Spanish Fork Santaquin Pipeline
Santaquin Reach

VOLUME 3

DIVISION 31 through DIVISION 49

CENTRAL UTAH WATER
CONSERVANCY DISTRICT

(801) 226-7100

October 2023

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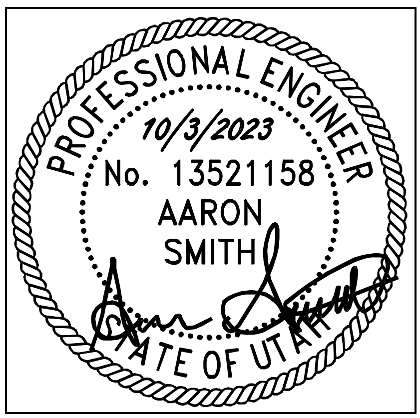

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Aaron Smith, P.E.

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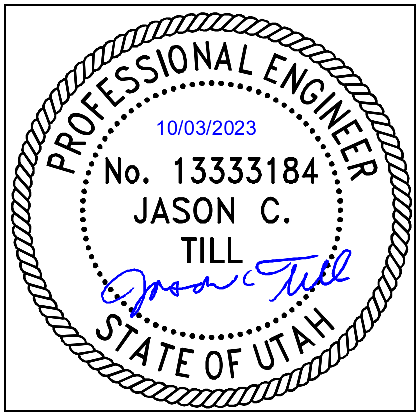

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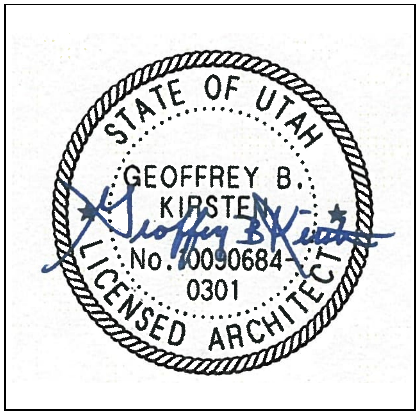

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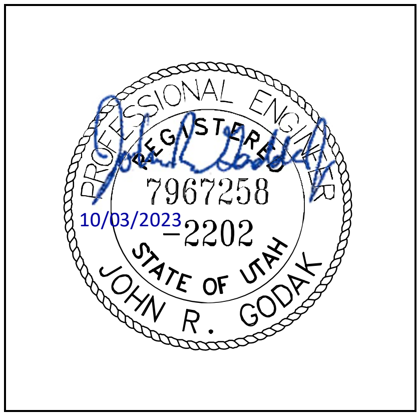

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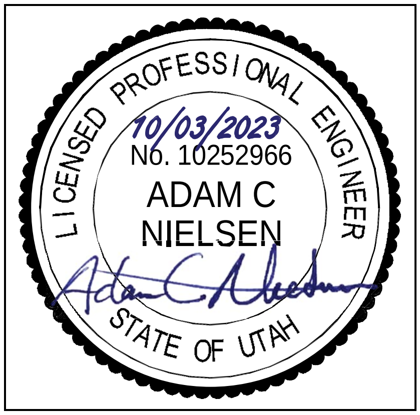

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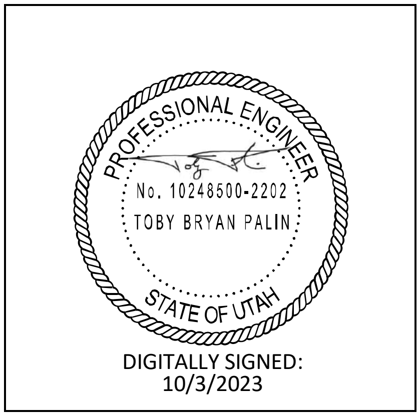

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SECTION 31 10 00
SITE CLEARING

PART 1 GENERAL

1.01 DEFINITIONS

A. Clearing: Removing interfering or objectionable material lying on or protruding above ground surface.

B. Grubbing: Removing vegetation and other organic matter, stumps, logs, root bulbs and roots greater than 1-inch caliper to 12 inches minimum below subgrade.

C. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

D. Scalping: Removing sod with topsoil to a maximum depth of 3 inches.

E. Stripping: Removing topsoil remaining after scalping is completed.

F. Topsoil: Top layer of native soil to approximately 24 inches below grade.

1.02 SUBMITTALS

A. Before clearing, submit copies of SWPPP complying with UPDES general permit for construction storm water discharges.

B. Contractor Clearing Plan:

1. Drawings clearly showing limits of clearing, grubbing, and stripping.
2. Identify locations identified for stockpiled materials.
3. Identify each plant and feature to be fenced and protected or removed and restored.

C. Submit for approval, all disposal sites and methods for all Project materials including clearing and grubbing materials.

D. Copies of permits for offsite disposal of cleared materials not being reused.

1.03 SCHEDULING AND SEQUENCING

A. Obtain Engineer acceptance of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

B. Prepare Site only after adequate erosion and sediment controls are in place.

C. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls in accordance with the approved SWPPP.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Inspection: Existing trees, shrubs, plants, and surface features may not be shown on Drawings. In Site visit with Engineer, inspect the Site as to the nature, location, size, and extent of plants and surface features that must be removed, restored, maintained, or protected in place to complete the Work. Submit Clearing Plan with each item labeled and protect each feature so labeled.

B. Clear, grub, and strip only the areas needed for the Work within the limits shown or specified.

C. Preserve and protect the existing vegetation not required, or otherwise authorized, to be removed. Vegetation specifically shown on Drawings to be protected shall be protected from damage or injury caused by Contractor's construction operations, personnel, or equipment by the use of protective barriers or other methods approved by the Engineer.

D. Replace vegetation injured, removed, or killed by construction activity that is not designated to be removed with in-kind vegetation. The term "injury" shall include, without exceptions, bruising, scarring, treating, and breaking of roots, trunks, or branches. Injured vegetation shall be repaired or treated without delay. Repairs or treatment shall be as recommended by, and under the direction of, an experienced horticulturist or licensed tree surgeon provided by the Contractor and approved by the Engineer. For trees over 3-inch caliper diameter, replace with multiple trees of combined equivalent caliper diameter. Fruit bearing orchard tree replacement shall be as specified in Section 01 31 13, Project Coordination. No noxious or non-native vegetation shall be planted or introduced into the construction areas.

3.02 LIMITS

A. Per accepted Contractor Clearing Plan for clearing, grubbing, and stripping.

3.03 PROTECTION

A. Protect each tree, plant, fence, structure, pavement, pole, post, rock, surface feature so called out on Drawings or on Contractor Clearing Plan. Field mark features to be protected. Do not use protected trees or plants as anchorages.

B. Do no excavate, fill, or stockpile in drip zones (defined as the smallest round horizontal area encircling all its outermost branch limits) of protected plants in, or adjacent to, Work Limits. Fence around protected plants and areas with 4-foot orange polypropylene fencing wired to steel posts at 8-foot spaces. Keep such in good condition through construction.

3.04 REMOVAL AND RESTORATION OF INTERFERING PLANTS AND WORK

A. Photograph and document location, orientation, and condition of each plant and landscape feature prior to removal. Record sufficient information to uniquely identify each plant removed and to assure accurate replacement.

B. Remove, maintain healthy, and restore (after construction) plants, shrubs, and trees not designated for removal, or replace them with new plants acceptable to Engineer.

C. Remove, protect from damage, store, and restore decorative rocks and other landscape features that interfere with Work.

D. Photograph and document location, orientation, and condition of each plant, rock, and feature before its removal. Record sufficient information to uniquely identify each item and assure its accurate restoration or replacement.

3.05 CLEARING

A. Clear areas as shown on Drawings and as approved in the Contractor's Clearing Plan.

B. Fell trees so they fall away from plants and features to be protected.

C. Remove and dispose of trash, rubbish, broken fencing, trees, snags, stumps, and other loose plant matter.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

E. Protect plants and other items designated for protection.

F. Cut and remove tree branches where necessary for construction. Remove other branches, than those required to complete the Work, to provide a balanced appearance. Treat cuts with a tree sealant. If Engineer allows, bend protected plants to do Work.

G. Treat plants pruned or injured (cut, bruised or scarred branches, trunks or roots) using an Engineer accepted horticulturist or licensed tree surgeon. Replace injured plants which cannot be treated to the acceptance of the Engineer.

3.06 GRUBBING

A. Grub areas as shown on Drawings and as approved in the Contractor's Clearing Plan.

3.07 SCALPING SOD

A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed. Scalp areas within limits shown or specified.

B. Scalp areas as shown on Drawings and as approved in the Contractor's Clearing Plan.

3.08 STRIPPING TOPSOILS

A. Do not remove topsoil until after scalping is completed.

B. Strip areas as shown on Drawings and as approved in the Contractor's Clearing Plan to the minimum depth shown or specified.

C. Do not remove subsoil with topsoil.

D. Stockpile topsoils in accordance with Section 32 91 13, Topsoil. Topsoil shall be placed back on lands from which it has been stripped.

3.09 MULCHING AND DISPOSAL OF CLEARING AND GRUBBING DEBRIS

A. Mulch onsite all cleared and grubbed vegetation that can be shredded to 2-inch max particle sizes.

B. Coordinate with Engineer to identify onsite locations to spread and dispose of mulched or shredded vegetation.

C. Remove from Work Site other cleared, grubbed, scalped, and stripped materials and dispose of in accordance with laws, codes, and ordinances. Obtain Engineer acceptance of disposal sites and methods for Project materials including cleared, grubbed, scalped and stripped materials.

END OF SECTION

SECTION 31 23 13
SUBGRADE PREPARATION

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM): D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3 (600 kN-m/m^3)).

1.02 DEFINITIONS

A. Influence Area: As specified in Section 31 23 23, Fill and Backfill.

B. Optimum Moisture Content: As defined in Section 31 23 23, Fill and Backfill.

C. 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.

D. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.

E. Relative Density: As defined in Section 31 23 23, Fill and Backfill.

F. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

G. Subgrade: Layer of existing soil after completion of excavation, clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

1.03 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02 41 00, Demolition, Section 31 10 00, Site Clearing, and Section 31 23 16, Excavation, prior to subgrade preparation.

1.04 QUALITY ASSURANCE

A. Notify Engineer when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity. Engineer will decide if subgrade requires over excavation and refill with foundation stabilization material.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 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 subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 COMPACTION

A. Within Influence Area of pavements, structures, foundations, concrete slabs, earth fills and at bottom of trenches: Scarify upper 12 inches of subgrade and compact to a minimum of 100 percent relative compaction as determined in accordance with ASTM D698.

B. After scarifying and compacting, Proof-roll using a heavily loaded vehicle. The vehicle must have a loaded gross vehicle weight (GVW) of 40,000 pounds with a loaded single axle weight of at least 18,000 pounds and minimum tire pressure of 90 pounds per square inch (psi). Vehicle must complete a minimum of two passes in opposite directions over each area.

C. For Trenches, see Section 31 23 23.15, Trench Backfill.

D. All Other Areas: Proof-roll with complete coverage using vehicle described in this Article. If rutting or pumping of subgrade is observed, remove and replace affected area in accordance with correction requirements.

3.03 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then grade and mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.04 CORRECTION

A. Final determination of unsuitable and/or soft or loose subgrade to be determined by Engineer and corrected as follows:

1. Soft or Loose Subgrade:
   a. Adjust moisture content and recompact.
   b. Overexcavate as specified in Section 31 23 16, Excavation, and replace with suitable material, as specified in Section 31 23 23, Fill and Backfill.
2. Unsuitable Material: Overexcavate as specified in Section 31 23 16, Excavation, and replace with suitable material, as specified in Section 31 23 23, Fill and Backfill.

END OF SECTION

SECTION 31 23 16
EXCAVATION

PART 1 GENERAL

1.01 DEFINITIONS

A. Excavation: Removal of all materials to accomplish the construction, including rock, cemented materials, groundwater, and all other materials regardless of type, nature, or condition.

B. Overexcavation: Excavation beyond lines, grades and dimensions in Drawings and Specifications.

1.02 SUBMITTALS

A. Informational Submittals:

1. Excavation Plan Detailing:
   a. Excavation methods and sequencing.
   b. Proposed locations of stockpiled excavated material.
   c. Proposed onsite and offsite spoil disposal sites.
   d. Proposed equipment and haul routes.
   e. Numbers, types, and sizes of equipment proposed to perform excavations.
   f. Anticipated difficulties and proposed resolutions.
2. Sloping and shoring plans for worker protection.
3. Method for excavating rock (blasting is not allowed).

1.03 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.04 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. See cold weather placing of fill and backfill in Section 31 23 23, Fill and Backfill.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.05 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 10 00, Site Clearing, prior to excavating.

C. Dewatering: Conform to applicable requirements of Section 31 23 19.01, Dewatering, prior to initiating excavation.

D. Excavation Support: Install and maintain, as specified in Section 31 41 00, Shoring, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

1.06 SUBSURFACE CONTAMINATION

A. Unless noted otherwise, the possibility of encountering subsurface contamination during excavation for the Work is not anticipated for this Project. Notify the Engineer immediately if contaminated soils are encountered.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown on Drawings, and as needed to accomplish Work. Allow for shoring, forms, working space, granular base, topsoil, and other items. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

3.02 STOCKPILING EXCAVATED MATERIAL

A. Stockpile and reuse native topsoils as outlined in Section 32 91 13 Topsoil.

B. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

C. Post signs indicating proposed use of material stockpiled clearly worded and readable by all equipment operators from all directions from their normal seated position.

D. Place excavated materials within Work Limits. To authorize work outside Work Limits, submit to Engineer letters of authorization from land owners. At end of Work, submit signed release forms from land owners. Staging or disposal of material outside of the work limits will require additional cultural resources clearance as identified in Article 5 of the Supplementary Conditions and as specified in Section 01 51 00, Permits and Regulatory Requirements.

E. Place material stockpiles outside of street rights of way. Do not obstruct roads or streets. Do not store material in streets except material to be used within the current working day. Conform to federal, state, and local codes governing the safe loading of trenches with excavated material.

F. Locate stockpiled excavated material a minimum of 5 feet from trenches and excavations, or further away if excavation side slopes and support systems are not designed for such loads.

G. Only operate cranes and other equipment near excavations, slopes and stockpiles that are made safe and OSHA compliant.

H. Do not place materials within 100 feet of mapped landslides.

I. Do not stockpile over 5 feet of excavated materials within 10 feet of (or over) existing facilities, pipelines, or completed Work.

3.03 EXCAVATION

A. Excavation is unclassified. Complete all excavation (including rock, cemented cobbles, groundwater, and all other materials) regardless of type, nature, or condition of material encountered to accomplish construction.

B. If Contractor overexcavates beyond excavation limits required, refill overexcavation at no additional cost to Owner.

3.04 SITE GRADING

A. See Section 31 23 23, Fill and Backfill.

B. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown.

C. Remove stones and rock that exceed 3-inch diameter or that are loose and may roll down slope. Remove exposed roots from cut slopes.

D. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work. Unless contract requires, do not overexcavate and backfill to achieve grade.

3.05 EXCAVATION SUBGRADE INSPECTION

A. After excavation and subgrade preparation is complete, Engineer will verify whether (and to what depth and limits) overexcavation and foundation stabilization material is required.

3.06 LIMITS OF FOUNDATION EXCAVATION

A. Excavate to the depths and widths needed to accomplish the construction and as indicated on Drawings. Allow for forms, working space, structural backfill, and site grading. Do not excavate for footings, slabs, or conduits below elevations indicated.

3.07 TRENCH EXCAVATION

A. Excavate trench to the widths, lines, and grades shown on Drawings or as required to complete the Work. Allow pipe thickness, pipe bedding and pipe zone placement, sloping, shoring, and foundation stabilization material if required.

B. If trench is excavated beyond (horizontal or vertical) that required on Drawings and Specifications, at no cost to Owner, refill overexcavation with same material as in adjacent pipe zone, trench zone, or other overexcavated zone.

C. Contractor is responsible for the cost of stabilizing and backfilling uneven trench bottoms and walls due to variable earthen conditions. Trenches in rock shall remove rock a minimum of 6 inches below the bottom of pipe.

3.08 LENGTH OF OPEN TRENCH

A. Limit length of open trench in and beside roads (in road rights-of-way) to 200 feet in advance of pipe-laying or the amount of pipe installed in 1 working day. Complete backfilling, including restoring drivable road surfaces, not more than 200 feet in rear of pipe laying. Open trench length in roads shall also comply with traffic control constraints and with paving constraints.

B. Limit length of open trench in unpaved areas to 500 feet in advance of pipe-laying or the amount of pipe installed in 1 working day. Complete backfilling not more than 500 feet in rear of pipe laying.

C. Open trenches in, or within 25 feet of, a traveled way or within 25 feet of an occupied structure, if not barricaded from the public traveled way using UDOT-approved barriers shall be fully backfilled at the end of each day, or covered with steel plating that is AASHTO HL-93 traffic rated. Trench length covered by steel plates shall not exceed 200 feet.

D. In case of any construction delay over 7 calendar days, whether Contractor or Owner caused, backfill open trench, install temporary paving and traffic markings, and restore traffic to preconstruction condition to minimize disruption to traffic and the community.

3.09 DISPOSAL OF SPOIL

A. Unless required otherwise, do not mound earth above preconstruction contours.

B. Dispose of excess excavated material at onsite areas designated for earthwork disposal, or in an offsite spoil disposal site acceptable to Engineer.

C. Dispose of materials unsuitable for fill or backfill in an offsite place and manner acceptable to the Owner.

D. Dispose of demolition debris as specified in Section 02 41 00, Demolition.

E. Dispose of debris resulting from removal of organic matter, trash, refuse, and junk as specified in Section 31 10 00, Site Clearing, for clearing and grubbing debris.

END OF SECTION

SECTION 31 23 19.01
DEWATERING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Water Control Plan. Submit at least 40 days prior to beginning any Work.
   a. System designer qualifications, including brief descriptions of at least two previous successful projects of complexity comparable to that required for this Contract.
   b. Water Control Plan stamped by professional engineer in the State of Utah.
2. Well permits.
3. Discharge permits.
4. Water levels in observation wells. Submit same day measured.
5. Settlement benchmark elevations and monitoring surveys. Submit weekly.
6. Discharge Flows and Silt Content (NTU) Records: Submit weekly.

1.02 WATER CONTROL PLAN

A. As a minimum, include:

1. Descriptions of proposed surface water and groundwater control facilities including, but not limited to the following:
   a. Equipment.
   b. Methods.
   c. Standby equipment.
   d. Power supply.
   e. Discharge locations.
   f. Means to measure discharge flow rate.
   g. Pollution control facilities.
   h. Downstream drainage paths.
2. Description of system startup, schedule, testing, operations, maintenance, monitoring, record keeping and removal.
3. Drawings with locations, dimensions, and relationships of system parts.
4. Design Calculations:
   a. Demonstrate adequacy of proposed system and components.
   b. Calculations shall be based on local site hydrology, geology, and geotechnical report.

B. If system is modified during installation or operation, revise and resubmit Water Control Plan.

C. Dewatering involving mitigation of wetlands or jurisdictional waters may be reviewed with U.S. Army Corps of Engineers and the State of Utah Division of Water Quality.

1.03 QUALITY ASSURANCE

A. Water Quality Control Plan System Designer Qualifications:

1. Licensed professional engineer in the State of Utah.
2. 10 years minimum responsible experience of the dewatering system designer and system operator-supervisor, each with at least two past projects of similar complexity to the Work.

B. System operator-supervisor shall ensure all requirements of water control plan and all state and local statutes; required testing, inspection, continuous system supervision and monitoring by skilled personnel, and dewatering system reporting are fulfilled.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Perform dewatering regardless of quantity or quality of water. If necessary, provide means to preclude water from excavations and trenches by methods acceptable to Engineer.

B. Continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

C. Dewatering Trenches: Do not drain trench water through the pipeline under construction. Keep water out of trench during pipe jointing, welding, coating and backfilling to prevent flotation and other damage to the Work.

3.02 SURFACE WATER CONTROL

A. See Section 01 50 00, Temporary Facilities and Controls, Article Temporary Controls.

B. Remove surface runoff controls when no longer needed.

3.03 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. Where indicated on Drawings, dewatering systems shall include wells or well points, and other equipment and appurtenances installed outside excavation and sufficiently below lowest point in the excavation, or to maintain specified groundwater elevation.

C. Design and Operate Dewatering Systems:

1. To keep excavations free of surface water, runoff, and groundwater.
2. To stabilize excavation and prevent ground loss as water is removed.
3. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
4. To relieve artesian pressures and resultant uplift of excavation bottom. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

D. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.

E. Provide supplemental ditches and sumps only as necessary to collect water from local seeps. Do not use ditches and sumps as primary means of dewatering.

F. Contractor shall repair damage caused by inadequate dewatering, including excavations, bottom heave, floating, existing facilities, or other damages.

3.04 MONITORING WELLS

A. Install and monitor groundwater observation wells where shown on Drawings. Record and submit water level in each observation well at frequency stated in Water Control Plan, but not less than weekly, and whenever any event, including but not limited to flood, storms, changes in water surface elevation of nearby water bodies, component failures, may have caused a change in the groundwater elevation.

B. After groundwater level observation wells are no longer needed to monitor water levels, abandon wells in compliance with regulations.

3.05 SETTLEMENT

A. Monitoring Dewatering-Induced Settlement: Establish monuments for monitoring dewatering induced settlement at locations shown on Drawings. Monitor vertical movement of each settlement monument, relative to remote benchmark selected by Engineer at the frequency stated in Contractor's Water Control Plan.

3.06 MONITORING FLOWS

A. Monitor volume of water pumped from each excavation, each day. Monitor daily volume of water introduced into excavation(s) for performance of Work. Monitor flows using measuring devices acceptable to Engineer.

3.07 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from jurisdictional authorities.

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. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency.

3.08 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, bracing, underpinning, or compaction grouting.

3.09 REMEDIATION OF GROUNDWATER 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 well owner prior to beginning the Work or as satisfactory to each well owner.

END OF SECTION

SECTION 31 23 23
FILL AND BACKFILL

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   c. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   e. C150/C150M, Standard Specification for Portland Cement.
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   g. D75, Standard Practice for Sampling Aggregates.
   h. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
   i. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
   j. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   k. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   l. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   m. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   n. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

A. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

B. CLSM: Controlled low strength material.

C. Completed Course: A course or layer that is ready for next layer or next phase of Work.

D. Fines: Material which will pass through a No. 200 sieve.

E. Geosynthetics: Geotextiles (or filter fabrics), geogrids, or geomembranes.

F. Imported Material: Material obtained by Contractor from source(s) offsite.

G. Influence Area: Unless otherwise shown on Drawings, area within planes sloped downward and outward at a 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.

H. Lift: Loose (or uncompacted) layer of material.

I. Optimum Moisture Content: Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

J. Prepared Subgrade: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

K. Relative Compaction: The ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698. Apply corrections for oversize materials to as-compacted field dry density as determined by Engineer.

L. 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.

M. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specified use.

N. Structural Fill: Fill required under structures, pavements, and other facilities.

O. Well-Graded: A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes. A material type that, when compacted, produces a strong and relatively incompressible soil mass free of voids, with a Coefficient of Curvature (per ASTM D2487) of 1 to 3; and a

Coefficient of Uniformity (per ASTM D2487) of over 4 for gravels, and over 6 for sands.

1.03 SUBMITTALS

A. Action Submittals:

1. Samples: All fill and backfill materials proposed to be used in the Work to demonstrate material conformance. Sample sizes shall be as determined by the Engineer, unless otherwise indicated herein.
2. Cold Weather Construction Plan:
   a. Earthwork and concrete work to be performed when temperatures are below 32 degrees F.
   b. CLSM placement and curing work to be performed when temperatures are below 40 degrees F.
3. Schedule for completing CLSM trial mixes to allow for Engineer sampling.
4. CLSM Mixes: Mix designs for all CLSM proposed for the Work.

B. Informational Submittals:

1. Catalog and manufacturer's data sheets for compaction equipment.
2. Certified test results from independent testing agency. Submit not less than 30 days prior to delivery for imported materials or 30 days prior to anticipated use for excavated materials.
3. Description and location of proposed sources of imported material.
4. Description of equipment and location of the proposed materials processing operation.
5. Quality Control Material Testing Work Plan. Include at a minimum:
   a. Qualifications of Contractor's independent testing agency, including agency staff.
   b. Address onsite and offsite soils/materials laboratory testing facility locations including CLSM and concrete backfill testing, facility details, laboratory and field testing certification, and experience of testing personnel.
6. CLSM Placement Plan to keep pipes from floating.
7. Batch Tickets for CLSM and concrete at time of delivery.
8. Results of Contractor's quality control testing.
   a. Include test locations, test date and time, test depth (in reference to finish grade), test method, and results.
   b. Submit copies of compaction test reports and laboratory worksheets by the next working day.
9. Describe sources of water used to complete the Work and lab analysis of water quality.

1.04 CONTRACTOR'S QUALITY CONTROL TESTING

A. Contractor shall provide an independent laboratory approved by the Engineer to perform the specified field and laboratory materials testing. Use a single firm for both onsite testing and lab work.

B. Tentative acceptance of the material source shall be based on an inspection of the source by the Engineer and/or the certified test results submitted by the Contractor to the Engineer, at the Engineer's discretion. Final acceptance is based on material tests performed on the completed Work.

C. No imported materials shall be delivered to the Site until the proposed source and materials tests have been accepted in writing by the Engineer.

D. All earthwork tests necessary for the Contractor to locate an acceptable source of imported material shall be made by the Contractor. All material samples shall be furnished by the Contractor at the Contractor's sole expense. Samples shall be representative and be clearly marked to show the source of the material and the intended use on the Project. Sampling of the material source shall be done by the Contractor in accordance with ASTM D75. Notify the Engineer at least 24 hours prior to sampling. The Engineer may, at the Engineer's option, observe the sampling procedures. Tentative acceptance of the material source shall be based on an inspection of the source by the Engineer and/or the certified test results submitted by the Contractor to the Engineer, at the Engineer's discretion. No imported materials shall be delivered to the Site until the proposed source and materials tests have been tentatively accepted in writing by the Engineer. Tentative acceptance of each material is based on its source, sample, and lab certified tests. Final acceptance is based on material tests performed on the completed Work.

E. Gradation tests by the Contractor shall be made on samples taken at the place of production or borrow area prior to transport or stockpiling. Samples of the finished product for gradation testing shall be taken from each 1,500 tons of prepared materials, or as identified in the Specifications, or more often as determined by the Engineer if variation in gradation is occurring, or if the material appears to depart from the Specifications. Submit test results to the Engineer next working day after sampling.

F. If earthwork tests conducted by the Contractor or the Engineer indicate that the material does not meet Specification requirements, material placement will be terminated until corrective measures are taken. Material which does not conform to the Specification requirements and is placed in the Work shall be removed and replaced at the Contractor's sole expense. Sampling and testing performed by the Contractor shall be done at the Contractor's sole expense.

G. Earthwork Laboratory Tests Required:

1. The following tests shall be performed for each principal type of material or combination of materials utilized to complete the Work:
    a. Compaction test (ASTM D1556).
    b. Compaction Qualities:
        1) For cohesion-less soils (ASTM D4253 and ASTM D4254).
        2) For all other materials (ASTM D698).
            a) If nuclear methods are used for in-place density determination, compaction test results for maximum dry density and optimum water content shall be adjusted in accordance with ASTM D4718.
    c. Atterberg limits (ASTM D4318).
    d. Gradation test (ASTM C136 and ASTM C117).

H. Earthwork Field Tests Required:

1. Where in-place, soil material is required to be compacted to a percentage of maximum density. Maximum density at optimum moisture content will be determined in accordance with ASTM D698. After an acceptable compaction procedure is established, in-place density and moisture tests shall be taken at random horizontal and vertical locations along trenches and near structures. Locate such tests in field with Engineer approval. In-place density tests shall be deemed to comply with Specifications when no test falls below the specified relative compaction or relative density.
2. Perform at least one in-place density test per lift each production day for each work area compacted and each heading (i.e., trench, road, structure, fill, etc.) compacted.
3. Excavation, Filling, and Backfilling:
    a. One in-place density test and one in-place moisture test per 600 square yards per lift.
    b. One in-place density test and one in-place moisture test per 600 square yards per lift in subareas enclosed by interior grade beams or interior stem walls prior to placement of fill, but not less than one per lift.
    c. In-place density and moisture tests within the structure (a) may be utilized as the in-place density and moisture tests indicated in, and (b) if they happen to coincide within the subarea.

4. Site Grading:
    a. Excavation, Filling, Raw Subgrade, and Base Course Preparation Under Paved Areas: One in-place density test and one in-place moisture test per 2,000 square yards per lift.
    b. Excavation, Filling, and Raw Subgrade Preparation Under Grassed or Nontraffic Areas: One in-place density test and one in-place moisture test per 3,000 square yards per lift.
5. Nuclear methods for determining in-place density may be used for a maximum of 80 percent of the required tests. The remaining tests shall be correlation check tests of the nuclear test results by use of the sand cone method, in accordance with ASTM D1556. The minimum depth for sand cone test holes shall be 12 inches. The minimum test hole diameter shall be 8 inches. Sand used for the test shall be size 16/30 or 10/20 silica sand.
6. Additional in-place density and moisture content tests shall be performed as directed by the Engineer.
7. CLSM Testing:
    a. Sample and submit strength break data for CLSM at frequency and intervals listed below:
        1) Minimum of four cylinders for each day CLSM is placed. If different mix designs are used, sample and submit minimum of four cylinders for each mix design.
        2) When more than 100 cubic yards of CLSM is placed each day, provide an additional two cylinders for each 100 cubic yards of CLSM.
        3) Store cylinders at project site adjacent to CLSM placed and in same curing conditions and do not move cylinders for 72 hours.
        4) For the initial four cylinders collected each day, break two cylinders at 7 days and one at 28 days. Remaining cylinder shall be tested after 90 days to test long-term strength gain.
        5) For additional cylinders collected when more than 100 cubic yards of CLSM is placed in one day, test one of the cylinders at 7 days and the other at 28 days.
        6) Submit results within a day after each break.

I. Contractor shall repeat quality control tests that fail to meet Specifications at no additional cost to the Owner.

J. If compaction fails to meet Specifications, remove failed Work, change compaction method, and/or replace material to meet Specifications. Perform all subsequent tests required to confirm reconstructed backfill meets Specifications at no additional cost to Owner. Confirmation tests frequency for remedial work shall be double the frequency specified.

K. Submit copies of all compaction test reports and laboratory worksheets to Engineer by the next working day. Delayed quality control test reports adversely affect Work quality and may result in delayed payment or payment withholding.

1.05 QUALITY ASSURANCE

A. Notify Engineer at least 24 hours prior to the following:

1. Sampling of source material.
2. Structures are ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
3. Subgrade is ready for inspection.
4. Soft or loose subgrade materials are encountered.
5. Fill and backfill material appears to be deviate from the Specifications.
6. Quality control test results indicate noncompliance with required Specifications.

B. The Engineer may perform independent testing to verify that the Work conforms to the requirements of the Specifications. Such tests are not intended to provide the Contractor with the information required for the proper execution of the Work and this testing shall not relieve the Contractor of the necessity to perform tests for that purpose.

C. Contractor shall provide safe access in the excavation for the soil compaction testing technician and inspection. This includes providing safety equipment and temporary shoring to enable compaction testing at multiple levels in the excavation as directed by Engineer.

D. Contractor shall provide safe access for the Engineer to offsite materials source locations to obtain independent samples for testing.

E. Should the Contractor have backfilled to an elevation above that required to be tested, Contractor shall excavate back down to the necessary level for testing and provide shoring as required.

1.06 WEATHER LIMITATIONS

A. Material excavated during inclement weather or below 32 degrees F shall not be used as fill or backfill until the material drains and dries sufficiently for proper compaction.

B. Saturated native materials that are over optimum moisture content shall be dried or blended with drier material before being considered suitable.

1.07 SEQUENCING AND SCHEDULING

A. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03 30 00, Cast-in-Place Concrete or as shown on Drawings.

B. Obtain Engineer's 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 23 13, Subgrade Preparation.

PART 2 PRODUCTS

2.01 EARTH BACKFILL AND EARTH FILL

A. Earth backfill and earth fill shall be excavated material that is free from organic matter, roots, debris, and rocks larger than 6 inches in the greatest dimension. Earth backfill and earth fill shall be a well-graded material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids and represents a mixture of particle sizes with no specific concentration or lack thereof of one or more sizes. Percent fines passing the No. 200 sieve shall be less than 35 percent and at least 5 percent.

A. Do not use materials with expansion index over 40 (ASTM D4829).

B. Where not indicated otherwise in the Contract Documents, fills are earth fills.

2.02 STRUCTURAL BACKFILL

A. Structural backfill shall be free from clay balls and have the following gradation:

Sieve Size	Percent Passing By Weight
3/4 inch	100
3/8 inch	50 – 100
No. 4	20 – 65
No. 40	10 – 30
No. 200	5 – 12

2.03 SELECT COHESIVE FILL

A. Free from cobbles, boulders, rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

B. Gradation as determined in accordance with ASTM C117 and ASTM C136:

Sieve Size	Percent Passing by Weight
No. 4	100
No. 200	75 – 100

C. Natural water content 0 percent to 3 percent above optimum water content as per ASTM D698.

D. Liquid Limit less than 50 percent and Plasticity Index between 7 percent and 25 percent, as determined in accordance with ASTM D4318.

2.04 SUBBASE COURSE (GRANULAR BORROW)

A. As specified in Section 32 11 23, Aggregate Base and Subbase Courses.

2.05 UNTREATED BASE COURSE (UTBC, BASE COURSE, ROAD BASE, OR AGGREGATE BASE)

A. As specified in Section 32 11 23, Aggregate Base and Subbase Courses.

2.06 PIPE ZONE MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

2.07 TRENCH ZONE MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

2.08 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. CLSM shall be a mixture of portland cement, aggregate, fly ash, water, and admixtures that forms a workable, flowable slurry mix that is nonsegregating, self-consolidating, and nonshrink with a compressive strength between 50 psi and 150 psi at 28 days in accordance with ASTM D4832. Prepare CLSM in accordance with ASTM C94.

B. Perform trial mixes before construction to demonstrate placing and strength characteristics. Notify Engineer 1 week before trial mix preparation. Provide both “stiff” and “fluid” CLSM mixes. Where indicated on Drawings, provide a CLSM wet density that is over 125 lbs/cubic foot to help prevent pipe flotation in areas with high ground water.

C. CLSM Mix Components:

1. Up to 80 lbs/CY Cement: ASTM C150/C150M, Type V or Type II/V.
2. Processed Aggregate: ASTM C33/C33M, 100 percent passing 3/8-inch sieve; 75 percent to 100 percent passing No. 4 sieve; 12 percent to 50 percent passing No. 30 sieve; 5 percent to 20 percent passing No. 100 sieve; and under 10 percent nonplastic fines.
3. Soluble sulfate shall be under 0.3 percent.
4. Up to 300 lbs/CY Fly Ash (Pozzolan): ASTM C618, Class C.
5. Water: Clean, potable, containing less than 500 ppm of chlorides.
6. Submit admixtures.

D. Batching equipment shall be accurate and demonstrate components remain within plus or minus 2 percent of design mix. Volumetric batching may be used if it provides same weight accuracy. Design and operate mixers so discharged CLSM have same consistency through each batch and so temperature stays between 50 degrees F and 90 degrees F. Do not add water after batching. Batch to placement time shall not exceed 120 minutes.

2.09 FOUNDATION STABILIZATION MATERIAL

A. Nonfriable, crushed or natural rock free from clay, organic materials, or debris, with less than 0.2 percent asbestos, having the following gradation:

Sieve Size	Percent Passing by Weight
3-inch	100
3/4-inch	60 - 100
No. 40	25 - 50
No. 200	0 - 10

2.10 SAND

A. Nonfriable hard particles, free of clay, organics, or other deleterious material.

B. Gradation as determined in accordance with ASTM C117 and ASTM C136.

Sieve Size	Percent Passing by Weight
1/4 inch	100
No. 4	95 - 100
No. 200	0 - 5

C. Sand equivalent of 30 percent in accordance with ASTM D2419.

2.11 DRAIN ROCK (GRANULAR DRAIN ROCK MATERIAL)

A. Drain rock, or crushed rock, shall meet the requirements of ASTM C33 Coarse Aggregate Size Number 67, consist of hard, durable particles crushed to the required gradation below per ASTM C136, and be free from vegetable matter, lumps of clay, and other deleterious matter:

Sieve Size	Percent Passing By Weight
1 inch	100
3/4 inch	90 – 100
3/8 inch	20 – 55
No. 4	0 – 10
No. 8	0 – 5
No. 200	0 – 3

2.12 PEA GRAVEL

A. Use pea gravel only where indicated on Drawings and permitted by the Engineer. Do not use in utility trenches.

B. Open graded hard crushed rock particles.

C. Gradation as determined in accordance with ASTM C117 and ASTM C136.

Sieve Size	Percent Passing By Weight
3/4 inch	100
1/2 inch	50 - 100
3/8 inch	20 - 100
No. 4	10 - 50
No. 200	0 - 10

D. Consolidate to 80 percent relative density.

2.13 WATER FOR MOISTURE CONDITIONING

A. Water shall have pH of 7.0 to 9.0, chloride and sulfate concentrations each under 500 mg/L, and be free of toxic or hazardous contaminants, including those deleterious to compaction, existing, and new piping and structures.

2.14 TOPSOIL

A. As specified in Section 32 91 13, Topsoil.

PART 3 EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill.

B. Place fill materials in horizontal lifts of uniform thickness in a manner that avoids segregation. Compact each lift to specified requirements before placing succeeding lifts. Slope lifts only where required to conform to final grade or as necessary to keep surfaces drained of water. Keep lifts level around each structure during backfilling.

C. Maintain uniform fill elevations around buried structures during backfilling unless shown otherwise on Drawings.

D. Moisture condition or aerate fill and backfill as required to obtain a moisture content within 2 percent of optimum in accordance with ASTM D698, unless noted otherwise.

E. Except for foundation stabilization material, fill and backfill shall not be placed until all water is removed from the excavation.

F. Maximum particle size under or adjacent to any structure is 3 inches in diameter, unless otherwise shown or specified.

G. Place fill and backfill in lift thicknesses not exceeding 8 inches of loose material unless otherwise specified or shown on Drawings. When hand compaction equipment is used, do not exceed 4 inches of loose material.

H. Unless required by Contract, do not dispose of excess materials by mounding earth above preconstruction grade, but restore preconstruction contours and spot elevations (and straight-line interpolations between them) shown on Drawings.

I. 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 patterns as shown. Reverse slopes are not permitted.

J. Settlement: Correct and repair any damages to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fills or backfills.

3.02 MINIMUM COMPACTION REQUIREMENTS

A. Compact materials to the following minimum relative compaction percentages (ASTM D698 unless indicated otherwise):

1. Pavement Zone (under asphalt): 100 percent.
2. Foundation Stabilization Material: 95 percent.
   a. Engineer may set a required number of equipment passes (proof rolling) in lieu of this requirement.
3. Fill below and within the influence area of structures: 100 percent.
4. Fill adjacent to structures and not within the influence are of structures: 95 percent.
5. UTBC:
   a. 100 percent when tested in accordance with ASTM D698.
   b. 95 percent when tested in accordance with AASHTO T 180, Method D for UDOT roadways.
6. Granular Barrow or Fill Below UTBC: 95 percent.
7. Topsoil: Match density of native topsoil.
8. Pipe Zone and Trench Zone: As specified in Section 31 23 23.15, Trench Backfill.

3.03 PLACING NEW UTILITIES IN FILL OR BACKFILL

A. 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 the top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding material, if applicable, as specified in Section 31 23 23.15, Trench Backfill.
4. Install pipe, conduit, duct bank, or cable.
5. Backfill pipe zone and remaining trench, as specified in Section 31 23 23.15, Trench Backfill, before resuming filling or backfilling specified in this section.

3.04 FOUNDATION STABILIZATION

A. Notify Engineer to allow observation of proof-rolling of compacted subgrade.

B. If compaction roll does not stabilize subgrade, Engineer may require overexcavation and foundation stabilization material.

C. If soft soils are encountered and Engineer determines that over excavation is required, remove soft material, and backfill with foundation stabilization material. In such areas, after the required excavation has been completed, the Engineer will inspect the exposed subgrade to determine the need for any additional excavation. It is the intent that additional excavation be conducted in all areas within the influence area where unacceptable materials exist at the exposed subgrade.

D. Backfill the over excavation with foundation stabilization material to the subgrade. Place the foundation stabilization material and compact in layers not exceeding 8 inches in depth to the required grade. Compact each layer with a track-hoe roller head to the satisfaction of the Engineer. Foundation stabilization material used by the Contractor for convenience will not receive any additional payment.

E. Where over excavation and foundation stabilization are not required on Drawings, foundation stabilization work shall be executed only by change order when unacceptable soft (as determined by the Engineer) subgrade materials are encountered in the excavation.

3.05 PLACING AND COMPACTING FILL AND BACKFILL

A. Excavated native material may be used for earth fill and backfill providing all deleterious materials are removed and it meets the Specifications for such.

B. Where fill is to be constructed on slopes steeper than 3:1, bench the fill into competent undisturbed native material as the fill progresses up the slope. Benches shall be sloped at least 2 percent into the slope and shall be of a width at least equal to the height of the lift. All benching shall be approved by the Engineer.

3.06 FILL AND BACKFILL UNDER AND AROUND STRUCTURES

A. Prepare subgrade in accordance with Section 31 23 13, Subgrade Preparation.

B. Do not backfill against concrete structures until concrete has obtained specified strength as specified in Section 03 30 00, Cast-in-Place Concrete.

C. Under Structural Facilities:

1. Unless noted otherwise, provide minimum 6-inch thick layer of structural backfill underneath all concrete structures, concrete slabs, and concrete pipe encasements. Within the influence area beneath structures and slab provide structural backfill unless noted otherwise.
2. Underneath and within influence area beneath pavements, sidewalks, curbs, and other similar facilities, provide minimum 6-inch thick layer of structural fill or UTBC unless otherwise shown.
3. Place backfill in lifts of 6-inch maximum thickness and compacted as specified. If structural backfill material is hand compacted, place in 4-inch lifts.
4. Provide concrete fill or CLSM under structures where shown on Drawings.

D. Adjacent to Facilities:

1. Fill or backfill around the walls of concrete structures that are not within the influence area of other structures, shall be earth fill compacted to 95 precent relative compaction (ASTM D698) unless noted otherwise. Within the influence area of other structures, fill shall be structural fill compacted to 100 percent relative compaction (ASTM D698) unless noted otherwise.
2. Do not use axle-driven or tractor-drawn compaction equipment within 5 feet of pipes, walls, or structures. Use equipment that will not damage structures, coatings, insulation, and other Work.
3. Place fill to lines and grades shown, with proper allowance for pavement sections or topsoil thickness.

3.07 SITE GRADING

A. Perform earthwork to lines and grades shown on Drawings.

B. Shape, trim, and finish fill slopes to conform with lines, grades, and cross sections shown. Rough grades shall be sufficiently below finished grade to allow for topsoils required. Provide drainage paths as shown on finished grading.

C. Round finished fill grades to no less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

D. Where excavation and backfill is required, but no regrading of finished grade is required, restore disturbed ground to native topography shown on Drawings and preserve existing drainage paths.

3.08 PLACING CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. General:

1. Deliver CLSM in ready mix trucks.
2. Batch Tickets:
    a. Deliver batch ticket for each load to Engineer.
    b. Batch tickets shall indicate the following:
        1) Design mix.
        2) Batch time.
        3) Water content.
3. Place CLSM as near to final position as practical.
4. Prevent cave-ins and mixing with subgrade or sides of excavation.
5. Vibrate CLSM to fill all voids.
6. Sample CLSM daily and submit break test results to Engineer.
7. CLSM Placement in the Pipe Zone, as specified in Section 31 23 23.15, Trench Backfill.

3.09 SITE TESTING

A. General:

1. The required frequency of testing shall be as specified or otherwise directed by the Engineer.
2. Samples for laboratory and field tests shall be taken at locations designated by the Engineer.
3. After an acceptable compaction procedure is established, take compaction tests at vertically and horizontally random locations and as directed by the Engineer.

B. Gradation:

1. One sample from each 1,500 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.

C. In-Place Density and Moisture Tests:

1. In accordance with ASTM D1556 (sand cone method) or D6938 (nuclear method). The nuclear method may be used for a maximum of 80 percent of the required tests, with the remaining tests being correlation check tests of the nuclear test results by use of the sand cone method.
2. The minimum depth for sand cone test holes shall be 12 inches. The minimum test hole diameter shall be 8 inches. Sand used for the test shall be size 16/30 or 10/20 silica sand.
3. If nuclear methods are used for in-place density determination, compaction test results for maximum dry density and optimum water content shall be adjusted in accordance with ASTM D4718.
4. During placement of materials, minimum testing frequency shall be as follows, with a minimum of one test performed per lift each production day:
   a. Earthfill: 100 cubic yards.
   b. Structural Fill: 75 cubic yards.
   c. Untreated Base Course: 75 cubic yards.
   d. Sand: 75 cubic yards.
   e. Other: 100 cubic yards.

3.10 COLD WEATHER REQUIREMENTS FOR FILL AND BACKFILL

A. Unless accepted otherwise in Cold Weather Construction Plan, earthwork below 32 degrees F shall comply with the following:

1. No frozen material is allowed in any fill.
2. Do not place CLSM, concrete, or any fill of backfill material if excavation or subgrade contains frozen moisture (snow, ice, sleet), frozen earthen materials, or earthen materials which have been deposited in the excavation due to freezing, thawing, precipitation, or other inappropriate means.

B. Material excavated during inclement weather or below 32 degrees F shall not be used as fill or backfill until the material drains and dries sufficiently for proper compaction.

C. Cold Weather CLSM Placement and Curing:

1. Do not place CLSM if ambient temperatures, pipe, or trench perimeter soils are below 40 degrees F unless conforming to cold weather placing and curing plan.
2. Submit CLSM cold weather placing and curing plan detailing materials, insulation, equipment and means to place and cure CLSM at temperatures below 40 degrees F. CLSM placed or cured outside CLSM cold weather placement and curing limitations is subject to rejection, removal, and replacement.
3. If CLSM is curing and ambient temperatures drop below 40 degrees F, measure (with a thermometer in CLSM or in soil just beside CLSM) during coldest time of 24-hour day (for example, 7:00 a.m.), the minimum curing temperature. Submit daily minimum curing temperatures each day if ambient temperatures are below 40 degrees F.
4. Adjust cold weather curing plan and methods, as needed, and provide all insulation, materials, heating, and means to keep CLSM above 50 degrees F for at least 7 days after placement.

3.11 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Engineer as follows or as otherwise specified or shown on Drawings:

1. Beneath Footings: Concrete fill or CLSM.
2. Beneath Fill or Backfill: Same material and requirements as specified for overlying fill or backfill.
3. Beneath Slabs-on-Grade: Structural fill.
4. Trenches:
   a. Unauthorized Overexcavation: Either foundation stabilization material or pipe zone bedding material, as specified in Section 31 23 23.15, Trench Backfill.
   b. Authorized Overexcavation: Foundation stabilization material, as specified in Section 31 23 23.15, 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 overcut 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 Engineer’s opinion, backfill will remain stable, and overexcavated material is replaced as compacted earthfill.

END OF SECTION

SECTION 31 23 23.15
TRENCH BACKFILL

PART 1 GENERAL

1.01 REFERENCES

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

1. American Public Works Association (APWA): Uniform Color Code.
2. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   e. C150/C150M, Standard Specification for Portland Cement.
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   g. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
   h. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
   i. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
   j. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   k. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   l. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   m. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   n. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

1.02 DEFINITIONS

A. Definitions are per Section 31 23 23, Fill and Backfill, and below.

B. CLSM: Controlled Low Strength Material.

C. Lift: Loose (uncompacted) layer of material.

D. Pavement Zone: Includes untreated base course, asphalt concrete, and bonded wearing course over trench and for at least 2 feet beyond each side of trench as shown on Drawings.

E. Pipe Bedding: Material upon which pipes, conduits, or duct banks will bear and are permanently supported. Pipe zone extending full trench width from bottom pipe (or conduits, cable, or duct bank) to trench bottom. Pipe bedding is 4 inches thick for pipe diameters, 12 inches and smaller, and 6 inches thick for pipes over 12 inches in diameter, unless noted otherwise.

F. Pipe Zone: Backfill zone that includes full trench width and extends from the bottom of the excavated trench to and upper limit above the pipeline. Unless noted otherwise on Drawings, the top of pipe zone is 6 inches above top of pipe (or conduit, cable, or duct bank) for pipes 6 inches and smaller, and 12 inches above top of pipe for pipes 8 inches and larger. Where multiple pipes or conduits are placed in the same trench, the pipe zone shall extend from the bottom of the lowest pipes to a horizontal level above the top of the highest or topmost pipe.

G. Road Zone (or Subbase): Compacted granular borrow over trench zone, and at least 2 feet beyond each side of trench, which is below the asphalt concrete.

H. Trench Bottom: Bottom surface of trench after excavation and before bedding placement. If trench bottom requires foundation stabilization material, trench bottom is the surface of the trench after it has been over excavation and placement of stabilization material.

I. Trench Zone: Trench backfill extending full width of trench from top of pipe zone to bottom of street zone or road zone in paved areas or final prepared subgrade (such as, bottom of topsoil at revegetated areas).

1.03 SUBMITTALS

A. Action Submittals:

1. Samples: All fill and backfill materials proposed to be used in the Work to demonstrate material conformance. Sample sizes shall be as determined by the Engineer, unless otherwise indicated herein.

2. Shop Drawings: Manufacturer's descriptive literature for marking tapes, tracer wire, and splices.
3. Mix Design: Submit mix designs for CLSM.
4. CLSM Installation:
   a. Plan to prevent pipe flotation during construction.
   b. CLSM cold weather placement and curing plan.

B. Informational Submittals:

1. CLSM batch tickets.
2. CLSM strength break tests.
3. See Section 31 23 23, Fill and Backfill, for additional requirements.

1.04 CONTRACTOR QUALITY CONTROL TESTING

A. As specified in Section 31 23 23, Fill and Backfill.

1.05 QUALITY ASSURANCE

A. As specified in Section 31 23 23, Fill and Backfill.

PART 2 PRODUCTS

2.01 PIPE ZONE (AND PIPE BEDDING)

A. Pipe Zone including Pipe Bedding: Pipe Zone Material shall have a pH between 7.0 and 10.0. Where indicated on Drawings, pipe zone material shall be CLSM from trench bottom to top of pipe zone. Where CLSM is not required, pipe zone material may be CLSM or processed granular material, defined as well graded sands and gravels meeting AASHTO M145 A-1-a group classifications, with 1-inch maximum particle size and shall contain a maximum of 15 percent and minimum of 5 percent fines (per ASTM C117) that will bind material when compacted. Open graded or poorly graded materials such as washed pea gravel (squeegee) will not be allowed.

B. Use CLSM to fill voids between shoring and excavated trench wall. Use CLSM to fill voids while/during pulling shoring system.

C. Filter Fabric or Geotextile: If any pipe zone material is open graded rock (for particles larger than coarse sands), provide filter fabric or geotextile complete wrapped around pipe zone to prevent fines migration. Open graded rock may only be used for pipe zone material where specifically shown on Drawings.

2.02 TRENCH ZONE MATERIAL

A. Under asphalt pavement and highway shoulders (to 10 feet from edge of asphalt) use Granular Borrow as specified in Section 31 23 23, Fill and Backfill, unless indicated otherwise.

B. Elsewhere, use Earth Fill as specified in Section 31 23 23, Fill and Backfill.

2.03 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. As specified in Section 31 23 23, Fill and Backfill.

B. Use bright red dyed CLSM for placing around electrical conduits.

C. Sample and submit strength break data for CLSM as specified in Section 31 23 23, Fill and Backfill.

2.04 PEA GRAVEL

A. As specified in Section 31 23 23, Fill and Backfill.

2.05 FOUNDATION STABILIZATION MATERIAL (ROCK REFILL)

A. As specified in Section 31 23 23, Fill and Backfill.

2.06 IMPERVIOUS BARRIERS

A. Where shown on Drawings, construct impervious barriers (trench cutoffs) at least 36 inches thick of CLSM. Impervious barriers shall consist of a collar cast around the pipe and extended at least 18 inches beyond the limits of the excavated trench as detailed on Drawings.

2.07 CONCRETE BACKFILL

A. Concrete for trench backfill, pipe encasements, and thrust blocks shall be as specified in Section 03 30 00, Cast-in-Place Concrete.

2.08 WATER FOR COMPACTION AND MOISTURE CONDITIONING

A. As specified in Section 31 23 23, Fill and Backfill.

2.09 UNTREATED BASE COURSE (UTBC, BASE COURSE, ROAD BASE, OR AGGREGATE BASE)

A. As specified in Section 32 11 23, Aggregate Base and Subbase Courses.

2.10 MARKING TAPE AND TRACER WIRE

A. Marking tape and tracer wire for non-CUWCD facilities shall comply with the standards of the owner of those facilities.

B. Fiber Optic Conduit Marking Tape: As specified in Section 40 95 80, Fiber Optic Communication System.

C. Underground Raceway Marking Tape: As specified in Section 26 05 33, Raceway and Boxes.

D. Marking Tape (Nondetectable):

1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: 5 mils (minimum).
3. Width: 12 inches.
4. Color:
    a. Per NEMA Z535.1, Safety Color Code, and APWA as follows:
        1) Red for electric power lines, cables, conduit, and lightning.
        2) Orange for fiber optic, cathodic protection, and telecommunications.
        3) Yellow for gas, oil, steam, petroleum, or gaseous materials.
        4) Green for sewers and drains.
        5) Blue for potable water.
        6) Purple for raw water, irrigation, and slurry lines.
5. One-inch minimum high, permanent black lettering imprinted continuously over entire length. Text shall read:
    a. Water: “CUWCD High Pressure Waterline”.
    b. Cathodic Protection Test Wires: “CUWCD CP Test Wires”.
    c. Fiber Optic: “CUWCD FO”.
    d. Buried Electric: “High Voltage Electric”.
6. Provide over utilities exposed in trenches if utility owner requires.
7. Manufacturers and Products:
    a. Northtown; Allen (Marline).
    b. Reef Industries (Terra Tape).

E. Tracer Wire: Place tracer wire over all CUWCD pipes and conduits, except steel pipes over 30-inch diameter. Use 12-gauge, copper, stranded UF, black 600V tracer wire. Submit manufacturer-recommended tracer wire splice method.

PART 3 EXECUTION

3.01 GENERAL

A. Comply with requirements of Section 31 23 23, Fill and Backfill.

B. Maintain trenches free of water while backfilling and until trench backfill is complete as specified in Section 31 23 19.01, Dewatering. Do not place fill material into standing water.

3.02 COMPACTION REQUIREMENTS

A. Comply with compaction requirements specified herein and those required in Section 31 23 23, Fill and Backfill.

B. Compact materials to the following minimum relative compaction percentages (ASTM D698 unless indicated otherwise):

1. Granular Pipe Zone/Bedding: 100 percent.
2. Trench Zone not under paving: 95 percent.
3. Trench Zone under paving or within 10 feet of paving: 100 percent.
4. Foundation Stabilization Material: As specified in Section 31 23 23, Fill and Backfill.

3.03 TRENCH BOTTOM

A. Excavation: Prepare a flat, stable trench bottom for placing bedding and pipe per Section 31 23 16, Excavation. Remove loose and disturbed material and trim off high areas and ridges left by excavating bucket teeth. Allow space for pipe bedding where shown and required.

