.

F. The electrical plans show diagrammatically the locations of the various electrical outlets and apparatus and the general method of circuiting and controlling. Exact locations of these outlets and apparatus shall be determined by reference to the general plans and to all detail drawings, etc., by measurements at the buildings, and in cooperation with other crafts, and in all cases shall be subject to the approval of the Owner and Engineer. The Engineer reserves the right to make any reasonable change in location of any outlet or apparatus before installation, without additional cost to the Owner.

G. These specifications and the accompanying drawings are intended to cover systems which will not interfere with the structure of the buildings, which will fit into the several available spaces, and which will ensure complete and satisfactory systems. Each bidder shall be responsible for the proper fitting of the material and apparatus into the buildings.

H. Should the particular equipment which any bidder proposes to install require other space conditions than those indicated on the Drawings, the Bidder shall arrange for such space with the Engineer before submitting the bid. Should changes become necessary on account of failure to comply with this clause, the Contractor shall make such changes at the Contractor’s expense.

I. Where wire sizes, conduit and other items of construction are shown or required for a complete installation, but are not adequately identified as to size or material requirements, the materials furnished shall be in accordance with “Code” requirements as though shown in detail on the Drawings.

J. All equipment shall be leveled and made plumb. Metal junction boxes, equipment enclosures and metal raceways mounted on water or earth-bearing walls shall be separated from walls not less than 1/4 inch by corrosion-resistant spacers. All electrical conduits and items of equipment shall be run or set parallel to walls, floors and other items of construction.

1.2 STANDARDS

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

B. Contractor shall utilize the most current editions of standards, which are current at time of bid and as recognized by the Authority Having Jurisdiction for the respective standard.

1.3 SUBMITTALS

A. Submittals shall comply with Section 01 33 00 SUBMITTAL PROCEDURES and the General and Supplementary Conditions.

B. Submittals shall be furnished by the Contractor for the work involved in sufficient time so that no delay or changes will be caused. Fax copies are not acceptable.

C. Submittals shall consist of manufacturing information, schematics, wiring diagrams, ladder logic diagrams, instrument loop diagrams, outline drawings, clearances and related information. Shop Drawings shall be so marked as to indicate the EXACT items offered.

D. Submittals shall bear Contractor's certification that the item complies in all respects with the item originally specified. It is the Contractor's responsibility to procure the proper sizes, quantities, rearrangements, structural modifications or other modifications in order for the substituted item to comply with the established requirements.

E. The Contractor shall combine each submittal set into one electronic file (pdf format). Group materials submitted by their Specification numbers, but do not submit the entire electrical within one submittal. Provide electronic bookmarks in the pdf to indicate the included equipment types and a title sheet to separate each section.

F. The Contractor shall submit complete descriptions, illustrations, specification data, etc., of all materials, fittings, devices, fixtures, special systems, etc., as required by the individual sections of this Division.

G. Submittal of shop drawings, product data and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Engineer will not be processed.

H. All submittals shall provide the following information:
   1. General Contractor.
   2. Sub-Contractor.
   3. Distributor and/or Supplier.
   4. Sales Agency.
   5. Submittals not supplying this information will be rejected.

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

1.4 QUALITY ASSURANCE

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

1.5 PRODUCT LISTING

A. Prepare listing of major electrical equipment and materials for the project.

B. Provide all information requested.

C. Submit this listing as a part of the submittal requirements.

D. When two or more items of same material or equipment are required they shall be of the same manufacturer when available. Product manufacturer uniformity does not apply to raw materials, bulk materials, wire, conduit, fittings, sheet metal, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment kits, and similar items used in Work, except as otherwise indicated.

E. Provide products that are compatible within systems and other connected items.

1.6 NAMEPLATE DATA

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

1.7 WORK SUPERVISION

A. The Contractor shall designate in writing the qualified electrical supervisor who shall provide supervision to all electrical work on this project. The minimum qualifications for the electrical supervisor shall be a master electrician as defined by the statutes of the State of the work being performed. The supervisor or his appointed alternate possessing at least a master electrician license shall be on site whenever electrical work is being performed. The qualifications of the electrical supervisor shall be subject to approval of the Owner and the Engineer.

B. All master and journeyman electricians shall be licensed in accordance with the statutes of the State of the work being performed. No unlicensed electrical workers shall perform work on this project. Apprentice electricians in a ratio of not more than one apprentice per journeyman electrician will be allowed if the apprentices are licensed and actively participating in an apprentice-ship program recognized and approved by the statutes of the State of the work being performed.

1.8 PRIMARY UTILITY SERVICE

A. The Contractor shall install all primary trenching, conduits, and backfilling for the primary service in accordance with utility requirements and utility specifications in conjunction with these plans and specifications. The Contractor shall construct concrete pads for all utility pad mount transformers in accordance with utility requirements and these plans and specifications.

B. The Contractor shall be responsible for coordinating all electrical work with the servicing utility prior to construction and providing all equipment, connectors, metering boxes and accessories to make all final connections.

1.9 SECONDARY SERVICE

A. New electrical work shall be as noted in the drawings. All secondary services are to be furnished and installed by the contractor.

B. The Contractor shall be responsible for coordinating all electrical work with the servicing utility prior to construction and providing all equipment, connectors, and accessories to make all final secondary connections.

C. The Contractor shall provide temporary service conductors and raceway system as may be required. The Contractor shall then provide and connect permanent service conductors and raceway system after the permanent installation. The Contractor shall coordinate temporary service, installation, metering and all other items as required with the servicing utility. The Contractor shall be responsible for paying all temporary electric monthly metering charges.

D. Service entrance electrical ducts shall be red blended concrete encased at a depth to provide 18 inches minimum cover over the top of the underground electrical duct, regardless of the soil conditions or substances encountered.

1.10 TELEPHONE WORK

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

1.11 LOCKOUT / TAGOUT PROGRAM

A. The Contractor shall provide a complete copy of and electrical energy source Lockout/Tagout Program to the Owner, with copy to the Engineer. The document shall clearly identify the on-site master electricians and their contact information, including office and mobile telephone numbers.

B. The Lockout/Tagout Program shall comply with Part 1910 - Occupational Safety and Health Standards (OSHA) Subpart S – Electrical, and meet the requirements of 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout), including requirements listed in 1910.331 through 1910.335.

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

1.12 SAFETY PROGRAM

A. The Contractor shall implement an electrical safety program that complies with NFPA 70E and 29 CFR 1926.

B. Implementation of the Electrical Safety Program, determining and providing proper Personal Protective Equipment (PPE), training and enforcing personnel to wear the prescribed PPE, conducting work area safety inspections (including correcting deficiencies), and all other related safety requirements are the sole responsibility of the Contractor.

1.13 EQUIPMENT CONNECTIONS

A. General: Provide connections for all equipment installed or modified by this contract, regardless of who furnished the equipment.

B. Provide all disconnect switches required by Code whether or not shown on the plans.

C. Contractor shall connect Owner-furnished equipment when specified.

1.14 GENERAL CONDITIONS

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

1.15 COORDINATION

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

B. The Contractor shall coordinate electrical equipment to be mounted on vendor supplied walkways with supplier.

1.16 SPECIAL NOTE

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

1.17 CONTINUATION OF SERVICES

A. The Contractor shall install any temporary lines and connections required to maintain electric services and safely remove and dispose of them when complete. The Contractor shall supply emergency power whenever any existing electrical service is without power. In general, the existing facility shall remain operational during construction.

B. Planned outages shall be coordinated two weeks in advance with duration and time of start approved by the Owner. Changeover work which may be required after normal hours or weekends shall not constitute the basis for additional cost to the Owner. When an outage begins, the Contractor shall proceed directly to completion of the work without unscheduled interruptions or delays due to lack of manpower, equipment or tools.

C. The Contractor shall refer to the sequence of construction and shall provide temporary connections as may be required to complete each phase of construction as may be required. The Contractor shall submit proposed electrical service plans for each phase of construction to the Owner and Engineer for consideration.

1.18 LAYOUT

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

1.19 RELATED WORK SPECIFIED ELSEWHERE

A. Mechanical Equipment: The Contractor shall rough-in for and make final electrical connections to all motor, panels, fixtures, and equipment furnished under other sections of the specifications, providing all material and equipment required for such final connections, except hereinbefore described. This includes, but is not limited to, control panels and other miscellaneous equipment.

B. The Contractor shall refer to other sections of these specifications for all information relating to the requirements of all electrical connections to the equipment and shall furnish and install electrical items required for a complete installation, ready for operation.

C. Roughing-in shall be accomplished from approved shop drawings.

D. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

E. Refer to equipment specifications in other Divisions for rough-in requirements.

1.20 LOCAL CONDITIONS

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

1.21 RECORD DOCUMENTS

A. Refer to the General and Supplementary Conditions for requirements. The following paragraphs supplement the requirements of the General and Supplementary Conditions:
   1. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned for column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangements; support and hanger details; Change Orders; concealed control system devices.
   2. The Contractor shall locate all underground and concealed work, identifying all equipment, conduit, circuit numbers, motors, feeders, breakers, switches, and starters. The Contractor will certify accuracy by endorsement. Record drawings shall be correct in every detail, such that the Owner can properly operate, maintain, and repair exposed and concealed work.
   3. The Contractor shall store the Record drawings on the site. Drawings shall not be rolled. Make corrections, additions, etc., with pencil, with date and authorization of change.
   4. Mark specifications to indicate approved substitutions; Change Orders; actual equipment and materials used.

1.22 OPERATION AND MAINTENANCE DATA

A. Refer to Section 01 33 00 SUBMITTAL PROCEDURES and Section 01 78 23 OPERATION AND MAINTENANCE DATA for procedures and requirements for preparation and submittal of maintenance manuals.

B. In addition to the information required by Sections 01 33 00 and 01 78 23, include the following information:
   1. Installation manual: Description of function, installation and calibration manuals, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
   2. Operations manual: Manufacturer’s printed operating instructions and procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; summer and winter operating instructions; and all programming and equipment settings.
   3. Maintenance manual: Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   4. Service manual: Servicing instructions and lubrication charts and schedules, including the names and telephone numbers of personnel to contact for both routine periodic and warranty service for equipment and materials provided under this Division.
   5. Final approved equipment shop drawings, clearly labeled.
   6. Final test reports, clearly labeled, including motor certification tests.
   7. Final certified calibration sheets for all equipment and instruments.

C. After approval of the O&M Manuals, the Contractor shall provide three (3) complete electronic copies of all documentation in Adobe PDF file format using a storage media device of the Owner and Engineer’s choosing.

1.23 GUARANTEE

A. The Contractor shall guarantee the work and materials for a period of one (1) year from the date of completion. If there are failures due to faulty material or workmanship, the Contractor shall correct the failure at no cost to the Owner.

B. Refer to the General and Supplementary Conditions for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.
   1. Compile and assemble the warranties specified in Division 26, into a separate set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

D. Upon completion of the installation, the Contractor shall adjust the systems to the satisfaction of the Engineer.

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

1.24 CLEANING

A. Refer to Section 01 77 00 CLOSEOUT PROCEDURES for general requirements for final cleaning.

B. Clean all light fixtures, lamps and lenses prior to final acceptance. Replace all inoperative lamps.

C. The electrical system shall be thoroughly cleaned inside and outside, of all enclosures to remove all debris, dust, concrete splatter, plaster paint and lint.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 HEAT TRACING

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

B. Contractor shall meet all National Electrical code requirements for heat tracing and particularly to Resistance Heating Elements Article 427-21, 22 and 23.

PART 3 - EXECUTION

3.1 SALVAGE

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

3.2 DEMOLITION AND DISPOSAL

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

3.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.

C. Equipment and materials shall be stored in accordance with the manufacturer's recommendations and instructions.

D. All equipment, including but not limited to equipment containing coils and/or electronics, shall be stored in a clean, dry, ventilated and heated building. The storage area shall be free from condensation or other injurious environmental conditions. Freedom from condensation shall be essential and shall be accomplished by the use of auxiliary heaters as required to raise the temperature to 5-degree C above the ambient temperature. The equipment shall be protected from excessive dust.

E. In addition, certain electronic equipment that requires cooling based upon its specific storage temperature range shall be stored in an air-conditioned building.

F. All motors shall be stored in a clean, dry, ventilated and heated building. The storage area shall be free from condensation or other injurious environmental conditions. Freedom from condensation shall be essential and shall be accomplished by the use of auxiliary heaters as required to raise the temperature to 5 degree C above the ambient temperature. The motors shall be protected from excessive dust.

G. Cables and wiring shall be kept in a dry location out of the sun.

H. Outdoor storage, even when protected by a tarpaulin, is unacceptable.

I. Equipment may be rejected if the storage criteria are not followed.

3.4 INSTALLATION

A. Coordinate electrical equipment and materials installation with other building components.

B. Verify all dimensions by field measurements.

C. Arrange for chases, slots, and openings in other building components to allow for electrical installations.

D. The Contractor shall keep ends of conduits, including those extending through roofs, equipment and fixtures covered or closed with caps or plugs to prevent foreign material from entering during construction.

E. Coordinate the installation of required supporting devices and sleeves to be set in concrete and other structural components as they are constructed.

F. Sequence, coordinate, and integrate installations of electrical materials and equipment for maintaining the required operation of the facility. Give particular attention to large equipment requiring positioning prior to closing-in the building.

G. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials.

H. Where mounting heights are not detailed or dimensioned, install electrical services and overhead equipment to provide the maximum headroom possible.

I. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

J. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.

K. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

L. Coordinate installation of electrical equipment on vendor supplied walkways with supplier.

3.5 MATERIALS AND WORKMANSHIP

A. All materials shall be new, and shall be of the latest standard design of a manufacturer regularly engaged in the manufacture of that type of equipment. Materials shall be in good condition and shall be free from dents, scratches or other damage incurred in shipment or installation.

B. All equipment shall comply with the National Electrical Code, Underwriters Laboratories or other appropriate agency.

C. Installation shall be made in a neat and workmanlike manner, and all materials shall be installed in accordance with the recommendations of the various manufacturers. The installation shall be subject to the approval of the Owner and Engineer.

D. Incidental materials required to complete the installation as intended by these Specifications shall be of the type and quality in keeping with specified equipment.

3.6 COORDINATION

A. Carefully examine specification and drawings to be thoroughly familiar with items which require electrical connections and coordination. (Electrical drawings are diagrammatic and shall not be scaled for exact sizes.)

B. Notify other tradesmen of any deviations or special conditions necessary for the installation of work. Interference between work of various contractors shall be resolved prior to installation. Work installed not in compliance with specifications and drawings and without properly checking and coordinating as specified above shall, if necessary, be removed and properly reinstalled without additional cost to the Owner. Engineer to be mediating authority in all disputes arising on project.

C. Equipment shall be installed in accordance with manufacturer's recommendation. Where conflicts occur between contract documents and these recommendations, a ruling shall be requested of the Engineer for decision before proceeding with such work.

3.7 CUTTING AND PATCHING

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

B. Correct unnecessary damage caused due to installation of electrical work, brought about through carelessness or lack of coordination.

C. Holes cut through floor slabs to be sleeved or core drilled with drill designed for this purpose. All openings, sleeves, and holes in slabs to be properly sealed, fire proofed and water proofed.

D. Repairs to be performed with materials which match existing materials and to be installed in accordance with appropriate sections of these specifications.

E. All cutting and patching work shall be coordinated in advance with the Engineer and Owner prior to any work.

3.8 TRENCHING, EXCAVATION, BACKFILLING, AND REPAIRS

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

3.9 FOUNDATIONS AND PADS

A. Foundations and pads required for equipment shall be provided as indicated. Proper size and location of foundations, pads and anchor bolts shall be determined under this Division.

B. Provide anchors and bases for electrical equipment to withstand lateral forces and accommodate displacements.

3.10 NOISE AND VIBRATION CONTROL

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

3.11 TESTS

A. On completion of work, installation shall be completely operational and entirely free from ground, short circuits, and open circuits. Perform a thorough operational test in presence of the Owner and Engineer. Furnish all labor, materials and instruments for above tests.

B. Furnish the Engineer, as part of closing file, a copy of such tests including identification of each circuit and readings recorded. Test information to be furnished to the Engineer includes ampere readings of all panels and major circuit breakers, isolation resistance reading of motors and transformers.

C. Prior to final observation and acceptance test, all electrical systems and equipment shall be in satisfactory operating condition. Including, but not limited to the following:
1. Electrical power and distribution system.
2. Lighting systems.
3. Transformers.
4. Electric motors for all equipment.
5. Telecommunication system.
6. Emergency power system.
7. Special electrical control systems.

D. After installation of the electrical system and before operating equipment, functional checking shall be conducted in accordance with the manufacturer's recommendations, with the contract drawings and as follows:
1. Functional checking shall include inspection, testing and repair, replacement or adjustments as necessary to ensure compliance with the requirements of the specifications. Tests and inspections shall be recorded on appropriate yellow lined contract and shop drawings, standard test forms and checklists to indicate that wiring and controls are in place in accordance with requirements and to form the basis of record drawings.
2. The functional test procedures shall be signed and dated by the Contractor and presented to the Owner's construction observation personnel prior to operating any equipment.
    a. Visual Inspection – The electrical system shall be examined as outlined below:
        1). Parts of components missing
        2). Improper assembly
        3). Parts or components not functioning properly
        4). Finish not as specified
        5). Materials not as specified
        6). Connections not tight
        7). Mounting and supports loose or unsatisfactory
        8). Nameplates missing or inaccurate
    b. Grounding System Tests
        1). Measure the resistance of the counterpoise grounding system by the rate-of-fall of potential method. Record all measurements on an approved standard test form made specifically for the purpose. The resistance of the grounding system to ground shall not exceed NFPA 70 requirements.
    c. Continuity Tests
        1). Each wire and each wire in each cable rated 300 volts and below shall be tested for continuity. Record wire number and pass or fail on checklist for each wire.
    d. Dielectric Tests
        1). Each power conductor rated 600 volts and above shall be tested (meggered) for dielectric strength to ground.
        2). Prior to testing, all components that could be damaged should be disconnected. After testing, the circuit shall still register a resistance value of not

less than 1 megohm at 600 volts, dc. This test shall apply between all insulated circuits and external metal parts. Record equipment name, phase or wire number and all observed values for each wire.

3). Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning of all circuits. Record equipment or circuit number and pass or fail on function test checklist for each circuit.

4). The Contractor shall develop non-conforming material reports for each failure. Repair and report failures all failures to Owner and Engineer.

5). The Contractor shall replace defective parts, correct malfunctioning units, make all repairs and retest to demonstrate compliance. The Contractor shall document all actions taken on appropriate non-conforming material report.

3.12 INSPECTION FEES AND PERMITS

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

3.13 IDENTIFICATION OF EQUIPMENT

A. Properly identify all electrical equipment, including but not limited to the following:
1. Switchgear, switchboards, motor control centers, and control panels.
2. Main distribution panel and individual devices within it.
3. Panelboards and individual devices within it.
4. Safety switches and disconnects.
5. Contactors and lighting control center, including all branch circuits.
6. Individually mounted circuit breakers.
7. Relays.
8. Transformers.
9. Generators and automatic transfer switches.
10. Any other type of enclosure that includes electrical equipment.

3.14 TEMPORARY LIGHTS AND POWER

A. Provide a temporary electrical lighting and power distribution system of adequate size to properly serve the required temporary loads. Temporary work to be installed in a neat and safe manner in accordance with the National Electrical Code, Article 590, and as required by OSHA or applicable local safety codes.

B. The Contractor will pay for power consumption.

END OF SECTION

SECTION 26 05 14 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

1.3 SUBMITTALS

A. Product Data: for each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate specified in each color specified.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as type are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

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

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD1, NEMA WD6, UL498 and UL 943, Class A and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20A:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to the following:
      a. Cooper; GF20.
      b. Pass & Seymour; 2084.

2.4 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to the following:
      a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
      b. Hubbell; CSI221 (single pole), CSI222 (two pole), CSI223 (three way), CSI224 (four way).
      c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 12224-2 (four way).
      d. Pass & Seymour; 20ACI (single pole), 20AC2 (two pole); 20AC3 (three way), 20AC4 (four way).

C. Pilot Light Switches, 20A:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to the following:
      a. Cooper; 2221PL for l20 V and 277V.
      b. Hubbell; HPL1221PL for 120 V and 277V.
      c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277V.
      d. Pass & Seymour; PS20ACI-PLR for 120 V.
   2. Description: Single pole, with neon-lighted handle, illuminated when switch is “OFF.”

2.5 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
   1. Plate-Securing Screws: Stainless steel or unbreakable nylon in damp areas.
   2. Material: 0.035-inch-(1mm-) thick, satin-finished stainless steel.
   3. Provide in-use covers for all exterior installations and interior damp locations.

2.6 FINISHES

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
   1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint and other material that may contaminate the raceway system, conductors and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting is complete.

C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing conductors:
      a. Cut back and pigtail or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection such as plastic film and smudge covers until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

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

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

3.2 IDENTIFICATION

A. Comply with Division 26 Section “Identification for Electrical Systems.”
1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

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

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

END OF SECTION

SECTION 26 05 15 - ELECTRIC MOTORS

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

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

1.3 QUALITY ASSURANCE

A. Provide routine (short commercial) test data complying with NEMA MG 1-12.51 and MG 1-23.46.

B. Test thermally protected motors in accordance with NEMA MG 1 winding temperature and trip current tests.

C. Comply with NEMA MG 1.

D. Motors for applications in hazardous locations shall bear the UL label listing its use in accordance with the NEC.

1.4 COORDINATION

A. Furnish reviewed shop drawings from motor controller manufacturer for coordination and sizing of the controller.

B. Coordinate supplied motor connection box with conduits sizes indicated in the drawings.

C. Coordinate motor leads and lugs with wire sizes indicated in the drawings.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Unless otherwise specified or specifically required by the manufacturer of the equipment to be driven, all motors shall be single speed, squirrel cage, a-c induction type motors. Electric motors shall be NEMA Design B constant speed squirrel cage induction motors having normal starting torque with low starting current except for motors controlled by variable speed operation and other special motors. In no case shall starting torque or breakdown torque be less than the value specified in ANSI/NEMA MG 1. In all cases, motors shall be suitable for the indicated starting method.

B. Stator winding shall be copper.

C. The maximum motor loading of each motor shall not exceed its nameplate horsepower rating (exclusive of service factor) under any operating condition.

D. Motors shall be sized to start and accelerate the design loading and operate the full range of driven equipment without exceeding any of the specified design requirements. Motors that fail to meet these requirements shall be replaced at no additional cost to the Owner.

E. All three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated without exceeding Class B temperature rise limits stated in ANSI/NEMA MG1-12, 42. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class. Motors to be operated with variable frequency drives shall be provided with insulation systems to withstand 1600 volt spikes, with dV/dt as defined in NEMA MG 1-31.

F. All motors shall have a minimum service factor of 1.15.

G. Motors for use in hazardous locations shall have enclosures suitable for the classification of the location. Such motors shall be UL listed and stamped.

H. Motors larger than 50 HP located outdoors or in non-conditioned areas shall have 120-volt AC space heaters and temperature sensors.

I. For motors controlled by variable frequency drives, the critical vibration speed of the motor/load combination shall either not fall within the operating range of the drive or such frequencies shall be blocked with the drive critical speed avoidance circuit. All motors connected to variable frequency drives shall be inverter duty rated.

J. Unless otherwise specified, motors shall have no-load sound power levels not to exceed the values specified in NEMA MG 1-12.53.3.

K. Premium Efficiency Motors:

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

2.2 MOTOR BEARINGS

A. All motors greater than 2 horsepower shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.

B. Motors less than 2 horsepower shall be provided with sealed, permanently lubricated ball bearings.

C. Horizontal motors over 2 horsepower shall be shielded open-type bearing installed with labyrinth sealed end bells with pipe plugs. Bearings shall be regreasable and have provisions for purging old grease.

D. Vertical motors over 2 horsepower shall be provided with relubricatable ball, spherical, roller or plate type trust bearings. Lubrication shall be per manufacturer’s recommendation for smooth operation and long life of the bearing. Drains shall be provided to prevent over lubrication.

2.3 MOTOR THERMAL PROTECTION

A. All single phase motors shall have integral thermal overload protection or shall be current limited.

B. Winding thermostats shall be provided in accordance with NEMA MG-1. Thermostats shall be snap action, bi-metallic, temperature actuated type switches and shall be provided with a normally closed contact. Thermostats shall be precalibrated by the manufacturer and shall be series connected.

2.4 ACCESSORIES

A. All vertical motors and horizontal motors 3 horsepower and larger shall have split-type conduit boxes with a gasketed moisture seal between the conduit box and motor frame. Motors less than 3 horsepower shall have the manufacturer’s standard conduit boxes. Motors other than open drip-proof shall be gasketed.

B. All motors weighing 250 pounds or greater shall have suitable lifting eyes for installation and removal.

C. Motor grounding lugs shall be provided and shall be suitable for terminating ground wires.

D. All motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA Standard motor data.

E. Refer to equipment specifications for special requirements such as space heaters or motor winding thermal protection.

PART 3 - EXECUTION

3.1 STORAGE

A. Protect motors from exposure to elements for which they are not designed. Install and energize temporary electrical service to motors with electrical heaters.

B. Store motors in an air-conditioned, ventilated or protected environment similar to or better than the destination environment.

3.2 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment.

B. Connections, switches, controls, disconnects and other items shall be provided in accordance with the plans and specifications for each motor.

C. The Contractor shall coordinate conduit sizes indicated in the drawings with the supplied motor connection box. The Contractor shall be responsible for providing larger connection boxes as may be required.

3.3 FIELD TESTING

A. Perform insulation resistance tests in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of motor.

B. Inspect the physical and mechanical conditions of each motor installation including any deviations from the nameplate, drawings, specifications and manufacturer's written guidelines. Verify expected rated voltage, phase and frequency for each motor installation. Confirm the presence of and correct application of lubrications for each motor along with proper securing and torque settings for bolted installations of each motor.

C. Check for proper phase and ground connections for each motor are connected. For multi-voltage motors, verify that motors are connected properly for the supplied voltage.

D. Verify that space heaters, where provided, are functional.

E. Test the motor for proper rotation prior to connection to the driven equipment. Measure and record running current and evaluate the current relative to the load conditions and nameplate full-load amps.

F. Simulate operating conditions for each motor to demonstrate proper operation of interlocks and control features.

G. Record operating current in each phase for each motor ½ horsepower and larger. Motors exceeding motor nameplates values shall be repaired or replaced.

H. For motors 50 horsepower and larger or when a discernible abnormal vibration is detectible, a vibration test shall be completed. Vibration shall not exceed 0.25 in./sec. For horizontal motors, the N-S and E-W vibrations shall be measured at the top and bottom of the front and rear bearing housing. For vertical motors, the N-S and E-W vibrations shall be measured at the upper and lower bearing housing.

I. All testing shall be witnessed by the Engineer and Owner.

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

3.4 MOTOR TEST REPORT

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

END OF SECTION

MOTOR TEST REPORT

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

1. Name and Horsepower of Motor Tested:_____

2. Overcurrent Protection:_____

3. Overload Protection: _____

4. Visual Inspection Checklist:

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

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

   ϕA-ϕB_____ ϕB-ϕC_____ ϕC-ϕA_____

   ϕA-G_____ ϕB-G_____ ϕC-G_____

6. Record full load voltage and current:

   Vab_____ Van_____ Ia_____

   Vbc_____ Vbn_____ Ib_____

   Vca_____ Vcn_____ Ic_____

7. Motor Nameplate FLA:_____

   Running Amps:_____

   P.F. _____

8. Comments:

Signature Required: _____

Company: _____

Date: _____

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

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

B. Related Sections include the following:
   1. Division 26 Sections

1.2 DEFINITIONS

A. EPDM: Ethylene-propylene-diene monomer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For testing agency.

A. Field quality-control test reports.

1.4 QUALITY ASSURANCE

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

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.5 COORDINATION

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

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

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

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

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

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

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

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper, stranded.

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

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

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

B. Exposed Feeders: Type RHH-RHW-USE or XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type RHH-RHW-USE or XHHW-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type RHH-RHW-USE or XHHW-2, single conductors in raceway.

E. Feeders in Cable Tray: Type RHH-RHW-USE or XHHW-2, single conductors in raceway for larger than 4/0 AWG; Otherwise Type TC tray cable.

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

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

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

I. Variable Frequency Drive Branch Circuits: Shielded cable, size adjusted for published ampacity of cable.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. Class 1 Control Circuits: Type THHN-THWN, in raceway.

L. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

D. Cable splicing, in general, will not be allowed. Where applicable, all wiring connections to be made using terminal block type connections. Wire nut use will permitted only where allowed by the Owner and Engineer.

3.5 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test the following for compliance with requirements.
    a. All panel feeders.
    b. All motor feeders.
    c. All control wires for continuity.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Test Reports: Prepare a written report to record the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 “Field Quality Control” Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For grounding to include the following in emergency, operation and maintenance manuals.
   1. Instructions for periodic testing and inspection of grounding features at test wells ground rings grounding connections for separately derived systems based on ANSI/NETA MTS.
      a. Test shall be to determine if ground resistance or impedance values remain within specified maximums and instructions shall recommend corrective action if they do not.
      b. Include recommended testing intervals.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare copper Conductors:
   1. Solid Conductors: ASTM B3
   2. Stranded Conductors: ASTM B8.
   3. Tinned Conductors: ASTM B 33.
   4. Bonding Conductor: No. 4 AWG, stranded conductor or per NFPA 70.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. Pipe connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

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

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.
   1. Bury at least 30 inches below grade.

C. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.
   4. Connections to Structural Steel: Bolted connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with ANSI/IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole and Handhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

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

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   4. Single-phase motor and appliance branch circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment and components.

E. Metal Poles Supporting Outdoor Lighting fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact or damage.

B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

C. Ground rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section “Underground Ducts and Raceways for Electrical Systems,” and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit from building's main service equipment, or grounding bus, to main metal water service entrance to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and indicated item, extending around the perimeter of building.
   1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
   2. Bury ground ring not less than 24 inches from building foundation at a depth not less than 30 inches below finished grade.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

3.5 FIELD QUALITY CONTROL

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

2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at ground test wells. Make tests at ground rods before any conductors are connected.
    a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.
3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole and Handhole Grounds: 10 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.2 DEFINITIONS

A. RMC: Rigid metal conduit.

B. NECA: National Electrical Contractors Association.

1.3 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Equipment supports.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.; a division of cooper Industries.
      c. ERICO International Corporation

d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101. NECA publications are available at www.NECAnet.org.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size and shape of conductor gripping pieces as required to suit individual conductors or cables supported.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes and bars.

F. Mounting, Anchoring and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded 304 stainless steel stud, for use in hardened Portland cement concrete, steel or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
1). Hilti Inc.
2). ITW Ramset/Red Head; a division of Illinois tool works, Inc.
3). MKT Fastening, LLC
4). Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened Portland cement concrete with tension, shear and pullout capacities appropriate for supported loads and building materials in which used.
a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
1). Cooper B-Line, Inc.; a division of Cooper Industries
2). Empire Tool and Manufacturing Co., Inc.
3). Hilti Inc.
4). ITW Ramset/Red head; a division of Illinois tool works, Inc.
5). MKT Fastening, LLC.
3. Concrete Inserts: Stainless steel, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F 3125.
6. Toggle bolts: All-steel springhead type.
7. Hanger Rods: Threaded 304 stainless steel.
8. Nuts: Match threaded rod or bolt; double nut vertical hanger rods.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES.

A. Description: bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Outdoor locations: Supporting material shall be stainless steel or PVC-Coated galvanized steel or as described within the Drawings.

C. Indoor locations: Supporting materials shall be aluminum in dry areas and stainless steel or PVC-Coated galvanized steel in damp areas, or as described within the Drawings.

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for RMC as required by NFPA 70. Minimum rod size shall be ¼ inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lbs.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
   6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
   7. To Light Steel: Stainless steel sheet metal screws.

8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Cut, fit and place miscellaneous metal supports accurately in location, alignment and elevation to support and anchor electrical materials and equipment.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000 psi, 28-day compressive-strength concrete.

C. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION

SECTION - 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:
1. Division 26 Section “Underground Ducts and Raceways for Electrical Systems” for exterior ductbanks, manholes, and underground utility construction.
2. Division 26 Section “PVC Coated Conduit.”

1.2 DEFINITIONS

A. LFMC: Liquidtight flexible metal conduit.

B. LFNC: Liquidtight flexible nonmetallic conduit.

C. GRS: Galvanized Rigid Steel Conduit.

D. RNC: Rigid nonmetallic conduit.

E. EMT: Electrical Metallic Tubing.

1.3 SUBMITTALS

A. Product Data: for surface raceways, wireways and fittings, hinged-cover enclosures and cabinets.

B. Custom enclosures and cabinets.

C. Source quality-control test reports.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.

8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. PVC-Coated Steel Conduit: PVC-coated.
1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.
3. Comply with ETL Verified PVC-001.

D. Joint Compound for Rigid Steel Conduit: Listed for use in cable connector assemblies and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group
6. Condux International, Inc.
7. ElecSYS, Inc.
8. Electri-Flex co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company
12. Thomas & Betts Corporation.

B. RNC: NEMA TC2, Type EPC-40-PVC, unless otherwise indicated.

C. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

2.3 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company
4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell company.
8. Scott Fetzer Co.; Adalet Division.
9. Spring City Electrical Manufacturing Company.
10. Stahlin Non-Metallic Enclosures.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The)
13. Woodhead, Daniel Company; Woodhead Industries, Inc. subsidiary.

B. Sheet Metal Outlet and Device boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device boxes: NEMA FB 1, Type FD, with gasketed cover.

D. Small Sheet Metal Pull and Junction boxes: NEMA OS 1.

E. Cast-Metal Access, Pull and Junction boxes: NEMA FB 1.

F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch for conditioned spaces only, unless otherwise indicated.

G. Hinged-Cover Enclosures: NEMA 250, Type 4 Stainless steel, with continuous-hinge cover with latches for outdoor, process buildings, above and below grade structures and damp locations, unless otherwise indicated.

2.4 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A, 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated “wall pipe,” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052-or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with Engineer.

2.5 SLEEVE SEALS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Advance Products & systems, Inc.
   2. Calpico, Inc.
   3. Metraflex Co.
   4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
   1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
   2. Pressure Plates: Stainless steel. Include two for each sealing element.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: apply raceway products as specified below, unless otherwise indicated:
   1. Exposed: PVC-Coated Rigid Steel
   2. Concealed: PVC-Coated Rigid Steel.
   3. Underground: RNC, Schedule 40 in concrete encasement.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

B. Indoors:
   1. Exposed: Aluminum, or as noted in the Drawings.

2. Concealed: Aluminum, or as noted in the Drawings.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic. Pneumatic, Electric Solenoid or Motor-Driven Equipment): LFMC.
4. Damp or Wet Locations: PVC-coated Rigid Steel, Aluminum, or as noted in the Drawings.

C. Minimum Raceway Size: ¾-inch trade size; 1-inch trade size for below grade installation.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section “Hangers and Supports for Electrical Systems.”

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of four 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Raceways Embedded in Slabs:
1. Run conduit larger than 1 inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Do not install conduits in such a manner as to compromise the structural integrity of walls, roofs, ceilings or floor. Where necessary, provide additional supporting members to support conduit runs. Below grade conduits 1 1/2” and larger shall be routed 24” below the concrete floor slabs.
4. Comply with Chapter 6 of ACI 318.
5. Change from nonmetallic conduit to Galvanized Rigid Steel or PVC-Coated Rigid Steel Conduit before rising above the floor.

H. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer’s written instructions.

I. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

J. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

K. Install raceway sealing fittings at suitable, approved and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where otherwise required by NFPA 70.

L. Expansion-Joint Fittings: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg. F, and that has straight-run length that exceeds 25 feet.
   1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
      c. Indoor Spaces: connected with the Outdoors without Physical Separation: 125 deg F temperature change.
      d. Attics: 135 deg F temperature change.
   2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
   3. Install each expansion-joint fitting with position, mounting and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

M. Flexible conduit connections: Use maximum of 36 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement, and for transformers and motors.
   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

N. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application Engineer.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Size pipe sleeves to provide ¼-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with fire-stop materials.

J. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground, Exterior-Wall Penetrations: Install cast-iron “wall pipes” for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

A. Install to seal underground, exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.6 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION

SECTION 26 05 33.13 - PVC COATED CONDUIT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes PVC-coated raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:
1. Division 26 Section “Raceway and Boxes for Electrical Systems”.

1.2 SUBMITTALS

A. Product Data: for surface raceways, wireways and fittings, hinged-cover enclosures and cabinets.

B. Custom enclosures and cabinets.

C. Source quality-control test reports.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. All the conduit, fittings, and supporting products shall be provided by the same manufacturer to ensure that a five-year product warrantee is achieved.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
1. Perma-Cote
2. Plasti-Bond
3. KorKap

2.2 MATERIALS

A. PVC-coated, Galvanized Rigid Conduit (GRC) and fittings shall meet all the performance standards specified herein and such performance standards shall require verification by a nationally recognized testing agency including American Society for Testing and Materials (ASTM) and Underwriter Laboratories (UL).

B. The PVC coated galvanized rigid conduit shall be UL Listed. The PVC coating shall have been investigated by UL as providing the primary corrosion protection for the rigid metal conduit. Ferrous fittings for general service locations shall be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to plastic coating shall be UL listed. All conduits and fittings must be new, unused material. Applicable UL standards shall include: UL 6 Standard for Safety, Rigid Metal Conduit, UL514B Standard for Safety, Fittings for Conduit and Outlet Boxes.

C. The PVC coated galvanized rigid conduit shall be Electrical Testing Laboratory (ETL) Verified to the Intertek ETL SEMKO High Temperature H_2O PVC Coating Adhesion Test Procedure for 200 hours. The PVC coated galvanized rigid conduit shall bear the ETL Verified PVC-001 label to signify compliance to the adhesion performance standard.

D. The conduit shall be hot dip galvanized inside and out with hot galvanized threads.

E. A PVC sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening except unions. The inside sleeve diameter shall be matched to the outside diameter of the conduit.

F. The PVC coating on the outside of conduit couplings shall have a series of longitudinal ribs 40 mils in thickness to protect the coating from tool damage during installation.

G. Form 8 Condulets, 1/2" through 2" diameters, shall have a v-seal tongue-in-groove gasket to effectively seal against the elements. The design shall be equipped with a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 in. of mercury (vacuum) for 72 hours shall be available. Form 8 Condulets shall be supplied with plastic encapsulated stainless steel cover screws.

H. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings. This internal coating shall be a nominal 2 mil thickness. Conduit or fittings having areas with thin or no coating shall be unacceptable.

I. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30°F (-1°C).

J. All male threads on conduit, elbows and nipples shall be protected by application of a urethane coating.

K. All female threads on fittings or conduit couplings shall be protected by application of a urethane coating.

L. Independent certified test results shall be available to confirm coating adhesion under the following conditions:
   1. Conduit and condulet exposure to 150°F (65°C) and 95% relative humidity with a minimum mean time to failure of 30 days (ASTM D1151).
   2. The interior coating bond shall be confirmed using the Standard Method of Adhesion by Tape Test (ASTM D3359).
   3. No trace of the internal coating shall be visible on a white cloth following six wipes over the coating which has been wetted with acetone (ASTM D1308).
   4. The exterior coating bond shall be confirmed using the methods described in Section 3.8, NEMA RN1. After these tests the physical properties of the exterior coating shall exceed the minimum requirements specified in Table 3.1, NEMA RN1.

M. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit. All U bolts will be supplied with plastic encapsulated nuts that cover the exposed portions of the threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All clamping, cutting, threading, bending, and assembly instructions listed in the manufacturer's installation guide should be vigorously followed.

B. Installation of the PVC Coated Conduit System shall be performed in accordance with the Manufacturer's Installation Manual. To assure correct installation, the installer shall be certified by Manufacturer to install coated conduit.

C. Installer certification, before installation, is required.

D. Clamps, bolts, angles, pipe straps, struts, rods, nuts and other supporting products for PVC-coated conduits shall be PVC-coated or stainless steel.

E. The Contractor shall use equipment specifically designed for PVC-coated conduit when cutting, clamping, reaming, threading, bending, assembling or performing other installation procedures. PVC-coating shall be protected.

F. Touch-up compound for PVC-coated conduit shall not be allowed. All conduits with damaged coatings shall be removed and replaced at no cost to owner.

END OF SECTION

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

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 DEFINITIONS

A. RNC: Rigid nonmetallic conduit.

B. SCTE: Society of Cable Telecommunications Engineers.

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Accessories for manholes, handholes, boxes.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Reinforcement details/
   3. Step details.
   4. Grounding details.
   5. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
   6. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections and elevations, and fabrication and installation details, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Cover design.
   3. Grounding details.
   4. Dimensioned locations of cable rack inserts and pulling-in lifting irons.

D. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

E. Product Certificates: for concrete and steel used in precast concrete handholes, as required by ASTM C858.

F. Source quality-control test reports.

G. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.6 COORDINATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

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

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel conduit: Galvanized. Comply with ANSI C80.1.

B. PVC-Coated Steel Conduit: Comply with ANSI C80.

C. RNC: NEMA TC2, type EPPC-40-PVC, UL 651 , with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 PRECAST CONCRETE HANDHOLES AND BOXES

A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
   1. Oldcastle Precast Group.

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosure are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
   1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
   2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive cover-securing bolts.

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

2.3 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: comply with SCTE 77.
1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, “ELECTRIC” or as noted.
6. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin and reinforced with steel or fiberglass or a combination of the two.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
    a. Amorcast Products Company.
    b. Quazite
    c. Carson Industries LLC.

d. CDR Systems Corporation.
e. NewBasis.

2.4 UTILITY STRUCTURE ACCESSORIES

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

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

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

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

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

3.2 UNDERGROUND ENCLOSURE APPLICATION

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

3.3 EARTHWORK

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

B. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top soiling, fertilizing, timing, seeding, sodding, sprigging and mulching.

C. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.4 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from high point in runs between two manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 36 inches, both horizontally and vertically unless otherwise indicated. All below grade elbows and bends to be galvanized.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to end-bell spacing 10- feet from the end bell without reducing duct line slope and without forming a trap in the line.
   2. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall or Floor Penetrations: Make a transition from underground duct to PVC coated rigid steel conduit unless otherwise indicated, at least 5 feet outside the building wall without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition.

F. Sealing: Provide temporary closures at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

G. Pulling cord: Install 100-lbf-test nylon cord in ducts, including spares.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES AND BOXES

A. Precast Concrete Handhole and Manhole Installation:
   1. Comply with ASTM C 891, unless otherwise indicated.
   2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
   3. Unless otherwise indicated, support units on a level 12" bed of crushed stone or gravel graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:
   1. Install handholes with bottom below the frost line.
   2. Handhole covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
   3. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms as required for installation and support of cables and conductors and as indicated.

D. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below the frost line.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading form and pour a concrete ring encircling and in contact with, enclosure and with top surface screeded to top of box cover frame.
   1. Concrete: 3000 psi, 28-day strength, with a troweled finish.
   2. Dimensions: 12 inches wide by 12 inches deep.

3.7 GROUNDING

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

3.8 FIELD QUALITY CONTROL

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

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

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

END OF SECTION

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Identification for conductors and communication and control cable.
   2. Warning labels and signs.
   3. Instruction signs.
   4. Equipment identification labels.
   5. Miscellaneous identification products.

1.2 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with NFPA 70E

D. Comply with 29 CFR 1910.145.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

PART 2 - PRODUCTS

2.1 CONDUCTOR AND COMMUNICATION – AND CONTROL-CABLE IDENTIFICATION MATERIALS.

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.2 WARNING LABEL AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145 and NFPA 70E.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door or other access to equipment unless otherwise indicated.

C. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend and size required for application. ¼ inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

D. Sample warning label and sign shall include, but are not limited to the following legends:
   1. Multiple Power source Warning: “DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES.”
   2. Workspace Clearance Warning: “WARNING - OSHA REGULATION – AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES.”
   3. WARNING – ARC FLASH AND SHOCK HAZARD –APPROPRIATE PPE REQUIRED.

2.3 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sized.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.
   3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.4 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark gray background. Minimum letter height shall be 3/8 inch.

B. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.5 MISCELLANEOUS IDENTIFICATION PRODUCTS.

A. Cable ties: fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength: 50 lb minimum.
   3. Temperature Range: Minus 40 to plus 185 degrees F.
   4. Color: Black, except where used for color-coding.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

A. Outlet Boxes for Receptacles: Identify branch circuit by panel name and circuit number.

B. Power-Circuit Conductor Identification: of secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

C. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

D. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
   1. Identify conductors, cables and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker type designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

E. Warning Labels for Indoor Cabinets, Boxes and Enclosures for Power and Lighting: comply with 29 CFR 1910.145 and apply metal-backed, butyrate warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover or other access.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to the following:
      a. Power transfer switches
      b. Controls with external control power connections.
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

F. Instruction Signs:
   1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
   2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.

G. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with ½-inch high letters on 1-1/2-inch high label; where 2 lines of text are required, use labels 2 inches high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
   2. Equipment to Be Labeled:
      a. Panelboards, electrical cabinets and enclosures.
      b. Access doors and panels for concealed electrical items.
      c. Electrical switchgear and switchboards.
      d. Transformers.
      e. Motor-control centers.
      f. Disconnect switches.

g. Enclosed circuit breakers.
h. Motor starters.
i. Push-bottom stations.
j. Power transfer equipment.
k. Contactors.
l. Remote-controlled switches and control devices.
m. Power-generating units.
n. Voice and data cable terminal equipment.
o. Terminals, racks and patch panels for voice and data communications and for signal and control functions.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder and branch-circuit conductors.
1. Color shall be factory applied or, for sized larger than No. 6 AWG if authorities having jurisdiction permit, field applied.
2. Colors for 480/277-V Circuits:
   a. Phase A: Brown
   b. Phase B: Orange
   c. Phase C: Yellow
3. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

END OF SECTION

SECTION 26 09 43 - FIBER OPTIC NETWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Definitions, Symbols, Definitions, and Abbreviations: All symbols, definitions and engineering unit abbreviations utilized shall conform to IEEE 100-84, S50.1 and S51.1, where applicable.

B. System Description

1.2 PATENTS

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

1.3 SUBMITTALS

A. Product Data: Installation Details
   1. The Contractor shall submit to the Engineer, for approval, Shop Drawings of the equipment to be installed to meet the Specifications. The Drawings shall be supported by notes or written directions as required to fully define the installation.
   2. The submission shall be made as soon as feasible after award of the Contract and, in any event, shall be submitted and approval obtained before installation of the equipment. The Contractor shall furnish the Engineer with six (6) copies of the submission.
   3. The information required on the Shop Drawings shall include, but is not necessarily limited to, the following:
      a. Full and complete Specifications covering the equipment proposed to be furnished.
      b. Detail Drawings showing plan, network connections and elevation dimensions of the equipment proposed to be furnished.
      c. Guarantees of performance of the equipment proposed to be furnished.
      d. Nearest location of factory maintenance and service facilities that will be available to service the equipment offered.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection: Delivery, storage, and handling shall be in accordance with manufacturer’s recommendation and other sections herein.

PART 2 - PRODUCTS

2.1 FIBER OPTIC CONNECTORS

A. All fiber optic connectors shall be type ST. All connectors on equipment and cables shall be fully compatible.

B. Number cables and connect each cable to its numbered port on the indicated switch.

2.2 6-STRAND ALL ENVIRONMENT MULTI-MODE FIBER OPTIC CABLE

A. Fiber optic cable shall be industrial grade, extended performance. The cable shall consist of 12 fibers with 62.5-micron core and 125-micron cladding and shall be suitable for multimode operation at 850 and 1300 nanometers. Acceptable losses for multimode fiber lengths with connector pairs at each end shall not be greater than 3.75 dB/km at 850 nm and 1.5dB/kM at 1300nm. Cable shall be rated for installation in harsh environments such as direct burial, aerial lashing, and conduit and pathways that are subject to wide temperature variations. Cable shall be plenum rated. Cable shall comply with ANSI/TIA/EIA-568-B including all addendums for fiber optic cable performance specifications.

B. The cable shall be suitable for the installation as certified by the fiber optic interface manufacturer and proven by test results. Fiber optic cable shall be supplied in continuous lengths between patch panels. Cable shall be as manufactured by Phoenix Digital or Optical Cable Corporation or Corning Cable Systems or Berk-Tek or equal.

2.3 FIELD FIBER OPTIC PATCH PANEL / TERMINATION PANEL

A. Patch panel shall be a wall mountable enclosure specifically designed for fiber optic cable termination and distribution. Cabinet shall be constructed of metal and shall include cable strain relief and radius limiting, buffer tube fan-out kits, space for a splice tray holder, and capacity for a minimum of 12 ST connectors.

B. Install patch panel in control panel. Terminate into ST connectors the two fibers required at each location. Terminate and jumper each fiber that continues on to another location.

C. Provide Corning WCH-02P or Siemon or equal.

2.4 FIBER OPTIC PATCH CORDS

A. Fiber optic patch cords shall be duplex ST to ST cords with two tight buffered 62.5/125 multi-mode strands. Patch cords must comply with ANSI/EIA/TIA standards. Provide Ortronics or Lucent or Amp or Molex Premise or NORDX/CDT or Panduit or Siemon or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide and install fiber optic cable, connectors, transceivers and converters, network cable, connectors, hubs and network switches to interconnect the PLCs. Fiber optic materials and equipment shall be installed, tested and terminated by experienced fiber optic system personnel.

B. Cable shall be carefully installed and professionally terminated. Submit credentials and a sample of fiber termination technician. All terminations shall be compatible with the terminal and communicating equipment. Fiber optic cable shall be installed in underground concrete encased conduit. Network cable shall be installed in interior locations in conduit.

C. Fiber Optic splices are not desired or permitted except in unavoidable circumstances. In the event of fiber optic cable damage exterior splices shall be made in handholes at no additional cost to the Owner and at the contractor's risk. The losses due to the splice shall not exceed 0.2dB per mechanical splice. No more than 1 set of splices shall be allowed in a run. The Contractor shall protect exposed ends of cable during construction. Network cable shall not be spliced.

D. All required splicing materials shall be included with the fiber optic cable and shall meet the requirements of the terminal and communicating devices, transceivers and media converters and the fiber optical cable manufacturer's specifications.

E. Fiber Optic Cable with connectors on each fiber strand shall be coiled in each Control Panel with 5 feet minimum slack ready for immediate use.

F. Cable Testing: The fiber optic cable shall be tested at the factory and at the job site before and after installation. Provide docket of shipment report with attenuation test results to the engineer prior to installation. These tests shall be signed, dated and immediately transmitted to the Engineer. Category 5 cable shall be third party verified to TIA/EIA 568-A Category 5.

G. OTDR Tests: This test shall utilize an OTDR test instrument with signature trace printout capability and shall document the end-to-end attenuation for fiber, connectors and mechanical splices (if any).

H. Site acceptance test: While cable is still on the reel as delivered to the site, prior to installation submit printed, signed and dated results of on-site, on-reel OTDR attenuation test of each fiber strand. Verify Category 5 cable performance with 100MHz test set.

I. Post installation test: Following installation of fiber cable and termination of all strands submit results of on-site attenuation test of each terminated fiber strand. Tests shall be performed with an OTDR test instrument with printout capability. Test each terminated Category 5 cable with 100MHz test set.

J. All cable with attenuation results lower than acceptable limits shall be removed and replaced at no additional cost to the Owner.

K. Fiber optic and network devices installation: Modems and connecting cables shall be preconfigured at the factory for the application. No modem field settings, programming or adapters shall be required

L. Fiber Optic Cable Installation: Fiber optic cable installation and termination shall be accomplished by technicians skilled and experienced in the type work indicated. Experience shall include 5 years of installation experience with proper training in use of the tools and equipment recommended by the fiber optic cable manufacturer for installation and termination in an approved manner. The installer shall have test equipment available to demonstrate that the completed installation complies with the specified bandwidth and transmission parameters. A licensed electrical or specialty controls contractor in the State of Colorado shall perform this work.

3.2 DEMONSTRATION

A. System Demonstration and Final Acceptance Test:
   1. The Contractor shall conduct a 10 day Final Acceptance test of the completed installation. The test shall start after the Engineer has received marked record (as-built) drawings from the Contractor and when directed by the Owner/Engineer.
   2. The system shall operate with 100 percent reliability during the test period. Failure of hardware shall require repair or remedy of the defect to the satisfaction of the Engineer within a two hour period. If the problem cannot be repaired in this time, the test shall be aborted and restarted after the problem is corrected and when directed by the Owner/Engineer. Restarting and satisfactory completion of the test shall be conducted at no additional cost to the Owner.
   3. The Contractor shall complete the Operations and Maintenance Manuals including all updated documentation of programmable devices to the satisfaction of the Engineer.

4. The Contractor will be allowed two attempts at successfully completing the Final Acceptance Test. After that time, the Contractor will become responsible to reimburse the Owner for liquidated damages.

B. Service: Manufacturers shall provide as part of the equipment cost sufficient days of service by a factory-trained service engineer specifically trained on the type equipment herein specified to assist the Contractor during installation and start-up. The service time shall be sufficient to place the units in satisfactory service and instruct the Owner's personnel in proper operation and maintenance of the equipment.

C. Maintenance Instruction: Operating and maintenance instructions, along with a separate parts list, shall be furnished in three (3) copies to the Owner. Operating instructions shall also incorporate a functional description of the system, including the system schematics which reflect "as-built" modifications. Maintenance requirements particular to the system shall be clearly defined, along with calibration and test procedures.

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

END OF SECTION

SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
   1. Dry-Type distribution transformers.

1.2 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection.
   1. Wiring Diagrams: Power, signal and control wiring.

C. Qualification Data: For testing agency

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For transformers to include in emergency, operation and maintenance manuals.

1.3 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

D. Comply with IEEE C57.12.91, “Test Code for Dry-Type Distribution and Power Transformers.”

1.4 DELIVERY, STORAGE AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer’s written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03. Construct housekeeping pad for floor mounted transformers.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Products.
   2. Siemens Energy & Automation, Inc.
   3. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and –tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Aluminum

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.

E. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

G. Energy Efficiency for Transformers Rated 15 kVA and larger:
   1. Complying with NEMA TP 1, Class 1 efficiency levels.
   2. Tested according to NEMA TP 2.

H. Electrostatic Shielding: Each winding shall have an independent, single full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.

3. Shield Effectiveness:
    a. Capacitance between Primary and Secondary windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
    b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
    c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

I. Wall Brackets: Manufacturer's standard brackets.

J. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 16 Section "Grounding and Bonding for Electrical systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions and requirements.

C. Ground the neutral on the secondary of all transformers.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section “Grounding and Bonding for Electrical Systems.”

B. Connect wiring according to Division 26 Section “Low-Voltage Electrical Power Conductors and Cables.”

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed “Satisfactory Test” label to tested component.

3.5 ADJUSTING

A. Monitor transformer secondary voltage at each unit for at least 2 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 PERFORMANCE REQUIREMENTS

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

1.3 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types and details for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
   5. Include evidence of NRTL listing for series rating of installed devices.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include wiring diagrams for power, signal, and control wiring.
   8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

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

F. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.4 QUALITY ASSURANCE

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

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

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

D. Comply with NEMA PB 1.

A. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

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

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

1.6 PROJECT CONDITIONS

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

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.7 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

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

B. Incoming Mains Location: Top and bottom as required by job conditions.

C. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Compression type.
3. Ground Lugs and Bus-Configured Terminators: Compression type.
4. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Square D; a brand of Schneider Electric.
2. Siemens.
3. Eaton.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Square D; a brand of Schneider Electric.
2. Siemens.
3. Eaton.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Square D; a brand of Schneider Electric.
   2. Siemens.
   3. Eaton.

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

2.5 ACCESSORY COMPONENTS AND FEATURES

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

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

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete or Miscellaneous Cast-in-Place Concrete."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
   2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to panelboards.
   5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.

H. Install filler plates in unused spaces.

I. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

K. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1). Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

F. ADJUSTING

G. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

H. Set field-adjustable circuit-breaker trip ranges as indicated and recommended by manufacturer.

I. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes if directed by the Engineer.
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.5 PROTECTION

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

END OF SECTION

SECTION 26 24 19 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes modifications to the existing MCC-2 located in the headworks electrical room at the Persigo WWTP.

1.2 SUBMITTALS

A. Product Data: For each type of controller and each type of motor-control center. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings and finishes.

B. Shop Drawings: for each motor-control center.
   1. Include dimensioned plans, elevations, sections and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Nameplate legends.
      c. Short-circuit current ratings of buses and installed units.
      d. Vertical and horizontal bus capacities.
      e. UL listing for series rating of overcurrent protective devices in combination controller.
      f. Features, characteristics, ratings, and factory settings of each motor-control center unit.
   2. Wiring Diagrams: Power, signal and control wiring for class and type of motor-control center. Provide schematic wiring diagram for each type of controller.

C. Coordination Drawings: floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around motor-control centers where pipe and ducts are prohibited. Show motor-control center layout and relationships between electrical components and adjacent structural and mechanical elements. Show compliance with NFPA 70, Article 240.24 height limitation of overcurrent device operating handles. Show support locations, type of support and weight on each support. Indicate field measurements.

D. Qualification Data: for manufacturer and testing agency.

E. Field quality-control test reports.

F. Operation and Maintenance Data: for motor-control centers, all installed devices and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for motor-control centers and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

G. Load-Current and Overload-Relay heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 250 miles of Project site, a service center capable of providing training, parts and emergency maintenance and repairs.

B. Source Limitations: Obtain motor-control centers and controllers of a single type through one source from a single manufacturer.

C. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

D. Comply with NFPA 70.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver motor-control centers in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Handle motor-control centers according to the following:
   1. NEMA ICS 2.3, “Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers Rated Not More Than 600 Volts.”
   2. NECA 402, “Recommended Practice for Installing and Maintaining Motor Control Centers.”

1.5 COORDINATION

A. Coordinate layout and installation of motor-control centers with other construction including conduit, piping, equipment and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

C. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.

D. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Spare fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
   2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Siemens

2.2 MOTOR-CONTROL CENTERS

A. Wiring: NEMA ICS 3, Class I, Type B.

B. Enclosures: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location. Standard, 20" depth.
   1. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
   2. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in motor-control center; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
   3. Final installation height of disconnect devices, accounting for pad height under the motor control center, shall be in compliance with NFPA 70, Article 240.24.
   4. Wiring spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.

C. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location.

2.3 FUNCTIONAL FEATURES

A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center.

B. Controller Units: Combination controller units of types and with features, ratings and circuit assignments indicated:
   1. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
   2. Provide units with short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center sections.
   3. Equip units in Type B and Type C motor-control centers with pull-apart terminal strips or drawout terminal boards for external control connections.
   4. Controller Disconnecting Means: Factory-assembled combination disconnect and controller.
      a. Circuit-Breaker Disconnecting Means: NEMA AB1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

C. Overcurrent Protective Devices: Individual feeder-tap units through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions. Installed height, including that of the concrete base, of operating handles of overcurrent protective devices shall not exceed the height limitation of NFPA 70, Article 240.24.

D. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

E. Spare Units: Type, sizes, and ratings indicated; installed in compartments indicated "spare."

2.4 FEEDER OVERCURRENT PROTECTION

A. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   1. Electronic Trip Unit circuit Breakers: RMS Sensing; field-replaceable rating plug; with the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long-and short-time pickup levels.
      c. Long-and short-time time adjustments.
      d. Ground-fault pickup level, time delay and I^2t response.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings and number of poles.
   1. Lugs: Mechanical Compression style, suitable for number, size, trip ratings and material of conductors.
   2. Application Listing: Appropriate for application: Type SWD for switching fluorescent lighting loads; type HACR for heating, air-conditioning, and refrigerating equipment.
   3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.5 FACTORY FINISHES

A. Finish: manufacturer's standard paint applied to factory-assembled and –tested, motor-control centers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive motor-control centers for compliance with requirements, installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 IDENTIFICATION

A. Identify motor-control center, motor-control center components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

3.5 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings and specialties.

B. Ground equipment according to Division 26 Section “Grounding and Bonding for Electrical Systems.”

3.6 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder and control circuit.
   2. Test continuity of each circuit.

B. Perform the following field test and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection tests, stated in NETA ATS “Motor Control Centers.” Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.7 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

END OF SECTION

SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, controllers and motor-control centers.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
   2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics and ratings.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Ambient temperature adjustment information.
   2. Current-limitation curves for fuses with current-limiting characteristics.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

1.4 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.5 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Bussmann, Inc.
   2. Edison Fuse, Inc.
   3. Ferraz Shawmut, Inc.
   4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Feeders: Class L, fast acting Class RK1or fast acting Class RK5.
   2. Motor Branch Circuits: Class RK1, time delay.
   3. Control Circuits: Class CC, fast acting.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems” and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket and holder.

END OF SECTION

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories and finishes.
   1. Enclosure types and details for all types indicated, including NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of Nationally Recognized Testing Laboratory listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: for power, signal, and control wiring.

C. Qualification Data: For qualified testing agency.

D. Field quality-control reports.
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.3 QUALITY ASSURANCE

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

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

C. Comply with NFPA 70.

1.4 COORDINATION

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

1.5 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
   1. Square D; a brand of Schneider Electric.
   2. Siemens.
   3. Eaton.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   4. Lugs: Mechanical type, suitable for number, size and conductor material.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Square D; a brand of Schneider Electric.
   2. Siemens.
   3. Eaton.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Square D; a brand of Schneider Electric.
   2. Siemens.
   3. Eaton.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Features and Accessories:
   1. Standard frame sizes, trip ratings and number of poles.

2.4 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include:
   1. Square D; a brand of Schneider Electric.
   2. Siemens.
   3. Eaton.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:
   1. Standard frame sizes and number of poles.

2.5 ENCLOSURES

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

   1. NEMA 4X stainless steel for outdoor locations
   2. NEMA 1 for clean indoor locations

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Installation height of disconnect devices shall be in conformance with NFPA 70, Article 240.24.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts form enclosures and components.

D. Furnish and install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

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

END OF SECTION

SECTION 26 56 00 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Exterior luminaires with lamps and ballasts.
   2. Luminarie-mounted photoelectric relays.
   3. Poles and accessories.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. HID: High-intensity discharge.

D. LER: Luminaire efficacy rating.

E. Luminaire: Complete lighting fixture, including ballast housing if provided.

F. Pole: Luminaire support structure, including tower used for larger area illumination.

G. Standard: Same definition as “Pole” above.

1.3 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes and the following:
   1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
   2. Details of attaching luminaires and accessories.
   3. Details of installation and construction.
   4. Luminaire materials.
   5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts and accessories.
      a. Manufacturer Certified Data: Photometric data shall be certified by manufacturer’s laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
   6. Photoelectric relays.
   7. Ballasts, including energy-efficiency data.
   8. Lamps, including life, output, CCT, CRI, lumens and energy-efficiency data.
   9. Materials, dimensions and finishes of poles.
   10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
   11. Anchor bolts for poles.

B. Shop Drawings: Include plans, elevations sections, details and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection.
   2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
   3. Wiring Diagrams: for power, signal, and control wiring.

C. Qualification Data: for qualified agencies providing photometric data for lighting fixtures.

D. Field quality-control reports.

E. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation and maintenance manuals.

F. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

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

C. Comply with IEEE C2, “National Electrical Safety Code.”

D. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.6 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
   1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
   2. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer’s standard warranty period, but not less than three years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: One for every 10 of each type and rating installed. Furnish at least one of each type.
   2. Glass and Plastic Lenses, Covers and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Ballasts: One for every 10 of each type and rating installed. Furnish at least one of each type.

4. Gloves and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the work include, but are not limited to, product(s) indicated on Drawings.

B. Substitutions:
   1. Provide complete literature for each luminaire substitution:
   2. Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
      a. Photometric data:
         1) IES file in standard IES format.
         2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
         3) Candlepower distribution curves.
         4) Average luminaire brightness.
         5) Lumen output charts.
         6) Power requirements in watts and volt-amperes.
      b. Calculations:
         1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
            a) Use surface reflectance values and luminaire light loss factors approved by the ENGINEER to perform all calculations.
   3. Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
   4. Substitutions shall comply with all applicable building codes.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent
   3. Diffusing specular Surfaces: 75 percent.

J. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

K. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and test luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

L. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
   2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
      a. Color: As selected by Engineer from manufacturer's full range.

M. Factory-Applied Finish for aluminum Luninaires: comply with NAAMM's "Metal finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Class 1, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Engineerural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

N. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp and ballast characteristics:
      a. "USES ONLY" and include specific lamp type.
      b. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
      c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
      d. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
      e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
      f. CCT and CRI for all luminaires.

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
   1. Relay with locking-type receptacle shall comply with ANSI C136.10.
   2. Adjustable window slide for adjusting on-off set points.

2.4 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:
   1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
   2. Minimum Starting Temperature: Minus 22 deg. F.
   3. Normal Ambient Operating Temperature: 104 deg F.
   4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

2.5 HID LAMPS

A. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65 Insert value, and CCT color temperature 4000 K.

2.6 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.
   1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed.
   2. Strength Analysis: for each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and washers: Stainless steel unless otherwise indicated.
   3. Anchor-bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws. Provide on all poles.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange.

2.7 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with STM B429/B 429M, alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B209, 5052-H34 marine sheet alloy with access handhole in pole wall.
   1. Shape: Round, tapered Round, straight Square, tapered Square, straight.
   2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded ½-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
   1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
   2. Finish: Same as pole and luminaire.

F. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Finish designations prefixed by AA comply with the system established by the aluminum Association for designating aluminum finishes.
   2. Class 1, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Engineerural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
      a. Color: As selected by Engineer from manufacturer's full range.

2.8 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.2 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
   1. Fire Hydrants and Storm Drainage Piping: 60 inches.
   2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
   3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer.

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
2. Install base covers unless otherwise indicated.
3. Use a short piece of ½ inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Raise and set poles using web fabric slings (not chain or cable).

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section “Raceway and Boxes for Electrical Systems.” In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section “Grounding and Bonding for Electrical Systems.”
1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Division 26 Section “Grounding and Bonding for Electrical Systems.”
1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
1. Verify operation of photoelectric controls.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate and maintain luminaire lowering devices.

END OF SECTION

DIVISION 31

EARTHWORK

SECTION 31 05 19.13 – GEOTEXTILE FILTER FABRIC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the installation of a non-woven geotextile fabric below the riprap.

B. Related sections:
   1. Section 31 37 00 - Riprap

1.2 REFERENCE STANDARDS

A. ASTM International:
   1. ASTM D3786 – Standard Test Method for Bursting Strength of Textile Fabrics – Diaphragm Bursting Strength Tester Method
   2. ASTM D4355 – Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
   3. ASTM D4491 – Standard Test Methods for Water Permeability of Geotextiles by Permittivity
   4. ASTM D4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
   5. ASTM D4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
   6. ASTM D4751 – Standard Test Method for Determining Apparent Opening Size of a Geotextile
   7. ASTM D4886 – Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding block Method)
   8. ASTM D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles
   9. ASTM D6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Related Products Using a 50mm Probe

1.3 QUALITY ASSURANCE

A. The installation shall be performed in accordance with the manufacturer's recommendations and as directed by Engineer.

1.4 SUBMITTALS

A. See Section 01 33 00, SUBMITTAL PROCEDURES.

B. Certificates: Certify that products meet or exceed specified requirements.

PART 2 - PRODUCTS

2.1 MATERIAL

A. The non-woven geotextile fabric shall be an 8-ounce fabric, US Fabrics US 205NW or equal. The fabric shall be of non-woven needle punched construction and consist of long-chain polymeric filaments or fibers composed of polypropylene, polyethylene or polyamide. The filaments and fibers shall be oriented whereby they retain their relative positions with each other and allow the passage of water as specified.

B. The fabric shall be mildew, insect and rodent resistant and shall be inert to chemicals commonly found in soil. The non-woven fabric shall conform to the physical property requirements below:

Physical Property	Test Method	Test Results
Weight	ASTM D 5261	8 oz/sy
Tensile Strength, wet, lbs	ASTM D 4632	205 lbs
Elongation, wet, %	ASTM D 4632	50%
Permittivity	ASTM D 4491	1.35 sec-1
Puncture Strength, lbs	ASTM D 4833	130 lbs
CBR Puncture	ASTM D 6241	535 lbs
Mullen Burst Strength, psi	ASTM D 3786	350 psi
Abrasion Resistance, % Strength Retained	ASTM D 4886	90
Apparent Opening Size (AOS)	ASTM D 4751	80 US Sieve
Ultraviolet Resistance, % Strength Retention	ASTM D 4355 (After 500 Xenon Weatherometer hrs.)	70%
Trapezoidal Tear	ASTM D 4533	85 lbs
Water Flow Rate	ASTM D 4491	90 gal/min/sf

C. The non-woven geotextile fabric shall be furnished in a protective wrapping which shall protect the fabric from ultraviolet radiation and from abrasion due to shipping and handling.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fabric Exposure Following Placement - Exposure of the geotextile filter fabric to the elements, particularly the sun, between lay down and cover shall be a maximum of 7 days.

B. The non-woven geotextile fabric shall be placed in the manner and at the locations shown on the drawings or as directed by the Engineer. The surface to receive the fabric shall be prepared to a smooth condition free of obstructions, depressions and debris. The fabric shall be placed loosely, not in a stretched condition.

C. The Contractor shall anchor the geotextile fabric at outer edges of the riprap courses by embedding the fabric down, across, and up a 1-foot deep by 1-feet wide trench. The fabric shall be centered on the pipe. The anchoring trench shall be backfilled with rock material approved by Engineer. There will be no separate payment for Geotextile Fabric; it shall be subsidiary to other items.

D. Where necessary, the fabric shall be placed so as to provide a minimum 24-inch overlap. The fabric shall be placed transverse to the direction of the flow with the upstream panel overlapping the downstream panel. All installations shall be subject to approval by Engineer.

E. Repairs - A geotextile patch, of the same material, shall be placed over any damaged area and shall extend 12-inches beyond the perimeter of the tear or damaged area. Patch shall be either glued or sewn to the mother fabric or as approved by Engineer.

END OF SECTION

SECTION 31 11 00 - SITE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes clearing, grubbing, scalping, stripping, and disposal of waste debris.

1.2 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 inches caliper to a depth of 12 inches below subgrade.

D. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.

E. Stripping: Removal of topsoil remaining after applicable scalping is completed.

F. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

1.5 SCHEDULING AND SEQUENCING

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.2 LIMITS

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

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

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

3.3 CLEARING

A. Clear areas within limits shown or specified.

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

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

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

3.4 GRUBBING

A. Grub areas within limits shown or specified.

3.5 SCALPING

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

B. Scalp areas within limits shown or specified.

3.6 STRIPPING

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

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

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

3.7 TOPSOIL

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

3.8 DISPOSAL

A. Clearing and Grubbing Debris:
    1. Dispose of debris
    2. Burning of debris will not be allowed.
    3. Woody debris may be chipped. Chips may be sold to CONTRACTOR'S benefit or used for landscaping as mulch or uniformly mixed with topsoil, provided that resulting mix will be fertile and not support combustion. Maximum dimensions of chipped material used

shall be 1/4-inch by 2 inch. Dispose of chips that are unsaleable or unsuitable for landscaping or other uses with unchipped debris.

4. Limit disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.

B. Scalpings: As specified for clearing and grubbing debris.

C. Strippings:
   1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil
   2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

SECTION 31 22 13 - SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work and testing required for preparing subgrade.

B. Related sections:
1. Section 02 41 00 – Demolition.
2. Section 31 11 00 – Site Preparation.
3. Section 31 23 16 – Excavation.
4. Section 31 23 23.13 – Fill and Backfill.

1.2 REFERENCE STANDARDS

A. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3)

B. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3)

1.3 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 31 23 23.13, FILL AND BACKFILL.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Relative Compaction: As defined in Section 31 23 23.13, FILL AND BACKFILL.

D. Relative Density: As defined in Section 31 23 23.13, FILL AND BACKFILL.

E. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

F. Standard Specifications: The latest edition, including supplements of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction.

1.4 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Sections 02 41 00, DEMOLITION; 31 11 00, SITE PREPARATION; and 31 23 16, EXCAVATION, prior to preparation.

1.5 QUALITY ASSURANCE

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

1.6 ENVIRONMENTAL REQUIREMENTS

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.2 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.3 TESTING

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

3.4 CORRECTION

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

END OF SECTION

SECTION 31 22 19 - GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Removal and storage of topsoil.
   2. Rough grading the site for site structures, building pads, and drive and parking isles.
   3. Finish grading for planting.

B. Related sections:
   1. Section 31 23 16 – Excavation.
   2. Section 31 23 23.13 – Fill and Backfill.
   3. Section 31 23 16.13 – Trenching for Site Utilities.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. Perform Work in accordance with State of Colorado Department of Transportation (CDOT) standards.
   1. Maintain one copy on site.

1.4 PROJECT CONDITIONS

A. Protect above – and below – grade utilities that remain.

B. Protect plants, lawns, rock outcroppings, and other features to remain as a portion of final landscaping.

C. Protect benchmarks, survey control points, existing structures, fences, sidewalks, paving and curbs from grading equipment and vehicular traffic.

PART 2 - PRODUCTS

2.1 MATERIALS.

A. Topsoil: Shall be soil suitable for sustaining grass and vegetation and shall not have any particles larger than ¾” in diameter and shall be free of any trash, debris, or deleterious material.

B. See Section 207 of Colorado Department of Transportation (CDOT) Standard Construction Specifications.

C. Other Fill Materials: See Section 31 23 23.13, FILL AND BACKFILL.

PART 3 - EXECUTIONS

3.1 EXAMINATION

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

3.2 PREPARATION

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

B. Stake and flag locations of known utilities.

C. Locate, identify, and protect utilities that remain from damage.

D. Notify utility company to remove and relocate utilities.

3.3 ROUGH GRADING

A. Remove topsoil from areas to be further excavated, re-landscaped, or re-graded without mixing with foreign materials.

B. Do not remove topsoil when wet.

C. Remove subsoil from areas to be further excavated, re-landscaped, or re-graded.

D. Do not remove wet subsoil, unless it is subsequently processed to obtain optimum moisture content.

E. When excavating through roots, perform work by hand and cut roots with sharp axe.

F. Stability: Replace damaged or displaced subsoil to same requirements as for specified fill.

3.4 SOIL REMOVAL

A. Stockpile excavated topsoil on site.

B. Stockpile excavated subsoil on site.

C. Stockpiles: Use areas designated on site; pile depth not to exceed 8 feet; protect from erosion.

3.5 FINISH GRADING

A. Before Finish Grading:
   1. Verify building and trench backfilling have been inspected.
   2. Verify subgrade has been contoured and compacted.

B. Remove debris, roots, branches, stones, in excess of ½ inch in size. Remove soil contaminated with petroleum products.

C. In areas where vehicles or equipment have compacted soil, scarify surface to depth of 3 inches.

D. Place topsoil in areas where seeding are indicated.

E. Place topsoil to the following compacted thicknesses:
   1. Areas to be Seeded with Grass: 6 inches.
   2. Areas to be Sodded: 4 inches.
   3. Shrub Beds: 18 inches.
   4. Flower Beds: 12 inches
   5. Planter Boxes: To within 3 inches of box rim.

F. Place topsoil during dry weather.

G. Remove roots, weeds, rocks, and foreign material while spreading.

H. Near plants spread topsoil manually to prevent damage.

I. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of subgrade.

J. Lightly compact placed topsoil.

3.6 TOLERANCES

A. Top Surface of Subgrade: Plus or minus 1/10 foot from required elevation.

B. Top Surface of Finish Grade: Plus or minus ½ inch.

3.7 FIELD QUALITY CONTROL

A. See Section 31 23 23.13, FILL AND BACKFILL for compaction density testing.

3.8 CLEANING AND PROTECTION

A. Remove unused stockpiled topsoil and subsoil. Grade stockpile area to prevent standing water.

B. Leave site clean and raked, ready to receive landscaping.

END OF SECTION

SECTION 31 23 16 - EXCAVATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work and materials associated with excavation.

B. Related sections:
1. Section 01 50 00 – Temporary Facilities and Controls.
2. Section 02 41 00 – Demolition.
3. Section 31 11 00 – Site Preparation.
4. Section 31 23 19 – Dewatering.
5. Section 31 50 00 – Excavation Support Systems.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.4 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.5 SEQUENCING AND SCHEDULING

A. Demolition: Complete applicable Work specified in Section 02 41 00, DEMOLITION, prior to excavating.

B. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 11 00, SITE PREPARATION, prior to excavating.

C. Dewatering: Conform to applicable requirements of Section 31 23 19, DEWATERING, prior to initiating excavation.

D. Excavation Support: Install and maintain, as specified in Section 31 50 00, EXCAVATION SUPPORT SYSTEMS, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1-foot except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not over excavate without written authorization of Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, TEMPORARY FACILITIES AND CONTROLS.

3.2 UNCLASSIFIED EXCAVATION

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

3.3 TRENCH WIDTH

A. Minimum Width of Trenches:
   1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
      a. Less than 4-inch Outside Diameter or Width: 18 inches.
      b. Greater than 4-inch and up to 18-inch Outside Diameter or Width: 12 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
      c. Greater than 18-inch Diameter or Width: 24-inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
   2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
   3. Increase trench widths by thicknesses of sheeting.

B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.4 PIPE BEDDING GROOVES FOR NONPERFORATED DRAIN LINES

A. Semicircular, trapezoidal, or 90-degree-V.

B. Excavated or plowed into trench bottom. Forming groove by compaction will not be acceptable.

3.5 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.6 DISPOSAL OF SPOIL

A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill,

B. Dispose of debris resulting from removal of underground facilities as specified in Section 02 41 00, DEMOLITION, for demolition debris.

C. Dispose of debris resulting from removal of organic matter, trash, refuse, and junk as specified in Section 31 11 00, SITE PREPARATION, for clearing and grubbing debris.

3.7 EXCAVATION SAFETY

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

3.8 SUBGRADE PREPARATION

A. The excavation for all structures and facilities shall be in dewatered, firm, undisturbed earth. If, in the Engineer's opinion, the has been disturbed, corrective measures may include:
   1. Scarification and recompaction to 95 percent relative compaction or,
   2. Overexcavation and replacement with compacted granular fill.

B. If the source of disturbance is determined to be the result of the actions, or inactions of the Contractor, (for example, inadequate dewatering, disturbance by excavating or hauling equipment) the cost of additional subgrade preparation will be at the Contractor's expense.

END OF SECTION

SECTION 31 23 16.13 - TRENCHING FOR SITE UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Backfilling and compacting for utilities outside the building to utility main connections.

B. Related sections:
   1. Section 31 22 19 – Grading.
   2. Section 31 23 16 – Excavation.
   3. Section 31 23 23.13 – Fill and Backfill.
   4. Section 31 23 23.16 – Trench Backfill.

1.2 DEFINITIONS

A. Subgrade Elevations: 4 inches below finish grade elevations indicated on drawings, unless otherwise indicated.

B. Finish Grade Elevations: 4 inches above subgrade elevations indicated on drawings, unless otherwise indicated.

1.3 SUBMITTALS

A. See Section 01 33 00, SUBMITTAL PROCEDURES, for submittal procedures.

B. Compaction Density Test Reports.

1.4 PROJECT CONDITIONS

A. Provide sufficient quantities of fill to meet project schedule and requirements. When necessary, store materials on site in advance of need.

B. Verify that survey bench marks and intended elevations for the work are as indicated.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. As specified in Section 31 23 23.16, TRENCH BACKFILL.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Locate, identify, and protect utilities that remain and protect from damage.

C. Notify utility company to remove and relocate utilities.

D. See Section 31 22 19, GRADING, for additional requirements.

3.2 TRENCHING

A. Notify Owner's Representative of unexpected subsurface conditions and discontinue affected Work in areas until notified to resume work.

B. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.

C. Do not interfere with 45 degree bearing splay of foundations.

D. Cut trenches wide enough to allow inspection of installed utilities.

E. Hand trim excavations. Remove loose matter.

F. Remove excavated material that is unsuitable for re-use from site.

G. Remove excess excavated material from site.

3.3 PREPARATION FOR UTILITY PLACEMENT

A. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.

B. Compact subgrade to density equal to or greater than requirements for subsequent fill material.

C. Until ready to backfill, maintain excavations and prevent loose soil from falling into excavation.

3.4 BACKFILLING

A. Backfill to contours and elevations indicated using unfrozen materials.

B. Employ a placement method that does not disturb or damage other work.

C. Systematically fill to allow maximum lime for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.

D. Maintain optimum moisture content of fill materials to attain required compaction density.

E. Store grade away from building minimum 2 inches in 10 ft. unless noted otherwise. Make gradual grade changes. Blend slope into level areas.

F. Correct areas that are over-excavated.
   1. Thrust bearing surfaces: Fill with concrete.
   2. Other areas: Use general fill, flush to required elevation, compacted to minimum 97 percent of maximum dry density.

G. Compaction Density Unless Otherwise Specified or Indicated.
   1. Under paving, slabs-on-grade, and similar construction: 97 percent of maximum dry density.
   2. All other locations: 95 percent of maximum dry density.

H. Reshape and re-compact fills subjected to vehicular traffic.

3.5 BEDDING AND FILL AT SPECIFIC LOCATIONS

A. Utility Piping, Conduits, and Duct Bank:
   1. Bedding: Use general fill.

2. Cover with general fill.
3. Fill up to subgrade elevation.
4. Compact in maximum 8 inch lifts to 95 percent of maximum dry density.

B. At Pipe Culverts:
1. Bedding: use general fill.
2. Place filter fabric specified in Section 31 05 19.13, GEOTEXTILE FILTER FABRIC, over compacted bedding.
3. Cover with general fill.
4. Fill up to subgrade elevation.
5. Compact in maximum 8 inch lifts to 95 percent of maximum dry density.

3.6 TOLERANCES

A. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.7 FIELD QUALITY CONTROL

A. Perform compaction density testing on compacted fill in accordance with ASTM D1556, ASTM D2167, ASTM D6938, or ASTM D3017.

B. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASSTM D698 (“Standard Proctor”), ASTM D1557 (“Modified Proctor”), or AASHTO T180.

C. If tests indicate work does not meet specified requirements, remove work, replace and retest.

D. Frequency of Tests; each lift.

3.8 CLEAN-UP

A. Leave unused materials in a neat compact stockpile.

B. Remove unused stockpiled material, leave area in a clean and neat condition. Grade stockpile areas to prevent standing surface water.

C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION

SECTION 31 23 19 – DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work required to dewater excavations.

B. Related sections:
   1. Section 01 50 00 – Temporary Facilities and Controls.

1.2 WATER CONTROL PLAN

A. As a minimum, include:
   1. Descriptions of proposed groundwater and surface water control facilities including, but not limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
   2. Drawings showing locations, dimensions, and relationships of elements of dewatering system.

B. If system is modified during installation or operation revise or amend and resubmit Water Control Plan.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and control surface and subsurface water during periods when necessary to properly accomplish Work.

3.2 SURFACE WATER CONTROL

A. See Section 01 50 00, TEMPORARY FACILITIES AND CONTROLS.

B. Remove surface runoff controls when no longer needed.

3.3 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.

B. Design and Operate Dewatering Systems:
   1. To prevent loss of ground as water is removed.
   2. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
   3. To relieve artesian pressures and resultant uplift of excavation bottom.
   4. Prevent softening, loosening or otherwise disturbing the excavation subgrade.

C. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

D. Provide supplemental ditches and sumps only as necessary to collect water from local seeps.

3.4 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from authorities having jurisdiction.

B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.

C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

D. The discharge of ground water into treatment facilities will not be permitted unless specifically authorized by the Owner. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency. If Owner allows groundwater discharge into facilities.

3.5 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems, including but not limited to reinjection wells, infiltration trenches and cutoff walls, necessary to prevent damage to existing facilities, completed Work, and adjacent property.

B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, sheeting bracing, underpinning, or compaction grouting.

3.6 REMEDIATION OF GROUNDWATER AFTER DEPLETION

A. If dewatering reduces quantity or quality of water produced by existing wells, temporarily supply water to affected well owners from other sources. Furnish water of a quality and quantity equal to or exceeding the quality and quantity available to the well owner prior to beginning Work or as satisfactory to each well owner.

END OF SECTION

SECTION 31 23 23.13 - FILL AND BACKFILL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work and materials required for fill and backfill for all excavations other than trench type excavations.

B. Related sections:
   1. Section 02 41 00 – Demolition.
   2. Section 03 30 00 – Cast-In-Place Concrete.
   3. Section 31 11 00 – Site Preparation.
   4. Section 31 22 13 – Subgrade Preparation.
   5. Section 31 23 16 – Excavation.
   6. Section 31 23 23.16 – Trench Backfill.
   7. Section 32 11 00 – Base Course.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Society for Testing and Materials (ASTM):
      a. ASTM C117, Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
      b. ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      c. ASTM D75, Standard Practice for Sampling Aggregates.
      d. ASTM D698, Standard Test Methods for Laboratory Characteristics of Soil Using Modified Effort (12,400 ft-lbf/ft^3).
      e. ASTM D1556, Standard Test Method for Density of Soil in Place by the Sand Cone Method.
      f. ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
      g. ASTM D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
      h. ASTM D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      i. ASTM D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

1.3 DEFINITIONS

A. Relative Compaction:
   1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698.
   2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.

B. Optimum Moisture Content:
   1. Determined in accordance with ASTM D698 specified to maximum dry density for relative compaction.
   2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. Well-Graded:
   1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
   2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
   3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

I. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:
   1. 1-foot outside outermost edge at base of foundations or slabs.
   2. 1-foot outside outermost edge at surface of roadways or shoulder.
   3. 0.5-foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near site.

K. Selected Backfill Material/Earthfill: Materials available onsite that Engineer determines to be suitable for specific use.

L. Imported Material: Materials obtained from sources suitable for specified use.

M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

O. Standard Specification: The latest edition, including supplements of the Colorado Department of Transportation Standard Construction Specifications.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

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

1.6 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Sections 02 41 00, DEMOLITION; 31 11 00, SITE PREPARATION; 31 23 16, EXCAVATION; and 31 22 13, SUBGRADE PREPARATION, prior to placing fill or backfill.

B. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE. Obtain acceptance of concrete work and attained strength prior to placing backfill.

C. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

D. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 22 13, SUBGRADE PREPARATION.

PART 2 - PRODUCTS

2.1 SOURCE QUALITY CONTROL

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

2.2 EARTHFILL

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

2.3 GRANULAR FILL

A. See Section 32 11 00 Base Course Part 2.1 “Base Course Rock“

2.4 SELECT FILL/ STRUCTURAL FILL

A. Earthfill material exhibiting PI between 7 and 15 with liquid limit less than 35 and a maximum of 70% passing the No. 200 sieve. Organics shall be less than 2%.

2.5 WATER FOR MOISTURE CONDITIONING

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

2.6 BASE COURSE ROCK

A. As specified in Section 32 11 00, BASE COURSE.

2.7 FOUNDATION STABILIZATION ROCK

A. Crushed rock or pit run rock.

B. Uniformly graded from coarse to fine.

C. Free from excessive dirt and other organic material.

D. Maximum 2-1/2 inches particle size.

PART 3 - EXECUTION

3.1 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:
   1. Fill or backfill to an elevation 2 feet above top of item to be laid.
   2. Excavate trench for installation of item.
   3. Install bedding, if applicable, as specified in Section 31 23 23.16, TRENCH BACKFILL.
   4. Install item.
   5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.16, TRENCH BACKFILL, before resuming filling or backfilling specified in this section.

F. Tolerances:
   1. Final Lines and Grades: Within a tolerance of 0.1-foot unless dimensions or grades are shown or specified otherwise.
   2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

H. Fill and backfill materials shall be conditioned to a water content that is within 2 percentage points (plus or minus) of the optimum required for compaction as determined by ASTM D698.

3.2 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Facilities: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with granular fill, unless otherwise shown. Place granular fill in lifts of 6-inch maximum thickness and compact each lift to minimum of 95 percent relative compaction as determined in accordance with ASTM D698, Method C.

B. Subsurface Drainage: Backfill with granular drain material, where shown. Place granular drain material in lifts of 6-inch maximum thickness and compact each lift to minimum of 90 percent relative density.

C. Other Areas: Backfill with earthfill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 95 percent relative compaction as determined in accordance with ASTM D698, Method C.

3.3 FILL

A. Outside Influence Areas Beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities: Unless otherwise shown, place earthfill as follows:
   1. Allow for 6-inch thickness of topsoil where required.
   2. Maximum 9-inch thick lifts.
   3. Place and compact fill across full width of embankment.
   4. Compact to minimum 95 percent relative compaction as determined in accordance with ASTM D698, Method C.
   5. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

3.4 SITE TESTING

A. Gradation:
   1. One sample from each 400 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from Specifications.
   2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
   3. Remove material placed in Work that does not meet Specification requirements.

B. In-Place Density Tests: In accordance with ASTM. During placement of materials, test as follows:
   1. One test per every other lift per 200 lineal feet of roadway or trench.
   2. A minimum of two tests on granular fill beneath structures.
   3. A minimum of two test per 300 cubic yards during backfilling of walls.

C. Testing shall be the Contractor’s responsibility and conducted by persons experienced in such work.

3.5 GRANULAR BASE, SUBBASE, AND SURFACING

A. Place and Compact as specified in Section 32 11 00, BASE COURSE.

3.6 REPLACING OVEREXCAVATED MATERIAL,

A. Replace excavation carried below grade lines shown or established by Engineer as follows:
   1. Beneath Footings: Concrete of strength equal to that of respective footing.
   2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
   3. Beneath Slabs-On-Grade: Granular fill.
   4. Trenches:
      a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.16, TRENCH BACKFILL.
      b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.16, TRENCH BACKFILL.
   5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
      a. Flat to Moderate Steep Slopes (3: 1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
      b. Steep Slopes (Steeper than 3: 1):

1) Correct overexcavation by transitioning between areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
2) Backfilling overexcavated areas is prohibited unless, in opinion, backfill will remain stable, and overexcavated material is replaced as compacted earth fill.

END OF SECTION

SECTION 31 23 23.16 - TRENCH BACKFILL

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI): 253.1, Safety Color Code.
   2. American Public Works Association (APWA): Uniform Color Code for Temporary Marking of Underground Utility Locations.
   3. American Society for Testing and Materials (ASTM):
      a. ASTM D448, Standard Classification for Sizes of Aggregate for Road and Bridge Construction.
      b. ASTM C94, Specification for Ready-Mixed Concrete.
      c. ASTM C117, Standard Test Method for Materials Finer than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
      d. ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      e. ASTM C150, Standard Specification for Portland Cement.
      f. ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
      g. ASTM D422, Standard Test Method for Particle-Size Analysis of Soils.
      h. ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Standard Effort (12,400 ft-lbf/cubic ft).
      i. ASTM D1140, Standard Test Methods for Amount of Material in Soils Finer than the No. 200 (75 micrometer) Sieve.
      j. ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf).
      k. ASTM D3776, Standard Test Methods for Mass per Unit Area (Weight) of Fabric.
      l. ASTM D3786, Standard Test Method for Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method.
      m. ASTM D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      n. ASTM D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
      o. ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
      p. ASTM D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
      q. ASTM D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
      r. ASTM D4991, Standard Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method.
      s. ASTM D5034, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test).

1.2 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by the Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after stabilization and installation of bedding material.

G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either the as-compacted field dry density or the maximum dry density, as determined by the Engineer.

H. Relative Density: As defined by ASTM D4253 and ASTM D4254.

I. Selected Backfill Material: Material available that the Engineer determines to be suitable for a specific use.

J. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Well-Graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.

1.3 SUBMITTALS

A. Shop Drawings: Manufacturer's descriptive literature for marking tapes.

B. Samples:
1. Trench stabilization material.
2. Bedding and pipe zone material.
3. Granular drain.
4. Granular backfill.
5. Earth backfill.
6. Sand(s).
7. Geotextile.

C. Quality Control Submittals: Catalog and manufacturer's data sheets for compaction equipment.

D. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to site.

E. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 - PRODUCTS

2.1 MARKING TAPE

A. Plastic:
1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: Minimum 4 mils.
3. Width: 12 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.

5. Manufacturers and Products:
    a. Reef Industries; Terra Tape.
    b. Allen; Markline.

B. Metallic:
1. Solid aluminum foil, visible on unprinted side, encased in a protective high visibility, inert polyethylene plastic jacket.
2. Thickness: Minimum 5 mils.
3. Width: 12 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Joining Clips: Tin or nickel-coated, furnished by tape manufacturer.
6. Manufacturers and Products:
    a. Reef Industries; Terra Tape Sentry Line.
    b. Allen; Detectatape.

C. Color: In accordance with APWA Uniform Color Code for Temporary Marking of Underground Facilities.

Color[a]	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communicating alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Water, irrigation, and slurry lines
[a]As specified in ANSI Z53.1, Safety Color Code.	

2.2 TRENCH STABILIZATION MATERIAL

A. Clean, hard, durable 3-inch minus crushed rock gravel, or pit run, free from clay balls, other organic materials, or debris.

B. Uniformly graded from coarse to fine, less than 8 percent by weight passing the 1/4-inch sieve.

2.3 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and no clay balls, roots, or other organic material.

B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.
1. Duct Banks: 3/4-inch maximum particle size.
2. PVC Irrigation System Piping, and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
3. Pipe Under 18 Inches Diameter: 3/4-inch maximum particle size, except 1/4-inch for stainless steel pipe, copper pipe, tubing, and plastic pipe under 3 inches diameter.

4. Pipe Greater than 18 Inches Diameter: 1-1/2-inch maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe. 3/4-inch maximum particle size for PVC, FRP, or HDPE Pipe.
5. Perforated Pipe: Granular drain material.
6. Conduit and Direct-Buried Cable:
    a. Sand, clean or clean to silty, less than 12 percent passing the No. 200 sieve.
    b. Individual Particles: Free of sharp edges.
    c. Maximum Size Particle: Pass a No. 4 sieve.
    d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

2.4 EARTH FILL

A. As specified in Section 31 23 23.13, FILL AND BACKFILL.

2.5 CONTROLLED LOW STRENGTH FILL

A. Select and proportion ingredients to obtain compressive strength between 50 and 150 psi at 28 days in accordance with ASTM D4832.

B. Materials:
1. Cement: ASTM C150, Type I or II.
2. Aggregate: ASTM C33, Size 7.
3. Fly Ash (if used): ASTM C618, Class C.
4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.6 CONCRETE BACKFILL

A. Provide as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

2.7 TOPSOIL

A. Topsoil removed and stockpiled from onsite excavation.

2.8 SOURCE QUALITY CONTROL

A. Perform gradation analysis in accordance with ASTM C136 for:
1. Earth backfill, including specified class(es).
2. Trench stabilization material.
3. Bedding and pipe zone material.

B. Certify Laboratory Performance of Mix Designs:
1. Controlled low strength fill.
2. Concrete.

PART 3 - EXECUTION

3.1 TRENCH PREPARATION

A. Water Control: Conform to Section 31 23 19, DEWATERING.
1. Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe, conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water.
2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.

3. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.2 TRENCH BOTTOM

A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.

B. Soft Subgrade: If it is encountered that it may require removal to prevent pipe settlement, notify Engineer. Engineer will determine the depth of overexcavation, if any, required.

3.3 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with trench stabilization material.

B. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.

C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

3.4 BEDDING

A. Furnish imported bedding material where, in the opinion of the Engineer, excavated material unsuitable for bedding or insufficient in quantity.

B. Place over the full width of the prepared trench bottom in two equal lifts when the required depth exceeds 8 inches.

C. Hand grade and compact each lift to provide a firm, unyielding surface.

D. Minimum Thickness:
1. Pipe, 15-inch and Smaller: 4 inches.
2. Pipe, 18-inch to 36 inch: 6 inches.
3. Pipe, 42-inch and Larger: 12 inches.
4. Conduit: 3 inches.
5. Direct-Buried Cable: 3 inches.
6. Duct Banks: 3 inches.

E. Check grade and correct irregularities in bedding material. Loosen top 1 to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.5 BACKFILL PIPE ZONE

A. Upper limit of pipe zone shall not be less than following:
1. Pipe: 12 inches above top of pipe, unless shown otherwise.

2. Conduit: 3 inches above top of conduit, unless shown otherwise.
3. Direct-Buried Cable: 3 inches above top of cable, unless shown otherwise.
4. Duct Bank: 3 inches above top of duct bank, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.
1. Pipes 10 Inches and Smaller Diameter: First lift less than or equal to pipe-diameter.
2. Pipes Over 10 Inches Diameter: Maximum 6-inch lifts.

D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by "walking in" and slicing material under haunches with a shovel to ensure that voids are completely filled before placing each succeeding lift.

E. After the full depth of the pipe zone material has been placed as specified, compact the material by a minimum of three passes with a vibratory plate compactor only over the area between the sides of the pipe and the trench walls.

F. Do not use power-driven impact compactors to compact pipe zone material.

3.6 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of all buried piping, at depth of 2 feet. Coordinate with piping installation drawings.
1. Metallic Marking Tape: Install with nonmetallic piping
2. Plastic Marking Tape: Install with metallic piping.

3.7 BACKFILL ABOVE PIPE ZONE

A. General:
1. Process excavated material to meet specified gradation requirements.
2. Adjust moisture content as necessary to obtain specified compaction.
3. Do not allow backfill to free fall into the trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over the top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for adjacent trench unless otherwise shown or specified.

B. Select Excavated Backfill:
1. Place in lifts not exceeding 9-inch thickness.
2. Mechanically compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.

C. Excavated Backfill: Backfill trench above the pipe zone with granular backfill in lifts not exceeding 8 inches. Compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.

D. Concrete Backfill:
1. Place above bedding.

2. Minimum Concrete Thickness: 6 inches on top and sides of pipe.
3. Do not allow dirt or foreign material to become mixed with concrete during placement.
4. Allow sufficient time for concrete to reach initial set before additional backfill material is placed in trench.
5. Prevent flotation of pipe.
6. Begin and end concrete backfill within 4 inches of a pipe joint on each end.
7. Do not encase pipe joints except within the limits of the concrete backfill.

E. Controlled Low Strength Fill:
1. Discharge from truck mounted drum type mixer into trench.
2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.

3.8 REPLACEMENT OF TOPSOIL

A. Replace topsoil in top 6 inches of backfilled trench.

B. Maintain the finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.9 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain the surface of the backfilled trench even with the adjacent ground surface until final surface restoration is completed.

B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep the surface of the backfilled trench even with the adjacent ground surface, and grade and compact as necessary to keep the surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.

C. Topsoil: Add topsoil where applicable and as necessary to maintain the surface of the backfilled trench level with the adjacent ground surface.

D. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 32 12 16, ASPHALT CONCRETE PAVEMENT.

E. Other Areas: Add excavated material where applicable and keep the surface of the backfilled trench level with the adjacent ground surface.

3.10 SETTLEMENT OF BACKFILL

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

END OF SECTION

SECTION 31 23 23.33 – FLOWABLE FILL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies controlled low strength concrete flowable fill.

B. Comply with all requirements of Section 03 30 00 except as specifically modified in this Section.

C. Related sections:
   1. Section 03 30 00 - Cast-In-Place Concrete.

1.2 DEFINITIONS

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

1.3 SUBMITTALS

A. Comply with the requirements of Section 03 30 00.

1.4 QUALITY ASSURANCE

A. Comply with the requirements of Section 03 30 00.

PART 2 - PRODUCTS

2.1 PRODUCTS

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

PART 3 - EXECUTION

3.1 EXECUTION

A. Comply with the requirements of Section 03 30 00.

END OF SECTION

SECTION 31 32 00 - SOIL EROSION STABILIZATION

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 STABILIZATION

A. Soil Erosion Stabilization:
   1. Ground surfaces exposed during the wet weather conditions:
   2. Areas which will not be subjected to heavy wear by ongoing construction traffic.
   3. Temporary and long term stabilization of new or disturbed ditches, swales, detention ponds, or disturbed ground with intermittence construction traffic.

B. Permanent Stabilization:
   1. Permanently stabilize exposed soil surfaces at finished grades.
   2. Permanent stabilization methods include, but are not limited to, seeding (permanent), mulching, and landscaping.
   3. Immediately perform permanent stabilization at each completed excavation and areas except for areas that are scheduled to be redisturbed.
   4. Incorporate all permanent erosion control features into the project at the earliest practical time.

C. Buffer Zone: Undisturbed area or strip of natural vegetation or an established suitable planting adjacent to a disturbed area that reduces erosion and runoff.

D. Standard Specification: The latest edition, including supplements of the Colorado Department of Transportation Standard Construction Specifications.

1.3 SUBMITTALS

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

1.4 DELIVERY, STORAGE, AND PROTECTION

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

B. Seed:
   1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
   2. Keep dry during storage.

C. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.5 SEQUENCING AND SCHEDULING

A. Install erosion and sediment control devices before starting earth disturbance activities and as drainage facilities get constructed.

B. Complete Soil Preparation: Seeding, fertilizing, mulching and matting on disturbed areas that will require stabilization either because the area has reached final grade (permanent landscaping) or because the area will remain unworked for over 14 days (temporary seeding) during the wet season.

C. Notify Engineer at least 3 days in advance of:
   1. Materials delivery.
   2. Start of stabilization activity.

D. Seeding: Perform between March 15 and September 15.

1.6 MAINTENANCE

A. Operations:
   1. Seeded Areas: Perform during maintenance period to include:
      a. Watering: Keep seeded surface moist.
      b. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.
      c. Mulch: Replace wherever and whenever washed or blown away.
      d. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
      e. Reseed during next planting season if scheduled end of maintenance period falls after September 15.
      f. Reseed entire area if satisfactory stand does not develop by July 1 of the following year.
      g. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.
   2. Inspect, repair, and replace as necessary all erosion control measures during the time period from start of construction to completion of construction.
   3. Inspect a minimum of at least once every 7 days or after a 1/2-inch storm event in a 24-hour period.
   4. Furnish and install a rain gauge at the project site to monitor rainfall. At no time shall more than 1-foot depth of sediment be allowed to accumulate in any erosion control device.

B. Sediment Removal:
   1. Remove sediment from erosion control devices and work into the grading plan at least once a week as required to maintain proper operation of devices. The cleaning operation shall not dispose of sediment offsite
   2. Sediment shall be removed and the controls upgraded or repaired as needed as soon as practicable, but not later than 2 days after the surrounding exposed ground has dried sufficiently to prevent further damage from equipment needed for repair operations.

3. In the event of continuous rainfall over a 24-hour period, or other circumstances that preclude equipment operation in the area, hand carry and install additional sediment controls as approved by the Engineer.

PART 2 - PRODUCTS

2.1 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose.

B. Fertilizer shall have the following minimum percentage of plant food by weight:
   1. Summer Hydroseed Mix:
      a. Nitrogen: 20 percent.
      b. Phosphoric Acid: 10 percent.
      c. Potash: 10 percent.
   2. Winter Hydroseed Mix:
      a. Nitrogen: 16 percent.
      b. Phosphoric Acid: 8 percent.
      c. Potash: 0 percent.

2.2 SEED

A. Common grass seed recommended by local supplier and approved by engineer.

2.3 MULCH

A. Wood Cellulose Fiber Mulch:
   1. Specially processed wood fiber containing no growth or germination inhibiting factors.
   2. Dyed a suitable color to facilitate inspection of material placement.
   3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form a homogenous slurry.
   4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.

B. Straw:
   1. Clean salt hay or threshed straw of oats, wheat, barley, or rye, free from seed of noxious weeds. Suitable for spreading with mulch blower equipment.
   2. Average Stalk Length: 6 inches.
   3. Seasoned before baling or loading.

2.4 EROSION CONTROL MATTING

A. Excelsior mat or straw blanket; staples as recommended by matting manufacturer.

B. Manufacturers and Products:
   1. American Excelsior Company, Dallas, TX; Curlex Mat.
   2. North American Green, Evansville, IN; S150 blanket.

2.5 REINFORCED PLASTIC COVERING

A. Co-extruded, copolymer laminate reinforced with a nonwoven grid of high strength nylon cord submersed in a permanently flexible adhesive media allowing for equal tear resistance in all directions.

B. Black in color and ultraviolet stabilized.

C. Physical Requirement (Minimum Average Roll Values):
   1. Tear Strength: 130 pounds.
   2. Elongation: 620 percent.
   3. Minimum Thickness: 6 mil.

D. Manufacturers:
   1. Reef Industries, Inc., Houston, TX.
   2. Griffolyn Co., Houston, TX.

2.6 SILT FENCE

A. Support Posts: As recommended by manufacturer of geotextile.

B. Fasteners: Heavy-duty wire staples at least 1-inch long, tie wires, or hog rings, as recommended by manufacturer of geotextile.

C. Filter Fabric: Polyester, polypropylene, or nylon filaments, woven into a uniform pattern, distinct and measurable openings.
   1. Filaments: Resistant to damage from exposure to ultraviolet rays and heat.
   2. Material Edges: Finish so that, filaments retain their relative positions under stress.

D. In accordance with requirements of Table No. 1:

Table No. 1 – Filter Fabric

Physical Property	Required Value	Test Method
Weight, pz/sq yd, min.	4	ASTM D3776
Equivalent Opening Size, max.	50-70	U.S. Standard Sieve
Grab Tensile Strength, lb, min. ARV	160	ASTM D4632
Elongation, % max.	25	ASTM D1682
Mullen Burst Strength, psi, min. ARV	200	ASTM D3786
Ultraviolet Radiation Resistance, % Strength Retention	70	ASTM D4355
Flow Rate, gpm/sf, min. ARV	30 to 50	ASTM D4491

E. Manufacturers:
   1. Polyfelt, Evergreen, AL.
   2. Dupont Co., Wilmington, DE.
   3. Mirafi, Inc., Charlotte, NC.

2.7 STRAW BALES

A. Machine baled clean salt hay or straw of oats, wheat, barley, or rye, free from seed of noxious weeds, using standard baling wire or string.

2.8 POSTS FOR STRAW BALES

A. 2-inch by 2-inch untreated wood or commercially manufactured metal.

2.9 DUST CONTROLLER

A. Nontoxic materials that do not have an adverse effect on soil structure or establishment and growth of vegetation.

PART 3 - EXECUTION

3.1 GENERAL

A. Erosion control measures are required during all construction and site disturbance activity and shall remain until permanent site ground covers are in place.

B. The implementation of the erosion control plan and the construction maintenance, replacement and upgrading the erosion control devices are the responsibility of the Contractor until all construction is completed and landscaping established and approved. During the construction period, the erosion control devices shall be upgraded for unexpected storm events and to ensure that sediment and sediment laden water do not leave the site.

C. Maintain existing buffer zones adjacent to project limits. Keep all construction equipment, debris and soils out of the natural buffer zone.

3.2 GRAVEL CONSTRUCTION ENTRANCES

A. Provide a graveled construction access at each access point between the site and any public or private road or other paved surface.

B. Place subgrade geotextile, as specified, on the ground prior to erosion control rock placement.

C. Place erosion control rock over the geotextile to a minimum thickness of 8 inches.

D. Minimum dimensions for construction entrances are 50-foot in length by 16-foot width.

E. Contractor shall provide a minimum of 4 inches of erosion control rock for each entrance 3 times during the project at times directed by the Engineer to maintain proper function. More frequent applications of rock may be required, and if so, shall be considered as incidental work.

3.3 SOIL PREPARATION

A. Before start of hydroseeding, and after surface has been shaped and graded, and lightly compacted to uniform grade, scarify soil surface to minimum depth of 1 inch.

3.4 FERTILIZER

A. Apply evenly over area in accordance with manufacturer's instructions. Mix into top 1-inch of soil.

B. Application Rate: 5 pounds per 1,000 square foot over areas to be seeded. Use of approved hydraulic equipment to sow seed and distribute fertilizer at the same time will be acceptable.

3.5 SEEDING

A. Prepare 1-inch depth seed bed; obtain Engineer's acceptance prior to proceeding.

B. Apply by hydroseeding method on moist soil, but only after free surface water has drained away. Prevent drift and displacement of mixture into other areas.

C. Summer Application:
   1. Prepare and apply slurry as follows:

Item	Rate
Seed Mix	200 pounds per acre
Fertilizer	750 pounds per acre
Wood Cellulose Fiber Mulch	As recommended by manufacturer
Water	As necessary

   2. Irrigation: 1-inch per week to seeded areas.

3.6 MULCHING

A. Apply uniformly on disturbed areas that will remain undisturbed for 7 days or more, as requested by Engineer, and on all seeded areas.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.
   1. Straw: Apply by hand or mechanical means to minimum depth of 2 inches.
   2. Wood Cellulose Fiber: 1,000 to 1,500 pounds per acre.

3.7 EROSION CONTROL MATTING

A. Place on seeded slopes 4H:1V and steeper.

B. Apply seed and fertilizer prior to matting.

C. At top of slope, entrench material in a 6-inch by 6-inch trench and staple at 1-foot intervals. At the bottom of the slope, extend the mat 2 feet beyond the toe of slope, turn material under 4 inches and staple at 1-foot intervals.

D. Mats shall be stapled in place as they are installed down the slope face. The mat shall have direct contact with the soil surface.

E. Overlap:
   1. Lengthwise: 1-foot minimum.
   2. Crosswise: 6-inches minimum.

3.8 REINFORCED PLASTIC COVERING

A. Place on areas where hydroseeding and erosion control matting have not controlled erosion and over all temporary stockpiles.

B. Install in single thickness, strips parallel to direction of drainage. Anchor plastic in 6-inch by 6-inch trench backfilled with compacted native material.

C. Maintain tightly in place by using sand bags on ropes with a maximum 10-foot grid spacing in all directions.

D. Tape or weight down full length, overlap seams at least 12 inches.

E. Remove at final acceptance unless notified otherwise by Engineer.

3.9 SILT FENCE

A. Install prior to starting earth disturbing activities upslope of fence.

B. One-piece filter fabric or continuously sewn to make one-piece filter fabric for full height of the fence, including portion buried in the toe trench.

C. When joints are necessary, splice filter fabric together only at a support post, with a minimum 6-inch overlap, and securely fasten both ends to support post.

D. Filter fabric shall not extend more than 24 inches above the ground surface. Securely fasten to upslope side of each support post using ties. Filter fabric shall not be stapled to existing trees.

E. Fasten wire mesh material support fence securely to upslope side of post fasteners. Extend wire into the trench a minimum of 4 inches, and not more than 36 inches above the ground surface.

F. Take precaution not to puncture filter fabric during installation. Repair or replace damaged area.

G. Remove silt fence after upslope area has been permanently stabilized. Immediately dress sediment deposits remaining after the silt fence has been removed to conform to existing grade. Prepare and seed graded area.

3.10 TEMPORARY SOIL STOCKPILES

A. Cover with reinforced plastic covering, as directed in Article REINFORCED PLASTIC COVERING.

B. Protect perimeter of stockpile from erosion with ditches.

3.11 STRAW BALES

A. Embed minimum of 4 inches in flat-bottomed trench. Place across swales or ditches to reduce velocities of concentrated flows. Space bales a minimum of 100-foot spacing.

B. Place with ends tightly abutting or overlapped. Corner abutment is not acceptable.

C. Install so that bale bindings are oriented around the sides and not over the top and bottom of the bale.

D. Use two posts for each bale. Drive posts through the bale until top of post is flush with top of bale.

E. Wedge loose straws in any gaps between bales.

3.12 DUST CONTROL

A. Apply appropriate dust control measures on a continuous basis until permanent stabilization measures are in place.

B. Apply on construction routes and other disturbed areas subject to surface dust movement and where off-site damage may occur if dust is not controlled.

C. Avoid creating erosion when using water as a dust controller.

3.13 CLEAN-UP

A. Sediment trapped in erosion control devices shall be regraded into the slopes on the site. Do not flush sediment-laden water into the drainage system.

B. After site restoration is complete and when approved by the Engineer, all temporary erosion control measures shall be completely removed. Immediately shape and permanently stabilize areas affected by the removal process.

C. Silt fence, straw bales, reinforced plastic covering, and any other erosion control devices shall be disposed off site to locations that are approved by federal, state, and local authorities.

END OF SECTION

SECTION 31 37 00 – RIPRAP

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the procurement and installation of riprap.

B. Related sections:
   1. Section 31 23 16 - Excavation
   2. Section 31 23 23.16 – Trench and Backfill
   3. Section 31 05 19.13 – Geotextile Filter Fabric

1.2 REFERENCE STANDARDS:

A. American Society for Testing and Materials (ASTM) latest edition.
   1. ASTM C97 – Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
   2. ASTM D4992 – Standard Practice for Evaluation of Rock to Be Used for Erosion Control.
   3. ASTM D5240 – Standard Test Method for Evaluation of Durability of Rock for Erosion Control Using Sodium Sulfate or Magnesium Sulfate.
   4. ASTM D5312 – Standard Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions.
   5. ASTM D5313 – Standard Test Method for Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions.
   6. ASTM D5779 – Standard Test Method for Field Determination of Apparent Specific Gravity of Rock and Manmade Materials for Erosion Control.

1.3 SUBMITTALS

A. Provide as specified in Section 01 33 00, SUBMITTAL PROCEDURES.

B. Certificates: Certify that products meet or exceed specified requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The riprap shall be hard, sound, and durable. It shall be reasonably free of fines and shall be well graded between the maximum and minimum rock sizes so as to produce a minimum of voids. No riprap shall be placed on the project until it has been accepted by Engineer.

B. The minimum density of stone shall be 130 pounds per cubic foot and the maximum absorption shall be 6 percent.

C. The maximum size shall not be greater than 12-inches in any dimension and approximately 50 percent of the material shall consist of pieces weighing 20 pounds or more. The stones shall be predominantly angular in shape with not more than 25 percent having a length more than 2.5 times its breadth or thickness and none having a length exceeding 3.0 times its breadth or thickness.

D. Geotextile fabric shall be as specified or equal.

E. Contractor shall obtain and submit certification that the proposed rock meets density and absorption requirements specified herein. Testing for certification shall be in accordance with

ASTM C97. Certified test results shall be submitted to Engineer prior to the use of the proposed material as riprap.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The riprap layer shall be a minimum of 24-inches thick when placed over the geotextile fabric.

B. When placed on the embankment, the smaller stones shall be well distributed throughout the mass. Hand placing may be required to obtain the results specified above.

C. The areas to be protected with riprap shall be dressed to the lines and grades shown on the Drawings and covered with the geotextile fabric prior to placing the riprap.

D. Riprap graded so that the smaller stones are uniformly distributed throughout the mass shall then be placed, starting at the toe of the slope, with a maximum vertical drop onto the geotextile fabric of 2 feet. In no case shall stones be allowed to roll down the fabric covered slope. Placement of the riprap over the fabric shall proceed so that the upper boundary of the riprap layer is at essentially the same level for the entire length of the fabric.

E. Care shall be taken so that the geotextile fabric is not damaged during riprap installation. Any rips or tears shall be repaired by Contractor, as specified in Section 31 05 19.13, GEOTEXTILE FILTER FABRIC, before proceeding with further riprap installation.

END OF SECTION

SECTION 31 50 00 - EXCAVATION SUPPORT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work required to install and remove excavation support systems.

B. Related sections:
   1. Section 31 23 23.13 – Fill and Backfill

1.2 SUBMITTALS

A. Shop Drawings:
   1. Excavation support plan.
   2. Movement monitoring plan.

B. Quality Control Submittals: Movement measurement and data and reduced results indicating movement trends.

1.3 QUALITY ASSURANCE

A. Provide surveys to monitor movements of critical facilities.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Design, provide, and maintain shoring, sheeting, and bracing as necessary and where shown to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work. Shoring plan shall be signed and sealed by a Professional Engineer licensed in the State of Colorado.

B. Minimum areas for sharing, sheeting and bracing are shown on the Drawings. It will be the Contractor's responsibility to determine if areas will require excavation slope retention to protect existing structures and facilities from damage resulting from the Contractor's excavation or excavation methods.

C. The Contractor will also be responsible for providing shoring, sheeting and bracing of excavations as needed for worker safety and as may be required by federal, state, and local regulations.