B. Trench and Foundation Stabilization:

1. Where required on Drawings or as directed by the Engineer, overexcavate trench bottom, refill and compact with foundation stabilization material.
2. If a soft trench bottom is encountered, notify Engineer. Engineer will inspect and may order over excavation and compacted foundation stabilization material to stabilize trench bottom.
3. Over excavation for trench and foundation stabilization material shall include the removal of all material that exists directly beneath the pipeline to a width 24 inches (minimum) greater than the pipe outside diameter and to the depth required. In such areas, after the required excavation has been completed, the Engineer will inspect the exposed subgrade to determine the need for any additional excavation. It is the intent that additional excavation be conducted in all areas within the influence of the pipeline where unacceptable materials exist at the exposed subgrade.

4. Backfill the trench to subgrade of pipe base with foundation stabilization material. Place the foundation stabilization material over the full width of the trench and compact in layers not exceeding 8 inches in depth to the required grade. Compact each layer with a track-hoe roller head to the satisfaction of the Engineer. Foundation stabilization material used by the Contractor for convenience will not receive any additional payment.
5. Where overexcavation and foundation stabilization are not required on Drawings, foundation stabilization work shall be executed only by change order when unacceptable, soft (as determined by the Engineer) subgrade materials are encountered in the trench.

3.04 PLACING PIPE ZONE MATERIAL

A. General:

1. Do not use axle-driven or tractor-drawn compaction equipment within 5 feet of pipes or structures.
2. Use equipment that will not damage pipe, structures, coatings, insulation, and other Work.
3. For pipes without rock shields, use hand operated tampers that will not damage pipe within 12 inches of pipe.

B. CLSM Pipe Zone:

1. General: See Section 31 23 23, Fill and Backfill.
2. Sequence:
   a. Set pipe to grade on sandbags or other means acceptable to Engineer.
   b. Place CLSM (bedding) under pipe. Place the CLSM such that it flows easily into all open spaces and voids between the pipe and the excavated trench. Bedding shall be placed under pipe from one side and vibrated, as necessary, so that it flows under the pipe until it appears on the other side.
   c. CLSM shall then be added to both sides of the pipe and vibrated until it completely fills the space between the pipe and the excavated trench bottom. This operation shall follow as closely behind pipelaying operations as possible.
   d. Place CLSM in such a way as to prevent floating, uplift, buckling, or movement of the pipe.
   e. Place CLSM to upper extents of pipe zone as shown on Drawings.
   f. Placement methods and sequence shall prevent voids under the pipe.
   g. Place CLSM as soon as possible after joint welding and coating placement is completed and approved.

h. Do not compact over CLSM until it reaches initial set. If temperatures drop below 40 degrees F (or exceed 90 degrees F), a 1-foot-thick layer of loose trench zone material may be gently placed over CLSM to provide insulation during curing. Test CLSM for initial set before compacting that layer.

3. At pipe-to-vault transitions, form sides of CLSM 2 feet minimum on both sides of the pipe within the excavated area for the vault.
4. When fiber optic conduits are required in CLSM, first place CLSM, then excavate fiber optic trench in CLSM. Set fiber optic conduits to grade and backfill with CLSM.
5. Pipe Flotation Prevention:
   a. Contractor shall prevent pipe from floating due to buoyant uplift created by the CLSM or groundwater.
   b. If movement occurs during placement of CLSM, Contractor shall remove CLSM, reset pipe or conduit to grade, and replace CLSM.
6. Backfilling with Slide Rail Shoring.
   a. Place CLSM to fill the following voids in the pipe zone:
      1) Fill pipe zone between shoring.
      2) Fill voids between shoring and excavated trench wall.
      3) Fill voids created by pulling shoring system.
      4) Fill voids left by removing shoring posts or supports.
   b. Trench Zone Slide Rail Removal.
      1) Raise upper slide rail panels incrementally to facilitate compaction of each trench zone lift against the trench walls and not against rail panels.
      2) Remove native earth that collapses into trench if it is not trench zone material.
      3) Immediately after removing slide rail posts, fill rail post holes with fluid mix CLSM.
   c. Do not disturb pipe position when removing slide rail shoring.

C. Granular Pipe Zone:

1. Sequence:
   a. Place and compact granular pipe zone bedding over full width of trench bottom.
   b. Check grade and correct irregularities in bedding.
   c. Loosen at center of pipe (by rake or other means) the top 1 inch to 2 inches of compacted bedding to provide a cushion before laying each section of pipe (or conduit, direct-buried cable, or duct bank).
   d. Excavate bell holes adequate for proper joint assembly and inspection.
   e. Set pipe to grade so it is uniformly supported by bedding, except at bell holes.

f. Place granular pipe zone material in lifts simultaneously on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.

2. Restrain pipe, conduit, cables, and duct banks to prevent their movement during backfilling.
3. Each lift shall not exceed 8 inches. First lift shall not exceed half of pipe diameter. Compact to specified relative compaction each lift and under haunches.
4. Do not use water jetting.
5. Placing and curing CLSM in cold weather.

D. As specified in Section 31 23 23, Fill and Backfill, Article Cold Weather Requirements for Fill and Backfill.

3.05 INSTALLING MARKING TAPE

A. Install marking tape in the following locations:

1. Over fiber optic ducts, water pipes, and cathodic test wires.
2. Where otherwise specified or shown on Drawings.

B. Secure marking tape to prevent movement during backfill.

3.06 INSTALLING TRACER WIRES AND POSTS

A. Tape tracer wires to center of marking tape at 10-foot intervals and keep tape centered over pipe during backfill. Tracer wire is required over all fiber optic, I&C, and electric ducts, and all pipelines except welded steel pipelines larger than 30 inches in diameter.

B. Terminate tracer wire on a post-mounted (or flush-mounted) terminal per Standard Details. Provide separate posts for tracer wires than for cathodic test station posts. Locate tracer wire posts at each fiber optic pull box and CT Station, and at least every 1,200 feet. If Drawings do not list tracer wire posts at least every 1,200 feet, add trace wire posts to provide the 1,200-foot spacing.

C. Test continuity of tracer wire using electronic pipe locator in presence of Engineer prior to paving and other trench surface restoration.

3.07 TRENCH COMPACTION TESTING

A. Test backfill(s) for compaction per Section 31 23 23, Fill and Backfill.

B. After an acceptable compaction procedure is established, test trench zone compaction with at least two tests per day. For granular pipe zone backfill that is allowed in leu of CLSM, test with an additional two tests per day. Stagger test locations to be at different trench positions and depths and note where each is taken.

C. If any test falls below specified compaction, submit additional tests every 50 feet in each side of failed test until failure extent is identified. Remove and rework failed area until specified compaction is achieved.

3.08 TRENCH SURFACE RESTORATION

A. Unless required otherwise, replace or restore ground surfaces as follows:

1. Restore native ground elevations and drainage patterns.
2. Restore topsoils per Section 32 91 13, Topsoil.
3. Replace paving per Section 32 12 16, Asphalt Paving.
4. Replace vegetation per Section 32 93 00, Revegetation and Surface Restoration.

3.09 MAXIMUM LENGTH OF OPEN TRENCH

A. Limit length of open trench per Section 31 23 16, Excavation.

END OF SECTION

SECTION 31 32 19.16
GEOTEXTILE

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. D737, Standard Test Method for Air Permeability of Textile Fabrics.
   b. D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
   c. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   d. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   e. D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
   f. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   g. D4716, Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
   h. D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   i. D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   j. D4884, Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Geotextiles.
   k. D4886, Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding Block Method).
   l. D5199, Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
   m. D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   n. D6193, Standard Practice for Stitches and Seams.
   o. D6241, Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
2. Federal Specifications and Standards (FS): 751A(1), Stitches, Seams, and Stitchings.

1.02 DEFINITIONS

A. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

B. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile furnished.

C. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile furnished.

D. Nondestructive Sample: Sample representative of finished Work, prepared for testing without destruction of Work.

E. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

F. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D4884.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer material specifications and product literature.
   b. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.
   c. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, adhesives (if any), and provisions for holding geotextile temporarily in place until permanently secured.
2. Samples:
   a. Geotextile: One-piece, minimum 18 inches long, taken across full width of roll of each type and weight of geotextile furnished for Project. Label each with brand name and furnish documentation of lot and roll number from which each Sample was obtained.
   b. Field Sewn Seam: 5-foot length of seam, 12 inches wide with seam along center, for each type and weight of geotextile.
   c. Securing Pin and Washer: One each.

B. Informational Submittals:

1. Certifications from each manufacturer that furnished products have specified property values. Certified property values shall be either minimum or maximum average roll values, as appropriate, for geotextiles furnished.
2. Field seam efficiency test results.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify it for inventory and quality control.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

1.05 SCHEDULING AND SEQUENCING

A. Where geotextile is to be laid directly upon ground surface, prepare subgrade as specified in Section 31 23 13, Subgrade Preparation, first.

B. Notify Engineer whenever geotextiles are to be placed. Do not place geotextile without Engineer’s approval of underlying materials.

PART 2 PRODUCTS

2.01 WOVEN GEOTEXTILE

A. Composed of polymeric yarn interlaced to form planar structure with uniform weave pattern.

B. Calendared or finished so yarns will retain their relative position with respect to each other.

C. Polymeric Yarn: Long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

D. Sheet Edges: Selvaged or finished to prevent outer material from separating from sheet.

E. Unseamed Sheet Width: Minimum 12 feet.

F. Physical Properties:

Physical Property Requirements for Woven Geotextile		
Property	Requirement	Test Method
Nominal Weight per Square Yard	7 oz	ASTM D5261
Apparent Opening Size (AOS)	40 U.S. Standard Sieve Size	ASTM D4751
Water Permittivity	0.5 $sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)
Waterflow Rate	40 gpm/sq ft, MinARV	ASTM D4491 (Falling Head)
Grab Tensile Strength	350x200 lb, MinARV	ASTM D4632
Grab Elongation	15 percent, MaxARV	ASTM D4632
Trapezoidal Tear Strength	100x70 lb, MinARV	ASTM D4533
CBR Puncture Strength	800 lb, MinARV	ASTM D6241
Ultraviolet Radiation Resistance	90 percent strength retention, MinARV after 500 hours	ASTM D4355

2.02 NONWOVEN GEOTEXTILE

A. Pervious sheet of polyester, polypropylene, or polyethylene fabricated into stable network of fibers that retain their relative position with respect to each other. Nonwoven geotextile shall be composed of continuous or discontinuous (staple) fibers held together through needle-punching or spun-bonding.

B. Geotextile Edges: Selvaged or otherwise finished to prevent outer material from pulling away from geotextile.

C. Unseamed Sheet Width: Minimum 12 feet.

D. Nominal Weight per Square Yard: 16 ounces per ASTM D5261.

E. Physical Properties: Conform to requirements in Table No. 1.

Table No. 1
Physical Property Requirements for Nonwoven Geotextile

Property	Requirement	Test Method
Water Permittivity	0.8 sec.-1, MinARV	ASTM D4491 (Falling Head)
Apparent Opening Size (AOS)	100 U.S. Standard Sieve Size	ASTM D4751
Grab Tensile Strength, Machine Direction	300 lb/in, MinARV	ASTM D4632
Grab Elongation, Machine Direction	50 percent, MaxARV	ASTM D4632
Puncture Strength	190 lb, MinARV	ASTM D4833 or 5% more if D6241
Trapezoid Tear Strength	115 lb, MinARV	ASTM D4533
Ultraviolet Radiation Resistance	90 percent strength retention, MinARV after 500 hours	ASTM D4355

2.03 ADHESIVES

A. In accordance with geotextile manufacturer recommendations.

2.04 SEWING THREAD

A. Polypropylene, polyester, or Kevlar thread.

B. Durability: Equal to or greater than durability of geotextile sewn.

2.05 SECURING PINS

A. Steel Rods or Bars:

1. 3/16-inch diameter.
2. Pointed at one end.
3. With head on other end sufficiently large to retain washer.
4. Minimum Length: 12 inches.

B. Steel Washers for Securing Pins:

1. Outside Diameter: Not less than 1.5 inches.
2. Inside Diameter: 1/4 inch.
3. Thickness: 1/8 inch.

C. Steel Wire Staples:

1. U-shaped.
2. 10 gauge.
3. Minimum Length: 6 inches.

2.06 SILT (SEDIMENT) FENCING

A. Fabric: Non-woven geotextile fabric as specified in Article Non-woven Geotextile. Height of fabric to be 16 inches for slopes equal to or less than 6 percent. For slopes greater than 6 percent, use up to 28 inches as directed by the Engineer.

B. Support Posts: Wood post style type 1-1/2-inch by 1-1/2 inches by 36 inches minimum dimensions. Height to be 16 inches taller than the fabric height with 16-inch bury depth. Set posts no more than 10 feet apart.

C. Fasteners: Heavy-duty wire staples at least 1-inch long, tie wires, or hog rings as recommended by manufacturer of geotextile.

PART 3 EXECUTION

3.01 LAYING GEOTEXTILE

A. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.02 SHEET ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

B. Geotextile may be oriented with long dimensions of sheet transverse to direction of the slope only if the sheet width, without seams, is sufficient to cover entire slope and anchor trench and to extend at least 18 inches beyond toe of slope.

3.03 JOINTS

A. Unseamed Joints: Overlap minimum 18 inches.

B. Sewn Seams: Made wherever stress transfer from one geotextile sheet to another is necessary and as directed by the Engineer.

1. Seam Efficiency:
    a. Minimum 90 percent.
    b. Verified by preparing and testing minimum of one set of nondestructive samples per acre of each type of weight of geotextile installed.
    c. Test in accordance with ASTM D4884.
2. Acceptable Types:
    a. “J” type.
    b. Flat.
    c. Butterfly.
3. Stitch Count: Minimum three to maximum seven stitches per inch.
4. Stitch Type: Double-thread chainstitch according to ASTM D6193.
5. Sewing Machines: Capable of penetrating four layers of geotextile.
6. Stitch Location: 2 inches from geotextile sheet edges, or more, if necessary to develop required seam strength.

3.04 SECURING GEOTEXTILE

A. Secure geotextile during installation with sandbags or other means approved by Engineer until permanent anchors are installed.

B. Secure Geotextile on slopes with Securing Pins or Staples as follows except when used in connection with geomembrane:

1. Insert securing pins with washers through geotextile.
2. Securing Pin Alignment:
    a. Midway between edges of overlaps.
    b. 6 inches from free edges.
3. Spacing of Securing Pins:

Slope	Maximum Pin Spacing
Steeper than 3:1	2 feet
3:1 to 4:1	3 feet
Flatter than 4:1	5 feet

4. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.

5. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.
6. Where staples are used instead of securing pins, install in accordance with alignment and spacing above. Push in to secure geotextile firmly to subgrade.

3.05 PLACING MATERIALS OVER GEOTEXTILE

A. Before placing material over geotextile, notify Engineer. Do not cover geotextile until after Engineer provides authorization to proceed.

B. Place materials over geotextile so as to prevent damage. Place materials by dumping and then spreading onto geotextile. Dump only on previously spread materials.

C. Equipment: Limit the weight of equipment to spread material over geotextile as required to prevent damage. Avoid sharp turns and sudden starts or stops that could damage geotextile. Operate equipment on a minimum of 8 inches of material over geotextile.

D. Spread material in same direction as un-seamed overlaps to avoid separation of seams and joints. Maintain proper geotextile overlaps.

E. If tears, punctures, or other geotextile damage occurs during placement, remove overlying materials, expose damaged geotextile and repair damage as specified in Article Repairing Geotextile.

3.06 INSTALLING GEOTEXTILE AROUND GRANULAR DRAIN MATERIAL

A. Place geotextile in a way to completely envelope the granular drain material to be placed in the trench with specified joint overlaps.

B. Overlap geotextile in direction of flow.

C. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

D. After granular drain material is placed, fold geotextile over top of granular drain material unless otherwise shown. Maintain minimum overlap while overlying fill is placed.

3.07 RIPRAP APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

B. Sew joints where wave run-up may occur.

C. Limit height of riprap fall onto geotextile to prevent damage. Drop height shall be 0 feet for rocks over 200 pounds and under 3 feet for rocks 200 pounds and smaller.

3.08 SILT FENCE APPLICATIONS

A. Install geotextile in one piece, or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.

3.09 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile.

B. Repair Procedure:

1. Place patch of undamaged geotextile over damaged area and at least 18 inches in all directions beyond damaged area.
2. Remove interfering material as necessary to expose damaged geotextile for repair.
3. Sew patches or secure them with heat fusion tacking or with pins and washers, as specified above in Article Securing Geotextile, or by other means approved by Engineer.

3.10 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in Engineer's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

END OF SECTION

SECTION 31 37 00
RIPRAP

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   b. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. C150, Standard Specification for Portland Cement.
   d. C535, Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1.02 DEFINITIONS

A. Refer to applicable definitions in Section 31 23 23, Fill and Backfill.

B. D50 is the nominal rock size (diameter) of which 50 percent of the rocks are smaller.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Description and location of proposed sources of riprap bedding and riprap. Engineer must approve the source of riprap 30 days prior to its use on the Project.

B. Informational Submittals:

1. Notify the Engineer, in writing, of the intended source of rock at least 30 days prior to use.
2. Quarry Certificate of Conformance and supporting documentation showing proposed riprap bedding or riprap meet gradation and materials requirements for the Class or Type specified.
3. Certified Test Results:
   a. Riprap Bedding:
      1) Gradation.
      2) Abrasion resistance.

b. Riprap:
1) Gradation.
2) Abrasion resistance.
3) Bulk density.

4. Trip tickets showing source, type, and weight of each load of material delivered to Site.

1.04 QUALITY ASSURANCE

A. Riprap Source: Quarry that has produced riprap and has performed satisfactorily on other projects for at least 5 years.

B. Site Visit: Make arrangements for Engineer to visit quarry site to observe materials proposed for riprap and riprap bedding.

1.05 SCHEDULING AND SEQUENCING

A. Complete subgrade preparation as specified in Section 31 23 13, Subgrade Preparation, and geotextile installation as specified in Section 31 32 19.16, Geotextile, prior to placing riprap bedding or riprap.

PART 2 PRODUCTS

2.01 GEOTEXTILE FOR RIPRAP BEDDING

A. Nonwoven (heavy) geotextile as specified in Section 31 32 19.16, Geotextile.

2.02 RIPRAP BEDDING

A. Gravel with Cobbles or Crushed Rock with Cobble-Sized Pieces:

1. Gradation, as determined in accordance with ASTM C136:
   a. Well-graded from coarse to fine.
   b. All pieces pass a 6-inch square opening.
   c. Minimum 85 percent by weight passes 4-inch square opening.
   d. Minimum 10 percent by weight passes No. 4 U.S. standard sieve.
2. Abrasion Resistance: Maximum 35 percent wear when tested in accordance with ASTM C535.

B. Free of roots and other organic or deleterious matter.

C. Onsite material from excavations or designated borrow sources that meets or is processed to meet requirements specified above may be used as riprap bedding in lieu of importing material.

2.03 RIPRAP

A. Hard and durable quarry stone free from fractures, bedding planes, pronounced weathering, and earth or other adherent coatings.

B. Size as shown on Drawings.

C. Rock shall be of a shape that forms a stable riprap revetment. Rounded, flat and elongated shapes are not permitted unless thickness is at least one third the length. Engineer approval is required for reuse of any rock excavated onsite.

D. Minimum Dimension of Individual Pieces: Not less than one-third maximum dimension.

E. Abrasion Resistance: Maximum 35 percent wear as determined in accordance with ASTM C535.

F. Bulk Density: Minimum 160 pounds per dry cubic foot.

G. Gradation: Smaller pieces shall generally fill voids between larger pieces without either excess or deficiency of one or more sizes of stone.

Class	Thickness (Inches)	Weight (Pounds)	% Greater Than	Bedding Gradation
I	12	150 100 50 25	0 to 5 30 75 90	Per Article Riprap Bedding
II	18	250 150 50 25	0 to 5 30 75 90	Per Article Riprap Bedding
III	24	800 400 200 25	0 to 5 30 75 90	Per Article Riprap Bedding
IV	30	1,600 800 400 50	0 to 5 30 75 90	Per Article Riprap Bedding

Class	Thickness (Inches)	Weight (Pounds)	% Greater Than	Bedding Gradation
V	36	2,700 1,600 800 100	0 to 5 30 75 90	Use Class I Riprap for Bedding
VI (or "1 ton")	45	100 50 – 70 35 – 50 2 – 10	45 36 30 12	Use Class I Riprap for Bedding

2.04 GROUT FOR RIPRAP

A. Grout for riprap shall be concrete as specified in Section 03 30 00, Cast-in-Place Concrete.

PART 3 EXECUTION

3.01 PLACING RIPRAP BEDDING

A. Provide a layer of geotextile under bedding where shown on Drawings.

B. Place riprap bedding over prepared subgrade and geotextile to one-third the thickness of the riprap, and as shown on Drawings.

C. Place riprap bedding on geotextile without puncturing or damaging geotextile. If accidentally damaged, repair geotextile prior to proceeding.

D. No mechanical compaction of riprap bedding is required; however, work riprap bedding as necessary to distribute it and to eliminate detrimental voids. Avoid overworking or long pushes that result in segregation of particle sizes.

E. Grade surface of riprap bedding free from irregularities and to tolerances of 0.2 feet from established grade.

F. Place and grade riprap bedding in a manner that avoids subgrade disturbance and displacement or damage to geotextile. Do not push riprap bedding down slope. If wrinkles form in geotextile as riprap bedding is placed, correct them as specified in Section 31 32 19.16, Geotextile.

3.02 PLACING RIPRAP ON RIPRAP BEDDING

A. Place riprap over riprap bedding to uniform thickness specified or shown on Drawings.

B. Intermix different sizes of pieces to eliminate segregation and to fill voids between larger pieces with smaller pieces and work surface free from irregularities.

C. Use placement and intermixing methods that avoid disturbing prepared subgrade, riprap bedding, and underlying geotextile or damaging existing facilities, completed Work, or adjacent property.

3.03 GROUTING RIPRAP

A. Remove dirt and foreign substances from surfaces of riprap and then moisten.

B. Deposit grout by means of chutes, tubes, or buckets, or place by means of pneumatic equipment or other mechanical methods. Place grout in a continuous operation for any day’s run at any one location.

C. Limit flow distance of grout along slope to less than 10 feet.

D. Spade and rod grout into place with suitable spades, trowels, or other approved means immediately after depositing grout. Depths of grout shall be approximately 1/2 the thickness of the riprap.

E. Following placement of grout, thoroughly brush rocks so top surfaces are exposed. Outer rocks shall project 1/3 to 1/4 their diameter above grout surface. Brushing shall follow closely behind rodding such that grout shall not be in place more than 1 hour before brushing.

F. Once brushing of area is complete, no worker or load will be permitted on surface for period of at least 24 hours, or longer if so required by Engineer.

G. Cure grout as provided in Section 03 30 00, Cast-in-Place Concrete.

END OF SECTION

SECTION 31 41 00
SHORING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation support plan.
2. Movement monitoring plan.
3. Trench excavation plan.
4. Movement measurement and data and reduced results indicating movement trends.

1.02 QUALITY ASSURANCE

A. Excavation plans shall be prepared and stamped by a registered professional engineer in the State of Utah.

B. Provide surveys to monitor movements of critical facilities.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavation plans shall be based on subsurface conditions which are at least as stringent or conservative as those indicated in geotechnical reports provided by the Owner.

B. Provide excavations that comply with all applicable safety order, codes, and requirements (local, state, and federal) including, but not limited to sloping, shoring, bracing, dewatering, and others. Provide sheeting, shoring, and bracing conforming to 29 CFR 1926 Subpart P – Excavations, OSHA requirements, and the General Conditions.

C. Where excavations may induce ground movement in adjacent ground, provide ground monitoring before, during, and after excavation to document extent of movement. Provide measures to prevent, minimize and mitigate movement to prevent adverse effects.

D. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed the Work.

3.02 EXCAVATION SUPPORT PLANS

A. Prepare plan(s) for excavation support addressing the following topics:

1. Details of shoring, bracing, sloping, or other provisions for worker protection from hazards of caving ground.
2. Design assumptions and calculations, including applicable surcharge loads.
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, stockpiled excavated materials, and any other applicable surcharge load.
6. Anticipated difficulties and proposed resolutions.

B. Design and maintain shoring so soil does not migrate from behind the shoring into excavation and leave voids behind shoring. If voids are left or soils are softened by shoring removal, fill voids and re-compact such soils.

C. Prevent ground settlement and utility shearing/settlement during installation and removal of shoring. If shoring methods cause settlement or damage utilities or services, provide a shoring method that preserves utilities and services in acceptable and functional condition during and after Work.

3.03 SLIDE RAIL SHORING

A. Use slide rail shoring on trenches for all pipelines where shown on Drawings. Elsewhere slide rail shoring may be used as elected by the Contractor. Use slide-rail shoring system as manufactured by one of the following, “or-equal”:

1. Efficiency Production, Inc.
2. GME (Griswold Machine and Engineering).
3. PRO-TEC Equipment, Inc.
4. CERDA Industries.
5. Use manufacturer-supplied sacrificial spacer bars at base of each pair of slide rail posts to facilitate slide rail installation if ground conditions require.

B. Prevent potentially unsafe trench walls outside slide rail shoring. Fill all voids between slide rail shoring and excavated trench the day shoring is installed. Fill voids during removal of shoring panels and slide rail posts as specified in Section 31 23 23.15, Trench Backfill.

3.04 MOVEMENT MONITORING PLAN

A. Prepare movement monitoring plan addressing following topics:

1. Survey control.
2. Location of monitoring points.
3. Plots of data trends.
4. Interval between surveys.

3.05 REMOVAL OF EXCAVATION SUPPORT

A. Remove excavation support in a manner that will maintain support as excavation is backfilled.

B. Do not begin to remove excavation support until support can be removed without damage to existing facilities, completed Work, or adjacent property.

C. Remove excavation support in a manner that does not leave voids in the backfill or fill voids with CLSM during removal of shoring.

3.06 TRENCHES

A. For trench excavation exceeding 5 feet in depth, provide adequate safety system meeting requirements of applicable state and local construction safety orders, and federal requirements.

END OF SECTION

SECTION 31 60 00
INSTALLATION OF CARRIER PIPE IN GROUND SUPPORT AND CASING

PART 1 GENERAL

1.01 SUMMARY

A. This section includes requirements for installation of carrier pipe in ground support and casing at locations shown on Drawings. For requirements regarding the installation of ground support and casing for the tunneled crossings, see Section 02 33 00, Tunneled Crossings.

1.02 SUBMITTALS

A. Informational Submittals:

1. Describe methods, procedures, staging, and equipment for joining and installing carrier pipe inside the ground support.
2. A safety plan for the carrier pipe installation operations including air monitoring equipment and procedures and provisions for lighting, ventilation, and electrical system safeguards. Provide name of Site Safety Representative responsible for implementing safety program. Notify Engineer if safety plan is the same as for tunneling operations.
3. Emergency Response Plan for rescuing personnel trapped in a shaft, pipe, or tunnel.

B. Action Submittals: Shop Drawings of carrier pipe supports, blocking, and guide rails, as applicable.

1.03 QUALITY CONTROL

A. Carrier Pipe Installation Experience: Similar to Section 31 79 19, Open Face Rotary Wheel TBM Tunneling.

B. The surveyor responsible for carrier pipe line-and-grade control shall be a Licensed Surveyor registered in the State of Utah who has prior experience in similar projects.

C. Tolerances:

1. The carrier pipe shall be installed in accordance with the following tolerances:
   a. Variations from Design Line and Grade: As specified in Section 33 05 01.01, Welded Steel Pipe and Fittings.

1.04 DEFINITIONS

A. Carrier Pipe: As defined in Section 31 79 25, Guided Auger Boring.

B. Casing: As defined in Section 33 05 01.27, Steel Casing Pipe.

C. Ground Support: As defined in Section 31 79 19, Open Face Rotary Wheel TBM Tunneling.

D. Low Density Cellular Concrete (LDCC): As defined in Section 31 74 28, Backfill Grouting.

1.05 BASIS OF DESIGN

A. Carrier pipe shall be installed within the horizontal and vertical tolerances as indicated in the Contract Documents incorporating all support/insulator dimensions required.

B. Fill all voids between the carrier pipe and the casing with backfill grout as indicated. All exterior carrier pipe surfaces and all interior casing surfaces shall be in contact with the pressurized backfill grout as specified.

PART 2 PRODUCTS

2.01 MATERIALS

A. For Steel Casings:

1. 12-inch wide, steel band with steel risers and 2-inch nonconductive wide glass reinforced polyester runners.
2. Suitable for supporting weight of carrier pipe.
3. Runner lubrication shall be environmentally safe and within manufacturer’s recommendations.
4. Steel band to have nonconductive polyvinyl chloride inner liner.
5. Steel riser height with attached runner to be sufficient to provide required clearance between the outside of carrier pipe and the inside of the casing.
6. Studs, nuts, and washers shall be cadmium plated.
7. Manufacturers:
    a. PSI Products, Inc.
    b. Cascade Waterworks Manufacturing Co.
    c. Calpico.

B. For Tunneled Ground Support:

1. Wooden blocking to prevent movement in combination with steel casing spacers for support.
2. Steel casing spacers as specified for use with steel casings, in combination with steel channel guiderail or similar installed within the invert of the ground support to permit sliding of pipe into tunnel without damage to the carrier pipe, ground support, or spacers.

PART 3 EXECUTION

3.01 GENERAL

A. Do not begin carrier pipe installation until the following is completed:

1. Casing or ground support joints and grout ports are watertight.
2. No water enters casing from any sources.
3. Contact grouting of the casing or ground support is complete in accordance with Section 31 74 28, Backfill Grouting.
4. Casing or ground support has been cleaned of tunneled materials and debris.
5. Rough welds at casing joints have been ground smooth.

B. Install the carrier pipe within the casing or ground support to the line and grade indicated on Drawings, and utilizing methods which include due regard for safety of workers, adjacent structures and improvements, utilities, carrier pipe jointing requirements, and the public.

C. Furnish all necessary equipment, power, water, and utilities for carrier pipe installation, insulator runner lubricant, grouting, and other associated Work required for the Contractor's methods of construction.

D. Conduct all operations such that trucks and other vehicles do not interfere with traffic or create a dust or noise nuisance in the streets and to adjacent properties. Promptly clean up, remove, and dispose of spoils and slurry spillage and any slurry discharges.

E. All work shall be done so as not to disturb roadways, adjacent structures, landscaped areas, or existing utilities. Any damage shall be immediately repaired to original or better condition and to the satisfaction of the Engineer and facility/utility owner.

3.02 CONTROL OF LINE AND GRADE

A. Allow Engineer to check line and grade of casing or ground support prior to beginning carrier pipe installation. Provide access for Engineer to perform survey checks of line-and-grade of carrier pipe on a daily basis during installation operations. The Contractor is fully responsible for the accuracy of the Work and the correction of it, as required.

B. Where the carrier pipe installation exceeds the tolerances specified in Section 33 05 01.01, Welded Steel Pipe and Fittings, correct the installation, including, if necessary, redesign of the pipe, supports, or structures. All corrective Work shall be performed as approved by Engineer at no additional cost to Owner.

3.03 INSTALLATION OF CARRIER PIPE

A. Pipe Installation: Install carrier pipe as shown on Drawings in accordance with specified tolerances and approved submittals. Remove all loose soil from casing or ground support. Grind smooth all rough welds at casing joints. Provide casing spacers, blocking, or insulators, or other approved devices, as required, to prevent flotation, movement, or damage to the pipe during installation and grout backfill placement and to ensure electrical isolation of carrier pipe from casing or ground support. Every individual pipe section should be supported by at least two supports. Carrier pipe shall be installed without sliding or dragging it on the ground or in the casing or ground support in a manner that could damage the coatings on the pipe. Coat the casing spacer runners with a noncorrosive/environmentally safe lubricant to minimize friction when installing the carrier pipe.

B. Welding: Weld carrier pipe sections together and test welds in accordance with the requirements of Section 33 05 01.01, Welded Steel Pipe and Fittings. Repair protective coatings at pipe joints as specified.

C. Testing of Carrier Pipe: Complete hydrostatic testing of the carrier pipe prior to the backfilling of the shafts and backfilling of the annular space between casing or ground support and carrier pipe with grout. Pressure testing shall be performed in accordance with Section 33 05 05.31, Pressure Testing of Piping. Any leakage found during this inspection shall be corrected.

D. Electrical Isolation: Verify that the casing and ground support and carrier pipe are electrically isolated prior to backfilling and again after backfilling is complete. If electrical isolation is not achieved, perform the necessary work, including, but not limited to, removing and replacing the carrier pipe within the casing or ground support until isolation is achieved.

E. Backfill annular space between casing or ground support and carrier with Low Density Cellular Concrete (LDCC) in accordance with Section 31 74 28, Backfill Grouting.

3.04 SAFETY

A. The Contractor is responsible for safety on the Job Site. Perform all Work in accordance with the current applicable regulations of the federal, state, and local agencies. In the event of conflict, comply with the more restrictive applicable requirement.

B. No gasoline powered equipment shall be permitted in jacking shafts and receiving shafts. Diesel, electrical, hydraulic, and air powered equipment is acceptable, subject to applicable local, state, and federal regulations.

C. Methods of construction shall be such as to ensure the safety of the Work, Contractor's and other employees on Site, and the public.

D. Furnish and operate a temporary ventilation system in accordance with applicable safety requirements when personnel are underground. Perform all required air and gas monitoring. Ventilation system shall provide a sufficient supply of fresh air and maintain an atmosphere free of toxic or flammable gasses in all underground Work areas.

E. Perform all Work in accordance with all current applicable regulations and safety requirements of the federal, state, and local agencies. Comply with all applicable provisions of 29 CFR Part 1926, Subpart S, Underground Construction and Subpart P, Excavations, by OSHA.

F. If personnel will enter the pipe during construction, the Contractor shall develop an emergency response plan for rescuing personnel trapped underground in a shaft excavation or pipe. Keep onsite all equipment required for emergency response in accordance with the agency having jurisdiction.

END OF SECTION

SECTION 31 74 28
BACKFILL GROUTING

PART 1 GENERAL

1.01 SUMMARY

A. The Work specified in this section includes requirements for filling the annular space and any voids between the outside of the carrier pipe and the inside of the tunneled casing or ground support with low-density cellular concrete (LDCC).

1.02 DEFINITIONS

A. Low-Density Cellular Concrete (Foam Grout): A lightweight cementitious material that contains stable air or gas cells uniformly distributed throughout the mixture and with a minimum air percentage of 20 percent.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Submit mix designs for each LDCC mix proposed for use. Each mix design shall show the ingredients of the mix and shall include:
      1) Type, brand, source, and amounts of cement, pozzolans, admixtures, and other additives.
      2) Source and amount of water.
      3) Combined grading of each mix design.
      4) Specific gravity of all materials.
      5) Results of air content, unit weight, and 28-day compressive strength tests.
2. Submit a certificate of compliance signed by the supplier identifying the type of fly ash (if used) and stating that the fly ash is in accordance with ASTM C618 and these specifications. Supporting test data shall be furnished when requested by the Engineer. All testing and sampling procedures shall be in accordance with ASTM C311.
3. Submit material specifications and instructions for use of any proposed concrete admixtures, including evidence from foam manufacturer that proposed admixtures are compatible with the foaming agent.

4. Equipment: Submit the following for each type of LDCC proposed:
   a. Manufacturer's specifications and operation instructions for conveyance equipment.
      1) Pump specifications.
      2) Grout hose, valve and port sizes and specifications.
      3) Foam generators and ancillary equipment.
5. Submit a work plan for placing LDCC including:
   a. Sequence of work including sequence of placement and staging of backfill lifts and pumping.
   b. Type(s) and locations of equipment.
   c. Placing procedures, (i.e., batching, mixing, and pumping location and procedures).
   d. Pump line arrangement.
   e. Maximum pipe length to be backfilled.
   f. Maximum LDCC age before set initiation.
   g. Method of determining LDCC levels placed or completion of void filling.
   h. Communications provisions.
   i. Pumping pressures, rates, and volumes to be placed per day.
   j. Maximum injection pressures injection locations.
   k. Methods for monitoring mix.
   l. Method of surveying or monitoring carrier pipe for movement during LDCC placement.
   m. Methods and approaches to prevent deformation of carrier pipe during LDCC placement.
   n. Testing procedures.
   o. Cleanup procedures.
6. Preplacement Test Reports and Certifications:
   a. Mill test reports for Portland cement.
   b. Certificates of compliance for each load of portland cement and fly ash (if used).
   c. Certificates of compliance for foaming agent and all admixtures.

B. Informational Submittals:

1. Qualifications: Qualifications of contractor or subcontractor personnel (superintendent and foreman) and manufacturer supplying and placing the LDCC.
2. Daily reports and records of backfill grout placement, including but not limited to:
   a. A delivery ticket with the information stated in Section 16 of ASTM C94; except actual scale weights of materials shall be furnished to the Engineer with each batch of concrete before unloading at the Site.

b. A printout of the actual scale weights for all loads batched shall be submitted to the Engineer at the end of each working day.
c. Volumes placed and lift (stage) heights achieved.
d. Stationing of LDCC placement.
e. Injection locations and pressures.
f. Unit weight and air content testing results.
g. Time of placement.
h. Designation of cylinder samples prepared that day.
i. Compressive strength tests reports from a certified testing laboratory.

PART 2 PRODUCTS

2.01 BULKHEADS

A. Completely seal the annular space at the ends of each crossing with constructed bulkheads.

B. Construct bulkheads so the annular space will be completely backfilled.

C. Incorporate a minimum l-inch diameter drain pipe in the invert of the bulkhead to facilitate drainage of water during LDCC backfilling. This pipe shall be securely capped and plugged once LDCC begins to flow from the drain line.

D. Provide an opening in the crown of the bulkhead to allow entrapped air to escape. Vent outlets shall be provided as required.

2.02 MATERIALS

A. Cement: Portland Cement, ASTM C150, Type I or II.

B. Flyash: Type F, ASTM C618.

C. Water: Use potable water free from deleterious amounts of alkali, acid, and organic materials which would adversely affect the setting time or strength of the backfill grout.

D. Admixtures: Admixtures may only be used when specifically approved by foaming agent supplier in writing.

E. Foaming Agent:

1. Foaming agent shall comply with ASTM C869 when tested in accordance with ASTM C796.
2. Manufacturer and Products:
   a. Cellular Concrete Solutions; Mearl Geofoam Liquid Concentrate.
   b. Concrete Technologies, LLC; Foam Liquid Concentrate.
   c. Or approved equal.

2.03 MIX DESIGN

A. General: LDCC mix shall be designed in accordance with the requirements of Section 03 30 00, Cast-in-Place Concrete, ACI 523.IR, ACI 523.3R, and the additional requirements herein. Mixes shall be adjusted in the field as necessary to meet the requirements of these specifications. The foaming agent material manufacturer's field services representative shall approve all changes to the mix designs.

B. Minimum 28-day compressive strength in accordance with ASTM C495: 200 psi.

C. Limiting Requirements: Unless otherwise specified, each LDCC mix shall be designed and controlled within the following limits:

1. Wet Density: Wet density (unit weight) of the foam grout shall be not less than 50 pcf, at the point of placement.
2. Preformed Foam: Preformed foam shall be generated by combining controlled quantities of air, water, and foaming agent under pressure. Foam shall retain its stability until the cement sets to form a self-supporting matrix. The resulting LDCC shall have closed cell and low water absorptive characteristics. The concentration of foam agent shall be in accordance with the foaming agent material manufacturer's recommendations.
3. Admixtures: The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer's recommendations for minimum shrinkage and for compliance with these specifications. Admixtures may be used when specifically approved by foaming agent material manufacturer and shall be in accordance with their recommendations. No calcium chloride or admixture containing chloride from other than impurities from admixture ingredients will be acceptable.
4. A tentative mix shall be designed and tested in accordance with ASTM C796 for each consistency intended for use. These results will be compared with field test results to confirm consistent properties are obtained in the field. Testing for each mix shall be as follows:
   a. Two sets of compression test cylinders (3 inches by 6 inches), three cylinders per set, shall be made from each proposed

backfill grout mix. One set of three cylinders shall be tested at an age of 7 days and the other set shall be tested at an age of 28 days. Foam grout specimens shall be made, cured, stored, and tested in conformity with ASTM C 495.

b. Determine total air content of each proposed foam grout mix in accordance with ASTM C796.

c. Determine unit weight of each proposed foam grout mix in accordance with ASTM C567.

2.04 EQUIPMENT

A. General:

1. Use equipment for mixing and injecting foam grout, which is designed for underground backfill grouting service. Maintain equipment in good operating condition, capable of satisfactorily mixing, agitating, and forcing LDCC into injection ports at a uniform flow rate under the required constant pressure.
2. Backfill grouting equipment shall be configured so flushing can be accomplished with grout intake valves closed, with water supply valve open, and with grout pump running at full speed.
3. An adequate inventory of spare parts or backup equipment shall be provided to ensure that operable backfill grouting equipment is available at all times during the Work. Maintain sufficient quantities of spare pressure gauges, stop valves, and other wear parts on Site.

B. A foam generator shall be used to produce a predetermined quantity of preformed foam, which shall be injected into the mixer and blended with the cement slurry. A foam generator shall be used to produce a predetermined quantity of foam, which shall be injected into the mixer and blended with the cement slurry. The foam generator shall be timer-controlled to repetitively discharge a preselected quantity or to discharge continuously at a fixed rate. Foam generating equipment shall be tested and calibrated for dilution percentage, density, and volume output. Two types of foam generating systems, batch and continuous generating, are acceptable.

1. The batch system shall consist of a tank in which the foam liquid concentrate and water are first premixed. This dilute solution is then discharged from either a pressurized tank or by means of a mechanical pump through a foam-making nozzle in which this solution is blended with compressed air in fixed proportions.
2. A continuous generating system container, which continuously draws the concentrate directly from its shipping container, automatically blends it with water and compressed air in fixed proportions, and forms the stable micro-bubbled foam.

3. Both types utilize foam refining columns or nozzles calibrated for foam quality and discharge rate. The foam nozzles may be timer-controlled to repetitively discharge any preselected quantities or to discharge continuously at a fixed rate.
4. Batching, mixing, and pumping equipment shall be compatible and of sufficient size and capacity to place LDCC to distances and volumes proposed by the Contractor.
5. Provide graphical or digital printout records of batch scale readings, accurate to 1 pound, of the dry mix ingredients before delivery to mixer.

C. Specially designed batch mixers may also be used in conjunction with surge hopper equipped pumps. The rates of mixing and pumping shall be properly adjusted and a continuous flow of foam grout shall be obtained at the point of placement.

D. Injection Hoses and Connections:

1. Use hose of proper type and diameter to withstand maximum injection pressures used.
2. Provide suitable valves and calibrated pressure gauges with diaphragm gauge savers at the point of injection so that the pressure and grout flow at the grout hole may be regulated and monitored. Provide a meter to measure the total volume of LDCC pumped into each port. Provide at or very near the point of injection, a system of valves in the line transporting the grout that will allow easy access for collection of test specimens. Provide an automatic bypass valve set to the maximum pressure specified.
3. Injecting connections shall be a minimum of 1.5 and a maximum of 2.5 inches in diameter.
4. Provide suitable stop valves at collar of hole for use in maintaining pressure, as required, until LDCC has set.

2.05 QUALITY CONTROL

A. Qualifications:

1. The Contractor or Subcontractor supplying and placing LDCC shall be capable of developing a mix design, and batching, mixing, handling and placing LDCC under tunnel conditions; shall have furnished and placed LDCC on at least three tunnels of the general type and the size specified herein which have been in successful operation; and shall have a record of experience and quality of work using foam grout that is satisfactory to the Engineer.
2. As an alternative, the Contractor may employ a manufacturer's representative to supervise supplying and placing of LDCC. The manufacturer's representative shall be capable of complying with the qualifications specified for the Contractor and shall be

acceptable to the Engineer. The manufacturer's representative shall supervise all LDCC operations including training the Contractor's personnel, mixing designs, and placement of LDCC in the tunnel.

3. Personnel Qualifications: Workers, including the LDCC contractor's superintendent and foreman, shall be fully qualified to perform the Work. The LDCC contractor's superintendent shall have had previous experience under similar ground and tunnel conditions, or the foam grout supplying and placing shall be under the supervision of the foaming agent supplier's representative.
4. Field Services: The foaming agent material manufacturer shall provide engineering field services to review the Project and the material application prior to any preparation; to approve the applicator, the material used, the equipment, and the procedure to be used; to approve setup before production of LDCC; and to observe during initial application. The field representative of the material manufacturer shall submit, in writing, approvals of proposed material, equipment, application procedures, applicator, and setup before production.

PART 3 EXECUTION

3.01 GENERAL

A. Place LDCC properly as specified herein. LDCC shall be made using preformed foam process equipment approved by the foaming agent material manufacturer.

B. Utilize methods for completely filling the annular space between carrier pipe and the casing or ground support in accordance with submittals that are reviewed and approved by the Engineer. No standing water shall be allowed where LDCC is to be placed.

C. Inform the Engineer at least 24 hours in advance of the times and place where placement of LDCC is anticipated.

3.02 BATCHING AND MIXING

A. General: Conform to the requirements of accepted submittals and the foaming agent manufacturer's recommendations.

B. Mixing:

1. All LDCC shall be mechanically mixed to produce a uniform distribution of the materials with a suitable consistency and the specified limiting requirements. Excessive mixing shall be avoided in order to reduce the possibility of changes in unit weight and consistency.

2. In batch mixing operations, follow the manufacturer's recommendations concerning the order of charging the mixer with the various ingredients. The as-cast unit weight shall be monitored at the point of placement. Allowance should be made for any additional mixing that may result from the method of placement, such as mechanical or pneumatic pumping, and for any unit weight changes that may result from these methods.
3. For continuous mixing operations, provision shall be made for reasonably uniform and continuous rate of addition of all mix components at appropriate positions in the mixing machine, and in the correct ratio, to assure uniformity and the specified limiting requirements at the point of placement.
4. Alternative methods for batching and mixing LDCC will be considered by and must be acceptable to the Engineer.

3.03 PLACING LOW-DENSITY CELLULAR CONCRETE

A. General Requirements: All void space outside of the carrier pipe shall be completely filled with LDCC. Provide air release piping in the crown of the tunnel to allow displaced air and air lost from LDCC to escape and be replaced with LDCC. Place LDCC in accordance with approved submittals.

B. Backfilling of the annular space between the pipe and the casing or ground support shall be accomplished by placing LDCC in one or more stages (lifts). Monolithic placements (one stage) may be acceptable, provided the Contractor can demonstrate that his placement techniques will not induce movement of the pipe, pipe overstressing, or excessive deformation. The LDCC shall be placed through grout pipes installed within the annular space between the carrier pipe and casing or ground support. Multiple grout pipes should be installed to provide redundancy.

C. Pressure gauges of appropriate range for monitoring the backfill grout injection pressures shall be located in the line transporting the LDCC at the point of injection. Injection pressure shall be low enough to prevent pipe movement and shall not exceed 15 psi at the point of injection for stages below the crown of the pipe. Injection pressure shall not exceed 60 psi or a lower limit as submitted and approved by the Engineer at the point of injection for stages above the crown of the pipe.

D. Volume of LDCC injected shall be measured, recorded and compared with the anticipated volume per foot of pipe backfilled.

E. Provide a means of direct communication between the injection point and the pump operator.

3.04 FIELD QUALITY CONTROL

A. General: Field control tests, including unit weight (wet density), air content test, and compression tests shall be performed by the Contractor and the results submitted to the Engineer.

1. The frequency specified herein for each field control test is approximate. A greater or lesser number of tests may be made, as required by the Engineer.
2. Test specimens shall be collected within the shaft at or near the connection where the LDCC is being injected.
3. The Contractor shall assist the Engineer in obtaining additional test cylinders. Supply all materials necessary for fabricating the test cylinders.
4. Provide at or very near the point of injection, a system of valves in the line transporting the LDCC, which will allow easy access for collection of test specimens without disconnecting the line from the outlet. Submit the valve arrangement to the Engineer for review at least 15 days prior to commencing LDCC backfilling operations.

B. Unit Weight: Unit weight (wet density) tests shall be made from the first batch mixed each day, after a change in mix design, every 30 minutes during pumping, and from each batch of LDCC from which compression test cylinders are made. Unit weight shall be determined in accordance with ASTM C567. Unit weight at the point of placement shall be within plus or minus 5 percent of the unit weight established for the mix design being placed. Adjust mix as required to obtain the specified wet density.

C. Air Content: An air content test shall be made from the first batch mixed each day, and from each batch of LDCC from which concrete compression test cylinders are made. Air content at the point of placement will be the difference between the wet density at the point of placement less the wet density at the point immediately before the addition of preformed foam. Air content shall be determined in accordance with ASTM C138 except there shall be no vibration or rodding of the sample.

D. Compression Tests: One set of four test cylinders (3 inches by 6 inches) shall be made for each shift when LDCC is placed. One additional set shall be made from each additional 200 cubic yards, or major fraction thereof, placed in any one shift. Two cylinders from each set will be tested at an age of 28 days.

1. Compressive strength of LDCC shall be considered satisfactory if both of the following requirements are met:
    a. Average of three consecutive compressive strength tests equal or exceed the specified unconfined compressive strength.

b. No individual compressive strength test (average of two cylinders) is below the specified unconfined compressive strength by more than 20 percent.

2. A strength test shall be the average of two compressive strengths of two cylinders made from the same concrete sample and tested at 28 days.
3. Test cylinders shall be made in the field, cured and stored in the laboratory, and tested in accordance with ASTM C495.
4. Each set of compression test cylinders shall be marked or tagged with the date and time of day the cylinders were made, the location in the Work where the LDCC represented by the cylinder was placed, batch number, unit weight (wet density), and the air content.

3.05 PROTECTION AND CLEANUP

A. Take all necessary precautions to protect and preserve the carrier pipe from damage.

B. Spills shall be minimized and shall be cleaned up immediately. Any damage to the pipe caused by or occurring during the backfilling operations shall be repaired by a method approved by the Engineer, at no additional cost to the Owner.

END OF SECTION

SECTION 31 79 19
OPEN FACE ROTARY WHEEL TBM TUNNELING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Furnish labor, equipment, and materials necessary for installation of a steel casing or initial ground support using an open face rotary wheel tunnel boring machine (TBM), and other associated work.

1.02 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. Where conflicts between these specifications and the referenced specification, code, or standard occur, the more restrictive specification shall govern. The publications are referenced in the text by basic designation only. Where a date is given for referenced standards, that edition shall be used. Where no date is given for referenced standards, the latest edition available on the date of issue of Contract Documents shall be used.

1. Occupational Safety and Health Administration (OSHA) Regulations and Standards for Underground Construction, 29 CFR Part 1926, Subpart S, Underground Construction, and Subpart P, Excavations.

1.03 SUBMITTALS

A. Informational Submittals:

1. Qualifications: Submit the name of the Subcontractor that will perform the tunneling work and detailed qualifying project experience for the Subcontractor, Subcontractor's superintendent, and TBM operator(s) that meet the requirements of Article Quality Assurance. In addition, submit names and training/qualifications of personnel that will perform air quality monitoring, the Site Safety Representative, and the professional Land Surveyor.
2. Quality Control Methods: Submit a description of the quality control methods proposed for the open face rotary wheel TBM operation at least 30 days prior to the start of tunneling. Include the following:
   a. Supervision: Supervisory control to ensure that Work is performed in accordance with Drawings and Specifications, and Tunneling Work Plan and Drawings.
   b. Line and Grade: Procedures for surveying, controlling, and checking line and grade, including field forms.

c. Tunneling Observation and Monitoring: Procedures for preparing and submitting daily logs of tunneling operations, including example of proposed field log forms.
d. Products and Materials: A plan for testing and submittal of test results to demonstrate compliance with the Specifications and criteria for permanent products, materials, and installations. Identify applicable standards and procedures for testing and acceptance.

3. Safety Plan: A Safety Plan for the tunneling operations.
   a. Air monitoring equipment and procedures.
   b. Provisions for lighting, ventilation, and electrical system safeguards.
   c. Protection against soil instability and groundwater inflow.
   d. Safety for tunnel and shaft access and exit including ladders, stairs, walkways, and hoists.
   e. Protection against mechanical and hydraulic equipment operations, and for lifting and hoisting equipment and material.
   f. Monitoring for hazardous gases.
   g. Means for emergency evacuation and self-rescue.
   h. Protection of shaft including traffic barriers, accidental or unauthorized entry, and falling objects.
4. Schedule: Provide a schedule for tunneling work, identifying major construction activities as independent items. Include, as a minimum, the following activities:
   a. Mobilization.
   b. “One call” or “Blue Stakes” utility locate requests and visual confirmation of all crossing utilities and parallel utilities within 10 feet laterally of the bore centerline.
   c. Surface water control at launching and receiving shafts.
   d. Shaft excavation and support.
   e. Concrete working slab construction.
   f. Thrust wall construction.
   g. TBM equipment setup.
   h. Tunneling.
   i. Contact grouting.
   j. Installation of the carrier pipe.
   k. Annular space backfill grouting.
   l. Shaft backfill.
   m. Site restoration.
   n. Cleanup.
   o. Demobilization.
   p. Include the work hours and workdays for each activity, and a written description of the construction activities.
   q. Update every 2 weeks, or more frequently if requested by the Engineer.

5. Daily Records: The following daily records shall be submitted to the Engineer by noon on the day following the shift for which the data or records were taken.
   a. Jacking Records: Provide complete jacking records to the Engineer. These records shall include, at a minimum: date, time, name of operator, tunnel crossing identification, installed casing or ring number and corresponding tunnel length, cutterhead rotation speed and torque, rate of advance for each pipe, jacking forces, spoil feed rates, line and grade offsets, any movement of the guidance system, problems with the TBM or other components or equipment, and durations and reasons for delays. Manually recorded observations should be made at intervals of not less than three feet of advance, as conditions change, and as directed by the Engineer. Submit samples of the manual jacking records at least 7 days prior to the start of tunneling.
   b. Survey Measurements: Survey measurements of casing or ground support alignment.
6. Contact Grout Reports and Records: Maintain and submit daily logs of grouting operations, including grouting locations, pressures, volumes, and grout mix pumped, and time of pumping. Note any problems or unusual observations on logs.

B. Action Submittals:

1. Open Face Rotary Wheel TBM Tunnel Operations:
   a. Submit for review a Tunneling Work Plan with complete construction drawings and written description identifying details of the proposed method of construction and the sequence of operations to be performed during construction, as required by the method of tunneling. The Drawings and descriptions shall be sufficiently detailed to demonstrate whether the proposed materials and procedures will meet the requirements of this section. The Tunneling Work Plan, including drawings, shall at a minimum include the following items:
      1) Arrangement drawings and technical specifications of the TBM and experience record with this type of machine. Include the following information concerning the TBM:
         a) Dimensions.
         b) Cutterhead arrangement with dimensions.
         c) Cutters.
         d) Thrust capacity, as applicable.
         e) Horsepower, torque, and rotational speed.
         f) Procedure for replacing cutters.
         g) Overcut.

h) Articulation and steering capability.
i) Approximate percentage of face open area.
j) Cutterhead jets/ports.
k) Arrangement of flood doors, guillotine doors, or similar.
l) Mucking system.

2) Method of maintaining and controlling line and grade of tunneling operation.
3) Method and details of spoil removal, including equipment type and numbers, processing, and disposal procedures and locations.
4) Techniques to be used for both lubrication and contact grouting including equipment, pumping and injection procedures, pressure grout types, and mixtures, in accordance with the manufacturer's recommendations.
5) Arrangement and capacity of jacking frame, if used. Include pressure versus force relationship for hydraulics to allow Engineer to determine applied jacking force.
6) Details of the tunneling / pipe jacking operation.
7) Plans for storage and handling of casing or ground support.