D. Shoring Plan shall be signed and sealed by a Professional Engineer licensed in the State of Colorado. Submit shoring plan to Engineer for approval.

3.2 EXCAVATION SUPPORT PLAN

A. Prepare excavation support plan addressing following topics:
   1. Details of shoring, bracing, sloping, or other provisions for worker protection of existing structures or facilities.
   2. Design assumptions and calculations.
   3. Methods and sequencing of installing excavation support.
   4. Proposed locations of stockpiled excavated material.

5. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.

3.3 MOVEMENT MONITORING PLAN

A. Prepare movement monitoring plan addressing following topics:
   1. Survey control.
   2. Locations of monitoring points (at least one every 50 feet).
   3. Plots of data trends.
   4. Interval between surveys (not to exceed 5 working days).

B. Movement monitoring shall be done on every existing structure that is adjacent to the Contractor's excavations.

C. Results of movement monitoring will be delivered for the Engineer at least once a week.

3.4 REMOVAL OF EXCAVATION SUPPORT

A. Do not begin to remove excavation support until it can be removed without damage to existing facilities, completed Work, or adjacent property.

B. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities. Maintain soil wall support as excavation is backfilled.

C. Fill voids immediately with approved backfill compacted to density specified in Section 31 23 23.13, FILL AND BACKFILL.

END OF SECTION

SECTION 31 70 19 - BORED EXCAVATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Boring under streams, highways, roads and railroads.
   2. Casing pipe.

B. Related sections:
   1. Section 31 22 13 – Subgrade Preparation
   2. Section 31 23 23.16 – Trench Backfill

1.2 SUPERVISION AND QUALITY

A. Contractor's work shall comply with all codes governing and all insurance requirements. Work shall be undertaken only when the construction superintendent is present and supervising the work.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

A. Crossings shall be completed in accordance with applicable federal, state and local regulations. In the case of railroad crossings, the project shall comply with regulations established by the railroad company.

PART 2 - PRODUCTS

2.1 CASING PIPE

A. Smooth wall casing pipe shall be of welded steel construction and shall be new material with a minimum yield point of 35,000 psi. The pipe shall have a wall thickness as noted on the plans. The casing pipe shall be cleaned and coated both inside and outside with two coats of coal tar paint, Koppers "Bitumastic Super Service Black," Tnemec "450 Heavy Tnemecol," or USS Chemicals "Pitt Chem 103."
   1. Carrier Pipe 4" 6" 8" 10" 12" 14" 16" 18" 20"
   2. Casing 10" 12" 14" 18" 18" 20" 24" 30" 30"

B. Casing wall thickness shall be 1/4 inch thick for casing pipe 10 inch thru 16 inches, 3/8 inch thick for casing pipe 18 inch thru 24 inches, 1/2 inch thick for 30 inches. Casing wall thickness for any railroad bores shall be specified by the railroad.

2.2 CARRIER PIPE

A. Carrier pipe shall be as shown on plans.

2.3 CASING SPACERS

A. Spacers shall be made of injection molded high density polyethylene. The spacers shall be of a projection type that has a minimum number of projections around the circumference totaling the number of diameter inches. Spacers shall be spaced a maximum of 10 feet apart. Spacers shall be fastened tightly to the barrel of the carrier pipe to prevent slippage. Spacers must provide sufficient height to permit clearance between the pipe bell and the casing. Spacers shall be ISO 9002 certified for strength and quality.

2.4 CASING FILL MATERIAL

A. Sand fill shall be clean pea gravel with uniform gradation of 1/8" to 3/8" for blowing into casing pipe.

PART 3 - EXECUTION

3.1 GENERAL

A. Crossings under highways, roads and railroads shall be continuously encased under the through roadways, median, ramps and shoulder area to the limits called for or required by the federal, state and local regulations. Railroad crossings shall conform to the requirements of the regulations established by the railroad company.

B. Work shall be performed in a safe and proper manner, with suitable precautions being taken against hazards of every kind. All crossings shall be bored, unless rock formations or other obstructions are encountered that prevents boring or pushing operations. If such conditions are encountered, excavation shall be performed by standard tunneling methods.

C. Excavations shall provide adequate clearance for installation of and removal of equipment.

D. Backfilling and construction of fills and embankments during freezing weather shall not be done except by permission of the Engineer. No backfill, fill or embankment materials shall be installed on frozen surfaces nor shall frozen materials, snow or ice be placed in any backfill, fill or embankments.

E. When operating on pavements or walks all equipment shall be rubber tired, except for excavation equipment. Excavating equipment, in such cases, shall not have grousers, cleats or lugs on the tracks. The Contractor shall take all reasonable precautions to protect the existing pavements and walks.

F. No classification of excavated materials shall be made. Boring excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the contract work, regardless of the type, character, composition or condition thereof.

G. Pipe lines and other existing underground installations and structures in the vicinity of the work to be done hereunder are indicated on the plans according to the best information available to the Owner. The Owner does not guarantee the accuracy of such information. The Contractor shall make every effort to locate all underground pipe lines, conduits and structures by contacting owners of underground utilities and by prospecting in advance of excavation and boring. Damage to any existing underground installation caused by the Contractor's operation shall be repaired at the Contractor's expense.

H. Any delays or extra cost to the Contractor caused by pipe lines or other underground structures or obstructions not shown by the plans, or found in locations different than those indicated, shall not constitute a claim for extra work, additional payment or damages.

I. Erosion control of disturbed areas shall be required during the construction period through the use of check dams, siltation pools, mulching, etc.

J. The Contractor shall meet the specific requirements of the Highway Department or Railroad. The Contractor shall obtain all necessary permits and insurance.

K. Operation:

1. Use all means necessary to control dust or mud that may interfere with operation.

L. Protection:
1. Use all means necessary to protect material and preserve specification requirements.
2. Replace all damaged material or material that has lost specification requirements.

3.2 EXCAVATION

A. The Contractor shall, during the entire period of construction, provide and maintain any necessary equipment as will, whenever practicable, keep his excavations reasonably free from water pending construction. When necessary to use pumps the Contractor must dispose of the water without detriment to adjacent properties.

3.3 SHEETING AND SHORING

A. General:
1. Except where banks may be cut back on a stable slope, excavation for trenches shall be properly and substantially sheeted, braced and shored, as necessary, to prevent caving or sliding, to provide protection for the workmen and the work, and to provide protection for existing structures and facilities. Sheeting, bracing and shoring shall be designed and built to withstand all loads that might be caused by earth movement or pressure, and shall be rigid, maintaining its shape and position under all circumstances.

3.4 CASING AND CARRIER PIPE INSTALLATION

A. Casing pipe:
1. Before starting work on borings, complete details of the method of operation and casing to be used shall be submitted to the Engineer for review. All permits shall be obtained by the Contractor.
2. Casing pipes shall have a clear inside diameter not smaller than the size indicated on the schedule.
3. The casing pipe shall be installed by jacking into place. Earth displaced by the casing pipe shall be removed through the interior of the casing by hand, by auger, or by other acceptable means. Sections of the casing pipe shall be welded together to form a continuous casing capable of resisting all stresses, including jacking stresses. The casing pipe in its final position shall be straight and true in alignment and grade. There shall be no space between the earth and the outside of the casing.

B. Carrier pipe:
1. Polyethylene casing insulators shall be strapped to each end of each piece of pipe. The pipe shall then be pushed into the casing pipe with care being taken to ensure the joints are not displaced. The joints in the installed pipe within the casing shall be tested for leakage before the backfill is installed.

C. Casing backfill:
1. Following the installation of the carrier pipe in the casing pipe, the entire annular space between the pipe and the casing walls shall be filled. The ends of the casing shall then be closed with a concrete or masonry plug 8 inches thick.

D. Casing backfill:
1. Following the installation of the carrier pipe in the casing pipe, the ends of the casing pipe shall then be closed with wrap around or pull-on end seals.

3.5 FINAL GRADING AND DISPOSAL OF EXCESS EXCAVATED MATERIALS

A. General:
   1. Except as otherwise indicated, all excess excavated materials shall be disposed of by the Contractor away from the site of the work.
   2. Excavated rock, junk and debris encountered in excavation work, and other similar waste materials shall be disposed of away from the site of the work.
   3. The disposal of waste and excess excavated materials, including hauling, handling, leveling and surfacing, shall be at the Contractor's expense.

B. Restoration of disturbed earth:
   1. The Contractor shall restore all earth areas disturbed from the original condition by his operations. Restoration will be by seeding, fertilizing and mulching to obtain an established cover or by appropriate pavement and street repair.

3.6 RESPONSIBILITY OF CONTRACTOR FOR BACKFILL SETTLEMENT

A. The Contractor shall be responsible financially and otherwise, for:
   1. All settlement of trench and other backfill which may occur from time of original backfilling until the expiration of 1 year after the date of final payment for the entire contract under which the backfilling work was performed.
   2. The refilling and repair of all backfill settlement and the repair or replacement to the original or a better condition of all pavement, top surfacings, driveways, walks, surface structures, utilities, drainage facilities and sod which may have been damaged as a result of backfill settlement or which have been removed or destroyed in connection with backfill replacement operations.
   3. All damage claims or court actions against the Owner for any damage directly or indirectly caused by backfill settlement.

B. The Contractor shall make all necessary backfill replacements and repairs, or replacements appurtenant thereto, within 30 days after notification by the Owner or Engineer. Upon the Contractor's failure to do so, the Owner may do, or have done, the necessary work and charge the cost to the Contractor.

3.7 MAINTENANCE OF TRAFFIC

A. The Contractor shall conduct his work so as to interfere as little as possible with public travel, whether vehicular or pedestrian; whenever it is necessary to cross, obstruct, or close roads, driveways, and walks, whether public or private, the Contractor shall at his own expense provide and maintain suitable and safe bridges, detours, or other temporary expedients for the accommodation of public and private travel, and shall give reasonable notice to owners of private drives before interfering with them; provided however, that such maintenance of traffic will not be required at any point where the Contractor has obtained permission from the owner and tenant of private property, or from the authority having jurisdiction over the public property involved, to obstruct traffic at any designated point thereon and for the duration of whatever period of time as may be agreed upon.

END OF SECTION

DIVISION 32

EXTERIOR IMPROVEMENTS

SECTION 32 10 00 - CONCRETE SIDEWALKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work and materials required to install concrete sidewalk.

B. Related sections:
1. Section 03 30 00 – Cast-In-Place Concrete.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
1. American Society for Testing and Materials (ASTM):
a. ASTM C94, Standard Specification for Ready Mixed Concrete.
b. ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
c. ASTM D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
2. American Association of State Highway and Transportation Officials (AASHTO): T 99, The Moisture-Density Relations of Soils Using a 5.5 pound (2.5 kg) Rammer and a 12-inch (305 mm) Drop.
3. American Concrete Institute (ACI): ACI Guide for Measuring, Mixing, Transporting, and Placing Concrete.
4. Standard Specification: The latest edition, including supplements of the Colorado Department of Transportation Standard Construction Specifications.

1.3 SUBMITTALS

A. Shop Drawings:
1. Form Material: Information on metal forms, if used, including type, condition, surface finish, and intended function.
2. Complete data on concrete mix, including aggregate gradations and admixtures in accordance with requirements of ASTM C94.

B. Quality Control Submittals:
1. Curing Compound: Manufacturer’s Certificate of Compliance and application instructions.
2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.

PART 2 - PRODUCTS

2.1 EXPANSION JOINT FILLER

A. 1/2-inch thick, preformed asphalt-impregnated, expansion joint material meeting ASTM D994.

2.2 CONCRETE

A. As specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

B. Maximum Aggregate Size: 1-1/2-inch.

C. Slump: 2 to 4 inches.

2.3 CURING COMPOUND

A. Liquid membrane-forming, clear or translucent, suitable for and meeting ASTM C309, Type 1.

PART 3 - EXECUTION

3.1 FORMWORK

A. Lumber Materials:
   1. 2-inch dressed dimension lumber, or metal of equal strength, straight, free from defects that would impair appearance or structural quality of completed sidewalk.
   2. 1-inch dressed lumber or plywood may be used where short-radius forms are required.

B. Metals: Steel in new undamaged condition.

C. Setting Forms:
   1. Construct forms to shape, lines, grades, and dimensions.
   2. Stake securely in place.

D. Bracing:
   1. Brace forms to prevent change of shape or movement resulting from placement.
   2. Construct short-radius curved forms to exact radius.

E. Tolerances:
   1. Do not vary tops of forms from gradeline more than 1/8-inch when checked with 10-foot straightedge.
   2. Do not vary alignment of straight sections more than 1/8-inch in 10 feet.

3.2 PLACING CONCRETE

A. Prior to placing concrete, remove water from excavation and debris and foreign material from forms.

B. Place concrete as soon as possible, and within 1-1/2 hours after adding cement to mix without segregation or loss of ingredients, and without splashing.

C. Place, process, finish, and cure concrete in accordance with applicable requirements of ACI 304, and this section. Wherever requirements differ, the more stringent shall govern.

D. To compact, vibrate until concrete becomes uniformly plastic.

3.3 SIDEWALK CONSTRUCTION

A. Thickness:
   1. 4 inches in walk areas.
   2. 6 inches in driveway areas.

B. Connection to Existing Sidewalk:
   1. Remove old concrete back to an existing contraction joint.
   2. Clean the surface.
   3. Apply a neat cement paste immediately prior to placing new sidewalk.

C. Expansion Joints: Place at building corners and changes in sidewalk width around posts, poles, or other objects penetrating sidewalk. Install expansion joint filler at each joint.

D. Contraction Joints:
   1. Provide transversely to walks at locations opposite contraction joints in curb.
   2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
   3. Construct straight and at right angles to surface of walk.

E. Finish:
   1. Broom surface with fine-hair broom at right angles to length of walk and tool at edges, joints, and markings.
   2. Mark walks transversely at 5-foot intervals with jointing tool; finish edges with rounded steel edging tool.
   3. Apply curing compound to exposed surfaces upon completion of finishing.
   4. Protect sidewalk from damage and allow to cure for at least 7 days.

3.4 SLAB CONSTRUCTION ON GRADE

A. Thickness: Four inches or as shown.

B. Contraction Joints:
   1. As shown on Drawings.
   2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
   3. Construct straight and at right angles to surface of slab.

C. Finish:
   1. Broom surface with fine-hair broom and tool of edges, joints, and markings.
   2. Apply curing compound to exposed surfaces upon completion of finishing.
   3. Protect sidewalk from damage and allow to cure for at least 7 days.

END OF SECTION

SECTION 32 11 00 - BASE COURSE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work and materials required to install base course.

B. Related sections:
1. Section 31 22 13 – Subgrade Preparation.

1.2 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
a. T 89, Standard Method for Determining the Liquid Limit of Soils.
b. T 90, Determining the Plastic Limit and Plasticity Index of Soils.
c. T 96/ASTM C131, Standard Test Method for Resistance to Degradation of Small Size Course Aggregate by Abrasion and Impact in the Los Angeles Machine.
d. T 99, Standard Methods of Test for the Moisture-Density Relations of Soils Using a 5.5 pound (2.5 kg) Rammer and a 12-inch (305 mm) Drop.
e. T 180, Standard Methods of Test for the Moisture-Density Relations of Soils Using a 10 pound (4.54 kg) Rammer and an 18-inch (457 mm) Drop.
f. T 191, Standard Method of Test for Density of Soil In-Place by the Sand-Cone Method.

1.3 DEFINITIONS

A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

B. Completed Lift: Compacted with uniform surface reasonably true to cross- section.

C. Standard Specification: The latest edition, including supplements of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction.

1.4 SUBMITTALS

A. Quality Control Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 20 days prior to delivery of materials to project.
2. Certified Results of In-Place Density Tests from independent testing agency.

PART 2 - PRODUCTS

2.1 BASE COURSE ROCK

A. As specified for Class 4 or 5 in Section 702 of the Standard Specification.

2.2 SOURCE QUALITY CONTROL

A. Contractor: tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on materials' test results on installed materials.

C. Should separation of course from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 - EXECUTION

3.1 PREPARATION

A. As specified in Section 31 22 13, SUBGRADE PREPARATION.

B. Obtain Engineer’s acceptance of subgrade before placement of base course rock.

C. Do not place base materials in snow or on soft, muddy, or frozen subgrade.

3.2 EQUIPMENT

A. In accordance with Section 304 of the Standard Specification.

B. Compaction Equipment: Adequate in design and number to provide compaction and obtain the specified density for each layer.

3.3 HAULING AND SPREADING

A. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads: Of uniform capacity.
3. Measure capacity of truck to determine vehicle load and quantity.
4. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

B. Spreading Materials:

1. Distribute material to provide required density, depth, grade and dimensions with allowance for subsequent lifts.
2. Produce even distribution of material upon roadway without segregation.
3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.4 CONSTRUCTION OF COURSES

A. General: Complete each lift in advance of laying succeeding lift to provide required results and adequate inspection.

B. Base Course:

1. Maximum Completed Lift Thickness: 6 inches.
2. Completed Course Total Thickness: As shown.
3. Spread lift on preceding course to required cross-section.
4. Lightly blade and roll surface until thoroughly compacted.
5. Add keystone to achieve compaction and as required when aggregate does not compact readily due to lack of fines or natural cementing properties, as follows:
   a. Use base 1/4-minus crushed aggregate material as keystone.

b. Spread evenly on top of crushed base course, using spreader boxes or chip spreaders.
c. Roll surface until keystone is worked into interstices of crushed base course without excessive displacement. ,
d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.

6. Blade or broom surface to maintain true line, grade, and cross-section.

3.5 ROLLING AND COMPACTION

A. Blade or otherwise work existing surface as necessary to achieve a smooth and thoroughly compacted surface.

B. Commence compaction of each layer of base after spreading operations and continue until density of 95 percent of maximum density has been achieved as determined by AASHTO T 180, as modified by CP 23. The moisture shall be at plus or minus 2 percent of optimum moisture content.

C. Commence rolling at outer edges of surfacing and continue toward center; do not roll center of road first.

D. Apply water as needed to obtain densities.

E. Place and compact each lift to required density before succeeding lift is placed.

F. Bind up preceding course before placing leveling course. Remove floating or loose stone from surface.

G. Blade or otherwise work surfacing as necessary to maintain grade and cross- section at all times, and to keep surface smooth and thoroughly compacted.

H. Surface Defects: Remedy surface defects by loosening and rerolling entire area, including surrounding surface, until thoroughly compacted.

1. Finished Surface: True to grade and crown before proceeding with surfacing.

3.6 SURFACE TOLERANCES

A. Finished Surface of Base Course: Within plus or minus 0.04-foot of grade shown at any individual point.

B. Overall Average: Within plus or minus 0.01-foot from crown and grade specified.

3.7 FIELD QUALITY CONTROL

A. In-Place Density Tests:

1. Construct base course so areas shall be ready for testing.
2. Allow reasonable length of time for testing laboratory to perform tests and obtain results during normal working hours.
3. Show proof that areas meet specified requirements before identifying density test locations.
4. Perform a minimum of 2 tests on completed course per 200 cubic yards of material placed in accordance with T 191, or T 238 at locations acceptable to Engineer.

B. Cleaning

1. Remove excess material; clean stockpile areas of aggregate.

END OF SECTION

SECTION 32 13 13 - PORTLAND CEMENT CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Concrete sidewalks, curbs and gutters and aprons.

B. Related sections:
1. Section 01 33 00 – Submittal Procedures.
2. Section 03 30 00 – Cast-in-Place Concrete.
3. Section 07 92 00 – Joint Sealants.
4. Section 32 11 00 – Base Course.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
1. American Concrete Institute (ACI):
a. ACI 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
b. ACI 301 – Specifications for Structural Concrete for Buildings
c. ACI 304R – Guide for Measuring, Mixing, Transporting, and Placing Concrete; American Concrete Institute International; 2000.
d. ACI 305R – Hot Weather Concreting
e. ACI 306R – Cold Weather Concreting
2. American Society for Testing and Materials (ASTM):
a. ASTM A185 – Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
b. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
c. ASTM C33 – Standard Specification for Concrete Aggregates
d. ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
e. ASTM C94– Standard Specification for Ready Mixed Concrete
f. ASTM C150 – Standard Specification for Portland Cement
g. ASTM C260 – Standard Specification for Air-Entraining Admixtures for Concrete
h. ASTM C309- Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
i. ASTM C494– Standard Specification for Chemical Admixtures for Concrete
j. ASTM C685 – Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
k. ASTM D1751 – Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)
l. ASTM D1752 – Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction

1.3 SUBMITTALS

A. See Section 01 33 00, SUBMITTAL PROCEDURES for submittal procedures.

B. Product Data: Provide data on joint filler, admixtures, and curing compound.

C. Design Data: Indicate pavement thickness, designed concrete strength, reinforcement, and typical details.

1.4 QUALITY ASSURANCE

A. Perform work in accordance with ACI 301.

B. Obtain cementitious materials from same source throughout.

C. Follow recommendations of ACI 305R when concreting during hot weather.

D. Follow recommendations of ACI 306R when concreting during cold weather.

1.5 ENVIRONMENTAL REQUIRMENTS

A. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

B. Placement of concrete during cold weather shall conform to Section 412.15 Cold Weather Concrete Paving of the CDOT Standard Specifications.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

A. Form Materials: conform to ACI 301.

B. Joint Filler: Preformed; non-extruding bituminous type (ASTM D1751) or sponge rubber or cork (ASTM D1752).
1. Thickness: 1/2 inch.

2.2 REINFORCEMENT

A. Reinforcing Steel: ASTM A615 / A615M Grade 60 (420); deformed billet steel bars; unfinished finish.

B. Steel Welded Wire Reinforcement: Plain type, ASTM A185; in flat sheets; unfinished.

C. Dowels: ASTM A615 Grade 60 (420); deformed carbon steel bars; unfinished finish.

2.3 CONCRETE MATERIALS

A. Concrete Materials: As specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

2.4 ACCESSORIES

A. Curing Compound: ASTM C309, Type 1, Class A.

2.5 CONCRETE MIX DESIGN

A. Proportioning Normal Weight Concrete: Comply with ACI 211.1 recommendations. Refer to Civil Plans and Specifications for site concrete design.

B. Concrete Strength: Establish required average strength for each type of concrete on the basis of field experience or trial mixtures, as specified in ACI 301.

1. For trial mixtures method, employ independent testing agency acceptable to Owners Representative for preparing and reporting proposed mix designs.

C. Admixtures: Add acceptable admixtures as recommended in ACI 211.1 and at rates recommended by manufacturer.

D. Concrete Properties:
1. Refer to Construction Documents.

2.6 MIXING

A. On Project Site: Mix in drum type batch mixer, complying with ASTM C685. Mix each batch not less than 1-1/2 minutes and not more than 5 minutes.

B. Transit Mixers: Comply with ASTM C94 / C94M.

PART 3 - EXECUTIONS

3.1 EXAMINATION

A. Verify compacted subgrade is acceptable and ready to support paving and imposed loads.

B. Verify gradients and elevations of base are correct.

3.2 SUBBASE

A. Prepare subbase in accordance with the Colorado Department of Transportation Standard Construction Specifications.

3.3 PREPARATION

A. Moisten base to minimize absorption of water from fresh concrete.

3.4 FORMING

A. Place and secure forms to correct location, dimension, profile, and gradient.

B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

C. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

3.5 REINFORCEMENT

A. Place reinforcement as indicated.

B. Place dowels to achieve pavement and curb alignment as detailed.

3.6 PLACING CONCRETE

A. Place concrete in accordance with ACI 304R.

B. Ensure reinforcement, inserts, embedded parts and formed joints are not disturbed during concrete placement.

C. Place concrete continuously over the full width of the panel and between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

D. Apply surface retarder to all exposed surfaces in accordance with manufacturer's instructions.

3.7 JOINTS

A. Place control and expansion joints as indicated on drawings.

B. Place control and expansion joints and edge of new concrete to align with existing joints beyond.

C. Evenly space joint patterns not dimensioned on plans. Align joints with corners of masonry where shown on plans.

D. Place joint filler between new sidewalks and building or adjacent saw cut paving.

3.8 FINISHING

A. Sidewalk and Ramp Paving: Light broom, texture perpendicular to pavement direction.

B. Place during compound on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's instructions.

3.9 JOINT SEALING

A. See Section 07 92 00, JOINT SEALANTS for joint sealant requirements.

3.10 TOLERANCES

A. Maximum Variation of Surface Flatness: 1/4 inch in 10 feet.

B. Maximum Variation From True Position: 1/4 inch.

3.11 FIELD QUALITY CONTROL

A. An independent testing agency will perform field quality control tests.
   1. Provide free access to concrete operations at project site and cooperate with appointed firm.
   2. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of concrete operations.
   3. Tests of concrete and concrete materials may be performed at any time to ensure conformance with specified requirements.

B. Compressive Strength Tests: ASTM C39 / C39M. For each test, mold and cure three concrete test cylinders. Obtain test samples for every 100 cu yd or less of each class of concrete placed.
   1. Take one additional test cylinder during cold weather concreting, cured on job site under same conditions as concrete it represents.
   2. Perform one slump test for each set of test cylinders taken.

C. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.12 PROTECTION

A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures and mechanical injury.

B. Do not permit pedestrian traffic over pavement until 75 percent design strength of concrete has been achieved.

END OF SECTION

SECTION 32 31 13 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Society for Testing and Materials (ASTM):
      a. ASTM A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
      b. ASTM A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
      c. ASTM A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
      d. ASTM A1018, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
      e. ASTM A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
      f. ASTM B6, Standard Specification for Zinc.
      g. ASTM C94, Standard Specification for Ready-Mixed Concrete.
      h. ASTM C143, Standard Test Method for Slump of Hydraulic-Cement Concrete.
      i. ASTM C387, Standard Specifications for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar.
      j. ASTM F552, Standard Terminology Relating to Chain Link Fencing.
      k. ASTM F567, Standard Practice for Installation of Chain-Link Fence.
      l. ASTM F626, Standard Specification for Fence Fittings.
      m. ASTM F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
      n. ASTM F900, Standard Specification for Industrial and Commercial Swing Gates.
      o. ASTM F1043, Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework.
      p. ASTM F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
      q. ASTM F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
      r. ASTM F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
   2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: National Electrical Safety Code.
   3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

1.2 DEFINITIONS

A. Terms as defined in ASTM.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Detailed information and specifications for materials, finishes, and dimensions.
   2. Card access system serial communication interface card code message format.

B. Samples: Approximately 6 inches square, or 6 inches long of posts, rails, braces, fabric, wire, ties, and fittings.

C. Quality Control Submittals:
   1. Manufacturer's recommended installation instructions.
   2. Evidence of Supplier and installer qualifications.

1.4 SCHEDULING AND SEQUENCING

A. Complete necessary site preparation and grading before installing chain link fence and gates.

PART 2 - PRODUCTS

2.1 GENERAL

A. Match style, finish, and color of each fence component with that of other fence components.

2.2 CHAIN LINK FENCE FABRIC

A. Galvanized fabric conforming to ASTM, Class 1; galvanized after weaving.

B. Coating: Black PVC coated vinyl

C. Height: 72 inches, unless otherwise shown.

D. Wire Gauge: No. 9, barewire.

E. Pattern: 2-inch diamond-mesh.

F. Diamond Count: Manufacturer's standard and consistent for fabric furnished of same height.

G. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.

H. Wires of Twisted Selvages:
   1. Twisted in a closed helix three full turns.
   2. Cut at an angle to provide sharp barbs that extend minimum 1/4-inch beyond twist.

2.3 POSTS

A. General:
   1. Strength and Stiffness Requirements: ASTM F1043, Light Industrial Fence, except as modified in this section.
   2. Steel Pipe: ASTM F1083.
   3. Roll-Formed Steel Shapes: from ASTM A1018, Grade 45, Steel.
   4. Lengths: Manufacturer's standard with allowance for minimum embedment below finished grade of 22 inches plus 3 inches for each 1 foot of fence height greater than 4 feet.
   5. Protective Coatings:
      a. Zinc Coating: ASTM F1043, Type A external and internal coating.

B. Line Posts:
   1. Steel Pipe:
      a. Outside Diameter: 2.375-inch.
      b. Weight: 3.65 pounds per foot.

C. End, Corner, Angle, and Pull Posts:
   1. Steel Pipe:
      a. Outside Diameter: 2.875-inch.

b. Weight: 5.79 pounds per foot.

D. Posts for Swing Gates:
1. ASTM F900.
a. Outside Dimensions: 4-inch diameter.
b. Weight: 6.56 pounds per foot.

2.4 TOP RAILS AND BRACE RAILS
1. Galvanized steel pipe.
2. Protective Coatings: As specified for posts.
3. Strength and Stiffness Requirements: ASTM F1043, Top Rail, Heavy or Light Industrial Fence.
4. Steel Pipe:
a. ASTM F1083.
b. Outside Diameter: 1.66-inch.
c. Weight: 2.27 pounds per foot.

2.5 FENCE FITTINGS

A. General: In conformance with ASTM F626, except as modified by this article.

B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.

C. Tension and Brace Bands: No exceptions to ASTM.

D. Tension Bars:
1. One-piece, no exceptions to ASTM F626.
2. Equal in length to full height of fabric.

E. Truss Rod Assembly: 3/8-inch diameter.

F. Barb Arms: 45-degree arms for supporting three strands of barbed wire.

2.6 TENSION WIRE

A. Zinc-coated steel marcelled tension wire conforming to ASTM A824, Type II, Class 2.

2.7 BARBED WIRE

A. Zinc-Coated Barbed Wire: ASTM A121, Chain Link Fence Grade:
1. Line Wire: Two strands of No. 12-112 gauge.
2. Barbs:
a. Number of Points: Four.
b. Length: 318-inch minimum.
c. Shape: Round.
d. Diameter: No. 14-gauge.
e. Spacing: 5 inches.

2.8 GATES

A. General:
1. Gate Operation: Opened and closed easily by one person.
2. Welded Steel Joints: Paint with zinc-based paint.
3. Chain Link Fabric: Attached securely to gate frame at intervals not exceeding 15 inches.

B. Swing Gates: ASTM F900.
   1. Hinges:
      a. Furnished with large bearing surfaces for clamping in position.
      b. Designed to swing either 180 degrees outward, 180 degrees inward, or 90 degrees in or out, as shown, and not twist or turn under action of gate.
   2. Latches: Plunger bar arranged to engage stop, except single gates of openings less than 10 feet wide may each have forked latch.
   3. Gate Stops: Mushroom type or flush plate with anchors, suitable for setting in concrete.
   4. Locking Device and Padlock Eyes: Integral part of latch, requiring one padlock for locking both gate leaves of double gates.
   5. Hold-Open Keepers: Designed to automatically engage gate leaf and hold it in open position until manually released.

2.9 CONCRETE

A. Provide as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

2.10 REPAIR AND SALVAGE OF EXISTING FENCE

A. Non-Salvageable or Non-Reusable Parts:
   1. Fence posts.
   2. Gate posts.
   3. End, corner angle, and pull posts.
   4. Tension and brace bands.
   5. Tension wire.

B. Salvageable or Reusable Items:
   1. Fence fabric.
   2. Post caps.
   3. Top rails and brace rails.
   4. Truss rod assemblies.
   5. Barb arms.
   6. Barbwire.

C. All items noted as salvageable shall not be bent, twisted, dented, or damaged in any way. Any such items will not be considered for reuse.

D. All items not considered for salvage or reuse shall be disposed of offsite at the Contractor's expense. See Section 02 41 00, DEMOLITION.

PART 3 - EXECUTION

3.1 GENERAL

A. Install chain link fences and gates in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer's recommendations, as approved by Engineer. Erect fencing in straight lines between angle points.

B. Provide all necessary hardware for a complete fence and gate installation.

3.2 PREPARATION

A. Establish locations of fence lines, gates, and terminal posts.

3.3 POST SETTING

A. Driven posts are not acceptable.

B. Post Hole Depth:
   1. Minimum 3 feet below finished grade.
   2. 2 inches deeper than post embedment depth below finish grade.

C. Backfill post holes with concrete to 2 inches above finished grade.

D. Before concrete sets, crown and finish top of concrete to readily shed water.

3.4 BRACING

A. Brace gate and corner posts diagonally to adjacent line posts to ensure stability.

3.5 TOP RAILS

A. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

3.6 CHAIN LINK FABRIC

A. Do not install fabric until concrete has cured minimum 7 days.

B. Install fabric with twisted and barbed selvage at top.

3.7 BARBED WIRE

A. Install three strands of barbed wire on brackets, tighten, and secure at each bracket.

3.8 GATES

A. Hang gates and adjust hardware so gates operate satisfactorily from open or closed position.

B. Set gate stops in concrete to engage center drop rod or plunger bar.

3.9 FIELD QUALITY CONTROL

A. Gate Tests: Prior to acceptance of installed gates and gate operator systems, demonstrate proper operation of gates under each possible open and close condition specified.

3.10 REUSE OF EXISTING FENCE MATERIAL

A. Existing fence material shall be installed on new posts using new tension bars, brace bands, and tension wire.

B. Existing fence fabric shall not be spliced to new fence fabric at mid-length between posts where the existing fence fabric ends. A pull post shall be installed with new brace bands, tension bands, and tension wire. Provide a knuckled selvage at the cut portion of the fence as shown on the Drawings.

END OF SECTION

SECTION 32 84 23 - LANDSCAPE IRRIGATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Pipe sleeves under paving for irrigation system.
   2. Pipe and fittings, valves, outlets, backflow preventer, and accessories.
   3. Connection to utilities.
   4. Automatic control system.

B. Related sections:
   1. Section 31 22 19 - Grading
   2. Section 32 92 19 – Seeding, Fertilizing and Mulching

1.2 REFERENCES

A. ASTM D2241, Standard Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)

B. ANSI/ASTM D2564, Standard Specification for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems.

C. Section 623 of the Colorado Department of Transportation (CDOT) Standard Construction Specifications.

1.3 SUBMITTALS

A. Product Data: Provide manufacturer's information and specifications for system components.

B. Samples: Provide on component (outlet, valve, etc.) of each type. Accepted samples may be used in Work.

C. Manufacturer's installation instructions for controller, complete with wiring diagrams.

1.4 CONTRACTOR'S RESPONSIBILITIES

A. The Contractor shall provide for the design, installation, testing and startup of a complete irrigation system capable of servicing all landscape and turf areas. Design requirements shall meet or exceed the criteria for Work of this section.

1.5 SYSTEM DESCRIPTION

A. Provide automatic, electric solenoid controlled, irrigation system for landscape plantings and sodding areas. System shall include the following components:
   1. Water meter and service connection to water source.
   2. PVC pipe and fittings.
   3. Backflow preventer device.
   4. Automatic controller with power source.
   5. Flow control valves.
   6. Pressure regulating master valve.
   7. Valve boxes and covers.
   8. Outlets (sprinkler heads).
   9. Low point manual drain valves.

10. Schedule 40 PVC pipe sleeves at all pavement crossings.

1.6 PROJECT RECORD DOCUMENTS

A. Prepare record drawing of installed irrigation system and other system components.

1.7 OPERATION AND MAINTENANCE DATA

A. Provide instructions for operation and maintenance of system and controls, seasonal activation and shutdown, and manufacturer's parts catalog.

B. Provide schedule indicating length of time each valve zone is required to be open to provide appropriate amount of water for normal watering schedules at time of installation.

1.8 REGULATORY REQUIRMENTS

A. Conform to applicable plumbing codes for piping and component requirements.

B. Provide certificate of compliance from local authority having jurisdiction indicating approval of piping and backflow preventer installation.

1.9 FIELD MEASUREMENTS

A. Verify that field measurements of construction conditions are as shown on the plans. Revise for record drawing as required.

1.10 EXTRA MATERIALS

A. Furnish to Owner the following extra components:
1. Two sprinkler heads of each type and size.
2. Two nozzle inserts for each type and size
3. Two keys each for valve boxes and controller.
4. Two wrenches for each type head core and for removing and installing each type head.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. TORO by Toro Co, Irrigation Division.

B. Rain Bird by Rain Bird Sales, Inc.

C. Hunter by Hunter Industries.

D. Nelson by L. R. Nelson Corporation.

2.2 MATERIALS

A. Pipe: PVC in accordance with ASTM D2241; PVC 1120-1220, Schedule 40 main lines upstream from control valves. PVC 1120-1220, Class 200 pipe downstream. Solvent-weld sockets.

B. Fittings: Type and style of connection to match pipe.

C. Solvent Cement: ANSI/ASTM D2564 for PVC pipe and fittings.

D. Sleeve Materials: Schedule 40 PVC pipe size as shown in drawings.

2.3 OUTLETS

A. General: High impact plastic, plastic housed stainless steel, brass or bronze construction.

B. Rotary type Sprinkler Heads: Pop-up type with filter screens; adjustable for radius of throw; and nozzle type and size as indicated in drawings. Shrub type heads are mounted on fixed riser assemblies.

C. Spray Type Sprinkler Head: Pop-up head with full circle, partial circle, rectangular or adjustable arc patterns and adjustable radius of throw.

D. Bubbler: Adjustable outlet and fixed riser head assembly.

2.4 VALVES

A. Master Valve: As specified in the drawings. Pressure regulating; electric solenoid; plastic, plastic housed stainless steel, brass or bronze construction; male or female thread; globe or globe/angle type valve. Flow and operating pressure ranges as follows:
1. Flow: 1 1/2inch valves, 10-120 gpm; 2-inch valves, 10-180 gpm.
2. Operating Pressure: 10-150 psi inlet.

B. Control Valve: As specified in the drawings. Flow control; electric solenoid; plastic, plastic housed stainless steel, brass or bronze construction; male or female thread; glove type valve. Flow and operating pressure ranges as follows:
1. Flow: 3/4 inch valves, 5-15 gpm, 1 inch valves, 5-45 gpm; 1 1/2 inch valves, 10 – 120 gpm.
2. Operating Pressure: 10-150 psi.

C. Backflow Preventers: As specified in the drawings. Reduced pressure principle with relief valve, 150 psi working pressure, size as shown in drawings.

D. Valve Box and Cover: High impact plastic with lock at all control valves, master valves and drain valves.

E. Drain Valve: Manual plastic for low points in system.

2.5 CONTROLS

A. Controller: As specified in the drawings – Automatic controller, motor driven timer with relay switches, temporary override feature to bypass cycle for inclement weather, station capacity as shown in drawings with master valve circuit. Programmable for 7 day watering cycle with 3-60 minute run times and automatic start and shutdown.

B. Controller Housing: Steel, weatherproof, watertight, with lockable access door.

C. Accessories: include required fittings, galvanized metal electrical conduit, and accessories for installation.

D. Wire: Color coded with waterproof connectors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field conditions are acceptable and are ready to receive work.

B. Verify location of existing utilities. Repair utilities damaged as a result of this work at no increase in Contract Sum.

C. Verify that required utilities are available in proper location and ready for use.

D. Beginning of installation means installer accepts existing conditions.

3.2 PREPARATION

A. Provide service tap to water source and installation of water meter.

B. Layout and stake locations of system components.

C. Review layout requirements with other affected work. Coordinate locations of sleeves under paving to accommodate system. Notify Owners Representative for approval of field changes to system design.

3.3 TRENCHING

A. Trench Depth: In accordance to CDOT Section 623.17 Pipe Installation minimum depths.

B. Trench to accommodate grade changes and slope to drain valves at low points in system.

C. Maintain trenches free of debris, material, or obstructions that may damage pipe.

3.4 INSTALLATION

A. Install and bed sleeves under pavement crossings in accordance CDOT Standard Specifications for backfill and bedding.

B. Install pipe, backflow preventer, valves, controls, and outlets in accordance with manufacturer's instructions.

C. Provide 12" diameter by 18" deep, gravel filled drain sump, at manual drain valve locations at low points in system.

D. Connect to water and electrical service.

E. Set sprinkler heads and box covers at finish grade elevations.

F. Provide for thermal movement and thrust blocking of components in system.

G. Use threaded nipples for risers to each outlet to facilitate replacement.

H. Install control wiring. Provide 10-inch expansion coil at each valve and at 100 feet intervals. Bury wire beside pipe. Mark valves with installed valve boxes and covers.

I. Install automatic controller. Provide connection to power source, enclose wiring to system and power source in conduit where exposed.

J. After piping is installed but before sprinkler heads are installed and trenches backfilled, open valves and flush system with full head of water.

3.5 FIELD QUALITY CONTROL

A. Prior to backfilling, cap or plug outlet pipes and test system for leakage. Maintain 100 psi pressure for one hour. System acceptable if no leakage or loss of pressure occurs during test period.

3.6 BACKFILLING

A. Backfill sleeve trenches under pavement crossings and compact to subgrade elevation in accordance with CDOT Standard Specifications for backfill and bedding. Protect piping from displacement.

B. Backfill and compact all pipe trenches to prevent settlement.

C. Replace work damaged by the work of this section with equivalent products.

3.7 ADJUSTING

A. Adjust control system to achieve time cycles required for adequate watering.

B. Change or adjust head and/or nozzle types to achieve proper coverage and performance.

3.8 DEMONSTRATION

A. Provide system demonstration to Owner's Representative for final acceptance.

B. Instruct Owner's personnel in operation and maintenance of system, including adjusting of sprinkler heads. Use operation and maintenance material as basis for demonstration.

3.9 INSTALLER'S FIELD SERVICES

A. Provide one complete spring startup and a fall shutdown.

3.10 WARRANTY

A. Provide one year materials and workmanship warranty on all system components and installation beginning on date of acceptance of the work.

B. Replace failed components immediately upon notification by Owner or Owner's Representative.

END OF SECTION

SECTION 32 91 19 - SODDING, SEEDING, FERTILIZING, AND MULCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Sodding.
   2. Fertilizer.
   3. Mulch.
   4. Seed.
   5. Preparation.
   6. Maintenance.

B. Related Sections:
   1. Section 31 23 16 – Excavation
   2. Section 31 23 23.13 – Fill and Backfill

C. Alternate Methods and Products:
   1. Alternate methods from those specified will be considered for use, provided that in the Engineer's opinion the end product will be equal to or exceed that which would result from the specified methods and products.

1.2 DEFINITIONS

A. Weeds:
   1. As defined by the Colorado Department of Agriculture Noxious Weed Species ID.

1.3 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition.

1.4 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.5 MAINTENANCE DATA

A. Submit maintenance data for continuing Owner maintenance.

B. Include maintenance instruction, cutting method, maximum grass height, types, application frequency, and recommended coverage of fertilizer.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

PART 2 - PRODUCTS

2.1 AGRICULTURAL LIMESTONE

A. Shall be agricultural limestone with not less than 90 percent passing the No. 4 sieve and containing not less than 40 percent calcium carbonate equivalent. Lime shall be applied at the rate recommended by soil test.

2.2 FERTILIZER

A. Shall be a standard commercial product which when applied at the proper rate will supply the equivalent quantity of total nitrogen, available phosphoric acid and soluble potash specified. Fertilizer shall be delivered to the site in bags or other suitable containers, each fully labeled, conforming to applicable state fertilizer laws, and bearing the name, trade name or trademark, and warranty of the producer.

B. Requirements per acre:
   1. Six hundred pounds of 17-17-17 grade fertilizer or equivalent.

2.3 MULCH

A. Shall be vegetative mulch consisting of cereal straw from stalks of oats, rye, wheat or barley. Straw shall be free of prohibited weed seeds as stated in State Seed Law and shall be relatively free of all other noxious and undesirable seeds. Straw shall be clean and bright, relatively free of foreign material and be dry enough to be spread properly.

2.4 SEED

A. Common grass seed recommended by local supplier and approved by engineer.

B. Seed shall be labeled in accordance with USDA regulations. Care shall be taken during transportation to avoid segregation of seed mixtures.

C. Seed shall be sown at a rate of 217 pounds of seed mix per acre for drill seeding. Seed mixture shall be thoroughly mixed prior to application.

2.5 SODDING

A. Sodding shall consist of furnishing, and placing sod at all locations shown on the Plans, where directed by the Engineer, and in conformity with these Specifications. Sod shall consist of a live, dense, well-rooted growth of permanent grasses, free of weeds and weedy grasses. All sod shall be cleanly cut in strips having a reasonably uniform thickness of not less than 1 inch, a reasonable uniform width of not less than 8 inches, and a length not less than 12 inches.

B. Sod shall supplied by local supplier and recommend grass type for approval by owner. It shall be the obligation of the Contractor to secure a satisfactory growth of grass before final acceptance of the project.

PART 3 - EXECUTION

3.1 GENERAL

A. The application of fertilizer, seed, and mulch shall follow each other in successive sequence as closely as possible. Seeding shall be accomplished in the first of the following two periods after completion of earthwork.

Zone	Spring Seeding	Fall Seeding
Areas other than the Western Slope		
Below 6000’	Spring thaw to June 1	Sept. 15 until consistent ground freeze
6000’ to 7000’	Spring thaw to June 1	Sept. 1 until consistent ground freeze
7000’ to 8000’	Spring thaw to July 15	August 1 until consistent ground freeze
Above 8000’	Spring thaw to consistent ground freeze	
Western Slope		
Below 6000’	Spring thaw to May 1	August 1 until consistent ground freeze
6000’ to 7000’	Spring thaw to June 1	Sept. 1 until consistent ground freeze
Above 7000’	Spring thaw to consistent ground freeze	

B. Seeding outside the specified seeding periods may be permitted at the Engineer's option, provided the Contractor is willing to make appropriate modifications to his seeding operations, and will guarantee the crop.

3.2 INSPECTION

A. Contractor must request that Engineer inspect site grading, clean-up and surface preparation to determine if site is ready for the seeding, fertilizing and mulching operations.

B. Upon Engineer’s approval operations may begin.

3.3 SURFACE PREPARATION

A. Immediately in advance of fertilizing, the surface to be seeded shall be repaired, if necessary, to eliminate all damage from erosion or construction operations. The surface shall then be loosened and thoroughly pulverized by discing, harrowing and raking or other approved methods, to such an extent that it is free from sod, stones, clods, or roots. All growth of vegetation that will seriously interfere with planting operations shall be removed and disposed of as directed. The final surface shall be smooth and uniform, and left in such a condition as to prevent formation of low places and pockets.

3.4 FERTILIZING

A. Fertilizer and lime shall be dressed evenly over the areas to be seeded using approved mechanical type spreading equipment.

B. Fertilizer and lime after spreading shall be immediately incorporated into the soil to a depth of approximately 2 inches, by chisel, spike tooth harrow, or other approved methods.

3.5 SEEDING METHODS

A. General methods:
   1. The Contractor shall employ a satisfactory method of sowing by use of either approved mechanical hand seeders or mechanical power-driven drills. When delays in operation carry the work beyond the specified planting seasons, or when conditions are such that by reason of drought, high winds, excessive moisture, or other factors, satisfactory results are not likely to be obtained, seeding shall stop. It will be resumed only where the desired results are probable or when approved alternate procedures have been adopted.

B. Broadcast seeding:
   1. When broadcast seeding is utilized, the seed shall be uniformly broadcast by mechanical hand seeder, in two directions at right-angles to each other and at 1/2 of the specified rate

per acre in each direction. After the seed is broadcast it shall be covered by an approved method to a depth of 1/3 inch to 3/4 inch. Broadcast seeding shall not be done in windy weather.

C. Drill seeding:
   1. When drilling is utilized, it shall be done with approved equipment best suited to perform the work under prevailing conditions. The seed shall be uniformly drilled to a depth of one-third (1/3) inch to three-fourths (3/4) inch at the rate per acre specified. Drill seeding may be required in windy weather.

D. Prior to start of seeding, the Contractor shall demonstrate that the application of seed is being made at the specified rate. A final check of the total quantity of seed used shall be made against the area seeded. If the check shows that the Contractor has not applied seed at the specified rate, he shall uniformly distribute seed at a rate calculated to meet the shortage.

E. The Contractor shall maintain the seeded areas until all fertilizing, seeding and mulching is complete and the work accepted by the Engineer. Areas damaged from the Contractor's own operations shall be repaired at his expense. After acceptance of the work the Contractor will not be held responsible for erosion due to weather, or conditions not due to the Contractor's own operations or negligence. The Contractor is not required to guarantee a crop, if seeding is done during the specified seeding periods.

3.6 MULCHING

A. Immediately after seeding, the Contractor shall apply vegetative mulch at a rate between 1-1/2 and 2-1/2 tons per acre to all seeded areas. Quantity of mulch shall be adjusted within the above limits, as directed by the Engineer, to the particular area or slope being mulched. Total application of mulch for the project shall average approximately 2 tons per acre. Mulch shall be applied by mechanical mulch spreaders equipped to eject by means of a constant air stream controlled quantities of the vegetative mulch.

B. Mulch shall be embedded by a disc type roller having flat serrated discs spaced not more than 10 inches apart, with cleaning scrapers for each disc.

C. Where indicated, or in areas of the project where soil conditions are not suitable for satisfactory crimping, asphalt emulsion shall be applied with the mulching operation. The normal rate of application shall be 100 gallons per ton of straw; however, this rate may be varied as directed by the Engineer to suit the particular area or slope conditions.

D. All mulch shall be distributed evenly over the areas to be mulched within 24 hours after the seeding operation. Following the mulching operation, suitable precautions shall be taken to prohibit traffic over mulched areas. Displaced mulch shall be replaced immediately, including repair of the underlying seed bed, if damaged as well.

3.7 MAINTENANCE

A. The Contractor shall maintain all seeded areas until the grass is properly established (not less than 90 days) until satisfactory development. Maintenance shall be continued until final acceptance of the work.

B. Maintenance of seeded areas shall include protecting, watering, mowing, fertilizing, and such other work as may be necessary to establish a permanent lawn. The Contractor shall reseed those seeded areas in which a satisfactory growth is not obtained, and shall refill any areas which become eroded prior to final acceptance of the work.

C. Paved areas shall be kept clean while maintenance operations are in progress.

3.8 REPLACEMENT

A. The Contractor shall replace all trees, shrubs, and flowers damaged by construction activities in the areas designated on the construction plans. The replacement trees and shrubs shall be equal in size to the damaged or removed specimen.

END OF SECTION

DIVISION 33

UTILITIES

SECTION 33 05 23.16 – UTILITY PIPE JACKING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Encasement pipe installation specifications for roadway crossings.
   2. Encasement pipe installation specifications for pipe isolation requirements.

B. Related sections:
   1. Section 31 23 16 - Excavation
   2. Section 31 23 23.13 – Fill and Backfill
   3. Section 31 23 16.13 – Trenching for Site Utilities
   4. Section 31 50 00 – Excavation Support Systems

1.2 SUBMITTALS

A. Quality Control Submittals
   1. Diameter, thickness, and class of steel casing.
   2. Location of approach trenches, pits, and excavation.
   3. Schedule and method of construction including trench backfill and pipeline installation and backfill.
   4. Settlement control plan to protect existing utilities, streets, properties, or other structures and improvements from damage due to construction.
   5. As-builts information of the work.
   6. Certificate of insurance, applicable permits, bonds, and warranties and guaranties.

PART 2 - PRODUCTS

2.1 ENCASEMENT PIPE

A. Encasement pipe shall be used to provide a conduit for the carrier pipe passing below roadways, railroads, or other surfaces where the encasement pipe must be installed by jack and boring or at times open cut. Details for steel encasement are shown on the standard detail sheets in the Drawings.

B. Encasement pipe shall also be used to isolate new water lines in the proximity of existing sewer line to prevent possible sewage contamination of the water system. The locations, lengths and diameters are shown on the Drawings.

C. Encasement pipes used for road bores and isolation purposes shall be of the diameters shown on the Drawings and meet the requirements as specified herein. The minimum wall thickness for various nominal diameters is shown below:

Carrier Pipe Diameter	Minimum Casing Pipe Diameter	Casing Minimum Wall Thickness
(inches)	(inches)	(inches)
<6	8	0.188
6	10	0.281
8	14	0.281
10	18	0.313
12	22	0.344
14	24	0.375
16	26	0.406
18	28	0.438
20	28	0.469

D. The encasement pipe shall be a smooth wall, welded steel pipe conforming to the latest requirements of ASTM A139, Grade B, ASTM A211 or ASSA C202, Grade B with minimum yield strength of 35,000 psi. The encasement pipe shall be new. USED PIPE SHALL NOT BE ALLOWED.

E. In instances where encasement pipe is being used to isolate the water line, the length shall be the maximum possible to allow for one full joint of carrier pipe to be installed and extend out of both ends the minimum distance needed to install rubber end seals on both ends. The encasement pipe diameter shall be the smallest possible to install the carrier pipe and to center it in the encasement pipe by the use of manufactured casing spacers at both ends. The encasement pipe diameter shall also be compatible with the proper fit of rubber end seals. The encasement pipe wall thickness shall be a minimum of 0.1875" when used for isolation purposes only.

2.2 RUBBER END SEALS

A. Rubber end seals shall be manufactured products and shall be installed on both ends of the encasement pipe. They shall be the molded type secured to the encasement pipe and the carrier pipe via T-304 stainless steel worm gear bands.

B. The rubber end seals shall be as manufactured by:
1. Advance Products and Systems Inc. Model AC, AW
2. Calpico, Inc Model C, W
3. Or approved equal.

C. The Contractor shall submit shop drawings of the encasement pipe and rubber end seals for approval.

2.3 CASING SPACERS

A. A. Casing spacers shall be carbon steel or stainless steel, bolt on style type with a shell made of at least two halves. The bands shall be 14 gauge at a minimum; the risers shall be 10 gauge at a minimum, and the coating shall be fusion-bonded epoxy or heat fused PVC.

B. The casing spacers shall be manufactured by:
1. Advance Products and Systems, Inc. Model SI-12 or SSI-12
2. BWM Company Model SS-12 or FB-12
3. CCI Pipeline Systems
4. Pipeline Seal and Insulator, Inc. Model C12G

5. Calpico, Inc. Model M-12-FCE or M-12-SS

C. A minimum of three (3) bands per length of pipe shall be required.

2.4 DUAL CASING SPACERS

A. Casing Spacers shall be two-piece stainless steel (T304) shells
1. Three (3) Spacers per 20 foot run of pipe.

B. Shells shall be lined with ribbed PVC

C. Runners shall be mechanically bolted to spacer

D. Multiple carrier pipes shall be within the casing pipe and held at fixed distances.

E. Casing Spacers shall be manufactured by:
1. Cascade Waterworks - Style CCS08-MULTI

PART 3 - EXECUTION

3.1 EXAMINATION

A. Encasement pipe shop drawings shall be submitted to the Engineer for approval.

B. Rubber end seals shop drawings shall be submitted to the Engineer for approval.

3.2 INSTALLATION BY BORING AND JACKING

A. All encasement pipe specified in this Section shall be installed by the dry boring and jacking method unless called out otherwise herein and/or on the Drawings.

B. Installation of the encasement shall be carried out in such manner that there will be no settlement of the ground surface above the encasement. The Contractor shall take all precautions to prevent caving of the soils ahead of the pipe. During encasement installation, the Contractor shall use all care to minimize annular space (voids) between the outside of the encasement pipe and the surrounding ground. Therefore, the outside of encasement pipe installed by boring and jacking shall be pressure grouted to eliminate voids as specified below, unless excepted therein. Only the dry bore method shall be used. WATER JETTING OR SIMILAR METHODS USING WATER ARE STRICTLY PROHIBITED.

C. The Contractor shall inspect the locations where the encasement pipe and bore pits are to be installed and familiarize himself with the conditions under which the work will be performed and with all necessary details for the orderly prosecution of the work. The omission of any details in the Plans and/or herein for installation of the encasement and carrier pipe shall not relieve the Contractor of full responsibility for the proper execution and integrity of the work.

D. The Contractor shall satisfy himself of soils condition by any means he deems necessary, i.e., exploratory boring or exploratory pit excavations at bore ends. Any such exploratory work shall be done in such manner as to not jeopardize railroad or highway roadbeds and rights-of-way and shall be backfilled and cleaned up to the satisfaction of the right-of-way owner. The Contractor shall be responsible to obtain his own permission and to furnish bonds, etc. as may be required by private landowners or the public authority having jurisdiction at the site of any such exploratory work unless otherwise indicated on the Drawings or by the Owner/Engineer.

E. The Contractor shall perform all excavation required to complete the work regardless of the material encountered. Excavation from the access shafts (bore pits) in excess of that required to backfill the access shafts and open cut portion of the line shall be disposed of by the Contractor outside the limits of the construction site and at an approved location. Pits and trenches shall be properly shored, sheeted, and braced according to Section 31 50 00 – EXCAVATION SUPPORT SYSTEMS, of these Specifications.

F. Any damage to the encasement pipe coating during shipment or handling shall be repaired by the Contractor. Boring and installation of smooth wall pipe shall be by competent supervisors and workmen specializing in this type of work.

G. IN ORDER TO MAINTAIN THE DESIGNED SLOPE OF THE SEWER GRADIENT, THE HORIZONTAL AND VERTICAL ALIGNMENT AT ALL POINTS ON THE ENCASEMENT PIPE SHALL BE HELD TO A TOLERANCE OF ONE-TENTH (0.10) OF A FOOT OF THE DESIGNED LINE AND GRADE. ENCASEMENT PIPES NOT MEETING THIS TOLERANCE SHALL BE SUBJECT TO REMOVAL AND REPLACEMENT AT THE CONTRACTOR'S EXPENSE.

3.3 PRESSURE GROUTING

A. During installation of the encasement pipe, care shall be exercised to prevent voids between the encasement and the surrounding ground.

B. On encasement pipes of 12" and larger nominal diameter, the annular space between the encasement pipe and the ground shall be pressure grouted to eliminate all voids. ENCASEMENT PIPES SMALLER THAN 12" SHALL ALSO BE GROUTED IF SO DIRECTED BY THE OWNER DEPENDING ON SOIL CONDITIONS AT THE BORE SITE IDENTIFIED AT THE TIME OF ENCASEMENT INSTALLATION.

C. When grouting encasement pipes of such diameter that entry by a worker is possible, the grout shall be injected through the encasement pipe wall through 1.5" diameter holes from the inside at one location for each 5.0-foot linear interval over the entire length of the encasement pipe. The sequence for grout injection locations shall be as follows:

D.	*Locations	F.	"Clock"
E.	(5' Spaces)	G.	Positions
H.	1st	I.	12:00
J.	2nd	K.	3:00
L.	3rd	M.	12:00
N.	4th	O.	9:00
P.	5th	Q.	12:00

R. *Repeat 2nd through 5th locations at 5-foot intervals for each location to the end of the encasement pipe.

S. NOTE: THE CONTRACTOR SHALL BE RESPONSIBLE TO SEE THAT ALL REQUIREMENTS OF OSHA CONCERNING ENTRY OF WORKERS INTO CONFINED SPACES ARE FOLLOWED AS WELL AS ANY OTHER REQUIREMENTS FOR THIS TYPE OF WORK.

T. For encasement pipes too small to be entered for grouting as addressed above, the annular space may be pressure grouted by means of an external grout pipe attached to the outside of the encasement pipe. After the encasement pipe and the grout pipe are in place, the grout pipe shall be withdrawn as the grout is introduced into the annular space.

3.4 BORE PITS

A. The bore pits or access shafts for encasement installation shall be rectangular in plan view, approximately 20'x10', with the longer dimension being in the direction of the encasement pipe. The bore pits shall be sheeted, shored, and braced on all sides as addressed herein. Sheeting shall be timber or steel piling of ample strength to safely withstand all structural loading of whatever nature due to site and soil condition. The top of the sheeting shall be at a minimum elevation equal to the natural ground line as it existed prior to construction.

3.5 INSTALLATION OF CARRIER PIPE IN A BORED ENCASEMENT

A. Installation of the carrier pipe in the encasement shall be accomplished in such manner that neither the pipe nor the encasement is damaged. Care must be exercised to assure that the joints of the pipe are not over-deflected or pulled out during the process. The pipe shall be jointed and pushed or jacked through the encasement. Cables, chains, jacks or other equipment or devices used shall not be in direct contact with the pipe unless thoroughly padded.

B. The carrier pipe barrel, regardless of its diameter, shall be centered diametrically in the encasement pipe by the use of manufactured casing spacers compatible with the material of the carrier pipe. Also, all carrier pipe bell/spigot joints inside the encasement shall be restrained from movement in the axial direction by the use restrained casing spacers. There shall be a restrained casing spacer installed at each carrier pipe joint and another casing spacer without axial restraint (non-restrained) installed at the midpoint of each carrier pipe barrel or at a maximum interval of 10’. All casing spacers, whether restrained or non-restrained, shall also function as hold-down jacks to prevent the carrier pipe from floating.

C. All metal parts of casing spacers shall be ductile iron, or hot rolled pickled steel, or stainless steel. All casing spacers except stainless steel shall be shop coated with fusion bonded epoxy at 10-15 mils thickness or shall have a bituminous coating. For carrier pipe diameters larger than 24”, casing spacers with axial joint restraint and casing spacers for diametrical centering shall be stainless steel and shall be fitted with UMHW polyethylene runners (or skids) to contact the I.D. of the encasement pipe. They shall provide dielectric insulation between the carrier pipe and the encasement pipe. All such casing spacers shall have passed factory testing at a minimum pressure equal to the water line test pressure addressed herein.

D. Restrained casing spacers for carrier pipe diameters 24” and smaller shall be Uniflange Series USRCF1390 for the pipe joints or approved equal. Casing spacers without axial restraint for pipe barrels shall be Uniflange Series USRCF1300 or equal.

E. THE CONTRACTOR SHALL SUBMIT DRAWINGS, SPECIFICATIONS, AND CALCULATIONS DEMONSTRATING THE STRUCTURAL ADEQUACY OF HIS PROPOSED CENTERING/RESTRAINT SYSTEM TO PROPERLY SUPPORT THE CARRIER PIPE THE SAME AS SHOP DRAWINGS FOR REVIEW AND POSSIBLE APPROVAL.

F. If, after installation of the carrier pipe, adequate stability has not been provided, in the opinion of the Owner, the annular space between the carrier pipe and the inside of the encasement pipe shall be filled with sand or other material approved by the Owner.

G. After the carrier pipe has been installed in the encasement pipe, both ends of the encasement pipe shall be tightly bulk headed, sealed, and vented, substantially as shown or indicated on the Drawings.

3.6 INSTALLATION BY OPEN TRENCH METHOD

A. Where encasement pipe for isolation of water lines from sewer lines is used as addressed herein, the encasement pipe shall be installed so as to preserve the planned line and grade of the water pipe. It shall be considered the same as the water pipe for trenching, bedding, and backfill purposes.

B. The carrier pipe, the end seals, the casing spacers, and the encasement pipe shall be assembled outside of the trench and shall be installed as a single unit.

C. Extreme care shall be used by the Contractor to assure that the rubber end caps are not damaged during installation and backfilling. It is essential that a water-tight seal exist where the rubber end seals contact the carrier pipe and the encasement pipe.

3.7 MEASUREMENT AND PAYMENT

A. Bored Encasement Pipe and Carrier Pipe: Measurement and payment shall be made by the linear foot of encasement pipe installed based on horizontal measurement for the various diameters shown in the Unit Price Schedule herein, but not to exceed the planned length shown on the Plans or modified as provided herein. PAYMENT WILL BE MADE FOR THE COMPLETE INSTALLATION OF THE ENCASEMENT PIPE AND SHALL INCLUDE INSTALLING THE CARRIER PIPE INSIDE THE ENCASEMENT. Such payment shall be total compensation for furnishing and installing the encasement pipe and installing the carrier pipe within the encasement pipe as described herein and all other items of work or materials needed for a complete installation. No separate measurement or payment will be made for bore pit excavation, sheeting, shoring, etc., or fittings, skids, casing spacers, straps, or other appurtenances, or for sealing, venting, marking, or protecting the encasement pipe unless outlined herein and shown in the Unit Price Schedule.

B. Open Cut Installation of Encasement Pipe and Carrier Pipe: Where encasement pipe is used for isolation of water lines from sewer lines, it shall be measured per each installation as shown in the Drawings, specified herein, or directed by the Owner. MEASUREMENT SHALL INCLUDE INSTALLING THE ASSEMBLED ENCASEMENT PIPE, CARRIER PIPE, CASING SPACERS, AND RUBBER END SEALS AND SHALL ALSO INCLUDE FURNISHING THE ENCASEMENT PIPE, THE CASING SPACERS, AND THE RUBBER END SEALS. THE CARRIER PIPE MATERIAL IS MEASURED AS “WATER LINE & FITTINGS”. Payment shall be at bid price per each shown in the Unit Price Schedule.

END OF SECTION

SECTION 33 05 23.53 – HORIZONTAL DIRECTION DRILLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Section includes requirements for Horizontal Directional Drilling (HDD) of crossings and related work for the construction of the designated pipeline and other incidental work

B. The work shall include, but is not limited to, the following:

1. Furnish all materials to construct work according to drawings and specifications.
2. Permits, bonds, insurance and other as required by regulating authorities.
3. Coordination with regulating authorities.
4. Protective fence, berms and/or guard rails as required by regulating authorities.
5. Temporary traffic control as required by regulating authorities,

C. Related sections:
1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
   a. Section 31 11 00 – Site Preparation
   b. Section 33 11 10 – Water Mains Pressure & Leakage Tests
   c. Section 33 41 00 – Reinforced Fiberglass (FRP) Pipe
   d. Section 40 23 39.43 – Polyvinyl Chloride (PVC) Pipe
   e. Section 40 23 39.56 – High Density Polyethylene (HDPE) Pipe

1.2 QUALITY ASSURANCE

A. Compliance with specifications:
1. Furnish proof acceptable to the Owner, when called for during construction, that all pipe installed equal or exceed all requirements specified for this work.
2. If such proof is not submitted or is unacceptable, replace all such items to conform to the specifications, and repair any damage, all at no cost to the Owner.

3. Experience: Actively engaged in horizontal directional drilling for minimum of 3 years.

4. Field supervisory personnel: Experienced in the performance of work and tasks as stated herein for minimum of 3 years.

1.3 SUBMITTALS

A. Information Only Submittal:

1. Presentation of similar experience in the last 3 years.
2. Include, but not limited to, owner name, address, telephone number, contact person, date and duration of work, location, pertinent project information, and contents handled by pipeline.

3. Supervisory field personnel and historical information of HDD experience. At least one field supervisor listed must be at site when HDD operations are in progress.

B. Insertion or Access Pits: The location and number of insertion or access pits shall be planned by the Contractor and submitted in writing for approval to the Engineer prior to excavation. The pits shall be located such that their total number shall be minimized, and the footage of liner pipe installed in a single pull shall be maximized. Locations of damaged pipe shall be used for insertion pits as directed by the Engineer.

C. As-built drawings: During progress of the work, maintain an accurate record of all changes made in the PIPING installation from the layout and materials shown on the approved shop drawings.

PART 2 - PRODUCTS

2.1 PIPE MATERIAL

1. PVC Pressure Pipe - Integrally restrained joint PCV pipe or fusible PVC pipe
2. Drilling Fluid – Bentonite drilling product compatible with environment. Waste oil or environmentally non-compatible polymers cannot be part of composition.
3. Tracer Wire – 45-mil, high density, high molecular weight polyethylene (HDPE) insulation

PART 3 - EXECUTION

3.1 PREPARATION

A. Excavate pits according to trenching standard detail and Section 31 23 16 Excavation.

B. Provide equipment to guard against electrocution and alarm system on drilling equipment capable of detecting electrical current as it approaches electric lines.

C. Verify depth and location of underground utility crossings before HDD operation.

3.2 GENERAL OPERATION

A. Determine drilling length and equipment pull strength for type of soil encountered.

B. Provide method to control line and grade and maintain instrumentation that accurately locates pilot hole.

C. Drill pilot hole along path following Drawings to these tolerances:

1. Vertical alignment ± 0.5 feet. Vertical path of pilot hole must not establish new high points not shown on Drawings.
2. Horizontal alignment ± 1.0 feet.

D. Include electronic monitoring of horizontal and vertical drilling head location. Obtain accuracy range within 1 inch of actual position of pipeline. Record position readings at maximum of 10 foot intervals.

E. At completion of pilot hole drilling, furnish bore log which should include at a minimum, tabulations of horizontal and vertical alignment to Engineer for approval prior to reaming and pipe installation.

3.3 DRILLING OPERATION FLUIDS

A. Maintain drilling fluid in bore hole to increase stability of surrounding soil and reduce drag on pulled pipe.

B. Dispose of drilling fluid and other spoils at location following laws, ordinances, rules, and regulations of local jurisdiction.

C. Transport excess fluids and other spoils to disposal site, at no additional cost to the Owner.

D. Minimize drilling fluid at locations other than entry and exit points. Immediately clean up any drilling fluids that inadvertently surface.

E. Provide clean water for drilling, at no cost to the Owner, at Engineer's requirement.

3.4 PILOT HOLE DRILLING OPERATION

A. Angle entry hole so that curvature of pilot hole does not exceed 75% of the manufacturer's allowable bending radius for PVC pipe.

B. Alignment Adjustment and Restarts:

1. Follow pipeline alignment on Drawings within tolerances specified herein. Before adjustments, notify Engineer for approval.
2. Notify Engineer when forward motion of operation is stopped by an obstruction. Abandon in place with drilling fluid, unless Engineer directs otherwise.

C. Withdrawals, abandonments, and restarts are at no additional cost.

D. Exercise caution including, but not limited to, locating utilities, drilling downholes (test pits) to observe drill stems or reamer assembly to clear other existing utilities at locations following Drawings.

E. Keep the number of boring pits to a minimum, unless otherwise approved by Engineer.

3.5 INSTALLATION

A. Provide a swivel to reaming assembly and pull section of pipe to minimize torsional stress on pull section after drilling pilot hole.

B. Hold reaming diameter to 1.5 times outside diameter of PVC pipe being installed.

C. Protect pull section as it proceeds during pull back so it moves freely and is not damaged.

D. Pull tracer wire along with PVC pipe:

1. Securely connect tracer wire to the top of pipe at intervals to prevent movement or separation from the pipe tracer wire.
2. Connect at each end of PVC pipe without unnecessary splices.
3. Consider installing tracer wire in redundancy or other methods to assure continuity of assembled tracer wire.
4. Test tracer wire installation to ensure successful continuity of signal.

E. When connecting to adjacent pulled or non-pulled section of PVC pipe, allow pull section of pipe to extend past termination point. Make tie-ins after pullback of PVC pipe has had an opportunity to expand or contract.

F. Test pit pipe installation to verify horizontal and vertical alignment at Engineer's direction.

1. One test pit for every 500 feet along length of pipeline.
2. Engineer may order additional test pit for each test pit that reveals pipeline installation is not in compliance with Contract Documents at no additional cost to the Owner.

G. Replace portions of pipeline not in compliance with Contract Documents at Engineer's direction and at no additional cost.

3.6 FIELD QUALITY ASSURANCE

A. Perform field testing (disinfection and hydrostatic pressure testing) of PVC pipe following Section 33 11 11.

END OF SECTION

SECTION 33 11 11 – PIPING LEAKAGE TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work, materials, and procedures required to test installed piping other than gravity sewer piping.

B. Related sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 40 23 39 – Process Piping General.

C. See Section 40 23 39, PROCESS PIPING GENERAL, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

1.2 SUBMITTALS

A. Submittals shall be made as required in Section 01 33 00, SUBMITTAL PROCEDURES. The following specific information shall be provided:
   1. Quality Control Submittals:
      a. Testing Plan: Submit at least 30 days prior to testing and include at least the information that follows.
         1) Testing dates.
         2) Piping systems and sections(s) to be tested.
         3) Test type.
         4) Method of isolation.
         5) Calculation of maximum allowable leakage for piping sections(s) to be tested.
      b. Certifications of Calibration: Testing equipment.
      c. Certified Test Report.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:
   1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
   2. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
   3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
   4. New Piping connected to Existing Piping:
      a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.
      b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Engineer.
   5. Items that do not require testing include: Equipment seal drains, tank overflows to atmospheric vented drains, and tank atmospheric vents.
   6. Test Pressure: As indicated on the Piping Schedule.

C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

D. Gravity Piping:
1. Perform test as specified hereinafter.
2. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
3. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.

3.2 HYDROSTATIC TEST FOR PRESSURE PIPING

A. Test piping as indicated in pipe schedule.

B. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.

C. Exposed Piping:
1. Perform testing on installed piping prior to application of insulation.
2. Maximum Filling Velocity: 0.25 feet per second, applied over full area of pipe.
3. Vent piping during filling: Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
4. Maintain hydrostatic test pressure continuously for 60 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
5. Examine joints and connections for leakage.
6. Correct visible leakage and retest as specified.
7. Empty pipe of water prior to final cleaning.

D. Buried Piping:
1. Test after backfilling has been completed.
2. Expel air from piping system during filling.
3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
6. Maximum Allowable Leakage:

$$L = \frac{S\,D\,\sqrt{P}}{148{,}000}$$

Where:
L = testing allowance (makeup water) (gph)
S = length of pipe tested (ft)
D = nominal diameter of the pipe (in.)
P = average test pressure during the hydrostatic test (psi [gauge])

7. Correct leakage greater than allowable, and retest as specified.

3.3 PNEUMATIC TEST FOR PRESSURE PIPING

A. Test piping as indicated in pipe schedule.

B. Do not perform on:
1. PVC or CPVC pipe.
2. Piping larger than 18 inches.
3. Buried and other non-exposed piping.

C. Fluid: Oil-free, dry air.

D. Procedure:
   1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections, examine for leakage.
   2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
   3. Gradually increase pressure in system to half of specified test pressure. Thereafter increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
   4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
   5. Correct visible leakage and retest as specified.

E. Allowable Leakage: Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

F. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

3.4 HYDROSTATIC TEST FOR 18-INCH THROUGH 30-INCH GRAVITY PIPING.

A. Testing Equipment Accuracy: Plus or minus 1/2-gallon of water leakage under specified conditions.

B. Maximum Allowable Leakage: 0.16 gallons per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.

C. Exfiltration Test:
   1. Hydrostatic Head:
      a. At least 6 feet above maximum estimated groundwater level in section being tested.
      b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
   2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

D. Infiltration Test:
   1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

E. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered *defective* even if pipe previously passed a leakage test.

F. *Defective* Piping Sections: Replace or test and seal individual joints, and retest as specified.

3.5 PNEUMATIC TEST FOR GRAVITY PIPING 12-INCH AND SMALLER

A. Equipment:
   1. Calibrate gauges with standardized test gauge at start of each testing day.
   2. Install gauges, air piping manifolds, and valves at ground surface.
   3. Provide pressure release device, such as rupture disc or pressure relief valve, to relieve pressure at 6 psi or less.
   4. Restrain plugs used to close sewer lines to prevent blowoff.

B. Procedure:
   1. Require that no person enter manhole where pipe is under pressure.

2. Slowly introduce air into pipe section until internal air pressure reached 4 psi greater than average back pressure of groundwater submerging pipe.
3. Allow 2 minutes minimum for air temperature to stabilize.

C. Allowable Leakage: Test section will be considered *defective* when time required for pressure to decrease from 3.5 to 2.5 psi greater than average back pressure of groundwater submerging pipe is less than that computed utilizing values from following table:

D.

TABLE 1*

A	B	C	D	E	F
Pipe Diameter (Inches)	**Time per Foot up to Length in Col C (Seconds)**	**Test Length (Feet)**	**Test Time for any Length Between Col C & E**	**Length at Which time in Col F Applies (Feet)**	**Time per Foot for Total Length (Seconds)**
	0.18	636	1:54	1.114	0.10
	0.40	424	2:50	743	0.23
	0.71	318	3:47	557	0.41
10	1.11	255	4:43	446	0.63
12	1.60	212	5:40	371	0.91
15	2.50	170	7:05	297	1.42
18	3.62	141	8:30	248	2.06
21	4.92	121	9:55	212	2.81
24	6.42	106	11:20	187	3.67

EXAMPLE: 15-inch diameter pipe:
For 150 feet, T = 2.50 sec (Col B) x 150 ft = 375 sec – 6:15
For 250 feet, T = 7:05 (Col D)
For 500 feet, T = 1.42 sec (Col F) x 500 ft = 710 sec = 11:50

* Based on 0.003 cfm per square foot with a minimum significant loss of 2 cfm and a maximum loss of 3.5 cfm.

E. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered *defective* even if pipe previously passed a leakage test.

F. *Defective* Piping Sections: Replace or test and seal individual joints, and retest as specified.

3.6 JOINT TESTING FOR 36-INCH AND LARGER GRAVITY PIPING

A. The Contractor shall develop a numbering system for the pipeline joints so that the test logs can be tied to the tested joint.

B. The Contractor shall develop a test system that allows the Engineer reasonable access for witnessing the joint testing. The contractor shall submit his proposed testing plan to the Engineer for approval prior to the start of testing.

C. Pressurize the void at the joint with air to 3.5 psi greater than the pressure exerted by groundwater above the pipe. Allow the air pressure and temperature to stabilize before shutting off the air supply, and start of test timing. If pressure holds, or drops less than 1 psi in 5 seconds, the joint is acceptable.

D. If there is any visible leakage within the pipeline after the joint testing, repairs will be required before the pipeline is accepted.

3.7 FIELD QUALITY CONTROL

A. Test Report Documentation:
   1. Test date.
   2. Description and identification of piping tested.
   3. Test fluid.
   4. Test pressure.
   5. Remarks, including:
      a. Leaks (type, location).
      b. Repair/replacement performed to remedy excessive leakage.
   6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 33 31 13 – STEEL ENCASEMENT PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the Work necessary to provide and install steel encasement pipe for water and sewer lines.

B. Related sections:

1. Section 31 23 16.13 – Trenching for Site Utilities.

1.2 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:

1. Quality Control Submittals:
   a. Steel encasement diameter, and thickness.
   b. End seal shop drawings.
   c. Casing spacer shop drawings.
   d. Special shipping, storage and protection, and handling instructions.
   e. Test procedures.
   f. Test results, reports, and certifications.

PART 2 - PRODUCTS

2.1 ENCASEMENT PIPE

A. Encasement pipe shall be used to provide a conduit for the carrier pipe passing below roadways, railroads, or other surfaces where the encasement pipe must be installed by jack and boring or at times open cut. Details for steel encasement are shown on the Plans.

B. Encasement pipe shall also be used to isolate new water lines in the proximity of existing sewer line to prevent possible sewage contamination of the water system. The locations, lengths and diameters are shown on the Plans.

C. Steel encasement pipes shall be of the lengths shown on the Drawings and meet the requirements as specified herein. The encasement pipe shall be a smooth wall, welded steel pipe conforming to the latest requirements of ASTM A139, Grade B, ASTM A211 or ASSA C202, Grade B with minimum yield strength of 35,000 psi. The encasement pipe shall be new. USED PIPE SHALL NOT BE ALLOWED. The minimum diameter wall thickness for various nominal diameters of carrier pipes is shown below:

Carrier Pipe Nominal Diameter (inches)	Steel Encasement Pipe Diameter (inches)	Steel Encasement Pipe Minimum Wall Thickness (inches)
6	12	0.2500
8	16	0.3125
10	20	0.3750
12	20	0.3750
14	24	0.4375
16	24	0.4375
18	30	0.5000
20	30	0.5000
24	36	0.5625

D. In instances where encasement pipe is being used to isolate the water line, the minimum length of encasement pipe shall be 20 linear feet. The encasement pipe shall be centered on the crossing water or sewer line.

2.2 CASING SPACERS

A. Shall be stainless steel, Cascade Model CCS as manufactured by Cascade Waterworks Mfg. Co., or approved equal.

B. Restrained joints shall have restrained joint type stainless steel casing spacers, Cascade Model CCS-JR as manufactured by Cascade Waterworks Mfg. Co., or approved equal.

C. Spacers shall be designed to support the carrier within the casing and to maintain a maximum clearance of one (1) inch between the casing pipe and runner. Spacers shall be 8 inches wide for carrier pipes up to 14 inches in diameter and 12 inches wide for carrier pipes greater than 14 inches in diameter.

D. The quantity of runners shall be dependent on the carrier pipe diameter as follows, unless otherwise approved:

Carrier Pipe Nominal Diameter	Quantity of Runners
≤ 14 inches	4
16-36 inches	6
42-48 inches	8

E. Runners shall be abrasion resistant glass-filled polymer or ultra-high weight molecular polyethylene, with a minimum length of seven (7) inches and a minimum width of one (1) inch. Risers, when required, shall be stainless steel and welded to the band. Interior surfaces of the circular stainless steel band shall be lined with a minimum thickness of 0.09 inches of EPDM or PVC, or approved alternative.

2.3 RUBBER END SEALS

A. Rubber end seals shall be installed on both ends of the encasement pipe. They shall be the Pull-On type secured to the encasement pipe and the carrier pipe via T-304 stainless steel worm gear bands. The rubber end seals shall be as manufactured by CCI Piping Systems; model ESC, Cascade Waterworks Mfg. Co.; model CCES, or approved equal.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Highway Bore: Do not set up equipment or begin excavating pit on state highway right-of-way without permission of Colorado Department of Transportation Engineer or his authorized representative.

B. Railroad Bore: Do not set up equipment or begin excavating pit on or near railroad property without permission of the respective railroad company.

C. Highway and railroad permits will be obtained by the Owner. Contractor shall coordinate with Engineer on obtaining Right-of-Way permit from railroad and shall conform to all requirements therein.

3.2 INSTALLATION, ENCASEMENT PIPE

A. General

1. Install encasement pipe at grade and alignment shown on Plans. Allow for height of casement spacers when establishing grade for gravity line encasement pipe. Refer to Standard Details.

B. Bores

1. Excavate pits and trenches required at each side of crossing to minimum width and length necessary for boring and jacking operation and carrier pipe installation.
2. Carefully set steel guide rails in pit to attain specified grade and alignment.
3. Keep pit pumped free of standing water. Maintain pit bottom to provide stable base for rails and equipment and firm footing for workmen. Granular material used in bottom of pit will not be paid for as extra work, it is subsidiary to encasement pipe.
4. Provide temporary sheeting and bracing as necessary to prevent earth slides.
5. Bore tunnel and simultaneously jack encasement pipe forward one section at a time. Connect sections by full penetration butt welding performed in accordance with AWS D1.1.
6. Remove excavated soil from boring operation as it enters pit and dispose of it offsite.
7. All bored encasement pipe shall be installed by the dry boring and jacking method. Wet boring shall not be allowed.
8. Installation of the encasement shall be carried out in such manner that there will be no settlement of the ground surface above the encasement. The Contractor shall take all precautions to prevent caving of the soils ahead of the pipe. During encasement installation, the Contractor shall use all care to minimize annular space (voids) between the outside of the encasement pipe and the surrounding ground. Therefore, the outside of encasement pipe installed by boring and jacking shall be pressure grouted to eliminate voids as specified below, unless excepted therein. Only the dry bore method shall be used. WATER JETTING OR SIMILAR METHODS USING WATER ARE STRICTLY PROHIBITED.
9. The Contractor shall inspect the locations where the encasement pipe and bore pits are to be installed and familiarize himself with the conditions under which the work will be performed and with all necessary details for the orderly prosecution of the work. The omission of any details in the Plans and/or herein for installation of the encasement and carrier pipe shall not relieve the Contractor of full responsibility for the proper execution and integrity of the work.
10. The Contractor shall satisfy himself of soils condition by any means he deems necessary, i.e., exploratory boring or exploratory pit excavations at bore ends. Any such exploratory work shall be done in such manner as to not jeopardize railroad or highway roadbeds and rights-of-way and shall be backfilled and cleaned up to the satisfaction of the right-of-way

owner. The Contractor shall be responsible to obtain his own permission and to furnish bonds, etc. as may be required by private landowners or the public authority having jurisdiction at the site of any such exploratory work unless otherwise indicated on the Plans or by the Owner/Engineer.

11. The Contractor shall perform all excavation required to complete the work regardless of the material encountered. Excavation from the access shafts (bore pits) in excess of that required to backfill the access shafts and open cut portion of the line shall be disposed of by the Contractor outside the limits of the construction site and at an approved location. Pits and trenches shall be properly shored, sheeted, and braced according to Section 31 50 00, EXCAVATION SUPPORT SYSTEMS, of these Specifications.
12. Any damage to the encasement pipe coating during shipment or handling shall be repaired by the Contractor. Boring and installation of smooth wall pipe shall be by competent supervisors and workmen specializing in this type of work.
13. IN ORDER TO MAINTAIN THE DESIGNED SLOPE OF THE SEWER GRADIENT, THE HORIZONTAL AND VERTICAL ALIGNMENT AT ALL POINTS ON THE ENCASEMENT PIPE SHALL BE HELD TO A TOLERANCE OF ONE-TENTH (0.10) OF A FOOT OF THE DESIGNED LINE AND GRADE. ENCASEMENT PIPES NOT MEETING THIS TOLERANCE SHALL BE SUBJECT TO REMOVAL AND REPLACEMENT AT THE CONTRACTOR'S EXPENSE.

C. Open-Cut

1. See Section 31 23 16.13 for trenching and backfilling requirements.
2. Steel encasement installed by open-cut shall conform to this specification.
3. When practical, the carrier pipe, the end seals, the casing spacers, and the encasement pipe shall be assembled outside of the trench and shall be installed as a single unit.
4. Extreme care shall be used by the Contractor to assure that the rubber end caps are not damaged during installation and backfilling. It is essential that a water-tight seal exist where the rubber end seals contact the carrier pipe and the encasement pipe.

3.3 INSTALLATION, CARRIER PIPE

A. Installation of the carrier pipe in the encasement shall be accomplished in such manner that neither the pipe nor the encasement is damaged. Care must be exercised to assure that the joints of the pipe are not over-deflected or pulled out during the process. The pipe shall be jointed and pushed or jacked through the encasement. Cables, chains, jacks or other equipment or devices used shall not be in direct contact with the pipe unless thoroughly padded.

B. The carrier pipe barrel, regardless of its diameter, shall be centered diametrically in the encasement pipe by the use of casing spacers compatible with the material of the carrier pipe. Also, all carrier pipe bell/spigot joints inside the encasement shall be restrained from movement in the axial direction by the use restrained casing spacers. There shall be a restrained casing spacer installed at each carrier pipe joint and another casing spacer without axial restraint (non-restrained) installed at the midpoint of each carrier pipe barrel or at a maximum interval of 10'. All casing spacers, whether restrained or non-restrained, shall also function as hold-down jacks to prevent the carrier pipe from floating.

C. If, after installation of the carrier pipe, adequate stability has not been provided, in the opinion of the Owner, the annular space between the carrier pipe and the inside of the encasement pipe shall be filled with sand or other material approved by the Owner.

D. After the carrier pipe has been installed in the encasement pipe, both ends of the encasement pipe shall be sealed with end seals.

3.4 PRESSURE GROUTING

A. During installation of bored encasement pipe, care shall be exercised to prevent voids between the encasement and the surrounding ground.

B. On encasement pipes of 12" and larger nominal diameter, the annular space between the encasement pipe and the ground shall be pressure grouted to eliminate all voids. ENCASEMENT PIPES SMALLER THAN 12" SHALL ALSO BE GROUTED IF SO DIRECTED BY THE OWNER DEPENDING ON SOIL CONDITIONS AT THE BORE SITE IDENTIFIED AT THE TIME OF ENCASEMENT INSTALLATION.

C. When grouting encasement pipes of such diameter that entry by a worker is possible, the grout shall be injected through the encasement pipe wall through 1.5" diameter holes from the inside at one location for each 5.0-foot linear interval over the entire length of the encasement pipe. The sequence for grout injection locations shall be as follows:

*Locations (5' Spaces)	"Clock" Positions
1st	12:00
2nd	3:00
3rd	12:00
4th	9:00
5th	12:00

*Repeat 2nd through 5th locations at 5-foot intervals for each location to the end of the encasement pipe.

NOTE: THE CONTRACTOR SHALL BE RESPONSIBLE TO SEE THAT ALL REQUIREMENTS OF OSHA CONCERNING ENTRY OF WORKERS INTO CONFINED SPACES ARE FOLLOWED AS WELL AS ANY OTHER REQUIREMENTS FOR THIS TYPE OF WORK.

D. For encasement pipes too small to be entered for grouting as addressed above, the annular space may be pressure grouted by means of an external grout pipe attached to the outside of the encasement pipe. After the encasement pipe and the grout pipe are in place, the grout pipe shall be withdrawn as the grout is introduced into the annular space.

3.5 BORE PITS

A. Excavation and backfill shall be as specified in Section 31 23 16.13.

B. The bore pits or access shafts for encasement installation shall be rectangular in plain view, approximately 20'x10', with the longer dimension being in the direction of the encasement pipe. The bore pits shall be sheeted, shored, and braced on all sides as addressed herein. Sheeting shall be timber or steel piling of ample strength to safely withstand all structural loading of

whatever nature due to site and soil condition. The top of the sheeting shall be at a minimum elevation equal to the natural ground line as it existed prior to construction.

END OF SECTION

SECTION 33 31 23 – TESTING SANITARY SEWER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the Work necessary to test gravity sewer pipe, force main pipe, manholes and appurtenances.

B. Related sections:
   1. Section 33 39 13 – Concrete Manholes
   2. Section 33 34 13 – Ductile Iron Force Main Pipe and Fittings
   3. Section 33 34 16 – Solid Wall PVC Force Main Pipe and Fittings
   4. Section 33 41 16 – Ductile Iron Gravity Sewer Pipe and Fittings
   5. Section 33 41 20 – Solid Wall PVC Gravity Sewer Pipe and Fittings

1.2 GENERAL

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. The contractor is responsible for supplying all equipment required to conduct testing and all testing shall be conducted by the Contractor.

B. All testing shall be conducted in the presence of the Engineer.

3.2 GRAVITY SEWER TESTING

A. The Contractor shall have the option of verifying water tightness by either air testing or water testing. The Engineer shall have the option to require testing by both methods to verify marginal results.

B. Gravity Sewers – Air Testing:
   1. After gravity sanitary sewer and service pipe have been laid, all newly laid sewer main pipe shall be subject to an air pressure test to determine watertightness from air loss.
   2. Test Equipment:
      a. All necessary equipment to perform the air test in accordance with this specification shall be provided by the Contractor. The test gauge shall have incremental divisions of 0.10 psi and have an accuracy of at least plus or minus 0.04 psi. In no case shall a test gauge be used which has incremental divisions of greater than 0.25 psi. The gauge shall be of sufficient size to determine accuracy.
   3. Procedure:
      a. As each section of sewer is completed between manholes, each section shall be air tested. When practical, house connections in each section shall be completed. Air test shall be low-pressure air test based on the principal of air-pressure loss per time period. Contractor shall prepare a log of testing and submit this to the Engineer as each section is completed and tested. All tests shall be accomplished in the presence of the Engineer.

b. The test section of the sewer line is plugged at each end. One of the plugs used at the manhole must be tapped and equipped for air inlet connection for filling the line from the air compressor.

c. All service laterals, stubs and fittings into the sewer test section shall be properly capped or plugged, and carefully braced against the internal pressure to prevent air leakage by slippage and blowouts.

d. Connect air hose to tapped plug selected for the air inlet. Then connect the other end of the air hose to the portable air control equipment which consists of valves and pressure gauge used.
   1) To control air entry rate to the sewer test section, and
   2) To monitor the air pressure in the pipe line.

   More specifically, the air control equipment includes a shutoff valve, pressure regulating valve, pressure reduction valve and a monitoring pressure gauge having a pressure range from 0-5 psi. The gauge shall have minimum divisions of 0.10 psi and an accuracy of 0.04 psi.

e. Connect another air hose between the air compressor (or other source of compressed air) and the air control equipment. This completes the test equipment set-up. Test operations may commence.

f. Supply air to the test section slowly, filling the pipe line until a constant pressure of 4.0 psig is maintained. The air pressure must be regulated to prevent the pressure inside the pipe from exceeding 5.0 psig.

g. When constant pressure of 4.0 psig is reached, throttle the air supply to maintain the internal pressure between 3.5 to 4.0 psig for at least 5 minutes. This time permits the temperature of the entering air to equalize with the temperature of the pipe wall. If leakage is detected at any cap or plug, release the pressure in the line and tighten all leaky caps and plugs.

   Then start the test operation again by supplying air. When it is necessary to bleed off the air to tighten or repair a faulty plug, a new five-minute interval must be allowed after the pipeline has been refilled.

h. After the stabilization period, adjust the air pressure to 3.5 psig and shutoff or disconnect the air supply. Observe the gauge until the air pressure reaches 3.5 psig. At 3.5 psig commence timing with a stop watch which is allowed to run until the line pressure drops to 2.5 psig at which time the stop watch is stopped. The time required, as shown on the stop watch for a pressure loss of 1.0 psig, is used to compute the air loss.

i. If the time in minutes and seconds for the air pressure to drop from 3.5 to 2.5 psig is greater than that shown in the table for the designated pipe size, the section undergoing test shall have passed and shall be presumed to be free of defects. The test may be discontinued at that time.

j. If the time in minutes and seconds for the 1.0 psig drop is less than that shown on the table for the designated pipe size, the section of pipe shall not have passed the test; therefore, adequate repairs must be made and the line retested.

k. Pipe sizes with their respective recommended minimum times, in minutes and seconds, for acceptance by the air test method are as shown below.

Minimum Time For A 1.0 psig Pressure Drop (Min:Secs)										
Distance Between Manholes	Nominal Diameter (inches)									
	8	10	12	15	18	21	24	30	36	42
100'	7:33	9:26	11:20	14:10	17:00	19:50	22:47	35:37	51:17	69:48
150'	7:33	9:26	11:20	14:10	17:00	26:11	34:11	53:25	76:55	104:42
200'	7:33	9:26	11:23	17:48	25:38	34:54	45:34	71:13	102:34	139:37
250'	7:33	9:53	14:14	22:15	32:03	43:38	56:58	89:02	128:12	174:30
300'	7:35	11:52	17:05	26:42	38:27	52:21	68:22	106:50	153:50	209:24
350'	8:51	13:51	19:56	31:09	44:52	61:08	79:46	124:38	179:29	244:19
400'	10:07	15:49	22:47	35:36	51:17	69:48	91:10	142:26	205:07	279:13
450’	11:23	17:48	25:38	40:04	57:41	78:32	102:33	160:15	230:46	314:07
500’	12:39	19:47	28:29	44:31	64:06	87:15	113:57	178:03	256:24	349:01

Times for distances not listed in the table can be obtained by calculating the straight-line ratio between distances given.

l. For testing of long sections or sections of larger diameter pipes, or both, a timed-pressure drop of 0.5 psig may be used in lieu of a 1.0 psig timed-pressure drop as approved by the Owner or Engineer. If a 0.5 psig pressure drop is used, the appropriate required test time shall be exactly one-half the values shown in the table above.

m. An air pressure correction is required when the prevailing ground water is above the sewer line being tested. Under this condition, the air test pressure must be increased 0.433 psi for each foot the ground water level is above the invert of the pipe.

n. Height of ground water above sewer pipe shall be determined by a method approved by the Engineer.

o. Any leaks in the system shall be repaired immediately upon discovery. Costs for repairing faulty work, including excavating and re-backfilling and for making tests, shall be paid for by the Contractor.

4. Safety Precautions:

a. The low pressure air test may be dangerous to personnel if, through lack of understanding or carelessness, a line is over pressurized or plugs are installed improperly. It is extremely important that the various plugs be installed to prevent the sudden expulsion of a poorly inflated plug. As an example of the hazard, a force of 250 pounds is exerted on an 8 inch plug by an internal pressure of 5 psi. Observe the following safety precautions.

1) No one shall be allowed in the manholes during the test or when a plugged pipe is under pressure.

2) Gauges, air piping manifolds, and valves shall be located at the top of the ground.

3) Install and brace all plugs securely.

4) Do not over pressurize the lines.

C. Gravity Sewers – Water Testing:

1. Water testing will be by either the infiltration method or by the exfiltration method if approved by the Engineer. Testing for water-tightness shall be made by the Contractor in the presence of the Engineer. The Contractor shall provide all equipment, plugs, bulkheads, fittings, water, etc. needed for the testing. The water used for testing shall be paid for by the Contractor.

2. The Engineer shall have the right to direct that either the infiltration or the exfiltration water testing be performed based on groundwater conditions at the time.

3. The tests and measurements of the infiltration method shall be as approved by the Engineer. In all cases, the pipeline shall not leak under exterior ground water pressure in excess of 100 gallons per inch of nominal pipe diameter per mile of pipe per 24 hours. Leaks causing any sewer to fail such test shall be repaired until infiltration meets the allowable limit.
4. If, in the opinion of the Engineer, the ground water table at the time of testing is too low to produce dependable infiltration measurement results, the Contractor shall perform the exfiltration method test. The allowable limit shall be as given above including any manholes in the section(s) being tested. Water required for exfiltration test shall be obtained at the Contractor's expense.
5. Where the exfiltration test method is used, the following shall apply:
    a. The downstream end of the pipe section being tested shall be plugged and the plug shall be braced and blocked securely. No one shall be allowed to enter a manhole where a plugged pipe is under pressure. Any other pipe entrances to the upstream manhole shall likewise be securely plugged.
    b. Only water from a source approved by the Engineer shall be used to perform the test. Waste water shall not be used to perform exfiltration testing.
    c. Water shall be added through the upstream manhole of the line section being tested to a depth of 2.0 feet above the inside top of the outgoing pipe (or 2.0' above the ground water level - see d. below). The water shall be maintained at this level for 24 hours prior to beginning the exfiltration test measurement.
    d. There shall be a minimum of 2.0' positive head above the inside top of the pipe at the high end of the section being tested. This means, if the ground water in the trench is at (or above) the top of the pipe, then the manhole shall be filled to a point at least 2.0' above the ground water level.
    e. The test shall be conducted for two hours. The leakage shall be determined by the calculated change in total volume of water used in the test.

3.3 PIPE DEFLECTION TESTING

A. General
1. All PVC, FRP, and Ductile Iron gravity sewer lines shall be mandrel tested in accordance with these specifications prior to acceptance.

B. Allowable Deflection:
1. The maximum allowable pipe deflection shall not exceed 5 percent of the inside diameter.

C. Mandrel:
1. The mandrel shall be hand-pulled by the Contractor through all PVC, FRP, and Ductile Iron gravity sewer lines no earlier than 30 days after the trench has been completely backfilled. Any sections of the sewer not passing the mandrel shall be uncovered and the Contractor shall rebed, reround, or replace the sewer to the satisfaction of the Engineer. Any repaired section shall be retested after a sufficient time has elapsed to ensure that trench settlement has stopped. This retest time shall be totally dependent upon method of repair. If the trench has been opened, the retest shall have the same requirements as the original installation. If the pipe has been rerounded, retest shall not occur sooner than seven days after rerounding.
2. The mandrel (go/no-go) device shall be cylindrical in shape and constructed with either 9 or 16 evenly spaced arms or prongs. Mandrels with fewer arms will be rejected as not sufficiently accurate. The contact length of the mandrel's arms shall equal or exceed the nominal diameter of the sewer to be inspected. Critical mandrel dimensions shall carry a tolerance of plus or minus 0.01 inch. The mandrel and all necessary equipment for the mandrel test shall be provided by the Contractor.
3. The Owner reserves the right to mandrel test any PVC, FRP, or Ductile Iron sewer pipe before acceptance, and also prior to expiration of the first year of operation. If a previously

accepted line fails a mandrel test performed during the first year of operation, the defects must be corrected at the Contractor's expense.

3.4 TELEVISION INSPECTION

A. The Contractor shall televise all newly installed sewer mains as follows:

B. The Contractor shall clean all lines thoroughly prior to the start of televising.

C. The Contractor shall televise each segment of pipe.

D. The camera shall be moved through the line in either direction at a uniform slow rate not to exceed 60 feet per minute, by means of cable winches, or similar mechanisms. **Under no circumstances shall the camera be tethered to a hydraulically propelled or high-velocity jet cleaning device while the cleaning device is on.**

E. The Contractor shall review the video for possible defects in material or workmanship.

F. The Contractor shall correct any defects discovered during the television inspection at the Contractor’s expense.

G. The Contractor shall deliver to the Engineer final video in DVD format and logs after all defects have been repaired.

3.5 INSPECTION OF SERVICE LINES

A. All building sewer lines shall be installed and tested in accordance with all state, regional, and local plumbing codes.

B. All building sewer installations shall be inspected and approved by an authorized local governing agency inspector.

C. Backfill may only be placed on the completed portions of a building sewer following inspection. No approval certificate shall be issued until all portions of a building sewer from the main connection to the building foundation have been inspected and approved by an authorized inspector. At the time of inspection, the pipe should be in place in the trench and "safed-up", but the top half of the pipe barrel exposed. No approval will be given for building sewers all or a portion of which are covered at the time of inspection.

D. All building sewers are subject to testing to insure water tightness. All tests must be performed in the presence of the Engineer. Tests may be either by:
   1. Water Loss Test Procedure; or,
   2. Low Pressure Air Loss Procedure.

E. If, in the opinion of the Engineer, the line in question is properly installed and free from open joints and breaks, building sewers constructed entirely of cast iron soil pipe may be connected to the sewer without testing.

F. Water Loss Test Procedure
   1. Plug the section of line to be tested at the lower end and fill section with water so that at least four (4) feet of head is obtained.
   2. The maximum acceptable water loss while so filled is not more than 100 gallons per twenty-four hours per inch of pipe diameter per mile of pipe. This is approximately 3/16 gallon for a one hundred (100) foot long section of four (4) inch pipe tested thirty minutes.

G. Low Pressure Air Loss Procedure
   1. Plug securely both ends of the line to be tested.
   2. Charge the line with air to a pressure of 4.5 psig.
   3. Allow at least five minutes for the temperature in the pipe to stabilize.
   4. Measure the time required for a one (1.0) psi drop in pressure.
   5. The minimum time for a one psi loss is 28.5 x d seconds where d = the nominal diameter in inches of the pipe being tested.

3.6 MANHOLE TESTING

A. Testing, Observations and Guarantee Period:
   1. The testing required shall be performed by the Contractor at all manholes and documented to the satisfaction of the Engineer.
   2. Testing shall not be performed on a specific manhole until all work has been completed for that specific manhole.
   3. Any manholes that are observed to be leaking by the Engineer shall be subject to additional repairs and retested by the Contractor at no additional cost to the Owner.

B. Inflow Testing:
   1. All rehabilitated manholes and new manholes shall be dye tested. Manholes shall be dye water tested in the presence of the Engineer. The dye test shall consist of applying a concentrated dye solution around the manhole frame. Dyed water shall be applied for at least ten (10) minutes.
   2. Manholes observed to be actively leaking will have failed the test and will not be acceptable. Manholes failing the test will require additional rehabilitation by the Contractor at no additional compensation. The manhole shall then be retested as described above until a successful test is made.

C. Vacuum Testing:
   1. All new and rehabilitated manholes shall be vacuum tested by the Contractor in the presence of the Engineer for sources of infiltration. Testing will be made during high groundwater conditions, wherever possible.
   2. Manholes shall be tested after installation with all connections (existing and/or proposed) in place. Drop-connections and gas sealing connections shall be installed prior to testing. The lines entering the manhole shall be temporarily plugged with the plugs braced to prevent them from being drawn into the manhole. The plugs shall be installed in the lines beyond drop-connections, gas sealing connections, etc. The test head shall be placed inside the frame at the top of the manhole and inflated in accordance with the manufacturer's recommendations. Plate type test heads that rest on top of the frame are also acceptable. A vacuum of 10 inches of mercury shall be drawn, and the vacuum pump will be turned off. With the valve closed, the level of vacuum shall be read after the required test time. If the drop in the level is less than 1-inch of mercury (final vacuum greater than 9 inches of mercury), the manhole will have passed the vacuum test. After a successful test, the temporary plugs will be removed. The required test time is determined from the table below.

Minimum Time Required for a Vacuum Drop of 1" H_g (10"H_g - 9"H_g) (min:sec)				
Depth of Manhole (ft.)	Manhole Inside Diameter (inches)			
	48"	60"	72"	96"
8'	:20	:26	:32	:45
10'	:25	:33	:40	1:00
12'	:30	:39	:48	1:07
14'	:35	:46	:57	1:18
16'	:40	:52	1:05	1:29
18'	:45	:59	1:13	1:40
20'	:50	1:05	1:21	1:52
22'	:55	1:12	1:29	2:03
24'	:60	1:19	1:37	2:14
26'	1:05	1:25	1:45	2:25
28'	1:10	1:32	1:53	2:36
30'	1:15	1:38	1:01	2:47
Add for each Additional 2'	:05	:07	:08	:11

3. Manhole vacuum levels observed to drop greater than 1-inch of mercury (Final vacuum less than 9 inches of mercury) will have failed the test and will require additional rehabilitation. The Contractor shall make the necessary repairs at no additional compensation for only those work items completed by the Contractor. The manhole shall then be retested as described above until a successful test is made.

3.7 PRESSURE TEST FOR FORCE MAINS

A. Perform hydrostatic leakage tests for force mains by filling the force main with water and increasing the pressure to a testing pressure of 150% of the working pressure with a minimum of 100 psi.

B. The duration of the leakage test shall be two hours or as specified by the Engineer.

C. The force main will not be accepted until the actual leakage is equal to or less than the allowable. In addition, all obvious leaks shall be repaired.

D. The allowable leakage rate per hour for ductile iron, PVC, FRP or concrete pipe shall be calculated by the following formula:

$$L = \frac{ND \times P^{.5}}{7400}$$

L = Allowable Leakage (gallons per hour)

N = Number of Joints in Pipeline Tested

D = Nominal Diameter (inches)

P = Test Pressure (psi)

3.8 SYSTEM COORDINATION

A. Maintain existing sewer flow through new connecting manholes until new sewer is approved by Engineer.

B. Reshape manhole bottom to divert sewer flow into new sewer after new sewer is approved by Engineer.

C. Locate sewer services before completing the first manhole downstream from the sewer service.

END OF SECTION

SECTION 33 39 17 – POLYMER CONCRETE MANHOLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work for the construction of polymer concrete manholes. The Contractor shall be responsible for the correct final elevations and slopes of manholes and the proper setting and elevations of manhole rings and covers.

B. General Requirements:
   1. Manholes of different diameters are required on this project. See the Plans for manhole locations and sizes.
   2. The top surface of the barrel shall be constructed truly plumb and level, except where located within roadway limits where it shall match existing slopes and grades, and shall have a light broom finish. There shall be no exposed aggregate on the top edge of the barrel.
   3. Manholes where the top elevation is greater than 2-feet above adjacent ground shall use frames and covers conforming to Paragraph 2.5 of this specification. Manholes where the top elevation is less than 2-feet above adjacent ground shall use frames and covers conforming to either Paragraph 2.4 or 2.5 of this specification, at the Contractor's discretion.
   4. Polymer Concrete Manhole Rehabilitation Insert shall be installed where required in the Drawings and shall be configured to fit the existing structures and piping connections to provide a fully functional rehabilitated manhole upon completion.

C. Related Sections:
   1. Section 03 30 00 – Cast-In-Place Concrete
   2. Section 31 23 16 – Excavation
   3. Section 33 31 23 – Testing Sanitary Sewer Systems

1.2 QUALITY ASSURANCE

A. Manhole testing is specified in Section 33 31 23, TESTING SANITARY SEWER SYSTEMS.

B. Concrete testing is specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

1.3 REFERENCE STANDARDS:

A. American Society for Testing and Materials (ASTM) latest edition.
   1. ASTM A48, Standard Specification for Gray Iron Castings
   2. ASTM C361, Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
   3. ASTM C443, Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
   4. ASTM C478, Standard Specification for Precast Reinforced Concrete Manhole Sections
   5. ASTM D1248, Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable

1.4 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Procedures for submittals.

B. Certificates: Certify that products meet or exceed specified requirements.

C. Submit design calculations supporting reinforcing, thicknesses, and dimensions proposed for use on this project, signed and sealed by a Professional Engineer in the State of Colorado.

D. Shop drawings of manhole sections, base units and construction details, jointing methods, materials and dimensions.

E. Materials to be used for grade adjustments

F. Materials to be used for bench area finishing

PART 2 - PRODUCTS

2.1 POLYMER CONCRETE MANHOLES

A. General Requirements:
1. Provide corrosion proof polymer manhole sections, base sections and related components conforming to ASTM C-478. ASTM C-478 material and manufacturing is allowed compositional and dimensional differences required by a polymer product.
2. Provide base riser section with integral floors, unless shown otherwise.
3. Provide riser sections joined with bell and spigot / ship-lap design seamed with butyl mastic (ASTM C 990) and rubber gaskets (ASTM C990) so that on assembly, manhole base, riser and top section make a continuous and uniform manhole.
4. Construct riser sections for polymer manholes from standard polymer manhole sections of the diameter indicated on drawings. Use various lengths of polymer concrete manhole sections in combination to provide correct height with the fewest joints unless otherwise noted on plans.
5. Design wall sections for depth and loading conditions with wall thickness as required by polymer manufacturer.
6. Provide tops to support HS-20 or HL-93 vehicle loading and receiving cast iron frame covers, as indicated on drawings.
7. Where polymer transition slabs are required provide precast base sections with flat polymer slab top sections used to transition to 48-inch diameter manhole access riser sections. Transition can be concentric or eccentric as shown on drawings. Locate transition to provide minimum of 7-foot head clearance from base to underside of transition unless otherwise approved by engineer.

B. Design Criteria:
1. Polymer Concrete Manhole risers, transition slabs, cones, flat lids, grade rings and manhole base sections shall be designed, by manufacturer, to meet the intent of ASTM C 478 with allowable compositional and sizing differences required by a polymer product. The following design criteria apply:
    a. AASHTO LRFD HS-20 or HL-93 design live loading applied to manhole cover and transition and base slabs.
    b. Polymer manholes will be designed based upon live and dead load criteria in ASTM C 857 and ACI 350-06.
    c. Unit soil weight of 120 pcf located above portions of manhole, including base slab projections.
    d. Internal liquid pressure based on unit weight of 63 pcf.
    e. Dead load of manhole sections fully supported by transition and base slabs.

C. Design:
1. Polymer Concrete Manhole risers, transition slabs, cones, flat lids, grade rings and manhole base sections shall be designed, by manufacture, to requirements of ASTM C 478, ASTM C 857, and ACI 350-06 as modified to accept polymer construction in lieu of concrete as follows:

a. Polymer Mixture - the mixture shall consist solely of thermosetting resin sand and aggregate. No Portland cement shall be allowed as part of the mix design matrix. All sand and aggregate shall be inert in an acid environment.
b. Reinforcement – Shall use acid resistant reinforcement (FRP Bar) in accordance with ACI 440.1R-06 as applicable for polymer concrete design.
c. Required wall thickness for all members will be that stated by polymer manhole manufacturer based upon loading conditions and material properties. The wall thickness of risers and conical tops shall be not less than that prescribed by the manufacturer's design by more then 5%. A wall greater than the prescribed design shall not be cause for rejection.
d. Thermosetting Resin - The resin shall have a minimum of deflection temperature of 158° F when tested at 264 psi (1.820 mPa) following Test Method D 648. The resin content shall not be less than 7% of the weight of the sample as determined by test method D 2584. Resin selection shall be suitable for applications in the corrosive conditions to which the structures will be exposed.
e. Each manhole component shall be free of all defects, including indentations, cracks, foreign inclusions and resin starved areas that, due to their nature and degree or extent, detrimentally affect the strength and serviceability of the component part. The internal diameter of manhole components shall not vary more than 1%. Variations in height of two opposite sides of risers and conical tops shall not be more the 5/8 inch. The under run in height of a riser or conical top shall not be more than 1/4in./ft of height with a maximum of ½ inch in any one section.
f. Marketing and Identification - Each manhole shall be marked on the inside and outside with the following information - Manufacturer's name or trademark, Manufacturer's location and Production Date.
g. Manhole joints shall be assembled with a bell/spigot or shiplap butyl mastic joint so that on assembly, manhole base, riser and top section make a continuous and uniform manhole. Joint sealing surfaces shall be free of dents, gouges and other surface irregularities that would affect joint integrity.
h. Minimum clear distance between two wall penetrations shall be a minimum of 6" on 48" to 72" diameter manholes and a minimum of 8" on larger diameter manholes. A clearance of 3" is required between wall penetration and joint.
i. Construct invert channels to provide smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Invert slope through manhole is as indicated on drawings. All precast base sections to be cast monolithically. Provide curves for side inlets and smooth invert fillets for flow transition between pipe inverts. Polymer bench and channel are to be constructed with all resin aggregate material – no alternative fill material is allowed. Extended base footer requirements for buoyancy concerns can be addressed with cementitious concrete material.
j. Provide resilient connectors conforming to requirements of ASTM C 923 or as a required by owner. All connectors are to be watertight. Install approved resilient connectors at each pipe entering and exiting manholes in accordance with manufacturer's instructions.
k. Exceptions to ASTM C 478- components shall be designed for the intended combinations of manufacturing materials. Component designs may be as reinforced members as recommended by the manufacturer. Steel or Fiberglass reinforcement is not required for circumferential reinforcement, joint reinforcement, base slab reinforcement or hoop reinforcement, but may be placed for the purpose of product handling.

D. Manufacturers
1. Armorock, Las Vegas, NV
2. Approved Equal

2.2 POLYMER CONCRETE MANHOLE REHABILITATION INSERTS

A. General Requirements:
   1. Provide corrosion proof polymer concrete manhole insert riser, cone sections and related components conforming with ASTM C-478.
   2. Insert system shall contain sufficient structural strength to carry all live, dead and hydrostatic loads for the installation. The original manhole being rehabilitated will not be depended on to provide any structural support.
   3. Riser sections, and flat lids shall be provided with flush edge configurations assembled with alignment guides and butyl mastic to make a continuous and uniform insert structure manhole matching the approximate configuration of the existing structure unless otherwise noted.
   4. Polymer concrete structural insert manhole riser and flat lid sections are to be provided in various lengths in combination to provide correct height with the fewest joints.
   5. The polymer concrete structural insert shall have a minimum wall thickness of 2 inches and a minimum outside diameter clearance to the existing structure of 1.5 inches. Additional wall thickness shall be provided as necessary for structural design by the manufacturer.
   6. Surfacing shell material for invert and structure bottom shall be in accordance with Specification 09 96 40.

B. Design Criteria:
   1. In accordance with Section 2.1

C. Design:
   1. In accordance with Section 2.1

D. Manufacturers
   1. Armorock, Las Vegas, NV
   2. Approved Equal

2.3 INVERTS

A. Inverts shall be formed as shown on the detail drawings to the grades specified. Manholes with inverts not conforming to these grades may be subject to removal and replacement at the Contractor's expense.

2.4 STEPS

A. Manhole steps are not required and will not be accepted.

2.5 FRAMES AND COVERS

A. Frames:
   1. Frame material shall be composite material. Plastic adjustment ring is not acceptable.
   2. Frames shall be traffic rated frames EJ Composite, by East Jordan Iron Works or approved equal.
   3. Bearing surfaces between the ring and cover shall be machine finished or ground to assure non-rocking fit in any position, and interchangeability.

B. Covers:
   1. Manhole cover material shall be composite material.
   2. The cover shall form a water-resistant seal between the frame and manhole cover surface. The cover shall have concealed pick holes and a machined bearing surface on the bottom of the casting.
   3. Covers shall be traffic rated EJ Composite, by East Jordan Iron Works, or approved equal.

4. Covers shall set flush with the rim of the frame and shall have no larger than a 1/8-inch gap between the frame and cover.
5. Lid shall have “SANITARY SEWER” on the surface.
6. Cover shall be 24” diameter minimum.

C. Bolts:
1. Bolts for frames and covers shall be Stainless Steel.

D. Watertight Manhole Inserts:
1. Where required in drawings.
2. his standard covers the furnishing and installation of watertight gasketed manhole inserts in the sanitary sewer collection system.
3. Materials (Stainless Steel)
   a. Stainless steel inserts shall be installed at locations with outfall pipe diameters greater than 15-inches and as directed by the Engineer.
   b. Stainless steel inserts shall be TETHERLOK stainless steel Rainstopper by Southwestern Packing and Seals, Inc., or approved equivalent.
   c. Insert shall be constructed of 304 stainless steel.

2.6 MANHOLE FRAME SEALS

A. The material for the seals between the frames and concrete shall be a bitumastic gasket material, meeting or exceeding ASTM C990. Bitumastic gasket material shall be Ram-Nek, EZ-STIK, or approved equal.

2.7 PIPE CONNECTIONS

A. Manufactured pipe-to-manhole connectors shall be installed at each opening to assure a flexible watertight seal of the pipe to the manhole.