2. Calculations: Calculations shall be submitted in a neat, legible format. Assumptions used in calculations shall be consistent with information provided in Section 02 33 00, Tunneled Crossings. Calculations shall be prepared by Professional Engineer licensed in the State of Utah, who shall stamp and sign calculations.
   a. Design calculations demonstrating that the proposed casing in Section 33 05 01.27, Steel Casing Pipe and/or ground support is capable of supporting the maximum stresses to be imposed during jacking with the required factor of safety. The calculations shall take into account earth and hydrostatic loads, jacking forces, external loads such as live loads due to traffic and rail and any other loads that may be reasonably anticipated. Loads shall be shown and described. Include assumed maximum drive length.
   b. Calculations demonstrating that the materials behind the thrust block can transfer the maximum planned jacking forces exerted by the jacks to the ground during casing installation with the minimum factor of safety, without excessive deflection or displacement.
   c. Contact grout pressure calculations to provide sufficient pressure to fill overcut and any voids without excessive ground heave or settlement.
3. Contingency Plans: The following list includes problem scenarios that may be encountered during the tunneling operations. Submit contingency plans for dealing with each problem scenario while satisfying the specifications. These plans shall include the

observations and measurements required to clearly identify the cause of the problems.

a. Machine Unable to Advance:
   1) Insufficient auger torque or jacking capacity.
   2) Machine malfunction.
   3) Excess cutter wear or damage requiring access to replace or repair cutters.
b. Spoil Feed Problems:
   1) Strong hydrocarbon smell is detected in the spoils or in the shaft.
   2) Rock fragment jamming cutterhead and/or mucking system.
c. Jacking Forces:
   1) Jacking forces increase dramatically or suddenly.
   2) Jacking forces reach design capacity of casing, jacking frame, or thrust wall (treat these scenarios as separate incidents).
d. Settlement and Subsidence:
   1) Survey measurements indicate deformations exceed allowable limits as defined in Section 31 80 00, Geotechnical Instrumentation.
   2) Excavated volumes with appropriate bulking factors exceed casing volume installed by over 20 percent.
e. Line and grade tolerances being exceeded.
   1) Laser distorted by heat, humidity, or physical disturbance.
f. Pipe has been damaged or has been found to be out of compliance with Specifications during, or after installation.
g. Thrust block deforms excessively under jacking loads, or provides insufficient capacity to advance casing.

4. Abandonment Contingency Plan: Prepare an approved Abandonment-Recovery Contingency Plan as required in Section 02 33 00, Tunneled Crossings. Follow provisions of the approved Plan.
5. Contact Grout Work Plan and Methods:
   a. Submit Work plan, for each type of contact grouting required, including contact grouting methods and details of equipment, grouting procedures and sequences, injection pressures, monitoring and recording equipment, pressure gauge calibration data, methods of controlling grout pressure, method of transporting grouting equipment and materials within the casing or ground support, and provisions to protect interior of casing and shaft supports.
   b. Submit details of grout mix proportions, admixtures, including manufacturers' literature, and laboratory test data verifying the strength of the proposed grout mix.

1.04 DEFINITIONS

A. Open Face Rotary Wheel TBM Tunneling: A steerable tunneling or pipe jacking process that utilizes an open face rotary wheel TBM with a rotating cutterhead for excavation and a conveyor belt and muck car spoil removal system. The TBM may be jacked at the leading end of steel casing pipe or jacked from the last segment of installed ground support.

B. Open Face Rotary Wheel TBM: Steerable tunneling shield that achieves soil excavation by means of a rotating cutter-wheel. TBM operations are usually performed from within the TBM, and excavated soil is discharged to a conveyor or muck car where it is transported to the ground surface for disposal. The guidance system consists of a laser or theodolite and EDM device mounted in the launching shaft communicating a reference line to a target mounted in the TBM's articulated steering head. The target in the TBM provides the operator with information about machine attitude and pitch, and allows for accurate steering control.

C. Carrier Pipe: As defined in Section 31 79 25, Guided Auger Boring.

D. Casing: As defined in Section 31 79 25, Guided Auger Boring except it is installed by open face rotary wheel tunneling and pipe jacking.

E. Ground Support: Earth support consisting of smooth four-flange steel tunnel liner plate placed during or immediately after excavation from within the TBM to stabilize the ground until the final support is installed.

F. Final Support: Carrier pipe, backfill grout, ground support, and contact grout.

G. Grout Port: A threaded port located within the casing or ground support. During tunneling, the port will be sealed with a threaded plug. During contact grouting, the port will be fitted with a one-way valve for injection of grout into the annular space between the casing or ground support and the ground.

H. Jacking Record: A manually recorded report that contains information on TBM operations and may include date, time, name of operator, tunnel crossing identification, installed tunnel length, rate of advance, jacking forces, spoil production rates, line and grade offsets, any movement of the guidance system, problems encountered with the TBM or other components or equipment, and durations and reasons for delays.

I. Settlement Monitoring Point: Survey points, as defined in Section 31 80 00, Geotechnical Instrumentation. Re-survey the point periodically to monitor ground movements, as specified.

J. Radial Overcut: As defined in Section 02 33 00, Tunneled Crossings.

1.05 DESIGN CRITERIA

A. Open Face Rotary Wheel TBM:

1. Select tunneling and pipe jacking equipment suitable for and capable of efficiently advancing through the geologic conditions defined in the GBR contained in Section 02 33 00, Tunneled Crossings, and the geologic conditions anticipated by the Contractor.
2. The cutterhead shall have a reversible drive system so that it can rotate in either direction.
3. Provide lubrication injection system to inject pipe lubricant around the casing to reduce functional resistance. Lubrication materials may include a mixture of bentonite and/or polymers and water.

B. Utilize methods and equipment to control surface settlement and heave above the pipeline to prevent damage to existing utilities, facilities, and improvements. Limit ground movements (settlement/heave) to values that do not cause damage or distress to surface features, utilities, or improvements. In no case shall settlements exceed the applicable values listed in Section 31 80 00, Geotechnical Instrumentation. Comply with the requirements of Section 31 80 00, Geotechnical Instrumentation.

C. Design casing and ground support for jacking loads, dead loads, and live loads and acceptable fabrication tolerances. Maximum jacking loads applied to the casing shall not exceed 50 percent of the ultimate compressive strength of the casing material or the maximum design strength of the casing or ground support as established by the manufacturer, whichever is lower.

D. The maximum radial overcut for each crossing is specified in Section 02 33 00, Tunneled Crossings.

E. If required, use a thrust block to transfer jacking loads to the soil behind the launching shaft. Construct the thrust block perpendicular to the proposed casing alignment. Design the thrust block to withstand the maximum jacking forces developed by the main jacks, without excessive deflection or displacement. Do not exceed the allowable passive earth pressure, with a minimum factor of safety of 2.0 of forces applied to the soil.

1.06 QUALITY CONTROL

A. Grout Strength Tests: Prepare and test in accordance with the requirements of Section 31 79 25, Guided Auger Boring.

1.07 QUALITY ASSURANCE

A. Perform open face rotary wheel TBM tunneling, and pipe jacking work, if applicable, by prequalified tunneling Subcontractor.

B. Provide a Site Safety Representative and personnel responsible for air quality monitoring experienced in tunnel construction.

C. Provide a professional Land Surveyor licensed in the State of Utah who has prior experience in similar underground projects to be responsible for line-and-grade control.

D. Provide at least 72 hours advance written notice to Engineer of the start of the tunneling. Immediately notify the Engineer, in writing, when any problems are encountered with equipment or materials, or if the conditions encountered are materially and significantly different than those represented within the Contract Documents. Perform Work in the presence of the Engineer, unless the Engineer grants prior written approval to perform such Work in Engineer's absence.

E. Allow access to the Engineer and furnish necessary assistance and cooperation to aid the Engineer in observations, measurements, data, and sample collection, including, but not limited to the following:

1. Allow Engineer access to the launching and reception shafts prior to, during, and following jacking operations. This shall include, but not be limited to, visual inspection of installed casing and verification of line and grade. Provide safe access in accordance with safety regulations.
2. Allow Engineer full access to the spoil material. Allow the Engineer to collect soil samples from the spoil removal system a minimum of once per installed casing section, or every 8 feet, whichever is more often, and at any time when changes in soil conditions or obstructions are apparent or suspected.

1.08 SAFETY

A. Be responsible for safety on the Jobsite. Ensure the safety of the Work, personnel onsite, and the public. Perform Work in accordance with current applicable regulations and safety requirements of the federal, state, and local agencies. Comply with applicable provisions of 29 CFR Part 1926, Subpart S, Underground Construction and Subpart P, Excavations, by OSHA.

B. No gasoline powered equipment is permitted in launching and receiving shafts and pits. Diesel, electrical, hydraulic, and air powered equipment is acceptable, subject to applicable local, state, and federal regulations.

C. Furnish and operate a temporary ventilation system in accordance with applicable safety requirements when personnel are in the shaft or in the casing. Perform required air and gas monitoring. Provide a ventilation system sufficient to supply fresh air and maintain an atmosphere free of toxic or flammable gasses in underground Work areas.

PART 2 PRODUCTS

2.01 MATERIALS

A. Carrier Pipe: Pipe used as a carrier pipe, to be installed inside a jacked steel casing pipe or tunneled ground support, shall conform to Section 33 05 01.01, Welded Steel Pipe and Fittings.

B. Steel Casing Pipe: Steel casing to be installed by pipe jacking to serve as continuous casing for carrier pipe shall conform to Section 33 05 01.27, Steel Casing Pipe.

C. Tunnel Liner Plate:

1. Tolerances:
    a. Variation in thickness of liner plates: Maximum, plus or minus 0.01 inch.
    b. Variation in Erected Outside Diameter: Plus or minus 1 inch, sized to maximize outside diameter within the tail shield and in consideration of the maximum allowable radial overcut and shield dimensions.
2. Fabricate similar segments to be interchangeable in individual rings in similar segments of other rings.
3. Space holes accurately so two rings may be bolted in any relative position with same size bolts in every bolt hole.
4. Tolerance of Diameter to Bolt Holes: Plus or minus 0.02 inch from specified diameter.
5. Replace segments not complying with tolerances indicated.
6. Steel Liner Skin: ASTM A569.
    a. Use liner plate steel with minimum mechanical properties of flat plate before cold forming:
        1) Tensile Strength: 42,000 psi.
        2) Yield Strength: 28,000 psi.
        3) Elongation, 2 Inches: 30 percent.
        4) Minimum liner plate thickness shown on Drawings.
    b. Contractor to increase liner plate thickness or provide bracing to withstand jacking force to be imposed as necessary.
    c. Use smooth liner plates of four-flange type.
    d. Manufacturers:
        1) DSI-American Commercial, Inc.
        2) Contech Construction Products, Inc.

7. Bolts and Nuts: ASTM A307, Grade A, with rolled threads on bolts.
8. Grout Holes for Each Ring of Liner Plate: Unless otherwise indicated on Drawings, use two minimum per ring.

D. Contact Grout: Per Article Materials of Section 31 79 25, Guided Auger Boring.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Do not begin TBM tunneling until the following tasks have been completed:

1. Required Submittals have been provided, reviewed, and approved.
2. Launching shaft and receiving shaft excavations and support systems have been completed in accordance with approved Submittals. Locations and elevations of shafts shall have been surveyed to confirm that Work can be completed in accordance with alignment and grade shown on Drawings.
3. Settlement monitoring points have been installed and baseline measurements established.
4. The location, orientation and grade of the jacking frame or launch cradle has been surveyed to ensure it is on the proper line and grade and to verify that it is properly supported. Take special care when setting the jacking frame or launch cradle in the launching shaft to ensure stability and accuracy of the alignment and grade. Securely attach jacking frame to a concrete working slab, with supplementary concrete or grout if necessary, to prevent movement or shifting during the Work.
5. Complete startup inspection of mechanical and hydraulic systems associated with tunneling operations. Test the system on the surface to ensure that the open face rotary wheel TBM and supporting equipment is functioning properly.

B. Do not discharge surface water inflows into storm sewers, sanitary sewers, drainage ditches, water bodies, or streets without an approved discharge permit.

C. Conduct operations such that trucks and other vehicles do not interfere with traffic or create a mud, dust, or noise nuisance in the streets and to adjacent properties. Promptly clean up, remove, and dispose of mud and spoils spillage, and any material discharges.

D. Conduct Work so as not to disturb roadways, adjacent structures, landscaped areas, or existing utilities. Repair damage immediately to original or better condition and to the satisfaction of Engineer.

E. Operate with a full crew 24 hours a day whenever the tunnel face is within UPRR ROW and when there is a condition that is likely to endanger the stability of the excavation or adjacent structures, including weekends and holidays, without interruption, until those conditions no longer jeopardize stability.

3.02 JACKING OPERATIONS

A. Provide a concrete working slab at the base of the excavation and securely anchor the rails or guides to the working slab. Provide a suitable jacking frame and thrust block to perform the Work.

B. Transport the casing pipe from storage to the launching shaft without damage. Transport methods shall be acceptable to casing manufacturer. Do not use damaged casing pipe in the Work, unless permitted in writing by the Engineer. Set the casing on a properly braced and supported jacking frame.

C. Distribute the axial forces from the thrust jacks to the casing uniformly through a thrust ring and cushion material, if applicable, to prevent damage to the ends of the pipe. Do not exceed the specified allowable compressive stresses on the casing.

D. Jack casing into position following the design line and grade without damaging casing.

3.03 OPEN FACE ROTARY WHEEL TBM TUNNELING

A. Complete the open face rotary wheel TBM tunneling in accordance with approved Submittals, and applicable permit conditions.

B. Control surface settlement and heave above the pipeline to prevent damage to existing utilities, facilities, and improvements. Repair damage resulting from construction activities. Pressure grout voids caused by or encountered during the shaft construction and tunneling. Modify equipment and procedures as required to avoid recurrence of excessive settlements or damage.

C. Control the advance of the shield so as to restrict the excavation of the materials to a volume equal to the shield and pipe jacked or ground support installed, plus allowance for the allowable radial overcut, to prevent loss of ground and settlement or possible damage to overlying structures. Control the advance rate and monitor the volume of material excavated and adjust advance rate, as required, to avoid loss of ground, overexcavation, or surface heave.

3.04 GROUND SUPPORT

A. Install ground support within the tail of the shield in accordance with manufacturer's recommendations to provide a safe and stable opening through which to install the carrier pipe.

B. Do not expose the excavation support to the ground until it is fully assembled.

C. Provide additional bracing as required to provide resistance to axial jacking forces.

3.05 CONTROL OF LINE AND GRADE

A. Establish and protect benchmarks as necessary prior to the start of construction.

B. After establishing required benchmarks, use these benchmarks to furnish and maintain reference lines and grades for tunneling. Use these lines and grades to establish the location of the TBM using a laser or theodolite guidance system. Submit to Engineer copies of field notes used to establish all lines and grades and allow Engineer to check guidance system setup prior to beginning each TBM drive. Provide access for Engineer to perform survey checks of guidance system and line-and-grade of casing as necessary. Be fully responsible for the accuracy of the Work and the correction of it, as required.

C. Install the casing and ground support in accordance with the following tolerances:

1. Variations from Design Line: 4 inches maximum.
2. Variations from Design Grade: 4 inches maximum.
3. Installed casing pipe or ground support shall be straight to allow carrier pipe to be installed with a minimum of 2 inches of clearance between outside of carrier pipe and inside of casing pipe or flanges of ground support and to accommodate installation of fiber optic conduits.

D. Control the TBM advancement to maintain line and grade within the tolerances specified. If the installation is off line or grade, attempt to make the necessary corrections, as identified in the submitted and approved contingency plans.

E. Mount the guidance system independently from the thrust block and jacking frame. Stop tunneling operations and reset guidance system if its alignment shifts or is moved off design alignment and grade. Check guidance system setup at least once per shift. Guidance system should only be reset by experienced, competent surveying personnel in accordance with approved procedures outlined in the Submittals.

F. Monitor line and grade continuously during tunneling operations. Record deviation with respect to design line and grade at least once per foot and submit records to Engineer as requested. Control line and grade of the casing and ground support to within the specified tolerances.

G. Correct the installation, including any necessary redesign of the pipeline or structures and acquisition of necessary easements, if the casing installation does not meet the specified tolerance. Performance of corrective work is subject to the written approval of the Engineer.

3.06 CONTACT GROUTING EQUIPMENT

A. In accordance with the requirements of Article Contact Grouting Equipment of Section 31 79 25, Guided Auger Boring.

3.07 MIXING AND INJECTION OF CONTACT GROUT

A. In accordance with the requirements of Article Mixing and Injection of Contact Grout of Section 31 79 25, Guided Auger Boring.

3.08 CONTACT GROUTING

A. In accordance with the requirements of Article Contact Grouting of Tunneled Casing of Section 31 79 25, Guided Auger Boring.

3.09 INSTALLATION OF CARRIER PIPE

A. Installation of carrier pipe within the casing and ground support and backfilling of annular space between the casing and ground support and carrier shall be in accordance with Section 31 60 00, Installation of Carrier Pipe in Ground Support and Casing.

3.10 CLEANUP

A. After completion of tunneling and carrier pipe installation, remove construction debris, spoils, oil, grease, and other materials from the tunneled casing, launching and receiving shafts, and Work areas.

B. Contractor shall restore the existing surfaces to preconstruction conditions.

END OF SECTION

SECTION 31 79 25
GUIDED AUGER BORING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Furnish labor, equipment, and materials necessary for guided auger boring installation of a steel casing, and other associated work.

1.02 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. Where conflicts between these specifications and the referenced specification, code, or standard occur, the more restrictive specification shall govern. The publications are referenced in the text by basic designation only. Where a date is given for referenced standards, that edition shall be used. Where no date is given for referenced standards, use the latest edition available on the date of issue of Contract Documents.

1. Occupational Safety and Health Administration (OSHA) Regulations and Standards for Underground Construction, 29 CFR Part 1926, Subpart S, Underground Construction, and Subpart P, Excavations.

1.03 SUBMITTALS

A. Informational Submittals:

1. Qualifications: Submit the name of the Subcontractor that will perform the auger boring tunneling work and detailed qualifying project experience for the Subcontractor, Subcontractor's superintendent, and auger boring machine operator(s) that meet the requirements of Article Quality Assurance. In addition, submit names and training/qualifications of personnel that will perform air quality monitoring, the Site Safety Representative, and the professional Land Surveyor.
2. Quality Control Methods: Submit a description of the quality control methods proposed for the auger boring operation at least 30 days prior to the start of tunneling. Include the following:
   a. Supervision: Supervisory control to ensure that Work is performed in accordance with Drawings and Specifications, and Auger Boring Work Plan and Drawings.
   b. Line and Grade: Procedures for surveying, controlling and checking line and grade, including proposed field forms.

c. Auger Boring Observation and Monitoring: Procedures for preparing and submitting daily logs of auger boring operations, including examples of proposed field log forms.
d. Products and Materials: A plan for testing and submittal of test results to demonstrate compliance with the Specifications and Contractor's criteria for permanent products, materials, and installations. Identify applicable standards and procedures for testing and acceptance.

3. Safety Plan: A Safety Plan for the auger boring tunneling operations including air monitoring equipment and procedures, and provisions for lighting, ventilation, and electrical system safeguards. The plan should also include at a minimum:
   a. Protection against soil instability and groundwater inflow.
   b. Safety for tunnel and shaft access and exit including ladders, stairs, walkways, and hoists.
   c. Protection against mechanical and hydraulic equipment operations, and for lifting and hoisting equipment and material.
   d. Monitoring for hazardous gases.
   e. Means for emergency evacuation and self-rescue.
   f. Protection of shaft including traffic barriers, accidental or unauthorized entry, and falling objects.
4. Schedule: Provide a schedule for auger boring tunneling work, identifying major construction activities as independent items. Include, as a minimum, the following activities: mobilization, "One call" or "Blue Stakes of Utah" utility locate requests and visual confirmation of crossing utilities and parallel utilities within 10 feet laterally of the bore centerline, surface water control at launching and receiving shafts, shaft excavation and support, concrete working slab construction, thrust wall construction, guided boring equipment setup, installation of the temporary guide casing, augering equipment setup, auger boring, contact grouting, installation of the carrier pipe inside auger bored casing, annular space backfilling, shaft backfill, Site restoration, cleanup, and demobilization. Include the work hours and workdays for each activity, and a written description of the construction activities. The schedule will be reviewed by the Engineer. Update every 2 weeks, or more frequently if requested by the Engineer.
5. Daily Records: Submit the following daily records to Engineer by noon on the day following the shift for which the data or records were taken.
   a. Daily Logs: Provide complete jacking records to the Engineer. Include, at a minimum, date, time, name of operator, tunnel crossing identification, installed pipe number and corresponding tunnel length, auger rotation speed and torque, rate of advance for each pipe, jacking forces, line and grade offsets, any damage to the guidance system, problems with the

auger boring machine or other components or equipment, and durations and reasons for delays. Make manually recorded observations at intervals of not less than 10 feet of advance, as conditions change, and as requested by the Engineer.

b. Survey Measurements: Survey measurements of casing alignment.

6. Contact Grout Reports and Records: Maintain and submit daily logs of grouting operations, including grouting locations, pressures, volumes, and grout mix pumped, and time of pumping. Note any problems or unusual observations on logs.

B. Action Submittals:

1. Auger Boring Tunnel Operations:
   a. Submit for review an Auger Boring Work Plan with complete Contractor's construction drawings and written description identifying details of the proposed method of construction and the sequence of operations to be performed during construction, as required by the method of tunneling. Sufficiently detail Drawings and descriptions to demonstrate to the Engineer whether the proposed materials and procedures will meet the requirements of this section. Include the following items, at a minimum, in the Auger Boring Work Plan (including Drawings):
      1) Arrangement drawings and technical specifications of the guided boring machine and auger boring machine and experience record with these types of machines. Include the following information concerning the machines:
         a) Dimensions.
         b) Cutterhead position relative to casing.
         c) Casing and band diameters.
         d) Torque, speed, and thrust.
         e) Auger and muck casing diameters.
         f) Procedure for replacing cutters.
         g) Overcut.
      2) Method of maintaining and controlling line and grade of tunneling operation.
      3) Method and details of spoil removal, including equipment type and numbers, processing, and disposal procedures and locations.
      4) Techniques to be used for both lubrication and contact grouting including equipment, pumping and injection procedures, pressure grout types, and mixtures, in accordance with the manufacturer's recommendations.
      5) Details of the auger boring method and operation.

6) Plans for storage and handling of casing.
7) Plans for disposal of any pipe lubricants (if used).

2. Calculations: Submit calculations in a neat, legible format. Ensure that the assumptions used in calculations are consistent with information provided in Section 02 33 00, Tunneled Crossings. Provide calculations prepared by and stamped and signed by a Professional Engineer licensed in the State of Utah.
   a. Submit design calculations demonstrating that the casing proposed in Section 33 05 01.27 Steel Casing Pipe is capable of supporting the maximum stresses to be imposed during jacking and final operation with the required factor of safety. Take into account earth and hydrostatic loads, jacking forces, external loads such as live loads due to traffic and trains, and any other loads that may be reasonably anticipated. Show and describe loads. Include assumed maximum drive length.
   b. Submit calculations demonstrating that the soils behind the thrust block / backstop can transfer the maximum planned jacking forces exerted by the jacks to the ground during pipe installation with the minimum factor of safety, without excessive deflection or displacement.
   c. Submit contact grout pressure calculations to provide sufficient pressure to fill overcut and any voids without causing excessive ground heave or settlement.
3. Contingency Plans: The following list includes problem scenarios that may be encountered during the auger boring operations. Submit contingency plans for dealing with each problem scenario while satisfying the specifications. Include the observations and measurements required to clearly identify the cause of the problems.
   a. Machine Unable to Advance:
      1) Insufficient auger torque or jacking capacity.
      2) Machine malfunction.
      3) Excess cutter wear or damage requiring access to replace or repair cutters.
      4) Cobbles or boulders present at the face.
   b. Spoil Feed Problems:
      1) Strong hydrocarbon smell is detected in the spoils or in the shaft.
      2) Cobble or boulder jamming auger mucking system.
   c. Jacking Forces:
      1) Jacking forces increase dramatically or suddenly.
      2) Jacking forces reach design capacity of casing, jacking frame, or thrust wall (treat these scenarios as separate incidents).

d. Settlement and Subsidence:
   1) Survey measurements indicate deformations exceed allowable limits as defined in Section 31 80 00, Geotechnical Instrumentation.
   2) Excavated volumes with appropriate bulking factors exceed casing volume installed by over 20 percent.
e. Line and grade tolerances being exceeded.
   1) Laser distorted by heat, humidity, or physical disturbance.
f. Pipe has been damaged or has been found to be out of compliance with Specifications during, or after installation.
g. Thrust block (if used) deforms excessively under jacking loads, or provides insufficient capacity to advance casing.

4. Abandonment Contingency Plan: Prepare and obtain approval for Abandonment Contingency Plan as required in Section 02 33 00, Tunneled Crossings. Follow the provisions of the approved Plan.
5. Contact Grout Work Plan and Methods:
   a. Submit Work plan, for each type of grouting required, including contact grouting methods and details of equipment, grouting procedures and sequences, injection pressures, monitoring and recording equipment, pressure gauge calibration data, methods of controlling grout pressure, method of transporting grouting equipment and materials within the casing pipe, and provisions to protect interior of casing pipe and shaft supports.
   b. Submit details of grout mix proportions, admixtures, including manufacturers' literature, and laboratory test data verifying the strength of the proposed grout mix.

1.04 DEFINITIONS

A. Guided Auger Boring: A guided, three-stage pipe jacking process that accurately installs a casing pipe to line and grade by use of a guided boring machine, followed by upsizing to install a temporary casing pipe using a process of reaming and muck transport via auger, and ultimately followed by the installation of the final casing pipe to replace the temporary casing. In no case shall use of a Boring Machine Tunnel Attachment (BMTA) be considered guided auger boring.

B. Guided Boring Machine: Remote-controlled, guided boring and augering process. The guided boring machine is operated from within the launching shaft. Soil excavation is achieved by a rotating reamer or powered cutter head and augers. The guidance system consists of a laser, or LED device installed in the pilot tube head to communicate with a theodolite mounted in the launching shaft. By monitoring the target at the head of the pilot tube the system provides the operator with accurate steering control.

C. Auger Boring: Auger boring technique using an auger boring machine to bore a hole and remove spoil via auger flights and jacks to advance steel casing pipe. The augers shall be securely attached to a temporary casing installed by a guided boring machine. In no case shall unguided auger boring be used.

D. Carrier Pipe: Permanent pipe for operational use that is used to convey water.

E. Casing Pipe: A steel pipe installed by guided auger boring that supports the ground and provides a stable underground excavation for the installation of a carrier pipe.

F. Grout Port: A threaded port located within the casing pipe. During augering, seal the port with a threaded plug. During contact grouting fit the port with a one-way valve for injection of grout into the annular space between the casing and the ground.

G. Jacking Record: A manually recorded report that contains information on auger boring operations and may include date, time, name of operator, tunnel crossing identification, installed tunnel length, rate of advance, jacking forces, spoil production rates, torque, rotation speed, line and grade offsets, any movement of the guidance system, problems encountered with the guided boring machine and auger boring machine or other components or equipment, and durations and reasons for delays.

H. Settlement Monitoring Point: as defined in Section 31 80 00, Geotechnical Instrumentation. Re-survey the point periodically to monitor ground movements, as specified.

I. Radial Overcut: As defined in Section 02 33 00, Tunneled Crossings.

1.05 DESIGN CRITERIA

A. Guided Boring Equipment:

1. Only guided boring equipment using auger spoil removal with reamers or powered cutter heads shall be used for all guided boring work required for this Project as defined in Article Definitions. The guided boring machine shall be manufactured by Akkerman, Wirth/Soltau, Bohrtec, Vermeer, or approved alternate company that specializes in the design and fabrication of this type of equipment.
2. Guided boring equipment selected for the Project shall be suitable for and capable of efficiently advancing through the geologic conditions defined in the GBR and anticipated by the Contractor.
3. The guided boring shall be steerable in both the vertical and horizontal directions to allow the operator to maintain line and

grade within the specified tolerances. The guidance system shall be designed to function at the maximum required drive length without loss of accuracy or reliability of function. A display showing the position of the machine in relation to design line-and-grade shall be provided at the control panel to allow the operator to continuously monitor line and grade deviations.

4. A lubrication injection system may be provided to inject pipe lubricant around the guided boring machine, pilot tube, and temporary casing pipe to decrease frictional resistance. Lubrication materials may include a mixture of bentonite and/or non-toxic polymers and water.

B. Auger Boring Equipment:

1. Select guided boring and auger boring equipment suitable for and capable of efficiently advancing through the geologic conditions defined in the GBR contained in Section 02 33 00, Tunneled Crossings, and the geologic conditions anticipated by the Contractor.
2. Provide the auger or cutterhead with a reversible drive system so that it can rotate in either direction.
3. If required, provide a lubrication injection system to inject pipe lubricant around the head casing, and casing to reduce frictional resistance. Lubrication materials may include a mixture of bentonite and/or non-toxic polymers and water.

C. Utilize methods and equipment to control surface settlement and heave above the pipeline to prevent damage to existing utilities, facilities, and improvements. Limit ground movements (settlement/heave) to values that do not cause damage or distress to surface features, utilities, or improvements. In no case shall settlements exceed the applicable values listed in Section 31 80 00, Geotechnical Instrumentation. Comply with the requirements of Section 31 80 00, Geotechnical Instrumentation.

D. Design casing for jacking loads and acceptable fabrication tolerances. Do not exceed 50 percent of the ultimate compressive strength of the casing material or the maximum design strength of the casing as established by the manufacturer, whichever is lower for the maximum jacking loads applied to the casing. Include grout ports for each casing as specified in Section 33 05 01.27, Steel Casing Pipe.

E. The maximum radial overcut for each crossing is presented in Section 02 33 00, Tunneled Crossings.

F. Use a thrust block to transfer jacking loads to the soil behind the launching shaft. Construct the thrust block face perpendicular to the proposed casing alignment. Design the thrust block to withstand the maximum jacking forces developed by the main jacks, without excessive deflection or displacement. Do not exceed the allowable passive earth pressure, with a minimum factor of safety of 2.0 of forces applied to the soil.

1.06 QUALITY CONTROL

A. Grout Strength Tests: Prepare samples for 24-hour and 28-day compressive strength tests according to ASTM C31 for cylinders or ASTM C109 for cubes. Prepare cylinder molds at least 2 inches in diameter and 4 inches long. Prepare grout cubes either 2 inches or 50 millimeters square. Test samples according to ASTM C39 or ASTM C109 as applicable. Take grout for the cylinders or cubes from the nozzle of the contact grout injection line. Provide at least one set of four samples for each 100 cubic feet of grout injected but not less than one set for each grouting shift, unless directed otherwise by the Engineer.

1.07 QUALITY ASSURANCE

A. Perform auger boring tunneling work by a qualified tunneling Subcontractor.

B. Provide a Site Safety Representative and personnel responsible for air quality monitoring experienced in tunnel construction.

C. Provide a professional Land Surveyor licensed in the State of Utah who has prior experience in similar underground projects to be responsible for line-and-grade control.

D. Provide at least 72 hours’ advance written notice to Engineer of the start of the guided auger boring. Notify immediately the Engineer, in writing, when problems are encountered with equipment or materials, or if the conditions encountered are materially and significantly different than those represented within the Contract Documents. Perform Work in the presence of the Engineer, unless the Engineer grants prior written approval to perform such Work in Engineer’s absence.

E. Allow access to the Engineer and furnish necessary assistance and cooperation to aid the Engineer in observations, measurements, data, and sample collection, including, but not limited to the following:

1. Allow Engineer full access to the launching and receiving shafts prior to, during, and following jacking operations. Access includes, but is not to be limited to, visual inspection of installed casing and verification of line and grade. Provide safe access in accordance with safety regulations.
2. Allow Engineer full access to the spoil material. Allow the Engineer to collect soil samples from the spoil removal system a minimum of once per installed casing section, or every 8 feet, whichever is more

often, and at any time when changes in soil conditions or obstructions are apparent or suspected.

1.08 SAFETY

A. Be responsible for safety on the Jobsite. Utilize methods of construction to ensure the safety of the Work, personnel onsite, and the public. Perform Work in accordance with current applicable regulations and safety requirements of the federal, state, and local agencies. Comply with applicable provisions of 29 CFR Part 1926, Subpart S, Underground Construction and Subpart P, Excavations, by OSHA.

B. No gasoline powered equipment is permitted in launching and receiving shafts. Diesel, electrical, hydraulic, and air powered equipment is acceptable, subject to applicable local, state, and federal regulations.

C. Furnish and operate a temporary ventilation system in accordance with applicable safety requirements when personnel are in the casing. Perform required air and gas monitoring. Provide a ventilation system to provide a sufficient supply of fresh air and maintain an atmosphere free of toxic or flammable gasses in underground Work areas.

PART 2 PRODUCTS

2.01 MATERIALS

A. Carrier Pipe: Pipe used as a carrier pipe, to be installed inside a jacked steel casing pipe, shall conform to Section 33 05 01.01, Welded Steel Pipe and Fittings.

B. Steel Casing Pipe: Steel casing to be installed by guided auger boring to serve as continuous casing for carrier pipe shall conform to Section 33 05 01.27, Steel Casing Pipe.

C. Contact Grout:

1. Cement: Cement shall be Type II or Type V portland cement conforming to ASTM C150. Type II cement shall meet Table 4 false set requirements of ASTM C150.
2. Bentonite: Bentonite shall be a commercially processed powdered bentonite, Wyoming type, such as Baroid, Imacco-gel, and Black Hills.

3. Sand: Conform to ASTM C144 except where modified in the following subparagraphs.
   a. Fineness Modulus: Between 1.50 and 2.00.
   b. Grading Requirements:

Sieve Sizes	Percentage Passing by Weight
No. 8	100
No. 16	95 - 100
No. 30	60 - 85
No. 50	20 - 50
No. 10	10 - 30
No. 200	0 - 5

4. Fluidifier: Fluidifiers shall hold the solid constituents of the grout in colloidal suspension, be compatible with the cement and water used in the grouting work, and comply with the requirements of ASTM C937.
5. Admixtures: Other admixtures may be used subject to the written approval of the Engineer to improve the pumpability, to control set time, to hold sand in suspension, and to prevent segregation and bleeding.
6. Probe the portal eye before cutting and take any additional measures to ensure face stability and control of any present groundwater.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Do not begin guided auger boring until the following tasks have been completed:

1. Required Submittals have been provided, reviewed, and approved.
2. Launching shaft and receiving shaft excavations and support systems have been completed in accordance with approved Submittals. Locations and elevations of shafts have been surveyed to confirm that Work can be completed in accordance with alignment and grade shown on Drawings.
3. Settlement monitoring points have been installed and baseline measurements established and submitted to the Engineer.
4. The location, orientation and grade of the jacking frame or guide rails have been surveyed to ensure they are on the proper line and grade and to verify that they are properly supported. Take special care when setting the guide rails or jacking frame in the launching

shaft to ensure stability and accuracy of the alignment and grade. Securely attach guide rails or jacking frame to a concrete working slab, with supplementary concrete or grout if necessary, to prevent movement or shifting during the Work.

5. A startup inspection of mechanical and hydraulic systems associated with the auger boring tunneling operations has been completed. Test the system on the surface to ensure that the auger boring tunneling machine and supporting equipment is functioning properly.

B. Do not discharge surface water inflows into storm sewers, sanitary sewers, drainage ditches, water bodies, or streets without an approved discharge permit.

C. Conduct operations such that trucks and other vehicles do not interfere with traffic or create a mud, dust, or noise nuisance in the streets and to adjacent properties. Promptly clean up, remove, and dispose of mud and spoils spillage, and any material discharges.

D. Conduct Work so as not to disturb roadways, adjacent structures, landscaped areas, or existing utilities. Repair damage immediately to original or better condition and to the satisfaction of Engineer.

E. Operate with a full crew 24 hours a day whenever the tunnel face is within UPRR ROW and when there is a condition that is likely to endanger the stability of the excavation or adjacent structures, including weekends and holidays, without interruption, until those conditions no longer jeopardize stability.

3.02 JACKING OPERATIONS

A. Provide a concrete working slab at the base of the excavation and securely anchor the rails or guides to the working slab. Provide a suitable jacking frame and thrust block (if required) to perform the Work.

B. Transport the casing pipe from storage to the launching shaft without damage. Utilize transport methods acceptable to casing manufacturer. Do not use damaged casing pipe in the Work, unless permitted in writing by the Engineer. Set the casing on properly braced and supported guide rails or jacking frame.

C. Distribute the axial forces from the thrust jacks to the casing uniformly through a thrust ring and cushion material, if applicable, to prevent damage to the ends of the pipe. Do not exceed the specified allowable compressive stresses for the jacking forces applied to the casing.

D. Jack casing into position following the design line and grade without damaging the casing.

3.03 AUGER BORING TUNNELING

A. Complete guided auger boring tunneling completed in accordance with approved Submittals, and applicable permit conditions.

B. Do not start auger boring until temporary guide casing has been installed from launching shaft to receiving shaft and surveyed to demonstrate to the Engineer that the temporary guide casing has been installed within the tolerances specified herein. The size of the temporary guide casing shall be per the Contractor, except that it shall not be smaller than 12 inches in outside diameter.

C. Conduct auger boring operations to control surface settlement and heave above the pipeline to prevent damage to existing utilities, facilities, railroad, and improvements. Repair damage resulting from construction activities. Pressure grout voids caused by or encountered during the shaft construction and auger boring tunneling. Modify equipment and procedures as required to avoid recurrence of excessive settlements or damage.

D. Control the advance of the auger and casing so as to restrict the excavation of the materials to a volume equal to the pipe jacked plus allowance for the allowable radial overcut, to prevent loss of ground and settlement or possible damage to overlying structures. Control the advance rate and monitor the volume of material excavated and adjust advance rate, as required, to avoid loss of ground, overexcavation, or surface heave.

E. Completely contain, transport, and dispose of excavated materials and fluid additives away from the construction site. Contain spoils in trucks or other containers. Dumping of spoil on the ground, discharge into sewers or ditches, or discharge into the shafts is not permitted. Only use the disposal sites identified in approved Submittals for muck and spoil disposal.

F. Contact Grouting: After casing installation is complete, fill the annular space created by the radial overcut of the machine with contact grout.

3.04 CONTROL OF LINE AND GRADE

A. Establish and protect benchmarks as necessary prior to the start of construction.

B. After establishing required benchmarks, use these benchmarks to furnish and maintain reference lines and grades for guided auger boring. Use these lines and grades to establish the exact location of the casing using a laser or theodolite guidance system. Submit to Engineer copies of field notes used to establish lines and grades and allow Engineer to check guidance system setup prior to beginning each auger boring tunneling drive. Provide access for Engineer to perform survey checks of guidance system and line-and-grade of casing as necessary. Be fully responsible for the accuracy of the Work and the correction of it, as required.

C. Install the casing in accordance with the following tolerances:

1. Variations from Design Line: 4 inches.
2. Variations from Design Grade: 4 inches.
3. Installed casing pipe shall be straight to allow carrier pipe to be installed with a minimum of 2 inches of clearance between outside of carrier pipe to inside of casing pipe and to accommodate installation of fiber optic conduits.

D. Control the auger and casing advancement to maintain line and grade within the tolerances specified. If the installation is off line or grade, attempt to make the necessary corrections, as identified in the Contractor's Contingency Plans.

E. Mount the guidance system independently from the thrust block (if used) and jacking frame to maintain alignment if there is movement of equipment during jacking. Stop auger boring operations and reset guidance system if its alignment shifts or is moved off design alignment and grade for any reason. Check guidance system setup at least once per shift. Guidance system should only be reset by experienced, competent surveying personnel in accordance with approved procedures outlined in the Submittals.

F. Monitor line and grade continuously during guided boring operations. Record deviation with respect to design line and grade at least once per 4 feet and submit records to Engineer as requested. Control line and grade of the casing to within the specified tolerances.

G. Correct the installation, including any necessary redesign of the pipeline or structures and acquisition of necessary easements, if the casing installation does not meet the specified tolerance. Performance of corrective work is subject to the written approval of the Engineer.

3.05 OBSTRUCTIONS

A. In accordance with Section 02 33 00, Tunneled Crossings.

3.06 CONTACT GROUTING EQUIPMENT

A. Provide equipment for mixing and injecting grout to satisfactorily mix and agitate the grout and force it into the grout holes, in a continuous flow at the desired pressure. Provide pumps capable of continuously developing a sustained pressure of 15 pounds per square inch at the grout hole connection.

B. Provide two pressure gauges, one at the grout pump and one at the collar of each hole being grouted. Check the accuracy of the gauges periodically with an accurately calibrated pressure gauge. Make available on site a minimum of two spare pressure gauges.

C. Provide the grouting equipment with a meter to determine the volume of grout injected. Calibrate the meter in cubic feet to the nearest one-tenth of a cubic foot.

D. Maintain the grouting equipment in satisfactory operating condition throughout the course of the Work to ensure continuous and efficient performance during grouting operations.

E. Provide suitable stop valves at the collar of each hole for use in maintaining pressure as required until the grout has set.

F. Provide grout hoses with an inside diameter not less than 1-1/4 inches nor greater than 2 inches and capable of withstanding the maximum water and grout pressures to be used.

G. Provide and install diaphragm gauge savers to prevent grout from entering gauge body.

3.07 MIXING AND INJECTION OF CONTACT GROUT

A. Provide materials free of lumps when put into the mixer. Constantly agitate the grout mix. Install grout that flows unimpeded and completely fill voids. Waste grout not injected after 90 minutes of mixing.

B. Operate and control the grouting process so that the grout will be delivered uniformly and steadily. The locations of contact grout holes in the pipe are shown on Drawings. Drilling grout holes through pipe will not be permitted.

C. Recirculate grout mixes when any new mix is batched or after adding water, fluidifier, or sand to mix. Recirculate mix for at least 2 minutes prior to pumping grout into grout hole.

D. Grouting will be considered completed when less than one cubic foot of grout of the accepted mix and consistency can be pumped in 5 minutes under the specified maximum pressure. After the grouting is finished, close the valve before the grout header is removed and remain closed until grout has set.

E. The maximum sustained grouting pressure shall be 15 pounds per square inch (psi) or 1/2 psi per foot of earth cover, whichever is less, at the grout hole collar connection unless otherwise approved in writing by the Engineer.

3.08 CONTACT GROUTING OF TUNNELED CASING

A. Commence contact grouting outside of the casing pipe within 24 hours following the completion of each tunneled drive of 30 inches or greater in diameter. Conduct grouting operations continuously until completed.

B. Install contact grout ports in the pipe in accordance with Section 33 05 01.27, Steel Casing Pipe. Drilling grout holes through installed casing pipe will not be permitted. Provide grout ports threaded to accept valve fittings and plugs.

C. Attempt to hook up and pump grout at every pipe grout port unless approval is granted by the Engineer in writing to omit grouting of selected ports.

D. Inject grout through the grout connections in such a manner as to completely fill voids outside the pipe resulting from, or encountered during, tunneling operations. Control grout pressure so as to avoid damaging the pipe, and to avoid movement of the surrounding ground or improvements.

E. Grout to generally progress sequentially in a constant upgradient direction from one grout port to the next grout port in the sequence indicated in the approved submittals.

F. During the grouting operations, clean and make ready for grouting the sufficient contact grout ports ahead of the port to be grouted. Attach valves or other suitable devices and place in the fully open position on ungrouted ports within the maximum grout communication distance.

G. For any hole ahead of the grouting operation, with a valve attached, and the valve in the open position, such hole shall be considered grouted if grout issues forth of the same consistency and color, and at the same rate as that being pumped. Replace grout plugs in pipe at the completion of grouting.

H. Seal pipe grout fittings with screw type plugs upon completion of grouting.

3.09 INSTALLATION OF CARRIER PIPE

A. Installation of carrier pipe within the casing and backfilling of annular space between the casing and carrier shall be in accordance with Section 31 60 00, Installation of Carrier Pipe in Ground Support and Casing.

3.10 CLEANUP

A. After completion of auger boring tunneling and carrier pipe installation, remove construction debris, spoils, oil, grease, and other materials from the tunneled casing, launching and receiving shafts, and Work areas.

B. Contractor shall restore the existing surfaces to preconstruction conditions.

END OF SECTION

SECTION 31 80 00
GEOTECHNICAL INSTRUMENTATION

PART 1 GENERAL

1.01 WORK INCLUDED

A. The Work specified in this section includes furnishing, installing, measuring, and abandoning settlement instrumentation to monitor ground movements around and above tunneled crossings.

1.02 SUBMITTALS

A. Informational Submittals:

1. Qualifications: Submit surveying personnel qualifications in accordance with the requirements herein.
2. Submit the following, at least 1 month before scheduled installation of monitoring points:
   a. Instrumentation Schedule: Submit the proposed schedule for installing the monitoring points.
   b. Drawings with locations of proposed monitoring points shown in plan and profile Drawings. If the proposed locations do not vary from the Project Drawings, state so in the Submittal.
   c. Monitoring Plan: Submit the monitoring plan for each crossing separately. The plan should identify the procedures and frequency of measurements, the procedure by which the information is tabulated graphically for each point and submitted electronically in Microsoft Excel format to the Engineer, and the procedures to be used to identify and communicate values that have exceeded the threshold values defined in this section.
   d. Contingency Plan: Submit and establish a contingency plan in the event of ground loss and/or the monitoring points exceed the response values specified herein. The plan shall include the actions that will be taken to prevent or correct settlement.
3. Settlement correction plan: As required per Paragraph Response Values.
4. Reports and Records:
   a. Within 72 hours following installation of the monitoring points, submit drawings to the Engineer showing the actual as-built installed location (x, y, z), the identification number, the type, the installation date and time, the tip elevation and instrument length, as applicable. Include details of installed instruments, accessories and protective measures including all dimensions and materials used.

b. Within 24 hours following each survey measurement, submit the survey data to the Engineer in Microsoft Excel format. Identify and communicate values that have exceeded the threshold values defined in this section.

c. At least 72 hours prior to commencement of any adjacent construction activities, including dewatering, and shaft construction, submit baseline survey values of each monitoring point in Microsoft Excel format.

1.03 DEFINITIONS

A. Monitoring Points: Surface, subsurface, utility, and track monitoring points as defined herein.

B. Surface Monitoring Point: Settlement monitoring point established as a reference for measuring elevation of the ground surface or structural element using optical survey methods.

C. Subsurface Monitoring Point: A cased borehole settlement monitoring point located above the tunnel crown elevation used for detecting settlement between the location of the settlement point and the tunneled bore.

D. Utility Monitoring Point: A cased borehole settlement monitoring point located above the crown of an existing utility used for detecting settlement of the utility.

E. Track Monitoring Point: Fixed prism settlement monitoring point established as a reference for measuring elevation of the rail using optical survey methods. The monitoring point is installed on the side of the rail and eliminates the need to routinely access the tracks to perform measurements.

1.04 QUALITY CONTROL

A. Surveyor Qualifications: Perform surveying for establishing surface monitoring points by a professional Land Surveyor licensed in the State of Utah with previous experience surveying for the detection of structural or surface deformations.

B. Install monitoring points within 0.5 foot of the horizontal locations described herein, shown on Drawings on approved submittals, or as directed by the Engineer. Install additional monitoring points if directed by the Engineer.

C. Should actual field conditions prevent installation of instruments at the locations shown on Drawings, or specified herein, obtain written acceptance from the Engineer for new instrument locations and elevations.

PART 2 PRODUCTS

2.01 MATERIALS

A. Surface Monitoring Point: Establish surface monitoring points by an inscribed marking or approved surveyor’s nail driven flush with the surface in asphalt or concrete paved areas. In unimproved areas, establish surface monitoring points by driving a 5/8-inch diameter by 30-inch long reinforcing bar flush with the ground. Provide each monitoring point with a tag or marking indicating the station and offset from centerline. Assign each point a unique identification number and protect from damage or burial. Flag each point so as to remain visible.

B. Utility Monitoring Points: Utility monitoring points shall be established and installed as shown on Drawings. Each point shall consist of a No. 6 rebar settlement rod installed within and isolated from a PVC cased borehole. Do not use drilling techniques. Vacuum excavation of the hole is acceptable provided overexcavation is avoided. Do not damage the existing utility. Each point shall be assigned a unique identification number. The settlement rod shall be located at the crown of the utility to be monitored. The settlement rod shall be secured to the PVC casing with a 12-inch length of loose cable or chain to prevent the rod from falling more than approximately 12 inches. The casing shall be flush with pavement or recessed and capped and protected with a road box, if installed within traffic lanes, shoulders, parking lots, or bike lanes and shall be in accordance with Utah Department of Transportation (UDOT) and other applicable permit agencies.

C. Subsurface Monitoring Points: Subsurface monitoring points shall be established and installed as shown in the Drawings. Each point shall consist of a #6 rebar settlement rod installed within and isolated from a PVC cased borehole. Each point shall be assigned a unique identification number. The settlement rod shall be driven 6 inches to 12 inches past the bottom of the borehole casing and the tips shall be located at 5 feet above the tunnel pipe or casing crown, as noted on the Drawings, or as directed by the Engineer. The settlement rod shall be secured to the PVC casing with a 12-inch length of loose cable or chain to prevent the rod from falling more than approximately 12 inches. The casing shall be flush with pavement or recessed, and capped and protected with a road box if installed within traffic lanes, shoulders, parking lots, or bike lanes and shall be in accordance with UDOT and other applicable permit agencies.

D. Track Monitoring Point: Establish track monitoring points by securely affixing a prism to the rail at locations shown on Drawings. The monitoring point shall not interfere with track use. Provide each monitoring point with a tag or marking indicating the station and offset from centerline. Assign each point a unique identification number and protect from damage. Flag each point so as to remain visible.

1. Geo-Track Clip, as manufactured by Geo Instruments of Narragansett, RI, or equal as approved by Engineer and UPRR.

PART 3 EXECUTION

3.01 GENERAL

A. Install instrumentation at the locations shown on Drawings, as described in these specifications, and as approved by the Engineer. Install instruments in accordance with the approved installation schedule.

B. Install instruments and perform a baseline survey of surface monitoring points at least 7 days prior to the commencement of any construction activities within 100 feet of the monitoring point, including the start of any dewatering or shaft construction.

C. Once tunneling commences, survey monitoring points at the beginning and ending of each work day and at least once every 8 hours should the tunneling operations be continuous, and as required per Article Response Values. Once the tunneled crossing is complete, survey monitoring points once per day while adjacent shafts are open. Once tunneling operations are complete and the shafts backfilled, survey settlement monitoring points once every other day or as directed by the Engineer for a period of 1 week, and once again at 14 days after tunneling and shaft backfill is completed.

D. Provide access and assistance to the Engineer for obtaining additional monitoring data, as discussed herein and as requested by Engineer.

3.02 MONITORING POINT LOCATIONS

A. Establish an array of survey monitoring points in accordance with Drawings and Contractor approved submittals. If the Contractor elects to tunnel in the opposite direction from the direction shown on Drawings, the Contractor shall modify the surface monitoring point layout and obtain Engineer’s approval, as required.

B. Install the monitoring points as close as practicable to the locations shown on Drawings or as defined in these specifications.

C. Locate and visually confirm utilities within 15 feet laterally of monitoring point locations and protect utilities or relocate monitoring points as necessary to protect utilities. Follow accepted industry procedures for one-call notification (Blue Stakes of Utah) and visual confirmation of locations of adjacent utilities.

D. For Track Monitoring Points: establish and measure the location (X, Y) and elevation (Z) of points on the rail over the tunnel centerline and at points offset 31 feet on either side of the centerline of the tunnel. Either rail may be used as the line rail; however, the same rail shall be used for the full length of that tangential segment of track. The measurement compared to the response value shall be taken as the deviation (plus or minus) of the middle monitoring point from a 62-foot line between the outer two monitoring points, centered over the tunneled crossing in accordance with CFR Title 49 Part 213—Track Safety Standards. Class V track assumed.

E. Coordinate with UPRR to obtain access to tracks for installation and removal of track monitoring points. Obtain permits and provide flaggers, as required, and pay all fees associated with providing access to establish and perform settlement monitoring, including necessary insurance. Provide all required worker training to access railroad ROW and tracks.

3.03 INSTRUMENT PROTECTION, MAINTENANCE, AND REPAIR

A. Protect the monitoring points from damage. Replace or repair damaged installations within 24 hours prior to continuing dewatering, excavation, or tunneling, unless permitted otherwise in writing by the Engineer.

3.04 RESPONSE VALUES

A. Response Values:

Site Feature	Threshold Value (Contractor Action Required)	Contractor Response Value	Shutdown Value (Maximum Allowable)
Surface Monitoring Points (central)	0.60 inch V	1.10 inch V	1.20 inch V
Surface Monitoring Points (offset)	0.25 inch V	0.45 inch V	0.50 inch V

Site Feature	Threshold Value (Contractor Action Required)	Contractor Response Value	Shutdown Value (Maximum Allowable)
Utility Monitoring Points	0.50 inch V	0.90 inch V	1.00 inch V
Subsurface Monitoring Points (central)	1.20 inch V	2.20 inch V	2.40 inch V
Subsurface Monitoring Points (offset points)	0.22 inch V	0.40 inch V	0.45 inch V
Track Monitoring Points	0.40 inch V	0.70 inch V	0.75 inch V

B. When the instruments indicate movement equal to 50 percent of the maximum allowable value has occurred, the Threshold Value is said to have been reached. Meet with the Engineer to discuss construction means and methods and determine what changes, if any, will be made to better control ground movement. Submit written settlement correction plan documenting proposed changes. Take instrument readings on a daily basis until 5 consecutive working days of readings below the Threshold Value are observed, or more often as specified elsewhere in this section.

C. When the instruments indicate movement equal to 90 percent of the maximum allowable value has occurred, the Contractor Response Value is said to have been reached. Actively control ground movement in accordance with the approved settlement correction plan to prevent reaching the Shutdown Value. Instrument readings will be taken by the Engineer on a daily basis until 5 consecutive working days of stabilized readings are observed, or more often as specified elsewhere in this section.

D. When the instruments indicate movement equal to 100 percent of the maximum allowable value has occurred, the Shutdown Value is said to have been reached. Stop excavation Work immediately. Meet with the Engineer to develop a plan of action before excavation Work can be resumed at the Engineer’s direction. No standby time will be paid if excavation Work is shut down because the Shutdown Value is reached.

E. Record all surveyed measurements in a field log book that is located at the project site at all times. The field log book shall be made available to all concerned parties upon request at any time during construction. Copies of the field measurements shall be submitted to the Engineer daily.

3.05 ABANDONMENT OF INSTRUMENTS

A. Surface Monitoring Points: Keep in place the surface monitoring points on public property at the completion of the Work. Remove surface monitoring points on private property during the cleanup and restoration work, or as directed by the Engineer.

B. Track Monitoring Points: Completely remove track monitoring points from the rail during the cleanup and restoration work, or as directed by the Engineer.

C. Utility and Subsurface Monitoring Points:

1. Monitoring points shall be abandoned unless directed by the Engineer or Engineer to remain in place.
2. Grout utility monitoring point holes with contact grout conforming to the requirements of Section 31 79 25, Guided Auger Boring, or lean cement grout with 5 percent bentonite.

END OF SECTION

SECTION 32 11 23
AGGREGATE BASE AND SUBBASE COURSES

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. C29, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate.
   b. C88, Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   c. C117, Standard Method of Test for Materials Finer Than 75μm (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C131, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   e. C183, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
   f. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3 (600 kN-m/m^3)).
   g. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft^3 (2700 kN-m/m^3)).
   h. D1883, Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
   i. D2216, Standard Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
   j. D2419, Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   k. D2844, Standard Specification for Resistance R-Value and Expansion Pressure of Compacted Soils.
   l. D4318, Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
   m. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
   n. D5195, Standard Test Methods for Density of Soil and Rock In-Place Below Surface by Nuclear Methods.
   o. D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

A. Base Course: Crushed aggregate or similar as specified placed and compacted on prepared subgrade or subbase course.

B. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

C. Completed Lift: Compacted with uniform cross-section thickness.

D. Gravel Surfacing: Aggregate used for construction of low-volume access and staging area that can be easily graded and compacted.