B. The connector shall be capable of a 7-degree pipe deflection after installation without loss of sealing.

C. The connector shall be manufactured expressly for embedment in the wall of concrete manholes and shall be specifically designed for the pipe material and size being utilized on the project.

D. No adhesives or lubricants shall be employed in the installation of the connector into the manhole.

E. All stainless steel parts of the connector shall be totally non-magnetic Series 304 Stainless except the worm screw for tightening the steel band which shall be Series 305 Stainless. The worm screw shall be torqued by a break-away type torque wrench set for 60 – 70 in/lbs.

F. The connector shall be installed in the manhole so that it shall have a minimum cover of 3-inches of concrete at all points and in strict accordance with the manufacturer's recommendations.

2.8 GROUTING

A. All materials needed for grouting and patching will be a polyester mortar compound provided by the manufacturer or an approved equal by the manufacture. No Portland cement material may be used within the structure.

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and keep all water clear from the excavation during construction and testing operations.

B. Place imported pipe base material on undisturbed earth; thoroughly compact with a mechanical vibrating or power tamper.

3.2 EXCAVATION AND BACKFILL

A. Excavation: As specified in Section 31 23 16, EXCAVATION.

B. Backfill: As specified in Section 31 23 23.13, FILL AND BACKFILL.

3.3 INSTALLATION OF PRECAST MANHOLES

A. Concrete Base:
   1. Cast-In-Place:
      a. Vibrate to densify concrete and screed so first precast manhole section to be placed has a level, uniform bearing for full circumference.
      b. Deposit sufficient mortar on base to assure watertight seal between base and manhole wall, or place first precast section of manhole in concrete base before concrete has set. Properly locate and plumb first section.
   2. Precast:
      a. Place on compacted imported base material.
      b. Properly locate, ensure firm bearing throughout, and plumb first section.

B. Sections:
   1. Thoroughly clean ends of sections to be joined.
   2. Thoroughly wet joint with water prior to placing mortar.
   3. Locate precast steps in line with each other to provide a continuous vertical ladder.

C. Preformed Plastic Gaskets (In lieu of mortar joints):
   1. Carefully inspect precast manhole sections to be joined.
   2. Do not use sections with chips or cracks in the tongue.
   3. Use only pipe primer furnished by gasket manufacturer.
   4. Install gasket material in accordance with manufacturer's instructions.
   5. Completed Manholes shall be rigid and watertight.

D. Rubber Gasketed Joints: Install in accordance with manufacturer's instructions.

E. Extensions:
   1. Provide on manholes in streets or other locations where a subsequent change in existing grade may be likely.
   2. Install to height not exceeding 12 inches.
   3. Lay grade rings in mortar with sides plumb and tops level.
   4. Seal joints with mortar as specified for sections and make watertight.

3.4 INSTALLATION OF POLYMER CONCRETE MANHOLE REHABILITATION INSERTS

A. Install in accordance with manufacturer recommendations.

B. Preparation

1. Excavate area around existing manhole as necessary to provide for removal of the existing manhole top and/ or cone to access the largest cross sectional area of the structure while preventing soil and debris from falling into the manhole.
2. Follow all requirements for safety and ventilation in accordance with all applicable Federal, State and local requirements.
3. Provide means, labor and equipment to prevent solid waste contamination during construction activities. Install bypass pumping as required.
4. Make any repairs to existing manhole necessary to receive inserts. Power wash/ clean any loose debris from wall areas. Remove dirt, grease and debris in bench area to prepare bench surfaces for resurfacing. Remove all debris. Repair any active leaks. Repair and level the bench to prepare for polymer insert installation. Saw cut polymer riser section if necessary to accommodate pipe entry and bench slopes.

C. Insert Installation
1. Prepare the manhole base in accordance with Section 09 96 40. This shall allow for a level surface above the existing top of the highest pipe. Lower the first riser section, clean and wipe down the polymer riser wall above the base to allow for application of the epoxy coating.
2. When the base is sufficiently dry and clean, a shell coating of epoxy meeting the requirements of Section 09 96 40 shall be built over the existing concrete. The epoxy shell shall continue 4-6 inches up the polymer riser face to allow for polymer interlinking. No additional surface coating is required.
3. All non-booted or flexible coupler pipe entry areas shall be grouted by an epoxy patch kit provided by the manufacturer.
4. After the initial bottom seal has cured, the additional riser sections shall be installed using the appropriate wall alignment guides, gaskets and/ or mastic. The risers shall be lifted into place with approved manufacturer's lifting device or as approved by Engineer.
5. Fill the annular space between old and new structure with a one sack slurry mix/ mixed fill, stabilized sand or stone (85% standard proctor) or a backfill material approved by Engineer.
6. Install grade rings and frame and cover and foul air piping connection. Level to grade. Grout where required with the manufacturers grout kit.
7. Finish the remainder of the backfill, remove any deleterious material and debris from the manhole and replace pavement if required.
8. Upon completion of the installation, remove all surplus materials, coverings, trash and thoroughly clean all surfaces.

3.5 MANHOLE INVERT

A. Construct with smooth transitions to ensure an unobstructed flow through manhole. Remove sharp edges or rough sections which tend to obstruct flow.

B. Where full section of pipe is laid through manhole, break out top section as shown and cover exposed edge of pipe completely with mortar. Trowel mortar surfaces smooth.

3.6 MANHOLE FRAMES AND COVERS

A. Set frames in bed of mortar with mortar carried over flange as shown.

B. Set tops of covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

3.7 WATERTIGHT MANHOLES

A. Provide watertight manholes where required in the Drawings.

B. Install frame fasteners and riser connection brackets at locations shown on the Drawings. Submit design details of brackets to Engineer for approval.

3.8 MANHOLE PIPING

A. Flexible Joints:
   1. Provide in all pipe not more than 1-1/2 feet from manhole walls.
   2. Where last joint of pipe is between 1-1/2 and 6 feet from manhole wall, provide a flexible joint in the manhole wall.

3.9 MANHOLES OVER EXISTING PIPING

A. Maintain flow through existing pipe lines at all times.

B. Concrete Pipe: Apply a bonding agent on all surfaces to be in contact with concrete.

C. Construct base under existing piping.

D. Construct manhole as specified.

E. Break out existing pipe within new manhole, cover edges with mortar, and trowel smooth.

F. Protect new concrete and mortar work for 7 days after placing concrete.

3.10 CONNECTIONS TO EXISTING MANHOLES

A. Core drill neat hole in manhole.

B. Clean all surfaces and apply a bonding agent.

C. Regrout to provide smooth flow into and through manholes.

D. Provide diversion facilities and perform work necessary to maintain flow during connection.

3.11 FIELD QUALITY CONTROL

A. Hydrostatic Testing (Cast-In-Place and Precast):
   1. When, in Engineer's opinion, the groundwater table is too low to permit visual detection of infiltration leaks, hydrostatically test all project manholes.
   2. Procedure: Plug inlets and outlets and fill manhole with water to height determined by Engineer.
   3. 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.
   4. Leakage in each sanitary sewer manhole shall not exceed 0.1 gallon per hour per foot of head above the invert.
   5. Leakage is not permitted in primary sludge manhole.
   6. Repair manholes that do not meet the leakage test, or do not meet specified requirements from visual inspection.

B. Test manhole in accordance with Section 33 31 23, TESTING SANITARY SEWER SYSTEMS.

END OF SECTION

DIVISION 40

PROCESS INTEGRATION

SECTION 40 05 00 – PIPING SYSTEMS TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Test requirements for piping systems.

B. Related Sections:
   1. Section 01 41 00 – Regulatory Requirements.
   2. Section 01 50 00 – Temporary Facilities and Controls.
   3. Section 40 23 39 – Process Piping, General.

1.2 REFERENCES

A. National Fuel Gas Code (NFGC):
   1. ANSI Z 223.1 or NFPA 54.

B. American Society of Mechanical Engineers (ASME):
   1. B31.8 – Gas Transmission and Distribution Piping Systems.
   2. B31.1 – Power Piping.
   3. B31.3 – Process Piping.

1.3 TESTING REQUIREMENTS

A. General Requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 40 23 39; are specified in the specifications covering the various types of piping; and are specified herein.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01 41 00, and UL requirements.
   4. Test Natural Gas or Digester Gas Piping:
      a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01 41 00, or the National Fuel Gas Code, whichever is more stringent.
      b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
   5. When testing with water, the specified test pressure is considered to be the pressure at the highest point of the piping section under test. Lower test pressure as necessary to prevent testing the lowest point above a safe test pressure.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for Testing, Cleaning, and Disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01 50 00.

D. Pipes to be Tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and

install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful Tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test Completion: Drain and leave piping clean after successful testing.

G. Test Water Disposal: Dispose of testing water at the RPCF Sludge Handling Facility in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 00.

B. Schedule and Notification of Tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of Readiness to Test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.5 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING, ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and Grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection Test:
   1. Pull a mandrel through the clean piping section under test.

2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within one percent plus or minus.
4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.2 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with “AM” in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 40 23 39:
1. Provide temporary pressure relief valve for piping under test. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1. AS<E B31.3, ASE B31.8, or the pipe manufacturer’s stated maximum working pressure.
3. Gradually increase test pressure to an initial test pressure equal to the lesser of one-half the test pressure or 25 pounds per square inch gauge.
4. Perform initial check of joints and fittings for leakage.
5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage at each step increase until test pressure reached.
6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.3 TESTING GRAVITY FLOW PIPING

A. Test Gravity Flow Piping indicated with “G” in the Piping Schedule, as follows:
1. Unless specified otherwise, subject gravity flow piping to the following tests:
    a. Alignment and grade.
    b. For plastic piping test for deflection.
    c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
2. Inspect piping for visible leaks before backfilling. Provide temporary restraints when needed to prevent movement of piping. Pressure test piping with maximum leakage allowance after backfilling.
3. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours.
    a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
    b. Maintain piping with water or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
    c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of four hours while accurately measuring the volume of water added to maintain the test pressure.
        1). Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:

a). For Concrete Piping with Rubber Gasket Joints: 80 gallons per day per inch of diameter per mile of piping under test.
(1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
(2) For Vitrified Clay and Other Piping: 500 gallons per day per inch of diameter per mile of piping under test.

3.4 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated “HH” in the Piping Schedule.

B. General:
1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve’s maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
3. Do not include valves, equipment or piping specialties in test sections if test pressure exceeds the valve, equipment or piping specialty safe test pressure allowed by the item’s manufacturer.
4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
6. When test results indicate failure of selected sections, limit tests to piping:
a. Between valves.
b. Between a valve and the end of the piping.
c. Less than 500 feet long.
7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing Procedures:
1. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Piping Schedule.
2. Before pressurizing for the test, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
3. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure Test with Maximum Leakage Allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
2. Pressure test piping after completion of visible leaks test.
3. For piping systems using joint designs other than flanged threaded or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piing and appurtenances has occurred.
b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
c. Successful completion of the pressure test with maximum leakage allowance shall have been achieved with the observed leakage during the test period is equal or

less than the allowable leakage and no damage to piping and appurtenances has occurred.

d. When leakage is allowed, calculate the allowable leakage by the following formula:

$$L = \frac{S\ D\ \sqrt{P}}{148{,}000}$$

Where:

L = testing allowance (makeup water) (gph)
S = length of pipe tested (ft)
D = nominal diameter of the pipe (in.)
P = average test pressure during the hydrostatic test (psi [gauge])

3.5 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
1. Test pressures shall be as scheduled in Section 40 23 39.
2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible Leaks Test:
1. Subject piping under test to the specified pressure measured at the lowest end.
2. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Piping Schedule.
3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure Test with Maximum Leakage Allowance:
1. Pressure test piping after completion of visible leaks test.
2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
   a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours and no damage to piping and appurtenances has occurred.
   b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional Joint Test:
1. When Joint Testing Is Allowed by Note in the Piping Schedule, the Procedure Shall Be as Follows:
   a. Joint testing will be allowed only for low head pressure piping.
2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint Testing with Water:

a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
b. Maintain test pressure for one minute.
c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.

5. Joint Testing with Air:
   a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
   b. Maintain test pressure for 2 minutes.
   c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 40 05 13 - COMMON WORK RESULTS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies piping materials and installation methods common to more than one section of Division 40 and includes joining materials, piping specialties, and basic piping installation instructions.

B. Related Sections:
1. Piping materials and installation methods peculiar to individual systems are specified within their respective system specification sections of Division 40.
2. Valves are specified in a separate section and in individual piping system sections of Division 40.
3. Supports and Anchors are specified in a separate section of Division 40.
4. Mechanical Identification is specified in a separate section of Division 40.
5. Fire Barrier Penetration Seals are specified in Division 07.

1.2 SUBMITTALS

A. Refer to Division 01 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit product data on the following items:
1. Escutcheons
2. Dielectric Unions and Fittings
3. Mechanical Sleeve Seals

C. Quality Control Submittals:
1. Submit welders' certificates specified in Quality Assurance below.

1.3 QUALITY ASSURANCE

A. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

B. Welding procedures and testing shall comply with ANSI Standard B31.1.0 - Standard Code for Pressure Piping, Power Piping, and The American Welding Society, Welding Handbook.

C. Soldering and Brazing procedures shall conform to ANSI B9.1 Standard Safety Code for Mechanical Refrigeration.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, Manufacturers offering piping materials and specialties which may be incorporated in the work include, but are not limited to, the following:

B. Pipe Escutcheons:
1. Chicago Specialty Mfg. Co.
2. Sanitary-Dash Mfg. Co.
3. Grinnell

C. Dielectric Waterway Fittings:
1. Epco Sales, Inc.
2. Victaulic Company of America

D. Dielectric Unions:
1. Eclipse, Inc.
2. Perfection Corp.
3. Watts Regulator Co.

E. Mechanical Sleeve Seals:
1. Thunderline Corp.

2.2 PIPE AND FITTINGS

A. Refer to the individual piping system specification sections in Division 15 for specifications on piping and fittings relative to that particular system.

2.3 JOINING MATERIALS

A. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

B. Brazing Materials: Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials appropriate for the materials being joined.

C. Soldering Materials: Refer to individual piping system specifications for solder appropriate for each respective system.

D. Gaskets for Flanged Joints: Gasket material shall be full-faced for cast-iron flanges and raised-face for steel flanges. Select materials to suit the service of the piping system in which installed and which conform to their respective ANSI Standard (A21.11, B16.20, or B16.21). Provide materials that will not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

2.4 PIPING SPECIALTIES

A. Escutcheons: Chrome-plated, stamped steel, hinged, split-ring escutcheon, with set screw. Inside diameter shall closely fit pipe outside diameter or outside of pipe insulation where pipe is insulated. Outside diameter shall completely cover the opening in floors, walls, or ceilings.

B. Unions: Malleable-iron, Class 150 for low pressure service and class 250 for high pressure service; hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.

C. Dielectric Unions: Provide dielectric unions with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

D. Dielectric Waterway Fittings: electroplated steel or brass nipple, with an inert and non-corrosive, thermoplastic lining.

E. Sleeves:
   1. Sheet-Metal Sleeves: 10 gauge, galvanized sheet metal, round tube closed with welded longitudinal joint.
   2. Steel Sleeves: Schedule 40 galvanized, welded steel pipe, ASTM A53, Grade A.
   3. Mechanical Sleeve Seals: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.

3.2 INSTALLATIONS

A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated. Refer to individual system specifications for requirements for coordination drawing submittals.
   1. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated otherwise.
   2. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
   3. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Drawings.
   4. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
   5. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.
   6. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4" ball valve, and short 3/4" threaded nipple and cap.

B. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6" shall be steel; pipe sleeves 6" and larger shall be sheet metal.

C. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, or floors, the fire rated integrity shall be maintained. Refer to Division 07 for special sealers and materials.

3.3 FITTINGS AND SPECIALTIES

A. Use fittings for all changes in direction and all branch connections.

B. Remake leaking joints using new materials.

C. Install strainers on the supply side of each control valve, pressure reducing or regulating valve, solenoid valve, and elsewhere as indicated.

D. Install unions adjacent to each valve and at the final connection to each piece of equipment and plumbing fixture having 2" and smaller connections, and elsewhere as indicated.

E. Install Flanges in piping 2-1/2" and larger, where indicated, adjacent to each valve, and at the final connection to each piece of equipment.

F. Install dielectric unions to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air, vacuum).

G. Install dielectric fittings to connect piping materials of dissimilar metals in wet piping systems (water, steam).

3.4 JOINTS

A. Steel Pipe Joints:
1. Pipe 2" and Smaller: Thread pipe with tapered pipe threads in accordance with ANSI B2.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended on the male threads at each joint and tighten joint to leave not more than 3 threads exposed.
2. Pipe Larger Than 2": Weld pipe joints (except for exterior water service pipe) in accordance with ASME Code for Pressure Piping, B31.
3. Weld pipe joints of exterior water service pipe in accordance with AWWA C206.
4. Install flanges on all valves, apparatus, and equipment. Weld pipe flanges to pipe ends in accordance with ASME B31.1.0 Code for Pressure Piping. Clean flange faces and install gaskets. Tighten bolts to torque specified by manufacturer of flange and flange bolts, to provide uniform compression of gaskets.

B. Non-ferrous Pipe Joints
1. Brazed And Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ANSI B31.1.0 - Standard Code for Pressure Piping, Power Piping and ANSI B9.1 - Standard Safety Code for Mechanical Refrigeration.
2. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine Emory cloth prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.

C. Mechanical Joints: Flared compression fittings may be used for refrigerant lines 3/4" and smaller.

D. Joints for other piping materials are specified within the respective piping system sections.

3.5 FIELD QUALITY CONTROL

A. Testing: Refer to individual piping system specification sections.

END OF SECTION

SECTION 40 05 36.13 – FRP PIPE AND ACCESSORIES FOR ODOR CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Filament wound and hand lay-up circular fiberglass reinforced plastic (FRP) pipe (duct) and fittings for transporting foul air in the odor control system.
2. Hand layup and contact molded rectangular fiberglass reinforced plastic (FRP) duct and fittings for transporting foul air in the odor control system.
3. Fiberglass dampers for odor control duct, including balancing, isolation, and back draft dampers.
4. EPDM expansion joints for odor control duct.
5. Accessories.

B. Definitions
1. The terms “pipe” and “duct” in this section are used interchangeably.

C. Related sections:
1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

1.2 REFERENCES

A. American Water Works Association (AWWA):
1. M-45 American Water Works Manual of Water Supply Practices “Fiberglass Pipe Design”

B. ASTM International, Inc. (ASTM):
1. C582 Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
2. D2310 Classification for Machine-Made “Fiberglass” Pipe
3. D2996 – Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
4. D3982 Specification for Contact Molded “Fiberglass” Duct and Hoods

C. Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA)
1. Thermoset FRP Duct Construction Manual
a. Use only for rectangular duct.

D. Voluntary Product Standard, U.S. Department of Commerce (VPS):
1. PS 15-69 Custom Contact-Molded Reinforced Polyester Chemical-Resistant Process Equipment.

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 00 – Submittal Procedures.

B. Product Data: For the following products:
1. FRP Duct
2. Expansion Joints
3. Dampers

4. Accessories

C. Shop Drawings:
1. Scaled layout drawings of fiberglass ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment, required clearances, method of field assembly, components, and location and size of each field connection.
2. Provide a detailed layout of the duct support system showing locations and type of hangers and supports to be provided.
3. Provide field butt and wrap joint connection details on shop drawings.
4. Expansion joint dimensions, connections and retainer rings.
5. Damper cutsheets, dimensions, and connections.
6. A statement on letterhead sealed by a Professional Engineer stating that the duct wall thickness has been calculated to meet the requirements of this specification and is suitable for the installation. Complete calculations, if submitted, will be received as record data and will not be reviewed.

D. Operation and Maintenance Data: Provide in accordance with Section 01 78 23 - Operation and Maintenance Data.

1.4 QUALITY ASSURANCE

A. Manufacturers: The following Manufacturers are acceptable:
1. FRP Duct:
   a. Daniel Company
   b. Engineered Composite Systems
   c. Belco Manufacturing
   d. Ameron
   e. Smith Fibercast
2. FRP Balancing and Isolation Dampers
   a. Daniel Company
   b. Engineered Composite Systems
   c. Belco Manufacturing
   d. Swartwout
3. FRP Backdraft Dampers
   a. Daniel Company
   b. Engineered Composite Systems
   c. Belco Manufacturing
   d. Approved Equal
4. Expansion Joints
   a. Red Valve
   b. Mercer Rubber Company
   c. Approved equal

B. All materials and equipment supplied under this section shall be suitable for use in a wastewater treatment plant environment exposed to sunlight, variable weather conditions, temperatures ranging from 0°F to 110°F, internal hydrogen sulfide concentrations exceeding 1,000 ppm, external ambient hydrogen sulfide, and incidental exposure to chemicals in common use at such facilities.

C. Sole Source Responsibility:
1. All items specified in this section and provided by the BTF Manufacturer as part of the BTF Manufacturer's equipment package as specified in Section 44 31 31 – Odor Control Biotrickling Filter Equipment shall be provided by the same supplier.

a. BTF Manufacturer shall supply the biotrickling filters, fans, and interconnecting FRP duct and accessories.
b. The BTF Manufacturer is required to supply the FRP duct from the fan discharge up to the discharge of the system; any named Supplier may provide the FRP duct from the origination point to the fan inlet.

2. Supplier may acquire items from different manufacturers as listed herein; however, the supplier shall have sole source responsibility for all equipment in the specification section.

D. Warranty
1. Provide a one-year warranty beginning from the time the equipment is placed into continuous service.

1.5 COORDINATION

A. Coordinate sizes, dimensions, and locations with connecting equipment and structures.

PART 2 - PRODUCTS

2.1 FRP DUCT AND FITTINGS

A. Design conditions for FRP Duct and Fittings
1. Minimum structural wall thickness: Designed by Manufacturer to meet the following:
a. Minimum Internal Pressure: 25 psig
b. Minimum Internal Vacuum: 30 in. w.c.
c. Design safety factors: FS=10 for pressure and FS=5 for vacuum.
d. Buried Duct: H-20 loading per AWWA M45.
e. Temperature range, °F: 0 to 110
f. Duct shall be designed for the support spacing shown on the drawings and spacing shown on the typical details (the most stringent of what is shown on the design drawings and the typical details shall govern). Duct shall not sag more than 0.25-inches long term for the support spacing shown on the drawings. Duct shall withstand loads imposed, including condensate buildup within the duct, without excessive sagging.
g. Total wall thickness shall be the greater of the design by the Manufacturer to meet the above requirements or:

Duct Inside Diame-ter, Inches	**Above Grade Minimum Wall Thickness, mils**	**Buried Minimum Wall Thickness, mils**
20” and less	340	340
24” to 36” inclusive	400	420
42” and larger	460	600

h. Structural wall thickness calculations shall not include the thickness of the interior corrosion barrier, inner surface, and interior layer.
i. Buried duct shall not deflect more than 5 percent in the installed condition and under HS20 loads.
2. Coefficient of linear thermal expansion: Shall not exceed 10.5 x 10-6 in/in/oF.

B. Materials
1. Resin:
a. Resin Type: Premium corrosion resistant and fire-retardant brominated bisphenol-A vinyl ester. Resin shall not contain pigments, dyes, colorants or fillers.
b. Flame Spread Rating: Class 1 flame spread rating (25 or less).

c. Thixotropic agents may be added to control resin viscosity per resin manufacturer's instructions. Corrosion liner shall be clear with no fillers or additives.
d. Resins shall be as recommended by AOC-Resins or Ashland. Submit resin manufacturer's certification that resin used is suitable for the intended application

2. Reinforcement:
a. Surfacing Veil: Class C with a silane finish and a styrene soluble binder.
b. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot with a silane finish and a styrene soluble binder.
c. Continuous Roving, Chopper Gun Spray-up: Type E glass.
d. Woven Roving: Type E glass, minimum 24 ounces per square yard with a five by four weave.
e. Continuous Roving, Filament Wound: Type E glass with a silane finish.

C. Fabrication:
1. Duct sizes 10-inch diameter and smaller shall be fabricated using hand layup or filament wound construction.
2. Duct sizes 12-inch diameter and larger shall be fabricated using filament wound construction.
3. Rectangular duct shall be fabricated using hand layup or contact molded construction.
4. Duct fabricated using centrifugally cast construction is not acceptable.
5. Laminates:
a. Interior corrosion barrier shall be 100 mil total thickness.
1) Inner surface shall consist of a 10 mil thickness composed of a single ply of type C glass surfacing veil embedded in resin rich surface. Resin content shall be 90%
2) Interior layer shall consist of a 90 mil thickness composed of at least two layers of chopped strand mat. Resin content shall be 75%.
b. Structural Layer shall be Type E glass to meet wall thickness requirements.
1) Hand lay construction shall include alternate layers of chopped strand mat and woven roving.
2) Filament wound construction shall be preceded by a layer of chopped strand mat or spray chop. The structural layer shall consist of a minimum of two complete cross hatched layers of continuous filaments applied in a helix angle of 55 degrees for above ground duct and 75 degrees for buried duct.
c. Exterior corrosion layer shall be 10 mil thickness composed of a single A or C veil.
d. UV Coating shall be a gel coat with UV inhibitors.
6. Fittings:
a. Elbows 12-inch diameter and smaller shall be smooth radius with a laying length of 1-1/2 times the pipe diameter.
b. 90° Elbows 14-inch diameter and larger shall be 5 piece mitered duct construction with a laying length of 1-1/2 times the pipe diameter.
c. 45° Elbows 14-inch diameter and larger shall be 3 piece mitered duct construction with a laying length of 1-1/2 times the pipe diameter.
d. Tees and crosses shall be the manufacturer's standard product constructed to attach to the connecting duct.
e. Wyes and specials shall be constructed of duct, mitered and FRP wrapped. Special fittings called out on the drawings may have a laying length other than 1.5D.
7. Flanges shall be hand layup construction, with a minimum thickness of 3/4 inches, drilled to match connecting equipment and accessories.

D. Curing:
1. Post curing with indirect heaters or steam. Temperatures and length of curing shall be per resin manufacturer recommendations.

2.2 FRP DAMPERS

A. Isolation Dampers: All dampers shall be isolation dampers unless noted otherwise on the drawings.
   1. Materials of construction:
      a. Body: Vinyl Ester FRP
      b. Blade: Vinyl Ester FRP
      c. Blade Seal: PTFE encapsulated O-ring, EPDM O-ring.
      d. Blade Stop: FRP integral to the damper body
      e. Shaft: 316 stainless steel or vinyl ester FRP.
      f. Shaft Seal: Viton O-ring
      g. Bearings and bushings: Graphite impregnated PTFE
      h. Hardware: 316 stainless steel
      i. Maximum Operating Temperature: 175°F
      j. Minimum Pressure: 30 in. w.c.
      k. Resin System: Fire retardant vinyl ester with MEKP cure system
      l. Internal Corrosion Barrier:Minimum 100 mils thickness
      m. Connections: Flanged per NBS PS15-69 Table 2
      n. External Coating: Gel coat with UV inhibitors
      o. Gaskets: EPDM
      p. Maximum leakage: 4.4 cfm/sq. ft. at 30 in. w.c.

B. Bubble Tight Dampers: Use where shown on the drawings.
   1. Materials of construction:
      a. Body: Vinyl Ester FRP
      b. Blade: Vinyl Ester FRP
      c. Blade Seal: PTFE encapsulated O-ring, EPDM O-ring.
      d. Blade Stop: FRP or elastomeric integral to the damper body
      e. Shaft: 316 stainless steel
      f. Shaft Seal: Viton O-ring
      g. Bearings and bushings: Graphite impregnated PTFE
      h. Hardware: 316 stainless steel
      i. Maximum Operating Temperature: 175°F
      j. Minimum Pressure: 30 in. w.c.
      k. Resin System: Fire retardant vinyl ester with MEKP cure system
      l. Internal Corrosion Barrier:Minimum 100 mils thickness
      m. Connections: Flanged per NBS PS15-69 Table 2
      n. External Coating: Gel coat with UV inhibitors
      o. Gaskets: EPDM
      p. Maximum leakage: 0.0 cfm/sq. ft. at 20 in. w.c.

C. Balancing Dampers: Use where shown on the drawings.
   1. Materials of construction:
      a. Body: Vinyl Ester FRP
      b. Blade: Vinyl Ester FRP
      c. Shaft: 316 stainless steel or Vinyl Ester FRP
      d. Shaft Seal: EPDM, Viton, or PTFE
      e. Bearings and bushings: Graphite impregnated PTFE
      f. Hardware: 316 stainless steel
      g. Maximum Operating Temperature: 175°F
      h. Minimum Pressure: 30 in. w.c.
      i. Resin System: Fire retardant vinyl ester with MEKP cure system
      j. Internal Corrosion Barrier:Minimum 100 mils thickness
      k. Connections: Flanged per NBS PS15-69 Table 2
      l. External Coating: Gel coat with UV inhibitors
      m. Gaskets: EPDM

D. Backdraft Dampers: Use in line with duct and where shown on the drawings.
   1. Backdraft dampers shall allow the flow of air though the damper in one direction only and shall close when air reverses direction.
   2. Materials of construction: As specified for balancing dampers.
   3. Horizontal backdraft dampers: Dual parallel blades mounted on independent shafts which are linked together externally with an adjustable gravity counter weight to adjust opening pressure.
   4. Vertical backdraft dampers: Wafer style dual blades mounted to independent axles along the centerline axis of the duct with independent adjustable gravity counter weight to adjust opening pressure.
   5. Backdraft dampers shall open when a differential pressure of 1 in. w.c. is present when the adjustable counter weight is located at the middle of the adjustment range.
   6. When used on tank covers, backdraft dampers shall open to relieve vacuum under the cover when the vacuum exceeds 1 in. w.c.

E. Inlet Vane Dampers: As specified in Section 43 11 20 – Centrifugal Fans for Odor Control

F. Actuators:
   1. Dampers 24-inches and smaller: Hand quadrant actuator fabricated from 316 stainless steel with a fully adjustable slot with extra hole drilled in handle to permit locking pin once system has been balanced. Provide drilled hole in the actuator handle support plate to permit locking in the full open and full closed positions.
   2. Dampers larger than 24-inches: Epoxy coated gear operator with locking handwheel.
   3. Dampers below grade or located in areas not normally accessible (all sizes) such as in wetwells or junction boxes:
      a. Operator: Geared ¼ turn, Dynatorque stainless steel series DT7 (no chain wheel) or DT21 (with chain wheel) or equal.
      b. Shaft: 316 stainless steel
      c. Enclosure: 316 stainless steel
      d. Hardware: 316 stainless steel
      e. Gears: 316 stainless steel or 6061 aluminum
      f. Extension: 316 stainless steel with 2” operating nut, minimum 1-inch diameter or equal to the shaft diameter, whichever is larger. Provide an indicator at the top of the extension stem to indicate full open and full closed positions.
   4. Dampers located 6 feet or more above finished floor or grade elevation shall use geared operators as specified above with chain wheel operator and chain extending to within 3 feet of finished floor or grade elevation. Chain wheels shall be aluminum or 316SS by Babbitt, Rotohammer or equal and shall come equipped with 316SS chain. Wheels shall be 316SS. For installations where operator and chain weight exceed 40 lbs the damper shall be reinforced to accommodate the added weight.

2.3 EXPANSION JOINTS

A. One piece reinforced EPDM arched expansion joints with integral flanges and backer rings. Slip on expansion joints are not acceptable unless specifically noted on the drawings.

B. Materials of construction:
   1. Body: EPDM
   2. Reinforcing: Nylon, polyester or steel fully encapsulated within the EPDM body.
   3. Flange Rings: 316 Stainless Steel
   4. Hardware: 316 stainless steel
   5. Minimum Operating Temperature: 0°F
   6. Minimum Pressure: 30 in. w.c.
   7. Connections: Flanged per NBS PS15-69 Table 2

C. Performance Requirements:
   1. Minimum Compression:
      a. Duct size up to 6 inches: 1-3/16 inches
      b. Duct size 8 to 36 inches: 2-1/16 inches
      c. Duct size over 36 inches: 3 inches
   2. Minimum Extension:
      a. Duct size up to 6 inches: 3/4 inches
      b. Duct size 8 to 36 inches: 1-1/8 inches
      c. Duct size over 36 inches: 1-11/16 inches
   3. Minimum Lateral deflection:
      a. All Duct Sizes: 1-1/2 inches
   4. Rectangular duct: As needed to accommodate the thermal movement of the duct for the installation condition.

PART 3 - EXECUTION

3.1 INSPECTION

A. General: Examine areas and conditions under which fiberglass ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

B. Coat duct, dampers and fittings after installation as specified in Section 09 90 00 – Coatings. After painting, in 2-inch black lettering stencil “FOUL AIR” and a flow direction arrow on the duct at each vertical riser duct, at each horizontal duct at maximum 40-ft spacing, and at each duct junction. Coordinate stencil locations with Owner.

3.2 INSTALLATION OF DUCTWORK

A. General:
   1. Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight and noiseless (no objectionable noise) systems, capable of performing each indicated service.
   2. Shop fabricate duct to the maximum extent possible.
   3. Install each run with minimum number of joints.
   4. Align ductwork accurately at connections, within 1/8-inch tolerance and with internal surfaces smooth.
   5. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor or as recommended by manufacturer.
   6. Duct connections shall be by butt connections with FRP wrap per ASTM D3982. Connections to equipment, structures, dampers, and expansion joints shall be flanged.
      a. Duct manufacturer shall supply all field weld kits. Field weld kits shall include all necessary fiberglass reinforcing material precut and individually packaged for each joint.
      b. Hardware shall be type 316 stainless steel. Duct manufacturer shall provide a materials list of all hardware required for procurement by the contractor.
   7. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.
   8. Routing: Locate ductwork runs as indicated in the plans.
   9. Coordination: Coordinate duct installations with installation of accessories, dampers, equipment, controls, odor control covers, and other associated work of ductwork system.
   10. A condensate drain shall be provided at each low point in the suction ductwork and be connected to the plant drain system. Condensate drains shown on the drawings are at anticipated low points; however, any additional low points in the duct after installation shall have condensate drains installed at no additional cost. Slope duct to drain to connected equipment and covers where possible.

3.3 INSTALLATION OF DAMPERS

A. The dampers shall be positioned to fit in the connecting piping. Unless otherwise necessary for proper operation of the damper, the axles shall be installed in the horizontal position. The inside of the dampers shall be smooth, clean, and free from blisters and dirt when installed. Dampers in isolation service shall be installed with the shaft side of the damper on the pressure side (toward the equipment isolated).

3.4 FIELD QUALITY CONTROL

A. Any ductwork found to be improperly installed shall be removed and replaced with ductwork, liner or fittings meeting these specifications. Improper installation shall include, but not be limited to, the following:
   1. Fiberglass duct smaller than specified.
   2. Construction joints not properly sealed.

3.5 EQUIPMENT CONNECTIONS

A. General: Connect ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors as indicated.

3.6 ADJUSTING AND CLEANING

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of fiberglass or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

B. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

C. Balancing: Refer to Section 44 31 83 – Adjusting and Balancing Odor Control Systems for air distribution balancing of odor control duct. Seal any leaks in ductwork that become apparent in balancing process.

END OF SECTION

SECTION 40 23 39 - PROCESS PIPING - GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Basic Process Piping Materials, Methods, and Appurtenances.

B. Related sections:
1. Section 01 60 00 – Product Requirements.
2. Section 03 30 00 – Cast-In-Place Concrete.
3. Section 09 90 00 – Painting and Protective Coatings.
4. Section 22 05 29 – Process Supports and Anchors.
5. Section 22 05 53 – Mechanical Identification.
6. Section 31 23 23.16 – Trench Backfill.
7. Section 33 11 11 – Piping Leakage Testing.
8. Section 33 13 00 – Disinfection of Water Systems.
9. Section 40 41 13 – Heat Tracing.
10. Section 40 24 00 – Process Piping Specialties.
11. Section 40 42 00 – Process Mechanical Insulation.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this Section and any supplemental Data Sheets:
1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
2. American National Standards Institute (ANSI):
a. A21.52, Ductile Iron Pipe, Centrifugally Cast, for Gas.
b. B1.20.1, Pipe Threads, General Purpose (Inch).
c. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
d. B16.3, Malleable Iron Threaded Fittings.
e. B16.5, Pipe Flanges and Flanged Fittings.
f. B16.9, Factory-Made Wrought Steel Butt welding Fittings.
g. B16.11, Forged Fittings, Socket-Welding and Threaded.
h. B16.15, Cast Bronze Threaded Fittings, Classes 125 and 250.
i. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
j. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
k. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150,300,400,600,900, 1500 and 2500.
l. B16.25, Butt Welding Ends.
m. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300.
3. American Petroleum Institute (API): 5L, Specification for Line Pipe.
4. American Society of Mechanical Engineers (ASME):
a. Boiler and Pressure Vessel Code, Section VITI, Division 1, Pressure Vessels.
b. Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
c. B31.1, Power Piping.
d. B31.3, Chemical Plant and Petroleum Refinery Piping.
e. B31.9, Building Services Piping.
f. B36.10M, Welded and Seamless Wrought Steel Pipe.
5. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Nondestructive Testing Personnel Qualifications.
6. American Society for Testing and Materials (ASTM):
a. A47, Standard Specification for Ferritic Malleable Iron Castings.
b. A53 Rev A, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

c. A105/ A105M, Standard Specification for Forgings, Carbon Steel, for Piping Components.
d. A106, Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
f. A135, Standard Specification for Electric-Resistance-Welded Steel Pipe.
g. A139 Rev A, Standard Specification for Electric-Fusion (Arc) -Welded Steel Pipe (NPS 4 and Over).
h. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
i. A181/A181M Rev A, Standard Specification for Forgings, Carbon Steel, for General-Purpose Piping.
j. A182/A182M Rev C, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
k. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.
l. A193/A193M Rev A, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.
n. A197, Standard Specification for Cupola Malleable Iron.
o. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service.
p. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
q. A240, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
r. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
s. A283/A283M Rev A, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
t. A285/ A285M, Standard Specification for Pressure Vessel Plates, Carbon Steel, Low and Intermediate Tensile Strength.
u. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
v. A312/A312M, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
w. A320/A320M, Standard Specification for Alloy Steel Bolting Materials for Low-Temperature Service.
x. A395, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
y. A403/ A403M Rev A, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
z. A409/ A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
aa. A536, Standard Specification for Ductile Iron Castings.
bb. A563, Standard Specification for Carbon and Alloy Steel Nuts.
cc. 587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
dd. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
ee. A778 Rev A, Standard Specification for Welded, Un-annealed Austenitic Stainless Steel Tubular Products.
ff. B32, Standard Specification for Solder Metal.
gg. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
hh. B61, Standard Specification for Steam or Valve Bronzed Casting.

ii. B62, Standard Specification for Composition Bronzed or Ounce Metal Castings.
jj. B75, Standard Specification for Seamless Copper Tube.
kk. B88 Rev A, Standard Specification for Seamless Copper Water Tube.
ll. B98, Standard Specification for Copper-Silicone Alloy Rod, Bar, and Shapes.
mm. 582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
nn. D412, Standard Testing Method for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension.
oo. D413, Standard Testing Methods for Rubber Property-Adhesion to Flexible Substrate.
pp. D1248, Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
qq. D1784, Standard Specifications for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
rr. D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
ss. D2000, Standard Classification System for Rubber Products in Automotive Applications.
tt. D2310, Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
uu. D2464, Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
vv. 2466, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
ww. D2467, Standard Specification for Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
xx. D2564, Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
yy. D2665, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe for Drain, Waste, and Vent Pipe and Fittings, Schedule 40.
zz. D2996, Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.
aaa. D3222 Rev A, Standard Specification for Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
bbb. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
ccc. D4101 Rev B, Standard Specification for Propylene Plastic Injection and Extrusion Materials.
ddd. F437, Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
eee. F439 Rev A, Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
fff. F441, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
ggg. F491 Rev A, Standard Specification for Poly (Vinylidene Fluoride) (PVDF) Plastic-Lined, Ferrous Metal Pipes, and Fittings.
hhh. F493 Rev A, Standard Specification for Solvent Cements for Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
iii. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) based on outside diameter.

7. American Welding Society (AWS):
   a. A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   b. QC 1, Standard for AWS Certification of Welding Inspectors.
8. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.

b. C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3" through 48"for Water and Other Liquids.
c. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
d. C115/A21.15, Flanged Ductile-Iron Pipe with Threaded Flanges.
e. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
f. C153/A21.53, Ductile-Iron Compact Fittings 3" through 16", for Water and Other Liquids.
g. C200, Steel Water Pipe – 6" and Larger.
h. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4" and Larger-Shop Applied.
i. C207, Steel Pipe Flanges for Water Works Service, Sizes 4" through 144".
j. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
k. C214, Fusion Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
l. C606, Grooved and Shouldered Type Joints.
m. M11, Steel Pipe - A Guide for Design and Installation.

9. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP 43, Wrought Stainless Steel Butt-Welding Fittings Including Reference to Other Corrosion Resistant Materials.
10. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.3 DEFINITIONS

A. Submerged or Wetted:
1. Zone below elevation of:
a. Top face of channel walls and cover slabs.
b. Top face of basin walkways.
c. Top face of clarifier walkways.
d. Top face of digester walls, including structure piping penetrations.
e. Liquid surface or within 2 feet above top of liquid surface.
f. Top of tank wall or under tank cover.

1.4 SUBMITTALS

A. Shop Drawings:
1. Shop Fabricated Piping:
a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
4. Thrust Blocks: Concrete quantity, bearing area on pipe, and fitting joint locations.
5. Dissimilar Buried Pipe Joints: Joint types and assembly drawings.
6. Gasket material, temperature rating, and pressure rating for each type of pipe and each type of service.

B. Quality Control Submittals:
1. Manufacturer's Certification of Compliance.
2. Qualifications:
a. Weld Inspection and Testing Agency: Certification and qualifications.
b. Welding Inspector: Certification and qualifications.

c. Welders:
1). List of qualified welders and welding operators.
2). Current test records for qualified welder(s) and weld type(s) for factory and field welding.

3. Weld Procedures: Records in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
4. Nondestructive inspection and testing procedures.
5. Manufacturer's Certification of Compliance:
a. Pipe and fittings.
b. Factory applied resins and coatings.
6. Certified weld inspection and test reports.
7. Test logs.

1.5 QUALITY ASSURANCE

A. Weld Inspection and Testing Laboratory Qualifications:
1. Retain approved independent testing laboratory that will provide the services of an AWS certified welding inspector qualified in accordance with AWS QC1 with prior inspection experience of welds specified herein.
2. Perform weld examinations with qualified testing personnel who will carry out radiography, ultrasonic, magnetic particle, and other nondestructive testing methods as specified herein.
3. Welding Inspector:
a. Be present when shop or field welding is performed to certify that welding is in accordance with specified standards and requirements.
b. Duties include, but are not limited to, the following:
1). Job material verification and storage.
2). Qualification of welders.
3). Certify conformance with approved welding procedure specifications.
4). Maintain records and prepare reports in a timely manner.
5). Notify Engineer within 1 hour of discovery of unsatisfactory weld performance and within 24 hours of weld test failure.
6). Supervision of testing personnel.

B. Welder and Welding Operator Performance:
1. Qualify welders and welding operators by approved testing laboratory before performing any welding under this section.
2. Perform welder qualification tests in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code.
3. Qualification tests may be waived if evidence of prior qualification is deemed suitable by the Engineer.
4. Qualify welders and operators in the performance of making groove welds in each different pipe material, including carbon steel pipe, in Positions 2G and 5G for each welding process to be used.
5. Qualify welders and welding operators for stainless steel as stated herein on the type of stainless steel being welded with the welding process used.

C. Certifications:
1. Coal-Tar Epoxy Applicator: Certified by Piping Manufacturer to be qualified to apply coal-tar epoxy coating to submerged or embedded ductile iron or cast iron soil piping.
2. Weld Testing Agency: Certified in accordance with current American Society for Nondestructive Testing (4153 Arlingate Plaza, Columbus, OH 43228) recommended practice SNT-TC-1A, NDT Level II.

D. Quality Control Submittals:
1. Manufacturer's Certification of Compliance.

2. Laboratory Testing Equipment: Certified calibrations, Manufacturer's product data, and test procedures.
3. Certified welding inspection and test results.
4. Qualifications:
    a. Weld Inspection and Testing Agency: Certification and qualifications.
    b. Welding Inspector: Certification and qualifications.
    c. Welders:
        1). List of qualified welders and welding operators.
        2). Current test records for qualified welder(s) and weld type(s) for factory and field welding.
5. Weld Procedures: Records in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
6. Nondestructive inspection and testing procedures.
7. Manufacturer's Certification of Compliance:
    a. Pipe and fittings.
    b. Welding electrodes and filler materials.
    c. Factory applied resins and coatings.
8. Certified weld inspection and test reports.
9. Pipe coating applicator certification.

1.6 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 60 00, PRODUCT REQUIREMENTS, and:
1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 - PRODUCTS

2.1 PIPING

A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.

B. Diameters Shown:
1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME 836.l0M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.2 JOINTS

A. Grooved End System:
1. Rigid, except where joints are used to correct misalignment, to provide flexibility, or where shown, furnish flexible type.
2. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.

B. Flanged Joints:
1. Flanges for ductile iron pipe shall conform to AWWA C115 at pressure rating meeting requirements of the connecting piping.
2. Flanges for steel pipe shall conform to ANSI/ASME B16.5 at pressure rating meeting requirements of the connecting piping

3. Higher pressure rated flanges as required, to mate with equipment when equipment flange is of higher pressure rating than required for piping.

C. Threaded Joints: NPT taper pipe threads in accordance with ANSI B 1.20. 1.

D. Thrust Tie-Rod Assemblies: NFPA 24; tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.

E. Mechanical Joint Anchor Gland Follower:
1. Ductile iron anchor type, wedge action, with break off tightening bolts.
2. Manufacturer and Product: EBAA Iron Inc.; Megalug.

F. Flexible Mechanical Compression Joint Coupling:
1. Stainless steel, ASTM A276, Type 305 bands.
2. Manufacturers:
   a. Pipeline Products Corp.
   b. Ferno Joint Sealer Co.

G. Mechanical connections of the high density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through flanged connections consisting of the following:
1. A polyethylene stub end thermally butt-fused to the end of the pipe.
2. ASTM A240, Type 304 stainless steel backing flange, 125-pound, ANSI B16.1 Standard. Insulating flanges shall be used where shown.
3. Bolts and nuts of sufficient length to show a minimum of three complete threads when the joint is made and tightened to the Manufacturer's standard. Re-torque the nuts after 4 hours.
4. Gaskets as specified on Data Sheet.
5. Connection to buried mechanical joint fittings and valves shall be by restrained mechanical joint follower glad designed for HDPE pipe. Provide stainless steel stiffener as required by pipe manufacturer.

2.3 COUPLINGS

A. Steel Middle Rings and Followers:
1. Fusion bonded, epoxy-lined, and coated in accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

B. Flexible Couplings:
1. Manufacturers and Products:
   a. Steel Pipe:
      1). Dresser; Style 38.
      2). Smith-Blair; Style 411.
      3). Romac 501
   b. Ductile Iron Pipe:
      1). Dresser; Style 38.
      2). Smith-Blair; Style 411.
      3). Romac 501

C. Transition Couplings:
1. Manufacturers and Products:
   a. Dresser; Style 62.
   b. Smith-Blair; Style 413.
   c. Romac RC501

D. Flanged Coupling Adapters:
   1. Manufacturers and Products:
      a. Steel Pipe:
         1). Smith-Blair; Series 913.
         2). Dresser Industries, Inc.; Style 128-W.
         3). Romac FC400
      b. Ductile Iron Pipe:
         1). Smith-Blair; Series 912.
         2). Dresser Industries, Inc.; Style 128-W.
         3). Romac FCA501

E. Dismantling Joints:
   1. Manufacturers and Products:
      a. Steel or Ductile Iron Pipe:
         1). Smith-Blair; Series 975.
         2). Dresser Industries, Inc.; Style 131.
         3). Romac DJ400.

2.4 HARDWARE

A. All hardware on submerged piping or piping below the top elevation of tanks and directly exposed to water, wastewater and/or wastewater solids , including but not limited to bolts, nuts, washers, and threaded rod shall be stainless steel.

2.5 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe Manufacturer and no substitute or “or-equal” will be allowed.

2.6 DOUBLE WALL CONTAINMENT PIPING SYSTEM

A. All system components shall be pre-engineered, factory fabricated, tested, and assembled such that field assembly is minimized to primarily that of straight joints.

2.7 THRUST RESTRAINT

A. Buried piping shall be restrained joint piping unless specified otherwise or when connecting to existing pipe lines. When connecting to existing pipe lines concrete thrust blocking shall be used as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

B. All above grade piping shall be adequately restrained and supported.

2.8 VENT AND DRAIN VALVES

A. Pipeline 2-1/2” Diameter and Larger: Vent connections shall be 3/4-inch with V300 ball valve. Drain connection shall be 1-inch with V300 ball valve, unless shown otherwise.

B. Pipeline 2” Diameter and Smaller: Vent connections shall be 1/2-inch with V300 ball valve. Drain connection shall be 1-inch with V300 ball valve, unless shown otherwise.

C. Provide galvanized steel pipe plug in each ball valve.

2.9 FABRICATION

A. Mark each pipe length on outside:
   1. Size or diameter and class.

2. Manufacturer's identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Flanged pipe shall be fabricated in the shop, not in the field, and delivered to the site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by the Manufacturer.

2.10 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s), Piping Schedule, and Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

B. Galvanizing:
1. Hot-dip applied, meeting requirements of ASTM A153.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Welding Electrodes: Verify proper grade and type, free of moisture and dampness, and coating is undamaged.

3.2 PREPARATION

A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

B. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

C. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with Manufacturer's instructions, except for damaged glass-lined pipe or PVDF-lined pipe that is to be promptly removed from the site.

3.3 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.1 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting Manufacturer.

B. Weld Identification: Mark each weld with symbol identifying welder.

C. Pipe End Preparation:
1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.

3. Beveled Ends for Butt Welding: ANSI B16.25.

D. Surfaces:
1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:
1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1", whichever is greater.

F. Climatic Conditions:
1. Do not perform welding if there is impingement of any rain, snow, sleet or high wind on the weld area, or if the ambient temperature is below 32 °F.
2. Stainless Steel and Alloy Piping: If the ambient is less than 32° F, local preheating to a temperature warm to the hand is required.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Passes: As required in welding procedure.

J. Weld Quality: Free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity slag inclusions, and other defects in excess of limits shown in applicable piping code.

3.4 INSTALLATION - GENERAL

A. Join pipe and fittings in accordance with Manufacturer's instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:
1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.

D. Threaded and Coupled Joints:
1. Conform to ANSI B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.

4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Soldered Joints:
1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply non-corrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

F. Couplings:
1. General:
   a. Install in accordance with Manufacturer's written instructions.
   b. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
   c. Remove pipe coating if necessary to present smooth surface.
2. Application:
   a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
   b. Nonmetallic Piping Systems: Teflon bellows connector.
   c. Concrete Encased Couplings: Sleeve type coupling.
   d. Corrosive Service Piping: Elastomer bellows connector.
   e. Grit Slurry Piping: Elastomer bellows connector.

G. Pipe Connections at Concrete Structures: As specified in article PIPING FLEXIBILITY PROVISIONS in Section 40 24 00, PROCESS PIPING SPECIALTIES.

H. Penetrations:
1. Watertight Penetrations:
   a. Provide wall pipes with thrust collars, as specified in Section 40 24 00, PROCESS PIPING SPECIALTIES.
   b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Non-watertight Penetrations:
   a. Pipe sleeves with seep ring as specified in Section 40 24 00, PROCESS PIPING SPECIALTIES.
   b. Pipe sleeves with modular mechanical seal may be provided where fabrication of seep ring on pipe sleeve is impractical.
3. Existing Walls:
   a. Rotary drilled holes with modular mechanical seal as specified in Section 40 24 00, PROCESS PIPING SPECIALTIES.
4. Fire-Rated or Smoke-Rated Walls, Floor, or Ceilings: Insulated and encased pipe sleeves as specified in Section 40 24 00, PROCESS PIPING SPECIALTIES.

I. PVC and CPVC Piping:
1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not over tighten fittings.
3. Do not thread Schedule 40 pipe.

J. Ductile Iron, Cement-Lined Ductile Iron, and Glass-Lined Ductile Iron Piping:
1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive saw cutter. Do not flame cut.
2. Dressing Cut Ends:
   a. General: As required for the type of joint to be made.
   b. Rubber Gasketed Joints: Remove sharp edges or projections.

c. Push-On Joints: Bevel, as recommended by pipe Manufacturer.
d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter Manufacturer.

3.5 INSTALLATION-EXPOSED PIPING

A. Piping Runs:
1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 22 05 29, PROCESS SUPPORTS AND ANCHORS.

C. Group piping wherever practical at common elevations; installing to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment Manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:
1. Over Walkway and Stairs: Minimum of 7’ 6”, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3’ 0”, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 1” from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Head room in front of openings, doors, and windows shall not be less than the top of the opening.
6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.6 INSTALLATION-BURIED PIPE

A. Joints:
1. Dissimilar Buried Pipes:
a. Provide flexible mechanical compression joints for pressure pipe.
b. Provide concrete closure collar for gravity and low pressure (maximum 10 psi) piping or as shown.
2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete unless specifically shown.

B. Placement:
1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.16, TRENCH BACKFILL.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.

4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last pipe section laid when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in the direction the pipe is laying.
9. Install closure sections and adapters for gravity piping at locations where pipe laying changes direction.
10. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
    a. Shorter pipe lengths.
    b. Special mitered joints.
    c. Standard or special fabricated bends.
11. After joint has been made, check pipe alignment and grade.
12. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
13. Prevent uplift and floating of pipe prior to backfilling.

C. PVC and CPVC Pipe Placement:
1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by Manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 °F, or above 90 °F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:
1. Deflection from Horizontal Line, Except PVC, CPVC, or HDPE: Maximum 2".
2. Deflection from Vertical Grade: Maximum 1/4".
3. Joint Deflection: Maximum of 75% of Manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75' from position shown.
5. Pipe Cover: Minimum 5', unless otherwise shown.

3.7 THRUST RESTRAINT

A. Location:
1. Buried Piping: At pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist.
2. Exposed Piping: At all joints in pressure piping.

B. Thrust Ties:
1. Install as detailed.
2. Anchoring retainer glands or thrust ties with setscrews is unacceptable.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint Manufacturer's adapter gland follower and pipe end retainer, or thrust tie-rods and socket clamps.

D. Thrust Blocking:
1. Place between undisturbed ground and fitting to be anchored.
2. Quantity of Concrete: Sufficient to cover bearing area on pipe and provide required soil bearing area as shown.
3. Place blocking so that pipe and fitting joints will be accessible for repairs.

4. Place concrete in accordance with Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.8 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including the first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:
1. Ductile Iron Piping: Connect only with service saddle or at a tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded thread-o-let or half-coupling as specified on Piping Data Sheet.
3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.9 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install the vents on high points, and drains on low points of pipelines, whether shown or not.

3.10 CLEANING

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines (except as stated below) with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris plant process air, natural gas, and instrument air-lines with compressed air at 4,000 fpm; do not flush with water.

C. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

E. Remove accumulated debris through drains 2” and larger or by removing spools and valves from piping.

3.11 DISINFECTION

A. Disinfect pipelines intended to carry potable water (W1).

B. See Section 33 13 00, DISINFECTION OF WATER SYSTEMS.

3.12 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of any surface preparation or coating application work.

B. As specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

3.13 PIPE IDENTIFICATION

A. See Section 22 05 53, MECHANICAL IDENTIFICATION and 09 90 00 PAINTING AND PROTECTIVE COATINGS.

3.14 INSULATION

A. See Section 40 42 00, PROCESS MECHANICAL INSULATION.

3.15 HEAT TRACING

A. See Section 40 41 13, HEAT TRACING.

3.16 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified. See Section 33 11 11, PIPING LEAKAGE TESTING.

B. Minimum Duties of Welding Inspector:
1. Job material verification and storage
2. Qualifications of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:
1. Perform Examinations in accordance with Piping Code ASME B31.1.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for all piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welder operator.
4. For each weld found to be defective under the acceptable standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above 3. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.17 SUPPLEMENTS

A. The supplements listed below, following “END OF SECTION,” are a part of this Specification.
1. Piping Schedule.
2. Data Sheets.

Number	Title
40 23 39.13	Cement Mortar Lined Ductile Iron Pipe and Fittings
40 23 39.16	Welded Steel Pipe and Fittings
40 23 39.42	Polyvinyl Chloride (PVC) Pipe and Fittings (DWV)
40 23 39.43	Polyvinyl Chloride (PVC) Pipe and Fittings
40 23 39.46	Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings
40 23 39.53	Copper and Copper Alloy Pipe, Tubing, and Fittings
40 23 39.56	High Density Polyethylene (HDPE) Pipe and Fittings
40 23 39.59	Double Wall Containment Piping
40 23 39.62	Polyethylene Tubing
40 23 39.72	Polytetrafluoroethylene Tubing

END OF SECTION

PROCESS PIPING SCHEDULE

Service	Flow Stream Identifier	Installation (Note 1)	Nominal Diameter (Note 2)	Material (Note 3)	Coating (Note 8)	Spec / Data Sheet No.	Max Operating Temp (°F)	Max Operating Pressure (psig)	Test Pressure (psig) & Method (Note 4)	Pipe Color (Note 5)	Remarks
Air Low Pressure, Odorous	APLO	Exposed	All	FRP	SPEC	40 05 36.13	175	25	AM	SPEC	4
Foul Air	FA	Exposed Buried	All	FRP	SPEC	40 05 36.13	175	25	AM	SPEC	4
Irrigation	IRR	Buried	All	PVC		40 23 39.42	Ambient	100	150, H		
Process Drain	PD	Exposed Buried	All	PVC		40 23 39.43	Ambient	Gravity	4, G	Gray	3
Water, Potable	W	Exposed Buried	All	C900 PVC	None	40 23 39.40	Ambient	100	150, H	Dark Blue	4

Notes:

1 Encased – All buried piping under concrete slabs and/or structures shall be concrete encased per standard detail D40/2400-009 unless indicated otherwise on the Drawings.
Exposed – Inside/Outside
Submerged – Below Liquid Surface
Buried – Directly into Soil

2 > Greater Than
< Less Than
<= Less Than or Equal To
>= Greater Than or Equal To

3 BS – Black Steel
CELDI – Ceramic Epoxy Lined Ductile Iron
CLDI – Cement Lined Ductile Iron
CPVC - Chlorinated Polyvinyl Chloride
GLDI – Glass Lined Ductile Iron
CU – Copper
DWV – Drain Waste Vent
HDPE – High Density Polyethylene
MDPE – Medium Density Polyethylene
STL – Carbon Steel
SST - Stainless Steel
FL PVC – Flanged Polyvinyl Chloride Pipe
PO PVC – Push on Joint Polyvinyl Chloride Pipe
SW PVC – Solvent Weld Polyvinyl Chloride Pipe
CLSTL – Cement Lined Welded Steel
VISS – Vacuum Insulated Stainless Steel
FRP – Fiberglass Reinforced Plastic

4 H - Hydrostatic Test
P - Pneumatic Test
G - Gravity Piping
AM – Air Method
HH – High Head
LH – Low Head
LP – Low-Pressure Pneumatic Test
See Section 40 05 00 for Piping Systems Testing for requirements
Pipe testing required as specified above.

5 See Section 09 96 00 for required painting.
For buried piping, no color shall be required; coordinate for proper coatings, as necessary.
Where no color is indicated, color to be selected by Owner.
For exposed piping not coated, provide colored banding and identification.

6 General - Deviations from this schedule are indicated directly by note on Drawings where deviation is required.

7 General – The piping material shall conform to the requirements for the service listed being drained or vented.

8 EPP – Epoxy and Polyurethane Coating System
HSE – High Solids Epoxy
CTP – Coal Tar Pitch
HT – High Temperature
SPEC – See pipe specification for coating

Remarks:

1 Where buried piping transitions to exposed PVC piping, the buried piping shall be extended at least six (6) inches above the finished floor before transitioning to exposed PVC piping.
2 Natural gas piping shall be tested in accordance with Section 406 of the International Fuel Gas Code.
3 SW PVC or FL PVC, FL PVC where shown
4 Heat trace and insulate all outside piping equal to or less than 4 inches in diameter.
5 Buried is flexible tubing in PVC carrier.

END OF SECTION

SECTION 40 23 39.40 C900 & C905 PVC Pipe and Fittings		
Item	**Size/Installation**	**Description**
Pipe	4 IN. – 12 IN. 14 IN – 48 IN.	C900 DR 18: Conforming to ASTM D1784 with a cell classification of 12454. Conforming to AWWA C900 C905 DR 18: Conforming to AWWA C905
Fittings	Buried	Ductile Iron Mechanical Joint Fittings as specified in 40 23 39.13 CM LINED DUCTILE IRON PIPE AND FITTINGS with restraint gland
Joints	All	Push-on: Meeting ASTM D3139 with gasket meeting ASTM F477 Restrained Joints: • C900: Proprietary Locking Gaskets • C905: Joint Restraint Harness; EBAA Iron Series 2800 or equal
Flanges	None	Not allowed
Couplings	Dissimilar Pipe Materials Similar Pipe Materials	Transition Coupling: Smith-Blair Style 413 or equal Ductile Iron Mechanical Joint Solid Sleeve

END OF SECTION

SECTION 40 23 39.42 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS (DWV)		
Item	**Size**	**Description**
Pipe	All	Schedule 40 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D2665 or F1866. Threaded Nipples: Schedule 40 PVC.
Fittings	All	Schedule 40 PVC as specified above: Conforming to the requirements of ASTM D2665.
Joints	All	Solvent socket-weld except where connection to valves and equipment may require future disassembly. Threaded joints shall not be used unless specifically approved by ENGINEER.
Flanges	All	One piece, molded hub type PVC flat face flange in accordance with Fittings above, 125-pound ANSI B16.1-89 drilling.
Bolting	All	Flat Face Mating Flange or In Corrosive Areas: ASTM A193/A193M Rev A-94 Type 316 stainless steel Grade B8M hex head bolts and ASTM A194/A194M-94 Grade 8M hex head nuts. With Raised Face Mating Flange: Carbon steel ASTM A307-94 Grade B square head bolts and ASTM A563-93 Grade A heavy hex head nuts.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8" thick. Raised Face Mating Flange: Flat ring 1/8" thick, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment. Gasket material shall be suitable for each service. Submit recommended gasket material for each service to ENGINEER.
Solvent Cement	All	As recommended by the pipe and fitting manufacturer conforming to ASTM F493 Rev A. Solvent cement shall be rated for use with each service. Provide manufacturer's certification that the solvent is appropriate for respective service.
Thread Lubricant	All	Teflon Tape

END OF SECTION

SECTION 40 23 39.43 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 23447-B conforming to ASTM D1785-05. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule 80 PVC as specified above: Conforming to the requirements of ASTM D2467.
Joints	All	Solvent socket-weld except where connection to valves and equipment may require future disassembly. Threaded joints shall not be used unless specifically approved by ENGINEER
Flanges	All	One piece, molded hub type PVC flat face flange in accordance with Fittings above, 125-pound ANSI B16.1-89 drilling.
Bolting	All	Flat Face Mating Flange or In Corrosive Areas: ASTM A193/A193M Rev A-94 Type 316 stainless steel Grade B8M hex head bolts and ASTM A194/A194M-94 Grade 8M hex head nuts. With Raised Face Mating Flange: Carbon steel ASTM A307-94 Grade B square head bolts and ASTM A563-93 Grade A heavy hex head nuts.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8" thick. Raised Face Mating Flange: Flat ring 1/8" thick, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment. Gasket material shall be suitable for each service. Submit recommended gasket material for each service to ENGINEER.
Solvent Cement	All	As recommended by the pipe and fitting manufacturer conforming to ASTM F493 Rev A. Solvent cement shall be rated for use with each service. Provide manufacturer's certification that the solvent is appropriate for respective service.
Thread Lubricant	All	Teflon Tape

END OF SECTION

SECTION 40 24 00 - PROCESS PIPING SPECIALTIES

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI):
      a. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
      b. B16.5, Pipe Flanges and Flanged Fittings.
   2. American Society for Testing and Materials (ASTM):
      a. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
      b. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
   3. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.2 SUBMITTALS

A. Shop Drawings: Manufacturer's data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide required piping specialty items, whether shown or not shown on the Drawings, as required by applicable codes and standard industry practice.

B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded pipe joints are not.

2.2 CONNECTORS

A. Teflon Bellows Connector:
   1. Type: Two convolutions unless otherwise shown, with metal reinforcing bands.
   2. Flanges: Ductile iron, drilled 150 psi ANSI B16.5 standard.
   3. Working Pressure Rating: 140 psi, minimum, at 120 ° F.
   4. Thrust Restraint: Limit bolts to restrain the force developed by the specified test pressure.
   5. Manufacturers and Products:
      a. Garlock; Style 214.
      b. Resistoflex; No. R6904.

B. Elastomer Bellows Connector:
   1. Type: Fabricated spool, with single filled arch.
   2. Materials: Nitrile tube and neoprene cover.
   3. End Connections: Flanged, drilled 125-pound ANSI B16.1 standard, with full elastomer face and steel retaining rings.
   4. Working Pressure Rating: 140 psig, minimum, at 180° F for sizes 12" and smaller.
   5. Thrust Restraint: Control rods to limit travel of elongation and compression.
   6. Manufacturers and Products:
      a. Goodall Rubber Co.; Specification E-1462.
      b. Garlock; Style 204.

C. Sleeve Type Coupling Manufacturers:
1. Dresser.
2. Rockwell.

D. Closure Collar Concrete: As specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

2.3 EXPANSION JOINTS

A. Elastomer Bellows:
1. Type: Reinforced, molded wide-arch.
2. End Connections: Flanged, drilled 125-pound ANSI B16.1 standard with split galvanized steel retaining rings.
3. Washers: Over the retaining rings to help provide a leak proof joint under test pressure.
4. Thrust Protection: Control rods to protect the bellows from overextension.
5. Bellows Arch Lining: Buna-N, nitrile, or butyl.
6. Rated Temperature: 250° F.
7. Rated Deflection and Pressure:
    a. Lateral Deflection: 3/4” minimum.
    b. Burst Pressure: Four times the working pressure.
    c. Compression deflection and minimum working pressure as follows:

Size (inch)	Deflection (inch)	Pressure (psig)
2-1/2 to 12	1.06	150
14	1.65	130
16 to 20	1.65	110

8. Manufacturers and Products:
    a. General Rubber Corp.; Style 1015 Maxijoint.
    b. Mercer; Flexmore Style 450.
    c. Goodall Rubber Co.; Specification E-711.

B. Teflon Bellows:
1. Type: Three convolutions, with metal reinforcing bands.
2. Flanges: Ductile iron, drilled 150 psi ANSI B 16.5 standard.
3. Working Pressure Rating: 100 psig, minimum, at 120° F.
4. Thrust Restraint: Limit bolts to restrain the force developed by the specified test pressure.
5. Manufacturers and Products:
    a. Garlock; Style 215.
    b. Resistoflex; No. R6905.

C. Copper Pipe Expansion Compensator:
1. Material: All bronze.
2. Working Pressure Rating: 125 psig, minimum.
3. Accessories: Anti-torque device to protect the bellows.
4. Manufacturers and Products:
    a. Flexonics; Model HB.
    b. Hyspan; Model 8509 or 8510.

D. Galvanized and Black Steel Pipe Expansion Compensator:
1. Material: Carbon steel with stainless steel bellows.
2. Working Pressure Rating: 150 psig, minimum.
3. Accessories: Anti-torque device to protect the bellows.
4. Manufacturers and Products:
    a. Flexonics; Model H.

b. Hyspan; Model 8503.

E. Flexible Metal Hose:
1. Type: Close pitch, annular corrugated with single braided jacket.
2. Material: Stainless steel, ASTM A276, Type 321.
3. End Connections:
a. 3” and Larger: Shop fabricated flanged ends to match mating flanges.
b. 2-1/2” and Smaller: Screwed ends with one union end.
4. Minimum Burst Pressure: 600 psig at 70° F for 12” and smaller.
5. Length: Provide hose live-length equal to the lengths shown on the Drawings.
6. Manufacturers and Products:
a. Flexonics; Series 401M.
b. Anaconda; BWC21-1.

2.4 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Manufacturers and Products:
1. Flexonics; Model TCS, with tie bolts.
2. Keflex;Type 152-TR, with tie bolts.

2.5 SERVICE SADDLES

A. Double-Strap Iron:
1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with the outside diameter of the pipe on which the saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
a. Body: Malleable or ductile iron.
b. Straps: Galvanized steel.
c. Hex Nuts and Washers: Steel.
d. Seal: Rubber.
5. Manufacturers and Products:
a. Smith-Blair; Series 313 or 366.
b. Dresser; Style 91.

B. Nylon-Coated Iron:
1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with the outside diameter of the pipe on which the saddle is installed.
3. Materials:
a. Body: Nylon-coated iron.
b. Seal: Buna-N.
c. Clamps and Nuts: Stainless steel.
4. Manufacturer and Product:
a. Smith-Blair; Style 315 or 317.

2.6 INSULATING FLANGES, COUPLINGS, AND UNIONS

A. Materials:
1. In accordance with the applicable piping material specified in the Pipe Data Sheets.
2. Galvanically compatible with piping.

B. Union Type:
   1. 2” and Smaller: Screwed or solder-joint.
   2. 2-1/2” and Larger: Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.

C. Working Pressure Rating: Suitable for specified system working pressure.

D. Manufacturers and Products:
   1. Dielectric Flanges and Unions:
      a. Epco Sales, Inc.
      b. Capitol Insulation Unions.
   2. Insulating Couplings:
      a. Dresser; STAB-39.
      b. R. H. Baker; Series 216.

2.7 WALL PIPES

A. Ductile Iron Wall Pipe:
   1. For penetrations through concrete walls, floors, slabs, or roofs that are to be watertight.
   2. Diameter and Ends: Same as connecting ductile iron pipe.
   3. Thickness: Equal to or greater than remainder of pipe in line.
   4. Fittings: In accordance with applicable Pipe Data Sheet.
   5. Thrust Collars:
      a. Provide for all wall pipes.
      b. Rated for thrust load developed at 250 psi.
      c. Safety Factor: 2, minimum.
      d. Material and Construction:
         Ductile iron or cast iron, cast integral with wall pipe wherever possible. Fabricate welded attachment of ductile iron thrust collar to pipe where casting impossible. Perform in pipe manufacturer’s shop by qualified welders. Electric arc welds of ductile iron with NI-55 or FC-55 nickel-iron-carbon weld rod. Continuously weld on each side all around.
   6. Manufacturers: American Cat Iron Pipe Co.; U.S. Pipe and Foundry Co.
   7. Coating After Fabrication: Prepare and coat wall pipe in accordance with and as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS, System No. 2

B. Steel or Stainless Steel Wall Pipe:
   1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
   2. Lining: Same as connecting pipe.
   3. Thrust Collar: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe. Continuously fillet weld on each side all around.
   4. Coating After Fabrication: Prepare and coat wall pipe in accordance with and as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS, System No. 2
   5. Restraint: Provide lugs for use with thrust ties as specified.

2.8 PIPE SLEEVES

A. Steel Pipe Sleeve:
   1. Material: 3/16” minimum thickness steel pipe.
   2. Seep Ring:
      a. 3/16” minimum thickness center steel flange for water stoppage on sleeves in exterior or water-bearing walls.
      b. Outside Diameter: 3” greater than pipe sleeve outside diameter.
      c. Continuously fillet weld on each side all around.
   3. Factory Finish:
      a. Galvanizing:

Hot-dip applied, meeting requirements of ASTM A153.
Electroplated zinc or cadmium plating is unacceptable.

b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, PROTECTIVE PAINTING AND COATINGS, System No.2.

B. Insulated and Encased Pipe Sleeve:
1. Manufacturer: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

C. Modular Mechanical Seal:
1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication: Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts, nuts, and pressure plates.
3. Size: According to Manufacturer's instructions for the size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40 feet of water.
4. Manufacturer: Thunderline Link-Seal.

2.9 MISCELLANEOUS SPECIALTIES

A. Strainers for Process Water Service, 2" and Smaller:
1. Type: Bronze Body, Y-Pattern, 200 psi non-shock rated, with screwed gasketed bronze cap.
2. Screen: Heavy gauge Type 304 stainless steel or Monel, 20-mesh
3. Manufacturers:
a. Armstrong International, Inc.; Model F
b. Mueller Steam Specialty; Model 351M.

B. Strainers for CPVC, Plastic Piping Systems, 4" and Smaller:
1. Type: Y-pattern CPVC body, 150 psi non-shock rated, with screwed CPVC cap; and PTFE Teflon seals as recommended by manufacturer for service.
2. End Connections: Screwed or solvent weld, 2" and smaller. Class 150 ANSI flanged, 1-1/2" and larger.
3. Screen: Heavy-gauge CPVC, 1/32" mesh, minimum 2 to 1 screen area to pipe size ratio.
4. Manufacturers and Products: Hayword; Series 85/80, or equal.

C. Spray Nozzles:
1. Scum Spray Nozzle Type 1:
a. Spray Pattern: Even
b. Spray Angle: 140° at 60 psi
c. Material: 316 Stainless Steel
d. Deflection Angle: 75°
e. Capacity: 8 gpm at 40 psi
f. Size: 1/2" NPT
g. Provide nozzle with adjustable ball fitting
h. Manufacturer and Produce: Spraying System Co., Nozzle Type K; or equal.
2. Scum Spray Nozzle Type 2:
a. Spray Pattern: Solid narrow angle cone-shaped spray pattern with round impact area
b. Spray Angle: 15° at 40 psi
c. Material: 316 stainless steel
d. Capacity: 3 gpm at 40 psi
e. Size: 1/4" NPT
f. Provide nozzle with adjustable ball fitting
g. Manufacturer and Product: Spraying System Co., Nozzle Type G-15; or equal.
3. Scum Spray Nozzle Type 3:

a. Spray Pattern: Deflected flat spray pattern at low pressure
b. Counterweight lever which when lifted, allows the solid stream flow to purge nozzle.
c. Material: Bronze with neoprene rubber deflector
d. Size: 1/4” NPT
e. Manufacturer and Product: Spraying System Co., 22561 Foam Control Spray Nozzles; or equal.

D. Quick Couplings:
1. Provide female NPT by male quick-connect hose adaptors. All adapters and couplers shall satisfy dimensional requirements of MIL-C-27487E and shall be cast iron and sized shown on the Drawings.
2. Manufacturers and Products: Swagelock; Series QH.

E. Quick Disconnect Cam Operating Couplings for Chemical Service:
1. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
2. Material: Glass-filled polypropylene and PVDF with Teflon gaskets and as recommended for the service by Manufacturer.
3. End Connections: NPT threaded or flanged to match piping connections.
4. Hose shanks for chemical installations.
5. Plugs and Caps: Female dust cap for each male end, male dust plug for each female end.
6. Pressure Rating: 125 psi, minimum at 70° F.
7. Manufacturers:
a. OPW; Kamlock
b. Ryan Herco; 1300 Series
c. Goodall; Basic Eight

F. Chemical Injection Quills:
1. Retractable injection quill, service rated for 250 psi, including stainless steel check valve, ball valve, solution tube adaptor, packing nut, restraint system, and limit chains, and 300 Series O-ring gaskets.
2. Manufacturer and Products: SAF-T-FLO; or equal.

PART 3 - EXECUTION

3.1 SHIPPING, STORAGE, HANDLING, AND PROTECTION

A. As specified in Section 01 60 00, PRODUCT REQUIREMENT.

B. Install process piping specialties in accordance with manufacturer's directions, as shown on the Drawings, and as specified herein.

3.2 PIPING FLEXIBILITY PROVISIONS

A. General:
1. Install thrust protection.
2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.

B. Flexible Joints at Concrete Backfill or Encasement: Install within 18” or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures:

1. Install 18” or less from the face of structures; joint may be flush with face.
2. Install a second flexible joint, whether or not shown.
    a. Pipe Diameter 18” and smaller: Within 18” of the first joint.
    b. Pipe Diameter Larger than 18”: Within one pipe diameter of the first joint.

3.3 PIPING TRANSITION

A. Applications:
1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipes where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:
1. Flexible Transition Couplings: Install in accordance with coupling Manufacturer’s instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
    a. Locate away from structures so that there are at least two flexible joints between the closure and pipe entering the structure.
    b. Clean pipe surface before closure collars are placed.
    c. Wet non-metallic pipe thoroughly prior to pouring collars.
    d. Prevent concrete from entering pipe.
    e. Extend collar a minimum of 12” on each side of joint with minimum thickness of 6” around outside diameter of pipe.
    f. Make entire collar in one placement.
    g. After concrete has reached initial set, cure by covering with well moistened earth.

3.4 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:
1. Grooved Joint and Flanged Piping Systems: Elastomer Bellows Expansion Joint.
2. Nonmetallic Pipe: Teflon Bellows Expansion Joint.
3. Screwed and Soldered Piping Systems: Copper or Galvanized and Black Steel Pipe Expansion Compensator, as applicable.
4. Pipe Run Offset: Flexible Metal Hose.

C. Anchors and Anchor Walls: Install as specified in Section 22 05 29, PROCESS SUPPORTS AND ANCHORS, to withstand expansion thrust loads and to direct and control thermal expansion.

3.5 SERVICE SADDLES AND THRUST TIES

A. Service Saddles:
1. Ferrous Metal Piping (except stainless steel): Double-strap iron.
2. Plastic Piping: Nylon-coated iron.

B. Thrust Ties:
   1. Install where shown and where required to restrain the force developed by the specified test pressure.
   2. Steel Pipe: Attach with fabricated lugs.
   3. Ductile Iron Pipe: Attach with socket clamps against a grooved joint coupling or flange.
   4. Flanged Coupling Adapters: For exposed installations, install Manufacturer's anchor studs through the coupling sleeve.

C. Installation: Install in accordance with Manufacturer's written instructions.
   1. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
   2. Remove pipe coating if necessary to present smooth surface.

3.6 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Tie Bolts: Tighten snug prior to applying any pressure to the system.

3.7 INSULATING FLANGES, COUPLINGS, AND UNIONS

A. Applications:
   1. Copper to ferrous metal piping connections.
   2. Cathodically protected piping penetration to buildings and watertight structures.
   3. Submerged to un-submerged metallic piping connections.
   4. Where required for electrically insulated connection.

B. Installation of Insulating Kits: Drill oversize to accommodate insulating sleeves through the bolt holes, assuming standard bolt sizes.

C. Pipe Installation:
   1. Insulating joints connecting immersed piping to non-immersed piping shall be installed above maximum water surface elevation.
   2. All submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete basins shall be isolated from the concrete reinforcement steel.

3.8 WALL PIPES

A. Applications:
   1. As specified in Section 40 23 39, PROCESS PIPING - GENERAL
   2. Watertight and Below Ground Penetrations:
      a. Wall pipes with thrust collars.
      b. Provide taps for stud bolts in flanges to be set flush with wall face.
      c. Existing Walls: Rotary drilled holes.
   3. Wall Pipe Installation:
      a. Isolate embedded metallic piping from concrete reinforcement.
      b. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

3.9 PIPE SLEEVES

A. Application:
   1. As specified in Section 40 23 39, PROCESS PIPING - GENERAL.
   2. Above Grade in Non-submerged Areas: Hot-dip galvanized after fabrication.
   3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.

B. Installation:

1. Support non-insulating type securely in form work to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with rubber sealant or seal with wall penetration seal.

3.10 MISCELLANEOUS SPECIALTIES

A. Install in accordance with manufacturer's instructions.

END OF SECTION

SECTION 40 41 13 – HEAT TRACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes basic requirements for heat tracing including:
   1. Heating Cables.
   2. Control Panels.
   3. Temperature Sensors.
   4. Temperature Controllers.
   5. Contactors.
   6. Enclosures.
   7. All other auxiliary equipment and controls required to complete a heat tracing system.

B. Related sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 40 42 00 – Mechanical Insulation.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI).
   2. American Society for Testing and Materials (ASTM):
      a. B193 – Standard Test Method for Resistivity of Electrical Conductor Materials.
      b. D2633 – Standard Test Methods for Thermoplastic Insulations and Jackets for Wire and Cable.
   3. Factory Mutual Research Corp. (FM).
   4. Institute of Electrical and Electronic Engineers(IEEE):
      a. IEEE P515 – Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
      b. IEEE 622 – Design & Installation of Electric Heat Tracing SY.
   5. International Electro-Mechanical Commission (IEC).
   6. National Electrical Manufacturers' Association (NEMA):
      a. 1CS1-110.
   7. National Fire Protection Association (NFPA):
      a. NFPA 70 – National Electric Code (NEC).
   8. Occupational Safety and Health Standards (OSHA).
   9. Underwriters' Laboratories, Inc. (UL):
      a. UL 746B – Polymeric Materials – Long Term Property Evaluations.

1.3 SUBMITTALS

A. Submittals shall be made in accordance with Section 01 33 00, SUBMITTAL PROCEDURES.

B. Product Data:

   1. Catalog number, wattage output, voltage rating, and product data.
   2. Installation instructions.
   3. Warranty.

C. Shop Drawings: Include isometric drawings for each heat traced pipe showing installation details, and size and type of heat tracing cable.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements and Reference Standards: The electric heat tracing system shall conform to this specification and shall be designed, manufactured and tested in accordance with the minimum applicable requirements of the latest edition of the following codes and standards. Additional specific requirements shall be further defined in the testing requirements for each section.

1.5 WARRANTY

A. Cables: All cables shall be warranted for a period of 10 years for manufacturing defects.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Design Requirements:
   1. General: Heat tracing applications up to a maintain temperature of 250 degrees Fahrenheit and intermittent exposure to 420 degrees Fahrenheit shall us self-regulating heating cables and pads.
   2. Self-regulating heating cable shall vary its heat output relative to the temperature of the surface of the pipe or the tank allowing cable to be crossed over itself without overheating and to be cut to length in the field.
   3. Design for a useful life of 20 years or more with “power on” continuously. The criteria for life shall be to retain at least 75 percent of its original power when tested according to UL 746B.

2.2 HEAT TRACING CABLE

A. Self-regulating and self-limiting, 5 watts per foot, 120 volts, 60 hertz, flexible twin 16 AWG copper bus wires, with tinned copper braid overshield.

B. Manufacturers: One of the following or equal:
   1. Raychem Chemelex Auto-Trace.
   2. Chromalox Type SLR Rapid Trace.
   3. Thermon, BSX.
   4. Nelson, CLT or LT.

2.3 CONTROLLER

A. Manufacturer: One of the following or equal:
   1. Raychem Monitrace1000.

B. Operating Characteristics:
   1. Controller shall provide continuous monitoring of heat tracing circuit analyzing temperature through a hard-wired RTD.
   2. Controller shall energize system automatically if the temperature drops below a preset point. Controller shall be equipped with local alarm to alert maintenance personnel if heat trace circuit is interrupted.
   3. Controller shall have the capability of performing a self-diagnostic check on the system and advising maintenance personnel of the exact nature of any circuit problems.

C. Controller shall be fully compatible with heat trace and provided by same manufacturer as heat trace.

1. Controller shall be powered from 120 VAC. A configurable dry contact shall be provided for heat trace fault.
2. Controller shall have double pole solid state switching, temperature control from -40°F to 125° F and a 30-amp rating from -40° F to 125° F, ambient temperature.
3. Power Supply: Controller power supply shall be either 110-240 VAC with adjustable ground fault detection.
4. Controller shall have battery backup system to retain programmed parameters in the event of a power failure.
5. Enclosure: Unit shall be enclosed in a NEMA 4X panel.
6. Controller shall be rated for Class I Division 2 locations.
7. Network Capabilities: Controller shall have network capabilities enabling monitoring and programming from a central location.

2.4 CONNECTION KITS, END SEALS, SPLICE AND TEE KITS

A. Heat trace connection, end, splice and tee kits shall be designed to meet or exceed the life of the heat trace and shall be given equal consideration and evaluation.

2.5 ACCESSORIES

A. Power connection kits.

B. Termination kits.

C. Splice kits.

D. End seal kits.

E. Straps.

F. Thermostat.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install heat tracing cable on piping subject to freezing in the following areas and as indicated on the Drawings:
1. Persigo Wastewater Treatment Plant Biotrickling Filter System.
2. Persigo Wash Air Jumper System.
3. Dos Rios Biotrickling Filter System.
4. Dos Rios Biotrickling Filter Sump System.

B. Wrap heat tracing tape with aluminum tape prior to installing insulation.

C. Install pipe insulation as specified in Section 40 42 00, MECHANICAL INSULATION.

D. Install heat tape and controls in accordance with manufacturer’s published installation instructions.

E. Thermostat:
1. Thermostat shall be powered by 120 VAC.
2. One single 120-volt power source will be provided to the heat tracing control system panel as indicated on the Drawings.
3. Thermostats will be powered from the power panel provided by the Contractor.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service.
   1. Inspect installed systems for proper installation.
   2. Instruct OWNER's personnel on operations and maintenance of the systems.

END OF SECTION

SECTION 40 42 00 – PROCESS MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Insulation, jackets, and accessories for piping and related systems. Refer to 23 07 13 Mechanical Insulation for HVAC related piping insulation requirements.

B. Related sections:
1. Section 01 33 00 – Submittal Procedures.
2. Section 09 90 00 – Painting and Protective Coatings.
3. Section 22 05 29 – Process Supports and Anchors.
4. Section 22 05 53 – Mechanical Identification.
5. Section 40 23 39 – Process Piping General.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
1. American Society for Testing and Materials (ASTM):
a. A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
b. C168 – Standard Terminology Relating to Thermal Insulation.
c. C177 – Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
d. C335 – Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation.
e. C518 – Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
f. C533 – Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
g. C534 – Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
h. C547 – Standard Specification for Mineral Fiber Pipe Insulation.
i. C552 – Standard Specification for Cellular Glass Thermal Insulation.
j. C585 – Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
k. C591 – Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
l. C795 – Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
m. C929 – Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation materials for Use in Contact with Austenitic Stainless Steel.
n. C1136 – Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
o. D2310 – Classification of Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
p. E84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
q. E96 – Standard Test Methods for Water Vapor Transmission of Materials.

1.3 DEFINITIONS

A. Buried: Piping that is installed below buildings, foundations or finish grade, either in soil or encased in concrete in soil.

B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.

C. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.

D. Flame Spread and Smoke Density: Burning characteristics determined in accordance with ASTM E84. No units apply to value.

E. Interior: Piping that is installed inside a building.

F. K Factor: Thermal conductivity determined in accordance with ASTM C177 or C518 and expressed in units of Btu-inch/hour-feet^2 – deg F.

G. Mineral Fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.

H. Water Vapor Permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

1.4 SUBMITTALS

A. Submittals shall be made in accordance with Section 01 33 00.

B. Product Data:
1. Insulation Properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
2. Jacket Properties: Include covering material, cover thickness, tensile strength, tear strength, permeability per ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
3. Insulating Blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.

C. Manufacturer's Application Instructions: Include assembly and application drawings and detailed instructions.

D. Laboratory Report: Provide certified laboratory report stating that insulation is not manufactured using chlorinated polymers and does not contain chlorides, bromides, sulfates, or fire-rated materials.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store insulation materials and accessories under cover and protected from moisture.

B. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

1.6 SEQUENCING AND SCHEDULING

A. Pressure test piping and complete application of coating system before applying insulation.

B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.

C. Before beginning installation of piping insulation, verify that the ENGINEER has accepted piping tests, pipe coating applications, and heat tracing tests.

1.7 WARRANTY

A. Furnish one – year minimum warranty.

B. Furnish five – year manufacturer warranty.

PART 2 - PRODUCTS

2.1 PIPE INSULATION, GENERAL REQUIREMENTS

A. Insulation Thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal manufacturing tolerance of 15 percent variation is permissible.

Required Insulation Thicknesses (inches)					
SERVICE TEMPERATURE RANGE AS DESIGNATED IN INSULATION SCHEDULE AT END OF THIS SECTION	**Nominal Pipe Diameters**				
	1 inch & less	**1.25 to 2 inch**	**2.5 to 4 Inch**	**5 to 10 Inch**	**Over 10 inch**
Above 200 deg F	2.0	2.5	3.0	3.5	3.5
100 to 200 deg F	1.5	1.5	1.5	2.0	2.5
40 to 100 deg F	0.5	1.0	1.0	1.5	2.0
Below 40 deg F	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0

2.2 PIPE INSULATION

A. Insulation Types: Provide in accordance with the insulation types listed and scheduled.

B. Insulation, Type 1:
   1. Insulation Material: Closed cell elastomeric insulation
   2. Minimum Temperature Range: Minus 40 deg F to plus 220 deg F.
   3. K Factor at 75 deg F: Not more than 0.27 BTU-in/hr-sq ft-deg F.
   4. Fire Ratings:
      a. Flame Spread: 25 or less.
      b. Smoke Density: 50 or less for insulation thicknesses up to 1.5 inches.
   5. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.
   6. Manufacturers: One of the following or equal:
      a. Armacell Engineered Systems, AP/Armaflex

C. Insulation, Type 2:
   1. Insulation Material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
      a. Conform to ASTM C547, Class 1.
      b. Provide with factory installed vapor barrier.

1) Material: White kraft paper bound to aluminum foil meeting ASTM C1136, Type I.
2) Longitudinal Lap Seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
3) Circumferential Butt Seals: 4-inch wide tape or similar properties or 4-inch wide overlap with adhesive seal.
4) Vapor Barrier Permeability: 0.02 perms or lower.
5) Vapor Barrier Flame Spread Rating: 25 or less.

2. Minimum Temperature Range: Minus 0 deg F to plus 850 deg F.
3. K Factor at 75 deg F: Not more than 0.23 BTU-in/hr-sq ft-deg F.
4. Average Insulation Density: 3.3 pounds per cubic foot.
5. Maximum Moisture Absorption, Volume Percent: 0.2.
6. Manufacturers: One of the following or equal:
   a. Owens-Corning Fiberglass Corp.
   b. Johns Manville
   c. Knauf Insulation

D. Insulation, Type 3:
1. Insulation Material: Rigid polyisocyanurate foam in accordance with ASTM C591, Type IV.
2. Temperature Range: Minus 297 deg F to plus 300 deg F.
3. K Factor at 75 deg F: Not more than 0.19 BTU-in/hr-sq ft-deg F.
4. Minimum Average Density: 4.0 pounds per cubic foot.
5. Maximum Moisture Absorption, Volume Percent: 0.7.
6. Minimum Compressive Strength: 25 pounds per square inch.
7. Moisture Permeability: 4.00 perm-inch.
8. Manufacturers: One of the following or equal:
   a. ITW.
   b. Dyplast.
   c. or Equal.

E. Insulation, Type 4:
1. Insulation Material: Rigid cellular glass in accordance with ASTM C553, Type II.
2. Temperature Range: Minus 450 deg F to plus 900 deg F.
3. K Factor at 75 deg F: Not more than 0.32 BTU-in/hr-sq ft-deg F.
4. Minimum Average Density: 7.5 pounds per cubic foot.
5. Maximum Moisture Absorption, Volume Percent: 0.2.
6. Minimum Compressive Strength: 87 pounds per square inch.
7. Moisture Permeability: 0.00 perm-inch.
8. Manufacturers: One of the following or equal:
   a. Pittsburgh Corning Corporation, Foamglas.
   b. Cell-U-Foam Corporation, Ultra-CUF.

F. Insulation, Type 5:
1. Insulation Material: Asbestos free, rigid calcium silicate in accordance with ASTM C533; Type 1 for process temperatures up to 1,200 deg F.
2. K Factor at 500 deg F: 0.55 for Type 1.
3. Maximum Average (Dry) Density: 14.5 pounds per cubic foot.
4. Compressive Strength: 100 pounds per square inch, to produce a 5 percent compression.
5. Manufacturers: One of the following or equal: In accordance with ASTM C533 Type I:
   a. Industrial Insulation Group, LLC, Thermo-12 Gold.

2.3 INSULATION JACKETS

A. Jacket, Type 1:

1. Material, 28 ounces per square yard polyvinyl chloride on polyester fabric; total thickness 0.028 inches minimum.
2. Fire Rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: As selected by the Engineer from manufacturer's standard colors.
4. Overlap: One-inch minimum at joints and fittings.
5. Joint Seal: Self-sealing lap tape.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
    a. Accessible Products Company

B. Jacket, Type 2:
1. Material: Ultraviolet resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
2. Fire Rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: White.
4. Overlap: One-inch minimum at joints and fittings.
5. Joint Seal: PVC solvent welded or adhesive as recommended by the manufacturer.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
    a. Johns Manville, Zeston 2000 PVC.
    b. Proto Corp., LoSMOKE PVC.
    c. Speedline Smoke Safe PVC Jacketing System.
    d. Knauf Covering System.

C. Jacket, Type 3:
1. Material: Aluminum, Allow 5005; 0.016-inch (26 gauge) minimum thickness.
2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
3. Bands: 0.5 inch wide, 0.0508 inch (16 gauge) thick aluminum, same alloy as jacket or 0.0179-inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
4. Joint Seal: Apply waterproof adhesive at joints and overlaps.
5. Fittings: Custom fit of same materials.
6. Manufacturers: One of the following or equal:
    a. Childers Products.

2.4 VAPOR BARRIERS

A. Vapor Barrier, Type 1:
1. Material: White kraft paper bound to aluminum foil and meeting requirements of ASTM C1136, Type 1.
2. Permeability: 0.02 perms or lower.
3. Maximum Flame Spread Rating: 25.
4. Edge Seal: Pressure sensitive tape lap seal.
5. Circumferential Joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
6. Manufacturers: One of the following or equal:
    a. Owens-Corning Fiberglass Corp., all service jackets with double sure adhesive lap seal.
    b. Schuller, Micro-Lok AP-T plus.

B. Vapor Barrier, Type 2:
1. Material: Mastic.
2. Manufacturers: One of the following or equal:
    a. Foster Products, 36-10/46-10 Weatherite.
    b. Childers Products CP10/11 Vi-Acryl.

2.5 RELATED MATERIALS

A. Cover Adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard duty adhesives are not permitted.

2.6 REMOVABLE INSULATING BLANKETS

A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, and other in-line piping appurtenances and equipment requiring periodic servicing.

B. Size Limits: Use removable insulating blankets for equipment and piping appurtenances 3-inch in nominal size and larger. Insulate equipment and piping appurtenances less than 3-inch with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.

C. Manufacturers: One of the following or equal:
   1. Pittsburgh Corning, Temp-Mat.
   2. Accessible Products.
   3. Thermal Energy Products, Inc., Energy Wrap.

D. Low temperature insulating blankets rated up to 800 deg F:
   1. Use: For service temperatures up to 800 deg F.
   2. Insulation: Fiberglass fiber, K factor 0.27 at 75 deg F.
   3. Cover: 17-ounce fabric with both sides covered with silicone impregnated glass cloth suitable for temperatures up to 800 deg F.
   4. Dover Fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire; or
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

E. High temperature insulating blankets rated up to 1,400 deg F:
   1. Rated for sustained service temperatures up to 1,400 deg F.
   2. Insulation: Ceramic fiber, K factor 0.50 at 600 deg F, insulation material suitable for up to 2,300 deg F, thickness to match adjacent piping insulation specified thickness.
   3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 deg F.
   4. Cover Fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire; or
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verification of Conditions: Before installing insulation, verify satisfactory completion of pressure tests of piping systems and functional tests of heat tracing equipment.

B. Examine piping surfaces and verify that surfaces are dry and free of loose scale, rust, dirt, oil, or water before applying insulation. When specified, paint or coat pipe surfaces as specified in Section 09 90 00.

C. Examine insulation materials and accessories before installation. Do not install insulation and jackets that have been damaged or insulation that has become wet due to exposure to water.

3.2 INSTALLATION

A. Install insulation and jacket materials in accordance with manufacturer's written instructions.

B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fits insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. Do not use cut pieces or scraps to complete the installation.

C. Butt longitudinal and circumferential insulation joints firmly together.

D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.

E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.

F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.

G. Fittings:
   1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
   2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
   3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.

H. Valves:
   1. Insulate valves 3-inch in nominal size and larger with removable insulating blankets.
   2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.

I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.

J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide water tight end seals and covers where insulation terminates.

K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.

L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.

M. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.

N. For Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees F shall be thermally isolated from piping at all insulation closure locations (end caps, transitions, etc.).

O. Apply piping identification on jackets as specified in Section 22 05 53.

3.3 INSULATION SCHEDULE

Service Designation[1]	Location[2]	Insulation Type[3]	Jacket Type[3]	Service Temp. °F[4]	Vapor Barrier
Heat Traced Pipes [5]	Exterior	1 or 2	2	Use thickness established in Table in paragraph 2.1	Install on Type 2 insulation

Notes:

1. Refer to Process Piping Schedule in Section 40 23 39 for service designations.
2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
3. Contractor may select from options listed.
4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table in paragraph 2.1 A.
5. Insulate all piping systems that are specified to be heat traced.

END OF SECTION

SECTION 40 61 13 – PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SUMMARY

A. The work to be included under this section shall consist of furnishing all materials, labor, equipment, tools, supplies, and incidentals necessary for the installation and testing of all process control systems.

B. Related Sections:
   1. Section 40 63 43 – Programmable Logic Controllers
   2. Section 40 67 23 – Control Panels

1.2 REFERENCES

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

1.3 SCOPE OF WORK

A. The Contractor shall furnish all materials, equipment, labor and services to achieve a fully functional process control system for this project.

B. The Contractor shall be responsible for providing and installing all instrumentation, PLC control panels, networking equipment, and other control system hardware as specified for a complete process control system installation. The Owner will provide programming of the existing plant SCADA system.

C. The scope of the instrumentation, control, and SCADA system for this project includes:
   1. Furnish, install, configure, and calibrate instrumentation as detailed on the drawings and in the specifications.
   2. Fabricate and install all control panels as indicated in the drawings. Terminate all field control wiring inside control panels.
   3. Establish communications between the new control panels and the existing plant SCADA network, per the drawings and specifications.
   4. Provide all hardware required to properly communicate between all control panels, whether or not explicitly identified in the drawings or specifications.
   5. Install networking equipment and communication cables between control devices as indicating in the drawings and specifications and provide configuration of equipment to

ensure proper communication between all devices associated with the integrated operating platform.

6. Modification to existing instrumentation and control systems as required to new and existing equipment to maintain process operations.
7. Provide overall coordination, installation, supervision, and installation of control panels, instrumentation, networking systems, and other miscellaneous control system components as specified.
8. Provide overall coordination, installation, and supervision of process control systems.
9. Execute the testing procedures outlined in this document.

D. Vendor system packages may be provided under other sections of this contract that may interface with the process control system via communications protocol and/or hard-wired I/O. Refer to the associated specification sections and the contract drawings for additional details. The Contractor shall be responsible for coordination, furnishing, installing, and configuring any communication devices or drivers necessary to ensure proper communication with each of the vendor-furnished systems.

E. Vendor system packages may include instrumentation or control panels that shall be installed and configured by the Contractor according to vendor instructions. Upon satisfactory installation, configuration, and calibration, the Contractor shall coordinate with each vendor to inspect finished work.

1.4 SUBMITTALS

A. Product Data:
1. Instrument Installation Details.
2. Certified Calibration Sheets.
3. Complete and detailed instruction manuals on each item furnished including but not limited to all devices and instruments. Information to be contained in the instruction manuals shall include but not be limited to drawings, dimensions, manufacturer's recommendations, ratings, performance charts, power requirements, schematics, maintenance requirements and procedures, calibration recommendations and procedures, repair instructions, complete and recommended spare parts lists and related information.
4. Proposed tagging and attachment materials and methods.

B. Shop Drawings shall be submitted for approval by the Engineer.
1. The Contractor shall submit to the Engineer, for approval, Shop Drawings of the equipment to be installed to meet the Specifications. The Drawings shall be supported by notes or written directions as required to fully define the installation. The submission shall be made as soon as feasible after award of the Contract and, in any event, shall be submitted and approval obtained before installation of the equipment.
2. The information required on the Shop Drawings shall include, but is not necessarily limited to, the following:
    a. Full and complete specifications covering the equipment proposed to be furnished.
    b. Detail Drawings showing plan, network connections and elevation dimensions of the equipment proposed to be furnished.
    c. Guarantees of performance of the equipment proposed to be furnished.
    d. Nearest location of factory maintenance and service facilities that will be available to service the equipment offered.
    e. To scale plans, sections and elevations detailing entire installation. Include mounting hardware, brackets, assemblies and other devices as required for a complete installation.
3. Control panels:
    a. Panel and sub-panel layout
    b. Point-to-Point Wiring Diagrams
    c. Interconnection drawings

d. System hardware

C. Contract Closeout Submittals:
1. Project Record Documents
2. Operating and Maintenance Data
3. Warranty

D. Instrumentation and control testing documents shall be submitted for approval by the Engineer:
1. Credentials of technicians doing the inspection and testing
2. Written certification as detailed under testing requirements in this specification section

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 PROJECT AND SITE CONDITIONS

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

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

B. Where the ratings of individual components cannot meet the requirements, provide suitable means of physical protection. Suitable physical protection shall consist of an assembly which meets the requirements listed, while limiting the ambient conditions at the non-conforming component to 90% of the component's rating (Example: A component rated for vibration at only 5 G. acceleration would be required to be combined with vibration isolation to limit the acceleration of the component to 4.5 G. when subjected to ambient acceleration of 10 G. from 10 - 2000 Hz.).

C. Operating Environmental Conditions: All instruments and control devices provided shall be rated for continuous operation in their installed operating environment and shall be capable of continuous operation at the operating conditions without significant reduction of their operating life.

D. All controlling devices shall be NEMA or IEC rated.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. All meters, instruments, control units, and other components shall be the most recent field proven models marketed by their respective manufacturers at the time of the submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Analog measurements and control signals shall be electrical and shall vary in direct linear proportion to the variable being measured. All analog signals whether inputs or outputs shall be 4-20mA DC unless otherwise noted. The analog input signals shall maintain loop integrity with the installation of properly sized resistors across the input terminals. Provide surge protection for all analog signal terminations

C. All of the elements, instruments, accessories, and assemblies shall be installed in accordance with the manufacturer's installation instructions, and as detailed on the Drawings. Shielded instrumentation cables shall be used for all analog signals from the instruments to the programmable logic controller panels. Separate conduits shall be used for instrument power, instrument signals, and fiber optic cables.

D. All instruments installed outdoors subject to direct sunlight shall include a stainless steel sunshade.

E. All digital outputs shall be isolated from the field equipment through an interposing relay. The relays shall be mounted inside the cabinet housing the associated programmable logic controller as shown on Drawings.

F. The Contractor shall make the necessary power connections and signal connections from the field devices (i.e. instruments, control valves, etc.) to the programmable logic controllers.

G. The Contractor shall configure and verify proper operation of the Integrated Operating Platform, included but not limited to the following requirements:
   1. The PLCs, OITs, networking hardware, surge protection devices, uninterruptible power supplies, and other incidental equipment shall be configured and installed as shown on the Drawings and as specified herein.
   2. All networked devices shall be configured for proper communication via the topology and protocol shown on the Drawings or specified herein.
   3. Verify that all system devices power up, function and properly communicate prior to commencing any startup or testing procedures as described herein.

3.2 TESTING AND INSTALLATION REQUIREMENTS

A. Testing and Installation Requirements: The Contractor shall be required to coordinate the following services during construction related to the testing and installation of the process control system. The complete system testing shall include all PLCs, SCADA software and hardware, network devices, interconnecting cables, and other peripheral devices required for a complete and functional system. The testing of the system shall occur in the following stages: a Site Readiness Test, a Functional System Test, and a Final Acceptance Test.

B. Site Readiness Test
   1. A Site Readiness Test shall be performed after the installation of all control system components including PLC control panels, communications, control wiring, device configurations, instrument calibrations, motor controllers, and variable frequency

controllers in accordance with the Contract Documents. The test will typically not include the Engineer or Owner; however, any of these parties shall be provided the opportunity to witness the testing if desired.

2. The purpose of this test is for the Contractor to verify the following:
   a. All instruments have been properly configured and calibrated
   b. All field control wiring has been properly installed and terminated
   c. All PLC control panel hardware is operating and communicating properly
   d. The installation is ready for functional process control testing.
3. Site Readiness Test shall include energization and testing for correct hardware integration of all system components, including PLC remote I/O assemblies, and reliable communications between components with correct protocols.
4. Provide point-to-point wiring checks for continuity between field devices to final PLC I/O terminations.
5. To the greatest extent possible, the Contractor shall check I/O under process conditions to the end elements. For example, I/O for valve limit switches shall be checked by operating the valve to full open and closed positions, rather than using jumpers or other means to simulate valve operation.
6. Provide verification and documentation of normally closed or normally open contacts for discrete I/O signals.
7. Discrete inputs shall be tested by operating the end device to force a signal change. Observe results on all indicators such as PLC register, panel light, etc.
8. Discrete output signals shall be tested by forcing a value in the PLC register. Observe that the connected equipment properly responds.
9. Analog inputs shall be verified at 0 percent, 25 percent, 50 percent, 75 percent, and 100% of span. Observe results on all indicators such as PLC register, digital panel meters, etc.
10. Analog outputs shall be tested by entering values in the PLC register to force the outputs at 0 percent, 25 percent, 50 percent, 75%, and 100% of span. Observe that the connected equipment properly responds.
11. Personnel performing the test shall have International Society of Automation (ISA) Certified Control Systems Technicians (CCST) or equivalent credentials as approved by the Engineer or Owner.
12. Provide written tests results documenting satisfactory completion of the Site Readiness Test.

C. Functional System Test
   1. Upon approval of the Site Readiness Test, the Contractor shall begin functional testing of control strategies.
   2. The purpose of the functional system testing is to implement and test the automatic and manual process control strategies through PLC and HMI programming.
   3. The Contractor shall be present during the duration of the functional testing to address any issues with hardware, wiring, or instrumentation modifications. The Contractor shall also be available to assist with equipment operations as necessary.
   4. For this test, all equipment shall be installed, calibrated, and functioning as required in the contract documents.
   5. Each analog and discrete I/O signal shall be checked through the PLC to the HMI screens to verify proper mapping of tags.
   6. Functionality of the system shall be checked to ensure conformance with process control strategies.
   7. PLC control loops shall be tuned to achieve stable process control.
   8. If during the Functional System Test, the Engineer or Owner finds that process control is not achievable due to errors in the installation, the functional testing shall stop and the Contractor shall correct the installation and repeat the testing at no additional cost to the Owner.

D. Final Acceptance Test:

1. After the system has been started up and running in automatic control to the greatest extent possible, the Contractor shall conduct a Final Acceptance test of the completed installation. The test shall start after the Engineer has received marked record (as-built) drawings from the Contractor and when directed by the Owner/Engineer.
2. During this test, the Owner and Engineer shall have full use of the system. The duration of the test shall be 30 days.
3. Contractor personnel shall be readily available to address issues onsite during the acceptance test.
4. The system shall operate with 100% reliability during the test period. Failure shall be defined as the inability to control or indicate status of specified inputs or outputs or any specified function of the control systems as described herein caused by defective hardware or software furnished in this project. Failure of hardware or software shall require repair or remedy of the defect to the satisfaction of the Engineer/Owner within 2 days. If the problem cannot be repaired in this time, the test shall be aborted and restarted after the problem is corrected and when directed by the Owner/Engineer. Restarting and satisfactory completion of the test shall be conducted at no additional cost to the Owner.
5. Throughout the duration of the test, no modifications shall be made to the system without prior approval from the Engineer or Owner.

3.3 TRAINING, STARTUP ASSISTANCE, & WARRANTY

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

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

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

D. Maintenance Instruction:
1. Operating and maintenance instructions, along with a separate parts list, shall be furnished in three (3) copies to the Owner. Operating instructions shall also incorporate a functional description of the system, including the system schematics which reflect "as-built" modifications. Maintenance requirements particular to the system shall be clearly defined, along with calibration and test procedures.

E. Warranty:

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

END OF SECTION

SECTION 40 63 43 – PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. The work to be included under this section shall consist of furnishing all materials, labor, equipment, tools, supplies, and incidentals necessary for the installation and testing of all programmable logic controllers (PLCs).

B. Related Sections:
   1. Section 40 61 13 – Process Control System General Provisions
   2. Section 40 67 23 – Control Panels

1.2 REFERENCES

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

1.3 QUALITY ASSURANCE

A. Manufacturer’s Support: The PLC system manufacturer shall maintain, as a part of a national network, engineering service facilities within 100 miles of the project, to provide start-up service, emergency service calls, repair work, service contracts, maintenance, and training. Emergency service shall be available within twenty-four hours of notification.

1.4 SUBMITTALS

A. Refer to specification 40 61 13 for submittal requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 PROGRAMMABLE LOGIC CONTROLLERS

A. Biotrickling Filter Control Panels:

1. Manufacturer:
    a. Siemens SIMATIC S7-1500
2. Components: The PLCs shall consist of the following basic components:
    a. Power supply module properly sized for the I/O load.
    b. Chassis with capacity for modules, including spares, as detailed in the plans.
    c. Processor module with sufficient memory for the application. Processors shall be the same model for all provided PLCs.
    d. Ethernet communication module.
    e. I/O modules as required for the application.

B. Dos Rios RTU Panel
1. Manufacturer:
    a. Samsara IG41 Industrial Gateway
2. Components: Provide the following components:
    a. Provide Samsara IG license registered to the City of Grand Junction.
    b. DIN rail power supply.
    c. I/O modules as required for the application.
    d. LTE antenna.

C. Features:
1. Each PLC shall be installed with a minimum of 25% spare I/O points of each type utilized in its I/O structure.
2. The PLCs shall be capable of and shall be configured to provide stand-alone operation in the event of a communications link failure.
3. The necessary interface cables, communications cables, power cables, bus extension cables, modular card slot fillers, and other ancillary parts shall be furnished and installed as integral parts of the control system.
4. Nameplates shall be provided for each module, device, and other equipment with appropriate data such as the equipment number, rating, serial number, and manufacturer.

D. Spare Parts:
1. The Contractor shall furnish the Owner the following spare replacement parts:
    a. One (1) processor module of each type
    b. One (1) I/O modules of each type
    c. One (1) communication module of each type

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall utilize personnel who are skilled and experienced in the installation, setup, and configuration of the PLCs being furnished under this contract.

B. Any PLC furnished as part of a vendor supplied equipment package shall be accessible for future program monitoring and revisions. If password protection of any kind is implemented, the vendor or Contractor shall supply all passwords or other security information to the Owner and the Engineer.

C. The Contractor shall furnish the Owner final as-built copies of documented PLC programs for vendor supplied equipment packages, on electronic media, suitable for future troubleshooting or modifications by others.

D. All components and assemblies shall be installed in accordance with the manufacturer's installation instructions.

END OF SECTION 40 63 43

SECTION 40 67 23 – CONTROL PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. This specification covers all control panels provided as part of the project. Major control panels provided as part of this project include, but are not limited to:
   1. Persigo WWTP BTF control panels – vendor supplied.
   2. Dos Rios BTF control panel – vendor supplied.
   3. Dos Rios Condensate Pumps control panel – vendor supplied.
   4. Dos Rios RTU control panel – contractor supplied.

B. Furnish and install functional control panels to manually or automatically operate control systems as specified in the detailed requirements of this section and related sections.

C. Related Sections:
   1. Section 40 61 13 – Process Control System General Provisions
   2. Division 40 63 43 – Programmable Logic Controllers

1.2 SUBMITTALS

A. Submittals shall contain information on related equipment to be furnished under this Specification but described in the related Sections listed in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will also be returned un-reviewed.

B. All submittals for control panels provided as part of an equipment vendor's scope shall be submitted as a part of the Process Equipment manufacturer's submittal.

C. All submittals for control panels provided by the Contractor shall be submitted as a part of the Contractor's submittals.

D. The equipment manufacturer shall create all equipment shop drawings, including all wiring diagrams, in the manufacturer's Engineering department. All equipment shop drawings shall bear the mechanical equipment manufacturer's logo, drawing file numbers, and shall be maintained on file in the mechanical equipment manufacturer's archive file system.

E. Submit to the Owner/Engineer, shop drawings and product data, for the following:
   1. Custom unit elementary drawings. Drawings shall include all schematics for control logic as described in the Process Equipment Specifications, and any associated control schematics shown on the Engineer's Drawings for this project. Show interconnections between components and to remotely mounted devices. Include and identify all connecting equipment and remote devices on the schematics. The notation "Remote Device" will not be acceptable. Show wire and terminal numbers. Indicate special identifications for devices as required by the mechanical equipment manufacturer or as may be shown on the Drawings.
   2. Equipment outline drawings showing elevation, plan and interior views, front panel arrangement, dimensions, weight, shipping splits, conduit entrances and anchor bolt pattern. Indicate all options, special features, ratings and deviations from this Section.
   3. Power and control schematics including external connections. Show wire and terminal numbers and color-coding.
   4. Instruction and replacement parts books, including manufacturer's part numbers and selections of component ratings.
   5. As-built final drawings.

6. Documentation that the panel assembly facility is a UL-508 certified facility.
7. Furnish complete Bill of Materials indicating manufacturer's name and part numbers.
8. Manufacturer's cut sheets for every component used in the panel assembly adequately marked to show the items being included. The manufacturer's name shall be clearly visible on each cut sheet submitted.
9. Assembly ratings including:
    a. Short-circuit rating
    b. Voltage
    c. Continuous current
10. Major component ratings including:
    a. Voltage
    b. Continuous current
    c. Interrupting ratings
11. Cable terminal sizes.
12. Instruction and renewal parts books.

F. Factory Tests. Submittals shall be made for factory tests specified herein.

G. Field Test Reports. Submittals shall be made for field tests specified herein.

H. Operation and Maintenance Manuals.
1. Operation and Maintenance Manuals shall include the following information:
    a. Manufacturer's contact address and telephone number for parts and service.
    b. Instruction books and/or leaflets
    c. Recommended renewal parts list
    d. Record Documents for the information required by the Submittals paragraph above.

I. The manufacturer shall submit for approval, a training agenda for all training specified herein. Training agenda shall not be submitted until final approval of the Operation and Maintenance Manual.

1.3 REFERENCE CODES AND STANDARDS

A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):
1. NEMA Standard ICS 2 – 2000 Industrial Control and Systems
2. NFPA 70 – National Electrical Code (NEC)
3. NFPA 70E – Standard for Electrical Safety in the Workplace
4. NFPA 79 – Electrical Standard for Industrial Machinery
5. UL 508/508A – Industrial Control Enclosures

B. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.4 QUALITY ASSURANCE

A. The manufacturer of the control panels shall have produced similar equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The control panels shall be assembled in a UL-508 certified facility. A submittal of documentation certifying that the panel fabrication facility is a UL-508 certified facility, is required. A UL label shall be affixed to the inside of the external door by the panel fabrication assembly.

C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.

D. Control panels submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.

E. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

1.5 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, onsite factory work, or failed factory tests will not be permitted.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two (2) copies of these instructions shall be included with the equipment at time of shipment, and shall be made available to the Contractor and Owner/Engineer.

C. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.

D. Where space heaters are provided in equipment, provide temporary electrical power and operate space heaters during storage, and after equipment is installed in permanent location, until equipment is placed in service.

1.6 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for the same length of time as the associated mechanical equipment, but not less than 1 year from date of final acceptance of the equipment. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work, requiring shipping or transporting of the equipment, shall be performed by the Manufacturer, at no expense to the Owner.

PART 2 - PRODUCTS

2.1 RATINGS

A. The service voltage shall be as specified and as shown on the Drawings. The overall short circuit withstand, and interrupting rating of the equipment and devices shall be not less than 22,000 amperes RMS symmetrical for panels operating at 480/277 Volts, and equal to or greater than the overall short circuit withstand and interrupting rating of the feeder device immediately upstream of the Control Panel. This includes all circuit breakers and combination motor starters. Systems of motor controllers employing series connected ratings for main and feeder devices shall not be used. Motor starter units shall be tested and UL 508A labeled for the specified short circuit duty in combination with the motor branch circuit protective device. The overall short circuit rating of the panel shall be not less than 10,000 amperes RMS symmetrical for panels operating at 120VAC.