E. Leveling Course: Crushed aggregate placed and compacted on base course to be used for finish grading.

F. Subbase Course: Sandy, gravelly material placed and compacted on prepared subgrade.

G. UDOT Standard Specifications: When referenced in this section, shall mean the standard specification of the Utah Department of Transportation, current version.

1.03 SUBMITTALS

A. Action Submittals:

1. Samples: Submit for specified materials 20 days prior to delivery to Site.

B. Informational Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 20 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.
2. Certified results of in-place density tests from independent testing agency.

PART 2 PRODUCTS

2.01 SUBBASE COURSE (GRANULAR BORROW)

A. Use granular borrow as specified in Section 02056, Embankment, Borrow, and Backfill, of the UDOT Standard Specifications.

2.02 BASE COURSE (UNTREATED BASE COURSE OR UTBC)

A. Use aggregate that meets the requirements of Section 02721, Untreated Base Course, of the UDOT Standard Specifications. If gradation is not specified, use 1-1/2-inch gradation.

2.03 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. As specified in Section 31 23 13, Subgrade Preparation.

B. Obtain Engineer's acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials in snow or on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.03 HAULING AND SPREADING

A. In accordance with UDOT Standard Specifications.

B. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads of uniform capacity.
3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

C. 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 or prepared surface without segregation.
3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 ROLLING AND COMPACTION

A. In accordance with UDOT Standard Specifications, and as follows.

1. Roll each layer of material until material does not creep under roller before succeeding layer is applied.
2. Commence rolling at outer edges and continue toward center; do not roll center of road first.
3. Apply water as needed to obtain specified densities.
4. Place and compact each lift to the required density before succeeding lift is placed.
5. Remove floating or loose stone from surface of preceding course before placing leveling course.
6. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.
7. Finished surface shall be true to grade and crown before proceeding with surfacing.

B. Compact subbase course and base course to relative compaction as specified in Section 31 23 23, Fill and Backfill, except in UDOT roadways meet compaction requirements per UDOT Standard Specifications.

3.05 SURFACE TOLERANCES

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Untreated Aggregate Base Course: Within plus or minus 0.04 foot of grade shown at any individual point.

C. Overall Average: Within plus or minus 0.01 foot from crown and grade specified.

3.06 DRIVEWAY RESURFACING

A. Replace gravel surfacing on driveways that were gravel surfaced prior to construction.

B. Provide compacted gravel surfacing to depth equal to original, but not less than 8 inches.

C. Leave each driveway in as good or better condition as it was before start of construction.

3.07 FIELD QUALITY CONTROL

A. In-Place Density Tests:

1. Coordinate with Contractor's testing laboratory and provide at least 2 hours' advance notification prior to testing.
2. Show proof that areas meet specified requirements before performing density tests.
3. Refer to Table 1 for minimum sampling and testing requirements for aggregate base course and surfacing.

Table 1
Minimum Sampling and Testing Requirements

Property	Test Method	Frequency	Sampling Point
Gradation	ASTM C117 and ASTM C183	One sample every 500 tons but at least every 4 hours of production	Roadbed after processing
Moisture Density (Maximum Density)	ASTM D698, Method D	One test for every aggregate grading produced	Production output or stockpile
In-Place Density and Moisture Content	ASTM D5195, ASTM D6938, and ASTM D2216 for moisture content	One for each 500 ton but at least every 10,000 sq. ft. of area	In-place completed, compacted area

3.08 CLEANING

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

END OF SECTION

SECTION 32 12 16
ASPHALT PAVING

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M17, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.
   b. M81, Standard Specification for Cut-Back Asphalt (Rapid Curing Type).
   c. M82, Standard Specification for Cut-Back Asphalt (Medium Curing Type).
   d. M140, Standard Specification for Emulsified Asphalt.
   e. M156, Standard Specification for Requirements for Mixing Plants for Hot-mixed, Hot-laid Bituminous Paving Mixes.
   f. M208, Standard Specification for Cationic Emulsified Asphalt.
   g. M320, Standard Specification for Performance Graded Asphalt Binder.
   h. R35, Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt.
   i. T166, Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Mixtures Using Saturated Surface-Dry Specimens.
   j. T176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
   k. T209, Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA).
   l. T230, Standard Method of Test for Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures.
   m. T245, Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus.
   n. T246, Standard Method of Test for Resistance to Deformation and Cohesion of Hot Mix Asphalt (HMA) by Means of Hveem Apparatus.
   o. T247, Standard Method of Test for Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor.
   p. T283, Standard Method of Test for Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage.

q. T304, Standard Method of Test for Uncompacted Void Content of Fine Aggregate.
r. T312, Standard Method of Test for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of a Superpave Gyratory Compactor.

2. Asphalt Institute (AI):
   a. Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete.
   b. Superpave Series No. 2 (SP-2), Superpave Mix Design.
3. ASTM International (ASTM):
   a. D75, Standard Method of Test for Sampling of Aggregates.
   b. D140, Standard Method of Test for Sampling Bituminous Materials.
   c. D979, Standard Method of Test for Sampling Bituminous Paving Mixtures.
   d. D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
   e. D2170, Standard Test Method for Kinematie Viscosity of Asphalts (Bitumens).
   f. D2489, Standard Method of Test for Determining Degree of Particle Coating of Asphalt Mixtures.
   g. D2950, Standard Test Method for Density of Bituminous Concrete in place by Nuclear Methods.
   h. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   i. D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
   j. D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
   k. E329 REV A, Standard Specification for Agencies Engaged in Construction Inspection Testing, or Special Inspection.
4. Utah Department of Transportation (UDOT): 2012 Standard Specifications for Road and Bridge Construction.

1.02 DEFINITIONS

A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.

B. Maximum Aggregate Size: One sieve size larger than the nominal aggregate size.

C. Nominal Aggregate Size: One sieve size larger than the first sieve that retains more than 10 percent aggregate.

D. Prime Coat: Low viscosity cutback or emulsified asphalt applied to granular base in preparation of paving to coat and bond loose materials, harden the surface, plug voids, prevent moisture migration, and provide adhesion.

E. Reclaimed Asphalt Pavement (RAP): Removed and/or processed pavement materials containing binder and aggregate.

F. Seal Coat: Term used for various applications of emulsified asphalt, with or without sand or aggregate, to protect the asphalt surface from aging due to wear, degradation from the sun, wind, and water. Also used to improve skid resistance and aesthetics. The term seal coat can be used to define fog seal, slurry seal, chip seal or sand seal, depending on application.

G. Standard Specifications: Utah Department of Transportation (UDOT) Standard Specifications for Road and Bridge Construction, most recent edition.

H. Tack Coat: Thin layer of emulsified asphalt applied to hard surfaces, including new pavement lifts, to promote adhesion and bonding.

I. ESALs: 18,000-pound equivalent single axle load.

1.03 DESIGN REQUIREMENTS

A. Prepare asphalt concrete mix design, meeting the following design criteria, tolerances, and other requirements of this Specification.

B. Unless noted otherwise, all permanent asphalt concrete paving shall meet all the requirements for a Superpave Volumetric Mix Design as specified in the UDOT Standard Specification Section 02741, Hot Mix Asphalt (HMA), with the following additions:

1. Design Gyrations, NDES: 75.
2. Coarse Aggregate Angularity, ASTM D5821: One or more fractured faces 95 percent minimum; two or more fractured faces 90 percent, minimum.
3. Fine Aggregate Angularity, AASHTO T304: 45 percent below 100 millimeters (4 inches) from surface and 45 percent above 100 millimeters (4 inches) from surface.
4. 20-year Design ESALS: 0.3 million to 3 million.
5. Flat and Elongated Particles, ASTM D4791: 10 percent, maximum.
6. Clay Content, AASHTO T176: Minimum sand equivalent of 60 percent.
7. Voids in Mineral Aggregate: 13 percent minimum.
8. Mixture Density as a Percentage of Theoretical Maximum Density at Initial Gyration Level: 90.5 percent, maximum.

9. Mix Density at Maximum Number of Gyrations: Less than 96.5 percent of theoretical maximum density.
10. Dust Proportion: 0.6 to 1.4.
11. Air Voids: 3.5 percent.
12. Tensile Strength Ratio, AASHTO T283: 80 percent, minimum.

C. Furnished Mix Tolerances:

1. Conform to asphalt concrete mix formula within the plus or minus limits shown in Table 3 of the Standard Specifications and the following:
    a. Aggregate Passing the 2.38 millimeter (No. 8) to 150 µm (100) Sieves: 4 percent.
    b. Aggregate Passing the 75 µm (No. 200) Sieve: 2 percent.
    c. Bitumen Content: 0.3 percent of volume or batch weight of aggregate.
    d. Temperature Leaving Mixer: 11 degrees C (20 degrees F).
    e. Temperature in Paving Machine Hopper: 11 degrees C (20 degrees F).

D. In lieu of preparing an asphalt concrete mix design, the Contractor may submit an asphalt-mix design that is currently approved by UDOT Region 3, if it meets the requirements of this Specification. The Project Representative reserves the right to request changes in the mix design to meet these requirements.

1.04 SUBMITTALS

A. Jurisdictional Agency Review: For paving within any roads, obtain the review and approval of paving submittals from the agency which has jurisdiction for maintaining the roadway. Submit paving submittals to the Engineer who will route them to jurisdictional agency for review comments.

B. Informational Submittals:

1. Asphalt Concrete Mix Formula:
    a. Submit minimum of 20 days prior to start of production.
    b. Submittal to include the following information:
        1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate within specified limits.
        2) Bulk specific gravity for each aggregate constituent.
        3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.

4) Properties as stated in Section 02741, Hot Mix Asphalt (HMA), of the UDOT Standard Specifications, for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.
5) Percent of asphalt lost due to absorption by aggregate.
6) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283.
7) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.
8) Optimum mixing temperature.
9) Optimum compaction temperature.
10) Temperature-viscosity curve of asphalt cement to be used.
11) Brand name of any additive to be used and percentage added to mixture.

2. Test Report for Asphalt Cement:
   a. Submit minimum 10 days prior to start of production.
   b. Show appropriate test method(s) for each material and the test results.
3. Manufacturer's Certificate of Compliance for the following materials:
   a. Aggregate: Gradation, source test results as defined in Section 02741 of the UDOT Standard Specifications.
   b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
   c. Prime coat.
   d. Tack Coat: Type and grade of asphalt.
   e. Additives.
   f. Mix: Conforms to job-mix formula.
4. Statement of qualification for independent testing laboratory.
5. Test Results:
   a. Mix design.
   b. Asphalt concrete core densities.
   c. Gradation and asphalt content of uncompacted mix.
   d. Field density.
6. Quality control procedures for testing asphalt concrete.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329.
2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.

1.06 TESTING FOR COMPACTION

A. Test embankment foundations, areas through cuts, embankments, dikes, backfill, and other materials for the specified densities as outlined in Section 31 23 23.15, Fill and Backfill.

B. Compaction of the untreated base course shall be to 100 percent relative compaction per ASTM D698 per Section 31 23 23, Fill and Backfill. For UDOT roadways, compaction of untreated base course shall be per UDOT Standard Specifications. Compaction of the asphalt concrete pavement shall be to an average density of 94 percent of maximum density (RICE method) with no single determination less than 92 percent, determined in accordance with AASHTO T-209. See UDOT Standard Specification 02741.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Do not apply asphalt materials or place asphalt mixes when ground temperature is lower than 50 degrees F (10 degrees C) or air temperature is lower than 40 degrees F (4 degrees C). Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.

B. Moisture: Do not apply asphalt materials or place asphalt mixes when application surface is wet.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Asphalt concrete delivery:

1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of all foreign materials.
2. Treat bodies as necessary to prevent material from sticking to the bodies.
3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.
4. Transfer the mixture directly from the transport vehicle to the paving machine. Dumping asphalt on the ground and “shuttling” it to the paver will not be allowed.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cut back asphalt, Grade MC-70, conforming to AASHTO M82.

B. Fog Sealing: Emulsified asphalt, Grade CSS-1, CSS-1h conforming to AASHTO M208.

C. As specified in Section 02748 of the UDOT Standard Specifications.

2.02 ASPHALT CONCRETE MIX

A. General: Mix formula shall not be modified except with written approval from the Engineer.

1. Source Changes:
   a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used.
   b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by the Engineer to confirm that properties are in compliance with design criteria.
   c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.
   d. Do not intermix the asphalt from two different sources or gradations.

B. Asphalt Concrete: Category 2, SHRP 19 mm as specified in Section 02741, Hot Mix Asphalt (HMA), of the UDOT Standard Specifications.

C. Composition: Hot-plant mix of aggregate, mineral filler if required, and paving grade asphalt cement. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that resulting mixture meets grading requirements of mix formula.

D. Aggregate:

1. General: As specified in Section 02741, Hot Mix Asphalt (HMA), of the UDOT Standard Specifications; RAP material may be used up to a maximum of 15 percent by total weight.
2. The 3/4 inch gradation is required for the friction course.
3. Natural Sand: Shall not be used.

E. Mineral Filler: In accordance with AASHTO M17.

F. Asphalt Cement: Performance Grade PG 64-34 meeting the requirements of UDOT Section 2745

G. Temporary Asphalt Concrete Paving: Temporary asphalt concrete paving shall be per Paragraph Temporary Asphalt Concrete Paving.

PART 3 EXECUTION

3.01 GENERAL

A. Traffic Control:

1. In accordance with Section 01 50 00, Temporary Facilities and Controls.
2. Minimize inconvenience to traffic, but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt. If detours cannot be provided, restrict operations to a width that will permit at least one-way traffic. Control traffic with flagging and barriers in accordance with an approved Traffic Control Plan.

B. Driveways: Repave driveways from which pavement was removed. Leave driveways in as good or better condition than before start of construction.

C. Sawcut existing asphalt (per Drawings and specifications) at all joints to new asphalt.

3.02 LINE AND GRADE

A. Provide and maintain intermediate control of line and grade, independent of underlying base, to meet finish surface grades and minimum thickness.

B. Shoulders: Construct to line, grade, and cross-section shown.

3.03 PREPARATION

A. Prepare subgrade as specified in Section 31 23 13, Subgrade Preparation. Compact subgrade to 100 percent relative compaction per ASTM D698.

B. Existing Roadway:

1. Modify profile by grinding, milling, or overlay methods as approved, to provide meet lines and surfaces and to produce smooth riding connection to existing facility.
2. Remove existing material to a minimum depth of 1 inch.
3. Remove cracked pavement within 10 feet of either side of the trench and all Contractor-damaged pavement regardless of distance from the trench. Remove entire travel lane if more than 50 percent is impacted by construction.

4. Sawcut at meet lines.
5. Paint edges of meet line with tack coat prior to placing new pavement.

C. Thoroughly coat edges of contact surfaces (curbs, manhole frames) with emulsified asphalt or asphalt cement prior to laying new pavement. Prevent staining of adjacent surfaces.

3.04 PAVEMENT APPLICATION

A. General: Place asphalt concrete mixture on approved, prepared base in conformance with this section.

B. Weather and Seasonal Limitations:

1. Place permanent surface course only between April 15 and October 15 unless authorized in writing by the Engineer.
2. Place permanent paving when the air temperature in the shade is above 50 degrees F and rising.
3. Do not place asphalt when frozen materials are present in the base or sub-base.
4. Cold weather patching, emergency paving, and all bituminous paving done after October 15 and before April 15 will be considered temporary asphalt concrete surfacing (see paragraph below) and shall be removed and replaced.

C. Temporary Asphalt Concrete Paving:

1. If temporary asphalt concrete paving is allowed by Engineer, it shall comply with the following:
   a. Do not use cold mix asphalt, rotomilling materials, or reclaimed asphalt pavement materials for temporary asphalt concrete.
   b. Temporary asphalt shall be the same as permanent asphalt except as follows. Contractor may use a hot mix asphalt that complies with UDOT Standard Specification Section 00850 and Section 00851 (instead of UDOT Section 02741 and Section 02745).
   c. Repaving after potholing shall comply with temporary asphalt concrete paving.
   d. Temporary asphalt shall have 8 inches minimum untreated base course and 3 inches minimum asphalt concrete in all areas except in US-189 where temporary asphalt concrete thickness shall be 3 inches minimum.
   e. Place as soon as the condition of the backfill is suitable and leave in place until ready for permanent resurfacing.

f. Provide temporary pavement marking as specified in UDOT Standard Specification Section 01520, Temporary Pavement Markings.
g. Maintain temporary surfacing and pavement markings until removal and replacement with permanent surface course.

D. Tack Coat:

1. Clean surface to be treated so it is free of dust or other foreign material.
2. Apply when temperature range of bituminous material at the time of application is such that the viscosity will be between 50 centistokes to 100 centistokes as determined in accordance with ASTM D2170. Apply only when air temperature in the shade and the roadbed temperature are at least 50 degrees F and rising. Do not apply during rain, fog, windy or other adverse conditions.
3. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
4. Apply with spray or brush to curbs, gutters, manholes, and waterways.
5. Do not apply more tack coat than necessary for the day's paving operation.
6. Application Rate:
   a. Minimum 0.05 gallon to maximum 0.15 gallon per square yard of surface area.
   b. Apply at rate, within range specified, sufficient to assure good bonding, but not so heavy that surplus asphalt flushes into asphalt concrete being placed.
7. Touch up missed or lightly coated surfaces and remove excess material including spattering or marring.
8. Provide pedestrian access across tack coat by blotting excess oil with blotter material.
9. Keep pedestrians, vehicles, pets, and others, from tracking onto sidewalks or driveways.

E. Asphalt Concrete Pavement Mix:

1. Prior to Paving:
   a. Sweep primed surface free of dirt, dust, or other foreign matter.
   b. Patch holes in primed surface with asphalt concrete pavement mix.
   c. Blot excess prime material with sand.
2. Place asphalt concrete pavement mix in at least two lifts.
3. Spread the bituminous mixture with self-propelled mechanical spreading and finishing equipment capable of spreading the mixture

to the proper grade, thickness, and typical section shown or as designated by the Project Representative.

4. Use spreader box or other methods of spreading the material approved by the Project Representative for areas under 200 yards, for irregular areas, for miscellaneous construction such as detours, sidewalks, and for initial leveling courses.
5. Compacted Lift Thickness:
   a. Minimum: Twice maximum aggregate size, but not less than 1 inch.
   b. Minimum Top Coarse: 2 inches.
   c. Maximum: 3 inches.
6. Total Compacted Thickness: As shown on Drawings.
7. Place the bituminous mix as a continuous operation. Do not allow rollers to pass over the unprotected end of freshly placed mix.
8. Apply such that meet lines are straight and edges are vertical.
9. If so authorized and the end will be subjected to traffic, bevel the end at approximately 5:1 (horizontal to vertical). Make transverse joints by cutting back on the previous run to expose the full depth of the layer or course. At bridge ends or at ends of other rigid-type structures, compact transversely as well as longitudinally.
10. Prevent traffic, including construction traffic, from crossing the vertical edge. Apply tack coat to the vertical edge prior to making another pass with the paver if the bituminous mix has cooled below 150 degrees F.
11. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
12. Joints:
    a. Offset edge of each layer a minimum of 12 inches so joints are not directly over those in underlying layer.
    b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
    c. Form transverse joints by cutting back on previous day’s run to expose full vertical depth of layer.
13. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
14. After placement of pavement, seal meet line by painting a minimum of 6 inches on each side of joint with cut-back or emulsified asphalt. Cover immediately with sand.

F. Compaction:

1. Roll the surface longitudinally, beginning at the outside edge or lower side and proceeding toward the higher side. Overlap each pass of one roller over the preceding pass by at least one-half the width of the roller. For finish rolling, pneumatic rollers are required.

2. Provide sufficient equipment to compact the mixture to the required density. Coordinate with an independent testing agency and the Project Representative to develop a rolling pattern for compaction. Use approved pattern as long as the compactive efforts are within Specifications.
3. Provide sufficient rolling equipment to keep pace with the laydown operation.
4. Adjust production of mixing plant and paving material delivery to obtain a continuous uninterrupted forward paving operation.
5. Complete compaction before the temperature of bituminous mixture drops below 220 degrees F.
6. Density of compacted asphalt shall meet the requirements of UDOT Standard Specification Section 02741, Hot Mix Asphalt (HMA).

G. Joint Compaction:

1. Place top or wearing layer as continuously as possible.
2. Pass roller over unprotected end of freshly laid mixture only when placing of mix is discontinued long enough to permit mixture to become chilled.
3. Cut back previously compacted mixture when Work is resumed to produce slightly beveled edge for full thickness of layer.
4. Cut away waste material and lay new mix against fresh cut.

H. Tolerances:

1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
2. Completed Friction Course Smoothness:
   a. Uniform texture, smooth, and uniform to crown and grade.
   b. Maximum Deviation: 1/8 inch from lower edge of a 12-foot straightedge, measured continuously parallel and at right angle to centerline.
   c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace friction course.
3. Transverse Slope Maximum Deviation: 1/4 inch in 12 feet from rate of slope shown.
4. Finished Grade: Perform field differential level survey on maximum 50-foot grid and along grade breaks.
   a. Maximum Deviation: 0.02 foot from grade shown.

3.05 PAVEMENT OVERLAY

A. Preparation:

1. Remove fatty asphalt, grease drippings, dust, and other deleterious matter.
2. Surface Depressions: Fill with asphalt concrete mix, and thoroughly compact.
3. Damaged Areas: Remove broken or deteriorated asphalt concrete and patch as specified in Article Patching.
4. Portland Cement Concrete Joints: Remove joint filler to minimum 1/2 inch below surface.

B. Application:

1. Tack Coat: As specified in this section.
2. Place and compact asphalt concrete as specified in Article Pavement Application.
3. Place first layer to include widening of pavement and leveling of irregularities in surface of existing pavement.
4. When leveling irregular surfaces and raising low areas, the actual compacted thickness of any one lift shall not exceed 2 inches.
5. Actual compacted thickness of intermittent areas of 120 square yards or less may exceed 2 inches, but not 4 inches.
6. Final wearing layer shall be of uniform thickness, and meet grade and cross-section as shown.

3.06 PATCHING

A. Preparation:

1. Remove damaged, broken, or unsound asphalt concrete adjacent to patches. Trim to straight lines exposing smooth, sound, vertical edges.
2. Prepare patch subgrade as specified in Section 31 23 13, Subgrade Preparation.

B. Application:

1. Patch Thickness: 6 inches or thickness of adjacent asphalt concrete plus 1 inch, whichever is greater.
2. Place asphalt concrete mix across full width of patch in layers of equal thickness.
3. Spread and grade asphalt concrete with hand tools or mechanical spreader, depending on size of area to be patched.

C. Compaction:

1. Roll patches with power rollers capable of providing compression of 200 pounds per linear inch to 300 pounds per linear inch. Use hand tampers where rolling is impractical.
2. Begin rolling top course at edges of patches, lapping adjacent asphalt surface at least one-half the roller width. Progress toward center of patch overlapping each preceding track by at least one-half width of roller.
3. Make sufficient passes over entire area to remove roller marks and to produce desired finished surface.
4. Density of compacted asphalt shall average at least 96 percent with no density determination less than 92 percent by a 50 blow laboratory Marshall (AASHTO T245).

D. Tolerances:

1. Finished surface shall be flush with and match grade, slope, and crown of adjacent surface.
2. Tolerance: Surface smoothness shall not deviate more than plus 1/4 inch or minus 0 inch when straightedge is laid across patched area between edges of new pavement and surface of old surfacing. Correct all humps or depression exceeding tolerance by method approved by Project Representative.

3.07 AC MILLING

A. AC milling shall conform to UDOT Standard Specifications.

3.08 PAVEMENT MARKING

A. Pavement marking shall conform to UDOT Standard Specifications.

3.09 FIELD QUALITY CONTROL

A. General: Provide services of approved certified independent testing laboratory to conduct tests.

B. Field Density Tests:

1. Perform tests from cores or sawed samples in accordance with AASHTO T230 and AASHTO T166.
2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.
3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

C. Testing Frequency:

1. Quality Control Tests:
    a. Asphalt Content, Aggregate Gradation: Once per every 500 tons of mix or once every 4 hours, whichever is greater.
    b. Mix Design Properties, Measured Maximum (Rice's) Specific Gravity: Once every 1,000 tons or once every 8 hours, whichever is greater.
2. Density Tests: Once every 500 tons of mix or once every 4 hours, whichever is greater.

END OF SECTION

SECTION 32 13 13
CONCRETE PAVING

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO).
   a. M6, Standard Specification for Fine Aggregate for Portland Cement Concrete.
   b. M80, Standard Specification for Coarse Aggregate for Portland Cement Concrete.
   c. M153, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
   d. M157, Standard Specification for Ready-Mixed Concrete.
   e. M213, Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   f. M227/M227M, Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties.
2. American Concrete Institute (ACI):
   a. 305R, Hot Weather Concreting.
   b. 306R, Cold Weather Concreting.
   c. 308, Standard Practice for Curing Concrete.
   d. 318/318R, Building Code Requirements for Structural Concrete and Commentary.
   e. 325.9R, Guide for Construction of Concrete Pavements and Concrete Bases.
3. ASTM International (ASTM):
   a. A615/A615M, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   b. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   c. C33, Specification for Concrete Aggregates.
   d. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78, Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).

g. C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
h. C94/C94M, Standard Specification for Ready-Mixed Concrete.
i. C143/C143M, Standard Test Method for Slump of Hydraulic Cement Concrete.
j. C150, Specification for Portland Cement.
k. C172, Standard Practice for Sampling Freshly Mixed Concrete.
l. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
m. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
n. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
o. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
p. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
q. C803/C803M, Test Method for Penetration Resistance of Hardened Concrete.
r. C1330, Specification for Cylindrical Seal Backing for Use With Cold Liquid Applied Sealants.
s. C805, Test Method for Rebound Number of Hardened Concrete.
t. D920, Standard Specification for Elastomeric Joint Seals.
u. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
v. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
w. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
x. D2628, Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete.
y. D2828, Specification for Non-Bituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type.
z. D3406, Specification for Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements.
aa. D3569, Specification for Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant Type for Portland Cement Concrete Pavements.
bb. D3581, Specification for Joint Sealant, Hot-Applied, Jet-Fuel-Resistant-Type, for Portland Cement and Tar-Concrete Pavements.

cc. D5249, Specification for Backer Material for Use With Cold- and Hot-Applied Joint Sealants in Portland Cement Concrete and Asphalt Joints.
dd. D5893, Specification for Cold-Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
ee. E329, Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
4. National Ready Mixed Concrete Association (NRMCA).

1.02 SUBMITTALS

A. Provide as required in Section 03 30 00, Cast-in-Place Concrete.

B. Action Submittals:

1. Jointing Drawings: Identify location and spacing of each type of joint.

1.03 QUALITY ASSURANCE

A. Provide as required in Section 03 30 00, Cast-in-Place Concrete.

B. Qualifications:

1. Mix Designer: Licensed professional engineer registered in the state of Project or a certified concrete mix designer approved by local Department of Transportation.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Transporting of ready-mix concrete shall be in accordance with ASTM C94/C94M.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

A. Cement:

1. Furnish cement for Project from one source.
2. Provide as required in Section 03 30 00, Cast-in-Place Concrete.
3. In accordance with ASTM C150.
4. Pozzolan: As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Aggregates:

1. General: As specified in Section 03 30 00, Cast-in-Place Concrete.

C. Water: ASTM C94/C94M.

D. Admixtures:

1. Add admixtures to mix at batch plant.
2. Air Entraining: ASTM C260.
3. Water Reducing:
   a. ASTM C494/C494M, Type A, normal, or Type D, retarding type, containing no chlorides and compatible with air-entraining admixtures.
   b. Do not use calcium chloride, salt, or antifreeze agents.

2.02 ANCILLARY MATERIALS

A. Tie Bars: Grade 40 deformed steel bars conforming to Section 03 21 00, Steel Reinforcement.

B. Dowels: Conform to requirements of AASHTO M227/M227M, Grade 70.

C. Joint Filler:

1. Conform toas specified in Section 03 15 00, Concrete Joints and Accessories.
2. Fillers furnished under AASHTO M213 shall be tested in accordance with ASTM D1751.

D. Backer Rod:

1. Backer material conforming to ASTM D5249.
2. Cylindrical sealant backing conforming to ASTM C1330.

E. Curing Membranes:

1. White polyethylene sheeting.
2. Waterproof paper.
3. Cotton or jute mats.

F. Evaporation Retardant: Confilm as manufactured by Master Builders Company.

2.03 EQUIPMENT

A. Ready-Mix Concrete Batch Plants: Certified by NRMCA.

B. Batch Plants:

1. Bins shall have adequate separate compartments for fine aggregate, each separate size of coarse aggregate and cement. Bins and

compartments shall be tight and ample to prevent spilling from one bin to another. Separate compartments, including weighting hoppers, shall discharge freely and efficiently.

2. Scales for weighing aggregates and cement may be either beam type or springless dial type. They shall be accurate within 0.5 percent under operating conditions throughout the range of use and, tested and adjusted as often as Engineer may deem necessary to assure their continued accuracy.
3. Equipment for dispensing water and admixtures shall provide a separate feed, accurate quantity measurement, and shall inject water and admixture at a time in mixing process to ensure thorough and complete mixing throughout batch of portland cement concrete.
4. Automatically controlled batchers shall have automatically interlocked mechanisms providing the following:
   a. Positive weighing and discharge of cement and of each separate size of aggregate.
   b. Interlocking between weighing hoppers to prevent part of batch from being discharged until each separate hopper has been filled with correct proportion.
   c. Simultaneous discharge of hoppers.
   d. Lockable compartment containing time setting controls.
5. Equip mixers with a timing device that will not permit batch to be discharged until specified mixing time has elapsed. The means of storing, measuring and introducing water into mixer shall provide positive control and accurate measurement.

C. Ready-Mix Concrete Trucks:

1. Agitator mixer type.
2. Equipped with operable electrically actuated drum revolution counters.
3. Use of nonagitator equipment will not be permitted.
4. Each mixer shall carry a clearly visible manufacturer’s plate showing capacity of mixer and other pertinent operating rates and limits.
5. Provision shall be made at mixer for controlled addition of air-entraining admixtures or other special components of mix.
6. Mixing Speed: 70 to 100 revolutions at a mixing speed recommended by truck mixer manufacturer.

D. Hauling Equipment:

1. Hauling equipment shall conform to AASHTO M157, Paragraph 11.6 and Paragraph 12.
2. Upon delivery of each batch of concrete to Site, a trip ticket shall be submitted to Engineer.

E. Concrete Saws:

1. Provide power driven concrete saws for sawing joints or finishing concrete, adequate in number of units and power to complete sawing at required rate.
2. Saws and related equipment shall be of proven adequacy and design to perform efficiently and shall be subject to immediate replacement, if specified results are not obtained.
3. Standby saw shall be available at Site.

F. Smoothness Testing Equipment: Supply two 12-foot straightedges for determining smoothness.

2.04 CONCRETE MIX DESIGN

A. As specified in Section 03 30 00, Cast-in-Place Concrete, with a minimum flexural strength of 650 psi.

B. Compressive strength of 4,000 psi minimum and flexural strength of 650 psi minimum, both at 28 days.

C. Concrete target strengths shall be in accordance with ACI 318/318R.

D. If Contractor proposes to use a current mix design that meets these Specifications, has been used on previous Utah DOT project, and less than 1 year has elapsed since it was last used; Contractor shall submit documentation of production of concrete produced from that mix design to Engineer for review. If review verifies concrete produced meets these Specifications and strength requirements, and establishes a correlation between compressive strength and flexural strength, no trial batches for proposed mix design will be required.

PART 3 EXECUTION

3.01 WEATHER LIMITATIONS

A. Concrete shall not be placed:

1. Until the air temperature in the shade is 5 degrees F and rising and is forecast to remain above 35 degrees F.
2. On frozen ground.
3. During periods of rain or snow.

B. Concrete placement shall not continue when air temperature drops below 40 degrees F.

C. Protect concrete pavement from inclement weather for 7 days after it has been placed, when rain is imminent, and when air temperature drops or is forecast to drop below 35 degrees F.

3.02 PREPARATION

A. Prepare base as specified in Section 32 11 23, Aggregate Base and Subbase Courses.

B. Dampen base thoroughly prior to concrete placement; standing water will not be permitted.

C. Formwork shall be complete prior to placement of concrete. Area in which concrete is to be placed, shall be smooth and free of ruts, projections, debris, spilled concrete, mud, sloughed soil, standing water, organic and other objectionable materials.

D. Construction Joints: Inspect prior to placement of concrete.

E. Prior to placing paving equipment in position, full width and length of the area on which the tracks of the paving equipment is to operate shall be brought to density and surface tolerances required.

F. Protect existing exposed surfaces such as grates, catch basins, air valves, manholes, and cleanout lids from splattered and spilled concrete during concrete placement by use of durable waterproof paper.

G. Furnish operable backup vibrator on Site prior to concrete placement.

3.03 STATIONARY SIDE FORM CONSTRUCTION

A. Where width of pavement is narrow, tapering, or of irregular pattern not lending itself to being constructed by prescribed machine methods, Contractor shall be permitted to place concrete as specified in Section 03 30 00, Cast-in-Place Concrete. Perform strike off, consolidation, final floating, and surface finishing with equipment, tools, means, labor, and methods other than those specified, provided the Work meets approval of Engineer and the following requirements:

1. As concrete is being placed, striking off and consolidating portland cement concrete shall be done without causing segregation of material and shall include thorough uniform vibration throughout the mass until it is uniformly compacted.
2. Portland cement concrete shall be struck off by means of templates or screeds designed and manipulated to shape portland cement concrete to specified cross section between forms, carrying a slight excess of portland cement concrete in front of leading edge of

templates or screeds at all times. Tamp portland cement concrete to reduce voids to a minimum.

3. Floating shall follow vibrating, striking off, and tamping operations and shall include transverse floating or other smoothing and finishing action. This shall provide a surface and evenness within a 12-foot straightedge tolerance of 0.01 foot. Test hardened surface in presence of Engineer. Surface shall be free from laitance, soupy mortar, marks, or irregularities.

B. Defects:

1. Fill areas of minor honeycomb or other minor defect in composition of portland cement concrete along exposed edges of portland cement concrete with a stiff mortar of cement and fine aggregate. Apply to moistened portland cement concrete to satisfaction of Engineer.
2. Area showing serious defects in composition of concrete shall be removed and replaced with pavement of specified quality for full width of strip between longitudinal joints or edges and for a length not less than between the nearest transverse joints.

3.04 JOINTS

A. General:

1. Referred to as contraction or construction, either of which may be transverse or longitudinal, as called for by Drawings or as approved by Engineer.
2. Joints, backer material, joint filler and joint sealants shall extend to pavement edges or to each other, as the case may be, and shall be constructed perpendicular to surface of pavement.
3. Joints shall not vary from specified or indicated line by more than 1/4 inch.
4. Contractor shall submit jointing plan and details to Engineer for approval. Take into consideration placement of joints in curb and gutter, at catch basins, and position of manholes and other large structures, as well as other limitations herein mentioned.
5. Place manhole or similar large structure in line of joint, or if impractical, isolate structure from pavement with premolded joint filler, 1/2-inch wide, conforming to AASHTO M213 and ASTM D1751.

B. Contraction Joints:

1. Sawed Type with Poured Filler:
   a. Sawing shall be to a depth as shown on Drawings with a maximum width of 1/4 inch and a minimum width of 1/8 inch, in straight lines as shown or as approved by Engineer.

b. Perform saw cuts as soon as portland cement concrete has set enough to permit sawing without tearing or raveling, before uncontrolled cracking results, and within 24 hours of placing portland cement concrete.
c. Saws may be single or tandem, as Contractor may elect, and shall be controlled by guides to true line.
d. Clean joints thoroughly of foreign matter before pouring approved rubber asphalt filler.
e. Tops of joint filler shall be true to pavement cross section within 1/8 inch and shall be protected from damage by portland cement concrete operations.
f. Areas containing uncontrolled cracks shall be removed and replaced.
g. Restore curing agents broken or damaged by sawing operations.

2. Space longitudinal joints as shown on Drawings at the interface between lanes, normally at intervals between 12 feet to 16 feet.
3. Transverse joints shall be as shown on Drawings or as approved by Engineer, with intervals of 12 feet to 16 feet.

C. Construction Joints:

1. Construct when there is an interruption of longer 45 minutes in portland cement concrete placing operations or where specified.
2. Place parallel with intended contraction joint.
3. Tool both free edges of joints with 1/8 inch radius rounder to remove laitance and mortar resulting from finishing operations and to provide clean rounded edge. Tooling shall not form ridges on surface of concrete.
4. New portland cement concrete placed contiguous to joint shall conform to proportions and consistency of previously placed concrete.
5. Transverse Construction Joint:
    a. If sufficient portland cement concrete has not been mixed at the time of interruption to place a construction joint at least 3 feet from a planned contraction joint, remove excess portland cement concrete back to a position to satisfactorily meet these criteria and to satisfaction of Engineer.
    b. Fill joint which has opened to a width of 1/8 inch or greater during construction or maintenance periods with poured filler.
    c. Do not construct within 3 feet of a transverse contraction joint.
6. Longitudinal Construction Joint:
    a. Tie Bars:
        1) Not required at construction joint between portland cement concrete pavement and gutter, except where shown on Drawings and mentioned above.

2) Placement:
   a) Plastic Portland Cement Concrete: Insert before vibrating and finishing portland cement concrete; or
   b) Hardened Concrete:
      (1) Drill hole, insert, and grout tie bars into place.
      (2) Drill holes large and deep enough to allow tie bars to be inserted with grout.
      (3) Perform any time after portland cement concrete has attained enough strength to resist any damage caused by drilling.
      (4) Tie bars shall be grouted a maximum of 3 hours prior to placement of adjacent portland cement concrete.
3) Replace loose tie bars by drilling and grouting as described.

D. Scored Joints:

1. Configuration: 1/4-inch wide by 1/4-inch deep at locations indicated on Drawings formed by tooling of concrete while it is still fresh.
2. Do not fill or seal.
3. Layout of joints shall be straight and true and shall not vary from indicated line by more than 1/4 inch.

3.05 SURFACE FINISHING

A. Use temporary screeds. Wet screeding and jitterbugging shall not be permitted.

B. Pavement shall have surface tolerance of 1/4 inch in 10 feet in accordance with ACI 325.9R.

C. Salting, spreading of cement or cement and sand mixture to speed up hardening shall not be permitted.

D. Exposed pavement edges shall be edged to a 1/2-inch radius and construction joints shall be edged to 1/8-inch radius after finishing. Edging shall not form ridges on pavement surface.

E. Pavement shall be treated and protected by use of evaporation retardant applied in accordance with manufacturer's written instructions. Flat surfaces shall be treated immediately after screeding and floating or if time period greater than 15 minutes occurs between finishing operations.

F. Pavement shall be screeded, floated, and given heavy nylon bristle-broomed skid-resistant surface.

1. Broomed surface with hand broom or mechanical broom device to produce 1/16-inch to 1/8-inch deep striations oriented perpendicular to the direction of travel.

3.06 CURING OF PORTLAND CEMENT CONCRETE

A. Immediately after the final floating, surface finishing, and edging has been completed, and while portland cement concrete surface is still moist, cover and cure entire exposed surface for at least 72 hours in accordance with one of the following provisions:

   1. Liquid Membrane-Forming Compounds: Apply compound uniformly to portland cement concrete by pressure spray methods at a rate which will form an impervious membrane, but at least at a rate of 1 gallon per 150 square feet.
   2. Other Membranes:
      a. Apply to damp portland cement concrete as soon as it can be placed without marring surface.
      b. Place in contact with surface, extend beyond sides or edges of slabs or forms, and fasten down to hold it in position as a waterproof and moistureproof covering.
      c. Laps shall be sufficient to maintain tightness equivalent to sheeting.
      d. Transverse laps for waterproof paper shall be at least 18 inches, and longitudinal seams shall be cemented.
      e. Cotton or jute mats shall be saturated with water prior to placing and kept fully wetted during curing period.

B. Concrete shall be cured by use of curing compound, for minimum of 7 days after concrete placement, in accordance with ACI 308. Curing compounds shall be applied in accordance with manufacturer’s written instructions.

C. Exposed surfaces shall be sprayed with curing compound immediately after free surface water has disappeared from finished surface.

D. Concrete temperature shall be maintained in accordance with ACI 306R.

E. Curing compounds shall not come in contact with hardened concrete that is to be concreted against.

3.07 FIELD QUALITY CONTROL

A. Retain independent testing or inspection agency to perform inspection, sampling, and testing.

B. Concrete Sampling: In accordance with ASTM C172. Take sample not less than every 5,000 square feet or fraction thereof of concrete placed each day.

C. Perform following tests on each sampling:

1. Slump: ASTM C143/C143M.
2. Air Content: ASTM C231.
3. Compressive Strength: ASTM C39/C39M.
4. Flexural Strength: ASTM C78.

D. Strength Tests:

1. Make and cure cylinders and beams in accordance with ASTM C31/C31M.
2. Cylinders: Make four, standard 6-inch diameter by 12 inches high. Cure one in field and three in laboratory.
3. Beams: Make three, standard 6 inches by 6 inches by 21 inches. Cure in field.
4. Compressive: Test one field-cured cylinder at 7 days and two laboratory-cured cylinders at 28 days. Test last cylinder at 56 days if 28-day cylinder is below specified strength.
5. Flexural: Test one beam at 7 days and two beams at 28 days.

E. Acceptance of concrete shall be in accordance with ACI 318/318R.

F. Concrete with compressive strength less than specified, as evidenced by cylinder tested at 56 days, shall be additionally tested as follows:

1. Less Than 500 psi Low in Compression or Less Than 75 psi Low in Flexure:
   a. Penetration Resistance Test: ASTM C803.
   b. Rebound Hammer Test: ASTM C805.
   c. Perform tests within 24 hours of noncomplying strength tests.
2. More Than 500 psi Low in Compression or More Than 75 psi Low in Flexure:
   a. Concrete Coring: Take three standard cores from concrete representing original specimens.
   b. Take and prepare cores in accordance with ASTM C42/C42M.
   c. Test cores in accordance with ASTM C39/C39M.
   d. Take cores within 24 hours of noncomplying strength test.

3.08 CLEANING

A. Clean concrete splatter from exposed surfaces.

B. Thoroughly broom and wash concrete surfaces before opening to traffic.

3.09 PROTECTION OF CONCRETE

A. Do not operate construction equipment or allow traffic on newly placed portland cement concrete until the following requirements are met:

1. Joints have been filled as per Article Joints.
2. Concrete has attained a compressive strength of at least 4,000 pounds per square inch.

B. Protect new concrete from construction operations, mechanical disturbances, water flow, and soiling until open for traffic.

C. Erect and maintain suitable barriers to protect concrete from traffic or other detrimental trespass until pavement is opened to traffic.

D. Maintain watchmen after normal working hours for at least a 24-hour period to ensure barriers are not removed or destroyed, and that trespass and vandalism upon pavement does not occur.

E. Wherever it is necessary that traffic, including Contractor's vehicles and equipment, be carried from one side of pavement to the other, construct suitable bridges over pavement, and maintain them in good condition as long as they may be required. Leaving gaps in pavement to facilitate movement of traffic will not be allowed, unless prior written permission is obtained from Engineer.

F. Protect new concrete from dirt, asphalt, and other deleterious substances that may be tracked onto new pavement from construction activities.

G. Pavement damaged by traffic or damaged from any other cause, prior to its official acceptance, shall be repaired or replaced to the satisfaction of Engineer.

END OF SECTION

SECTION 32 16 00
CURBS AND GUTTERS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): T 99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 in.) Drop.
2. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
3. ASTM International (ASTM):
    a. C94, Standard Specification for Ready-Mixed Concrete.
    b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
    c. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

1.02 SUBMITTALS

A. Action Submittals:

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. Informational Submittals:

1. Curing Compound: Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, and application instructions.
2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to the State of Utah Standard Specifications for Highway Construction.

PART 2 PRODUCTS

2.01 EXPANSION JOINT FILLER

A. Preformed asphalt-impregnated, expansion joint material meeting ASTM D994, 1/2-inch thick.

2.02 CONCRETE

A. As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Maximum Aggregate Size: 1-1/2 inch.

C. Slump: 2 inches to 4 inches.

2.03 CURING COMPOUND

A. Liquid membrane forming, clear or translucent, suitable for spray application and meeting ASTM C309, Type 1.

PART 3 EXECUTION

3.01 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.

3.02 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.

3.03 CURB CONSTRUCTION

A. Construct ramps at pedestrian crossings.

B. Expansion Joints: Place at maximum 45-foot intervals and at the beginning and end of curved portions of valley gutter and at connections to existing valley gutters. Install expansion joint filler at each joint.

C. Contraction Joints:

1. Maximum 15-foot intervals in valley gutter.
2. Provide open joint type by inserting thin, oiled steel sheet vertically in fresh concrete to force coarse aggregate away from joint.
3. Insert steel sheet to full depth of valley gutter.
4. Remove steel sheet with sawing motion after initial set has occurred in concrete and prior to removing front curb form.
5. Finish top of valley gutter with steel trowel and finish edges with steel edging tool.

D. Backfill valley gutter with earth upon completion of curing period, but not before 7 days has elapsed since placing concrete.

1. Backfill shall be free from rocks 2 inches and larger and other foreign material.
2. Compact backfill firmly.

3.04 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 in adjacent curb, where sidewalk ends at curb, and 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 or in pattern shown on Drawings, 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.

END OF SECTION

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section includes materials and installation for chain link fencing and gates. Install fencing per this specification and in accordance with manufacturer recommendations.

B. Use 6-foot high poles and fabric, unless noted otherwise on Drawings.

C. For wire fabric fence repairs comply with UDOT Standard Specification, Section U02822, “ROW Fence and Gates.”

1.02 REFERENCES

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

1. ASTM International (ASTM):
   a. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
   b. A313/A313M, Standard Specification for Stainless Steel Spring Wire.
   c. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
   d. A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
   e. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   f. A570, Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled.
   g. A585, Standard Specification for Aluminum-Coated Steel Barbed Wire.
   h. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   i. A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
   j. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
   k. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
   l. B6, Standard Specification for Zinc.

m. C94/C94M, Standard Specification for Ready-Mixed Concrete.
n. C150, Standard Specification for Portland Cement.
o. C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete.
p. F552, Standard Terminology Relating to Chain Link Fencing.
q. F567, Standard Practice for Installation of Chain-Link Fence.
r. F626, Standard Specification for Fence Fittings.
s. F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
t. F900, Standard Specification for Industrial and Commercial Swing Gates.
u. F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
v. F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
w. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
x. F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
y. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
z. F1916, Standard Specification for Selecting Chain Link Barrier Systems with Coated Chain Link Fence Fabric and Round Posts for Detention Applications.

2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: C2, National Electrical Safety Code.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

1.03 DEFINITIONS

A. Terms as defined in ASTM F552.

1.04 SUBMITTALS

A. Shop Drawings: Detailed information and specifications for materials, finishes, and dimensions.

B. Product Data: Include construction details, material descriptions, dimensions of individual components, and finishes for chain link fences and gates.

1. Fence, gate posts, rails, and fittings.
2. Chain link fabric.
3. Gates and hardware.
   1) Gate operators, motors, and mounting arrangements, switches, and controls; include operating instructions.

2) Gate access system, including access control features, power and control wiring diagrams, and operating instructions.
3) Accessories: Barbed wire
4. Samples:
   a. Chain Link Fabric: Approximately 6 inches square.
   b. Posts, Rails, Braces, Wire, and Ties: Approximately 6 inches long.
   c. Fittings: 1 each.
5. Test Reports: Field test result for compliance of installation of chain link fence, gates, and gate operators.

C. Quality Control Submittals:

1. Manufacturer’s recommended installation instructions.
2. Evidence of Supplier and installer qualifications.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Automatic Gate Operator System Supplier: 5 years’ experience in gate operator systems.
2. Automatic Gate Operator System Installer: Experienced installer who has completed chain link fences and gates similar in material, design, and extent to those indicated for Project and whose work has resulted with a record of successful in-service performance with a minimum 3 years’ experience.

B. Design, supply of equipment and components, installation, and on-call service shall be product of individual company with record of installations meeting requirements specified.

C. Preinstallation Conference: Conduct conference at project Site with gate installer to verify layout and operations of automatic gate operating system.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.07 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation and grading before installing chain link fence and gates.

B. Interruption of Existing Utility Service: Notify owner of utility 72 hours prior to interruption of utility services. Do not proceed with interruption of utility service without written permission from utility owner.

1.08 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of the following items found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

1. Faulty operations of gate operators and controls.
2. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
3. Deflection of fence fabric beyond limits.

PART 2 PRODUCTS

2.01 GENERAL

A. Match style, finish, and color of each fence component with that of other fence components.

B. Unless noted otherwise, replace existing chain link fencing in kind (same height, fabric, posts, extension arms, PVC coating, color, etc.).

C. Where existing fencing is not being replaced, new fencing shall be as follows.

2.02 CHAIN LINK FENCE FABRIC

A. Chain link fabric shall, as called out on the Drawings, either galvanized or PVC coated galvanized.

1. Galvanized fabric conforming to ASTM F668, Class 1 or Class 2a.
2. PVC-coated or Polymer-coated galvanized fabric conforming to ASTM F668, Class 1 or Class 2a over metallic-coated steel wire.
3. Color shall be as called out on Drawings and complying with ASTM F934.

B. Height: 96 inches, unless otherwise shown.

C. Wire Gauge: 0.15-inch diameter.

D. Pattern: 1-3/4-inch diamond-mesh.

E. Diamond Count: Manufacturer's standard and consistent for fabric furnished of same height.

F. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.

G. 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.

2.03 POSTS

A. General:

1. Strength and Stiffness Requirements: ASTM F1043, heavy industrial fence except as modified in this section.
2. Round Steel Pipe, Schedule 40: ASTM F1083.
3. Roll-Formed Steel Shapes: Roll-formed from ASTM A570, 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. Zinc with Polymer Film Coating: ASTM F1043, Type B external and internal coating. PVC coating to match fabric.
6. Color Coating: ASTM F1043, minimum 10 mils thickness over zinc coating to match color of chain link fabric.

B. Line Posts:

1. Round Steel Pipe:
   a. Outside Diameter: 2.375 inches.
   b. Weight: 3.65 pounds per foot.

C. End, Corner, Angle, and Pull Posts:

1. Round Steel Pipe:
   a. Outside Diameter: 2.875 inches.
   b. Weight: 5.79 pounds per foot.

D. Posts for Removable Fence Panels: As specified for end, corner, angle, and pull posts.

E. Posts for Swing Gates 8 Feet High and Under:

1. ASTM F900.
2. Roll-formed steel shapes may be substituted for steel pipe posts for gate leaf widths up to 6 feet and fabric heights up to 8 feet.
   a. Outside Dimensions: 3-1/2 inches by 3-1/2 inches.
   b. Weight: 4.85 pounds per foot.

F. Posts for Swing Gates Over 8 Feet High: As recommended by fence manufacturer.

2.04 TOP AND BRACE RAILS

A. Galvanized Round Steel Pipe:

1. ASTM F1083.
2. Outside Diameter: 1.66 inches.
3. Weight: 2.27 pounds per foot.

B. Galvanized Roll-Formed Steel C Shapes:

1. Roll formed from ASTM A570, Grade 45.
2. Outside Dimensions: 1.625 inches by 1.25 inches.
3. Weight: 1.40 pounds per foot.

C. Protective Coatings: As specified for posts.

D. Color Coating: ASTM F1043, minimum 10-mil thickness over zinc coating to match color of chain link fabric.

E. Strength and Stiffness Requirements: ASTM F1043, top rail, heavy or light industrial fence.

2.05 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: Vinyl-clad. PVC coating to match fabric.

D. Tension Bars:

1. One-piece vinyl-clad.
2. Equal in length to full height of chain link fabric.
3. Provide one bar for each gate and end post, and two for each corner and pull post.

E. Truss Rod Assembly: 3/8-inch diameter, steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment. Tie Wires, Clips, and Fasteners: According to ASTM F626.

F. Barbed Wire Supporting Arms: 45-degree arms for supporting three strands of barbed wire.

2.06 TENSION WIRE

A. Zinc-coated steel marcelled tension wire conforming to ASTM A824 Type II, Class 2

2.07 BARBED WIRE

A. Zinc-Coated Barbed Wire: ASTM A121, Chain Link Fence Grade:

1. Line Wire: Two strands of No. 12-1/2 gauge.
2. Barbs:
   a. Number of Points: Four
   b. Length: 3/8 inch minimum.
   c. Shape: Round.
   d. Diameter: No. 14 gauge.
   e. Spacing: 5 inches.

2.08 GATES

A. General:

1. Gate Operation: Opened and closed easily by one person.
2. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F1043 and ASTM F1083 for materials and protective coatings.

3. Frames and Bracing: Fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F900.
4. Gate leaves more than 8-feet wide shall have intermediate tubular members and diagonal truss rods to provide rigid construction, free from sag or twist.
5. Gate Fabric Height: Same as for adjacent fence height.
6. Welded Steel Joints: Paint with zinc-based paint.
7. Chain Link Fabric: Attached securely to gate frame at intervals not exceeding 15 inches.
8. Gate Posts and Frame Members: Extend gateposts and frame end members above top of chain-link fabric at both ends of gate frame to attach barbed wire assemblies.
9. Latches: Arranged for padlocking so padlock will be accessible from both sides of gate.

B. Swing Gates: Comply with ASTM F900.

1. Hinges: Offset type, malleable iron.
    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 leaves of double gate.
5. Hold-Open Keepers: Designed to automatically engage gate leaf and hold it in open position until manually released.

2.09 GATE OPERATOR SYSTEM

A. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, safety devices, and weatherproof enclosures; coordinate electrical requirements with Division 26, Electrical.

1. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
2. Provide operator with UL approved components.

3. Provide electronic components with built-in troubleshooting diagnostic feature.
4. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.

B. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor.

C. Gate Operator:

1. Heavy-duty, high frequency, electrical models designed to open and close gates provided.
2. For each gate, supply manufacturer of gate operator with complete details of gate, hardware, track rollers, adjacent fence posts, and fence construction for development and detailing of gate operator.
3. Furnish with following features:
    a. Metal enclosure, including attachments shall be constructed with finish and design suitable for exterior installation in all-weather environment.
    b. Minimum 1-hp motor, 208V ac, three-phase, 60-Hz electric power, reversible.
    c. Electric motor driven hydraulic power pack with hard rubber wheels in contact with operating type secured to gate. Transmission of opening or closing forces to gate shall be by rotation of wheels against operating type.
    d. Positive limit switch, to sense position of gate and provide control to prevent damage to gate operator.
    e. NEMA 250, Type 12 enclosure for motor control components.
    f. Motor Overload Protection: Industrial quality with manual reset.
    g. 24V ac control circuit to power remote control gate activation devices.
    h. Manual operation feature or disconnect, without use of tools, for easy operation during power failure, malfunction, or emergency.
    i. Aluminum drive rail designed for attachment to sliding gate in manner that reinforces gate assembly.
    j. Gate Travel Speed:
        1) Minimum 1 foot per second.
        2) Speed adjusting feature that provides range of appropriate speeds for slide gate operation is acceptable but not required.
        3) Maximum Gate Weight: 3,000 pounds.
        4) Frequency of Use: Continuous Duty.

5) Operating Type: Enclosed, Wheel and drive, or Roller chain with manual release.

k. Compatible with gate operator control devices provided.