B. There shall be selective device coordination between the Main Breaker, Feeder Breakers and control circuit protective devices. When using a circuit breaker or fuses as a main protective device, the instantaneous trip levels of the main protective device shall be higher than the available fault current to the control panel. If fuses are utilized in the control panel design, the

protective devices for 3 phase loads shall contain single phase protection of such equipment. If a fault occurs in the circuit of one load of a design with a backup load, the feeder protective device shall not remove both loads from the control system.

C. The complete control panel assembly shall be UL certified and carry a UL listing for "Industrial Control Panels".

D. The control panel shall meet all applicable requirements of the National Electrical Code.

E. The control panel enclosure shall be NEMA rated as specified herein.

F. Motor controllers, including associated devices, shall be designed for continuous operation at rated current in a 40 degree C ambient temperature.

G. For additional ratings and construction notes, refer to the mechanical equipment specifications and the Drawings.

2.2 CONSTRUCTION

A. General
1. Submit actual layout and location of equipment and components; current ratings of devices, bus bars, components; protective relays, voltage ratings of devices, components and assemblies; and other required details. NEMA ratings of all devices shall meet or exceed the rating of each panel.
2. Control units shall be arranged as shown on the Drawings.
3. Nameplates
   a. Exterior
      1) Nameplates shall be engraved, laminated impact acrylic. Nameplates shall be 316 SS screw mounted to all enclosures except for NEMA 4 and 4X. Nameplates for NEMA 4 and 4X enclosures shall be attached with double faced adhesive strips. Prior to installing the adhesive nameplates, the metal surface shall be thoroughly cleaned with 70% alcohol until all residues have been removed. Epoxy adhesive or foam tape is not acceptable.
      2) There shall be a master nameplate that indicates supply voltage equipment ratings, short circuit current rating, manufacturer's name, shop order number and general information. Cubicle nameplates shall be mounted on the front face, on the rear panel and inside the assembly, visible when the rear panel is removed.
      3) Provide permanent warning signs as follows:
      4) "Danger- High Voltage- Keep Out" on all doors.
      5) "Warning- Hazard of Electric Shock - Disconnect Power Before Opening or Working On This Unit" on Main Power Disconnect or Disconnects.
   b. Internal
      1) Provide the panel with a UL 508A label.
      2) Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification, corresponding to appropriate designations on manufacturer's wiring diagrams.
4. Control Devices and Indicators
   a. All operating control devices, indicators, and instruments shall be securely mounted on the panel door. All controls and indicators shall be 30mm, corrosion resistant, NEMA 4X/13, anodized aluminum or reinforced plastic. Booted control devices are not acceptable. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition. Additional controls shall be provided as specified herein and as required by the detailed mechanical and electrical equipment requirements.

b. Indicator lamps shall be LED type. For all control applications, indicator lamps shall incorporate a push-to-test feature.
c. Mode selector switches (HAND-OFF-AUTO, LOCAL-OFF-REMOTE, etc.) shall have the number of positions and contact arrangements, as required. Each switch shall have an extra dry contact for remote monitoring.
d. Panel meters for digital display of analog signal values shall be provided where indicated. Panel meters shall be 4-20mA loop powered, 1/8 DIN LCD displays, Precision Digital Model PD 6600 series or equal.
e. Panel Interface Connector (PIC): Each control panel with a PLC shall include a PIC mounted on the outside of the enclosure for providing a Ethernet connection to internal devices. The PIC shall include a 120 VAC single phase duplex receptacle with 3 Ampere externally resettable circuit breaker and an RJ45 pass-through connector.
f. Furnish nameplates for each device. All nameplates shall be laminated plastic, black lettering on a white background, attached with stainless steel screws. Device mounted nameplates are not acceptable.
g. The manufacturer shall not remove, reuse, alter, or replace original equipment nameplates or equipment tags associated with equipment or components supplied by the manufacturer's suppliers and sub-suppliers.

5. Control Relays
   a. Provide relays as required to implement indicated control functions. General purpose, alternating and time delay relays may be used within their ratings for logic, timing and sequencing but shall not be used to drive loads in excess of 80% of their contact "make" or "break" ratings. Provide interposing power relays to drive loads such as starters larger than NEMA size 1 and all other utilization equipment with loads greater than specified for general purpose and time delay relays. Provide relays rated to drive the load as required. Relays shall be provided with an LED status indicator.
   b. Discrete Output Relays: Terminal block style interposing relays shall be used for all controller outputs. Devices shall be PLC-RSC series as manufactured by Phoenix Contact or equal. Provide pull-up or pull-down resistors on all digital outputs as required for the application.
6. Control and Instrument Power Transformers.
   a. Control power transformers shall be provided. Transformer shall be sized for the entire load, including space heaters, plus 25% spare capacity, and shall be not less than 100VA.
   b. Control power transformers shall be 120 volt grounded secondary. Primary side of the transformer shall be fused in both legs. One leg of the transformer secondary shall be solidly grounded and the other leg shall be fused.
   c. Control power transformers shall be installed inside the control panel that they serve. They shall not be mounted exterior to the panel.
7. Power Supplies
   a. When required, the control panel shall be furnished with a separate DC power supply to provide DC power for control panel components and the loop power for 2-wire instruments. The power supplies shall be DIN rail mounted, 120VAC input, 24VDC output, with output load rated as required for the connected loads. Power supplies shall be provided by Phoenix Contact, Allen-Bradley, or Sola.

B. Enclosures
1. General
   a. Each enclosure shall incorporate a removable back panel, and side panels, on which control components shall be mounted. Back panel shall be secured to the enclosure with collar studs for wall mounted enclosures, and 316 SS hardware for free standing enclosures.
   b. All free-standing enclosures shall be provided with feet of the same construction as the enclosure.

c. Back panel shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any components.
d. All enclosure doors shall have bonding studs. The enclosure interior shall have a bonding stud.
e. Each enclosure shall be provided with a documentation pocket on the inner door.
f. Enclosures shall not have holes or knockouts.
g. Provide manufacturer's window kits where shown on the Drawings.
h. All enclosures shall be pad-lockable.

2. NEMA 4X
   a. NEMA 4X panels shall be provided for all outdoor locations, or indoor locations where directly exposed to process or wash-down water.
   b. NEMA 4X 316 Stainless Steel
   c. Type 316 stainless steel, body and door
   d. Stainless steel continuous hinge
   e. Foam gasket
   f. Single point quarter turn latches (20"x24" and below). All others 3-point latch.
   g. Manufacturers
      1) Hoffman Comline Series.
      2) EMF Company.
      3) NEMA Enclosures Company.
      4) Hammond Company.
      5) Approved Equal.
3. NEMA 12
   a. NEMA 12 panels shall be provided for clean and dry indoor locations.
   b. NEMA 12 Painted Steel.
   c. Painted steel, body and door.
   d. Continuous hinge.
   e. Foam gasket.
   f. Single point quarter turn latches (20"x24" and below). All others 3-point latch.
   g. Manufacturers
      1) Hoffman Comline Series.
      2) EMF Company.
      3) NEMA Enclosures Company.
      4) Hammond Company.
      5) Approved Equal.

C. Environmental Conditioning
1. Air Conditioning
   a. A panel air conditioner shall be provided where panels include variable frequency drives and are installed outdoors or unconditioned indoor spaces.
   b. The air conditioner shall be powered from the panel. A separate power source shall not be required.
   c. The enclosure cooling system shall not compromise the enclosure's NEMA rating and shall be sized for the environment in which the control panel will be installed.
   d. The air conditioner shall be sized to provide cooling to maintain the interior temperature of the panel to meet VFD manufacturer recommendations for maximum ambient temperature.
2. Ventilation
   a. Where air conditioning is not required, panel fans and louvers shall be provided where panels are installed in unconditioned indoor spaces.
   b. Panel ventilation shall also be provided in indoor conditioned spaces where the panel manufacturer has determined it necessary in order to maintain the interior temperature of the panel within manufacturer recommended limits.
   c. The fans shall be powered from the panel. A separate power source shall not be required.

d. The enclosure ventilation system shall not compromise the enclosure's NEMA rating and shall be sized for the environment in which the control panel will be installed.
e. The ventilation shall be sized to maintain the interior temperature of the panel to meet manufacturer recommendations for maximum ambient temperature of all electronic components.

3. Condensation Control
   a. A self-contained enclosure condensation heater with thermostat and fan shall be mounted inside the control panel, if panel is mounted outdoors or in a non-air-conditioned space.
      1) Enclosure heaters shall be energized from 120 volt, single-phase power supply and sized to prevent condensation within the enclosure.
      2) Locate enclosure heaters to avoid overheating electronic hardware or producing large temperature fluctuations on the hardware.
      3) Enclosure heaters shall have an internal fan for heat distribution and shall be controlled with adjustable thermostats. The thermostat shall have an adjustment range of 40 degrees Fahrenheit to 90 degrees Fahrenheit. Provide a circuit breaker or fused disconnect switch within the enclosure.
      4) Enclosure heaters shall be Hoffman type DAH or equal.
   b. Strip heaters may be provided if they are 240 volt rated, powered at 120 volts AC and do not have a surface temperature higher than 60°C. Strip heaters and thermostats shall be as manufactured by Chromalox or equal.
   c. Each panel shall have a ½" stainless steel condensate drain.

D. Internal Wiring
1. Power and control wiring shall be tinned stranded copper, minimum size No. 14 AWG, with 600 Volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation. Line side power wiring shall be sized for the full rating or frame size of the connected device.
2. Analog signal wires shall be 600 Volt Class, insulated stranded tinned copper, twisted shielded #18 AWG pair.
3. All interconnecting wires between panel mounted equipment and external equipment shall be terminated at numbered terminal blocks. Field wiring shall not be terminated directly on any panel-mounted device.
4. All wiring shall be tagged and coded with an identification number as shown on the Drawings. Coding shall be typed on a heat shrinkable tube applied to each end showing origination and destination of each wire. The marking shall be permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal.
5. All wiring shall be enclosed in PVC wire trough with slotted side openings and removable cover. Plan wire routing such that no low twisted shielded pair cable conducting analog 4-20 mA signals or low voltage analog signals are routed in the same wire trough as power conductors carrying greater than 120V.
6. All control panel wiring shall use the following color code.
   a. Black: AC power at line voltage.
   b. Red: switched AC power.
   c. Orange: May be energized while the main disconnect is in the off position.
   d. White: AC neutral.
   e. Orange/white stripe or white/orange stripe: separate derived neutral.
   f. Red/white stripe or white/red stripe: switched neutral.
   g. Green or green w/ yellow tracer: ground/earth ground.
   h. Blue: Ungrounded DC power.
   i. Blue/white stripe or white/blue stripe: DC grounded common.
   j. Brown: 480V AC 3 phase - phase A.
   k. Orange: 480V AC 3 phase - phase B.
   l. Yellow: 480V AC 3 Phase - phase C.
   m. Purple: common for analog signal wiring.
   n. Brown: positive leg of an analog signal.

E. Field Installed Internal Wiring
   1. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.
   2. All field wiring shall be tagged and coded with an identification number. Coding shall be typed on a heat shrinkable tube applied to each end of the wire. The marking shall be a permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal
   3. In general, all conduit entering or leaving outdoor panels shall be stubbed up into the bottom of the enclosure to the greatest extent possible.

F. Terminal Blocks
   1. Terminal blocks shall be DIN-rail-mounted one-piece molded plastic blocks with tubular-clamp-screw type and end barriers. Terminal blocks shall be rated for 600 volts except for control and instrumentation circuits, or 4-20 mA analog signal conductors.
   2. Provide 600 volt rated terminal blocks for any conductor carrying any voltage over 120 volts to ground.
   3. Provide 600 volt rated strap screw terminal blocks for any power conductors carrying over 20 amps, at any voltage. Terminals shall be double sided and supplied with removable covers to prevent accidental contact with live circuits.
   4. Power conductors carrying over 20 amps, at any voltage shall be terminated to strap-screw type terminal blocks with crimp type, pre-insulated, ring-tongue lugs. Lugs shall be of the appropriate size for the terminal block screws and for the number and size of the wires terminated. Do not terminate more than one conductor in any lug, and do not land more than two conductors under any strap-screw terminal point.
   5. Terminals shall have permanent, legible identification, clearly visible with the protective cover removed. Each terminal block shall have 20 percent spare terminals, but not less than two spare terminals.
   6. Use the manufacturer's provided bridge connectors to interconnect terminal blocks terminating common or ground conductors.
   7. Twisted shielded pair or triad cables shall have each individual conductor and shield drain wire landed on individual terminal blocks. Use the manufacturer's provided bridge connectors to interconnect terminal blocks terminating the shield drain wire conductors.
   8. Control circuits, 120 volts and below, and 4-20 mA analog signal conductors shall be terminated with manufacturer's recommended insulated connectors.
   9. Current Loop Surge Protection Devices: The 4-20mA signal loop channels on analog inputs and outputs shall be protected against static discharge, lightning, and faulty wiring with three stage surge protection terminal block devices. Devices shall be pluggable with indication status lights. Devices shall be PLUGTRAB series as manufactured by Phoenix Contact or equal.
   10. Provide an AC ground bar bonded to the panel enclosure (if metal) with 20 percent spare terminals.
   11. Provided ground terminal blocks for each twisted-shielded pair drain wire.

2.3 MAIN CIRCUIT PROTECTIVE DEVICE

A. For panels operating at 480VAC, unless otherwise shown on the Drawings, the main circuit protective device shall be a molded case (MCCB), 3 Pole, 600 Volt, fixed type, manually operated with stored energy closing mechanism. For MCCBs 200A and larger, trip device shall be solid state with adjustable long time pickup, and delay; adjustable short time pickup and delay; and short time i2t switch. Provide ground fault pickups where indicated on the drawings.
   1. Provide a flange mounted main power disconnect operating handle with mechanical interlock having a bypass that will allow the panel door to open only when the switch is in the OFF position. Where panels are shown or specified with inner and outer doors, disconnecting handles and controls shall be located on the inner door.

2.4 ACROSS THE LINE MOTOR CONTROLLERS

A. General
1. Provide the NEMA size starter, circuit breaker trip ratings, control power transformers and thermal overload heater element ratings matched to the motors and control equipment actually supplied, in compliance with the NEC and the manufacturer's heater selection tables. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the Owner.
2. Furnish lugs for incoming wiring. Allow adequate clearance for bending and terminating of cable size and type specified.
3. A NEMA rated magnetic motor starter shall be furnished for each motor. Each motor starter shall be provided with a motor circuit protector, or circuit breaker, and equipped to provide undervoltage release and overload protection on all three phases. The short circuit protective device shall have an adjustable magnetic trip range up to 1400 percent of rated continuous current and a trip test feature. MCPs shall be labeled in accordance with UL489. NEMA starter sizes and breaker trip ratings shall be as required for the horsepower indicated but shall be in no case less than NEMA Size 1. If the manufacturer of the equipment utilizing the motor, supplies a motor horsepower larger than that shown on the Drawings, the Contractor shall supply a motor starter sufficient in size to control the motor supplied.
4. A mechanical disconnect mechanism, with bypass, shall be installed on each motor circuit protector, capable of being locked in the "OFF" position to provide a means of disconnecting power to each motor. Disconnects mechanisms shall be located inside the enclosure such that the main circuit breaker handle is the only device interlocked with the panel door.
5. Each motor starter shall have a 120 volt operating coil unless otherwise noted.
6. Overload relays shall be standard Class 20, ambient compensated, manually reset by pushbutton located on front of the starter door. A normally closed contact shall be directly used in the start circuit and a normally open contact shall be wire to a terminal board for overload alarm.
7. All interfaces between control panel and remote devices shall be isolated via an interposing relay. Interposing relays shall have contacts rated for 250 VAC and 10 Amps continuous. Relays shall be Control Relays as specified herein.

B. Magnetic Motor Starters
1. Motor starters shall be 2 or 3 pole, single or 3 phase as required, 60 Hertz, 600 volt, magnetically operated, full voltage non reversing. NEMA sizes shall be as required for the horsepower shown on the Drawings.
2. Each motor starter shall have a 120 volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Drawings. A minimum of one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts required.
3. Overload relays shall be adjustable, ambient compensated and manually reset.
4. Built in control stations and indicating lights shall be furnished where shown on the Drawings.
5. All wires shall be terminated on terminal blocks and shall be tagged.
6. Provide as built wiring diagram and post it in a protective cover inside the cell.

C. Contactors
1. Contactors shall be a circuit breaker and contactor, 600 Volt, 3 Pole, 60 Hz, magnetically operated. NEMA size shall be as required for the kilowatt ratings required for the equipment provided, but shall be not less than NEMA size 1.
2. Contactors shall have a 120 Volt operating coil and control power transformer. Furnish the control power transformer with extra capacity for the unit heater fan.

D. Control Relays

1. Control relays shall be 300 volt, industrial rated, plug-in socket type, housed in a transparent polycarbonate dust cover, designed in accordance with UL Standard 508 for motor controller duty. Continuous contact rating shall be 10 amperes resistive, ¼ HP at 120 VAC, operating temperature minus 10 to plus 55 degrees C. Provide spare N.O. & N.C. contacts. Relays shall be Potter & Brumfield KRP Series or equal with neon coil indicator light. Timing relays shall be 300 Volt, solid state type, with rotary switch to select the timing range.

E. Elapsed Time Meter
1. A six-digit, non-resettable elapsed time meter shall be installed on the face of each motor starter.

2.5 VARIABLE FREQUENCY DRIVE MOTOR CONTROLLERS

A. Where variable frequency drives (VFDs) are provided for motor starting and control, comply with requirements of Division 26 specifications for VFDs.

2.6 INSTRUMENTATION DEVICES

A. Where instrumentation devices are specified or shown on the Drawings, refer to Division 40 Instrumentation specifications.

2.7 REMOTE MONITORING AND CONTROL INTERFACE

A. General: All control and interconnection points from the equipment to the plant control and monitoring system shall be brought to dedicated terminal blocks. No field connections shall be made directly to the equipment control devices. Functions to be brought out shall be as specified in related specification sections and the contract drawings.

B. Discrete control or status functions shall be form C relays with contacts rated at 120 volts AC. Analog signals shall be isolated from each other.

2.8 PROGRAMMABLE LOGIC CONTROLLERS (PLC)
1. Refer to specification 40 63 43 for PLC requirements.

2.9 NETWORK DEVICES
1. Provide industrial grade DIN-rail mountable ethernet switches for connection of networked devices within the panel. Provide switches with a minimum quantity of four RJ-45 ports.
2. Switch shall be rated for environmental operating temperatures from -40 to 70 deg C.
3. Provide fiber patch panel within enclosure for termination of multi-mode fiber optic cable. Patch panel shall have sufficient space for termination of all fiber pairs.
4. Provide fiber to ethernet cable media converter for connection of fiber network to ethernet switch.

2.10 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Each control panel provided with a PLC shall contain a UPS to provide seamless and continuous operation of control panel equipment during power outages. The UPS shall provide backup power meeting the following requirements:
1. True sine wave output with on-line double conversion configuration.
2. Fault, overload, and replace batteries indicators.
3. Voltage input: 120 VAC single phase.
4. Voltage output: 120VAC single phase.
5. Output power capacity: 1000 watts / 1500VA minimum.
6. Internal or external bypass.

7. Hot-swap batteries.
8. UPS to be manufactured by APC, Falcon, Trip-lite, or equal.

2.11 SPARE PARTS

A. Provide the following spare parts for each control panel in the quantities specified:
   1. One (1) PLC processor module of each type furnished.
   2. Two (2) PLC I/O modules of each type furnished.
   3. Six replacement fuses, all types and sizes.
   4. One replacement lamp, of each color, for pilot lights.
   5. One of each color replacement lens caps for pilot lights.
   6. One starter coil for each NEMA size furnished.
   7. One, 3-pole set of replacement overload heaters of each size range used.
   8. One, 3-pole set of starter contacts of each NEMA size used.

B. Spare parts shall be boxed or packaged for long term storage. Identify each item with manufacturer's name, description and part number on the exterior of the package.

2.12 FACTORY TESTING

A. The entire control panel shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer's routine shop tests and any other additional operational test to insure the workability and reliable operation of the equipment.

B. Factory test equipment and test methods shall conform with the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards.

C. The operational test shall include the proper connection of supply and control voltage and, as far as practical, a mockup of simulated control signals and control devices shall be fed into the boards to check for proper operation.

D. Factory test equipment and test methods shall conform to the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards, and shall be subject to the Owner/Engineer's approval.

PART 3 - EXECUTION

3.1 INSTALLER'S QUALIFICATIONS

A. Installer shall be specialized in installing this type of equipment, with minimum 5 years documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.2 EXAMINATION

A. Examine installation area to assure there is enough clearance to install the equipment.

B. Housekeeping pads shall be included for the floor mounted motor controllers as detailed on the Drawings with the exception of motor controllers which are to be installed adjacent to an existing unit. Housekeeping pads for these (if used) should match the existing installation.

C. Check concrete pads and baseplates for uniformity and level surface.

D. Verify that the equipment is ready to install.

E. Verify field measurements are as instructed by manufacturer.

3.3 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and Contract Drawings.

B. Install required safety labels.

C. All wiring shall be neatly installed and wire ways shall be used wherever possible. All wiring shall be identified at all terminating locations by Tag ID as identified in Drawings.

3.4 FIELD QUALITY CONTROL

A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.

B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in manufacturer's instructions.

C. Provide one set of as-built panel drawings laminated, in each panel pocket.

3.5 FIELD ADJUSTING

A. Adjust all circuit breakers, switches, access doors, operating handles for free mechanical and electrical operation as described in manufacturer's instructions.

3.6 FIELD TESTING

A. Perform all electrical field tests recommended by the manufacturer. Disconnect all connections to solid-state equipment prior to testing.

B. Megger and record phase to phase and phase to ground insulation resistance. Megger, for 1 minute, at minimum voltage of 1000 VDC. Measured Insulation resistance shall be at least 100 megohms. In no case shall the manufacturer’s maximum test voltages be exceeded.

C. Test each key interlock system for proper functioning.

D. Test all control logic before energizing the motor or equipment.

3.7 CLEANING

A. Remove all rubbish and debris from inside and around the motor controllers. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.8 EQUIPMENT PROTECTION AND RESTORATION

A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

END OF SECTION

DIVISION 43

PROCESS GAS AND LIQUID HANDLING, PURIFICATION AND STORAGE EQUIPMENT

SECTION 43 11 20 – CENTRIFUGAL FANS FOR ODOR CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish, install, startup and test Foul Air Fans for odor control systems complete with all necessary controls, panels, accessories, supports, tools, drives, connectors, guards and safety devices to obtain a fully operational installation suitable for continuous operation 24 hours per day, as shown and specified herein, in accordance with the requirements of the Contract Documents. The Supplier will provide field services to inspect the installation and observe testing and startup of the equipment as provided herein.

B. The Biotrickling Filter (BTF) Manufacturer has sole responsibility for the design, fabrication, furnishing, delivery, startup and testing of the odor control systems including the equipment specified in this section.

C. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 REFERENCES

A. Referenced Standards: This Section contains references to the following documents. They are part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section will prevail. Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. AFBMA, Anti-Friction Bearing Suppliers Association.
   2. AMCA 210-97, Laboratory Methods of Testing Fans for Rating.
   3. AMCA 300, Reverberant Room Method for Sound Testing of Fans.
   4. ASHRAE 51-1985 Laboratory Methods of Testing Fans for Rating.
   5. ASTM C 582, Specification for Contact-Molded Reinforced Thermosetting Plastic Laminates for Corrosion Resistant Equipment.
   6. ASTM D 2563, Practice for Classifying Visual Defects in Glass reinforced Plastic Laminate Parts.
   7. ASTM D4167, Standard Specifications for fiber-Reinforced Plastic Fans and Fans.
   8. IEEE 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   9. NEC, National Electric Code, Latest Edition.
   10. NEMA, MG1 - Motors and Generators.
   11. NFPA, National Fire Protection Association, including NFPA 820.
   12. SSPC, Steel Structures Painting Council.
   13. Underwriter's Laboratories, Inc.
   14. AMCA 211-94, Certified Ratings Program – Air Performance
   15. ANSI/AMCA 204-96, Balance Quality and Vibration Levels for Fans
   16. AMCA 311-05 Certified Ratings Program – Sound Performance

1.3 SYSTEM DESCRIPTION

A. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment for the overall odor control system description.

B. Design Requirements:
   1. All equipment including controls and drives specified herein shall be specifically designed for this service and the environment encountered in this installation.

1.4 PERFORMANCE REQUIREMENTS

A. Refer to the schedule at the end of this section for specific requirements for the foul air fans.

B. Structural Performance:
   1. All equipment, supports, anchors and fasteners shall be of adequate size and strength to withstand loads associated with starting, turbulence, debris, thrusts from liquid movement, thermal expansion and contraction and other loads encountered under operating conditions.

C. Operation: Equipment shall be designed and capable of either continuous or intermittent operation.

1.5 SUBMITTALS

A. Shop drawings specific to the project and applicable product data will be bound neatly in a single package and submitted as part of the BTF Manufacturer's submittal. The following information shall be submitted as a minimum:

B. Product Data: Provide construction details, material descriptions, dimensions of individual components and profiles, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: Provide plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Specific design parameters for this project as specified herein.
   3. Layout, sizes, types and materials for anchor bolts to be furnished.
   4. AFBMA Bearing Life calculations showing an L-10 life of 100,000 hours.
   5. Location of auxiliary instrumentation furnished with equipment and associated mounting brackets and hardware.
   6. Wiring Diagrams
   7. Complete motor nameplate data, as defined by NEMA, motor Supplier, and include any motor specifications.
   8. Equipment weights and lifting points.
   9. Warranties and service agreements.

D. Operation and Maintenance Data: Provide in accordance with Section 01 78 23 – Operation and Maintenance Data.

E. Information Submittals:
   1. Certification of Compliance.
   2. Special shipping, storage and protection, and handling instructions.
   3. Instructions for installation.
   4. Certificate of Proper Installation.
   5. Qualification Data
   6. Location of nearest stocking distributor of spare parts.
   7. Suggested spare parts list to maintain the equipment in service for a period of one year. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current pricing information.

1.6 QUALITY ASSURANCE

A. Qualifications:
   1. All equipment shall be the product of a single manufacturer having at least ten (10) U.S. installations of the type being proposed, each with a minimum of 5 years of satisfactory service.
   2. A list of similar installations shall be furnished with the shop drawing submittal, including names and telephone numbers of contacts.

B. Installer Qualifications: Authorized representative who is trained and approved for installation of units required for this Project.

C. Source Limitations: Equipment units of each type specified in this section shall be supplied by a single manufacturer. This does not require that all equipment be manufactured by a single manufacturer but does require that the manufacturer of the system shall be responsible for the complete system.

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

E. Testing and inspection of the factory assembled equipment shall be accomplished by manufacturer prior to shipment. Skid mounted units shall be delivered fully assembled.

F. Complete factory performance assurance testing shall be required prior to shipment.

G. Fans Performance: Fans performance shall be certified by fan Supplier for fan performance in an AMCA (Air Movement and Control Association) Bulletin 111 certified laboratory in accordance with AMCA Bulletin 210. Fans shall be licensed to bear the AMCA 211 94 Test Code Seal and be guaranteed by Supplier to deliver rated performance.

H. Fans Sound Rating: Fans sound rating shall be certified by fans Supplier for fans sound in an AMCA Bulletin 111 certified laboratory in accordance with AMCA Bulletin 300.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Fans shall be fully assembled and mounted on the skid at the factory. Equipment shall be crated and delivered to protect against damage during shipping. Flange faces shall be protected from damage. All openings shall be covered to prevent entrance of dirt, water, and debris.

B. Properly protect all parts so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and until the units and equipment are ready for operation.

C. Properly protect finished iron or steel surfaces to prevent rust and corrosion.

D. Protect all equipment, delivered, and designated for storage, from the weather (humidity and temperature), dirt and dust, and other contaminants. Motors shall have power connected to the motor heater.

E. Acceptance at Site: Equipment arriving at the site in a damaged condition shall be rejected.

1.8 PROJECT CONDITIONS

A. System Arrangement:
   1. The equipment, sizes, materials, and arrangements described in this Specification section are typically based on recommendations by equipment manufacturers and shall be considered minimum limits of acceptability. The equipment manufacturer shall be responsible for design, arrangement, and performance of all equipment supplied under this section.
   2. Modifications to structural design due to a manufacturer's varying space requirements, foundation requirements, or dimension changes to fit the Manufacturer's specific requirements shall be coordinated by the Contractor and included in the Bid.
   3. The Contractor shall be responsible for any modifications to the piping, electrical, structural, and mechanical layouts to accommodate, as well reimbursement to Owner for additional charges by Engineer for additional work required accomplishing changes.

1.9 ENVIRONMENTAL CONDITIONS:

A. All equipment including controls and drives specified herein shall be specifically designed for this service and the environment encountered in this installation.

B. When installed in wastewater treatment areas, the environment will be moist, and corrosive, exhibiting hydrogen sulfide and other corrosive gases encountered in municipal wastewater treatment plants.

C. Designed and capable of operation at ambient temperatures of 0 degrees F to 110 degrees F.

1.10 WARRANTY

A. Provide a one-year warranty beginning from the time the equipment is placed into continuous service.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hartzell Air Movement – Knape Associates (214) 694-2227
   2. Verantis Environmental Solutions Group – HVAC Rep Enterprises (972) 661-9090
   3. New York Blower – ML Industrial Air (214) 824-3800

2.2 GENERAL REQUIREMENTS

A. Foul Air Fans shall be of the single-stage, single width, single inlet backward inclined centrifugal type (Minimum Class II), suitable for continuous operation 24 hours per day. All equipment shall comply with NFPA 820 and Class I Div. 1 or 2 requirements depending on installation location.

B. Refer to schedule at end of this specification for specific fans requirements. Provide odor control fan complete with controls, dampers, vibration isolation, motor, drive, guards, baseplate, and sub-base (skid mounting). The fan shall be constructed such that all surfaces in contact with the corrosive gas stream are to be made of solid, corrosion resistant fiberglass reinforced plastic (FRP) for the fans housing and FRP fans wheel. All nuts, bolts, and fasteners in contact with the gas stream will be type 316 SS and encapsulated in FRP.

C. Unless otherwise indicated in the drawings or in the specifications, odor control fan's mounting shall be AMCA standard Arrangement 9 for up to two (2) horsepower. Three (3) horsepower and above shall be Arrangement 1 with fabricated channel base and slide rail type motor mounting (skid mounted). Fans sub-base will be bolted directly to equipment slab with an intermediate grout pad and shop painted with an epoxy coating for outside/ corrosive application. Arrangement 4, which places the motor shaft in the corrosive gas stream, is unacceptable. Motors shall be located in position W or Z; positions X and Y are not acceptable.

D. Motor: Premium efficiency TEFC 460/3/60 in accordance with Section 26 05 15 – Electric Motors. Motor shall be rated and labeled Class I, Div 2.

E. Base: Each fan and drive unit shall be mounted on a common unitary base provided by the fans Supplier. The base shall have all exposed seams and contact surfaces of steel plates and shapes continuously welded and ground smooth. An opening shall also be provided, if necessary, for electrical conduit to the drive unit. Base shall be constructed from 316SS and shall have the outer frame constructed from minimum 6-in. channel shapes.

F. Performance: Each fan shall be factory tested in accordance with AMCA Standard 210 and shall bear the AMCA Certified Ratings Seal for Air Performance and shall be tested for vibration and sound. Fans not licensed to bear the AMCA Seal for performance will be tested, at Supplier's expense, in an AMCA Registered Laboratory. Fans will have a sharply rising pressure characteristic extending throughout the operating range to assure quiet and stable operation. Fan motor horsepower shall be equal to or less than the maximum motor horsepower specified in the schedule at the listed static pressure and CFM.

G. Sound: Supplier will provide a sound power level rating for fans tested and rated in accordance with AMCA Standards 300 and 301. Sound power ratings will be in decibels (reference 10-12 watts) in eight octave bands. The maximum radiated sound pressure level will be at or below 80 dBA (reference 20 mPa) at 5 feet for the Persigo WWTP and 50 dBA (reference 20 MPa) at 5 feet for the Dos Rios location. Fan supplier shall provide FRP enclosure or acoustic blanket as necessary to meet the sound requirements.
   1. If an enclosure is provided, the enclosure shall be sized such that there is room to enter and maintain the fans without removing the enclosure.
   2. If an acoustic blanket is provided, it shall be approved for outdoor use by the manufacturer.

H. Construction: Fans will be constructed in accordance with the ASTM D4167 standard specification for fiber-reinforced plastic fans and fans to ensure structural integrity. All parts exposed to the gas stream will be constructed of, or encapsulated in, an FRP laminate capable of resisting continuous airstream temperatures of 250°F. Fans housing must be fabricated of premium vinyl ester resins; and "C" grade or better surface veil.
   1. Housing: Constructed from FRP using premium vinyl ester resin and antimony trioxide and electrically grounded. Fans housing will be designed so that air leakage through joints and seals is negated. All bolted pieces will be EPDM gasketed for air tightness.
   2. Fan Wheel: Fiberglass wheel, backward curved non-loading, high efficiency, one-piece, resin transfer mold. Utilize a premium vinyl ester resin.
   3. Fan Shaft: Shaft will be of Type 316 stainless steel designed to operate at 25% below first critical speed. Shaft and impeller will be statically and dynamically balanced at normal operating speed listed in schedule below. Provide double lip teflon or equivalent seal with 316 Stainless Steel mounting plate between shaft and fans housing. Shaft may be encapsulated with FRP at the manufacturer's discretion. Seal will positively prevent liquid and gas leakage and shall be field replaceable.
   4. Fan Bearings:
      a. Each fans shaft will be supported by approved, grease lubricated, self-aligning ball or roller bearings made of vacuum degassed 52100 steel. Ball or roller bearings will be made by manufacturer's who are members of the Anti-Friction Bearing Manufacturer's Association (AFBMA) and will be selected for a minimum rating life

(L-10) of 100,000 hours at the fans maximum rated speed and based on Basic Dynamic Load Ratings calculated from AFBMA formulas (AFBMA Standards, Section No. 9, and Section No. 11, Latest Revisions). Material factors used in formula calculations will be based on values assuming a conventional good quality, hardened bearing steel without benefit of vacuum degassing. Specifically, for pound and inch units, factor "f" will be as given in the tables of AFBMA Standards cited above.

b. The operating internal temperature of ball bearings with ambient temperature of 80°F will not exceed 200°F after a run time of two hours. Temperature measurements will be made with a mercury thermometer. (Thermometers will have an accuracy at 130°F of ±2°F). Where thermometer wells are not provided or required, the surface temperature of the bearing housing will be measured by a thermometer pressed firmly against the surface and sealed with a suitable plastic putty. Temperature readings during inspection and start-up that exceed 140°F as measured by the thermometer-surface method, will be deemed presumptive evidence that the operating internal temperature of the bearings exceed 200°F. It will be incumbent to reduce the temperature at or below 140°F with no additional cost to the Owner.

c. Bearing temperature will not exceed 225°F at the fans's maximum rated speed.

d. Computations on bearing selection will be submitted for approval and will show complete details of loading. A dynamic factor of 2.0 will be applied to loading. Ball and roller bearings will be enclosed in oil-tight housings equipped with approved shaft seal rings and will be suitably arranged for high pressure grease lubrication.

e. The bearing supports for the shaft will be of rigid design and will be securely fastened to the base to ensure the proper alignment of the main shaft bearings. Bearings located in the corrosive gas stream are not acceptable.

f. Bearings will be factory lubricated with a premium quality NLGI 2 or 3-grade multi-purpose ball bearing grease having corrosion inhibitors, anti-oxidant additives and mechanical stability for high speed operation. Bearing grease will be multi-purpose lithium soap grease. The grease will also have a minimum base oil viscosity of 500 SUS at 100°F and will be suitable to operate continuously at 225°F. Heavy, long fibered greased will not be acceptable for use in bearings.

g. The field installed and operating fans inboard and outboard bearing motions will not exceed the in-situ operation levels for Fan Application Category BV-3 of ANSI/AMCA 204-96. The instrument system used must have a flat response down to 120 rpm. Manufacturer will measure the vibrations after start-up in the presence of the Owner's representative.

h. Product and Supplier: Provide bearings as manufactured by one of the following:
   1) Link Belt
   2) Timkin
   3) SKF
   4) Dodge

5. Fan vibrations that exceed the ANSI/AMCA 204-96 in-situ operation levels, as described above, during operation in the warranty period will be reduced by Manufacturer. Manufacturer can choose to dynamically balance the fans in place using a recognized specialist, replace bearings or make structural modifications to reduce the vibrations, as approved by the Manufacturer.
6. Fan impeller and driving pulley shall be secured to shaft with keys and set screws.
7. Fan housing shall have flanged discharge and inlet drilled connection and companion flanges. Fans will be separated from ductwork at inlet and outlet by flanged flexible connections. Contractor shall coordinate flange drilling with duct. Field drilling of the flanges is acceptable provided all edges are sealed with resin.
8. Stainless steel nameplates giving the name of the manufacturer, serial number, model number, rated capacity in cfm, head in inches of water (gage), fans in rpm, and any other pertinent data will be permanently affixed to each fan with stainless steel hardware.

I. Accessories & Miscellaneous:

1. Access Doors: Raised type, stud mounted access doors with gaskets. Studs will be imbedded and encapsulated in FRP housing.
2. Drains: Provide drains at low point of scroll, minimum 1-inch pipe coupling affixed to housing with threaded corrosion resistant plug for connection to PVC ball valve during installation. Connect with a flexible coupling and transition to the drain size shown on the drawing.
3. Drive: Matched V belts and fixed sheave pulleys will be cast iron, sized for minimum 1.2 service factor.
4. Belt and Shaft Guard: Provide belt and shaft guard constructed with a stainless steel frame and expanded metal stainless steel screen. Guard shall have multiple sections as needed so that the lifting weight of each section is no more than 40 pounds installed.
5. Flexible connectors shall be supplied by the fan Manufacturer. Flex connectors shall be of EPDM construction with fully encapsulated nylon, polyester or steel reinforcement, and 316 stainless steel flanges drilled to match the fan flange and the connecting duct flange. Flex connectors shall be rated for a minimum vacuum of 30 inches water column. Face to face dimension shall be 4" min. to 6" max. with ¼" lateral motion in any direction.
6. Backdraft Damper: If shown on the drawing or specified in the equipment schedule, provide a round backdraft damper at the discharge of each FAB after the transition to circular duct. Backdraft dampers are specified in Section 40 05 36.13 – Fiberglass Reinforced Plastic (FRP) Pipe and Accessories for Odor Service
7. Inlet Vane Damper:
   a. Furnish and install a fiberglass reinforced plastic or 316 stainless steel manually operated multiple blade inlet vane damper on the suction side of each odor control fan. Unless noted otherwise, either FRP or 316SS may be provided.
   b. Rated for air velocities up to 6,000 fpm.
   c. Materials of Construction.

Component	**FRP Damper**	**316SS Damper**
Frame / Body	FRP with 100 mil Corrosion Barrier on all internal surfaces	316SS, Min. 10 ga. Channel
Blades	FRP with 100 mil Corrosion Barrier on all internal surfaces	316SS Min. 10 ga.
Resin	AOC F010 Vinyl Ester Resin with no fillers	N/A
Bearings	PTFE	Relubricable ball, mounted externally with 316SS sleeve bearings and stainless steel thrust washers at hub and frame
Drive Shaft	316SS Full Length Rod	316SS Full Length Rod
Axles	Pultruded FRP Rod	316SS
Shaft Seals	Double O-Ring	Double O-Ring
Operator	316SS Hand Lever, Drilled for Locking Bolts	316SS Hand Lever, Drilled for Locking Bolts
Linkage	316SS, including swivels and bearings	316SS, including swivels and bearings
Hub	FRP or 316SS Flat Panel or 316SS	316SS Flat Panel
Hardware	316SS	316SS

   d. Ends: Flanged with bolt holes drilled to match fan inlet.
   e. Provide Type 316 stainless steel nuts, bolts and washers for flanged connections to fans and fans inlet box or flexible connector flange as required.

f. Passivate all welds. Field paint FRP to match adjoining duct and equipment.
g. Acceptable manufacturers:
1) FRP:
a) Engineered Composite Systems
b) Daniel Mechanical
c) Swartwout
d) Approved equal
2) 316SS:
a) Swartwout
b) Greenheck
c) Approved equal

8. Lifting Lugs: Individual equipment and/or each field disassemble part weighing over 100 pounds shall be provided with lifting lugs
9. Anchor Bolts: Provide template and 316SS Hilti HY-200 or RE-500 adhesive anchors or 316SS embedded “J Bolts”. Anchor bolts may be provided by others however the Supplier shall provide the anchor bolt size.

J. Coat as specified in Section 09 90 00.

2.3 ELECTRICAL & INSTRUMENTATION

A. Motors shall be TEFC Class 1, Division 2 rated and shall comply with the requirements of Section 26 05 15 – Electric Motors. Provide high temperature shut down and alarm outputs.

B. Control Panels
1. Control panels (including fan controls and motor starters) are to be provided by the odor control equipment manufacturer as specified in Section 44 31 31 – Odor Control Biotrickling Filter Equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and adjust equipment in accordance with the Drawings, approved shop drawings, and the manufacturer’s instructions. Do not operate the equipment until the installation is approved by the manufacturer’s representative.

B. Odor control fan equipment will be installed as specified herein and as shown on Drawings, and in accordance with the manufacturer’s recommendations and instructions. Equipment shall be installed in such manner that connecting duct work or piping will not impose any load on the fan. Add additional supports if necessary, at no additional cost to the Owner. Equipment will be set upon grouted foundations, level or perpendicular, as the case may be, so that connecting flanges, screwed connections, or flexible connections will meet without strain or distortion. Base leveling nuts will be blocked out during grouting of foundations, the grout allowed to set for not less than three days, leveling nuts loosened and followed by grouting of block-outs, with non-shrink grout.

C. All equipment will be installed with Type 316 stainless fasteners.

D. Contractor will assure that all equipment furnished under this Section will be suitable for installation as specified. The Contractor will be responsible for determining the necessary clearances and headroom required to move all equipment to its final location.

E. In every case where a drive motor is connected to a driven piece of equipment by a flexible coupling, the coupling halves will be disconnected and alignment between motor and equipment checked and corrected. Machinery will first be perfectly aligned and leveled by means of Type

316 stainless steel wedges and shims near anchor bolts. Anchor bolts will be tightened against shims on wedges and equipment will again be checked for level and alignment before placing grout.

F. Equipment bases will not be grouted nor foundation bolts finally tightened until all piping connections are complete and in satisfactory alignment with no strain transmitted to the equipment.

G. Examine pads or supports to receive Foul Air Fans for:
1. Proper anchor bolt locations.
2. Unevenness, irregularities, and incorrect dimensions.

H. Supervise installation in accordance with odor control fan manufacturer's instructions and recommendations.

I. All equipment will be installed on concrete bases and secured with anchor bolts in accordance with the manufacturer's recommendations. Contractor shall accurately shim base to grade and spaces between shims filled with an approved non-shrink grout. After grout has reached its initial set, exposed edges will be cut back 1/2-inch and edges neatly finished with 1:2 cement mortar.

J. Installation will include furnishing and applying an initial supply of grease and oil, recommended by the Supplier.

K. Connect all duct, piping, valves, and accessories as necessary to complete the installation.

L. Install all conduit and wiring and complete all connections.

3.2 INSPECTION OF FOUL AIR FANS

A. Owner reserves right to reject any and all items of equipment found to have following: blisters, chips, crazing, exposed glass, dry cracks, burned areas, dry spots, foreign matter, or entrapped air at the laminate surfaces which does not satisfy the tolerances specified in ASTM D 2563 Table 1, Acceptance Level II for inside and outside surfaces or meet the specified requirements.

3.3 INSPECTION AND START-UP ADJUSTMENTS

A. The Contractor will perform the following inspection of equipment with the equipment manufacturer’s representative.
1. Verify proper equipment mounting and setting.
2. Verify that power wiring is complete.
3. Verify alignment of each motor and drive.
4. Verify proper piping connections and accessories.
5. Verify that lubrication is completed.
6. Verify direction of rotation.
7. Monitor heat buildup in bearings.
8. Check motor loads against nameplate data.
9. Verify proper operation of equipment.
10. Remove all loose materials and obstructions from interior of ducts and fans.
11. Remove debris and waste materials resulting from installation.

B. The Contractor will conduct the following Start-up Adjustments with the manufacturer’s representative:
1. Adjust fan for proper alignment and flow.
2. Set volume control devices for approximate positions in preparation for final testing and balancing.

3. Balance system for airflow in accordance with Section 44 31 83 – Adjusting and Balancing Odor Control Systems.

3.4 FIELD TESTS

A. After manufacturer and Owner have mutually agreed that the equipment installation is complete and ready for continuous operation, manufacturer will conduct an operating test of the equipment in the presence of Owner to demonstrate that the equipment will function correctly.

3.5 SUPPLIER'S SERVICES

A. Manufacturer will furnish the services of a qualified factory trained manufacturer's service person for areas where the Foul Air Fans are installed to assist in the installation of the equipment, check the installation before it is placed into operation, assist in the performance of field vibration tests, supervise initial operations, and instruct the plant operators in the care, operation and maintenance of the equipment. Submit a certificate of proper installation after inspection.

B. Service person will not make less than two visits to the site. The first visit will be for a period of not less than one 8-hour day to assist in the installation of the equipment. The second visit will be for a period of not less than one 8-hour day to approve the installation, perform the field vibration tests, provide training for Owner's personnel, and supervise initial operations.

C. Service person will verify that lubrication systems are complete, clean, and filled with the proper grade of lubricants.

D. Reports: Manufacturer will submit a report by service person of each visit to the site. Reports will provide complete information on time, schedule, tasks performed, persons contacted, problems corrected, test results, training, instruction, and all other pertinent information.

E. Training: In addition to above requirements, furnish services to instruct and train plant operators in the proper care, operation, and maintenance of equipment.

F. Equipment that has mechanical defects and does not meet manufacturer's vibration requirements will be rejected and will be replaced at manufacturer's full expense for furnishing, installing, removal, and replacement.

EQUIPMENT DATA SHEET

Equipment Tag Number(s)	10F01 & 10F02
Quantity	2
Equipment Name	Persigo WWTP Foul Air Fan I & II
Location	Persigo WWTP
Service	Foul Air
Elevation ASL, ft +/-	4700
Flow rate at 68°F, acfm, ea	7,050
Suction Static Pressure, in. w.c.(1)	2.0
Nominal Wheel Diameter, in.	27
Temperature Range,°F	0-110
Max. Fan Speed, rpm	3000
Max. Motor HP	50
Relative Humidity, %	100
Accessories	**R=Required, NR=Not Required(2)**
Inlet Vane Damper	R
Exhaust Backdraft Damper	R
Inlet Flexible Connection	R
Outlet Flexible Connections	R
Belt & Shaft Guard	R
Access Doors	R
Condensate Drain Connection	R
Motor Temperature Sensor	R

(1) The suction static pressure is the vacuum present at the point of suction duct connection to the fan. ***Supplier shall add the pressure loss through the supplied equipment*** and provide a fan meeting the required duty point at the specified airflow. Minor changes to the fan pressure may be required.
(2) Accessories specified in this specification section but not listed on the data sheet as "NR" are required on all units supplied. Refer to instrumentation drawings for all instrumentation

Equipment Tag Number(s)	30F01
Quantity	1
Equipment Name	Dos Rios Foul Air Fan
Location	Dos Rios
Service	Foul Air
Elevation ASL, ft +/-	4700
Flow rate at 68°F, acfm, ea	710
Suction Static Pressure, in. w.c.(1)	2.0
Nominal Wheel Diameter, in.	16
Temperature Range,°F	0-110
Max. Fan Speed, rpm	3000
Max. Motor HP	10
Relative Humidity, %	100
Accessories	**R=Required, NR=Not Required(2)**
Inlet Vane Damper	R
Exhaust Backdraft Damper	R
Inlet Flexible Connection	R
Outlet Flexible Connections	R
Belt & Shaft Guard	R
Access Doors	R
Condensate Drain Connection	R
Motor Temperature Sensor	R

(1) The suction static pressure is the vacuum present at the point of suction duct connection to the fan. ***Supplier shall add the pressure loss through the supplied equipment*** and provide a fan meeting the required duty point at the specified airflow. Minor changes to the fan pressure may be required.
(2) Accessories specified in this specification section but not listed on the data sheet as "NR" are required on all units supplied. Refer to instrumentation drawings for all instrumentation

END OF SECTION

DIVISION 44

POLLUTION CONTROL EQUIPMENT

SECTION 44 31 16 – ACTIVATED CARBON ADSORPTION ODOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Design, fabricate, furnish, install, startup and test activated carbon adsorption units (CAU's) to treat odorous air from the biotrickling filter located at the Dos Rios site. The system shall be complete and include vessel, media, duct, duct supports, fan, supports, prefilters, access hatches, test ports, anchors, controls, instrumentation, panels, electrical equipment, and all other equipment necessary for successful operation.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.2 DEFINITIONS

A. Carbon Adsorption Unit (CAU): A vessel with an activated carbon media through which air passes and contaminants are adsorbed to the surface of the media.

B. Foul Air Collection System (FACS): The duct, dampers, expansion joints, fittings, supports, condensate drains, and appurtenances that are used to transport foul air from its source to the odor treatment facility. On the drawings, this term is also used to denote the overall foul air collection and treatment systems.

C. Foul Air Fan (FAN): A corrosion resistant centrifugal fan that conveys foul air from the odor source through the Odor Control System.

D. Odor Control System (OCS): A complete system consisting of covers, containment, transport, and treatment of foul air resulting from wastewater treatment processes.

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM International)
   1. D638 – Standard Test Method for Tensile Properties of Plastics.
   2. D695 – Standard Test Method for Compressive Properties of Rigid Plastics.
   3. D790 – Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   4. D 883 – Definitions and Terms Relating to Plastics.
   5. D2563 – Recommended Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Tanks.
   6. D2583 – Standard Test Method for Indentation Hardness of Rigid Plastics by Means of Barcol Impressor.
   7. D2584 – Standard Test Method for Ignition Loss of Cured Reinforced Resins.
   8. D3299 – Standard Specification for Filament Wound Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks.
   9. D4097 – Standard Specification for Contact Molded Glass Fiber Reinforced Thermoset Chemical Resistant Tanks.
   10. D2652 - Standard Terminology Relating to Activated Carbon
   11. D2584 – Standard Test Method for Apparent Density of Activated Carbon
   12. D2862 – Standard Test Method for Particle Size Distribution of Granular Activated Carbon.

13. D4607 – Standard Test Method for Determination of Iodine Number of Activated Carbon
14. D5160 – Standard Guide for Gas Phase Adsorption Testing of Activated Carbon
15. D6646 – Standard Test for Determination of the Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Pelletized Activated Carbon.

B. National Fire Protection Association (NFPA)
1. 255 – Method of Test for Surface Burning Characteristics of Building Material
2. 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities

C. Voluntary Product Standard, U.S. Department of Commerce (VPS):
1. PS 15-69 Custom Contact-Molded Reinforced Polyester Chemical-Resistant Process Equipment.

1.4 SYSTEM DESCRIPTION

A. CAU Manufacturer shall design the system to meet the performance requirements in this specification.

B. Performance Requirements:
1. The CAU will treat 710 cfm of odorous air from a biotrickling filter.
2. Remove 99.9% of the inlet hydrogen sulfide.

1.5 SOLE SOURCE RESPONSIBILITY

A. The Biotrickling Filter (BTF) Manufacturer has sole responsibility for the design, fabrication, furnishing, delivery, startup, and testing of the odor control systems. BTF Manufacturer may acquire items from different manufacturers as listed in the individual specification sections; however, the BTF Manufacturer shall have sole source responsibility for all equipment delivered. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment.

B. System Arrangement:
1. The equipment, sizes, materials, and arrangements described in this Section are typically based on recommendations by equipment manufacturers and shall be considered minimum limits of acceptability. The equipment manufacturer shall be responsible for design, arrangement, and performance of all equipment supplied.
2. Modifications to structural design due to a manufacturer's varying space requirements, foundation requirements, or dimension changes to fit Manufacturer's specific requirements shall be coordinated by the Contractor and included in the Bid.
3. The Contractor shall be responsible for any modifications to the piping, electrical, structural, and mechanical layouts to accommodate, as well reimbursement to Owner for additional charges by Engineer for additional work required accomplishing changes.

C. Electrical devices shall be suitable for the environment they will be used in, including classification requirements of NFPA 820. Devices located within three (3) feet of any leakage source such as fans, dampers, duct, connections, flanges, expansion joints, and vessels shall comply with NEC Class I, Group D, Division 2 requirements unless located in an area classified as Division I by NFPA 820. Devices more than three (3) feet from leakage sources shall comply with any applicable requirements of NFPA 820. All electrical and control panels shall be UL508A panels.

1.6 SUBMITTALS

A. Submit in accordance with Section 01 33 00 – Submittal Procedures and with Section 01 78 23 – Operation and Maintenance Data.

B. A single submittal shall be provided by the BTF Manufacturer for all equipment provided. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment.

C. Product data
   1. Provide the following product data:
      a. MSDS sheets for all consumables supplied including media.
      b. Product data sheets on carbon media, including ordering information for media replacement.

D. Manufacturer's Qualifications:
   1. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment.

E. Shop Drawings
   1. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment.

F. Operation and Maintenance Data
   1. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment.

G. Closeout Submittals
   1. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment.

1.7 QUALITY ASSURANCE

A. Qualifications
   1. MANUFACTURER shall have a minimum of five years' experience of producing similar equipment and shall be able to show evidence of at least five installations, with design hydrogen sulfide concentrations in excess of 5 ppm, in satisfactory operation for at least two years.
   2. A list of similar installations shall be furnished with the shop drawing submittal, including names and telephone numbers of contacts. Include information on airflow, designed hydrogen sulfide concentration, foul air source, location, year installed, owner name and contact information.

1.8 DELIVERY STORAGE AND HANDLING

A. Preassemble parts to the largest extent possible, compatible with transportation limitations and equipment protection considerations. Field assembly, if any, shall require only bolting together of match-marked components. Equipment shall be crated and delivered to protect against damage during shipping. Flange faces shall be protected from damage. All openings shall be covered to prevent entrance of dirt, water, and debris.

B. Media shall not be delivered to site more than seven (7) days before installation. Media shall be covered and protected from degradation during storage.

C. Properly protect all materials and equipment so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and until the units and equipment are ready for operation.

D. Properly protect finished iron or steel surfaces to prevent rust and corrosion.

E. Protect all equipment, delivered, and designated for storage, from the weather (humidity and temperature), dirt and dust, and other contaminants.

F. Electrical equipment, panels, and instrumentation shall be stored indoors and protected from corrosion (including ambient hydrogen sulfide corrosion). Motors shall have power connected to the motor heater.

G. Acceptance at Site: Equipment arriving at the site in a damaged condition shall be rejected.

1.9 PROJECT/SITE CONDITIONS

A. System Arrangement:
   1. The equipment, sizes, materials, and arrangements described in this Specification section are based on recommendations by equipment manufacturers and shall be considered minimum limits of acceptability. The equipment manufacturer shall be responsible for design, arrangement, and performance of all equipment supplied under this section.

B. Environmental Conditions:
   1. All equipment including controls and drives specified herein shall be specifically designed for this service and the environment encountered in this installation.
   2. The environment will be moist, and corrosive, exhibiting hydrogen sulfide and other corrosive gases encountered in municipal wastewater treatment plants.
   3. The equipment shall be designed and capable of operation at ambient temperatures of 0^{o}F to 110^{o}F.

1.10 SPECIAL EQUIPMENT WARRANTIES

A. The Supplier shall provide a Special Equipment warranty for equipment provided under this Section as specified in paragraphs B & C below. A letter of acknowledgement (on corporate letterhead) accepting the Special Equipment Warranty shall be included with the Shop Drawings.

B. System: Special equipment warranty (non-prorated) shall be for 1 year from acceptance of the equipment and shall provide for repair and/or complete replacement of fan and vessel (in the event of corrosion damage), including equipment, materials, labor, shipping, and any and all costs associated with repair or replacement.

C. Media: Special equipment warranty shall be for one (1) year from startup and shall provide for complete replacement of the media, including equipment, materials, labor, shipping, and any and all associated costs. Media replacement will be on a pro rata cost basis provided the Manufacturer can submit evidence that the H_2S loading exceeded the average concentrations specified herein. If the Manufacturer does not submit evidence of over loading, then the warranty shall be non-prorated and the Manufacturer shall incur all costs for media replacement. Media failure includes increase in pressure drop through the media such that the specified airflow rates are not achievable with the installed equipment and/or the failure of the media to meet specified odorant removal levels.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Design shown on the drawings is based on one of the named Manufacturers. Costs for structural, electrical, mechanical and all other design and construction changes required to accommodate a design different from those shown on the plans shall be included in bid.

B. Subject to compliance with the Contract Documents, the following are acceptable:
   1. Daniel Mechanical
   2. ECS Environmental Solutions
   3. BioAir Solutions

4. Evoqua Water Technologies
5. Biorem Technologies

C. Carbon media shall be supplied by:
1. Cabot / Norit
2. Jacobi
3. Approved equal.

2.2 VESSEL AND DESIGN

A. Materials
1. All materials and equipment exposed to the air stream shall be protected from corrosion. Corrosion resistant materials are required unless specifically allowed by this specification.
2. All hardware, bolts, nuts, washers and anchors shall be 316 stainless steel.
3. All post installed anchors embedded in concrete shall be 316 stainless steel threaded rods using Hilti HIT-RE500 epoxy. All cast in anchors shall be 316 stainless steel “J” bolts. Sizing of anchors shall be by supplier.