4. Manufacturers:
   a. Hy-Security Gate Operator, Seattle, WA.
   b. Automated Equipment Co., Seattle, WA.
   c. Stanley.
   d. Richards Wilcox, Aurora, IL.

2.10 REMOVABLE FENCE PANELS

A. Panel Length:

1. Equal division of total length of removable fence section.
2. Maximum 10 feet.

B. Frames: ASTM F1184, Type I.

2.11 CONCRETE

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete, for securing posts and gate stops in excavated holes.

2.12 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1-inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Grounding Rods: Comply with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel.

PART 3 EXECUTION

3.01 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 necessary hardware for a complete fence and gate installation.

C. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780.

D. Drainage Crossings: Where the chain-link fence must cross drainage ditches or swales, the main fence shall be carried across a ditch or swale with additional fence added below.

1. Frames and Bracing: The fence added below shall be fabricated with galvanized round steel pipe conforming to the requirements for top and brace rails.
2. The construction of the frame shall be welded or assembled with corner fittings. The frame shall be rigid and to the extent necessary to maintain a 2-inch clearance between bottom of the frame and finish grade. If necessary to maintain rigidity, attach to the frame a series of 3/8-inch diameter galvanized steel pipe stakes that are embedded a minimum of 2 feet to the sides and bottom of the ditch.
3. Attach chain link fabric securely to frame at intervals not exceeding 12 inches.

3.02 PREPARATION

A. Clear area on either side of fence to the extent specified in Section 31 10 00, Site Clearing. Eliminate ground surface irregularities along fence line to the extent necessary to maintain a 2-inch clearance between bottom of fabric and finish grade.

B. Stake locations of fence lines, gates, and terminal posts for Construction Manager review prior to installing. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

C. Embedment Coating: Coat portion of galvanized or aluminum-coated steel posts that will be embedded in concrete as specified in Section 09 90 00, Painting and Coating. Extend coating 1 inch above top of concrete.

3.03 POST SETTING

A. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed soil. Driven posts are not acceptable. Postholes shall be clear of loose materials. Waste materials from postholes shall be removed from Site or regraded into slopes on Site.

B. Posthole Depth:

1. Minimum 3 feet below finished grade.
2. 2 inches deeper than post embedment depth below finish grade.

C. Set posts with minimum embedment below finished grade of 22 inches plus 3 inches for each 1 foot of fence height greater than 4 feet, and with top rail at proper height above finished grade. Verify posts are set plumb, aligned, and at correct height and spacing. Brace posts, as necessary, to maintain correct position and plumbness until concrete sets.

D. Backfill postholes with concrete to 2 inches above finished grade. Vibrate or tamp concrete for consolidation. Protect above ground portion of posts from concrete splatter.

E. Before concrete sets, crown and finish top of concrete to readily shed water.

F. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.

G. Line Posts: Space line posts uniformly at 10 feet on centers between terminal end, corner, and gate posts.

3.04 POST BRACING

A. Install according to ASTM F567, maintaining plumb position, and alignment of fencing. Install braces at gate, end, pull, and corner posts diagonally to adjacent line posts to ensure stability. Install braces on both sides of corner and pull posts.

1. Locate horizontal braces at mid-height of fabric or higher, on fences with top rail, and 2/3-fabric height on fences without top rail. Install so posts are plumb when diagonal truss rod assembly is under proper tension.

3.05 TOP RAILS

A. Install according to ASTM F567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps and terminating into rail end attached to posts or posts caps fabricated to receive rail at terminal posts. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

3.06 BARBED WIRE SUPPORTING ARMS

A. Barbed wire supporting arms shall be installed as indicated and as recommended by manufacturer. Bolt or rivet supporting arm to top of post in a manner to prevent easy removal with hand tools. Angle single arms to outside of fence.

3.07 TENSION WIRE

A. Install according to ASTM F567 and ASTM F1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with tie wires at a maximum spacing of 24 inches on center.

B. Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

3.08 CHAIN LINK FABRIC

A. Do not install fabric until concrete has cured minimum 7 days.

B. Install fabric with knuckled selvage at top, unless noted otherwise in the Drawings.

C. Apply fabric to outside of enclosing framework. Pull fabric taut to provide a smooth and uniform appearance free from sag, without permanently distorting fabric diamond or reducing fabric height. Tie fabric to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

D. Splicing shall be accomplished according to ASTM F1916 by weaving a single picket into the ends of the rolls to be joined.

E. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated.

F. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches on center.

G. Tie Wires: Fasten ties to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends of tie wire three full twists, and cut off protruding ends to preclude untwisting by hand.

1. Maximum Spacing: Tie fabric to line posts at 12 inches on center and to brace and top rails at 24 inches on center.

3.09 BARBED WIRE

A. Install barbed wire uniformly in configurations of three strands of barbed wire on supporting arms. Pull wire taut and install securely to supporting arms and secure to end terminal post or terminal arms.

3.10 GATES

A. Install gates according to manufacturer's written instructions, level, plumb and secure for full opening without interference. Attach fabric and hardware to gate using tamper-resistant or concealed means. Adjust hardware for smooth operation and lubricate where necessary so gates operate satisfactorily from open or closed position.

B. Set gate stops in concrete to engage center drop rod or plunger bar.

3.11 GATE OPERATOR SYSTEMS

A. Install gate operator systems in accordance with manufacturer's recommendations, aligned and true to fence line and grade.

B. Furnish with equipment and accessories necessary for complete installation.

C. Hand excavate holes for pads in firm undisturbed soil to dimensions, depths, and locations as required by gate operator component manufacturer's written instructions and as shown on the drawings.

D. Vehicle Loop Detector System: Cut grooves in pavement and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

3.12 ELECTRICAL GROUNDING

A. Ground fences at a maximum interval of 1,000 feet in accordance with applicable requirements of IEEE C2, National Electrical Safety Code.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

3.13 FIELD QUALITY CONTROL

A. Post and Fabric Testing: Test fabric tension and line post rigidity according to ASTM F1916.

B. Gate Tests:

1. Prior to acceptance of installed gates, demonstrate proper operation of gates under each possible open and close condition specified.
2. Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range.
3. Confirm that latches and locks engage accurately and securely without forcing and binding.

C. Automatic Gate Operator:

1. Energize circuits to electrical equipment and devices.
2. Adjust operators, controls, safety devises, and limit switches.
3. Start units to confirm proper motor rotation and unit operation free of binding. Test and adjust all gate controls for proper operation.
4. Replace damaged and malfunctioning controls and equipment.
5. Lubricate hardware, gate operator and other moving parts.

D. Gate Maintenance:

1. Maintain and repair to the manufacturer’s recommended standard quality of operation, any gates which are damaged during the full project construction period. If the manufacturer does not have a standard quality of operation, perform repairs to the Construction Manager’s satisfaction.

3.14 MANUFACTURER’S SERVICES

A. Provide manufacturer’s representative at Site in accordance with Section 01 43 33, Manufacturers’ Field Services, to train Owner’s personnel to adjust, operate, and maintain gates.

3.15 CLEANUP

A. Remove excess fencing materials and other debris from Site.

END OF SECTION

SECTION 32 31 26
WIRE FENCES AND GATES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes materials and installation for wire fences and (steel) gates. Where existing fences are removed they shall be replaced with new fencing of the same basic type as that which was removed. Replace barbed wire with barbed wire and wire fabric with wire fabric. Wire fabric fence is entitled as “Wire Field Fence” in Standard Detail (SD-XX) Drawings.

B. Stretch taut all wire and fabric until accepted by Engineer. If Engineer deems wires or fabric insufficiently taught remove attachments from posts and re-tighten until Engineer accepts tautness, then reattach wire and fabric to posts.

1.02 REFERENCES

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

1. American Wood-Preservers’ Association (AWPA):
   a. C1, All Timber Products - Preservative Treatment by Pressure Processes.
   b. C2, Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes.
   c. C5, Fence Posts - Preservative Treatment by Pressure Processes.
2. ASTM International (ASTM):
   a. A116, Standard Specification for Metallic-Coated Steel-Woven Wire Fence Fabric.
   b. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed for Concrete.
   e. A615/A615M, Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   f. A702, Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought.
   g. A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
   h. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   i. C150, Standard Specification for Portland Cement.

j. C387, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
k. F883, Standard Performance Specification for Padlocks.

1.03 DEFINITIONS

A. Assemblies: As defined in ASTM A702.

B. Line Posts: As defined in ASTM A702.

C. Sweep: Maximum deviation of center of post or brace from line drawn between centers of butt and tip of post or brace.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Include construction details, material descriptions, dimensions of individual components, and finishes for fence and gates.
2. Submit manufacturer's certificate or original shipping tags showing compliance with cited U.S. Federal and ASTM specifications.
3. Submit manufacturer's descriptive literature on protective coatings and wood preservatives.
4. Samples:
   a. Wire Fabric: Minimum 6 inches square.
   b. Posts, Rails, and Braces: Minimum 6-inch length.
   c. Barbed Wire: Minimum 12-inch length.
   d. Ties, Fasteners, Fittings: One each.
   e. Approved Sample fittings may be incorporated in the Work when no longer needed by Engineer.

1.05 GENERAL

A. Replace fences which are removed or relocated with new fences of the same type that is removed. Verify with Engineer and Landowner type of fence to be replaced. If existing wire fence is damaged, crooked, loose, or of poor quality, do not assume replacement fence shall be less than the new, straight, taut, wire fabric field fence with steel gates shown in the Standard Detail Drawings.

1.06 QUALITY ASSURANCE

A. Erect fencing using skilled mechanics experienced in wire fence and gate construction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.08 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation and grading before installing wire fences and gates.

PART 2 PRODUCTS

2.01 GENERAL

A. Fencing materials and gates shall carry a tag identifying manufacturer.

B. Legibly mark each roll of fencing material with style, class of zinc coating, and other pertinent identifying information.

C. Manufactured Materials: Same kind and color for each type of fence on Project.

D. Fencing materials shall comply with UDOT Specification 02822 for barbed wire and wire mesh fencing, except as modified herein.

2.02 BARBED WIRE

A. Galvanized steel barbed wire shall conform to AASHTO M280 that consists of two strands of nominal 0.099-inch diameter wire twisted with 4-point nominal 0.080-inch barbs no more than 5 inches on center.

B. Zinc Coated Barbed Wire: ASTM A121, Standard Grade.

1. Line Wire: Two strands of No. 12, 1/2-gauge.
2. Barbs:
    a. Number of Points: Four.
    b. Length: 1-inch.

2.03 VERTICAL FENCE STAYS

A. 9-1/2-gauge galvanized wire, 40 inches long.

2.04 WIRE MESH

A. Steel wire mesh shall conform to the UDOT Standard Specifications, Section 02822, AASHTO M279, nominal 0.099-inch farm grade wide mesh fencing with a 6-inch vertical wire spacing. Use Class I zinc coating.

2.05 METAL POSTS AND ASSEMBLIES

A. General: Conform to ASTM A702.

2.06 WOOD POSTS AND BRACES

A. General:

1. Cut from sound and solid timber. Free from bark and protruding knots.
2. Straight; free from sweep exceeding 1.67 percent of post length, not to exceed maximum 2 inches; free from multiple crooks. Acceptable crooks may be in one plane only.
3. Free from loose or unsound knots, shakes in excess of 1/3 post thickness, splits longer than post thickness, or other defects that would render them unfit structurally for purpose intended.
4. Dry and seasoned; small surface seasoning checks less than 1/4 inch wide are acceptable.
5. Square or Rectangular Posts and Braces:
   a. Rough sawn, S4S, or S2S.
   b. Free of heart center.

B. Untreated Wood Posts and Braces:

1. Species: Use native juniper, “or-equal.” All posts shall be sound and free of decay or defects to ensure structural suitability for purpose intended.
2. Line Posts: Line posts shall be 7.5 feet minimum long, 2.5 feet minimum buried in ground, 10-inch diameter minimum at base, and 4-inch diameter minimum at top.
3. End, Corner, and Brace Posts: Posts for gates, braces, and corners shall be 8 feet minimum long, 3 feet minimum buried in ground, 12-inch diameter minimum at base, and 6-inch diameter minimum at top.

C. Treated Wood Posts and Braces:

1. Round, Half-Round, and Quarter-Round Posts and Braces:
   a. Species: Limited to those addressed by AWPA C5; Douglas Fir, Western Hemlock, and Western Larch as round posts only.
   b. Treatment: In conformance with AWPA C1 and AWPA C5.
2. Posts and Braces Sawn on Four Sides:
   a. Species: Limited to those addressed by AWPA C2 for above ground, soil, and freshwater use.
   b. Treatment: In conformance with AWPA C1 and AWPA C2.

2.07 WIRE FASTENERS FOR METAL POSTS

A. Conform to ASTM A702.

2.08 BRACING WIRE

A. No. 9 or heavier, zinc-coated, soft smooth wire.

2.09 NAILS AND SPIKES

A. Hot-dipped, zinc-coated of best commercial quality, and of proper length.

2.10 STAPLES

A. Formed of No. 9 zinc-coated steel wire 1-1/2 inches long.

2.11 CONCRETE FOR CORNER POSTS AND GATES

A. Provide 2-inch to 3-inch slump, 3,000 psi concrete as specified in Section 03 30 00, Cast-in-Place Concrete for securing posts in excavated holes.

2.12 METAL GATES

A. Use IFA Powder River, Super Classic Bull Gates, fusion epoxy coated steel frame gates (14-gauge rails, 13-gauge frame, 14-gauge vertical supports), 180-degree hinges, 52-inch minimum height, 16-feet-wide (unless drawing requires a different width).

B. Use double piston lever latch mechanism with latch plates (or chain latch if Landowner prefers). Provide locking hasp that can accept Owner-supplied padlock.

C. Provide standard 5-year warranty with gates.

2.13 GROUND RODS

A. Galvanized or copper-coated steel rod.

B. Length: 8 feet.

C. Diameter: Minimum 1/2 inch.

PART 3 EXECUTION

3.01 PREPARATION

A. Clear area to extent specified in Section 31 10 00, Site Clearing, on both sides of fence. Eliminate ground surface irregularities along fence line to extent necessary to maintain 2-inch clearance between bottom of wire fence fabric and finish grade.

B. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.02 INSTALLATION—GENERAL

A. Erect fencing in straight lines between angle points.

B. Connections:

1. Junctions or Intersections:
    a. Install corner post with braces in every direction of strain for connections at each fence junction or intersection.
    b. Fasten wire of both new and existing fence segments to post.
2. Structures: Install end post and fasten wire to post.

C. Provide necessary hardware for a complete fence and gate installation.

D. Postholes:

1. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed soil. Driven posts are only acceptable for metal line posts.
2. Clear of loose materials.
3. Remove waste materials from postholes from Site or regrade into slopes on Site.
4. Depth: 2 inches deeper than post embedment depth below finish grade, minimum 38 inches below finished grade.

E. Posts:

1. Set with minimum embedment below finished grade of 36 inches.
2. Verify set plumb, aligned, and at correct height and spacing.
3. Set end posts at beginning and end of fence not terminating at gates.
4. Set gate posts at each end of each gate opening.
5. Set corner posts at angle points in fence alignment where deflection angle between adjoining panels of fence is 5 degrees or more for metal line posts and 15 degrees or more for wood line posts.
6. Spacing intermediate end posts between end, gate, and corner posts maximum 1,000 feet apart.

F. Drainage Crossings:

1. Where fence must cross drainage ditches or swales, main fence shall be carried across a ditch or swale with additional fence added below:
   a. Frames and Bracing: Fence added below shall be fabricated with 2-inch by 4-inch Redwood or Cedar lumber.
   b. Construction of frame shall be assembled with galvanized bolts. Frame shall be rigid and shall maintain 12-inch clearance between bottom of frame and finish grade. If necessary to maintain rigidity, attach to frame a series of 3/8-inch diameter galvanized steel pipe stakes that are embedded a minimum of 2 feet to sides and bottom of ditch.
   c. Attach wire securely to frame at intervals not exceeding 12 inches.

3.03 METAL POST INSTALLATION

A. Embedment Coating: Coat portion of galvanized or aluminum-coated steel posts that will be embedded in concrete as specified in Section 09 90 00, Painting and Coating. Extend coating 1 inch above top of concrete.

B. Backfill:

1. Place and vibrate or tamp concrete around posts and braces after they are in proper position and are securely restrained from movement.
2. Strike off concrete to a reasonably smooth surface to 2 inches above ground level. Crown each surface to drain away from post or brace.
3. Wait for concrete to cure for at least 7 days before subjecting posts and braces to stress or strain, unless otherwise authorized by Engineer.

C. Line Post Spacing: Maximum 10 feet. Set posts on lines and grades established or designated by Engineer. When posts are set, grade line on tops of posts shall present a neat, uniform appearance.

D. Line posts that are set by driving shall be free of damage when in place. Remove and replace with a new post any post which is twisted or bent, or which has a misshaped top.

E. Bracing:

1. Gate and End Posts: Install one metal brace in line of fence. Maintain plumb position and alignment of fencing.
2. Corner and Intermediate End Posts:
   a. Install two braces, one each way from post in line with fence.
   b. Install one additional brace at each intersection with another fence in line of intersecting fence.

3.04 WOOD POST INSTALLATION

A. General:

1. Do not cut off bottoms to avoid rock removal or additional excavation.
2. Cut butt end of post square.
3. Line Post Spacing: Maximum 10 feet. Set posts with large end down, plumb, and in good line on side on which wire is to be fastened. Set posts on line and grade established or designated by Engineer. When posts are set, grade line on tops of posts shall present a neat, uniform appearance
4. Backfill:
   a. After posts are placed and aligned, backfill holes with suitable earth material and compact with hand tampers or other approved method.
   b. Backfill shall be placed in layers of 9 inches or less.
   c. Mound excess earth around post to provide natural drainage.

B. Wood Bracing for End Posts and Gate Posts:

1. Brace end and gate posts with 4-inch by 4-inch bracing
2. Notch gate, brace and corner posts, fit braces in securely, and spike to post with 3/8-inch by 4-inch spikes.
3. Complete wood bracing before attaching barbed wire and fence fabric.
4. Maintain plumb position, and alignment of fencing.

3.05 WOVEN WIRE FABRIC INSTALLATION

A. Draw woven wire fabric tight and securely attach to posts.

B. Fastening:

1. Terminate woven wire fabric at each end post, gate post, corner post, and intermediate end post.
2. Wrap each longitudinal wire of woven wire fabric around terminating post and splice to itself with at least four turns.
3. At line post, fasten woven wire fabric to post at top, bottom, and at intermediate points spaced at intervals not exceeding 12 inches apart; minimum of five fasteners per post.
4. Staple fence wire to wooden posts, or tie fence wire to metal posts, as specified in the UDOT Standard Specifications, Section 02822. Staples shall be No. 9 wire minimum at least 1-1/2 inches long.

C. Stretching Woven Wire Fabric:

1. Ensure pull is evenly distributed over longitudinal wires and not more than half of original depth of tension curves is removed.
2. Splices of fabric between posts will be permitted, provided no more than one splice occurs in any one “run” of fence.
3. In final position, fabric shall be free from warp and sag.
4. Retighten brace guys and leave lever restrained against woven wire fabric or fence wires.
5. Fence Condition Upon Completion: Straight between corners.
   a. Posts: Vertical and firmly set.
   b. Braces, Fittings, and Fixtures: Tight and firm.

D. Covering Side or Bottom Openings:

1. Where bottom line of fence as normally constructed leaves an unfenced opening beneath it exceeding 12 inches in height, provide additional panel or additional panels of fence between line posts across opening with barbed wire, woven wire fabric, or combination thereof so that at no point along fence will there be side openings or bottom openings exceeding 4 inches in dimension.
2. Where bottom line of fence as normally constructed leaves an unfenced opening beneath it of 12 inches or less, pull normal fabric and wires down between posts and anchor by means of pins or posts, driven not less than 24 inches into ground, so that at no point along fence will there be any bottom opening exceeding 4 inches in height.

3.06 BARBED WIRE INSTALLATION

A. Draw barbed wire tight and securely attach posts.

1. Terminate barbed wire at each end post, gate post, corner post, and intermediate end post.
2. Wrap each line of barbed wire around terminating post and splice to itself with at least four turns.
3. Securely fasten each line of barbed wire at each metal line post with galvanized wire ties or clamps.
4. Securely fasten each line of barbed wire at each wood line post with staples.

B. Splices of barbed wire between terminating posts will be permitted provided no more than one splice occurs between two adjacent terminating posts.

C. In final position, barbed wire shall be tight and free from sag.

D. In crossing gullies, ditches, and abrupt depressions where bottom line of fence as normally constructed leaves an unfenced opening beneath it exceeding 10 inches in height, add an additional line of barbed wire, so that at no point along fence will there be side openings or bottom openings exceeding 10 inches in dimension.

E. Fence Condition Upon Completion: Straight between corners.

1. Posts: Vertical and firmly set.
2. Braces, Fittings, and Fixtures: Tight and firm.

3.07 VERTICAL FENCE STAYS

A. Install midway between posts. Twist wire to permit weaving into horizontal fence wires to provide rigid spacing. Weave barbed wires into stay.

3.08 TEMPORARY CONSTRUCTION FENCING

A. During nonworking hours, install and maintain fencing or other means to protect animals and persons from open trenches or excavations and keep them out of Work Limits. Maintain temporary fencing acceptable to the Engineer around open trenches. Damages to persons or property resulting from the failure to install and maintain temporary construction fencing around the Work area, or around open trenches or vaults, are the full financial and legal responsibility of the Contractor. Remove all temporary fencing after construction.

B. If Contractor does not provide the necessary fences and gates to adequately protect property adjacent to the construction right-of-way with a reasonable time after need for such precaution arises, the Engineer will cause the Work to be performed and back-charge the Contractor for such work.

C. Maintain temporary silt fencing to visually delineate Work Limits where directed on Drawings. Silt fencing shall be per Section 31 32 19.16, Geotextile. Install in a manner that retains sediment inside Work Limits. Remove after construction.

3.09 GATE INSTALLATION

A. Install gate at each location shown on Drawings.

B. Install gates with faces plumb and top level so gate will swing freely, without binding, through arc of 180 degrees inwards or outward. Adjust grade within area of gate swing if necessary, and as approved by Engineer, to prevent gate from dragging on ground.

C. Install hinges and hardware as recommended by gate manufacturer. Hinge pins, and hardware shall be welded or otherwise secured to prevent removal.

D. Attach padlocks to gates or gate posts with chains.

3.10 GROUNDING

A. General:

1. Ground fence fabric and barbed wire wherever fences are supported by wood line posts by substituting metal post for wood post at intervals not to exceed 500 feet with not less than one metal post between openings.
2. Tightly fasten each line of barbed wire and alternate longitudinal wire of fence fabric to metal posts with 11-gauge, or heavier, galvanized steel wire.

B. Overhead Power Lines:

1. At each location where electric transmission, distribution, or secondary line crosses fence with wood posts, ground fence with ground rod installed directly below point of crossing.
2. At each line where power line is parallel or nearly parallel to and within 100 feet of fence with wood posts, ground fence with ground rod at each end post or at intervals not to exceed 1,500 feet.
3. Drive ground rods vertically until top of rod is 6 inches below finished grade. If required vertical penetration cannot be achieved, install equivalent horizontal grounding system, as approved by Engineer.
4. Connect each fence element to grounding rod with No. 6 solid copper conductor, or equivalent. Braze connections or use noncorrosive clamps, as approved by Engineer.

3.11 REPAIR

A. Repair damage to galvanized surfaces, including welding, with paint containing zinc dust in accordance with ASTM A780.

3.12 CLEANUP

A. Remove excess fencing materials and other debris from Site.

END OF SECTION

SECTION 32 91 13
TOPSOIL

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C602, Standard Specification for Agricultural Liming Materials.
   c. D2974, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
   d. D5268, Standard Specification for Topsoil Used for Landscaping Purposes.

1.02 SUBMITTALS

A. Submit imported topsoil sample, details of source, and a USU certified soils analysis (including salinity, chemical and biological content) at least 30 days before order. Certify topsoil is suitable for intended revegetation.

B. Submit 5-gallon bucket sample of imported topsoil.

C. Submit Certified Testing and Analysis (from USU Extension testing) of imported topsoil that indicates:

1. Quantities of materials necessary to bring imported topsoil into compliance with textural/gradation requirements.
2. Quantity of lime, quantity and analysis of fertilizer, and quantity and type of soil additive.

1.03 SEQUENCING AND SCHEDULING

A. Schedule and complete all applicable Work specified in Section 31 10 00, Site Clearing; Section 31 21 16, Excavation; Section 31 23 13, Subgrade Preparation; Section 31 23 23, Fill and Backfill; Section 31 23 23.15, Trench Backfill; and this section.

B. Unless ground surface must be used for construction work, replace topsoil to each land parcel within 10 days after backfilling pipe or structure.

PART 2 PRODUCTS

2.01 NATIVE TOPSOILS

A. Comply with Section 31 10 00, Site Clearing.

B. Obtain Owner ruling on the depths of the native topsoils to be removed for each area and parcel. Strip and stockpile those topsoils. Unless allowed otherwise, restore topsoils after construction to the lands from which they were stripped. Assume topsoil exists in all areas to be disturbed for the Work except areas covered with asphalt, concrete, or aggregate base, or on slopes steeper than 1.5H to 1V.

C. Segregate and label native topsoil stockpiles by property and location and return each topsoil to the area from which it was stripped; including crop lands, sod areas, landscaped areas, irrigated and non-irrigated lands, areas of disturbed and undisturbed native vegetation, lands covered with weeds, and others.

1. Strip, segregate, stockpile, and return native topsoils to these areas:
   a. Pipeline and structure excavations.
   b. Road excavations, cut and fill slopes, and earth disposal areas.
   c. Staging, service, storage and stockpile areas.
   d. Other areas per Drawings and as directed by Owner.
2. Owner determines depth to strip all native topsoils.
   a. Strip topsoils on non-irrigated lands to 12 inches or shallower.
   b. Strip topsoils on irrigated crop land from 18 inches to 24 inches.
3. Replace topsoils to depths and areas from which they were stripped.
4. Topsoils may be stripped from trench heading and placed on backfilled trench without stockpiling if Owner deems both heading and backfilling topsoils are on same field and/or of same quality.
5. Where drainage occurs, leave gaps in between topsoil stockpiles to prevent increased water saturation in topsoils. Cease topsoil stripping during excessively wet weather.
6. Do not stockpile topsoils for longer than 12 months.
7. Topsoils Not to be Removed: Where Drawings require, do not remove topsoils containing scrub oak roots (see Section 31 10 00, Site Clearing, Article Protection). Leave topsoils in place allowing trees to regrow.

2.02 IMPORTED TOPSOILS

A. Provide and place imported where required on Drawings and as directed by Owner.

B. Imported Topsoils: Natural, friable, loam or sandy loam, obtained from well-drained areas, free from objects larger than 1-inch maximum dimension, and free of subsoil, large roots, live grass roots, other foreign matter, hazardous or toxic substances, invasive weeds species, foreign plant seeds, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

1. Amend imported topsoils until they conform to the below required composition by incorporating sand, peat, manure, or sawdust.
2. Submit Utah State University (USU) Extension testing demonstrating imported topsoils comply with the following:
   a. pH: 5.8 to 7.2.
   b. Electrical conductivity (ECe) of soil solution less than 2 dS/m.
   c. Sodium absorption ratio (SAR) less than 3.
   d. Organic Matter: Over 1.5 percent by weight per ASTM D2974.
   e. Less than 2 percent coarse fragments (over 2 mm diameter).
   f. Loam or silty loam with less than 30 percent clay; less than 70 percent silt and less than 70 percent sand with gradation in general accordance with ASTM D5268.

C. Place imported topsoils to a depth of 12 inches minimum and as detailed in Table 1 of Section 32 93 00, Revegetation and Surface Restoration. Import topsoil if the irrigated crop land native topsoil was less than 12 inches.

2.03 TOPSOIL AMENDMENTS

A. Sawdust or Ground Bark: Nontoxic, of uniform texture, and subject to slow decomposition when mixed with soil. Nitrogen-treated, or if untreated mix with minimum 0.15 pound of ammonium nitrate or 0.25 pound of ammonium sulfate per cubic foot of loose material.

B. Peat: Natural residue formed by decomposition of reeds, sedges, or mosses in a freshwater environment, free from lumps, roots, and stones; with over 90 percent organic matter (by dry weight per ASTM D2974) and under 65 percent water weight at delivery time.

C. Manure Fertilizer: Well-rotted, stable or cattle manure, free from weed seed and refuse with up to 50 percent (by volume) sawdust, 4 to 24 months old.

D. Sand: Clean, coarse, well-graded, per ASTM C33/C33M.

E. Mixing Soil Amendments: Mix amendments, lime, and other soil additives, identified in analysis reports with topsoil before placement or spread on topsoil surface and mix thoroughly into entire depth of topsoil before planting or seeding. Delay mixing of fertilizer if planting or seeding will not occur within 3 days. Place one-half of the total depth of topsoil and work into top 4 inches of subgrade soil to create a transition layer.

Place remainder of topsoil to depth 12 inches where seeding and planting are scheduled.

2.04 SOIL STERILANT

A. Granular Calcium Cyanamide: Herbicide, by American Cyanamide Co.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. Prepared areas over which topsoil will be placed shall be scarified to 6-inch depth and graded to achieve smoothly rounded lines, slopes and grades, free of stones, sticks, roots, rubbish and any materials larger than 3 inches in any dimension. Place topsoil within 2 days after subgrade preparation.

3.02 PLACING TOPSOIL

A. Do no compact topsoils on flat slopes. On slopes steeper than 2:5:1, compact lightly to about to 85 percent relative compaction.

B. Uniformly distribute topsoil to within 1 inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade. Remove stones, roots, sticks, debris, and foreign matter during and after topsoil placement if it is over 2 inches in any dimension.

C. Remove surplus subsoil and topsoil from Site. Grade stockpile area as necessary and place in condition acceptable for planting or seeding.

D. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

END OF SECTION

SECTION 32 93 00
REVEGETATION AND SURFACE RESTORATION

PART 1 GENERAL

1.01 REFERENCES

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

1. Agricultural Code of the State of Utah.
2. FS O-F-241D: Fertilizer, Mixed, Commercial.

1.02 DEFINITIONS

A. The terms “plant material” or “plants” refer to all vegetation and includes but is not limited to seeds, trees, shrubs, groundcover, or herbaceous vegetation.

1.03 GENERAL

A. Place and restore topsoils and revegetate areas disturbed by the Work, except those areas surfaced with concrete, asphalt, gravel or UTBC (such as, roads and road shoulders), riprap, and other types of rock surfacing and paving.

B. Maintain Revegetation: Irrigate, fertilize, mow, control erosion and weeds, replant, and reseed, as required, and specified herein, until final revegetation acceptance by the Landowner and Engineer.

C. Restore other surface improvements and features, unless required to remove them. Restore irrigation systems, canals, ditches, pipes, valving, controls, wells, springs, and land drains. Restore landscaping, boulders, surface rock grades, other improvements and features. See Revegetation Type and Surface Restoration on Drawings.

1.04 SUBMITTALS

A. Supplier and manufacturer certifications and information showing proposed materials (seeds, plants, mixtures, fertilizers, herbicides, straw mulch, wood fiber mulch, liquid tackifier, erosion control, hydraulic and blanket with anchorages) each meets specified requirements.

B. Hydroseeding company credentials, past work, and 5 years minimum experience.

C. Certificates accompanying delivery of seeds and plants listing all plant materials, source(s), quantities, and statements that each complies with Specifications and with state and federal standards.

D. Each Landowner's signed acceptance of revegetation type, fertilizer type, and herbicide type to be applied on their land.

E. Each Landowner's signed release (written by CUWCD) that work is complete and satisfactory. Payment may be withheld until all releases are provided.

1.05 NOXIOUS WEED CONTROL

A. Control invasive weeds listed by Utah State as Noxious Weeds, as described in Section 32 94 00, Invasive Weed Control. Use herbicide(s) per that section. Submit Landowner signature allowing herbicide type to be used on their land.

1.06 QUALITY ASSURANCE

A. Supply seeds and plants true to genus and species specified and tagged and delivered per standard practice of Utah Agricultural Code.

B. Supply seeds and plants complying with federal and state laws requiring inspection for plant diseases and infestations.

C. Use state of the art agricultural practices to salvage, store, maintain and transplant plant materials.

1.07 MAINTAINING REVEGETATION UNTIL ACCEPTANCE

A. Protect, control erosion, weed, and maintain all revegetation work until Landowner and Engineer acceptance. Partial utilization of Project does not relieve Contractor from Contract requirements.

B. Maintain plants from planting until 1 year after substantial completion in a vigorous, thriving condition by watering, fertilizing, spraying, and other needed operations. For erosion or poor plant establishment, repair and replant.

1.08 INSPECTION

A. Request inspection of Engineer at least 2 days before each inspection. Inspection is required each time the following Work occurs:

1. Before Excavation: Photograph and list landscaping and features to be removed, including irrigation, rocks, trees, shrubs, grasses, and other items.
2. Before Stripping and Stockpiling Native Topsoils: Define depth and limits to be stripped and where to stockpile.
3. Before Reseeding and Planting: Inspect prepared topsoils.
4. When Plant Materials Arrive Onsite: Plants, seeds, fertilizer, and others.
5. Completion of all revegetation work except plant establishment.
6. Inspect for guaranteed plant establishment.

1.09 PLANT ESTABLISHMENT GUARANTEE

A. By July 30, the summer after planting and seeding, Engineer will verify if plant establishment is satisfactory. In areas where plant establishment is inadequate, Engineer will notify Contractor those areas that need to be redone at Contractor cost that fall and re-inspected the following summer. This may involve work after contract closeout during the 1-year warrantee period.

PART 2 PRODUCTS

2.01 REVEGETATION TYPE

A. Landscaped Areas: Before the Work, photograph, document, and survey plant locations, species, irrigation systems, rocks, contours, features, trees, shrubs, sod, and other vegetation. Remove, maintain, and restore each after the Work.

1. Use Kentucky bluegrass or fescue per Landowner preference to resod. Use healthy, green, well-rooted, moist pads; free of diseases, insects, nematodes, and weeds. Don’t use yellow, torn, or uneven sod.

B. Unlandscaped Areas:

1. Reseed by hydroseeding or drilling unlandscaped vegetated areas (such as, fields, farmlands, open lands, roadway shoulders), except for areas not to be reseeded, with one of the following seed mixes:
   a. If existing vegetation is alfalfa, or farm crops as shown on Drawings as crop plantings by owner (except pasture grasses), do not revegetate. Leave bare topsoil, unless otherwise noted.

b. Where To Use Seed Mixes:
   1) UDOT highway mix: Where indicated.
   2) Dry Land Pasture: Dry pasture and where indicated.
   3) "Irrigated Pasture Mix" by Intermountain Farmers (IFA) for irrigated pastures, irrigated grass, and where indicated.
   4) Orchard Landowner Choice: Contact each orchard Landowner to determine the seed mixture or lack of seeding based on Landowner choice. Obtain signature from each Landowner agreeing to a seed mixture or to leave the land unseeded.

C. See Revegetation Type and Surface Restoration on Drawings.

2.02 SEED MIXTURES

A. Supply seed on a pure live seed (PLS) basis. Use seed from lots tested by a state-certified seed testing laboratory (Association of Seed Analyst or Society of Commercial Seed Technologists). Submit additional seed germination tests if grass seed is older than 18 months and if forb, shrub, tree, or other seeds are older than 9 months. Don't use seed if it is wet, moldy, or otherwise damaged. Use seed certified to UDOT State Standards for noxious weed content.

B. Furnish seeds in standard containers labeled with seed names, lot numbers, percent species in mix, net weight, percent purity, germination, and hard seed and maximum weed seed content.

C. Seed Substitutions: Before requesting a seed substitution, contact the major seed brokers in the state to verify that specified seed is unavailable. Have the Engineer contact a Landscape Architect to verify the seed is unavailable and to recommend a seed substitution. Replacement seed shall be of equal or greater cost to the originally specified seed.

2.03 FERTILIZER

A. Fertilize with every planting and seeding in the amounts, and in a manner, as recommended by seed and plant supplier. Submit to Engineer Landowner signature verifying they agree to fertilizer type and use rate.

B. Where IFA Irrigated Pasture Mix of seeds is used, fertilize with IFA "Pasture Blend," consisting of 70 percent urea nitrogen; 10 percent 11-52 phosphate; and 20 percent potash. Apply fertilizer at 300 pounds per acre if planting in spring or at 200 pounds per acre if planting in fall.

C. Furnish in standard containers or bags with name, weight, and guaranteed analysis of contents clearly marked. Use commercial fertilizer, uniform in composition, dry, free flowing, conforming to FS O-F-

241D, Type I, with percentages of nitrogen, phosphoric acid, and potash at specified rates.

2.04 WOOD FIBER MULCH

A. Use processed wood fiber containing no growth-inhibiting or germination-inhibiting materials, dyed a suitable color to ascertain material placement, and when hydraulically applied to the ground, will allow absorption and percolation of moisture.

B. First application of word fiber mulch shall be dyed red or brown.

C. Wood Fiber Mulch applied with Hydroseed mix shall be dyed green.

2.05 HYDROSEED MIX

A. Hydroseed Mix: Combine required seed mix with a slurry having 60 pounds per acre of tackifier and 1,500 pounds per acre of wood fiber mulch. Use a tackifier derived from natural organic plant sources containing no growth-inhibiting or germination-inhibiting materials, capable of hydrating in water.

2.06 TOPSOILS

A. As described in Part 3, Execution, and in Section 32 91 13, Topsoil.

2.07 HYDRAULIC EROSION CONTROL (HECP)

A. Use HECP on disturbed, non-irrigated slopes 3:1 and steeper as “long term” erosion control. Apply HECP per UDOT Standard Specification 02911, Hydraulic Erosion Control Products, and in conformance with Erosion Control Technology Council’s “Standard Specification for Hydraulic Erosion Control Products (HECP),” April 2014 or later edition, found at www.ectg.org. If “jute netting” is called for, apply HECP instead. Apply UDOT HECP Type 1, 2, and 3 products based on slope as follows:

1. UDOT Type 1, Wood Fiber Mulch, for 3:1 to 2:1 slopes.
2. UDOT Type 2, Bonded Fiber Matrix, for 2:1 to 1.7:1 slopes.
3. UDOT Type 3, Fiber Reinforced Matrix, for 1.7:1 to 1.4:1 slopes.

2.08 GEOCELL

A. Install geocell on, and to retain, fill slopes steeper than 2:1. Geocell shall be black HDPE, standard wall geocell, with 4-inch cell depth, infilled with topsoil and vegetation, anchored and installed per manufacturer recommendations.

1. Manufacturers and Products:
   a. Presto Geosystems, Appleton, Wisconsin; Geoweb WB30V.
   b. GeoProducts, LLC., Houston, Texas; EnviroGrid EGA30.
   c. “Or-equal.”

2.09 BLANKET EROSION CONTROL (EXCELSIOR)

A. Where required on Drawings, install blanket erosion control. Blanket shall be machine-made mat of curled wood excelsior of consistent thickness with 80 percent of fibers over 6-inch long, and fibers distributed evenly over blanket; with 0.21 inch by 0.42 inch fiber dimensions and weight at manufacture 0.08 pounds/sq. yard (average). Blanket top side shall be biodegradable extruded plastic mesh. Blanket shall be smolder-resistant with no chemical additives. Blanket shall be by American Excelsior Company, 350 N. Redwood Rd., North Salt Lake, UT; telephone 801/292-6060, “or-equal.”

B. Use 0.091 inch minimum diameter wire staples, “U” shaped with 6-inch legs and a 1-inch crown to attach excelsior blanket. Notify Engineer when onsite test is to verify staple size and gauge fit the site soil types and blanket slopes.

2.10 STRAW MULCH

A. Where required on Drawings, use straw mulch over scrub oak stumps pruned off to allow construction over them without killing useful scrub oak root systems. Use straw from oats, barley, wheat, or rye that is free of seeds or fumigated to prevent weeds. At least half of straw shall be 10 inches or longer. Do not use old, dry straw that breaks and does not bend.

PART 3 EXECUTION

3.01 REVEGETATION TYPE AND SURFACE RESTORATION—BY STATION

A. Revegetate and restore unpaved ground surfaces, by station and by Landowner parcel, as detailed in the Revegetation and Surface Restoration on Drawings.

3.02 NOXIOUS WEED CONTROL

A. Control invasive weeds listed by Utah State as Noxious Weeds, as described in Section 32 94 00, Invasive Weed Control.

3.03 GROUND PREPARATION FOR SEEDING

A. Strip, stockpile, and restore native topsoils, and install imported topsoils, as described in Section 32 91 13, Topsoil. Use native topsoils except where indicated otherwise.

B. If topsoils are not placed in their final location within 10 months after stripping or importing, perform interim seeding of topsoil stockpiles. Perform weed control of topsoil stockpiles if they are unused for over 3 months.

C. Rake topsoil surface to a 4 inch depth just before reseeding to create crevices for seeds to lodge in, shelter for seedlings, and water infiltration.

D. Rake soils parallel to (down) the slope to minimize drainage concentration and therefore minimize erosion. Note: Raking soils perpendicular to slope concentrates drainage and increases erosion. On slopes under 3:1, roughen topsoil to create small furrows parallel to (down) or diagonal to slope.

E. Restore topsoil surface to match native soil color and texture of adjoining areas as closely as possible. Boulders may be placed in some areas to replicate native landscape character, as agreed to by Engineer and Landowner.

F. After topsoils are complete, apply an initial wood fiber mulch application of 500 pounds per acre (before applying hydroseed mix with 1,500 pounds per acre of wood fiber mulch.)

3.04 SEEDING SEASON AND SEEDING METHODS

A. Reseed between October 1 and December 31 and as follows:

1. Drill in irrigated pasture mix, and other seed mixes in open fields with slopes generally flatter than 15 percent from horizontal. Drill seeds to 1/2 inch depth, and no deeper than 3/4 inch.
2. Hydroseed (broadcast) seed mix on slopes generally steeper than 15 percent. On 3:1 and steeper slopes, coordinate hydroseeding with hydraulic erosion control (HECP), geocell, and blanket erosion control.

B. Riparian Areas (Wetlands): Notify both Owner’s Environmental Specialist and Engineer to inspect before and after seeding and plant establishment.

3.05 DRILLING

A. Drill seed to 1/2 inch deep (plus or minus 1/4 inch variation) in rows spaced 12 inches apart. Drill in the direction of furrows.

B. When seeding mixtures, adjust amounts of each species to plant no more than 70 pure live seed per foot of drilled seed row (12-inch row spacing), and 112 pure live seed per square foot of broadcast seeding, for total seed mix. Seeding rates are in pounds of Pure Live Seed (PLS) per acre.

3.06 CLEANUP

A. Daily remove from Site, plant containers, seed and fertilizer bags, used erosion control materials, and other construction materials and debris.

3.07 SUPPLEMENTS

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

1. Irrigated Pasture Mix.
2. Dry Land Pasture Mix.
3. UDOT Highway Mix.

END OF SECTION

IRRIGATED PASTURE MIX										
Seed No.	Species Name		Number of Seeds Per Pound	Drill Seed			Hydroseeding			
	Botanical Name	Common Name		Pounds of Pure Live Seed Per Acre	Seeds Per Square Foot	Percent of Mix	Pounds of Pure Live Seed Per Acre	Seeds Per Square Foot	Percent of Mix
1	*Dactylis glomerata*	Pawnee orchardgrass				14.7%			14.7%
2	*Lolium arundinaceum*	Arido tall fescue				14.6%			14.6%
3	*Lolium arundinaceum*	Fawn tall fescue				13.9%			13.9%
4	*Dactylis glomerata*	Blizzard orchardgrass				13.1%			13.1%
5	*Lolium perenne*	Oro Verde perennial ryegrass				12.8%			12.8%
6		VNS intermediate ryegrass				12.0%			12.0%
7	*Phleum pratense*	Climax timothy				9.8%			9.8%
8	*Lolium multiflorum*	VNS annual ryegrass				9.0%			9.0%
		Total				100%			100%

DRY LAND PASTURE MIX

Seed No.	Species Name		Number of Seeds Per Pound	Drill Seed			Hydroseeding		
	Botanical Name	Common Name		Pounds of Pure Live Seed Per Acre	Seeds Per Square Foot	Percent of Mix	Pounds of Pure Live Seed Per Acre	Seeds Per Square Foot	Percent of Mix
1	*Achnatherum lettermanii*	Letterman needlegrass	225,000	2.0	10	15.2%	3.0	15	15.2%
2	*Elymus lanceolatus ssp. Lanceolatus*	Thickspike wheatgrass	156,000	4.0	14	21.0%	6.0	21	21.0%
3	*Festuca ovina 'Covar'*	Covar sheep fescue	680,000	0.8	12	18.3%	1.2	19	18.3%
4	*Linum lewisii 'Appar'*	Appar blue flax	293,000	1.0	7	9.9%	1.5	10	9.9%
5	*Pascopyrum smithii 'Arriba'*	Arriba Western Wheatgrass	110,000	4.5	11	16.7%	6.8	17	16.7%
6	*Pseudoroegneria spicata ssp. spicata*	Bluebunch Wheatgrass	140,000	4.0	13	18.9%	6.0	19	18.9%
		Total		16.3	68	100.0%	24.5	102	100.0%

UDOT HIGHWAY MIX										
	Species Name			Drill Seed			Hydroseeding			
Seed No.	Botanical Name	Common Name	Number of Seeds Per Pound	Pounds of Pure Live Seed Per Acre	Seeds Per Square Foot	Percent of Mix	Pounds of Pure Live Seed Per Acre	Seeds Per Square Foot	Percent of Mix
1	*Achnatherum hymenoides*	Indian ricegrass	141,000	2.50	8	10.81%	3.75	12	10.81%
2	*Agropyron cristatum 'Ephraim'*	Ephraim Crested wheatgrass	265,250	1.00	6	8.14%	1.50	9	8.14%
3	*Elymus lanceolatus ssp. lanceolatus*	Thickspike wheatgrass	154,000	2.00	7	9.45%	3.00	11	9.45%
4	*Elymus trachycaulus ssp. trachycaulus*	Slender wheatgrass	159,000	2.80	10	13.66%	4.20	15	13.66%
5	*Elymus wawaaiensis*	Snake River wheatgrass	120,000	3.00	8	11.04%	4.50	12	11.04%
6	*Festuca arizonica*	Arizona fescue	550,000	0.50	6	8.44%	0.75	9	8.44%
7	*Poa secunda ssp. sandbergii*	Sandberg bluegrass	1,047,000	0.30	7	9.64%	0.45	11	9.64%
8	*Sporobolus airoides*	Alkali sacaton	1,758,000	0.15	6	8.09%	0.23	9	8.09%
9	*Linum lewsii*	Lewis flax	170,000	2.00	8	10.43%	3.00	12	10.43%
10	*Penstemon strictus*	Rocky Mountain penstemon	592,000	0.30	4	5.45%	0.45	6	5.45%
11	*Gaillardia arisata*	Blanket flower	132,000	1.20	4	4.86%	1.80	5	4.86%
		Total		15.75	75	100.00%	23.63	112	100.0%

SECTION 32 94 00
INVASIVE WEED CONTROL

PART 1 GENERAL

1.01 REFERENCES

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

1. Adaptation of UDOT Section 02924.
2. Utah Noxious Weed Control Act.
3. Utah State University Weed Identification Publication.

1.02 UTAH STATE LISTED NOXIOUS WEEDS

A. Tables 1 and 2 list weeds officially designated and published as Noxious Weeds for the State of Utah and its counties. Control and eliminate each weed in the Work areas according to its Utah State classification as follows:

1. Class A Weeds—Early Detection and Rapid Response (EDRR): Pose a serious threat to the State of Utah and should be considered a very high priority for control.
2. Class B Weeds—(Control): Pose a threat to the State of Utah and should be considered a high priority for control.
3. Class C Weeds (Containment): Identified as widely spread, but pose a threat to agricultural industry and products with a focus on preventing the expansion of these species (Utah Noxious Weed Act 2009).

1.03 NOXIOUS WEED SPECIES IDENTIFICATION

A. Proper identification of noxious species is important to treat, control, and prevent the spread of state listed species. Contractors shall make certain target species are appropriately identified for treatment to avoid treating or removing nontarget, native species. The following reference can be used as resources for the identification of noxious and invasive species:

1. http://extension.usu.edu/files/publications/publication/pub_8746541.pdf

1.04 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Follow all regulatory, application, and safety precautions listed by the herbicide manufacturer. Refer to Utah Noxious Weed Control Act: Utah Code—Title 04—Chapter 17.
2. Apply herbicides using only state licensed pesticide applicators.

1.05 SEQUENCING

A. Clean all earth-moving equipment before bringing them on the Project.

B. Treat existing noxious weeds 10 days before starting earthwork operations.

1.06 HERBICIDE

A. Refer to Table 1 and Table 2 for a list of noxious weeds subject to control and the recommended herbicide for each species.

B. Use commercially available herbicides specified to control the weed species identified.

1.07 PREPARATION

A. Use high-pressure water blasting or steam cleaning methods to clean all earth-moving construction equipment (scrapers, bulldozers, excavators, backhoes, or trenchers) or dirt, mud, and seed residue before initially entering the Project.

1.08 EXAMINATION

A. Verify and locate all noxious weeds on the Project. If assistance is needed for identification, contact the County weed control supervisor or CUWCD's NEPA Compliance Coordinator.

1.09 CONTROLLING INVASIVE WEEDS

A. Spray invasive weeds located within the Project limits before starting earth disturbing activities and if they appear during construction. Use pre-emergent, selective, and nonselective herbicides as appropriate (see Noxious Weed Table 1 and Table 2 below). Apply herbicide as directed on the manufacturer's label.

Table 1
Utah State Noxious Weed List

Common/ Scientific Name	Class	Herbicide
Blackhenbane (*Hyosyamus niger*)	A	Tordon (Picloram) & Escort
Diffuse knapweed (*Centaurea diffusa*)	A	2,4-D+Dicamba or Picloram or Clopyralid
Leafy spruge (*Euphorbia esula*)	A	Dicamba or Picloram
Medusahead (*Taeniatherum caput-medusae*)	A	Glyphosate
Oxeye daisy (*Chrysanthemum leucanthemum*)	A	Tordon (Picloram) & Clopyralid
Perennial sorghum (*Sorghum halepense*)	A	Glyphosate
Purple loosestrife (*Lythrum salicaria*)	A	Glyphosate (Rodeo aquatic label)
Spotted knapweed (*Centaurea maculosa*)	A	2,4-D+Dicamba or Picloram or Clopyralid
Squarrose knapweed (*Centaurea spquarrosa*)	A	Picloram
St. Johnsworts (*Hypericum perforatum*)	A	Tordon (Picloram) & Escort
Sulfur cinquefoil (*Potentilla recta*)	A	Tordon (Picloram)
Yellow starthistle (*Centaurea solstitialis*)	A	Picloram or Clopyralid

Table 1
Utah State Noxious Weed List

Common/ Scientific Name	Class	Herbicide
Yellow toadflax (*Linaria vulgaris*)	A	Tordon (Picloram)
Bermudagrass (*Cynodon dactylon*)	B	Glyphosate
Peppergrass (*Lepidium latifolium*)	B	Metsulfuron or Chlorsulfuron
Dalmation toadflax (*Linaria dalmatica*)	B	Tordon (Picloram)
Dyers woad (*Isatis tinctoria*)	B	2,4-D+Dicamba or Chlorsulfuron
Hoary cress (*Cardaria* spp.)	B	2,4-D+Dicamba or Chlorsulfuron
Musk thistle (*Carduus nutans*)	B	2,4-D amine, Metsulfuron or Picloram
Poison hemlock (*Conium maculatum*)	B	Tordon (Picloram)
Russian knapweed (*Centaurea repens*)	B	Picloram, Clopyralid or Chlorsulfuron
Scotch thistle (*Onopordium acanthium*)	B	2,4-D amine, Metsulfuron or Picloram
Field bindweed (*Convolvulus* spp.)	C	Dicamba+2,4-D or Picloram
Canada thistle (*Cirsium arvense*)	C	2,4-D, Dicamba, Picloram
Houndstounge (*Cynoglossum officianale*)	C	Tordon (Picloram)
Saltcedar/Tamarisk (*Tamarix ramosissima*)	C	Habitat or Arsenal
Quackgrass (*Agropyron repens*)	C	Glyphosate
Use Rates: Use rates for herbicides vary; follow the use rate on the Manufacturer's Label for each herbicide.		

Table 2 County Listed Noxious Weeds	
Common/ Scientific Name	Herbicide
Beaver County	
Bull thiste (*Cirsium vulgare*)	2,4-D amine or Dicamba
Cache County	
Goatsrue (*Galega officinalis*)	2,4-D+Dicamba
Puncturevine (*Tribulus terrestris*)	2,4-D+Dicamba
Carbon County	
Russian olive (*Elaeagnus angustifolia*)	2,4-D, Dicamba, or Glyphosate
Davis County	
Yellow nutsedge (*Cyperus esculentus*)	Glyphosate
Duchesne County	
Russian olive (*Elaeagnus angustifolia*)	2,4-D, Dicamba, or Glyphosate
Iron County	
Western whorled milkweed (*Asclepias subverticillata*)	2,4-D or Dicamba
Juab County	
Blue lettuce (*Lactuca pulchella*)	2,4-D amine, Arsenal or Metsulfuron
Morgan County	
Common burdock (*Arctium minus*)	2,4-D+Dicamba
Millard County	
Buffalobur (*Solanum rostratum*)	2,4-D or Dicamba

Table 2 County Listed Noxious Weeds	
Common/ Scientific Name	**Herbicide**
Salt Lake County	
Garlic mustard (*Alliaria petiolata*)	Glyphosate
Myrtle spurge (*Euphorbia myrsinites*)	Glyphosate or Dicamba
San Juan County	
Camelthorn (*Alhagi pseudalhagi*)	Arsenal
Silverleaf nightshade (*Solanum elaeagnifolium*)	Imazapyr or Glyphosate
Jointed goatgrass (*Aegilops cylindrica*)	Glyphosate or Sulfometuron
Buffalobur (*Solanum rostratum*)	2,4-D or Dicamba
Western wholed milkweed (*Asclepias subverticillata*)	2,4-D or Dicamba
Sanpete County	
Velvetleaf (*Abutilon theophrasti*)	Glyphosate
Sevier County	
Russian olive (*Elaeagnus angustifolia*)	2,4-D, Dicamba, or Glyphosate
Uintah County	
Russian olive (*Elaeagnus angustifolia*)	2,4-D, Dicamba, or Glyphosate
Washington County	
Western whorled milkweed (*Asclepias subverticillata*)	2,4-D or Dicamba
Wayne County	
Russian olive (*Elaeagnus angustifolia*)	2,4-D, Dicamba, or Glyphosate

Table 2 County Listed Noxious Weeds	
Common/ Scientific Name	Herbicide
Weber County	
Puncturevine (*Tribulus terrestris*)	2,4-D+Dicamba
Use Rates: Use rates for herbicides vary; follow the use rate on the Manufacturer's Label for each herbicide.	

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 33 05 01
CONVEYANCE PIPING—GENERAL

PART 1 GENERAL

1.01 GENERAL

A. This section describes the general requirements for Project piping, including piping, flanges, bolts, nuts, gaskets, and miscellaneous piping items. Items contained and specified herein are applicable to the individual pipe material specifications that follow this section.

1.02 REFERENCES

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

1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
2. American Society of Mechanical Engineers (ASME):
    a. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 Through 24 Metric/Inch Standard.
    b. B16.47 Large Diameter Flanges and Flanged Fittings Through 60 Metric/Inch Standard.
    c. B16.9, Factory-Made Wrought Steel Buttwelding Fittings.
    d. B36.10M, Welded and Seamless Wrought Steel Pipe.
    e. BPVC SEC V, Nondestructive Examination.
    f. BPVC SEC VIII, Div. 1, Rules for Construction Pressure Vessels.
    g. BPVC SEC 1X, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
    h. PCC-1 Guidelines for Pressure Boundary Bolted Flange Joint Assembly.
3. American Water Works Association (AWWA):
    a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
    b. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
    c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
    d. C210 Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
    e. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
    f. C217, Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines.
    g. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.

h. C221, Fabricated Steel Mechanical Slip-Type Expansion Joints.
i. C606, Grooved and Shouldered Joints.

4. ASTM International (ASTM):
   a. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   d. C150/C150M, Standard Specification for Portland Cement.
   e. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.03 DEFINITIONS OF BURIED AND EXPOSED PIPING

A. Buried piping is piping buried in the soil commencing on the interior of concrete walls or floor slabs of a structure. Piping encased in concrete is considered to be buried.

B. Exposed piping is piping above ground, or inside buildings, vaults, or other structures.

C. Coating and lining of pipe shall be as specified in the individual specification(s) following this section and in accordance with Section 09 90 00, Painting and Coating, and Section 09 90 10, Pipeline Coating and Lining.

1.04 SUBMITTALS

A. Action Submittals:

1. Detailed pipe fabrication drawings showing pipe details, special fittings and bends, dimensions, coatings, and other pertinent information.
2. Layout drawing showing location of each pipe section and each special length.
3. Pipe wall thickness or pressure class.
4. Wall thickness, reinforcing, and strength calculations.
5. Product Data: Manufacturer’s data for couplings, saddles, gaskets, and other pipe accessories. Indicate maximum rated working pressure and test pressure for each item.
6. A complete and coordinated submittal of all flanges on the Project. Include information sufficient to verify complete compliance with

Drawings and Specifications for all items relating to all flanges including, but not limited to:

a. Flange class, facing, quantities, and where used.
b. Flange Details: Information indicating full listing of all materials, bolting requirements, and dimensions for applicable flange classes, including but not limited to, AWWA C110, AWWA C115, and AWWA C207 and ASME B16.1, ASME B16.5, and ASME B16.47.
c. Gasket Details: Type, material, diameter, thickness.
d. Bolts, Rods, Nuts, and Washers: All lengths, quantities, bolt/hole diameters, material strengths, metal finishes (zinc plated) provide all materials and dimensions mentioned in PCC-1 Guidelines.
e. Torque requirements for each flange, bolt, and gasket recommended by each flange or gasket manufacturer (of piping, valves, meter, dismantling joints, and others).
f. Facing Details: Finish grade, faces with and without gasket groves.
g. Mating flange facing for all valves, meters, dismantling joints, insulating flanges, and others, per the applicable valve and equipment specifications.
h. Submittals for flanged coupling adapters and dismantling joints shall include the following information:
    1) Pipe type with which coupling is to be used.
    2) Allowable pipe end tolerance.
    3) Pipe outside diameter, including coating.
    4) Service type.
    5) Rated working pressure.
    6) Test pressure.
    7) Rated operating temperature range (32 degrees F to 70 degrees F).
    8) Maximum allowable angular deflection of pipe (75 percent of manufacturer’s recommended).
    9) Hydrostatic test requirements and reporting.
    10) Method of restraint and operating pressure rating.
    11) Nondestructive examination requirements.

B. Informational Submittals:

1. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

2. Submit affidavit of compliance with referenced standards (such as, AWWA, ASME, ASTM, NFS, and others).
3. Submit certified copies of mill test reports for bolts and nuts, including coatings if specified. Provide recertification by an independent domestic testing laboratory for materials originating outside of the United States.

1.05 DELIVERY, STORAGE, AND HANDLING

A. In accordance with manufacturer's recommendations and as specified in individual specification(s) following this section.

B. Marking at Plant: Mark each pipe and fitting at plant. Include date of manufacture, manufacturer's identification, specification standard, diameter of pipe, dimension ratio, pipe class, pipe number for laying purposes, and other information required for type of pipe.

C. Pipe, specials, and fittings received at Project Site in damaged condition will not be accepted.

D. Gasket Storage: Store rubber gaskets in cool, well ventilated place, and do not expose to direct rays of sun. Do not allow contact with oils, fuels, petroleum, or solvents.

E. Store and support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.

F. Handling:

1. Pipe shall be handled with proper equipment in a manner to prevent distortion or damage. Use of hooks, chains, wire ropes, or clamps that could damage pipe, damage coating or lining, or kink and bend pipe ends is not permitted.
2. Use heavy canvas, or nylon slings of suitable strength for lifting and supporting materials.
3. Lifting pipe during unloading or lifting into trench shall be done using two slings placed at quarter point of pipe section. Pipe may be lifted using one sling near center of pipe, provided pipe is guided to prevent uncontrolled swinging and no damage will result to pipe or harm to workers. Slings shall bear uniformly against pipe.
4. Pipe and fittings shall not be stored on rocks or gravel, or other hard material that might damage pipe. This includes storage area and along pipe trench.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

B. Where 2-inch diameter and smaller incidental low pressure PVC pipe is called out on Drawings, comply with ASTM D1785 and ASTM D1784 for Schedule 80 PVC pipe and solvent weld material. Install in accordance with manufacturer instructions.

2.02 PIPE

A. As specified in the individual specification(s) following this section.

2.03 JOINTS

A. As specified in the individual specification(s) following this section.

B. Where piping connects to wall pipes, meters, valves, or other equipment, the pipe ends shall match the ends of the wall pipes, meters, valves, or equipment.

2.04 THREADED OUTLETS FOR STEEL PIPE

A. Threaded outlets of size 1-1/2 inches and smaller shall be of the threaded type. Outlets shall be 3,000-pound WOG forged steel per ASTM A105. Threads shall comply with ASME B1.20.1.

B. Manufacturers and Products:

1. Bonny Forge Co.; Thredolet.
2. Allied Piping Products Co.; Branchlet.
3. “Or-equal.”

C. Four-inch threaded outlets shall be per Standard Details.

2.05 COUPLINGS (INCLUDING DISMANTLING JOINTS)

A. General:

1. Couplings (which include dismantling joints) shall be rated for appropriate operating pressure and hydrostatic test pressure.
2. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
3. Exposed, bolted, sleeve-type couplings shall be lined and coated with fusion bonded epoxy in accordance with AWWA C213.
4. Buried, bolted, sleeve-type couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213 and wrapped with petroleum wax tape in accordance with AWWA C217 and as specified in Section 09 90 10, Pipeline Coating and Lining.

B. Pipe with Plain-Ends:

1. Bolted, sleeve-type coupling, in accordance with AWWA C219.
    a. Manufacturer of couplings shall observe same quality control requirements as specified in AWWA C221 for fabrication of pipe expansion joints.
    b. Unless thrust restraint is provided by other means, bolted, sleeve-type couplings shall be harnessed. Harness details shall be in accordance with requirements of appropriate reference standard or as shown on Drawings.
    c. Certified Welding Inspector at coupling fabrication facility shall verify welders and welding procedures are qualified, procedures are being followed, and quality assurance functions are being implemented.
    d. Bolted Sleeve Coupling Manufacturers:
        1) Smith Blair; Model 411 Coupling.
        2) Baker; Series 200 Couplings.

C. Pipe with Grooved Ends:

1. Grooved couplings, in accordance with AWWA C606. System shall provide for flexible or rigid joints as shown on Drawings.
2. Exposed couplings shall be lined and coated with liquid epoxy in accordance with AWWA C210.
3. Gaskets shall be EPDM and shall conform to ASTM D2000.
4. Buried couplings shall be lined and coated with liquid epoxy in accordance with AWWA C210 and wrapped with petroleum wax tape in accordance with AWWA C217.

5. Grooved Coupling Joint Manufacturers and Products:
    a. Victaulic; W77 Advanced Groove System (AGS).
    b. "Or-equal."

D. Pipe with Flanged Ends (including dismantling joints):

1. Flanged coupling adapters, in accordance with AWWA C219.
    a. Pipe Type to be Joined: Steel or ductile iron as shown on Drawings.
    b. Standard to Which Pipe is Manufactured: See individual pipe specification(s) following this section.
    c. Pipe Ends Tolerance: Conform to Table 4 of AWWA C219.
2. Dismantling joints for connecting flanged pipe shall be AWWA C219 compliant.
    a. All dismantling joints shall be the restrained type, unless noted otherwise on Drawings. Tie-bar restraint system and flanges shall be designed and rated for at least 30 psi above test pressure shown on Drawings.
    b. Provide studs and nuts to seal gasket separate and independent from tie-bar restraint system.
    c. Flanges for dismantling joints shall meet flange requirements specified herein. Reduced flange thickness or hollow back flanges are not allowed.
    d. Dismantling Joint Manufacturers and Products:
        1) Smith Blair; Model 975.
        2) Baker; Restrained Dismantling Joint.

E. Bolting Materials for Couplings: Same as bolts and nuts for flanges and adjoining pipe.

2.06 FLANGES (INCLUDING MATING FLANGES FOR VALVES, METERS, DISMANTLING JOINTS, AND OTHER PIPING)

A. Ductile Iron: Flanges and bolting materials for ductile iron flanges shall conform to AWWA C110 and AWWA C115.

B. Steel Flanges:

1. Use steel flanges based on design pressure and pipe diameter as follows (except where the specified valves or drawings require otherwise):
    a. Under 275 psi: Use ASME B16.5, Class 300 Series A, raced face flanges.
    b. 275 psi to 450 psi for 24-inch Diameter and Under: Use ASME B16.5, Class 300, Series A, raced face flanges.
    c. 275 psi to 450 psi for 26-inch to 60-inch Diameter: Use ASME B16.47, Class 300, Series A, raised face flanges.

d. Flanges for valves, meters, and couplings shall match adjacent steel flanges.
e. Provide rust inhibitor primer on non-raised portion of flange faces.
f. Insulating Flanges: Provide flat faced insulating flanges, with flange kits per Section 26 42 01, Pipe Bonding and Test Stations, and bolt holes 1/8-inch oversized for insulating sleeves (per AWWA C207), except 36-inch to 84-inch flanges shall have 1/4 inch (not 1/8-inch) oversized bolt holes.
g. Flanges fabricated from steel plate shall meet the requirements of ASTM A516, Grade 70. Forged steel flange material shall conform to ASTM A105/A105M. Castings shall conform to ASTM A216 WCB.
h. Weld all steel flanges to WSP (integral and loose) with complete joint penetration (CJP) per ASME BPVC Section VIII. For ASME B16.47 flanges, use integral, “hub” or “welding neck” type flanges, unless specifically required otherwise.

C. Wrap buried flanges with petroleum wax tape per AWWA C217.

D. Coordinate and mate all flanges and gaskets in submittals (for valves, meters, insulating flanges, couplings, and others) so that mating flanges are both of the same flange type and coordinate facing. Unmated flanges (of dissimilar facing, gasket or type) shall be corrected at Contractor expense.

E. Comply with all detailed requirements and provide a comprehensive flange submittal. Submit each mated flange assembly signed jointly by the manufacturer of both flanges (for example, pipe to valve, valve to meter, meter to dismantling joint).

2.07 BOLTS AND NUTS FOR STEEL FLANGES

A. Bolts for flanges located indoors, in vaults, outdoors above ground and in flange insulation kits shall be ASTM A193, Grade B7, with nuts conforming to ASTM A194, Grade 2H. Zinc plate steel bolts and nuts, unless noted otherwise.

B. Bolts for buried flanges shall be Type 316 stainless steel, ASTM A193/ A193M, Grade B8M hex head bolts; and ASTM A194/A194M, Grade 8M hex head nuts. Fabricate in accordance with ASME B18.2.2.

C. Provide two washers for each bolt and nut with a washer installed on each side of the flange. Washers shall be of the same material as the nuts.

D. Provide bolts of the proper length to accommodate flange, washer, and gasket thickness to accommodate minimum bolt length per AWWA C207.

2.08 GASKETS

A. Gasket manufacturer shall submit tables of their recommended bolt torques for each gasket supplied, tabulated by flange diameter, by AWWA/ANSI flange type used, and by flange face type used. Contractor shall torque bolts to gasket manufacturer recommended bolt torques.

B. For pipes with flat face flanges and raised face flanges and design pressures less than 400 psi:

1. Use full-face gaskets 1/8-inch-thick.
2. Manufacturer and Product:
   a. Garlock; Multi-Swell Style 3760-U.
   b. “Or-equal.”
   c. Gasket shall be rated at pressure of 500 psi and at a temperature of 100 degrees F.

C. For pipes with raised face flanges and design pressures greater than 400 psi, but less than 700 psi:

1. Use full-face gaskets 1/8-inch-thick.
2. Manufacturer and Product:
   a. Garlock; Blue-Gard Style 3000.
   b. “Or-equal.”
   c. Gaskets shall be suitable for a pressure of 700 psi at a temperature of 100 degrees F.

D. Provide manufacturer’s recommended adhesive to help center gasket prior to installation of bolts and torquing flange bolts.

2.09 THREADED CAPS FOR PROTECTION OF NUTS AND BOLT THREADS

A. Provide threaded grease caps or friction-fit for all flange bolts and threaded rods (including dismantling joints). Match grease cap threads to bolt threads. Select friction-fit caps to provide tight friction fit on nut size. Caps shall be filled with anticorrosive lubricant to prevent nuts and bolts from rusting and corroding. Where friction-fit caps are used, lubricate threads only. Lubricant shall be suitable for use in potable water. Caps shall withstand temperatures from minus 40 degrees F to 200 degrees F. Caps shall be suitable to use in exposed, buried, and submerged service conditions.

1. For bolts 2-inch diameter and smaller, provide silicone rubber caps sized to match bolt and nut dimensions.
   a. 50 durometer to 60 durometer Shore A hardness per ASTM D2240.
   b. 800 psi minimum tensile strength per ASTM D412.
   c. 200 percent minimum elongation per ASTM D412.

d. 75 psi minimum tear strength per ASTM D624.
e. Manufacturer and Product:
1) MOCAP; Silicone Rubber Caps.
2) “Or-equal.”

2. For bolts larger than 2-inch diameter, provide black high density polyethylene caps.
a. Manufacturers and Products:
1) Sap-Seal Products, Inc.
2) Advance Products and Systems, Inc.; Radolid.
3) MOCAP; Round Vinyl Caps (RVS Series).
4) “Or-equal.”
3. Bolts for flanges located indoors and in vaults, the bolt head shall be coated as specified in Section 09 90 00, Painting and Coating. Nuts and exposed threads shall be protected with caps as specified above.

2.10 LUBRICANT FOR STAINLESS-STEEL BOLTS AND NUTS

A. Lubricant shall be chloride free.

B. Manufacturers and Products:

1. Ramco; TRX-Synlube.
2. Ramco; Anti-Seize.
3. Husk-ITT Corporation; Husky Lube O-Seal.
4. “Or-equal.”

2.11 FLANGE INSULATION KITS AND INSULATING COUPLINGS

A. See Section 26 42 01, Pipe Bonding and Test Stations.

2.12 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Assemble interconnected rubber links with Type 316 stainless steel bolts, nuts, and pressure plates.
3. Size modular mechanical seals according to manufacturer’s instructions for the size of pipes shown to provide a watertight seal between pipe and wall sleeve opening.
4. Manufacturers and Products:
a. Thunderline/LinkSeal, Div. of PSI, Houston, TX; Link Seal.
b. Calpico, Inc., South San Francisco, California; Sealing Linx.
c. Advance Products and Systems, Lafayette, Louisiana; Innerlynx.

B. Wall Sleeves:

1. Provide fabricated steel wall pipes and sleeves with ends as shown on Drawings for connection to adjacent steel pipes, or for containing pipes, where they pass through concrete walls.
2. Provide seepage ring or wall flange on wall pipes and sleeves passing through concrete walls and slabs which are to be watertight. Wall thickness shall be the same as the pipe wall thickness when connecting to steel pipe. Minimum wall thickness for sleeves containing pipes shall be standard weight per ANSI B36.10.
3. Steel pipe used in fabricating wall sleeves containing pipes shall comply with ASTM 53 (Type E or S), Grade B; ASTM A135, Grade B; ASTM A139, Grade B; or API 5L or 5LX. Wall pipes connecting to steel pipe shall be of the same material as the connecting pipe. Wall collar material shall comply with ASTM A105, A181, or A182.
4. Line and coat sleeves and pipes per Section 09 90 00, Painting and Coating.
5. Sleeve to be electrically isolated from wall or floor reinforcement in accordance with Section 26 42 01, Pipe Bonding and Test Stations.

C. Wall Couplings:

1. Diameter, ends, and length shall be as shown on Drawings.
2. Provide flexible mechanical joint.
3. Body and end rings shall be coated with fusion bonded epoxy.
4. Body shall include integral seep ring.
5. Comply with AWWA C219.

D. If core drilling is required for penetrations of existing concrete walls or slabs, locations of drilling shall be determined by radiograph to avoid damage to reinforcing steel and conduits.

2.13 POLYETHYLENE FOAM FILLER FOR PIPE PENETRATIONS

A. Packing foam shall be an extruded closed-cell polyethylene foam rod.

B. The rod shall be 1/2-inch larger in diameter than the annular space.

C. Manufacturers and Products:

1. Industrial Systems Department, Plastic Products Group of Hercules, Inc., Middletown, Delaware; Minicel backer rod.
2. Dow Chemical Company, Midland, Michigan; Ethafoam.
3. “Or-equal.”

2.14 POLYURETHANE SEALANT FOR PIPE PENETRATIONS

A. Sealant shall be multipart, polyurethane sealant, to cure at ambient temperature, for continuous immersion in water. Install as recommended by the manufacturer.

1. Manufacturer and Product:
   a. SIKA; Sikaflex 2C.
   b. “Or-equal.”

2.15 CONCRETE FOR THRUST BLOCKS

A. Thrust Block Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Reinforcing Steel: ASTM A615/A615M, Grade 60 deformed bars.

C. Welded Wire Fabric: ASTM A497/A497M.

D. Formwork: Plywood or earth cuts may be used as approved by Engineer.

2.16 PIPE INSULATION

A. Where shown on Drawings, exterior of pipe shall be wrapped with insulation to prevent freezing of pipe contents. Insulation shall be 3-inch thick molded fiberglass insulation sized to fit outside diameter of the pipe.

1. Manufacturer and Product: Pittsburgh Corning Corporation; FOAMGLAS ONE.

2.17 PIPE LOCATING TAPE AND TRACER WIRE

A. As specified in Section 31 23 23.15, Trench Backfill.

2.18 PIPE BEDDING AND PIPE ZONE MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

2.19 TRENCH STABILIZATION MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

PART 3 EXECUTION

3.01 GENERAL

A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

B. Furnish feeler gauges of proper size, type, and shape for use during installation for each type of pipe furnished.

C. Distributing Materials: Place materials along trench only as will be used each day, unless otherwise approved by Engineer. Placement of materials shall not be hazardous to traffic or to general public, obstruct access to adjacent property, or obstruct others working in area.

3.02 EXAMINATION

A. Verify size, material, joint types, elevation, and horizontal location of existing pipeline to be connected to new pipeline or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Damaged Coatings and Linings: Repair using coating and lining materials in accordance with manufacturer's instructions.

D. Damaged Pipe: Pipe sections that have damage to the bell end, spigot end, or barrel shall be replaced at no additional cost to the Owner.

3.03 PREPARATION OF TRENCH

A. Prepare trench as specified in Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

3.04 INSTALLATION

A. General:

1. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
2. Install individual pipe lengths in accordance with approved lay diagram. Misplaced pipe shall be removed and replaced.
3. Inspect pipe and fittings before installation, clean ends thoroughly, remove foreign matter and dirt from inside.
4. Flanged Joints:
   a. Install perpendicular to pipe centerline.
   b. Bolt Holes: Straddle vertical centerline, aligned with connecting equipment flanges or as shown on Drawings.

c. Provide thread lubricant on bolts and nuts.
d. To provide uniform bearing and proper bolt tightness:
   1) Bolts 1-Inch and Smaller: Use torque-limiting wrenches.
   2) Bolts Greater than 1-Inch: Use hydraulic bolt tensioners (see ASME PCC-1, Paragraph 10, first NOTE).
e. Tighten flange bolts progressively, drawing up bolts on opposite sides gradually until bolts have uniform tightness around the flange.
f. Exposed pipe flanges install threaded grease cap protection.
g. Buried pipe flanges shall be greased, wax taped coated and wrapped.

5. Couplings:
   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 obtain smooth surface.
   d. Clean gaskets before installation.
   e. If necessary, lubricate with gasket lubricant for installation on pipe ends.
   f. Tighten coupling bolts progressively, drawing up bolts on opposite sides gradually until bolts have uniform tightness.

B. Buried Pressure Pipe:

1. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown on Drawings.
2. Placement:
   a. Keep trench dry until pipe laying and joining is completed.
   b. Provide and use proper implements, tools, and facilities for safe and proper prosecution of the Work.
   c. Lower pipe, fittings, and appurtenances into trench, piece by piece, by means of a crane, slings, or other suitable tools and equipment, in such a manner as to prevent damage to pipe materials, protective coatings, and linings.
   d. Do not drop or dump pipe materials into trench.
   e. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
   f. Measure for grade at pipe invert, not at top of pipe.
   g. Excavate trench bottom and sides of ample dimensions to permit proper joining, welding, visual inspection, and testing of entire joint.
   h. Prevent foreign material from entering pipe during placement.
   i. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day’s work.
   j. In general, lay pipe upgrade with bell ends pointing in direction of laying.

k. Check gasket position with feeler gauge to assure proper seating.
l. After joint has been made, check pipe alignment and grade.
m. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
n. Prevent uplift and floating of pipe prior to backfilling.

3. Tolerances:
   a. Deflection from Horizontal Line: Maximum 2 inches.
   b. Deflection from Vertical Grade:
      1) Slopes Greater than 0.5 Percent: Maximum 1 inch.
      2) Slopes 0.5 Percent or Less: Maximum 1/3 inch.
   c. Vertical deflection is measured at pipe control line (centerline or invert, as called out in profile).
   d. Joint Deflection: Maximum of 75 percent of manufacturer’s recommendation.
   e. Horizontal position of pipe centerline on alignment around curves maximum variation of 1 foot from position shown.
4. Cover Over Top of Pipe: As shown on Drawings.
5. Disposal of Excess Excavated Material: As specified in Section 31 23 16, Excavation.
6. Maintain the inside of the pipe free from foreign materials and in a clean and sanitary condition until its acceptance by the Owner.

3.05 THRUST RESTRAINT

A. Location: At pipeline tees, plugs, caps, bends, and locations where unbalanced forces exist.

B. Thrust Blocking:

1. Place only where shown on Drawings.
2. Quantity of Concrete: Sufficient to cover bearing area of pipe and provide required soil bearing area as shown on Drawings.
3. Place blocking so pipe and fitting joints are accessible for repairs.
4. Place concrete in accordance with Section 03 30 00, Cast-in-Place Concrete.

3.06 CORROSION PROTECTION

A. Buried Pipe: As specified in the individual specification(s) following this section.

3.07 PLACEMENT OF PIPE LOCATING TAPE AND TRACER WIRE

A. Place pipe locating tape in accordance with Section 31 23 23.15, Trench Backfill.

3.08 PIPE BEDDING AND ZONE MATERIAL

A. Place pipe bedding and pipe zone material in accordance with Section 31 23 23.15, Trench Backfill.

3.09 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in the individual specification(s) following this section.

3.10 CLEANING, HYDROSTATIC TESTING AND DISINFECTION

A. Maintain the pipe clean from sediment, cementitious materials, and other debris throughout construction.

B. Following assembly and prior to testing and disinfection, remove all foreign matter from the pipeline.

C. Thoroughly clean all interior surfaces of the pipeline by flushing pipelines with water at 2.5 fps minimum flushing velocity until foreign matter is removed. Dispose of water and flushed foreign matter.

D. If impractical to flush large diameter pipe at 2.5 fps, clean pipe in-place from inside by brushing and sweeping, then flush with pressurized water to remove accumulated loose materials and debris. Dispose of material and cleaning water appropriately.

E. Hydrostatic Testing: As specified in Section 33 05 05.31, Pressure Testing of Piping.

END OF SECTION

SECTION 33 05 01.01
WELDED STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section includes materials testing and installation of welded steel pipe with fittings and specials.

1.02 REFERENCES

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

1. American Society of Mechanical Engineers (ASME):
    a. B16.9, Factory-Made Wrought Buttwelding Fittings.
    b. B36.10M, Welded and Seamless Wrought Steel Pipe.
    c. BPVC SEC V, Nondestructive Examination.
    d. BPVC SEC VIII, Div. 1, Rules for Construction of Pressure Vessels.
    e. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society for Nondestructive Testing Inc. (ASNT): SNT-TC-1A, Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing.
3. American Water Works Association (AWWA):
    a. C200, Steel Water Pipe - 6 In. (150 mm) and Larger.
    b. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied.
    c. C206, Field Welding of Steel Water Pipe.
    d. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm.
    e. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
    f. C602, Cement-Mortar Lining of Water Pipelines in Place - 4 In. (100 mm) and Larger.
    g. M11, Steel Pipe - A Guide for Design and Installation.
4. American Welding Society (AWS):
    a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
    b. A3.0M/A3.0, Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.
    c. D1.1/D1.1M, Structural Welding Code - Steel.
    d. QC 1, Standard for AWS Certification of Welding Inspectors.

5. ASTM International (ASTM):
    a. A20/A20M, Standard Specification for General Requirements for Steel Plates for Pressure Vessels.
    b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
    c. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
    d. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
    e. A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
    f. A435/A435M, Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates.
    g. A516/A516M, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
    h. A770/A770M, Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications.
    i. A1018/A1018M, 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.
    j. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
    k. E1255, Standard Practice for Radioscopy.
6. International Organization for Standardization (ISO): 9001:2000, Quality Management Systems - Requirements.
7. Lloyd's Registry.
8. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
9. Steel Pipe Fabricators Association (SFPA).

1.03 DEFINITIONS

A. Fittings: Including, but not limited to fittings, closure pieces, bends, reducers, tees, wyes, bifurcations, crosses, outlets, manifolds, nozzles, wall sleeves, bulkheads, and other piping and appurtenances fabricated from steel plate, sheet, or coils as required to provide the Work, complete. Fittings shall include piping above ground or inside structures.

B. Acronyms:

1. CJP: Complete Joint Penetration.
2. CWI: Certified Welding Inspector.
3. MT: Magnetic Particle Testing.

4. NDE: Nondestructive Examination.
5. NDT: Nondestructive Testing.
6. PJP: Partial Joint Penetration.
7. PQR: Procedure Qualification Record.
8. PT: Liquid Penetrant Testing.
9. RT: Radiographic Testing.
10. UT: Ultrasonic Testing.
11. VT: Visual Testing.
12. WPQ: Welder/Welding Operator Performance Qualification.
13. WPS: Welding Procedure Specification.

1.04 DESIGN REQUIREMENTS

A. Fittings:

1. Design reinforcement, unless otherwise shown.
2. Design in accordance with AWWA M11, AWWA C200, and AWWA C208 as modified herein, and this Specification.
3. Provide outlet reinforcement as shown on the Drawings. Where not shown on the Drawings, design outlet reinforcement per AWWA Manual M11 4th Edition (not 5th Edition).

B. Pipe Layout:

1. Design in accordance with AWWA M11:
    a. General:
        1) Base stationing and elevation convention as shown on Drawings.
        2) Maximum Laying Lengths:
            a) Not limited, unless specifically shown on Drawings.
            b) Select lengths to accommodate installation operation.
    b. Include, as minimum:
        1) Specific number, location, and direction of each pipe, joint, and fitting. Number each pipe in installation sequence.
        2) Station and centerline elevation at changes in grade or horizontal alignment.
        3) Station and centerline elevation to which bell end of each pipe will be laid.
        4) Elements of curves and bends, both in horizontal and vertical alignment.
        5) Location of mitered pipe sections, beveled ends for alignment conformance, butt straps, and deep bell lap joints for temperature stress control.

6) Location of closures, cutoff sections for length adjustment, temporary access manways, vents, and weld lead outlets for construction convenience.
   a) Provide for adjustment in pipe laying headings and to conform to indicated stationing.
   b) Changes in location or number will require Engineer approval.
7) Location of bulkheads, both those shown and as required, for hydrostatic testing of pipeline.
8) Details of specials with developed plan dimensions, wall thickness, reinforcing at openings, and joint welding details.

C. Welding Procedure Specification (WPS):

1. Qualified by testing in accordance with ASME BPVC SEC IX for shop welds and AWS D1.1/D1.1M for field welds.
2. PQRs conducted on unlisted base metal to be production welded as required in the referenced welding Code shall be traceable to heat lots.
3. Written WPS required for welds, both shop and field.
4. Notch-tough welding procedures that require heat input control shall be required:
   a. AWS D1.1/D1.1.M prequalified welding procedures and AWS Standard Welding Procedures Specifications (SWPS) are not allowed.
   b. WPS used to shop fabricate pipe shall be qualified in accordance with ASME BPVC SEC IX and shall include Supplementary Essential Variables.
   c. WPS used to field install pipe shall be qualified for heat input control in accordance with AWS D1.1/D1.1M.
   d. PQRs shall be qualified for notch tough welding with consideration for thickness of steel, test temperature, and Charpy V-notch CVN values. Refer to AWS D1.1/D1.1M, Table 6.7 PQR Supplementary Essential Variable Changes for CVN Testing Applications and Clause 6, Part D Requirements for CVN Toughness Testing using, three specimens. The CVN test temperature and acceptance shall be same as pipe base metal specified herein.

D. Stulling (Strutting): Design for pipe and fittings such that over-deflection and damage is avoided during handling, storage, and installation, including backfill and compaction.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings showing pipe layout.
2. Material list and steel reinforcement schedules for materials specified.
3. Fabrication Information:
   a. Pipe and fitting details for temporary and permanent facilities indicating:
      1) Cylinder thickness.
      2) Manufacturing tolerances.
      3) Maximum angular deflection limitations of field joints.
      4) Closure sections and cutoffs for field length adjustment.
      5) Bulkheads, including details for removal of test bulkheads and repair of lining.
      6) Weld lead outlets and plugs.
      7) Stulling size, spacing, and layout.
   b. Welded joint details, including:
      1) Butt joints.
      2) Miter-cut ends for alignment conformance.
      3) Lap joints.
      4) Special thermal control joints required for control of temperature stresses.
      5) Butt strap joints.
4. Welding Data (Shop and Field Welding):
   a. Show on a weld map, complete information regarding ASTM base metal specifications and the location, type, size, and length of all welds. Welding symbols shall include references in the tail of each welding symbol that identify the WPS that will be used and the frequency of NDE that will be completed.
   b. Clearly distinguish between shop and field welds.
   c. Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for all welds.
   d. Welding and NDE symbols shall be in accordance with AWS A2.4.
   e. Welding terms and definitions shall be in accordance with AWS A3.0M/A3.0.
   f. Submit welding data together with Shop Drawings as a complete package.

5. Product data for the following:
   a. Welded Steel Pipe and Fittings:
      1) Material data.
      2) Chemical and physical test reports showing data consistent with specified requirements for each heat of steel proposed for use.
   b. Rubber Gasket Joint:
      1) Details with dimensions and fabrication tolerances for both bell and spigot ends.
      2) Materials.
      3) Performance history or test data.

B. Informational Submittals:

1. Certificates:
   a. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
   b. Lining Materials: Certificate that lining system is currently approved for potable water contact in accordance with NSF 61 and satisfies current applicable governmental health and safety requirements for use in potable water.
2. Pipe Manufacturer’s written Quality Assurance/Control Plan.
3. Statements of Qualification:
   a. Pipe manufacturer.
   b. Fittings fabricator.
   c. Welders Log Showing:
      1) Name of welder or welding operator and certification stamp number.
      2) Welding procedures/positions for which welder or welding operator is qualified.
      3) Certification date and current certification status.
   d. Certified Welding Inspector.
   e. Contractor’s Shop Inspector.
   f. Contractor’s Field Inspector.
   g. NDT Quality Control Personnel.
4. Procedures:
   a. Shop and field welding information; at a minimum include complete welding code paper trail with linkage to Shop Drawings.
   b. Welder Qualifications and Welding Procedure Specifications as specified below:
      1) Provide complete joint dimensions and details showing bevels, groove angles, root face, and root openings for all welds.
      2) Notch-tough welding procedures required. For shop and field welding, provide heat-input table on WPSs for welder guidance.

3) Written NDT procedures.
4) WPQ's conducted specifically for Contractor or fabricator performing the Work.
5) Written description of proposed sequencing of events or special techniques such as:
   a) Controlling pipe wall temperature stress during installation.
   b) Minimizing distortion of steel.
   c) Shop-Applied Cement-Mortar Lining: Include description of machine to be used and list of similar projects where machine was used. Identify pipe size and total footage.
   d) Monitoring pipeline temperatures during installation.

c. Written weld repair procedures for the Work.
d. Field coating application and repair.
e. Field lining application and repair.

5. Reports:
   a. Source Quality Control Test Reports:
      1) Hydrostatic testing.
      2) Destructive weld testing.
      3) Nondestructive weld testing.
      4) Steel impact testing using Charpy V-notch method.
      5) Letter from independent testing agency certifying pipe furnished meets requirements of this Specification.
      6) Coating and lining factory Site visit letter by qualified manufacturer's technical representative.
   b. Field Quality Control Test Reports:
      1) Weld tests, including re-examination of repaired welds, on each weld joint for the following tests, as applicable:
         a) Visual Testing (VT).
         b) Radiographic Testing (RT).
         c) Ultrasonic Testing (UT).
         d) Magnetic Particle Testing (MT).
         e) Liquid Penetrant Testing (PT).
         f) Leak Testing (LT).
   c. Cement-mortar lining compressive strength tests in accordance with AWWA C205.
   d. Cement-mortar coating absorption tests in accordance with AWWA C205.
6. Field Testing Plan: As specified in Section 33 05 05.31, Pressure Testing of Piping.
7. Design calculations prepared by a licensed professional engineer in the state of the Work for fittings, including opening reinforcement details of collars, wrappers, crotch plates; and harnessed joint assemblies.

8. Temperature Stress Control Plan: Submit at least 45 days prior to installing pipe and include at least the following information:
   a. Step by step installation procedures and sequencing to demonstrate compliance with temperature control requirements, including:
      1) Pipe installation.
      2) Joint welding of standard joints and temperature control joints.
      3) Pipe bedding and backfill.
   b. Methods to ensure compliance with procedures by installation personnel.
   c. Equipment to be used to monitor pipe wall temperature.
   d. Time of day, climatic, or seasonal installation limits to be used to achieve compliance with temperature control requirements.
9. Pipe manufacturer's design engineer's certification of training of Contractor's pipe installation crews.

1.06 QUALITY ASSURANCE

A. Qualifications:

1. Pipe Manufacturer:
   a. Experienced in fabricating pipe of similar diameters, lengths, and wall thickness required for the Work.
   b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.
   c. Demonstrate current production capability for volume of work required for Project.
   d. Experience shall include successful fabrication to AWWA C200 standards of at least 30,000 linear feet of 48-inch diameter or larger pipe and at least 3,000 linear feet of 60-inch diameter or larger pipe, with wall thickness of 0.5 inches or greater, within past 5-year period.
   e. Experience shall be applicable to fabrication plant facilities and personnel, not company or corporation that currently owns fabrication facility or employs personnel.
2. Fittings Fabricator:
   a. Experienced in fabricating fittings of similar diameters and wall thickness required for the Work.
   b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.
   c. Demonstrate current production capability for volume of work required for this Project.
   d. Experience shall include successful fabrication to AWWA C200 and AWWA C208 standards of at least 25 fittings of 60-inch or larger pipe, with wall thickness 0.5 inch or greater, within past 5-year period.

e. Experience shall include successful fabrication of at least five crotch plate fittings requiring post weld heat treatment within past 5-year period.
f. Experience shall be applicable to fabrication shop facilities and personnel, not company or corporation that currently owns fabrication facility or employs personnel.

3. Welders and Welding Operators:
   a. Shop Welders: In accordance with ASME BPVC SEC IX.
   b. Field Welders: In accordance with AWS D1.1/D1.1M.
4. Contractor’s Inspector for Shop and Field Welding:
   a. In accordance with AWS QC 1, with knowledge of welding code for the Work.
   b. After receiving CWI qualification, at least one Shop CWI and one Field CWI shall have 5 years’ minimum professional experience related to welding inspection similar to the Work. Other CWIs may work under the supervision of 5-year CWI, provided they have 1 year of related professional experience after receiving CWI qualification.
5. NDT Quality Control Personnel:
   a. In accordance with requirements of ASNT SNT-TC-1A, NDT Level II.
   b. After receiving NDT qualification, at least one NDT person shall have 5 years minimum professional experience related to NDT inspection similar to the Work. Other NDT personnel may work under the supervision of 5-year NDT, provided they have 1 year of related professional experience after receiving NDT qualification.

B. Contractor’s Certified Welding Inspector for Shop Welding:

1. In accordance with AWWA C200.
2. Responsibilities:
   a. Verify conformance to use of specified materials and their proper storage.
   b. Monitor conformance to approved WPS.
   c. Monitor conformance to approved NDT procedure specifications.
   d. Monitor conformance of WPQ.
   e. Provide 100 percent visual inspection before, during, and after shop welding.
   f. Coordinate NDT work and review test results.
   g. Maintain records and prepare report confirming results of inspection and testing.

C. Contractor’s Certified Welding Inspector for Field Welding:

1. In accordance with AWWA C206 and AWS D1.1/D1.1M.
2. Responsibilities:
   a. Verify conformance to use of specified materials and their proper storage.
   b. Monitor conformance to approved WPS.
   c. Monitor conformance to approved NDT procedure specifications.
   d. Monitor conformance of WPQ.
   e. Provide 100 percent VT before, during, and after field welding.
   f. Coordinate NDT work and review test results.
   g. Maintain records and prepare report confirming results of inspection and testing.

D. Prefabrication Meeting:

1. Hold prior to fabrication of pipe and fittings between representatives of Owner, Contractor, Engineer, and pipe fabricator to review following:
   a. Project scope.
   b. Submittal requirements.
   c. Testing.
   d. Inspection responsibilities.
   e. Shop welding requirements.
   f. Field welding requirements.
   g. Shop and field coating and lining requirements.
   h. Production and delivery schedule.
   i. Other issues pertinent to the Work.

E. Inspection of Coating and Lining Application: Qualified manufacturer’s technical representative shall visit pipe coating and lining shop and the Project site at beginning of application process to verify proper workmanship associated with coating and lining application and as may be required to resolve shop or field problems. Submit written report of visit to Engineer.

F. Contractor’s welding inspector for shop and field welding shall be CWI certified, per Paragraph Contractor’s Certified Welder Inspector (CWI) for Shop Welding, and Paragraph Contractor’s Certified Welding Inspector (CWI) for Field Welding. This welding inspection is the Contractor’s responsibility and is not classified as Special Inspection. Contractor shall submit CWI inspection records within 1 week after inspections are performed for all welds in the shop and in the field.

1.07 DELIVERY, HANDLING, AND STORAGE

A. Pipe Marking:

1. Legibly mark installation sequence number on pipe and fittings in accordance with piping layout. Standard pipe sections do not need sequence number labeled provided wall thickness is clearly marked.
2. Fittings shall be marked at each end with notation “TOP FIELD CENTERLINE”.
3. The word “TOP” shall be painted or marked on outside top spigot of each fitting.
4. Mark “TOP MATCH POINT” for compound bends per AWWA C208 so end rotations can be easily oriented in field.

B. Delivery:

1. Securely bulkhead or otherwise seal ends of pipe and fittings prior to loading at manufacturing site.
2. Pipe ends shall remain sealed until installation.
3. Damage to pipe and fittings, including linings and coatings, found upon delivery to Site shall be repaired to Engineer’s satisfaction or removed from Site and replaced.

C. Storage:

1. Support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.
2. Support on sand or earth berms free of rock exceeding 3 inches in diameter.
3. Storage of pipe within road rights-of-way will not be allowed.

1.08 SEQUENCING AND SCHEDULING

A. Notify Engineer in writing of the following:

1. Pipe Manufacturing: Not less than 14 days prior to starting.
2. Not less than 5 days prior to start of each of the following:
    a. Welding.
    b. Coating application.
    c. Lining application.
    d. Shop hydrostatic testing.

PART 2 PRODUCTS

2.01 GENERAL

A. Pipe Manufacturer:

1. Pipe and fabricated fittings shall be responsibility of one main Supplier.
2. If pipe and fabricated fittings are manufactured by separate Suppliers, one main Supplier shall be responsible for formally managing other Supplier. The one main Supplier is responsible for coordination and management of production of all pipe and fittings work of both Suppliers, including, but not limited to:
    a. Qualifications.
    b. Submittals.
    c. Dimensional consistency between pipe and fittings.
    d. Fabrication.
    e. Quality assurance.
    f. Quality control.
    g. Reporting.
    h. Shop lining.
    i. Shop coating.
    j. Shop testing.
    k. Field services.
    l. Delivery schedule.
    m. Warranties or guarantees.

B. Pipe Size:

1. Unless shown otherwise for pipe over 24 inches in diameter, diameter shown shall be considered finished inside diameter after lining.
2. For pipe 24 inches in diameter and less, diameter shown shall be per ASME B36.10M.
    a. Pipe size shall be nominal outside diameter for 14-inch diameter pipe and larger.
    b. Pipe size shall be nominal inside diameter for 12-inch diameter pipe and smaller.

C. Steel pipe and fittings shall be manufactured, tested, inspected, and marked to comply with AWWA C200 and additional requirements of these Contract Documents.

D. In lieu of collar reinforcement, pipe or fittings with outlets may be fabricated in their entirety of steel plate having thickness equal to sum of pipe wall plus required reinforcement, if approved by the Engineer.

E. Materials furnished shall be NSF 61 approved for use with potable water.

F. Materials originating outside of the United States of America shall have all required factory or mill tests completed at a domestic laboratory to verify material quality and composition. Domestic test laboratory shall be approved by the Engineer.

2.02 PIPE BARREL

A. Steel: Provide steel coils for spiral welded steel pipe or steel plate for straight seam welded steel pipe per AWWA C200 and as follows:

1. Specified Minimum Yield Strength: 42,000 psi.
2. Specified Minimum Tensile Strength: 65,000 psi.
3. Minimum Elongation in 2-inch Gauge Length: 21 percent.
    a. Weldability:
        1) Maximum Carbon Equivalent of 0.45, as Measured using AWS D1.1, Annex XI, Guideline on Alternative Methods for Determining Preheat Formula: CE=C+(Mn+Si)/6)+(Cr+Mo+V)/5+(Ni+Cu)/15.
4. Steel Quality as follows:
    a. Coils:
        1) For steel coils 0.230-inch or greater, use continuous cast process, fully killed, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A1018/A1018M, SS Grade 40 (modified).
            a) Steel Chemistry:
                (1) Carbon: 0.25 percent maximum.
                (2) Manganese: 1.5 percent maximum.
                (3) Aluminum: 0.020 percent minimum.
                (4) Phosphorus: 0.025 percent maximum.
                (5) Sulfur: 0.015 percent maximum.
        2) For steel coils less than 0.230 inch, use continuous cast process, fully-killed, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A1011/A1011M, SS Grade 40 (modified).
            a) Steel Chemistry:
                (1) Carbon: 0.25 percent maximum.
                (2) Manganese: 1.5 percent maximum.
                (3) Aluminum: 0.020 percent minimum.
                (4) Phosphorus: 0.025 percent maximum.
                (5) Sulfur: 0.015 percent maximum.
    b. Plate:
        1) Fully-killed, conforming to ASTM A20/A20M, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A516/A516M, Grade 70.
        2) Steel plates that are 3/4-inch thick or greater shall be normalized.

c. Toughness:
1) Charpy V-notch Acceptance Criteria: Transverse specimen orientation, full size specimens, 25 foot-pounds energy at test temperature of 30 degrees F.
2) Frequency: See Paragraph Steel Toughness Testing for Thickness Equal to or Greater than 7/16 Inches.

5. Minimum nominal wall thickness as shown on Drawings. Maximum allowable thickness variation for plate, sheet, or coil shall be 0.010 inch less than ordered thickness.

2.03 FITTINGS AND SPECIALS

A. Fabrication:

1. Shop fabricate. No field fabrication will be allowed, unless approved by Engineer.
2. Fabricate from materials or straight pipe in conformance with specified requirements and dimensions of AWWA C208, unless otherwise indicated.

B. Crotch Plate:

1. Fabricate from fully-killed, fine grain, pressure vessel steel conforming to ASTM A516/A516M, Grade 70, and as follows:
   a. Plates shall be normalized.
   b. Perform through-thickness tension testing of plates in accordance with ASTM A770/A770M.
   c. Charpy V-notch tests in direction transverse to final rolling shall be performed per ASTM A370 on full size specimens of coupons taken from each plate. Acceptance shall be 25 foot-pounds at 30 degrees F.

C. Wall Thickness:

1. General:
   a. Refer to ASME B36.10M for definitions of wall thickness for standard weight pipe and nominal pipe size (NPS).
   b. Reinforce to withstand either internal pressures, both circumferential and longitudinal, or external loading conditions, whichever is greater.
   c. Minimum Plate Thickness: The greater of adjacent mainline pipe, thickness shown, or thickness calculated as hereinafter specified.

D. Bends, Unless Otherwise Indicated:

1. Minimum Radius: Unless shown otherwise on Drawings, elbows shall have a minimum radius of 2.5 times the pipe diameter.

2. Minimum Bend Wall Thickness: For elbows with radius of 2.5 times the pipe diameter or greater, wall thickness shall be the same as adjoining pipe. For elbows with radius less than 2.5 times the diameter of the pipe the wall thickness shall be calculated considering bend stress intensities in accordance with AWWA M11.
3. Maximum Miter Angle: 11-1/4 degrees on each section resulting in a maximum deflection angle of 22.5 degrees per miter weld as recommended in AWWA C208.
4. Bevels: Vary bevels on miters to provide a constant weld groove angle. For 11-1/4-degree miter, (22.5-degree miter weld) bevels must vary from 18.75 degrees on OD of bend to 41.25 degrees on ID of bend to provide a constant 60-degree groove angle for CJP welding.
5. Complete joint penetration (CJP) welds on miter welds.

E. Outlets:

1. 24 Inches and Smaller: Fabricate from ASTM A53/A53M, Type E or Type S, Grade B, standard weight steel pipe.
2. Larger than 24 Inches: Fabricate from ASTM A106/A106M, Grade B, extra strong weight pipe. 30-inch outlets for manways may also use 3/8-inch minimum thick API 5L, Grade B pipe.
3. Fabricate collar or wrapper reinforcement using same steel as specified for main pipe barrel.

F. Steel Butt-Weld Fittings:

1. 24 Inches and Smaller: In accordance with ASME B16.9 conforming to ASTM A234/A234M.
2. Standard weight.
3. Taper pipe wall at welds at 4:1 for connection to pipe of different wall thickness.
4. Coordinate difference in diameter convention between fittings and AWWA C200 and AWWA C208 pipe and fittings to provide complete piping system as shown.

2.04 JOINTS

A. Shop Welded:

1. Fabricate in accordance with AWWA C200 as modified herein.
2. Complete joint penetration (CJP) butt joints shall be used for longitudinal, girth, and spiral welds, unless otherwise indicated.
3. Lengths of pipe shall not be shop-joined using lap joints.

B. Preparation of Joints for Field Welding:

1. Butt Joint Welded:
    a. Plain ends beveled as required by AWWA C200 and Contractor’s field WPS.
    b. Provide protection for factory beveled pipe ends so ends are not damaged during transport.
2. Lap Joint Welded:
    a. Lap joints in preparation for field welding shall be in accordance with AWWA C200.
    b. For pipe 30 inches in diameter and larger, provide one of the following:
        1) Tack weld four metal tabs at equal intervals around inside circumference of bell ends to indicate location at which spigot end has reached maximum penetration into bell. Remove stops after welding of joint.
        2) Paint a 3/4-inch wide white stripe on outside circumference of spigot end of pipe. Side of stripe furthest from pipe end shall indicate location at which spigot end has reached maximum penetration into bell. Side of stripe closest to end of pipe will indicate limit of maximum joint pull.
    c. Double welded lap joints and butt-strap joints shall be tapped and drilled for testing in accordance with AWWA C206.

C. Miter-End Cuts:

1. Welded Lap Joints:
    a. As shown on Drawings.
    b. Moderate deflections and long radius curves may be made using miter-end cuts.
    c. Use only with lap welded joints, unless specifically approved in writing by Engineer.
    d. Maximum Total Allowable Angle: 3 degrees per pipe joint.
    e. Provide miter-cut that is cold expanded square with face of miter-cut on bell ends only.
    f. Mitering of spigot ends will not be permitted.
2. Welded Butt Joints:
    a. Maximum Total Allowable Angle: 2.5 degrees per pipe joint.
    b. Minimum Pipe Wall Thickness: 3/8-inch.
    c. Welded Butt joints shall be CJP.

D. Special Temperature Control Joint:

1. Provide a special longer bell end (Special Temperature Control Joint) at a maximum spacing as indicated herein to account for movement on installed pipe as a result of temperature changes.
2. Minimum Special Temperature Control Joint length is as shown on Drawings.

2.05 FLANGES

A. As specified in Section 33 05 01, Conveyance Piping—General.

2.06 STULLING (STRUTTING AND BRACING)

A. Materials:

1. Shop-Lined Pipe: Wood stulls and wedges.
2. Unlined Pipe: Steel or wood.

B. Install stulling for pipe and fittings in accordance with approved submittal and as soon as practical after pipe is fabricated or, for shop-lined pipe, after lining has been applied.

C. Install stulling in manner that will not harm lining.

D. The steel pipe manufacturer shall furnish and install adequate bracing or strutting to keep the pipe from becoming deformed or damage the coating or linings. Stulls shall remain in place during handling, storage, transportation, and installation of pipe and fittings until after the pipe zone material is compacted. Adequate stulling shall be provided by pipe manufacturer, so that after completion of backfilling, pipe deflection or elongation will not exceed 1 percent of the nominal inside diameter of cement-mortar-lined pipe.

E. The minimum bracing shall consist of crossed stulls (horizontal and vertical). The maximum spacing along the pipe shall be near each end and at the one-third points for each nominal 40-foot section of pipe, with a minimum of four sets of stulls per 40-foot section of pipe. Random lengths of pipe shall have an equivalent number of sets of stulls, with a minimum of one set of stulls in a 10-foot section of pipe. Pipe manufacturer shall submit to Engineer for review and approval, proposed type, installation method, and spacing of bracing stulls.

F. The stulls shall be installed with pads and wedges in such a manner that the pipe lining will not be damaged and the stulls will not be dislodged during shipping and handling of the pipe. If stulls are welded, they shall be installed and removed in such a manner to prevent damage to the steel cylinder, lining, or coatings. All damage shall be repaired to the satisfaction of the Engineer.

2.07 COATINGS

A. As specified in Section 09 90 10, Pipeline Coating and Lining, and Section 09 90 00, Painting and Coating.

2.08 CEMENT-MORTAR LINING

A. General:

1. Cement-Mortar Lining for Shop Application: Unless shown otherwise on Drawings, or specified in Section 09 90 00, Painting and Coating, interior surfaces of all steel pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with AWWA C205.
2. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work and shall be approved by the Engineer. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found faulty at the delivery site, or after installation, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications at no additional cost to the Owner.
3. Defective linings, as determined by the Engineer, shall be removed from the pipe and replaced to the full thickness required. Defective linings shall be cut back to a square shoulder. Temperature and shrinkage cracks in the mortar less than 1/16-inch wide need not be repaired. For pipe, specials, and fittings with cracks 1/16-inch wide and greater, if it can be demonstrated to the satisfaction of the Engineer that the cracks will heal autogenously by soaking in water by the Substantial Completion date, those sections shall be accepted. Pipe, specials, and fittings not meeting these criteria shall be rejected.
4. The progress of the application of mortar lining shall be regulated in order that all hand work, including the repair of defective areas is cured in accordance with the provisions of AWWA C205. Cement-mortar for patching shall be the same materials as the mortar for shop or machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.
5. Notify Engineer at least 5 days prior to application of lining products.
6. Holdback of lining from field-welded joints shall be as shown on Drawings.

B. Shop-Applied:

1. Applied centrifugally in conformance with AWWA C205. Thickness shall be in accordance with AWWA C205.
2. Cement: Cement for mortar shall conform to the requirements of AWWA C205; provided that cement for mortar lining and coating shall be Type II or Type V, per ASTM C150. Fly ash or pozzolan shall not be used as a cement replacement.
3. Lining machine type that has been used successfully for similar work and approved by Engineer.
4. Maintain pipe in round condition during lining operation and thereafter by suitable bracing or strutting.
5. Provide polyethylene or other suitable bulkhead on ends of pipe and on special openings to prevent drying out of lining. Bulkheads shall be substantial enough to remain intact during shipping and storage until pipe is installed.
6. Pipe shall be left bare where field joints occur.
7. Ends of lining shall be left square and uniform. Feathered or uneven edges will not be permitted.

C. Field-Applied:

1. Materials conforming to AWWA C602.
2. Mortar for Joint Lining: The mortar for joint lining shall be cement mortar consisting of one part cement Type II or V, per ASTM C150 to two parts sand and sufficient water for dry-pack consistency.
3. Do not use pozzolanic material in mortar mix.
4. Admixtures shall contain no calcium chloride.
5. Wire mesh conforming to AWWA C205.

2.09 CATHODIC PROTECTION

A. Provide as shown and as specified in Section 26 42 02, Galvanic Anode Cathodic Protection System.

2.10 SOURCE QUALITY CONTROL

A. Steel pipe, fittings, and specials shall be manufactured, tested, inspected, and marked to comply with AWWA C200 and additional requirements of these Contract Documents.

B. Steel Toughness Testing for Thickness Equal to or Greater than 7/16 Inches:

1. Include three impact specimens; conduct test in direction transverse to final direction of the coil rolling.

2. Coils:
   a. Conduct Charpy Testing per ASTM A370 on an initial coil of each heat to establish uniformity of steel.
   b. Take test coupons from an initial coil of each heat at locations of outer and inner wrap of coil.
   c. For each coil that fails to meet acceptance criteria, conduct Charpy Testing on next two coils in that heat.
   d. Do not use coils that do not qualify in production of pipe.
3. Plate:
   a. Conduct Charpy Tests on each plate in accordance with ASTM A20/A20M.
   b. Conduct on full-size (10 mm by 10 mm) specimens from each plate in accordance with ASTM A20/A20M.
   c. Do not use plates that do not qualify in production of pipe.

C. Crotch Plate:

1. Perform through-thickness tension testing with acceptance criteria per Article 5 of ASTM A770/A770M on each plate.
2. Conduct straight-beam ultrasonic examination with acceptance criteria per Article 6 of ASTM A435/A435M on each plate.
3. Plates that do not qualify shall not be used.

D. Shop Hydrostatic Pressure Test:

1. In accordance with AWWA C200 Section 5.2, except as follows:
   a. General: Unless specified otherwise, testing of pipe and fittings shall be performed before lining and coating is applied.
   b. Pipe: Maintain test pressure for minimum of 5 minutes.
   c. Fittings:
      1) If fabricated from untested straight pipe, test to minimum pressure equal to field test pressure.
      2) Except as otherwise specified herein, no additional shop hydrostatic test will be required on fittings and specials fabricated from successfully tested straight pipe.
      3) Hydrostatically test fittings and specials with crotch plates, regardless of whether or not straight pipe sections used were previously tested.
      4) No leakage is allowed.

E. Joints, Lap-Welded:

1. Fit test minimum of five joints, selected by Engineer, of each pipe size used:
   a. Join pipe ends with proposed adjacent pipe end.
   b. Match-mark pipe ends.

c. Record Actual Annular Space:
   1) Maximum space at a point.
   2) Minimum space at a point.
   3) Space at 90-degree intervals; top, bottom, and spring line on both sides.