B. Vessel
1. Final design drawings for structure(s) and vessel(s) shall be sealed by a licensed engineer of the State of Colorado. Design of system shall be in accordance with applicable local, state, national and international standards and codes and shall be specific to the project location. Design loads shall be determined using ASCE/SEI 7-10 *Minimum Design Loads for Buildings and Other Structures*.
2. All materials used in the structure or vessel shall be inherently corrosion resistant. Acceptable materials include:
    a. Fiberglass Reinforced Plastic (FRP) construction:
        1) Resin:
            a) Resin Type: Premium corrosion resistant and fire-retardant brominated bisphenol-A vinyl ester. Resin shall not contain pigments, dyes, colorants, or fillers.
            b) Flame Spread Rating: Class 1 flame spread rating (25 or less).
            c) Thixotropic agents may be added to control resin viscosity per resin manufacturer’s instructions.
            d) Resin shall be
                (1) AOC Vipel
                (2) Ashland Dekrane
                (3) Or approved equal
        2) Structural reinforcement shall consist of chopped strand mat and direct roving using E-Glass with resin.
        3) Minimum interior corrosion barrier:
            a) C-Glass veil with 90% resin to 10% glass ratio
            b) Double Nexus veil with 90% resin to 10% glass ratio
            c) Minimum corrosion barrier thickness shall be 0.10 inches.
        4) Exterior laminate shall be a protective gel surface coat with UV inhibitors pigmented to a color selected by OWNER.
        5) Embedded materials shall be 316 stainless steel.
        6) Provide a gel coat on all surfaces and UV inhibitor on all external surfaces.
        7) All cut or drilled surfaces shall be sealed with resin.
3. Minimum material thicknesses for all structural shapes shall be 0.25 inches. Structural shapes shall be pultruded FRP with vinylester resin.
4. Minimum tank wall thickness shall be determined by the Manufacturer. Provide drawings sealed by a Colorado Professional Engineer.
5. The distance between the outer vessel wall and outer basket wall (outer air plenum width) should be at least 12-inches.

6. Inside floor of vessel should slope to the drain shown on the drawings.

C. Connections:
1. Provide flanged inlet drilled to match connecting duct.
2. Provide drain connection to fully drain tank. Extend to clear concrete pad or make provisions during concrete placement so that the connection does not conflict with concrete.
3. Provide access for removing and replacing media at each bed; top of vessel should be completely removable and include lifting attachments.
4. Manways shall be bolted flanged covers and shall include a davit or hinge to support the opened manway cover if mounted on the side of the vessel.

D. Fabrication
1. Shop assemble components to the extent practical. Ship carbon media in bulk bags to the project site separately from the vessel. Carbon shall not be stored on site more than seven (7) days prior to installation.

E. Access:
1. Provide aluminum or fiberglass reinforced plastic ladders to access the top of CAU's.
2. Provide aluminum or fiberglass reinforced plastic handrails around the top of the CAU's.
3. Provide aluminum or fiberglass reinforced plastic ladders, platforms and handrails where shown on the drawings and for accessing equipment and components requiring maintenance access more frequently than once per year.
4. Comply with OSHA 1910.21-30 requirements for railings, cages, ladders, platforms and stairs. Comply with Section 05 51 00 Metal Stairs for metal stairs and appurtenances.

F. Finishes
1. Provide a tinted gel coat with UV inhibitors.
2. Field coat all equipment and components (including the vessel) in accordance with Section 09 90 00 – Coatings.

2.3 CARBON MEDIA

A. Activated carbon shall be virgin carbon and shall meet the following requirements:

PARAMETER	**VALUE**	**ASTM TEST PROCEDURE**
H_2S Breakthrough Capacity	0.2 g/cc	D6646
Minimum Carbon Tetrachloride Activity	60%	D3467
Minimum Apparent Density,	0.56 g/ml	D2854
Min. Hardness No.	97	D3802
Mean Particle Diameter	4 mm	D2854
Maximum Moisture Content	2%	D2867
Maximum Total Ash Content	5%	D2866

B. Catalytic carbon shall not be used.

C. OWNER will collect samples of media for testing when the carbon is delivered. Any carbon that fails to meet the above requirements will be rejected and removed from the site.

2.4 ACCESSORIES

A. Provide the following accessories:
1. Minimum of three (3) 2-in. diameter sample ports for each bed, equipped with CPVC ball valves. Provide at locations so that sampled media can be analyzed for remaining bed life.
2. One (1) 2-inch drain port with CPVC ball valve.

3. 316SS grounding rod inserted in media bed and connected to ground loop.
4. Vessel ground connected to ground loop.
5. Exhaust stack extending at least eight (8) feet above the vessel and supported solely by the vessel.
    a. Exhaust stack shall include a rain guard constructed as shown on the drawings. Materials shall be as specified in 40 05 36.13 – Fiberglass Reinforced Plastic (FRP) Pipe and Accessories for Odor Service and in this specification.
6. FRP prefilter to remove excess moisture and grease with the following:
    a. Maximum velocity of 400 fpm through the pre-filter.
    b. Maximum pressure drop of 1.0 in. w.c.
    c. Remove 90% of droplets greater than 10 microns.
    d. Flanged inlet and outlet.
    e. One (1) 1-inch drain port with a CPVC ball valve.
    f. Two (2) air sample ports with CPVC ball valves.
    g. Access door for filter removal and replacement.
    h. Filter constructed of 316SS materials. Filter shall be cleanable and suitable for reuse. Provide one (1) spare filter for each prefilter assembly.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall be in accordance with the plans, specifications, and the Supplier's recommendations.

B. Supplier's Services:
1. Supplier or their authorized representative shall provide onsite services to assist the Contractor with installation, check equipment prior to startup, startup the systems, train Owner's personnel and test the installed system.
2. Supplier shall include in his bid the following minimum onsite services (excluding travel time) for *each* system:
    a. Assist Contractor: 4 hours
    b. Equipment checkout and startup: 4 hours
    c. Training: 2 hours
    d. Testing: As needed to complete the specified testing.

3.2 STARTUP AND TESTING

A. Startup of the odor control system shall be done in accordance with Supplier's recommendations.

B. In the presence of the Owner's representative, Supplier shall test the operation of the odor control system. Testing shall take place two to six weeks after startup of the unit or as recommended by the Supplier. Final acceptance (and beginning of warranty period) will not be made until after successful completion of the performance testing and receipt of installation report.

C. Testing Equipment: Supplier shall provide the equipment listed below for the duration of the performance testing for use by the Contractor and Owner. Submit current calibration certificates for each piece of equipment used along with test results. Comply with equipment Supplier recommendations for equipment use.
1. Odalog/Acrulog Hydrogen Sulfide Gas Loggers by Detection Instruments.
    a. 0-1000 ppm units
    b. 0-200 ppm units
    c. 0-50 ppm units
    d. Low Range 0.01-2.0 ppm units.
    e. Low Range Sampling System (LRSS-2) by Detection Instruments with sufficient PVC or Teflon hose for testing.

2. Micromanometer for airflow measurement.

D. Testing Procedure:
   1. Balance the odor control system as specified in Section 44 31 83 – Adjusting and Balancing Odor Control Systems.
   2. Measure the airflow (feet per minute), static pressure (inches water column) and velocity pressure (inches water column) into the unit. Airflows shall be within 5% of the specified value before testing may commence.
   3. Measure the airflows into each individual cell or tower. Airflows shall be within 5% of equal or specified distribution before testing may commence.
   4. Using an LRSS-2, connect the lowest range Odalog (0-50, 0-200, or 0-1000) that will record the anticipated range of concentrations to the system inlet. Use the same LRSS-2 to connect a Low Range (0.01-2.0 ppm) Odalog to the vessel exhaust. The intent is to record hydrogen sulfide concentrations at the inlet and exhaust to the odor control system.
   5. Record concentrations at 10 second intervals for two weeks continuously. Supply enough test units to test all components of each system concurrently. Change out Odalogs with fresh Odalogs as recommended by Detection Instruments to avoid sensor fatigue and to download data.

E. Testing Report - Submit the following:
   1. Original Odalog data files and files exported into Microsoft Excel format.
   2. Plots of the inlet and exhaust concentrations.
   3. Dimensioned drawing showing locations and identification of samples taken. Design drawings or shop drawings may be annotated for this purpose.
   4. Date, time, sample and results of each sample taken.
   5. Airflow rate, static and velocity pressures at the time of sampling.
   6. Any deviations from the test procedure with an explanation.

F. Acceptance: Determination of satisfactory performance shall be made by the Owner based on the above performance testing or additional testing as needed. Acceptable H2S removal shall be determined by calculating H2S removal at each recorded time point offset by the system residence time. For accurate results the Odalogs must be set to identical time.

G. If the sampling results do not meet the specified removal requirements, the Supplier shall be given four weeks to make necessary modifications to the odor control system before a retest is conducted. If the system fails two retests, the Supplier shall remove and replace the odor control system with one that meets the requirements and shall provide additional treatment units if necessary to meet the removal requirements and media life guarantee at the Supplier's sole expense. Subsequent tests may be performed by Owner at any time during the warranty period at the Owner's expense.

H. All warranty and guarantee periods shall begin from the date the CAU is placed in service. CAU shall have passed all performance testing before it may be considered as placed in service. Performance testing may not begin until the system is connected to all the foul air sources.

EQUIPMENT DATA SHEET – CARBON ADSORPTION UNITS

Parameter	**Value**
Equipment Tag Number(s)	35CP01
Foul Air Sources	Gravity sewer headspace
Foul Air Flow, cfm (each vessel)	710
Anticipated Average Inlet Hydrogen Sulfide Concentration, ppm	1
Maximum Outer Diameter of Vessel, ft (nominal)	6
Ambient Air Temperature, °F	0-110
Process Air Temperature, °F	60-90
Number of Vessels	1
Maximum Operating Weight, lbs.	5,000
Minimum Media Life based on H_2S, Years	3
Minimum activated carbon, lbs.	1,250

END OF SECTION

SECTION 44 31 31 – ODOR CONTROL BIOTRICKLING FILTER EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Design, fabricate, furnish, install, startup and test biotrickling filter (BTF) odor control systems to treat odorous air from municipal wastewater treatment processes. The system shall be complete and include BTF vessel, treatment media, centrifugal fan, recirculation pumps, booster pumps, irrigation system, nutrient feed system, FRP duct, supports, ladders, stairs, platforms, controls, instrumentation, panels, electrical equipment, and all other equipment necessary for successful operation.

B. Related sections:
   1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
   2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

C. Electrical devices shall be suitable for the environment they will be used in, including classification requirements of NFPA 820. Devices located within three (3) feet of any leakage source such as fans, dampers, duct, connections, flanges, expansion joints, and vessels shall comply with NEC Class I, Group D, Division 2 requirements unless located in an area classified as Division I by NFPA 820. Devices more than three (3) feet from leakage sources shall comply with any applicable requirements of NFPA 820. All electrical and control panels shall be UL508A panels.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM International)
   1. D638 – Standard Test Method for Tensile Properties of Plastics.
   2. D695 – Standard Test Method for Compressive Properties of Rigid Plastics.
   3. D790 – Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   4. D 883 – Definitions and Terms Relating to Plastics.
   5. D2563 – Recommended Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Tanks.
   6. D2583 – Standard Test Method for Indentation Hardness of Rigid Plastics by Means of Barcol Impressor.
   7. D2584 – Standard Test Method for Ignition Loss of Cured Reinforced Resins.
   8. D3299 – Standard Specification for Filament Wound Glass Fiber Reinforced Thermoset Resin Chemical Resistant Tanks.
   9. D4097 – Standard Specification for Contact Molded Glass Fiber Reinforced Thermoset Chemical Resistant Tanks.

B. National Fire Protection Association (NFPA)
   1. 255 – Method of Test for Surface Burning Characteristics of Building Material
   2. 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities

C. Voluntary Product Standard, U.S. Department of Commerce (VPS):
   1. PS 15-69 Custom Contact-Molded Reinforced Polyester Chemical-Resistant Process Equipment.

1.3 SOLE SOURCE RESPONSIBILITY

A. The Biotrickling Filter (BTF) Manufacturer has sole responsibility for the design, fabrication, furnishing, delivery, startup and testing of the odor control systems. BTF Manufacturer may acquire items from different manufacturers as listed in the individual specification sections; however, the BTF Manufacturer shall have sole source responsibility for all equipment delivered.

B. The integrated odor control systems include the odor control fans, biotrickling filters, carbon adsorption units, and all duct, supports, panels, accessories and appurtenances from the odor control fan inlet to the final discharge of the treated air. The following items shall be supplied by the BTF Manufacturer:
   1. All equipment specified in the following sections:
      a. 43 11 20 – Centrifugal Fans for Odor Control
      b. 44 31 31 – Odor Control Biotrickling Filter Equipment
      c. 44 31 16 – Activated Carbon Adsorption Odor Control Equipment
   2. From the inlet of the foul air fans to the discharge of the odor control system, the BTF Manufacturer shall supply the following:
      a. Motors complying with Section 26 05 15 – Electric Motors.
      b. Electrical and control panels complying with Section 40 67 23 – Control Panels.
      c. PLC's complying with Section 40 63 43 – Programmable Logic Controllers.
      d. Piping complying with Section 40 23 39 – Process Piping – General.
      e. FRP Duct and Accessories complying with Section 40 05 36.13 – Fiberglass Reinforced Plastic (FRP) Pipe and Accessories for Odor Control.
      f. Supports complying with Section 05 50 00 – Metal Fabrications and as shown on the drawings
      g. Water panels, instrumentation equipment, ladders, platforms, guardrail/handrail, appurtenances and all other items specified or shown on the drawings for a complete and functioning system.
   3. The following items are to be supplied by the Contractor:
      a. FRP Duct and Accessories complying with Section 40 05 36.13 – Fiberglass Reinforced Plastic (FRP) Pipe and Accessories for Odor Control that is not supplied by the BTF Manufacturer.
         1) Either the Contractor or the Biotrickling Filter Manufacturer may furnish the foul air collection system duct, supports and accessories from the point of collection to the inlet to the foul air fan as specified in Section 40 05 36.13 – Fiberglass Reinforced Plastic (FRP) Pipe and Accessories for Odor Control.
      b. Conduit, wire, cable, piping, valves, appurtenances, and all other work necessary to connect to the BTF Manufacturer's system.
      c. Conduit, wire, and cable for all equipment, including the BTF Manufacturer's equipment.
      d. Conduit, wire, and cable for instrumentation not integral to the instrumentation equipment supplied by the BTF Manufacturer. Integral to the instrumentation equipment shall mean conduit, wire and cable supplied by the instrumentation manufacturer as part of their equipment supply, such a cable permanently connected to sensors.
      e. Fan control panels.
      f. Heat tracing cable, insulation, and aluminum jacketing
      g. Anchor bolts (sized by the equipment manufacturer)
      h. Supports, piers, pads, and grouting.
      i. Adjusting and balancing of the foul air collection systems
      j. All equipment and work not provided by the BTF Manufacturer.
      k. Installation of all work.
   4. Any items necessary for a complete and operational system and not supplied by the BTF Manufacturer shall be supplied by the contractor.

5. Contractor bears responsibility for coordinating the equipment supply with the BTF Manufacturer and providing all equipment required by the Contract Documents for a complete system.

C. System Arrangement:
1. The equipment, sizes, materials, and arrangements described in this Specification section are typically based on recommendations by equipment manufacturers and shall be considered minimum limits of acceptability. The equipment manufacturer shall be responsible for design, arrangement, and performance of all equipment supplied.
2. Modifications to structural design due to a manufacturer's varying space requirements, foundation requirements, or dimension changes to fit Manufacturer's specific requirements shall be coordinated by the Contractor and included in the Bid.
3. The Contractor shall be responsible for any modifications to the piping, electrical, structural, and mechanical layouts to accommodate, as well reimbursement to Owner for additional charges by Engineer for additional work required accomplishing changes.

1.4 DEFINITIONS

A. Biotrickling Filter (BTF): An attached or suspended growth biological reactor designed specifically for the removal of odors from airstreams. The terms "Biotrickling Filter" and "Bioscrubber" are used interchangeably.

B. Foul Air Collection System (FACS): The duct, dampers, expansion joints, fittings, supports, condensate drains, and appurtenances that are used to transport foul air from its source to the odor treatment facility. On the drawings, this term is also used to denote the overall foul air collection and treatment systems.

C. Foul Air Fan (FAN): A corrosion resistant centrifugal fan that conveys foul air from the odor source through the Odor Control System.

D. Odor Control System (OCS): A complete system consisting of covers, containment, transport and treatment of foul air resulting from wastewater treatment processes.

1.5 SYSTEM DESCRIPTION

A. Design requirements:
1. Supplier shall design the BTF system to meet the sizing and performance requirements in this specification.
2. A minimum empty bed residence time is provided in the Equipment Schedule. Calculation or performance data supporting the selected residence time shall be provided.

B. The BTF's treats odorous air from the municipal wastewater influent screening structure.

C. Performance requirements:
1. Hydrogen Sulfide Removal: Remove 99% of the inlet hydrogen sulfide or achieve an outlet hydrogen sulfide concentration of 0.5 ppm, whichever is higher.

1.6 SUBMITTALS

A. Submit in accordance with Section 01 33 00 – Submittal Procedures.

B. A single submittal shall be provided by the BTF Manufacturer for all equipment provided. The submittal shall be subdivided into the following sections:

1. General Information – Include the names and contact information for the Owner, Engineer, Contractor, BTF Manufacturer, carbon media supplier, foul air fan manufacturer and local points of contact. Include a scope of supply for all systems separated by system.
2. Provide details for the specific installation, such as layout drawings, wire diagrams, sizes, capacities, and details for that installation.
3. Common equipment – Include data sheets and details for equipment common to multiple facilities, such as PLC's, instrumentation, piping, valves, and other equipment used in multiple locations. Information specific to one facility shall be included in that facilities' section. Do not provide duplicate information across multiple sections.

C. Product data
   1. Provide the following product data:
      a. MSDS sheets for all consumables supplied.
      b. Product data sheets on nutrients, including ordering information.

D. Manufacturer's Qualifications:
   1. General:
      a. Installation List: Include a comprehensive list of all installed units, with North American installations clearly identified. List must include equipment model and service application.
      b. Submittal shall identify the individual that will serve as the point-of-contact for the procurement, service, and warranty of the system.
   2. Service Network:
      a. Manufacturer shall describe their current service network, by listing the nearest factory authorized service center and/or qualified service representative. Identify service technicians and include pertinent certifications to substantiate their knowledge and expertise.
   3. Start-Up and Training Capabilities: Manufacturer shall describe and demonstrate their approach to field start-up and training.
   4. Field Training: Include a description of the typical field training and sample outline that will be available to the Owner, as specified in this Section. Identify the trainer and associated qualifications, including resume and/or training certifications.

E. Shop Drawings
   1. Provide the following submittals and shop drawings specific to the equipment being proposed in accordance with Section 01 33 00 – Submittal Procedures. Submittals for the Biotrickling Filters, Carbon Adsorption Units, and Foul Air Fans, including all electrical and instrumentation, shall be submitted as a single submittal.
      a. Supplier's contact information.
      b. Name and model number of equipment.
      c. Layout drawings including all proposed system components with dimensions, clearances required and sizes indicated, anchor locations and sizes, details of ductwork or piping connections, size and location of required electrical conduits and conduit openings, and total weights of the product. Include descriptions and provisions for adjustments and alarms on operating components. Indicate extent of shop fabrication and field joint types and locations. Layout drawings shall be to scale in English units, provided on 11"x17" bond paper.
      d. Detailed specifications and data describing the materials of construction, material thickness, and coatings for all components.
      e. Submit data that verifies the system is capable of uniformly distributing flow throughout the system without short-circuiting and shall meet the specified treatment requirements.
      f. Complete information on electric motors furnished including make and type of motor, brake horsepower and locked rotor current at full voltage, per 26 05 15 – Electric Motors.

g. Complete electrical control schematic and wiring diagrams and data on equipment, devices, and controls to be furnished, including support for control panel per 40 67 23 – Control Panels. Control panels shall bear UL508 labeling.
h. Complete point-to-point wiring diagrams and a list of all the monitoring parameters and alarms available over Ethernet communication.
i. Location and telephone number of nearest stocking distributor of spare parts.
j. Startup and test schedule with test procedures.
k. Equipment installation report with field test data and test records (submit as record data after startup).
l. Warranties and service agreements.
m. Structural drawings for the vessels, or contact chambers, sealed by a professional engineer licensed in the State of Colorado.
n. Humidification & irrigation requirements, including recirculation rates.
o. Any other information necessary for the ENGINEER to determine compliance with the specifications.
p. Certified drawings of the local control and Master Control Panels.
    1) Electrical ladder diagram.
    2) Interconnects to all components outside the panel.
    3) Preliminary I/O listings for all control panel PLCs.
    4) Door layout.
    5) Interior layout.
    6) Printout of operator Interface screens.
q. Process and instrumentation diagrams (P&IDs).
r. Complete description of control systems, including sequence of operation and list of functions monitored, controlled, and alarmed.
s. A network block diagram showing all the Panels, and interface with the plant control system.
    1) Show field and network components such as AFDs, Managed Ethernet Switches, PLCs, Human Machine Interface (HMIs), and other miscellaneous network components.
t. Complete I/O list:
    1) A table showing all the data available over EtherNet/IP communication protocol to the plant control system.
u. PLC cabinet:
    1) Panel exterior and internal elevations with detailed bill of materials.
    2) PLC power schematic and I/O shop drawings.
    3) Product data for panel and all components.
    4) PLC memory and spare I/O calculations.
    5) UPS calculations.
    6) Thermal management calculations.
v. Complete description of control systems, including sequence of operation and list of functions monitored, controlled, and alarmed.

F. Operation and Maintenance Data
1. Provide complete Operation and Maintenance manuals in accordance with Section 01 78 23 – Operation and Maintenance Data.
2. Provide a list of components and catalog cut sheets fully describing all items:
    a. Mechanical and structural components.
    b. Instruments.
    c. PLCs.
    d. Operator Interface/machine monitors.
    e. Electrical components.
3. Operating description for the VCPs. Provide a copy of the software ladder logic covering all logic and sequences of operation. Provide a soft copy of all documented PLC code on CD. Provide Owner with four software licenses of any PLC or touch screen OIT software that is used. Provide a list of instrument settings.

a. In the event that a soft copy of the PLC code cannot be provided to the Owner, provide one (1) spare pre-programmed PLC or microprocessor/CPU.

4. Provide a detailed description of the data acquisition, monitoring, and predicted preventative maintenance software. Provide typical Operator Interface screens with detailed descriptions, the various tattletale monitors, preventative maintenance items, and data logging features.
5. Provide I/O listing for all control panel PLCs.
6. Indicate all scheduled maintenance requirements and routine inspections. Include maintenance summary forms.
7. Provide list of recommended spare parts and lubricants.
8. Provide a troubleshooting guide.
9. Provide the local sales representative contact information with the company name, contact person, phone number, and address.

G. Closeout Submittals

1. Provide an Equipment Installation Report signed by the Manufacturer's representative.
2. Submit test reports as required in Part 3 of this specification.
3. Operation and Maintenance Manuals:
   a. Prepare operation and maintenance manuals for the system, including appurtenances included in this Section.
   b. Operating and maintenance manuals and maintenance summary sheets for the equipment specified herein shall conform to the provisions of Sections 01 33 00 and as specified in this Section.
   c. Provide Project Record Documents showing as-built dimensions, as-built wiring and control diagrams, as-built logic diagrams and design information for supplied parts and equipment.
   d. PLC and HMI Programs:
      1) Provide complete electronic copies of the PLC and HMI programs and configuration files for all equipment in the local control panels, in the native file format of each device, along with any supporting files. Programs shall be fully accessible for use by the Owner – programs that are locked, restricted, or contain hidden materials are not permitted.
   e. Provide a detailed description of control systems.
   f. Provide panel drawings, wiring diagrams, specifications, and a detailed description of the local panels.

1.7 TOOLS AND SPARE PARTS

A. The manufacturer shall furnish all special tools and appliances necessary to disassemble, service, repair, and adjust the equipment and appurtenances of the system. If no special tools are required, the manufacturer shall indicate this in the submittal.

B. The following spare parts shall be furnished:

1. One set of maintenance tools.

C. All spare parts shall be suitably packaged and clearly identified with indelible marking on the containers. Tools and spare parts shall be supplied in a tool chest for long-term storage and marked with manufacturer's name, along with a complete description on contents.

D. Manufacturer shall warrant that, after substantial completion, any submodule needed for repair shall be capable of being shipped to the project site within five days of notification. Critical service spares, including motor cores, inverters, HMIs, control cards, CPUs, etc. shall be available within 36 hours. Full system replacement, should it be needed, shall be guaranteed onsite within 21 days.

1.8 QUALITY ASSURANCE

A. Qualifications
   1. MANUFACTURER shall have a minimum of five years' experience producing similar equipment and shall be able to show evidence of at least five installations, of similar size and capacity, in satisfactory operation for at least two years.
   2. A list of similar installations shall be furnished with the shop drawing submittal, including names and telephone numbers of contacts. Include information on airflow, designed hydrogen sulfide concentration, foul air source, location, year installed, owner name and contact information.

B. Subject to meeting the requirements of the individual specification sections, the integrated systems shall be provided by one of the following:
   1. ECS Environmental Solutions
   2. Daniel Company
   3. Evoqua

1.9 DELIVERY STORAGE AND HANDLING

A. Preassemble parts to the largest extent possible, compatible with transportation limitations and equipment protection considerations. Field assembly, if any, shall require merely bolting together of match-marked components. Equipment shall be crated and delivered to protect against damage during shipping. Flange faces shall be protected from damage. All openings shall be covered to prevent entrance of dirt, water, and debris.

B. Properly protect all parts so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and until the units and equipment are ready for operation.

C. Properly protect finished iron or steel surfaces to prevent rust and corrosion.

D. Protect all equipment, delivered, and designated for storage, from the weather (humidity and temperature), dirt and dust, and other contaminants.

E. Electrical equipment, panels, and instrumentation shall be stored indoors and protected from corrosion (including ambient hydrogen sulfide corrosion). Motors shall have power connected to the motor heater.

F. Acceptance at Site: Equipment arriving at the site in a damaged condition shall be rejected.

1.10 PROJECT/SITE CONDITIONS

A. System Arrangement:
   1. The equipment, sizes, materials, and arrangements described in this Specification section are based on recommendations by equipment manufacturers and shall be considered minimum limits of acceptability. The equipment manufacturer shall be responsible for design, arrangement, and performance of all equipment supplied under this section.

B. Environmental Conditions:
   1. All equipment including controls and drives specified herein shall be specifically designed for this service and the environment encountered in this installation.
   2. The environment will be moist, and corrosive, exhibiting hydrogen sulfide and other corrosive gases encountered in municipal wastewater treatment plants.

3. The equipment shall be designed and capable of operation at ambient temperatures of 0°F to 110°F.

1.11 SPECIAL EQUIPMENT WARRANTIES

A. The Supplier shall provide a Special Equipment warranty for equipment provided under this Section as specified in paragraphs B & C below. A letter of acknowledgement (on corporate letterhead) accepting the Special Equipment Warranty shall be included with the Shop Drawings.

B. System: Special equipment warranty (non-prorated) shall be for 1 year from acceptance of the equipment and shall provide for repair and/or complete replacement of contact chamber, fan, pumps, vessel, coatings, linings (in the event of corrosion damage), including equipment, materials, labor, shipping, and any and all costs associated with repair or replacement.

C. Media: Special equipment warranty (non-prorated) shall be for 10 years from acceptance of the equipment and shall provide for complete replacement of the media, including equipment, materials, labor, shipping, and all associated costs. Media failure includes increase in pressure drop through the media such that the specified airflow rates are not achievable with the installed equipment and/or the failure of the media to meet specified odorant removal levels.

1.12 MAINTENANCE

A. Extra materials
   1. Provide a one year supply of nutrients for the Owner.

PART 2 - PRODUCTS

2.1 VESSEL AND DESIGN

A. Materials
   1. All materials and equipment exposed to the air stream, condensate or leachate shall be protected from corrosion. Corrosion resistant materials and equipment are required unless specifically permitted by this specification.
   2. All hardware, bolts, nuts, washers, and anchors shall be 316 stainless steel.
   3. All post installed anchors embedded in concrete shall be 316 stainless steel all thread rods using Hilti HIT-RE500 epoxy. All cast in anchors shall be 316 stainless steel “J” bolts. Sizing of anchors shall be by supplier.

B. Vessel:
   1. Final design drawings for structure(s) and vessel(s) shall be sealed by a licensed engineer of the State of Colorado. Design of system shall be in accordance with applicable local, state, national and international standards and codes and shall be specific to the project location. Design loads shall be determined using ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures.
   2. All materials used in the structure or vessel shall be inherently corrosion resistant. Vessel shall be fiberglass reinforced plastic.
      a. Fiberglass Reinforced Plastic (FRP) construction:
         1) Resin:
            a) Resin Type: Premium corrosion resistant and fire retardant brominated bisphenol-A vinyl ester. Resin shall not contain pigments, dyes, colorants or fillers.
            b) Flame Spread Rating: Class 1 flame spread rating (25 or less).
            c) Thixotropic agents may be added to control resin viscosity per resin manufacturer’s instructions.

d) Resin shall be
(1) AOC Vipel
(2) Ashland Dekrane
(3) Or approved equal

2) Structural reinforcement shall consist of chopped strand mat and direct roving using E-Glass with resin.

3) Minimum interior corrosion barrier:
a) C-Glass veil with 90% resin to 10% glass ratio
b) Double Nexus veil with 90% resin to 10% glass ratio
c) Minimum corrosion barrier thickness shall be 0.10 inches. Corrosion layer shall be clear with no additives or fillers.

4) Exterior laminate shall be a protective gel surface coat with UV inhibitors pigmented to a color selected by OWNER.

5) Embedded materials shall be 316 stainless steel.

6) Provide a gel coat on all surfaces and UV inhibitor on all external surfaces.

7) All cut or drilled surfaces shall be sealed with resin.

3. Minimum material thicknesses for all structural shapes shall be 0.25 inches. Structural shapes shall be pultruded FRP with vinyl ester resin.

4. Minimum tank wall thickness shall be as determined by the Manufacturer. Provide drawings sealed by a Colorado Professional Engineer.

5. Supplier shall provide a removable cover to cover the exhaust of the unit during shutdowns. The cover shall be constructed of materials listed as acceptable for the structure or vessel. Not required for vessels having a damper on the discharge stack.

2.2 WATER PANEL AND IRRIGATION

A. Water Panel:

1. Provide a separate NEMA 4X 316SS water panel to contain wetted parts. Cabinet shall have adequate room for maintenance and shall be mounted per the detail shown on the drawings.
2. One Water Panel for each BTF shall be provided.
3. Water panel shall contain the following which are completely pre-wired and pre-programmed:
   a. Solenoid or actuated valves
   b. Nutrient Pump
   c. Plant water bypass connection and valves
   d. Wye strainer for plant water supply and bypass lines.
   e. Flow meters for nutrient flow and water flow.
   f. Check valves
   g. Flow switch for plant water supply and recirculation (if included) as specified in the section below.
   h. pH probe as specified in section below.
   i. Pressure reducing valves.
   j. Panel heater with adjustable thermostat.
4. Electrical components in the water panel shall be rated for NEC Class I, Division 2, Group D.
5. Water supply is chlorinated effluent from municipal wastewater treatment plant process and may contain solids.
6. The Panel should house the pumps and controls required for the nutrient addition system.
7. The system shall operate based on the controls from the Water Panel or the Vendor Control Panel, depending on the mode of operation.
8. All of these components shall not be viewable from the outside of the enclosure and be prewired. The Water Panel shall be preprogrammed, and factory tested for proper operation prior to shipment.

9. The Water Panel shall in turn send and receive signal for the flowmeter, pH analyzer, and the solenoid valve to the Main Vendor Control Panel.

B. Humidification, Recirculation, and Irrigation:
   1. Spray nozzles shall be 316 stainless steel or polypropylene construction.
   2. Provide a humidification system to humidify inlet air if needed for the process. If used, humidification systems shall be configured so that neither humid air nor condensate enters the foul air fan.
   3. Provide a recirculation system and/or plant water booster system consisting of a recirculation pump, spray nozzle(s), sump, isolation valves, and flow meter.
      a. All wetted parts shall be inherently corrosion resistant materials (FRP, 316SS or titanium). Pump shall be powered from the main vendor control panel. Electrical Feed shall be 480 VAC, 3 phase 60 Hz.
      b. Recirculation/booster system shall have a connection to the plant water supply to allow for manual bypass of the recirculation system. Provide isolation valves for this purpose.
      c. If necessary for the process, provide a heater powered from the Suppliers panel for heating of recirculation water.
      d. Recirculation systems shall operate based on a timer or shall operate continuously.
      e. For systems that do not require recirculation water under normal operation, the pump shall be left installed and piped such that it may be used as a booster pump for plant water or for future startup needs.
      f. For systems where available plant water pressure is not sufficient for bypass operation, provide a plant water booster pump.
   4. Provide a plant water connection for irrigation, to supplement recirculation water lost to evaporation, and to replace water discharged in the plant drain system.
   5. Hardwired Control for Recirculation Pump:
      a. With the HOA switch at the main VCP in Auto Mode, the equipment shall start automatically. The START/STOP pushbuttons mounted on the face of the panel shall be used to START and STOP them.
      b. With the HOA in Auto Mode, the pump shall be automatically controlled by the VCP.
   6. Hardwired Interlocks for Recirculation Pump:
      a. The entire system is stopped and prohibited from running if any of the emergency pushbuttons are activated.
      b. The motor winding heater shall energize when the motor is off due to any condition.
   7. Software Interlocks for Recirculation Pump:
      a. The VCP shall be programmed to shut down the recirculation pump when a low flow is identified at the Water Panel, or when a Low or Low-Low level is identified at the BTF sump.

C. Paddle Flow Sensor with transmitter:
   1. Provide each Water Panel with a prewired paddle flow sensor on the recirculation water line. The transmitter shall be remotely mounted on the main VCP. It can send signals and receive power from the Main VCP as shown on the drawings.
   2. Manufacturer: One of the following or equal
      a. Sensor: GF Signet 2537 Paddle Flow Sensor
      b. Transmitter: Signet 9900
   3. Performance Requirement:
      a. Accuracy: Within 1% of reading.
   4. Transmitter:
      a. Power Supply: 24 VDC
      b. Output: Isolated 4 to 20 mA DC proportional to flow, Alarm contacts (SPDT) for flow indication in the main VCP.

c. Display: Backlit LCD digital display.
d. Enclosure: NEMA Type 4X.
e. Mounting: Panel mounting option.

D. pH probe:
1. Provide each Water Panel with a prewired pH probe in the BTF sump.
2. The transmitter shall be remotely mounted on the main VCP.
3. The probe shall send signals and receive power from the Main VCP as shown on the drawings.
4. pH measurement shall use the potentiometric measurement method utilizing a glass electrode. The pH sensitive glass membrane surface shall react to the acid content of the solution with a specific voltage, which is measured relative to a reference electrode.
5. Manufacturer: One of the following or equal
a. Sensor: GF 2724 signet pH electrode.
b. Transmitter: Signet 8750 with suitable pre-amplifier if required.
c. Transmitter: Performance Requirement:
1) Accuracy: Within 0.01 pH
2) Repeatability: Within 0.01 pH
6. Sensor Material: Glass pH sensor housed in a molded reinforced polypropylene body threaded for insertion, with a built-in temperature sensor, as indicated on the Drawings.
7. Transmitter:
a. Suitable for panel or field mounting options.
b. Power Supply: 24 VDC with pre-amplifier if required.
c. Output: Isolated 4 to 20 mA DC proportional to pH, Alarm contacts (SPDT) for low pH indication in the main VCP.
d. Display: Backlit LCD digital display.
e. Enclosure: NEMA Type 4X.
f. Mounting: Panel mounting option.

2.3 NUTRIENT FEED AND ACCESSORIES

A. Nutrient Feed System
1. Nutrient pump shall be located in the water panel.
2. Nutrient tank shall be polypropylene or HDPE, sized by the Supplier to allow for at least one month storage of nutrient solution.
3. Nutrient tank shall include a mixer if needed to maintain nutrient in solution.
4. Nutrient pump shall operate based on a timer or continuous feed.
5. Nutrient pump and mixer shall be powered from the Manufacturer’s control panel.
6. Nutrient pump and mixer shall be capable of sending signals and receiving controls from the main PLC based VCP, through the associated Water Panel.

2.4 ACCESSORIES

A. Provide a minimum of four (4) lifting/guiding eyebolts or lugs for use in transporting and placing the reactor vessel and vessel sections.

B. Provide a minimum of four (4) hold downs for anchoring the reactor vessel to the concrete foundation.

C. Each spray nozzle assembly shall be removable or accessible without entering the vessel.

D. Manways shall be bolted flanged covers and shall include a davit or hinge to support the opened manway cover.

E. If nutrients are required for operation, Supplier shall provide all nutrients needed for one year of operation (beginning at acceptance of performance testing of the odor control unit) in addition to supplies for startup and testing. The cost of shipping of the nutrients to the site at the required frequency during the first year of operation shall be included in the price of the unit.

F. Access:
1. Provide aluminum or fiberglass reinforced plastic ladders to access the top of BTF's.
2. Provide aluminum or fiberglass reinforced plastic handrails around the top of the BTF's.
3. Provide aluminum or fiberglass reinforced plastic ladders, platforms, and handrails where shown on the drawings and for accessing equipment and components requiring maintenance access more frequently than once per year.
4. Provide aluminum or fiberglass ladders, stairs, platforms and handrails for foul air fans where shown on the plans and where the fan shaft is located more than 48-inches above the adjacent finish floor. Platforms shall be a minimum 36-inches wide and extend the length of the fan and/or elevated fan pad to provide access.
5. Comply with OSHA 1910.21-30 requirements for railings, cages, ladders, platforms and stairs. Comply with Section 05 51 00 – Metal Stairs for metal stairs and appurtenances.
6. Provide fall arrest systems complying with current OSHA regulations and acceptable to the Owner for all ladders and platforms.

G. Sample Ports:
1. Provide sample ports or other access on leachate (blow down) drains for Owner's measurement of leachate pH.
2. Provide sample lines for sampling air at the inlet, between stages, and at the exhaust. Sample lines shall be 1-inch diameter schedule 80 CPVC routed to within four feet of finished grade. Terminate with true union CPVC ball valves.

H. Exhaust stack: extend at least three (3) feet above the vessel and supported solely by the vessel.

I. Provide level alarms in the BTF vessel sump to alarm if the liquid level nears the air inlet duct. The intent is to alert for conditions where water may enter the fan. The level switches provide in the BTF shall be ball float type level switches: Switches. Normal operation of the BTF shall not allow water to enter the air inlet duct.

2.5 ACCESSORIES FOR THE RECIRCULATION PUMPS, SUMP PUMPS AND CENTRIFUGAL FANS:

A. Provide all fans and recirculation pumps with local disconnects that meets the Division 26 requirements and as shown on the drawings.

B. Provide all fans and recirculation pumps with belted or cartridge space heaters mounted within the motor enclosure. The motor winding heater shall be rated for 120 VAC single phase. The power leads for the heater shall be wired into the conduit box. They shall be installed within the motor enclosure adjacent to core iron.

C. Provide Temperature and Moisture Protection relays for the sump pump application. The relays shall be rated for 120 VAC single phase. The temperature and moisture sensors shall be installed within the motor enclosure adjacent to the iron core. The contacts for temperature and moisture elements shall be rated for 120 VAC.

2.6 MISCELLANEOUS

A. Insulation, Heat Tracing and Jacketing:

1. Comply with specification sections 40 41 13 – Heat Tracing and 40 42 00 – Process Mechanical Insulation.
2. Provide insulation, heat tracing and aluminum jacketing for all exposed water lines, all exposed drain lines that normally have standing water, including all pressure lines 3-inch in diameter and smaller, and nutrient feed lines and accessories. Include all valves and appurtenances in affected pipes.
3. Insulation, heat tracing, and jacketing shall be furnished and installed by Contractor. Contractor to coordinate quantities with the selected BTF Manufacturer.

B. Miscellaneous:
1. All above grade water and drain piping shall be Schedule 80 CPVC. Provide supports for all piping at intervals recommended by the pipe manufacturer.
2. All ball valves shall be CPVC true union valves.
3. The BTF Manufacturer's design shall consider particulates and grease that may be present in the air stream and shall provide for their removal if performance will be hampered.
4. All pieces of equipment shall have a stainless-steel manufacturer's nameplate securely affixed in a conspicuous place on the equipment showing the ratings, serial number, model number, Supplier, and other pertinent nameplate data.

C. Fabrication
1. Shop assemble components to the extent practical.

D. Finishes
1. Shop coat the reactor vessel or provide a tinted gel coat with UV inhibitors.
2. Field coat all other equipment and components in accordance with Section 09 90 00 – Coatings.

2.7 ELECTRICAL, INSTRUMENTATION AND CONTROLS

A. Motors shall comply with the requirements of Section 26 05 15 – Electric Motors.

B. Electrical Panels shall comply with the requirements of Section 40 67 23 – Control Panels. Electrical panels shall power all equipment provided by the Supplier. Panel shall include motor starters for any motors such as the recirculation/booster pump motor and fan motor.

C. Control Panels: BTF Manufacturer shall provide a main Vendor Control Panel (VCP) for each BTF and will be located in the field. Panel shall power the recirculation pumps, nutrient pumps, odor control fans and all other BTF system components. The panels that are housed outdoors, shall be provided with sun-shields and required air conditioning units.
1. Controls:
    a. Instrumentation general requirements shall be in accordance with Section 40 61 13 – Process Control Systems General Provisions.
    b. Each panel shall have a Programmable Logic Controller. PLC shall be Siemens SIMATIC S7-1500.
        1) The Plant PLC shall receive at a minimum I/O, via Ethernet connection from the VCP, as provided in the section below.
        2) Each PLC shall support IEC Standard 61131-3 for all of the following programming languages:
            a) Ladder (LD)
            b) Function Block Diagram (FBD)
            c) Structured Text (ST)
        3) The CPU shall be installed with an SD card for memory backup.
    c. The PLC will be capable of the following communication protocols as shown on the Drawings.
        1) 10BASE-T/100BASE-TX Ethernet based PROFINET communication.

d. Provide a panel mount Siemens SIMATIC HMI for each BTF vendor control panel (VCP), minimum 12" screen size. Mount to panel face.
e. Provide UPS and manual maintenance bypass switch inside each BTF VCP.
f. Provide a fiber patch panel and fiber to Ethernet media converter inside the BTF VCP for the Persigo WWTP.
g. The VCP panel shall be provided with an Ethernet Switch.
h. Each VCP shall be provided with a single 480 VAC power supply as indicated on the drawings. Power to all the starters, fans, control circuits, the entire package system and all its appurtenances, shall be from the main VCP.
i. The VCP shall receive signals and send control commands to the associated Water Panels, Recirculation Pumps, and Centrifugal Fans
j. The Main VCP shall house starters for all associated with the system including fan motor starters.
k. Two 120 VAC circuits with redundant 24 VDC power supplies shall be provided within the BTF VCP. The BTF VCP power, monitoring and control schematic for the two 120 VAC circuits and 24 VDC circuits shall be provided in accordance with the drawings.
l. The Panel and all the associated components shall be furnished in accordance with Section 40 67 23 – Control Panels. The panel shall be rated for NEMA 4X 316 SS, with hinged doors for front access and panel stand.
m. The VCP enclosure shall be adequately sized and designed to dissipate the heat generated inside it. Provide air conditioners and heaters as required.
n. Provide sunshades for the panel when installed outdoors.
o. All panel components shall be provided in conformance with Section 40 67 23, and all controls and instruments shall fail into a safe condition. Provide necessary interlocks and tie delays (operator adjustable) for system requirement, when required.
p. Provide one unused 20 amp, 120 VAC circuits with duplex 120V grounded plug receptacle.
q. Provide two 20 amp unused circuits for heat tracing.

2. Panel Face:
   a. SIMATIC HMI shall be mounted on the panel face.
   b. RESET pushbutton.
   c. Emergency stop pushbutton.
   d. Valves and pumps:
      1) 3-way motorized Recirculation/Once-thru valve:
         a) Recirculation/Once-Thru selector switch.
      2) 2-way motorized water supply valve:
         a) HAND-OFF-AUTO selector switch.
      3) Makeup water flush valve:
         a) HAND-OFF-AUTO selector switch.
      4) Recirculation pump:
         a) HAND-OFF-AUTO selector switch.
         b) START pushbutton.
         c) STOP pushbutton.
         d) RESET pushbutton.
      5) Foul Air Fans:
         a) START pushbutton.
         b) STOP pushbutton.
         c) RESET pushbutton.
         d) Duty selector switch between fans.
      6) Indicators and Alarms:
         a) Refer to Section 40 67 23 for pilot light color convention.
            (1) pH transmitter with digital display.
            (2) Irrigation flow indication transmitter with digital display.
            (3) Water supply/irrigation valve open indication.

(4) Water supply/irrigation valve closed indication.
(5) Makeup water flush valve open indication.
(6) Makeup water flush valve closed indication.
(7) Recirculation/once-through valve open indication.
(8) Recirculation/once-through valve bypass indication.
(9) Recirculation Pump fail indication.
(10) Recirculation Pump low level indication.
(11) Recirculation Pump low flow indication.
(12) Recirculation Pump low low level indication.
(13) Foul Air Fan running indication.
(14) Foul Air Fan fail indication.

D. Power:
1. Provide 480V motor starters for all fan motors and pump motors at the BTF panels. Provide high temperature shutdown and alarm to the vendor control panel for all pump motors.
2. For the PLC, provide separate 120V power from the UPS provided inside each Main VCP by the vendor.

E. Wiring:
1. Factory assembled and wired control panel, such that filed wiring shall consist of only connections to the terminals.
2. Identify each end of each wire by a unique number printed on the heat shrink sleeve market.

F. Control System Programming:
1. The Vendor shall be responsible for preparing, writing, and testing all logic associated with the VCP.

G. Grounding:
1. Provide a ground wire and rod connected to vessel per the electrical standard details.

H. BTF Sumps:
1. Level switches shall be Contegra FS-90 or approved equal. Provide intrinsic safety barriers if level switches are located in classified areas

2.8 I/O LIST: (AS REQUIRED FOR THE APPLICATION)

A. Not limited to but at a minimum, the following I/Os shall be accommodated:
1. PLC failure
2. General alarm
3. System running status on/off
4. Centrifugal Fan(s) failure alarm
5. Centrifugal Fan(s) on/running
6. Centrifugal Fan(s) in high temp
7. Centrifugal Fan(s) in high vibration (if any)
8. Centrifugal Fan(s) in overload
9. Centrifugal Fan(s) failed to start/stop
10. Centrifugal Fan(s) high differential pressure switch for low flow condition
11. Centrifugal Fan(s) reset
12. Recirculation pump(s) fail alarm
13. Recirculation pump(s) on/running status
14. Recirculation pump(s) in remote/auto
15. Recirculation pump(s) in high temp
16. Recirculation pump(s) in overload
17. pH readings status

18. pH low/high alarm
19. pH set points low/high
20. Flow meter readings status
21. Flow meter low/high alarm
22. Flow meter set points low/high
23. Low level sump alarm
24. Low-low level sump alarm
25. Irrigation valve status open/close
26. Irrigation valve in remote/auto/once-through
27. Irrigation valve fail to open/close
28. Irrigation valve low pH open
29. Irrigation valve low-low sump level open
30. Once through irrigation mode ON/OFF
31. Once through irrigation timing settings
32. Recirculation irrigation mode ON/OFF
33. Ventilation Alarms (if any)
34. Combustible Gas Detectors signals/alarms (if any).

B. Refer to P&IDs for more information and details.

PART 3 - EXECUTION

3.1 GENERAL

A. Handling, storage, and installation shall be in accordance with the plans, specifications, and the Supplier's recommendations.

B. Supplier's Services:
1. Supplier or their authorized representative shall provide onsite services to assist the Contractor with installation, check equipment prior to startup, startup the systems, train Owner's personnel and test the installed system.

3.2 STARTUP AND TESTING

A. Startup of the odor control system shall be done in accordance with Supplier's recommendations.

B. In the presence of the Owner's representative, Supplier shall test the operation of the odor control system. Testing shall take place two to six weeks after startup of the unit or as recommended by the Supplier. Final acceptance (and beginning of warranty period) will not be made until after successful completion of the performance testing and receipt of installation report.

C. Testing Equipment: Supplier shall provide the equipment listed below for the duration of the performance testing for use by the Contractor and Owner. Submit current calibration certificates for each piece of equipment used along with test results. Comply with equipment Supplier recommendations for equipment use.
1. Odalog/Acrulog Hydrogen Sulfide Gas Loggers by Detection Instruments.
    a. 0-1000 ppm units
    b. 0-200 ppm units
    c. 0-50 ppm units
    d. Low Range 0.01-2.0 ppm units.
    e. Low Range Sampling System (LRSS-2) by Detection Instruments with sufficient PVC or Teflon hose for testing.
2. Micromanometer for airflow measurement.

D. Testing Procedure:
   1. Balance the odor control system as specified in Section 44 31 83 – Adjusting and Balancing Odor Control Systems.
   2. Measure the airflow (feet per minute), static pressure (inches water column) and velocity pressure (inches water column) into the unit. Airflows shall be within 5% of the specified value before testing may commence.
   3. Measure the airflows into each individual cell or tower. Airflows shall be within 5% of equal or specified distribution before testing may commence.
   4. Using an LRSS-2, connect the lowest range Odalog (0-50, 0-200, or 0-1000) that will record the anticipated range of concentrations to the system inlet. Use the same LRSS-2 to connect a Low Range (0.01-2.0 ppm) Odalog to the vessel exhaust. The intent is to record hydrogen sulfide concentrations at the inlet and exhaust to the odor control system.
   5. Record concentrations at 10 second intervals for two weeks continuously. Supply enough test units to test all components of each system concurrently. Change out instruments as recommended by the manufacturer to avoid sensor fatigue and to download data.

E. Testing Report: Submit the following:
   1. Original Odalog data files and files exported into Microsoft Excel format.
   2. Plots of the inlet and exhaust concentrations.
   3. Dimensioned drawing showing locations and identification of samples taken. Design drawings or shop drawings may be annotated for this purpose.
   4. Date, time, sample and results of each sample taken.
   5. Airflow rate, static and velocity pressures at the time of sampling.
   6. Any deviations from the test procedure with an explanation.

F. Acceptance: Determination of satisfactory performance shall be made by the Owner based on the above performance testing or additional testing as needed. Acceptable H2S removal shall be determined by calculating H2S removal at each recorded time point offset by the system residence time.

G. If the sampling results do not meet the specified removal requirements, the Supplier shall be given four weeks to make necessary modifications to the odor control system before a retest is conducted. If the system fails two retests, the Supplier shall remove and replace the odor control system with one that meets the requirements and shall provide additional treatment units if necessary, to meet the removal requirements and media life guarantee at the Supplier's sole expense. Subsequent tests may be performed by Owner at any time during the warranty period at the Owner's expense.

H. All warranty and guarantee periods shall begin from the date of the final acceptance of the odor control system based on the performance testing described in this Section. Performance testing may not begin until the system is connected to all the foul air sources.

EQUIPMENT DATA SHEET – BIOTRICKLING FILTERS

Parameter	Value
Equipment Tag Number(s)	10BF01
Number of Reactor Vessels:	1
Location	Persigo WWTP
Foul Air Source(s)	Gravity sewer headspace
Foul Air Flow, acfm, each BTF	7,050
Anticipated Average Inlet Hydrogen Sulfide Concentration ppm	100
Anticipated Daily Peak Inlet Hydrogen Sulfide Concentration, ppm	200
Maximum Diameter of Vessel, ft	12.5
Ambient Air Temperature, °F	0-110
Process Air Temperature, °F	60-90
Available plant water pressure at grade level, psig +/-	62*
Minimum EBRT, seconds	15
Maximum Operating Weight, lbs	88,000

Parameter	Value
Equipment Tag Number(s)	30BF01
Number of Reactor Vessels:	1
Location	Dos Rios
Foul Air Source(s)	Gravity sewer headspace
Foul Air Flow, acfm, each BTF	710
Anticipated Average Inlet Hydrogen Sulfide Concentration ppm	100
Anticipated Daily Peak Inlet Hydrogen Sulfide Concentration, ppm	275
Maximum Diameter of Vessel, ft	7
Ambient Air Temperature, °F	0-110
Process Air Temperature, °F	60-90
Available potable water pressure at grade level, psig +/-	50*
Minimum EBRT, seconds	15
Maximum Operating Weight, lbs	6,000
Maximum Vessel Height, ft	14

*Contactor to field verify. If the available water pressure does not meet BTF manufacturer requirements, the BTF manufacturer shall provide a booster pump per Section 2.2 above.

END OF SECTION

SECTION 44 31 83 – ADJUSTING AND BALANCING ODOR CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Adjusting and Balancing Odor Control air systems installed on this project unless noted otherwise.

B. Section does not include:
   1. Testing, adjusting, or balancing any building heating, ventilation, air conditioning, refrigeration, hydronic or any other systems.
   2. Adjusting and balancing of existing odor control systems unless specifically noted otherwise.

C. Performance testing of odor control equipment is specified in the specification sections pertaining to that equipment.

D. An initial balance shall be made to facilitate odor control startup and a final balance made after all equipment is started and functioning.

1.2 REFERENCES

A. NEBB: “Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.” (for NEBB Agencies)

B. AABC “National Standards for Total System Balance” and “Test and Balance Procedures” (for AABC Agencies).

C. ASHRAE Handbook, Latest Edition

1.3 SYSTEM DESCRIPTION

A. Refer to Section 44 31 31 – Odor Control Biotrickling Filter Equipment for the overall odor control system description.

1.4 QUALITY ASSURANCE

A. Agency Qualifications:
   1. The Agency performing the adjusting and balancing shall be regularly engaged in the practice of testing, adjusting and balancing ventilation systems. Experience in adjusting and balancing odor control systems is preferred but is not a requirement.
   2. The Agency and personnel performing the adjusting and balancing shall be certified by one of the following:
      a. National Environmental Balancing Bureau (NEBB); or
      b. Associated Air Balance Council (AABC)

B. Comply with the following:
   1. NEBB: “Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.” (for NEBB Agencies)
   2. AABC “National Standards for Total System Balance” and “Test and Balance Procedures” (for AABC Agencies).
   3. Recommendations in the latest ASHRAE Handbook.

1.5 SUBMITTALS

A. Qualification Data: Submit documentation of the balancing agency showing certification (NEBB or AABC) of agency and personnel.

B. Submit information describing the personnel, and instruments to be used.

C. Submit a sample report containing, at a minimum:
   1. Name, address, and phone number of Agency
   2. Identify the Owner, Contractor, Engineer and Project on an inside cover sheet.
   3. Site drawing noting locations where measurements will be taken. Copies of the construction drawings may be used for this purpose provided any field changes to duct systems have been incorporated.
   4. Sample forms to include the following at a minimum:
      a. Duct traverse reporting form (to include final damper position settings)
      b. Blower data reporting form (to include speeds and differential pressures)
      c. Forms to report damper positions
   5. Systems readiness checklists

D. Reports: Submit testing, adjusting, and balancing reports after completion of testing. The reports shall document that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems.

1.6 PROJECT CONDITIONS

A. All odor control systems shall be installed and started prior to beginning balancing, including installation of all media.

B. Buildings where odor control is exhausted shall be complete with HVAC systems operating and all doors closed.

C. Covered basins shall be filled to their normal operating levels and any equipment in the basin shall be operating.

D. Contractor shall coordinate the requirements of this specification with the startup and testing requirements of the odor control equipment specifications. An initial balance shall be made to facilitate odor control startup and a final balance made after all equipment is started and functioning.

PART 2 - PROCEDURES

2.1 MISCELLANEOUS

A. Contractor shall supply additional sheaves and belts for all fans as required to make adjustments to blowers, either existing or new. Sheaves shall be new and shall be of the type and material as recommended by the manufacturer of the blower.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with the project requirements. Notify Engineer of any conditions that might prevent accurately balancing the system.

B. Examine the system for dampers, fans, equipment, and locations for making measurements. Verify systems have been lubricated and greased, that belts are aligned and tight, and that odor control systems are functioning. Mark on the duct the proposed locations for measuring airflows and pressures.

C. Examine the equipment data including fan performance curves. Do not operate fans “off the curve” or against a closed damper. Examine fan and odor control equipment installation and startup reports.

3.2 PREPARATION

A. Prepare system readiness checklists that include the following at a minimum:
   1. Ductwork is complete with all connections made.
   2. Dampers are installed and functioning.
   3. Fans are operable, free of vibration and rotating in the correct direction.
   4. Doors and windows are installed and closed.
   5. Building HVAC systems are installed, functioning and balanced (if required elsewhere in the documents).
   6. Access for taking measurements is present.

B. Perform readiness checks before adjusting and balancing the system.

3.3 GENERAL PROCEDURES FOR ADJUSTING AND BALANCING

A. Perform full duct traverses in at least two directions for each location.

B. Drill holes in duct to measure pressure and flow at the selected location. Holes shall be no larger than needed to insert tube or probe into the duct and shall be plugged upon completion of testing.

C. Open all dampers in the system to their full open position.

D. Start odor control fans and adjust inlet vane dampers until fans are producing the specified air flow. Report inlet and exhaust static pressures. Fan adjustment, if needed, shall be by Contractor and fan manufacturer.
   1. Adjust fan by replacing sheaves and belts to achieve the specified airflow if the specified airflow cannot be achieved by adjusting the inlet vane dampers. Adjustable sheaves shall not be used.
   2. Not all fans have inlet vane dampers; fans without inlet vane dampers shall be adjusted by adjusting other dampers in the foul air collection system or by replacing sheaves and belts.

E. Adjust balancing dampers to until specified air flows are present in the ducts.

F. After all dampers have been adjusted repeat airflow measurements at all locations. Adjust damper positions until specified airflow if achieved. Repeat measurements until two consecutive measurements differ by less than 2%. Report final airflows only; preliminary and interim airflows are not to be included in the report.

G. System shall be balanced to within 3% of the specified air flows.

H. Mark damper positions at final set points neatly and indelibly for future reference.

I. Lock damper in final positions if damper design permits.

3.4 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms. Emphasis should be given to recording damper positions within 5%, blower speeds, and pressures at blowers and processes.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

3.5 DEMONSTRATION

A. Training:
   1. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting, and balancing procedures.
   2. Schedule training with Owner through the Engineer with at least 5 days prior notice.

END OF SECTION