F. Shop Nondestructive Testing:

1. Welds: 100 percent visually examined by Contractor's Shop Inspector to criteria in ASME BPVC SEC VIII, Division 1.
2. CJP Welds: Spot radiographically or radioscopically examine pipe in accordance with ASME BPVC SEC VIII, Division 1, Paragraph UW-52. Welds that, in opinion of Engineer, cannot readily be radiographed, shall be 100 percent ultrasonically examined in accordance with Paragraph UW-53.
3. Fillet Welds: 100 percent examine using magnetic particle inspection method in accordance with ASME BPVC SEC VIII, Division 1, Appendix 6.
4. All Other Groove Welds: 100 percent ultrasonically examine in accordance with ASME BPVC SEC VIII, Division 1, UW-53. Air test collars and wrappers in accordance with AWWA C206.

G. Inspection of Pipe Fabrication Procedure: Owner will select and provide independent testing agency to observe pipe fabrication. Agency staff will have experience in observation of steel pipe fabrication in accordance with ASTM E329. Representative of agency shall be present full time while pipe is being fabricated and while protective coating and lining is applied.

H. Provide a letter to Engineer certifying that pipe furnished meets requirements of this section.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Joints and related work for field assembly of fittings shall conform to requirements for straight pipe, unless otherwise shown.
2. Inspect pipe and fittings before installation. Clean ends thoroughly, remove foreign matter and dirt from inside.
3. Make minor field adjustments by pulling standard joints.
   a. Maximum Allowable Angle: 75 percent of manufacturer's recommended or angle which results from 3/4-inch pull out from normal joint closure, whichever is less.
   b. Maximum Allowable Gap: 1/8 inch between bell and spigot at weld location.

4. Horizontal deflections or fabricated angles shall fall on alignment, as shown within tolerances below.
5. Vertical deflections shall fall on alignment, and pipe angle point locations shall match those indicated on Drawings within tolerances below.
6. Field-welded Joints, Pipe 30 Inches in Diameter and Larger:
    a. Ensure maximum penetration of spigot end into bell end is achieved through use of shop-welded tabs on inside circumference of bell end or by use of a paint stripe.
    b. If welded metal tabs are used, remove tabs prior to welding inside of joint.
7. Stulling:
    a. Maintain stulling in place until pipe is completely backfilled and compacted.
    b. Reinstall stulls that were temporarily removed to facilitate interior welding prior to backfilling.
8. Pipeline Alignment Tolerances: As specified in Section 33 05 01, Conveyance Piping—General.

3.02 DELIVERY AND TEMPORARY STORAGE OF PIPE AT SITE

A. Keep plastic caps placed over the ends of each pipe until immediately prior to installation. Add water to interior of pipe if plastic cap is temporarily removed and replaced or repaired. Do not remove the plastic caps placed over the ends until the pipe is ready to be placed in the trench. Plastic caps may be opened temporarily to spray water inside the pipe for moisture control.

B. Transport pipe to the Job Site on padded bunks with nylon tie-down straps to protect the pipe.

C. Store pipe on earth berms or timber cradles adjacent to the trench in the numerical order of installation. Only store pipe and materials within road rights-of-way that can be installed during the current working shift. No pipe may be stored overnight in road rights-of-way.

3.03 HANDLING OF PIPE

A. Lift pipes with spreader beams or wide belt slings or padded forklifts that will not damage the pipe. Do not use cable slings or chains directly bearing on the pipe. Lift pipes at two points, at approximately 1/3 to 1/4 of the pipe length from the pipe ends. Maintain internal braces placed in pipes 24 inches and larger in diameter until backfilling is completed. Maintain at least one brace at each end of steel pipe to be lined in the field. Provide additional vertical stulls before installing and backfilling welded steel pipe.

3.04 SANITATION OF PIPE INTERIOR

A. During laying operations, do not place tools, food, clothing, trash, or other materials in the pipe. When pipelaying is not in progress, including the noon hour, close the ends of the pipe with a vermin- and child-proof plug.

3.05 PLACEMENT OF PIPE IN TRENCH

A. Control water in trench per Section 31 23 23.15, Trench Backfill.

B. Lay pipes uphill if the grade exceeds 10 percent. Lay pipes with bell facing uphill if the grade exceeds 30 percent. Secure pipes from sliding. Where the grade exceeds 30 percent, weld each joint sufficiently to support the next but in no case, less than 3/16-inch throat thickness around the full pipe circumference.

C. Keep backfilling up with pipelaying. Where grade exceeds 30 percent, no more than five joints totaling 100 feet of pipe shall remain unbackfilled.

D. Excavate below the subgrade as shown on Drawings. If in rock, complete excavation to a uniform foundation free of protruding rocks. Complete stabilization of foundation, per Section 31 23 23.15, Trench Backfill, then place material specified for the bedding in Section 31 23 23.15, Trench Backfill, to bring the trench bottom to grade.

E. Place and compact the bedding as specified in Section 31 23 23.15, Trench Backfill.

F. Cut a depression to accommodate the pipe bell and external joint filler form and spaces to permit removal of the pipe handling slings.

G. Lay each section of pipe in order and position shown on the installation schedule. Lower the pipe onto the bedding and install it to line and grade along its full length on firm bearing, except at the bell and at the sling depressions.

H. When installing pipe on a curve, do not deviate from the pipe top mark by more than 2 inches from the vertical line passing through the pipe center.

I. Stulling: Maintain stulling in place until pipe is completely backfilled and compacted. Reinstall stulls that were temporarily removed to facilitate interior welding prior to backfill.

3.06 FLANGED CONNECTIONS

A. Lubricate nuts and bolts per Section 33 05 01, Conveyance Piping—General, prior to installation. Coat or wrap buried flanges, bolts, and metal as specified in Section 33 05 01, Conveyance Piping—General.

Extend the coating or wrapping over the flanges and bolts and secure it around the adjacent pipe circumference.

3.07 WELDING

A. Conform to AWS D1.1/D1.1M, AWWA C206, approved welding procedures, and referenced welding codes. In case of conflict AWS D1.1/D1.1M shall govern.

B. Preheat and interpass temperature requirements for unlisted base metals shall be determined according to AWS D1.1/D1.1M, Annex XI Guideline on Alternative Methods for Determining Preheat.

C. Rejectable weld defects shall be repaired or redone, and retested until sound weld metal has been deposited in accordance with appropriate welding codes.

D. Control of Temperature Stresses:

1. In accordance with AWWA C206, approved Temperature Stress Control Plan submittal, and this Specification.
2. To control temperature stresses, shade unbackfilled special temperature control joint area of pipe from direct rays of sun by use of properly supported awnings, umbrellas, tarpaulins or other suitable materials until pipe is backfilled at least 1 foot over top of pipe. The special temperature control joint area is defined as the entire length of pipe left exposed. Shading materials shall not rest directly on pipe, but shall be supported to allow air circulation around pipe. Shading of special temperature control joints is not required when ambient air temperature is below 50 degrees F.
3. Locate special temperature control joints at 300-foot intervals.
4. Install special temperature control joints as indicated on Drawings.
5. Design, furnish and install a pipeline temperature monitoring system consisting of thermocouple temperature gauges to monitor temperature of steel pipe wall in trench. Gauges shall be located at top inside surface of pipe at intervals not exceeding 50 feet. Hand held portable temperature sensor devices may be used, provided temperature readings are taken at top of pipe at a frequency and spacing that demonstrates compliance with temperature control requirements.
6. Temperature Control Requirements:
    a. Prior to and during placement of pipe backfill, pipeline steel temperature shall be at or below 90 degrees F. Monitor specified temperature and control for at least 3 hours after placement of pipe backfill. Provide supplemental cooling as required.

b. Place pipe backfill from a single heading starting at one special temperature control joint and proceed toward next special temperature control joint.
c. During period of pipe backfill placement, pipeline section that is partially backfilled shall be shaded as indicated in above. Temperature of partially backfilled pipe shall not be allowed to exceed 100 degrees F. Provide supplemental cooling as required.
d. Prior to welding special temperature control joints, pipeline extending 300 feet each direction from joint shall be maintained at or below 70 degrees F. Additionally, pipeline extending 300 feet each direction from joint shall be backfilled to at least 1 foot over top of pipe. Weld special temperature control joint at specified temperature of 70 degrees F or below. Begin and complete weld during coolest time interval of the 24-hour day. Use pipeline temperature monitoring system data to demonstrate to Engineer coolest interval of the day.
e. After field welding of special temperature control joint, pipe temperature for 150 feet in each direction shall be maintained below 70 degrees F for a minimum of 24 hours after special temperature control joint area has been backfilled to at least 1 foot over top of pipe.

3.08 PIPELINE CLOSURE ASSEMBLIES

A. Field trimming of pipe may be done only when approved by the Engineer and shall be normal to the axis of the pipe only.

B. Employ pipeline closure assemblies to unite sections of pipeline laid from opposite directions and to adjust the field length of the pipeline to meet structures, other pipelines, and points established by design stations. Select either follower ring design or butt strap design. Install follower ring closures as recommended by the pipe manufacturer.

C. Center the shaped steel butt straps over the ends of the pipe sections they are to join. On pipes 30 inches in diameter and smaller, weld the butt straps to the outside of the pipes with complete circumferential fillet welds equal in size to the thinnest part being joined. Refer to the details shown on Drawings when joining larger pieces.

D. Cement-mortar line closure assemblies to a mortar thickness at least equal to the adjoining standard pipe sections. Clean the steel with wire brushes and apply a cement and water wash coat prior to applying the cement mortar. Where more than a 4-inch joint strip of mortar is required, place welded wire mesh reinforcement of 2-inch by 4-inch pattern of No. 13-gauge over the exposed steel.

E. Install the mesh so that the wires on the 2-inch spacing run circumferentially around the pipe. Crimp the wires on the 4-inch spacing to support the mesh 3/8-inch from the metal pipe surface. Steel-trowel finish the interior mortar to match adjoining mortar lined pipe sections.

F. Complete exterior coating of joints per Section 09 90 10, Pipeline Coating and Lining.

3.09 REPAIR OF SHOP-APPLIED CEMENT-MORTAR COATINGS

A. Exterior surfaces of steel pipe and fittings shall be inspected upon delivery to Site and just prior to backfilling trench.

B. Repair of Cement Mortar Coating: Field repairs shall be made in accordance with AWWA C205.

3.10 COATING OF FIELD-WELDED JOINTS

A. As specified in Section 09 90 10, Pipeline Coating and Lining.

3.11 FIELD-APPLIED CEMENT-MORTAR LINING

A. General:

1. Except for requirements specified in this section, lining of steel pipe shall be in accordance with AWWA C602.
2. After joints are welded, air tested, and coated, and bedding and backfill have been placed, begin cleaning and lining operation with approval of Engineer.
3. Internal Cleaning:
    a. Prior to placing lining, pipe shall be thoroughly cleaned of foreign matter, including water.
    b. Cleaning may be by hand or mechanical method that is approved by Engineer.
    c. Waste materials and water from cleaning operations shall not be passed through sections of existing pipe or pipe that has already been lined.
    d. No pipe shall be lined until inspected and approved by Engineer.
4. Protection of Appurtenances:
    a. Prevent mortar from being thrown into pipe openings in accordance with AWWA C602.
    b. Outlet openings shall be trimmed, smoothed, and beveled.
    c. Damaged or defective areas shall be repaired to satisfaction of Engineer.

3.12 CEMENT-MORTAR LINING APPLICATION AT JOINTS

A. Cement-Mortar Lining: For pipe with shop-applied cement-mortar lining, place lining at joints in accordance with AWWA C205.

3.13 FIELD MORTAR LINING PIPE JOINTS UNDER 24-INCHES

A. Video inspect by robotic camera mortar lined joints not inspected manually. Video inspect pipes every 500 feet (or to limit of robotic camera) before continuing pipe assembly.

B. Mortar line field joints under 24-inch diameter as follows:

1. At startup, show Engineer one successful mortar lined joint before lining other joints.
   a. Mix Stiff Mortar: One-part cement (Type II or Type V, per ASTM C150) to two parts sand with water to make a stiff mix of dry pack consistency.
   b. Insert a tight-fitting ball swab or squeegee in bell end of pipe in trench.
   c. Mortar line face of shop mortar lining in pipe bell. Apply enough mortar to fill space between shop mortar linings of the two pipes being joined.
   d. Clean and insert spigot end of next pipe into mortar-buttered pipe bell.
   e. Immediately after joining pipes, draw ball swab or squeegee through pipe to remove all excess mortar and expel it from open pipe end.
   f. Do not move the pipe after ball swab has been pulled.
   g. For pipes with field welded joints, immediately after pulling swab, tack weld joint in two places, then let mortar cure 4 hours minimum before welding. Welding with fresh mortar evaporates too much water and fails lining. Welding on cured mortar causes a small crack which self-heals when immersed. Then apply joint coatings.

C. Mortar line butt straps for pipes under 24-inch diameter. Show Engineer one successful mortar lined threaded port (on a butt strap) before mortar lining other ports. Use tack welded project pipe to demonstrate threaded port lining.

1. Provide butt strap with one or two “weldable” 5-inch threaded ports to allow arm-troweling mortar lining of butt strap.
2. Weld butt strap.
3. Trowel line with “stiff mortar” (described above) butt strap interior except for 5-inch port(s).
4. Mix “sticky mortar”, one-part cement (Type II or Type V, per ASTM C150) to one-part sand and enough water to make a sticky

mix that holds shape for a few minutes in a 3/4-inch cantilevered ring.
5. Apply sticky mortar 3/4-inch thick to back of 5-inch threaded plug.
6. Build "lips" of sticky mortar 3/4-inch into all sides of threaded port.
7. Thread on the plug visually checking that sticky mortar on port and plug contact each other as the threading begins.
8. Allow 4 hours to cure, then 1/4-inch seal weld (fillet or groove) full perimeter of threaded port/plug. Then apply joint coatings.

3.14 CATHODIC PROTECTION

A. Apply to pipe as shown and as specified in Section 26 42 02, Galvanic Anode Cathodic Protection System.

3.15 FIELD QUALITY CONTROL

A. Field Welding:

1. All welds, 100 percent inspection, shall be VT inspected by Contractor's CWI and marked to indicate acceptance or rejection.
2. Test butt-strap or double-welded lap joint welds by pressurizing connection between the two fillet welds in accordance with AWWA C206.
    a. Apply air or other Engineer-approved gas into connection between the two fillet welds.
    b. Paint welds with soap solution.
    c. Mark leaks indicated by escaping gas bubbles.
    d. Close threaded openings with flush pipe plugs or by welding them.
3. CJP Welds:
    a. Inspect 10 percent of butt joint welds with full circumference RT. Where RT testing is performed, remove backer plates after welding to conduct RT testing. Alternatively, inspect 100 percent of each joint with UT.
    b. Inspect 10 percent of other groove welds with UT.
4. Inspect 20 percent of PFP and lap joint welds with MT.
5. Weld Acceptance:
    a. If, in the opinion of Engineer, inspections indicate inadequate quality of welds, percentage of welds inspected shall be increased.
    b. Welds to be inspected, if less than 100 percent rate, shall be selected at random by Engineer.
    c. VT: Perform VT per AWS D1.1/D1.1M Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
    d. UT: Perform UT of CJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.13.1.

e. RT: Perform RT of CJP butt joint welds in accordance with AWS D1.1/D1.1M, Paragraph 6.12.1.
f. PT or MT:
1) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.10.
2) Acceptance shall be in accordance with VT standards specified above.
g. Remove in manner that permits proper and complete repair by welding.
h. Caulking or peening of defective welds is not permitted.
i. Retest unsatisfactory welds.
6. Submit all weld test to Engineer within 1 week after testing.
7. Verification Acceptance: Owner or Engineer may conduct random nondestructive inspections of field-welded joints. Inspections will be of an appropriate type for weld being evaluated. Possible types of inspection include, but are not limited to, RT, UT, PT, and VT. Testing will be performed and evaluated per AWS D1.1/D1.1M. Provide Owner’s Verification Inspector access to the Work.

3.16 CLEANING

A. After sweeping the pipe clean and before hydrostatic test, flush pipes with hoses and pressurized water to remove dirt and debris. Remove all foreign matter, including ponded water.

B. For pipelines 24 inches or larger in diameter, acceptable alternatives to flushing are use of high-pressure water jet, sweeping, or scrubbing. Water, sediment, dirt, and foreign material accumulated during this cleaning operation shall be discharged, vacuumed, or otherwise removed from the pipe.

3.17 HYDROSTATIC TESTING

A. As specified in Section 33 05 05.31, Pressure Testing of Piping.

3.18 OPERATIONS INCIDENTAL TO JOINT COMPLETION

A. Install metallic jumper bond or bars where detailed on Drawings.

B. Plan joint completion to accommodate temporary test bulkheads for hydrostatic testing.

3.19 PROTECTION OF MORTAR LINING

A. Until the pipeline is filled with water, install bulkheads and apply moisture inside the bulkhead portions in a manner that will effectively prevent the drying out of the mortar lining.

3.20 MANUFACTURER'S SERVICES

A. Manufacturer's representative available at Site for installation assistance and training of pipe installation crews.

1. Coordinate pipe manufacturer's representative services.
2. Pipe manufacturer's representative shall visit Site and instruct, guide, and provide procedures for pipe handling, laying, and jointing at start of pipe installation by each crew.

END OF SECTION

SECTION 33 05 01.09
POLYVINYL CHLORIDE (PVC) PRESSURE PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Water Works Association (AWWA):
    a. C110, Ductile-Iron and Gray-Iron Fittings.
    b. C153, Ductile-Iron Compact Fittings, for Water Service.
    c. C605, Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.
    d. C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches Through 60 Inches (100 mm Through 1500 mm), for Water Transmission and Distribution.
    e. 1,200 mm) for Water Transmission and Distribution.
    f. C907, Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 Inches through 12 Inches (100 mm Through 300 mm), for Water, Wastewater, and Reclaimed Water Service.
2. ASTM International (ASTM):
    a. D2241, Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
    b. D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
    c. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
    d. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
    e. D2672, Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.
    f. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
    g. D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
3. NSF International (NSF).

1.02 SUBMITTALS

A. Action Submittals:

1. Drawings showing pipe diameter, pipe class, dimension ratio (DR), and fitting details.
2. Layout drawings, showing fitting details, lengths, elevations, special closure details, and thrust blocks.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Hydrostatic Testing Plan: Submit at least 15 days prior to testing and at minimum, include the following:
   a. Testing dates.
   b. Piping systems and section(s) to be tested.
   c. Method of isolation.
   d. Method of conveying water from source to system being tested.
   e. Method of disposing of test water.
   f. Calculation of maximum allowable leakage for piping section(s) to be tested.
3. Certification of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
4. Test report documentation.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Solvent Cement: Store in accordance with ASTM D2855.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe:

1. PVC, conforming to requirements of AWWA C900 or ASTM D2241. PVC pipe shall be AWWA C900 pipe except where smaller diameter incidental piping is specifically called out on Drawings. Smaller diameter incidental piping shall be Schedule 80 per ASTM D2467.
2. DR or schedule rating shall be as shown on Drawings.
3. Pipe to be used for potable water conveyance shall meet the requirements of NSF 61.
4. Color:
   a. Potable: Blue.
   b. Irrigation: Purple.
   c. Casing: White or Blue.

B. Joints:

1. AWWA C900 pipe shall be rubber gasketed conforming to AWWA C900.
2. PVC Schedule 80 pipe shall be solvent welded conforming to ASTM D2672.

C. Fittings:

1. AWWA C900 pipe shall use ductile iron fittings, conforming to AWWA C153 or AWWA C110, or fabricated steel fittings with fusion bonded epoxy lining and coating.
2. PVC Schedule 80 pipe shall use PVC conforming to ASTM D2467.

D. Service Saddles:

1. Service saddles are only allowed where specifically shown on Drawings.
2. Double strap type with minimum strap width of 2 inches.
3. Straps: Type 316 stainless steel.
4. Saddles: Ductile iron, epoxy-coated, 10 mils minimum thickness.
5. Minimum Pressure Rating: 200 psi.

E. Restrained Joints: Provide pipe restraint, where indicated on Drawings, by system designed specifically for use with PVC pipe using restraining rods or wedges. Do not use systems with set screws, gripper rings, or gripper gaskets.

F. Marking Tape: As specified in Section 31 23 23.15, Trench Backfill.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with AWWA C605 and AWWA Manual 23.

B. Solvent cement used for joints as recommended by pipe manufacturer.

C. Joints:

1. Rubber Gasketed: In accordance with manufacturer’s written instructions.
2. Solvent Cemented: In accordance with ASTM D2855.
3. Restrained Joint Systems: In accordance with manufacturer’s written instructions.

D. Pipe Bending for Horizontal or Vertical Curves:

1. Bending of pipe barrels larger than 12 inches in diameter is not allowed.
2. Radius of curves shall not exceed 75 percent of manufacturer's recommended values.
3. Use blocks or braces at pipe joints to ensure axial deflection in gasketed or mechanical joints does not exceed allowable deflection.

E. Maximum Joint Deflection at Mechanical Joint Fittings: 75 percent of manufacturer's recommended values.

3.02 INSPECTION AND HYDROSTATIC TESTING

A. General:

1. Notify Engineer in writing at least 5 days in advance of testing. Perform testing in presence of Engineer.
2. Using water as test medium, all newly installed pipelines must successfully pass hydrostatic leakage test prior to acceptance.
3. Conduct field hydrostatic test on buried piping after trench has been completely backfilled and compacted. Testing may, as approved by Engineer, be done prior to placement of asphaltic concrete or roadway structural section.
4. Contractor may, if field conditions permit and as approved by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial informal service leak test. Final field hydrostatic test shall not, however, be conducted until backfilling has been completed as specified above.
5. Supply of Temporary Water: In accordance with Section 01 50 00, Temporary Facilities and Controls.
6. Dispose of water used in testing in accordance with federal, state, and local requirements.
7. Install temporary thrust blocking or other restraint as necessary to prevent movement of pipe and protect adjacent piping or equipment. Make necessary taps in piping prior to testing.
8. Wait until concrete thrust blocks have achieved design strength to perform pressure tests. High-early strength cement may be used for thrust blocking to help be reduce cure time.
9. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
10. New Piping Connected to Existing Piping:
    a. Isolate new piping with grooved-end pipe caps, blind flanges, or other means as acceptable to Engineer.
    b. Provide appropriate thrust blocking.

B. Hydrostatic Testing Procedure:

1. Furnish testing equipment, as approved by Engineer, which provides observable and accurate measurements of leakage under specified conditions.
2. Maximum Filling Velocity: 0.25 foot per second calculated based on full area of pipe.
3. Expel air from piping system during filling.
4. Test Pressure: As indicated on Drawings or 150 percent of system static or maximum operating pressure, but not less than 120 psi. Do not exceed pressure rating of the pipe.
5. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
6. Maintain hydrostatic test pressure continuously for 2 hours minimum, adding make-up water only as necessary to restore test pressure to within 5 psi of specified hydrostatic test pressure.
7. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

C. Maximum Allowable Leakage (Test Allowance) as indicated in AWWA M23 shall be:

$$Q = \frac{LD(P)^{1/2}}{148{,}000}$$

where:

Q = Allowable leakage (Test allowance makeup water), in gallons per hour.
L = Length of pipe section being tested, in feet.
D = Nominal diameter of pipe, in inches.
P = Average test pressure during leakage test, in pounds per square inch.

END OF SECTION

SECTION 33 05 01.27
STEEL CASING PIPE

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section provides the minimum requirements for steel casing pipe to be installed by the allowable tunneling method(s) identified in Section 02 33 00, Tunneled Crossings. Steel casing pipe is required where shown on the Drawings.

1.02 SUBMITTALS

A. Action Submittals:

1. Steel Casing Pipe for Tunneled Crossings: Furnish Shop Drawings illustrating the details of the casing pipe, grout/lubrication ports, joint details, joint seal system, and miscellaneous items to be furnished and fabricated for the pipe. Show dimensions, tolerances, wall thickness, properties, and strengths, and other pertinent information. Submit to Engineer for acceptance prior to fabrication.

B. Informational Submittals:

1. Statements of Qualification:
   a. Welder’s Log Showing:
      1) Name of welder or welding operator and certification stamp number.
      2) Welding procedures/positions for which welder or welding operator is qualified.
      3) Certification date and current certification status.

1.03 DEFINITIONS

A. Casing: A welded steel pipe that supports the ground and provides a stable underground excavation for the installation of a carrier pipe.

1.04 DESIGN CRITERIA

A. Be fully responsible for the design of steel casing pipe that meets or exceeds the design requirements of this Specification and that is specifically designed for installation by the allowable tunneling methods identified in Section 02 33 00, Tunneled Crossings.

B. Do not exceed the casing manufacturer's allowable jacking capacity or 50 percent of the minimum steel yield stress, whichever is lower.

C. Provide steel casing pipe with a minimum wall thickness as shown on the Drawings.

D. Furnish steel casing pipe with lengths between 10 feet and 20 feet, depending on the installation requirements, available work and staging areas, shaft dimensions, as well as the shop practices of the pipe manufacturer.

E. Achieve steel casing pipe connections by complete joint penetration (CJP) field butt joint welding or a water-tight integral machine press-fit connection (Permalok). Field butt joint welding a square end piece of steel pipe to a 35-degree beveled end of steel pipe is acceptable unless otherwise specified. Install integral machined press-fit connections in accordance with the manufacturer's installation procedures and recommendations.

F. Provide steel casing pipe with two grout/lubricant ports 20 degrees on either side of vertical centerline and one port at crown along the pipe at intervals of 10 feet or less. Attach ports and fittings to the pipe in a manner that will not materially affect the strength of the pipe or affect ramming operations.

G. Drilling grout holes through installed casing pipe will not be permitted.

H. Casing welding shall be in conformance to the requirements of AWS D1.1.

PART 2 PRODUCTS

2.01 MATERIALS FOR TUNNELED CROSSINGS

A. Materials, Design, Fabrication, Handling, and Testing of Steel Casing Pipe: Conform to the requirements of ASTM A139, AWWA C200 and AWWA Manual M11 "Steel Pipe – A Guide for Design and Installation," except as modified herein.

B. Steel Casing Pipe: New, smooth-wall, carbon steel pipe conforming to ASTM A139, Grade B.

C. Pemalok Steel Casing Pipe: New, smooth-wall, carbon steel pipe conforming to ASTM A515, Grade 60, or ASTM 572, Grade 42, with a watertight T7 joint profile.

D. Dimensional Tolerances:

1. Bear sole responsibility for furnishing and installing steel casing pipe with dimensional tolerances in accordance with ASTM A139:
   a. When pipe ends have to be field beveled for welding, bevel the ends on the outside to an angle of 35 degrees with a tolerance of plus or minus 2-1/2 degrees and with a width of root face 1/16 inch plus or minus 1/32 inch.

E. Prior to delivery of the pipe, furnish and install end/internal bracing as recommended by the manufacturer, for protection during shipping, storage, and installation.

PART 3 EXECUTION

3.01 GENERAL

A. Install steel casing pipe in accordance with the individual specification section identified for the allowable tunneling method in Section 02 33 00, Tunneled Crossings.

B. Install carrier pipe inside steel casing pipe in accordance with Section 31 60 00, Installation of Carrier Pipe in Steel Casing.

END OF SECTION

SECTION 33 05 05.31
PRESSURE TESTING OF PIPING

PART 1 GENERAL

1.01 GENERAL

A. Hydrostatic and leakage test all pipes and their appurtenances per this section. Hydrostatic test and document leakage from all pipelines including steel, DIP, PVC, HDPE, and other pipelines, except for drainage pipelines.

1.02 SUBMITTALS

A. Submit hydrostatic testing plan that includes detailed procedure for testing piping. Plan shall include identification of source water for testing, filling and draining plan, and equipment to be used for testing including pumps, flow meters, and pressure gauges.

B. Submit Shop Drawings in accordance with Section 01 33 00, Submittal Procedures.

C. Submit test bulkhead locations and design calculations, pipe attachment details, and methods to prevent excessive pipe wall stresses.

D. Submit Notice of Intent to fill pipeline for hydrostatic testing 15 days prior to filling.

E. Submit electronic copies of all test records to the Engineer upon completion of the testing.

F. Submit certification of calibrated pressure gauge used for hydrostatic testing.

1.03 TEST PRESSURES

A. Test pressures for the various services and types of piping shall be as follows:

1. ULS Santaquin Reach Pipeline: Test HGL as shown on Drawings.

1.04 TESTING RECORDS

A. Provide records of each piping installation during the testing. These records shall include:

1. Date and times of test.
2. Identification of process, pipeline, or pipeline section tested or retested, lengths(s), diameter(s), pipe material(s), and pipe specification(s).
3. Test fluid.
4. Test HGL.
5. Remarks: Leaks identified (types, leakage rates, and locations), types of repairs, or corrections made.
6. Certification by Contractor that the leakage rate measured conformed to the Specifications.

PART 2 PRODUCTS

2.01 MANUAL AIR-RELEASE VALVES FOR BURIED PIPING

A. Provide temporary manual air-release valves at test bulkheads for pipeline test. Construct the pipe outlet in the same manner as for a permanent air valve and after use, seal with a blind flange, pipe cap, or plug and coat the same as the adjacent pipe.

2.02 STEEL PIPE TEST BULKHEADS

A. Fabricate steel pipe test bulkheads per Section VIII of the ASME Boiler and Pressure Vessel Code (or use DIP test heads). Materials shall comply with Part UCS of said code. Unless shown otherwise on Drawings, design pressure shall be at least two times the specified test pressure for the section of pipe containing the bulkhead. Limit stresses to 70 percent of yield strength of the bulkhead material at the bulkhead design pressure. Include air-release and water drainage connections.

B. For Ductile Iron Pipelines, use ductile iron test heads rated for required test pressure.

2.03 TESTING FLUID

A. Testing fluid shall be clean water only.

B. The Contractor shall obtain by their own means the testing water and pay the cost for obtaining this water.

C. Obtain all permits required by regulatory agencies.

2.04 TESTING EQUIPMENT

A. Provide calibrated pressure gauges, pipes, bulkheads, pumps, compressors, chart recorder, and meters to perform the hydrostatic testing.

PART 3 EXECUTION

3.01 TESTING PREPARATION

A. Notify Engineer of test start date 14 days before start of test, and again one day prior to start of test.

B. Pipes shall be in place, backfilled, and anchored before commencing pressure testing. Verify that all air vacuum valves are functioning prior to commencing pressure testing.

C. Conduct pressure tests on exposed and aboveground piping after the piping has been installed and attached to the pipe supports, hangers, anchors, expansion joints, valves, and meters.

D. For buried piping, the pipe may be partially backfilled and the joints left exposed for inspection during an initial leakage test. Perform the final pressure test; however, after completely backfilling and compacting the trench.

E. Provide any temporary piping needed to carry the test fluid to the piping that is to be tested. After the test has been completed and demonstrated to comply with the Specifications, disconnect and remove temporary piping. Do not remove exposed vent and drain valves at the high and low points in the tested piping; remove any temporary buried valves and cap the associated outlets. Plug taps or connections to the existing piping from which the test fluid was obtained.

F. Provide temporary drain lines needed to carry testing fluid away from the pipe being tested. Remove such temporary drain lines after completing the pressure testing. Pipes shall remain full after testing.

G. Engineer shall witness start of test and intermediate and final measurements.

3.02 INITIAL PIPELINE FILLING FOR HYDROSTATIC TESTING

A. Maximum rate of filling shall not cause water velocity in pipeline to exceed 1 fps (assuming full pipe flow).

3.03 TESTING NEW PIPE WHICH CONNECTS TO EXISTING PIPE

A. Prior to testing new pipelines which are to be connected to existing pipelines, isolate the new line from the existing line by means of test bulkheads, spectacle flanges, or blind flanges. After the new line has been successfully tested, remove test bulkheads or flanges and connect to the existing pipe. Final closure piece shall include minimum 3 feet of cut to fit pipe.

3.04 HYDROSTATIC TESTING OF STEEL, DIP, PVC, AND OTHER PIPING

A. Where any section of the piping contains concrete thrust blocks or encasement, do not make the pressure test until thrust block(s) reach 100 percent of concrete design strength.

B. When testing piping, fill the pipe to be tested with water and allow it to soak for at least 48 hours to absorb water before conducting the pressure test.

C. Apply and maintain the test pressure by means of a positive displacement hydraulic force pump.

D. Maintain the test pressure for the following duration by restoring it whenever it falls an amount of 5 psi:

Pipe Diameter (inches)	Hours
18 and less	8
Over 18 inches	24

E. After the test pressure is reached, use a meter to measure the additional water added to maintain the pressure. This amount of water is the loss due to leakage in the piping system. The allowable leakage is zero for steel. The allowable leakage for other pipelines shall not exceed half the allowable leakage listed in AWWA C600 (DIP) or AWWA C605 (PVC).

3.05 LEAK TESTING ACROSS EACH VALVE

A. After completion of successful hydrostatic test of each pipeline section, conduct leak test across each isolation valve and flow control valve in its closed position. Hydrostatically test every valve for leakage with each valve test showing the full static system pressure across the closed valve. Provide and install outlets and pressure test gauges upstream and downstream pressure of each valve being leakage tested.

B. In-place (Field) Leakage Test: Contractor shall perform in-place (field) leakage test. Field leak test all valves to the specified system tests pressure in the closed position with zero leakage. After verifying zero leakage to Engineer satisfaction, exercise each valve through its full stroke at least two times prior to operational testing of valves.

1. Valves which function to isolate flow shall have zero leakage through a 4-hour hydrostatic test at the static operating pressures of the system. Document test pressures upstream and downstream of closed valves and leakage rate. Submit test pressure loss and/or leakage records demonstrating valve leakage is not leaking.
2. Both before and after leak testing, demonstrate to Engineer or to designated O&M staff representative that each valve opens and closes smoothly under operating conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.
3. Count and record number of turns to open and close valve; account for any discrepancies with manufacturer's data.
4. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.
5. Set, verify, and record set pressures for all pressure reducing relief and regulating valves.

3.06 REPETITION OF TEST

A. If the actual leakage exceeds the allowable on any test, locate and correct the faulty work and repeat the test. Restore the work and all damage resulting from the leak and its repair. Pay for water needed for retesting.

3.07 DISPOSAL OF CLEANING WATER AND TEST WATER

A. See Section 33 05 01.01, Welded Steel Pipe and Fittings, for cleaning requirements. Submit and obtain Engineer approval for Contractor method for treating water remaining from cleaning of pipeline.

B. Leave the pipe full after a successful hydrotest. If any hydrotest fails and testing water is deemed clean water by Engineer, drain test water in a manner acceptable to the Engineer.

END OF SECTION

SECTION 33 05 13
PRECAST MANHOLES AND STRUCTURES

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): M198, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Standard Specification for Gray Iron Castings.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A536, Standard Specification for Ductile Iron Castings.
   e. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   f. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
   g. C14, Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
   h. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   i. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   j. C150/C150M, Standard Specification for Portland Cement.
   k. C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
   l. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   m. C443, Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
   n. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   o. C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
   p. C990, Standard Specification for Joints in Concrete Pipe, Manholes, and Precast Box Sections using Preformed Flexible Joint Sealants.
   q. C1311, Standard Specification for Solvent Release Sealants.

r. C1244, Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
s. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
t. D4101, Standard Specification for Propylene Injection and Extrusion Materials.
u. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
v. F594, Standard Specification for Stainless Steel Nuts.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings including details of construction, reinforcing and joints, anchors, lifting, erection inserts, and other items cast into members.
2. Product Data:
   a. Concrete mix design.
   b. Frame and cover features, configuration, and dimensions.
   c. Frame to structure seals.
   d. Frame to structure anchor bolt.
   e. Rubber gaskets and sealants.
   f. Pipe connector materials and dimensions.
   g. Manhole step materials and dimensions.

B. Informational Submittals:

1. Experience Record:
   a. Precast concrete production capabilities.
   b. Evidence of current PCI plant certification or alternative certification approved by the Engineer.
2. Calculations: For depths greater than 20 feet provide design calculations for stresses in precast concrete members for loading conditions including earth pressures and transportation, handling, and erection. Calculations shall be stamped by engineer registered in the same state as the Project.
3. Test Reports: Precast manufacturer’s concrete test cylinders.
4. Manufacturer’s recommended installation instructions.
5. Field quality control report.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with 3 years' experience producing precast concrete products of quality specified.
2. Precast Plant Certification: PCI certified plant with current certification or alternative certification approved by the Engineer.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials of Construction and Service Conditions:

1. Screws, Bolts, or Nuts: Type 304 stainless steel conforming to ASTM F593 and ASTM F594.
2. Gaskets:
   a. Internal and external seals shall be made of materials that have been proven to be resistant to the following exposures and conditions:
      1) Sanitary sewage.
      2) Corrosion or rotting under wet or dry conditions.
      3) Gaseous environment in sanitary sewers and at road surfaces including common levels of ozone, carbon monoxide, and other trace gases at installation site.
      4) Biological environment in soils and sanitary sewers.
      5) Chemical attack by road salts, road oil, and common street spillages or solvents used in street construction or maintenance.
      6) Temperature ranges, variations, and gradients in construction area.
      7) Variations in moisture conditions and humidity.
      8) Fatigue failure caused by a minimum of 30 freeze-thaw cycles per year.
      9) Vibrations because of traffic loading.
      10) Fatigue failure because of repeated variations of tensile, compressive and shear stresses, and repeated elongation and compression. Material shall remain flexible allowing repeated movement.
3. Materials in contact with each other shall be compatible.
4. Designed to provide a 20-year service life.

B. Structures shall meet requirements of ASTM C478, this specification and the following:

1. Concrete:
   a. Cement: Meet requirements of ASTM C150/C150M.
   b. Compressive Strength:
      1) Minimum 4,000 psi.
      2) Minimum strength shall be confirmed at 7 days by making two standard cylinders per manhole or structure for testing.
2. Reinforcement:
   a. Grade 60, unless otherwise specified.
   b. Place with minimum rebar clear cover as recommended by ACI 318.
3. Ring: Custom made with openings to meet indicated pipe alignment conditions and invert elevations.
4. Floor: Minimum depth below pipe to provide clearance for grouting channels as shown on the Drawings.
5. Joint: Form joint contact services with machined castings.
6. Gasket: Meet requirements of ASTM C443.

C. Design Loads:

1. Earth Loads: As shown in the General Structural Notes on Drawings.
2. Roof Loads:
   a. Areas Subject to Traffic: AASHTO HS-20.
   b. Areas not Subject to Traffic: 300 psf.

2.02 PRECAST MANHOLES

A. Riser Sections:

1. Fabricate in accordance with ASTM C478.
2. Diameter: Minimum 48 inches or as shown on Drawings.
3. Wall Thickness: Minimum 4 inches or 1/12 times inside diameter, whichever is greater.
4. Top and bottom surfaces shall be parallel.
5. Joints: Tongue-and-groove.

B. Cone Sections:

1. Eccentric.
2. Same wall thickness and reinforcement as riser section.
3. Top and bottom surfaces shall be parallel.

C. Base Sections and Base Slab:

1. Base slab integral with sidewalls.
2. Fabricate in accordance with ASTM C478.

D. Manhole Extensions:

1. Concrete grade rings; maximum 6 inches high.
2. Fabricate in accordance with ASTM C478.

E. Joint Seal Manufacturers and Products:

1. Butyl Gaskets:
   a. Hamilton Kent, Sparks, NV; Kent-Seal No. 2.
   b. Henry Company, Houston, TX; Ram-Nek RN 101.
   c. Trelleborg Engineered Solutions, Park Hills, MO; NPC Bidco C-56.
   d. ConSeal, Tipp City, OH: ConSeal CS-102.

2.03 PRECAST STRUCTURES

A. General: Reinforced concrete structures and vaults designed for the applications and sizes as shown on Drawings.

B. Conform to requirements of ASTM C857, ASTM C858, or ASTM C913 as required.

C. Minimum wall thickness shall be 5 inches.

2.04 POLYPROPYLENE STEPS

A. Fabricate from minimum 1/2 inch, Grade 60, steel bar meeting ASTM A615/A615M.

B. Polypropylene encasement shall conform to ASTM D4101.

C. Minimum Width: 13 inches, center-to-center of legs.

D. Embedment: 3-1/2-inch minimum and 4-1/2-inch minimum projection from face of concrete at point of embedment to center of step.

E. Cast in manhole sections by manufacturer.

F. Load Test: Capable of withstanding ASTM C478 vertical and horizontal load tests.

2.05 FRAMES AND COVER

A. Castings:

1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.
2. Cast Iron: ASTM A48/A48M Class 30B.
3. Ductile Iron: ASTM A536, Grade 60-40-12.
4. Plane or grind bearing surfaces to ensure flat, true surfaces.

B. Cover: True and seat within ring at all points.

2.06 FRAME CONNECTION TO STRUCTURE

A. Butyl Sealant:

1. Conform to ASTM C1311, or AASHTO M198 and ASTM C990.
2. Trowelable or cartridge applied.
3. Manufacturers and Products:
   a. Tremco Commercial Sealants and Waterproofing, Beachwood, OH; Tremco Butyl Sealant.
   b. Bostik, Middleton, MA; Chem-Calk 300.
   c. Press-Seal Gasket Company, Fort Wayne, IN; EZ-Stik #3.

B. Frame to Structure Anchor Bolts:

1. 3/4-inch-diameter HAS stainless steel bolts; minimum 6-5/8-inch embedment.
2. Manufacturer and Product: Hilti; HVA Capsules Adhesive Anchoring System.

2.07 MORTAR

A. Standard premixed in accordance with ASTM C387/C387M, or proportion one part Portland cement to two parts clean, well-graded sand that will pass a 1/8-inch screen.

B. Admixtures:

1. May be included; do not exceed the following percentages of weight of cement:
   a. Hydrated Lime: 10 percent.
   b. Diatomaceous Earth or Other Inert Material: 5 percent.

C. Mix Consistency:

1. Tongue-and-Groove Type Joint: Such that mortar will readily adhere to pipe.
2. Confined Groove (Keylock) Joint: Such that excess mortar will be forced out of groove and support is not provided for section being placed.

2.08 BACKFILL

A. As specified in Section 31 23 23, Fill and Backfill.

2.09 FLEXIBLE JOINTS FOR SEALING PIPES

A. Manufacturers and Products:

1. NPC, Inc., Milford, New Hampshire; Kor-N-Seal flexible rubber boot with stainless steel accessories.
2. A-LOK Products, Inc., Tullytown, PA; Z-LOK XP or A-LOK flexible connectors.

B. Doghouse manhole/manhole over existing pipe where use of a boot is not possible: Green Streak; hydrophilic waterstop CJ-0725-3k.

2.10 SOURCE QUALITY CONTROL

A. Prior to delivery of precast sections to Site, yard permeability tests may be required at point of manufacture. Engineer or Owner will select precast sections not to exceed 5 percent of the total project quantity to test from material which is to be supplied to Project. Test specimens shall be mat tested and meet permeability test requirements of ASTM C14.

B. Concrete Testing: Test two concrete test cylinders for each manhole and structure. Compressive strength shall be tested in accordance with ASTM C31/C31M, ASTM C39/C39M, and ASTM C192/C192M.

C. Inspection:

1. Material Quality:
   a. Manufacturing process and finished sections shall be subject to inspection and approval by Owner and Engineer.
      1) Inspections may take place at manufacturer’s plant, at Site after delivery, or at both.
      2) Sections not meeting requirements of this Specification or that are determined to have defects which may affect durability of structure are subject to rejection.

3) Sections rejected after delivery shall be removed and replaced.
4) Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Engineer.
5) If structure cannot be repaired it shall be removed and replaced entirely at Contractor's expense.

2. At the time of inspection, the sections will be carefully examined for compliance with ASTM C478 and with manufacturer's drawings. Sections will be inspected for general appearance, dimensions, scratch strength, blisters, cracks, roughness, and soundness. Surface shall be dense and close textured.
3. Imperfections may be repaired, subject to approval of Engineer, after demonstration by manufacturer that strong and permanent repairs result.

PART 3 EXECUTION

3.01 GENERAL

A. Prior to installation, inspect materials.

1. Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.
2. Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Engineer.
3. Remove and replace structure that cannot be repaired.

B. If needed, dewater excavation during construction and testing operations.

3.02 EXCAVATION AND BACKFILL

A. Excavation: As specified in Section 31 23 16, Excavation.

B. Backfill: As specified in Section 31 23 23, Fill and Backfill.

3.03 INSTALLATION OF PRECAST MANHOLES AND STRUCTURES

A. Concrete Base:

1. Place on compacted structural fill.
2. Properly locate, ensure firm bearing throughout, and plumb first section.

B. Sections:

1. Inspect precast sections to be joined.
2. Clean ends of sections to be joined.
3. Do not use sections with chips or cracks in tongue.
4. Locate precast steps in line with each other to provide continuous vertical ladder.

C. Preformed Plastic Gaskets:

1. Use only pipe primer furnished by gasket manufacturer.
2. Install gasket material in accordance with manufacturer's instructions.
3. Completed Manhole and Structures: Rigid and watertight.

D. Mortar Joints:

1. Thoroughly wet joint with water prior to placing mortar.
2. Place mortar on groove of lower section prior to section installation.
3. Fill joint completely with mortar of proper consistency.
4. Trowel interior and exterior surfaces smooth on standard tongue-and-groove joint.
5. Prevent mortar from drying out and cure by applying approved curing compound or comparable approved method.
6. Do not use mortar mixed for longer than 30 minutes.
7. Chip out and replace cracked or defective mortar.
8. Completed Manhole and Structures: Rigid and watertight.

E. Extensions:

1. Provide on manholes in streets or other locations where 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.

3.04 MANHOLE INVERT

A. Construct with smooth transitions to ensure unobstructed flow through manhole. Remove sharp edges or rough sections that tend to obstruct flow.

B. Where full section of pipe is laid through manhole, break out top section and cover exposed edge of pipe completely with mortar. Trowel mortar surfaces smooth.

3.05 FRAMES AND COVERS

A. Install concrete grade rings as required to set covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

B. Set frames in three equally spaced beads of butyl sealant that run full circumference of frame.

C. Anchor frame to manhole or structure with specified bolts.

D. Install frame to structure seals in accordance with manufacturer's instructions. Seal shall cover grade rings.

3.06 WATERTIGHT COVERS

A. Unless otherwise noted, covers shall be bolted down with sealing gasket.

3.07 CONNECTIONS TO EXISTING MANHOLES

A. Core manhole bases and grouting as necessary.

B. Seal pipe in manhole using flexible connector.

C. Regrout to provide smooth flow into and through manholes.

D. Provide diversion facilities and perform work necessary to maintain flow during connection.

3.08 FIELD QUALITY CONTROL

A. Hydrostatic Testing:

1. Perform hydrostatic testing where indicated on Drawings.
2. Procedure: Plug inlets and outlets and fill manhole with water to height determined by Engineer.
3. Manhole may be filled 24 hours prior to time of testing, if desired, to permit normal absorption into pipe walls to take place.
4. Leakage in each manhole shall not exceed 0.1 gallon per hour per foot of head above invert.
5. Repair manholes that do not meet leakage test, or do not meet specified requirements from visual inspection.
6. If more than 25 percent of manholes tested fail the hydrostatic test, test all or as many manholes as Engineer deems necessary.

END OF SECTION

SECTION 33 44 13.13
CATCH BASINS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Welding Society (AWS): Code for Welding in Building Construction.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Standard Specification for Gray Iron Castings.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   f. C478, Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.

PART 2 PRODUCTS

2.01 CONCRETE

A. Type: Ready-mixed, conforming to ASTM C94/C94M, Alternate 2.

B. Compressive Field Strength: Not less than 2,500 psi at 28 days.

C. Maximum Size of Aggregate: 1-1/2 inch.

D. Slump: Between 2 inches and 4 inches.

E. Assumed Field Strength: 85 percent of strength of laboratory-cured cylinders.

2.02 FORMS

A. Exposed Surfaces: Plywood.

B. Other Surfaces: Steel, matched boards, plywood, or other acceptable material.

1. Trench walls, large rock, and earth are not acceptable form material.

C. Form vertical surfaces.

D. Provide fillets on re-entrant angles.

2.03 REINFORCING STEEL

A. Conform to ASTM A615/A615M, Grade 60, deformed bars.

2.04 PRECAST UNITS

A. At the option of Contractor, approved precast units may be substituted for cast-in-place units.

B. Conform to ASTM C478 except dimensions shall be as shown.

C. Concrete Risers for Extensions: 6 inches high maximum and of same quality as sections.

1. Confirm acceptability of risers with Engineer before installation.

2.05 MORTAR

A. Standard premixed mortar conforming to ASTM C387/C387M, Type S, or proportion one part portland cement to two parts clean, well-graded sand which will pass a 1/8-inch screen.

B. Admixtures may be used if not exceeding the following percentages of weight of cement:

1. Hydrated Lime: 10 percent.
2. Diatomaceous Earth or Other Inert Materials: 5 percent.

C. Consistency of Mortar: As required to readily adhere to concrete.

2.06 FRAMES AND GRATINGS

A. Frames and Grates for Catch Basins and Storm Drain Inlets: Cast iron conforming to ASTM A48/A48, Class 30.

B. Bearing Surfaces: Clean and provide uniform contact.

C. Castings: Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.

PART 3 EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Excavate as required to accomplish construction. Backfill as specified for adjoining pipe trench.

3.02 CONSTRUCTION OF CATCH BASINS AND INLETS

A. Construct inlets and catch basins at locations shown and in accordance with Drawings. Construct tight and well-braced forms to dimensions and elevations required. Chamfer form corners.

B. Prior to placing concrete, remove water and debris from forms. Moisten forms just prior to placing concrete. Handle concrete from transporting vehicle to forms in a continuous manner as rapidly as practical without segregation or loss of ingredients. Immediately after placing, compact concrete with mechanical vibrator. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

C. Screed top surface of exposed slabs and walls. When initial water has been absorbed, float surfaces with wood float and lightly trowel with steel trowel to smooth finish free from marks or irregularities. Finish exposed edges with steel edging tool. Remove forms and patch defects in concrete with mortar mixed in same proportions as original concrete mix.

D. Use a membrane-forming curing compound to prevent loss of moisture for 7 days. Apply curing compound immediately after removal of forms or finishing of slabs. Protect concrete from damage during curing period.

3.03 PLACING PRECAST UNITS

A. If material in bottom of trench is unsuitable for supporting unit, excavate and backfill to required grade with 3-inch minus, clean, pit-run material. Set units to grade at locations shown.

3.04 EXTENSIONS

A. Install watertight extensions as shown. Lay risers in mortar with sides plumb and tops to grade. Seal joints with mortar, with interior and exterior troweled smooth. Prevent mortar from drying out and cure by applying a curing compound.

3.05 INSTALLATION OF FRAMES AND GRATES

A. Set frames and grates at elevations indicated or as determined in field and in conformance with Drawings.

B. Frames may be cast in, or set in mortar.

3.06 CLEANING

A. Upon completion, clean structure of silt, debris, and foreign matter.

END OF SECTION

SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section includes materials, testing, and installation of valves.

1.02 RELATED WORK

A. Section 09 90 00 Painting and Coating.

B. Section 33 05 01 Conveyance Piping General.

C. Section 40 27 03, Electric Motor Actuators.

D. Section 40 27 06, Plunger Valves.

E. Section 40 27 08, Full Port Isolation Ball Valves.

1.03 REFERENCES

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

1. American Gas Association (AGA): 3, Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   b. B16.44, Manually Operated Metallic Gas Valves for Use in Above Ground Piping Systems up to 5 psi.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
   a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   b. C500, Metal-Seated Gate Valves for Water Supply Service.
   c. C504, Rubber-Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm).
   d. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
   e. C509, Resilient-Seated Gate Valves for Water Supply Service.

f. C510, Double Check Valve Backflow Prevention Assembly.
g. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
h. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
i. C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
j. C541, Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
k. C542, Electric Motor Actuators for Valves and Slide Gates.
l. C550, Protective Interior Coatings for Valves and Hydrants.
m. C606, Grooved and Shouldered Joints.
n. C800, Underground Service Line Valves and Fittings.

6. ASTM International (ASTM):
   a. A276, Standard Specification for Stainless Steel Bars and Shapes.
   b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
   e. B61, Standard Specification for Steam or Valve Bronze Castings.
   f. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
   g. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
   h. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
   i. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
   j. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
   k. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
   l. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
   m. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
   n. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
7. Canadian Standards Association, Inc. (CSA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.

8. Chlorine Institute (CI): Pamphlet 6, Piping Systems for Dry Chlorine.
9. FM Global (FM).
10. Food and Drug Administration (FDA).
11. International Association of Plumbing and Mechanical Officials (IAPMO).
12. Manufacturers Standardization Society (MSS):
    a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
    b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
    c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
    d. SP-88, Diaphragm Valves.
    e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
13. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
    c. NSF/ANSI 600, Drinking Water System Components – Updated Health Effects Criteria.
15. UL.
16. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
    b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
    c. Certification for compliance to NSF/ANSI 61 for valves used for drinking water service.
    d. Power and control wiring diagrams, including terminals and numbers.
    e. Complete motor nameplate data.
    f. Sizing calculations for open-close/throttle and modulating valves.
    g. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for:
   a. Electric actuators; full compliance with AWWA C542.
   b. Butterfly valves; full compliance with AWWA C504.
3. Tests and inspection data.
4. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.

D. Valve ends to suit adjacent piping. To mate properly with adjacent piping, some valves must have ring joint faced flanges and others must have raised face flanges. See Section 33 05 01 Conveyance Piping—General, for flange facing requirements.

E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure.

F. Size operators and actuators to operate valve for full range of pressures and velocities.

G. Valve to open by turning counterclockwise, unless otherwise specified.

H. Factory mount operator, actuator, and accessories.

I. Wax tape coat all buried valves and flanges in accordance with AWWA C217 unless required otherwise.

J. Deliver, store, and protect valves, linings, and coatings in accordance with manufacturer recommendations. Do not scratch valves, linings, or coatings. Keep seats, mating faces, and valves free of salt, dirt, grime, hydrocarbons, wind-blown dirt and salt, and other harmful materials.

K. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE

A. Additional requirements relative to this section are shown on the Valve Schedule located at the end of this section.

2.03 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

B. All valves shall have Type 316 stainless steel bolting throughout the valve. Valve flanges bolting to adjacent piping may be carbon steel where specified as such in Section 33 05 01 Conveyance Piping—General.

C. Valve materials in contact with or intended for drinking water service to meet the following requirements:

1. Materials to comply with requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
2. Coatings materials to be formulated from materials deemed acceptable to NSF/ANSI 61.

D. Supply certification product is certified as suitable for contact with drinking water by an accredited certification organization in accordance with NSF/ANSI 61. Provide certification for each valve type used for drinking water service.

2.04 FACTORY FINISHING

A. General:

1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating.
3. Material in contact with potable water shall conform to NSF/ANSI 61.
4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be “safety yellow.”

B. Where epoxy lining and coating are specified, factory finishing shall be as follows:

1. In accordance with AWWA C550.
2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES

A. Gate Valves:

1. Type V130 Resilient Seated Gate Valve 3 Inches to 12 Inches:
   a. Iron body, resilient seat, bronze stem and stem nut, ASME B16.1 Class 125 flanged ends, full port, nonrising stem with 2-inch operating nut in accordance with AWWA C509, minimum design working water pressure 250 psig, full port, fusion-epoxy coated inside and outside per AWWA C550, NSF/ANSI 61 certified.
   b. Manufacturers and Products:
      1) M&H Valve; AWWA C509.
      2) U.S. Pipe; A-USPO.
      3) Clow Valve Co.; 6100 Series.
      4) American Flow Control; Series 2500.

B. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl

grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.

b. Manufacturers and Products:
   1) Threaded:
      a) Conbraco Apollo; 70-100.
      b) Nibco; T-580-70.

2. Type V307 Stainless Steel Ball Valve 2 Inches and Smaller:
   a. Three-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end pieces, Type 316 stainless steel ball, NPT threaded ends, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout-proof stainless steel stem, stainless steel lever operator with vinyl grip, rated 1,000-pound WOG, 150 psi SWP. Valves shall be rated drip tight to 500 psi cold water pressure. Pressure rated 800 psig to 1,000 psig CWP, complies with NSF 61 and NSF 372.
   b. Manufacturers and Products:
      1) Milwaukee; 30 Series.
      2) Conbraco Apollo; 86R-100/86-500 Series.
      3) Nibco; T-595-S6-R-66-LL.

3. Type V308 Ball Valve 2 Inches to 24 Inches:
   a. Carbon steel ASTM A216 WCB, split body, Type 316 stainless steel full (round) port plug, and raised face flanged ends.
   b. ASME Class 300.
   c. Rating: 720 psi WOG, drip tight.
   d. Operator: Enclosed gear type with handwheel.
   e. Manufacturers and Products:
      1) Velan; Memory Seal.
      2) Apollo; 87A-60H-01. (2-inches up to 12-inches)
      3) Neles-Jamesbury; 5300.
      4) Double Offset Ball Valve; ERHARD GmbH & Co. KG, Heidenheim, Germany.
      5) Armacon GmbH; Triple Offset Ball Valve.

4. Type V317 Rubber Seated Full Port Ball Valve 4 Inches to 36 Inches: AWWA C507 compliant, water tight (zero leakage in both directions), flanged, 400 psi rated (working pressure), full port round ball aperture matching adjacent pipe and meter within 1/4 inch, with rubber seat that is field adjustable and replaceable.
   a. Provide electric operator per Section 40 27 03, Electric Motor Actuators. Submit operator orientation acceptable to fit vault.
   b. Body: Two body end pieces and a center piece through-bolted, O-ring sealed against leakage, integral support legs or pads.
   c. Ball: Taper-pinned to upper and lower fitted shaft turned, ground, and polished to 32 micro-inch finish per ASME B46.1.
   d. Bearings and Seals: fit center section with 1/4-inch minimum thick, (Teflon lined, fiberglass backed) sleeve-type, self-lubricating, bearings in body hubs. Isolate bearing surfaces

from flow by O-ring seals. Support ball assembly by a two-way thrust bearing assembly of a Type 304 stainless steel stud and a bronze thrust collar (ASTM B505, Alloy C93200) in a grease-packed cavity.

e. Seats: Double-seated synthetic rubber, mechanically retained in valve body without retaining rings, segments, screws, or hardware in-flow stream. 360-degree rubber seats to mate with spherical Type 316 stainless steel seating surface on ball. 360-degree seats to be field adjustable and replaceable without dismantling operator, ball, or shaft. Where line size permits, seats shall also be capable of being replaced or adjusted without removing the valve from line.

f. Position Indication: Where position limit switches are indicated in Valve Schedule or Drawings, provide visual position indicator, with two mechanical SPDT limit switches to provide opened and closed status feedback to the control system.

g. Manufacturers and Products:
   1) Valmatic Ener-G.
   2) Armacon.
   3) “Or-equal.”

h. Materials of Construction shall be as follows:

Component	Materials of Construction
Valve Body	Cast Iron: ASTM A126, Class B or ASTM A48, Class 35
Ball or Rotor	Cast Iron: ASTM A48, Class 35 (minimum)
Shaft and Taper Pins	Stainless Steel: ASTM A276, Type 304 or 316
Body Bolts, Studs, Nuts	Carbon Steel: ASTM A307, Grade B

C. Butterfly Valves:

1. General:
   a. In full compliance with AWWA C504 and following requirements:
      1) Suitable for throttling operations and infrequent operation after periods of inactivity.
      2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.

3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
4) No travel stops for disc on interior of body.
5) Self-adjusting V-type or O-ring shaft seals.
6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
8) Buried service operators shall withstand 450 foot-pounds of input torque at fully open and fully closed positions.
9) Provide linings and coatings per AWWA, unless otherwise indicated on Drawings or specified herein.
10) Valves to be in full compliance with NSF/ANSI 61.

b. Non-AWWA butterfly valves to meet the following actuator requirements:
1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on Drawings or specified herein.

2. Type V580 Double-Offset Butterfly Valve Water Works Service 3 Inches to 72 Inches:
a. Valves shall be rated to 275 psi with flanged ends compatible with and meeting or exceeding pressure rating of adjacent piping.
b. Elastomeric Seal: Valve seats shall be EPDM mounted on the valve disc with Type 316 stainless steel fasteners. It shall be one continuous 360-degree elastomeric ring. It shall not be penetrated by fasteners. The seat shall be field replaceable and adjustable in line. It shall not require special tools or skill sets to replace the seat. Seat removal, replacement and readiness for service must be able to be accomplished in a maximum of 8 hours. Seat methods which do not comply, or which use hardened epoxy or grout in a dovetailed groove, are not acceptable.
c. Body: Valve bodies shall be ductile iron ductile iron, ASTM A536 65-45-12 or A536 60-40-18. Shear stress vulnerable cast iron is not allowed. Valve body shall include a stainless steel stamped or engraved tag indicating manufacturer and reference build data. The valve build data shall be made available upon request by the Owner and shall be retained by the manufacturer for no less than 2 times the expected valve life.

d. Disc: The disc shall be ductile iron for valves sizes 3 inches to 20 inches and shall be ductile iron, ASTM A536 65-45-12 or ASTM A536 60-40-18 for valves 24 inches and larger. The disc elastomeric seal retainer shall be Type 316 stainless steel. Carbon steel is not acceptable. The disc shall be mechanically fastened to the valve shaft using tangential stainless steel shaft pins of Type 316 or higher alloy. Where disc pins extend completely through the valve, the disc pins shall be mechanically retained or fastened.

e. Shaft: Valve shafts shall be stainless steel ASTM A276 Type 316. The valve shaft material shall be suitable for the applications pressure and velocity.

f. Metallic Seat: The metallic valve seat shall be located in the valve body. It shall be stainless steel alloy. There shall be no gap between the valve body and metallic body seat and consequently no potential for corrosion or lifting of seat. The seat shall be applied through a high alloy weld overlay process.

g. Shaft Seals: Shaft seals shall not need periodic manual adjustment. They shall be multi-O-ring seals protecting both the outside and inside diameter of the shaft bearings. They shall prevent pressurized system water from entering the uncoated valve disc hub and valve body shaft bore. The valve shaft shall remain non-wetted and unpressurized. The nonwetted shaft shall allow the actuator to be removed without dewatering the pipeline. It shall prevent debris and system pressurized water from entering into the uncoated valve body shaft bore. It shall prevent waters or contaminated media, external to the valve, from entering through the valve shaft under vacuum/negative pressure conditions in the pipeline such as at line break. It shall additionally prevent an ingress breach where external hydrostatic forces exceed pipeline pressures such as in dewatered pipelines. Neither manual pulldown packing glands nor braided packing are allowed. The outer shaft seals shall be replaceable cartridge type, bolted to the valve body and shall not be held in place with an adapter plate or by the valve actuator.

h. Shaft Bearings: Valve shaft bearings shall be corrosion resistant, self-lubricating sleeve type made of bronze, stainless steel or stainless steel backed PTFE. Bearing choice and consequent bearing friction shall be correctly added to valve input torque requirements.

i. Strength: The proportion and dimensions of all parts of the valve and actuator shall be designed to withstand, without failure, the stresses occurring under the testing and operating conditions. The maximum allowable stress in any material shall not exceed 1/5 of the ultimate tensile strength or 1/3 of the minimum yield strength. Class 300 valves shall be capable of withstanding a onetime pressure test of 580 psi applied to one side of the disc with zero pressure applied to the other side of the disc while in the closed position, without damage or permanent deformation to any part of the valve, seat, disc, or shaft. The valve shall be capable of withstanding such pressures in both directions.

j. Hardware: All fasteners and hardware shall be Type 316 stainless steel.

k. Paint and Coatings:
   1) Valves 24 Inches and Smaller: All external and internal surfaces except for the seating surface shall be coated with fusion bonded epoxy. Coating damaged in shipping or installation shall be noted and properly repaired.
   2) Valves Larger than 24 Inches: All external and internal surfaces shall be coated with a minimum of 10 mils of an NSF61 approved two-part liquid epoxy. All sharp edges to be coated shall be beveled/radiused to assure consistent coating thickness. The coating inspection report will include inspection of at least six locations where the edges are most sharp and through the complete circumference of the disc edge to assure proper coating and compliance. Compliance of proper beveling of all sharp edges with proper coating of carbon steel valves will be strictly enforced as a condition of providing a proper continuous water service valve.

l. Manufacturers and Products:
   1) VAG Armaturen- Evanston Illinois/Manheim Germany. VAG ENK (double eccentric rubber seated).
   2) Av-Tek.
   3) Erhard.

D. Plug Valves:

1. Type V405 Eccentric Plug Valve 3 Inches to 12 Inches:
   a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, flanged ends per ASME B16.1 unless otherwise shown.
   b. Plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
   c. For buried service, provide external epoxy coating.

d. Operators:
   1) 3-Inch to 4-Inch Valves: Wrench lever manual.
   2) 6-Inch to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut, or chain wheel. Size operator for 1.5 times the maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.
e. Manufacturers and Products:
   1) Pratt; Ballcentric.
   2) DeZurik; Style PEC.
   3) Milliken; Millcentric Series 600.

2. Type V422 Lubricated Plug Valve 2-1/2 Inches to 14 Inches:
   a. Use the following for isolation and throttling valves at blow-offs:
      1) Ductile iron or carbon steel body, Type 316 stainless steel plug with straight-way rectangular ports, Teflon sleeves, flanged ends.
      2) ASME Class: 150.
      3) Rating: 250 psi WOG.
      4) For buried service, provide fusion bonded epoxy coating.
      5) Operator: Totally enclosed, geared, manual operator with handwheel, or 2-inch nut for buried service. Size operator for 1.5 times the maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.
      6) Manufacturer and Product: Nordstrom, Figure 1925, 1949, or equal.

E. Check and Flap Valves:

1. Type V600 Check Valve 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded or soldered ends, swing type replaceable bronze disc, rated 200 psi.
   b. Manufacturers and Products:
      1) Stockham; Figure B-319, threaded ends.
      2) Milwaukee; Figure 509, threaded ends.
2. Type V690 Flap Gate 6 Inches to 96 Inches:
   a. Cast-iron body and cover, bronze-mounted, flanged frame type, dual pivot-point hinge arms, hinge arms bronze, hinge pins Type 304 stainless steel, seat bronze and impacted into grooves in body and cover flap, lubrication fittings for each pivot, upper and lower pivot adjustment.

b. Manufacturers and Products:
1) Rodney Hunt Co.; Series FV-AC or FV-AR.
2) Hydro Gate; Model 50C or 50.

3. Type V694 Check Valve 1 Inch to 3 inch:
a. Elastomer type slip-on, round entry area to match pipe, contoured duckbilled shaped exit, valve open with approximately 2 inches of line pressure and return to CLOSED position under zero flow condition, plain-end valve attached with Type 316 stainless steel adjustable band.
b. Manufacturers and Products: Stayflow; Series CPO, or equal.

F. Self-Regulated Automatic Valves:

1. Type V715 Electronic Interface Flow Control Valve 3 Inches and Larger:
a. Electronically operated, diaphragm controlled globe valve with hydraulic pressure reducing pilot control, consisting of an electronic solenoid control system to provide the interface between remote telemetry and valve control. The controller accepts a set point and compares it with the flow or signal and makes incremental adjustments to modulate the valve to limit the maximum flow rate. When the demand exceeds the flow setting the valve shall limit flow to the pre-selected maximum flow rate. The pressure reducing feature of the valve shall reduce a higher inlet pressure to a steady lower outlet pressure as long as the flow rate is below a set maximum flow rate.
b. Valve shall be ductile iron, or steel body, MADE B16.5 or B16.42 Class 150 flanged ends, rated minimum 250 psi, stainless steel trim, stainless steel stem, stainless steel tubes and fittings, and externally mounted strainers with cocks. Provide valve with check feature, open and closing speed controls and additional cartridge strainer with manual flushing valve mounted to end of strainer to allow flushing of strainer and pilot tubing.
c. Provide controller, suitable for 120V ac power supply and for installation in RTU as shown. Provide solenoid valves as shown, suitable for 120V ac control.
d. Valve shall be supplied with electronic valve position transmitter (two-wire, 4 mA dc to 20 mA dc type, Model X117C), a cartridge filter with automatic flushing kit, and a manual bypass feature.
e. The valve shall be equipped with manual by-pass to provide emergency override operation.
f. FDA-approved fusion bonded epoxy lining and coating installed in accordance with AWWA C550.

g. Size: As shown in the Electronic Controlled Regulated Automatic Valve Schedule.
h. Manufacturer and Product: Cla-Val; 131-01.

2. Type V725 Electronic Interface Flow Control Valve, with Anti-Cavitation Trim, 3 Inches and Larger:
   a. Electronically operated, diaphragm controlled globe valve with hydraulic pressure relief pilot control, consisting of an electronic solenoid control system to provide the interface between remote telemetry and valve control. The controller has the ability to accept a set point and compare it with the flow or signal and make incremental adjustments to modulate the valve to limit the maximum flow rate. When the demand exceeds the flow setting the valve shall limit flow to the pre-selected maximum flow rate. The pressure relief feature of the valve shall open the valve when inlet pressure exceeds a preset pressure and allow enough flow through the valve to reduce the inlet pressure.
      1) Valve shall have anti-cavitation trim to successfully control flows without damaging valve or downstream piping.
   b. Valve shall be ductile iron, or steel body, ANSI B16.5 or ANSI B16.42, Class 300 flanged ends, rated minimum 400 psi, stainless steel trim, stainless steel stem, stainless steel tubes and fittings, and externally mounted strainers with cocks. Provide valve with check feature, open and closing speed controls and additional cartridge strainer with manual flushing valve mounted to end of strainer to allow flushing of strainer and pilot tubing.
   c. Provide controller, suitable for 120V ac power supply and for installation in RTU as shown. Provide solenoid valves as shown, suitable for 120V ac control.
   d. Valve shall be supplied with electronic valve position transmitter (two-wire, 4 mA dc to 20 mA dc type, Model X117C), a cartridge filter with automatic flushing kit, and a manual bypass feature.
   e. The valve shall be equipped with manual by-pass to provide emergency override operation.
   f. FDA-approved fusion bonded epoxy lining and coating installed in accordance with AWWA C550.
   g. Size: As shown in the Self-Regulated Valve Schedule.
   h. Manufacturer and Product: Cla-Val; 131-01KO t with removable anti cavitation trim.

G. Air Valves:

1. Type V746 Combination Air Release Valve 1 Inch to 16 Inches (400 psi rated):
   a. Suitable for water service, combines the operating features of 1) an air and vacuum valve and 2) an air release valve.
   b. Valve body for 1-inch to 3-inch valves shall be single body with NPT threaded inlet and outlet. Provide NTP threaded by flanged inlet for connection to isolation valve.
   c. Valve body for 4 inch and larger shall consist of an air and vacuum valve with an air-release valve attached to it. Air and vacuum portion to automatically exhaust air during filling of system and allow air to re-enter during draining or when vacuum occurs. Air release portion to automatically exhaust entrained air that accumulates in system with 3/32-inch orifice. Connect air release valve to air and vacuum valve with standard weight steel piping and isolation butterfly valve.
   d. Class 250 flanges, mating to pipe and isolation valve per Section 33 05 01, Conveyance Piping—General.
   e. Screened protective steel hood on air valves top outlet.
   f. Fusion-bonded epoxy lining and coating per AWWA C550.
   g. Type 304 stainless steel bolts, nuts and caps crews.
   h. Manufacturers and Products:
      1) DeZurik/APCO; Series 143C to 147C or 1100A, 250# with 400 psi drip tight certification for air valves.
      2) Valmatic; Series 100/38 combination air valve assembly with Vanessa 2-flange, Series 30,000 butterfly valve, Trim C, OV manual operator. Certify entire 2-valve assembly is:
         a) 400 psi rated drip tight.
         b) Vanessa BFV disc swing does not hit Valmatic float pin.
      3) “Or-equal.”

2.06 OPERATORS

A. Manual Operators:

1. General:
   a. Operator force not to exceed 40 pounds under any operating condition, including initial breakaway. Gear reduction operator when force exceeds 40 pounds.
   b. Operator self-locking type or equipped with self-locking device.
   c. Position indicator on quarter-turn valves.
   d. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator’s threaded

steel reach rod with internally threaded bronze or ductile iron nut.

2. Exposed Operator:
   a. Galvanized and painted handwheel.
   b. Lever operators allowed on quarter-turn valves 2 inches and smaller unless shown on Drawings or specified otherwise.
   c. Valve handles to take a padlock, and wheels a chain and padlock.
   d. Provide 2-inch AWWA operating nut and stainless steel extension stem where shown for valves in vaults with extension stems operated above grade.
3. Buried Operator:
   a. Buried service operators on valves larger than 2-1/2 inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by forked key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
   b. Buried service operators to be grease packed and gasketed to withstand submersion in water to 20 feet minimum.
   c. Buried valves shall have extension stems, bonnets, and valve boxes.

B. Electric Operators:

1. General: See Section 40 27 03, Electric Motor Actuators.

2.07 ACCESSORIES

A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each valve, bearing valve tag number shown on Electric Actuated Schedule and Valve Schedule.

B. Limit Switch:

1. Factory installed NEMA 4X limit switch by actuator manufacturer.
2. SPST, rated at 5 amps, 120V ac.

C. Cast-Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 5-1/4-inch ID shaft.

1. Box: Cast iron with minimum depth of 9 inches.
2. Lid: Cast iron, minimum depth 3 inches, marked WATER.
3. Extensions: Cast iron.

D. Sealed Floor Valve Box:

1. Manufacturer and Product: Trumbull manufacturing, Sealed Floor Box

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
   a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
   b. Install valves in location for easy access for routine operation and maintenance.
   c. Install valves per manufacturer’s recommendations.
2. Globe, and Ball Valves:
   a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
   b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Butterfly Valves:
   a. Unless otherwise restricted or shown on Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
   b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
   c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
   d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.

e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.

E. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

3.02 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer’s data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER’S SERVICES

A. Provide manufacturers services as follows, and for any additional valves listed as requiring such services in the Valve Schedule in Supplement to Section. Manufacturer services including a Manufacturer Representative present at Site for the minimum number of person-days listed below, travel time excluded:

1. 3 person-days for installation assistance and inspection of all pressure reducing, pressure relief, and flow control valves.

2. 3 person-days for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation of all pressure reducing, pressure relief, and flow control valves.

B. See Section 01 43 33, Manufacturers’ Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

3.04 SUPPLEMENTS

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

1. General Valve Schedule (4 Inches and Larger).
2. Self-Regulated Valve Schedule.

END OF SECTION

GENERAL VALVE SCHEDULE (4 INCHES AND LARGER)								
Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Maximum Operating Flow (cfs)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/ Supplements
MHP-FV-00002	V308, Ball	**NA**	12		NA	Open/Close	NA	
MHP-FV-00005	V308, Ball	**NA**	12		NA	Open/Close	NA	
SE-FV-00002	V308, Ball	**NA**	12		NA	Open/Close	NA	
SE-FV-00005	V308, Ball	**NA**	12		NA	Open/Close	NA	
SWH-FV-00002	V308, Ball	**NA**	16		NA	Open/Close	NA	
SWH-FV-00005	V308, Ball	**NA**	16		NA	Open/Close	NA	
SWH-FV-00008	V308, Ball	**NA**	12		NA	Open/Close	NA	
SWH-FV-00011	V308, Ball	**NA**	12		NA	Open/Close	NA	
S2W-FV-00002	V308, Ball	**NA**	16		NA	Open/Close	NA	
PE-FV-00002	V308, Ball	**NA**	12		NA	Open/Close	NA	

GENERAL VALVE SCHEDULE (4 INCHES AND LARGER)								
Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Maximum Operating Flow (cfs)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/ Supplements
PE-FV-00005	V308, Ball	NA	12		NA	Open/Close	NA	
PE-FV-00007	V308, Ball	NA	12		NA	Open/Close	NA	
PMS-FV-00002	V308, Ball	NA	12		NA	Open/Close	NA	
PMS-FV-00005	V580, Butterfly	NA	20		NA	Open/Close	NA	
PMS-FV-00006	V580, Butterfly	NA	20		NA	Open/Close	NA	
PMS-FV-00007	V580, Butterfly	NA	20		NA	Open/Close	NA	
PMS-FV-00009	V308, Ball	NA	4		NA	Open/Close	NA	
PMS-FV-00011	V308, Ball	NA	4		NA	Open/Close	NA	
PS-FV-00002	V308, Ball	NA	12		NA	Open/Close	NA	
PS-FV-00005	V308, Ball	NA	12		NA	Open/Close	NA	
SN-FV-00002	V308, Ball	NA	6		NA	Open/Close	NA	
SN-FV-00005	V308, Ball	NA	6		NA	Open/Close	NA	

GENERAL VALVE SCHEDULE (4 INCHES AND LARGER)								
Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Maximum Operating Flow (cfs)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/ Supplements
SS-FV-00002	V308, Ball	**NA**	20		NA	Open/Close	NA	
SS-FV-00004	V308, Ball	**NA**	20		NA	Open/Close	NA	
SS-FV-00006 (BY OTHERS)	V308, Ball	**NA**	12		NA	Open/Close	NA	
SS-FV-00009 (BY OTHERS)	V308, Ball	**NA**	12		NA	Open/Close	NA	
SS-FV-00012	V308, Ball	**NA**	24		NA	Open/Close	NA	
SS-FV-00015	V308, Ball	**NA**	24		NA	Open/Close	NA	

GENERAL VALVE SCHEDULE (4 INCHES AND LARGER)

Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Maximum Operating Flow (cfs)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/ Supplements
SS-FV-00018	V308, Ball	**NA**	24		NA	Open/Close	NA	
SS-FV-00021	V308, Ball	**NA**	24		NA	Open/Close	NA	

Service: O/C = Open-Close, T = Throttling, M = Modulating

Control Feature Modifications/Supplements:

A = Actuator shall open valve upon loss of signal.

B = Actuator shall close valve upon loss of signal.

C = Actuator shall remain in last position upon loss of signal.

D = Local OPEN-CLOSE momentary pushbuttons that must be continuously depressed to initiate/maintain valve travel; travel stops when pushbutton is released or when end of travel limit is reached.

E = Remote OPEN-CLOSE maintained dry contacts; travel stops when remote contact opens, or when end of travel limit is reached.

F = Three 24-volt dc interposing relays for remote OPEN-STOP-CLOSE control. Relays powered externally, thereby permitting valve control from greater distances.

G = Motor and control enclosure(s) NEMA 250, Type 4 with 120-volt space heaters.

H = Motor and control enclosure(s) NEMA 250, Type 6 (IP 68) with 120-volt space heaters.

I = Motor and control enclosure(s) NEMA 250, Type 7 with 120-volt space heaters.

J = Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.

K = 120-volt secondary control power transformer.

L = Externally operable power disconnect switch.

SELF-REGULATED VALVE SCHEDULE

Tag No.	Valve Type	Size (inches)	Inlet Pressure (psi)	Outlet Pressure (psi)	Maximum Flow (cfs)	Operator	Primary Control
PMS-FCV-00010	V725, Globe	4	50 to 100 psi +/- (normal) Max 338 psi @ Flow = 0	0	2	Electronic / Hydraulic Pilot	Pressure relief set at 125 psi

SECTION 40 27 03
ELECTRIC MOTOR ACTUATORS

PART 1 GENERAL

1.01 DESCRIPTION

A. Use intelligent electric motor actuators unless specifically required otherwise.

B. This section includes materials, installation and testing of electric actuators for valves in accordance with AWWA C540, except as modified below. The electric motor actuator shall include any necessary intermediate gearing between the electric actuator and the valve to which it is attached.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 09 90 00 Painting and Coating.

B. Section 40 27 02, Process Valves and Operators.

C. Section 40 27 06, Plunger Valves.

D. Section 40 27 08, Full Port Isolation Ball Valves.

1.03 REFERENCES

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

1. American Water Works Association (AWWA): C540, Power Actuating Devices for Valves and Sluice Gates.
2. National Fire Protection Association (NFPA): National Electrical Code, 2014 Edition.

1.04 SUBMITTALS

A. Action Submittals:

1. Submit complete manufacturer's descriptive information on each actuator and accessory. Provide actuator parts and materials of construction, referenced by AISI, ASTM, SAE, or CDA specification and grade.
2. Dimensions and weights.
3. Coatings.

4. Submit motor data including name plate data, insulation type, output torque, voltage, phases, frequency, current at running torque, and locked rotor, duty rating, and travel times open to close and close to open.
5. Show the maximum torque required to open and to close each motor-actuated valve or cast iron sluice gate.
6. Coordinate torque requirements with gate and valve manufacturer's to provide an actuator that meets the Specification requirements.
7. Submit electrical schematic drawings and physical wiring diagrams showing all power and control interfaces.
8. Submit information showing the relationship between the operator output torque and the torque limit switch settings.
9. Provide valve versus actuator arrangement drawing confirming orientation of actuator and maintenance/operation access. Obtain Owner's written approval prior to installation and mounting.

B. Informational Submittals:

1. Certification from actuator manufacturer, that actuator meets or exceeds all part of this section.
2. Factory and field test reports.
3. Operation and Maintenance Data: Manuals shall include the following:
   a. Complete installation instructions.
   b. Operating and maintenance instructions.
   c. Complete parts list.
   d. Part change-out instructions.
   e. The theory of operation for the actuator and the intermediate gearing.
   f. Expanded parts drawings, showing all mechanical and electrical parts.
   g. Electrical schematic drawings and physical wiring diagrams showing all components.
   h. Drawings of electrical component enclosure-physical layout in 3-D view.
   i. List of recommended spare parts.
   j. List of special tools for installation, maintenance, and adjustments.
   k. Lubrication guide with a list of recommended lubricants.
4. Copies of factory training certifications, from actuator manufacturer, for any maintenance or installation technicians, Training certifications shall be specific to the models installed. Certificates shall be approved by the Construction Manager before technicians are authorized to perform any work on the valve actuators.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Actuator shall be “Intelligent Electric Motor Actuators,” Rotork Controls; Flowserve Limitorque; Auma Sipos Himond, "or-equal."

2.02 ACTUATOR IDENTIFICATION

A. Identify electric motor actuators by tag number as shown in Electric Motor Actuator Schedule. Identification tags shall be round or oval aluminum tags attached to the actuators with aluminum wire. Tag numbers shall be engraved or stamped on tags in block letters.

2.03 GEARED OPERATORS

A. Geared operators shall be per Section 40 27 02, Process Valves and Operators.

B. Intermediate Geared Operators:

1. Provide intermediate operators of spur, helical, or bevel gears, between the new electric motor actuator and the new or existing geared valve operators, if needed to provide the specified open/close time, and to provide proper operation of the valve. The intermediate geared operators shall be designed with bearings suitable for adapting to an electric actuator. Operators designed with bushings are not permitted.
2. Intermediate geared operators do not need dial indicating valve position, but shall be enclosed, oil or grease lubricated, with seals provided on shafts to prevent entry of dirt and water.
3. Intermediate geared operators shall be totally enclosed design proportioned to permit operation of valve under full differential pressure equal to valve pressure rating with max input of 150 foot pounds on operating shaft, and shall be oriented to operate with valve stem and electric actuator as per Construction Manager.
4. Support gear shaft at each end by ball or tapered roller bearings. Provide reduction gearing to meet max torque and pull design requirement. The reduction gearing shall run in a proper lubricant.
5. Intermediate geared operator shall open valves by turning counterclockwise.

C. Handwheel: Provide handwheel for manual operation with arrow to indicate “open” rotation. Handwheel shall not rotate during motor operation, and operation of handwheel shall not cause motor to rotate. When in manual operating mode, actuator shall remain in this mode until motor is energized, at which time actuator will automatically return to electric operation. Movement from motor operation to handwheel operation shall be by a positive, pad-lockable declutching lever, which mechanically disengages motor and related gearing. Friction type declutch mechanisms are not acceptable. Size handwheel for a maximum pull of 50 pounds under full differential pressure at any point through valve travel including seating and unseating.

2.04 MOTORS FOR ELECTRIC ACTUATORS

A. Provide totally enclosed, high- torque, nonventilated, single-phase, or three-phase motors, suitable for the facility electrical service shown on Drawings. NEMA service factor rating shall not be used in rating motors for maximum load conditions.

B. Unless noted otherwise, motors for actuators shall be specifically designed and rated for 15-minute operating times (open to close and close to open).

C. Provide Class F or H insulation specifically designed for valve actuation service and rated for continuous duty operation and 60 start/stops per hour without overheating. Heat rise after 60 start/stops in an hour shall be less than 50 degrees C. Heat rise after three full consecutive valve cycles shall be less than 50 degrees C. If travel time requirements would cause the 3-cycle test to extend beyond 60 minutes, limit the test to 60 consecutive minutes.

D. Provide motor output capacity sufficient to open or close the valve against the maximum differential pressure when the voltage is 10 percent above or below normal at the specified service conditions.

E. Motor bearings shall be of the anti-friction type, and permanently lubricated.

F. Provide over temperature protection with thermostat sensor. Sensor shall automatically reset on cooling.

2.05 ACTUATOR TORQUE REQUIREMENTS

A. Provide actuator with rated output torque at least 1.5 times the maximum torque required to operate the valve in any position, including seating and unseating conditions and neglecting hammer-blow effect.

B. Maximum torque requirement is defined as torque required at the most severe operating conditions, including max differential pressure across the valve (defined at the valve pressure rating), and max mechanical friction or other restrictive conditions inherent in the valve assembly. Except where noted otherwise, the maximum line velocity is defined as the flow identified in the Drawings and specifications for each valve and pipe. For line water temperature, assume a range of from 40 degrees to 100 degrees.

C. Actuator maximum torque shall be calculated with the applied voltage 10 percent below nominal motor voltage rating.

D. Coordinate with the valve manufacturer to assure that the motor actuator stall torque output does not exceed the torque limits of the valve operating stem or shaft.

2.06 ELECTRICAL CHARACTERISTICS

A. Operating Speed and Indication:

1. Unless noted otherwise, design actuators for modulating operation (open to close and close to open, 15-minute travel time).
2. Design valve actuators for open/close operation and continuous modulating service to regulate flows.
3. Actuator shall have a built-in device that allows motor to reach full speed before engaging valve load. This hammer blow feature shall be engaged if the actuator is in handwheel or motor operation.

B. Actuator Housing:

1. Housing shall be NEMA 6P or IEC IP68.
2. Electrical motor and other electrical elements of the actuator shall be gas and water-tight when the terminal cover is removed.
3. All torque limits, limit switch adjustments, and other configuration shall be carried out without any removal of actuator covers. Configuration shall be available by remote device or at the actuator user interface.
4. Enclosures shall have at least two 1-inch minimum NPT threaded hubs for conduit entry.

C. Power Transmission:

1. Provide actuator with internal, multiple reduction power gearing unit, consisting of spur or helical gears and work gearing of hardened alloy steel, with the worm gear of alloy bronze. Manufacture all power gearing accurately.
2. Provide self-locking work gear set in the drive train to maintain valve position.
3. Use anti-friction bearings with caged ball or roller throughout.
4. All rotating power train component are to operate immersed in grease or oil with provisions for inspection and relubrication without disassembly
5. Lubricants shall be suitable for ambient conditions of minus 20 to 150 degrees F. Adequate seals shall be provided on all shafting.

6. Actuator noise shall not exceed 72 dBA at all times within a 3-foot radius.
7. Design shall permit gear case to be opened for inspection or disassembles without releasing stem thrust or taking the valve out of service.

D. Listing of Actuators: As a basis for approval under the National Electric Code actuators shall be listed by a Nationally Recognized Testing Laboratory (NRTL). Approved NRTLs include but are not limited to UL, FM, CSA-US, and ETL. OSHA maintains a complete list of acceptable NRTLs.

2.07 INTELLIGENT ELECTRIC MOTOR ACTUATORS (REQUIRED FOR ALL ELECTRIC ACTUATORS)

A. General Design:

1. Include as one integral assembly, the motor, internal reduction gearing, position limit switch functions, torque switch functions, travel limit switch functions, position indicator, declutch lever, handwheel.
2. Solid state reversing starter and operator controls may be integral to the actuator or mounted remotely as indicated in electric motor actuator schedule.
3. Actuator shall be an intelligent, microprocessor-based design suitable for service for temperatures from minus 30 degrees C to plus 70 degrees C.
4. Calibration and setup features shall be available by a nonintrusive front panel interface and handheld setting tool, accessible without requiring removal of covers or use of special tools.
5. Connect electric motor to actuator by a plug-in electrical connector. Motor shall be removable without draining oil or grease from gearbox.

B. Control Interface:

1. Actuator Shall:
   a. Be configurable for direct-wired remote open/close control, using 24V dc command lines. Control shall interrogate remote dry contacts providing open/close control.
   b. Both accept and supply 24V dc control power for remote control. Internal actuator power supplies shall be automatically protected against overcurrent or short circuit conditions.
   c. Allow programming of all programmable features via front-panel nonintrusive switches and local display.

d. Actuator shall be equipped and configured for remote Modbus/TCP interface for configuration, monitoring, and control.
e. Allow access to all programmable features via a laptop computer connected directly to actuator. If software other than terminal emulator is required for access, then software and cable shall be provided at the time of delivery.
f. Actuator shall provide torque trending data in local mode. The actuator shall be capable of displaying torque data in both “Reference” and “Recent” modes and shall be able to be viewed in “Local” actuator diagnostic mode. The reference data mode shall be User selectable as a baseline, and the recent data displayed shall be the torque generated during the last performance cycle. The User shall be able to select any of the recent data to replace the reference data. Torque shall be digitally displayed in the Diagnostics menu labeled “Torque Profile.” Torque shall be collected in either open or closed directions.”

C. Local/Remote Interface:

1. Actuator shall have a local interface/display screen capable of displaying at least 32 alphanumeric characters and a 0 percent to 100 percent display for valve position readout. All text messages or displays shall be in English.
2. Actuator shall have a local LOCAL-STOP-REMOTE (LSR) mode control switch, and a local OPEN- CLOSE (OC) position command switch. The LSR switch shall be lockable in any position by using a standard padlock.
3. Local and remote programming interfaces shall be protected by user-selectable password protection for all programmable features.
4. The local control switches shall not penetrate the actuator enclosure, and shall electrically isolate the operator from any external voltages.
5. The OC function shall be user-configurable for maintained or inching control.
6. Provide four status contacts, minimum, for remote indication of valve position. These contacts shall be configurable for normally-open or normally-closed function. These contacts shall be programmable for operation at any position between full open and full closed position, or shall be programmable to indicated any of the following: Mid-travel, local mode, over torque, motor over temperature, manual operation, remote mode, valve moving, close torque switch, open torque switch, hardware failure, or valve jammed. These contacts shall be rated 250V ac/30V dc, 5 amps.

D. Position/Limit/Torque Sensors:

1. Actuators shall employ noncontact-type absolute position encoders, capable of at least 32-bit resolution. Position encoders shall sense actual valve position at all times, during electrical or handwheel operation, with or without applied electrical power, and without the use of batteries. The encoder maximum error shall be less than 1 percent and shall include, repeatability, linearity, and positional accuracy throughout the entire range of motion.
2. Open and close valve travel-limit positions shall be a function of the absolute position encoder, shall be stored in permanent, nonvolatile memory, and shall be easily adjustable from the local or remote interface.
3. Torque shall be measured employing a nonmechanical, fully electronic sensor. The motor-torque limit shall be adjustable over 40 percent to 100 percent of design torque in 1 percent increments.
4. The motor shall automatically de-energize if an over-torque condition is sensed. Torque limit protection shall automatically adjust for initial valve unseating, or for programmed torque seating of valves. A valve movement in the opposite direction of the over torque move shall reset the torque limit protection.
5. The actuator shall provide a 4 mA to 20 mA analog output signal that is proportional to valve position. This signal shall employ the noncontact type absolute position encoders and conform to the accuracy requirements of this section.

E. Intelligent Control Module: Intelligent control module shall:

1. Be of a modular design, with replaceable circuit boards for troubleshooting.
2. Be entirely housed in actuator, and shall be easily accessible for maintenance.
3. Have control circuit boards or modules that connect with plug-in card connectors or wiring plugs.
4. Include a solid-state motor reversing circuit for modulating up to 1,200 starts per hour. Mechanical reversing contactors are not acceptable. Failure of the solid-state motor reversing module shall not result in unintended motor operation.
5. The control module shall include a possibility to reduce speed as it nears open or close limits based on valve percentage. This feature shall be able to be adjusted between 0 percent and 20 percent.
6. Include any necessary internal protection fuses. No external or accessory fuses shall be required for full protection of the motor or control electronics package.
7. Have solid-state motor reversing circuit that does not affect actuator performance, or degrade communications between actuator and remote control equipment.

8. All control transformers shall include vacuum impregnated coils, and have dual primary fuses.
9. Include an automatic directional reversal delay, to prevent current surges from rapid motor reversal.
10. Incorporate an automatic phase-correction circuit to correct motor rotation errors due to incorrect site wiring.
11. Include an automatic phase-failure detection circuit that shall disable motor rotation if a phase-loss is detected.
12. De-energize motor when it detects a fault or fails.
13. Allow actuator calibration without removing covers or requiring special tools.
14. Allow actuator calibration by answering simple questions on operator display.
15. Accumulate and store diagnostic information about actuator performance including, motor, position encoder, contractor performance, cycle time, handwheel operations, actuator identification, output turns, and a torque profile of valve baseline stroke and the last valve stroke for comparison.

F. Power/Control Wiring:

1. All customer connections shall be in a compartment that is separate from the control circuits and other internal spaces. Accessing the wiring compartment shall not require opening any other actuator compartments.
2. The wiring connections compartment shall contain a suitable number of screw-type terminals to allow connection of step-mode controls wiring and the control wiring shall be physically separated from the power wiring.

2.08 DRIVE SLEEVE

A. Provide a drop-in stem nut held in place with a snap ring, torque bushing, or threaded locknut and keyway which couples with actuator to the intermediate geared operator or valve stem and provides a versatile means of disassembling the actuator from the operator or valve.

2.09 FACTORY TESTING OF MOTOR ACTUATOR

A. Test each actuator prior to shipment in accordance with AWWA C540. Submit certified test reports. The application torque shall be the maximum torque required to open or close the valve at any position, including seating and unseating conditions.

PART 3 EXECUTION

3.01 ATTACHING ELECTRIC ACTUATORS

A. Protect actuators from damage per manufacturer recommendations at all times. Replace (at no cost to Owner) all electrical enclosures and electrical components found with condensation or related damage.

B. Valve manufacturer shall mount electric motor actuator and accessories on each valve and stroke the valve prior to shipment. Provide preliminary configuration and adjustment of all functions, including limit switches, valve position transmitter, and torque switches.

C. Valve manufacturer shall provide installation, configuration, and testing of each valve actuator by actuator manufacturer-certified technicians. Actuator mounting arrangements shall facilitate operation and maintenance and shall be as indicated, and as verified and acceptable to valve manufacturer and Owner. Provide certification that valve actuators have been installed and adjusted by valve manufacturer. The actuator access cover shall be oriented to prevent the cover from falling in the workspace, causing injury to personnel.

3.02 PAINTING AND COATING

A. Coat the exterior metal surfaces of electric motor actuators per Section 09 90 00, Painting and Coating. Provide rust inhibiting inorganic zinc-rich primer and intermediate and finish coats of high-build epoxy recommended by manufacturer of the equipment.

3.03 FIELD INSTALLATION

A. Install the valve and actuator as indicated on Drawings in accordance with the manufacturer's instructions. Keep units dry, closed, and sealed to prevent internal moisture damage during construction. Provide additional hangers and supports for actuators which are not mounted vertically over the valve or which may impose an eccentric load on the piping system.

3.04 FIELD TESTING OF ELECTRIC MOTOR ACTUATORS

A. Only maintenance technicians that are certified by the actuator manufacturer shall be employed to perform any field testing, adjustment, or set up of the valve actuator.

B. The motor actuators shall be tested, as installed by measuring the current drawn (in amperes) by each motor for unseating, seating, and running conditions. The measured current shall not exceed the current measurement recorded during the factory performance test by more than 5 percent.

C. If the measured current drawn exceeds the above value, provide a larger motor or gear drive or adjust the actuator so that the measured amperage does not exceed the value.

D. Verify that limit switch functions are adjusted to their correct settings. Open and close valves twice and assure that limit switches function. Verify the position transmitters and any other information being developed in the actuator complies with requirements contained within this section or listed on Drawings.

E. Electric motor actuator manufacturer or qualified representative shall be available at the work side to check installation, supervise startup, and conduct field testing and adjustment of equipment. Provide factory-authorized formal training in the operation and maintenance of the equipment to Owner personnel, such that Owner personnel shall be qualified by the equipment manufacturer to maintain their equipment. Documentation of their qualification shall be provided as part of the training package.

3.05 ELECTRIC MOTOR ACTUATOR WARRANTY

A. The electric motor actuator manufacturer shall warrant its product to be free from defects in materials, workmanship and performance for actuator incorporated in the work for a period of 5 years from the date of Substantial Completion or final acceptance, whichever occurs first. Upon notice by the Owner, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no cost to Owner.

B. In emergency situations, if warranty service is not immediately available from the Vendor/Supplier or Manufacturer, the Owner will perform repairs to re-establish proper operation of the actuator and valve. All defective parts returned by Owner shall be replaced with new parts. If the Owner replaces the entire actuator for cause, the Vendor/Supplier or Manufacturer shall repair or replace the entire actuator.

C. Maintenance or repair work performed by Owner during the warranty period shall not be cause for voiding the warranty.

3.06 SUPPLEMENT

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

1. Electric Motor Actuator Schedule.

END OF SECTION

ELECTRIC MOTOR ACTUATOR SCHEDULE

Tag Number	Valve Type	Valve Size (inches)	Process Fluid	Maximum Operating Flow (cfs)	Maximum ΔP (psi)	Service	Travel Time (Minutes)	Control Feature Modifications /Supplements
MHP-FCV-00004	Plunger	12	Raw Water	10	112	Modulating	15	B, C, D, F, H, I, K
SE-FCV-00004	Plunger	12	Raw Water	10	242	Modulating	15	B, C, D, F, H, I, K
SWH-FCV-00004	Plunger	16	Raw Water	25	144	Modulating	15	B, C, D, F, H, I, K
SWH-FCV-00010	Plunger	12	Raw Water	10	144	Modulating	15	B, C, D, F, H, I, K
S2W-FV-00002	Ball	16	Raw Water	25		Open-Close	15	B, C, D, F, H, I, K
S2W-FCV-00004	Plunger	16	Raw Water	25	374	Modulating	15	B, C, D, F, H, I, K

ELECTRIC MOTOR ACTUATOR SCHEDULE

Tag Number	Valve Type	Valve Size (inches)	Process Fluid	Maximum Operating Flow (cfs)	Maximum ΔP (psi)	Service	Travel Time (Minutes)	Control Feature Modifications /Supplements
PE-FCV-00004	Plunger	12	Raw Water	15	290	Modulating	15	B, C, D, F, H, I, K
PMS-FCV-00004	Plunger	12	Raw Water	15	242	Modulating	15	B, C, D, F, H, I, K
PS-FCV-00004	Plunger	12	Raw Water	10	242	Modulating	15	B, C, D, F, H, I, K
SN-FCV-00004	Plunger	6	Raw Water	3	155	Modulating	15	B, C, D, F, H, I, K
SS-FCV-00008 (BY OTHERS)	Plunger	12	Raw Water	10	112	Modulating	15	B, C, D, F, H, I, K

ELECTRIC MOTOR ACTUATOR SCHEDULE

Tag Number	Valve Type	Valve Size (inches)	Process Fluid	Maximum Operating Flow (cfs)	Maximum ΔP (psi)	Service	Travel Time (Minutes)	Control Feature Modifications /Supplements
SS-FCV-00014	Plunger	24	Raw Water	50	112	Modulating	15	B, C, D, F, H, I, K
SS-FCV-00020	Plunger	24	Raw Water	50	112	Modulating	15	B, C, D, F, H, I, K

Service: O/C = Open-Close, T = Throttling, M = Modulating

Control Feature Modifications/Supplements:

A = Actuator shall open valve upon loss of signal.

B = Actuator shall remain in last position upon loss of signal.

C = Local OPEN-CLOSE momentary pushbuttons that must be continuously depressed to initiate/maintain valve travel; travel stops when pushbutton is released or when end of travel limit is reached.

D = Remote OPEN-CLOSE maintained dry contacts; travel stops when remote contact opens, or when end of travel limit is reached.

E = Three 24-volt dc interposing relays for remote OPEN-STOP-CLOSE control. Relays powered externally, thereby permitting valve control from greater distances.

F = Motor and control enclosure(s) NEMA 250, Type 6 (IP 68) and Type 4.

G = Motor and control enclosure(s) NEMA 250, Type 7.

H = Valve position output converter that generates an isolated 4 to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24V dc.

I= Operation from 120-volt, single-phase power.

J= Local OPEN-CLOSE momentary selector switch that must be momentarily switched to initiate valve travel; travel stops when selector switch is switched to stop position or when end of travel limit is reached.

K = Capable of network communication through Modbus RTU protocol.

SECTION 40 27 06
PLUNGER VALVES

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish horizontal in-line 24-inch, 16-inch, 12-inch, and 6-inch plunger valve ANSI 300 class assemblies, complete with electric modulating type actuator and aeration device if specified for flow control and isolation, factory tested, and operable, as shown on Drawings, and as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 09 90 00 Painting and Coating.

B. Section 33 05 01, Conveyance Piping General.

C. Section 40 27 02, Process Valves and Operators.

D. Section 40 27 03, Electric Motor Actuators.

E. Section 40 27 08, Full Port Isolation Ball Valves.

1.03 REFERENCES

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

1. American National Standards Institute (ANSI):
   a. B1.20.1, Pipe Threads, General Purpose (Inch).
   b. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   c. B16.5, Steel Pipe Flanges and Flanged Fittings.
2. American Iron and Steel Institute (AISI):
   a. 304, Austenitic Stainless Steel (maximum percent: 0.08C, 2.0 Mn, 1.0 Si, 18-20 Cr, 8-10.5 Ni).
   b. 420, Martensitic Stainless Steel (minimum percent: 0.15C, maximum percent: 1.0 Mn, 1.0 Si, 12-14 Cr, 0.0 Ni,).
3. ASTM International (ASTM):
   a. A48, Specification for Gray Iron Castings.
   b. A216, Specification for Steel Casting, Alloy, Specially Heat-Treated, for Pressure Containing Parts, Suitable for High Temperature Service.
   c. A536, Specification for Common Requirements for Iron Castings for General Industrial Use.

d. A743, Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

4. Purchaser Furnished Data: European (EN or DIN) standards equivalent to referenced American standards, subject to Construction Manager approval.

5. Operating Conditions: Purchaser, whether Owner, or Contractor, will furnish valve-operating conditions, design criteria, process criteria, and facility drawings sufficient in detail and extent to allow the Manufacturer to properly customized plunger valve performance.

1.04 SUBMITTALS

A. Submittals shall be made to the Construction Manager.

B. Submit Manufacturer's data and descriptive literature written in the English language with quotation. Include catalog data, preliminary performance testing procedures, quality control procedures, calculations, detailed construction sheets showing all valve parts and descriptions of materials of construction with and applicable USA material specifications such as AISI, ANSI, ASTM, American Society of Automotive Engineers (SAE), or the Copper Development Association (CDA). Identify each valve by tag number to which the catalog data and detail sheets pertain.

C. Furnish for approval prior to manufacture, factory developed production drawings that clearly show valve dimensions, laying lengths, port sizes, component parts, and materials of construction. Provide graphical factory generated computer modeling results for both estimated noise levels in decibels and for cavitation and its control through the complete stroke of the valve and through all flow rates.

D. Furnish for approval prior to manufacture shop assembly drawings that clearly shows dimensions and orientation of valve actuators as installed on the valves. Clearly show location of internal stops for gear actuators. Provide valve actuator safety verification through the complete stroke specifically noting values for both break torque under maximum differential as well as maximum dynamic torque. Use the ratio of actuator output torque over valve input torque for validation. Valve manufacturer's compliance shall be factory signed and dated.

E. Furnish for approval prior to manufacture shop coating and lining specifications, which clearly identify all valve linings and coatings.

F. During manufacture, furnish coating and lining test reports that report and verify the valve interior lining condition is tested for absence of holidays, and lining thickness. Describe test results and repair procedures for each valve. Do not ship valves to project site until the reports have been approved by the Construction Manager and accepted by the Owner.

G. Furnish for approval prior to manufacture a valve summary data sheet that provides the station, valve structure, type, manufacturer, size, pressure rating, drilling pattern and model number of each valve; and type, manufacturer and model number of the valve actuator.

H. Furnish for approval prior to shipping six copies of factory shop hydrostatic test reports, functional performance test reports, and any other required test reports. Hydrostatic test reports shall be presented which reflects the requirement of the test procedures.

I. Submit for approval factory export packaging specifications, applicable to overseas shipping via surface carrier.

J. Submit for information with proposal current quality assurance program certificate of compliance.

K. Furnish Operations and Maintenance Manual for valve(s). Manuals shall include installation instructions, maintenance procedures and operation parameters. Detail operating characteristics, limiting conditions, performance cures, engineering data, nameplate data, tests, complete nomenclature and parts numbers, parts list, illustrations, assembly drawings showing each part and part number and diagrams of required maintenance. Provide spare parts ordering instructions. Identify routine maintenance and schedule for such, troubleshooting guides, adjustment and checking procedures, list of relay settings, control and alarm contact settings. Provide recommended spare parts list and current prices and recommended quantities. List briefly each maintenance operation required, frequency required and lubricant (or other material) required. Refer to specific information in manufacturer’s standard maintenance manual, where applicable. Provide local representative and corporate representative and their phones, emails, names and addresses.

1.05 SUBSTITUTION

A. Where plunger valves are shown or specified in Project specifications or Drawings issued by the Owner, no Contractor may substitute any other style of valve that has not been specifically approved by the Owner for that application.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage following spare parts and special tools.

Item	Quantity
Special tools required to maintain or dismantle	1 complete set

1.07 QUALITY ASSURANCE

A. The manufacturer shall be ISO 9001 and ISO 14001 Certified.

B. Shop Inspection: The manufacturer shall provide a 4-week advance notice to the Construction Manager prior to performing tests, and shall allow full access to designated Owner's representatives for inspection of manufacturing facilities and processes, and any specified testing. The manufacturer shall perform all testing at manufacturer's cost, unless such testing is specifically indicated to be provided by the Owner.

C. Shop Testing: Plunger valves shall be shop tested prior to shipment in accordance with the following minimum standards:

1. Leakage Test: Plunger valves shall be qualitatively tested to 1.1 times valve pressure rating to identify drop tight closure of valve seat, seal leaks and other problems in the assembly process.
2. Hydrostatic Test: Plunger valves shall be hydrostatically tested to withstand 1.5 times of the valve's maximum design operating pressure rating.
3. Functional Flow Performance Test: Plunger valves shall be subjected to an operational/test using potable water. The test procedure shall include three complete open/close cycles of operation with the valve actuator settings in place (limit switches, torque switches, pilot pressure settings, etc.).

1.08 EXPERIENCE AND SERVICE RESPONSE

A. The valve manufacturer shall have a minimum of 10 years of experience in the production and sales of plunger valves. The valve manufacturer shall also have at least 25 installed plunger valve references in North America that have been in operation in last 5 years. Valve manufacturer shall provide complete documentation to meet this requirement, including contact names and telephone and fax numbers that can verify field installations. Acceptance of the validity of submitted documentation is solely at the discretion of the client.

B. The valve manufacturer shall provide 24 hour manufacturer's response for any field service requirement. Approved service agents, licensee(s), or representatives of the manufacturer shall be permitted as long as the valve manufacturer is present. The valve manufacturer shall be responsible for its authorized agents and licensees. A detailed manufacturers signed service call write up, inclusive of photo-documentation, shall be provided without exception, by the valve manufacturer. The valve manufacturer shall be required to know and keep data files on all work performed, modifications and remediation's as well as the agents performing the work. This data shall be permanently kept with the manufacturer regardless of licensee.

1.09 NATIONAL SANITATION FOUNDATION (NSF) STANDARD 61 / NSF 372 / NSF 600

A. The entire plunger valve must have verifiable Certification of Compliance with the NSF 61 / NSF 372 / NSF 600 - Drinking Water System Components Standard. Certifications shall accompany submittals.

PART 2 PRODUCTS

2.01 PLUNGER VALVE PERFORMANCE REQUIREMENTS

A. Performance: Each valve shall be designed to operate smoothly throughout the specified flow range without cavitation, excessive noise, or vibration for the conditions stated below.

1. Valve design shall, if recommended by manufacturer, provide double multiple orifice cylinders, and/or other cavitation control features to break the heads and flows. Double multiple orifice cylinders shall (both at high head break and at low head break operating conditions) not cause blockage in valves requiring maintenance other than simply opening or closing valve to dislodge and flush water out of valve. This criteria does not apply to those types of items (i.e., woody, fibrous or hard particles) which would plug the valve openings anyway, even if the organic sludge were not present in the water.
2. Valve manufacturer shall notify Construction Manager in writing of any risk of cavitation damage to the piping downstream of the plunger valves due for the operating conditions indicated on Drawings and Specifications and suggest elongating straight piping downstream of the valve if such modifications are deemed needed to protect the downstream piping (including valves) from cavitation damage.
3. During startup and training, plunger valve manufacturer shall educate Owner staff of any cavitation and maintenance issues or concerns to watch for in operating the valves.

B. Noise: Operating noise levels shall not exceed 95 decibels (dBA) at a distance of 3 feet from the valve at the normal flow point. Material stresses shall not exceed 1/5 of the ultimate or 1/3 of the yield strength of the material. Flow rate as a function of pressure drop across the valve shall be linear to within 3 percent.

C. 24-inch, Type SZ 30-20, Flow Control Plunger Valve Operation Data: Intended valve use is to provide flow control and energy dissipation for breaking head from 281 psi static pressure down to 169 psi at the Santaquin South turnout as follows:

1. Normal Operating Flow: 3 cubic feet to 10 cubic feet per second (cfs).
2. Maximum Operating Flow: 50 cubic feet per second (cfs).
3. Maximum Inlet Pressure: 281 psi (at 0 cfs = static).
4. Minimum Inlet Pressure: 122 psi.
5. Maximum Outlet Pressure: 169 psi.
6. Minimum Outlet Pressure: 114 psi.
7. Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

D. 16-inch, Type SZ 40, Flow Control Plunger Valve Operation Data: Intended valve use is to provide flow control and energy dissipation for breaking head from 374 psi static pressure down to atmospheric conditions at the Salem 250 W blowoff as follows:

1. Normal Operating Range: 2 to 20 cubic feet per second (cfs).
2. Maximum Operating Flow: 25 cubic feet per second (cfs).
3. Maximum Inlet Pressure: 374 psi (at 0 cfs = static).
4. Minimum Inlet Pressure: 0 psi (when fully drained).
5. Maximum Outlet Pressure: 0 psi (at 25 cfs).
6. The valve must come with a venting device as described in Article Aeration Devices.
7. Discharge to concrete wall approximately 8 feet downstream of valve.
8. Operating Function: Drain valve that operates up to 20 hours per year.

E. 16-inch, Type SZ 30-20, Flow Control Plunger Valve Operation Data: Intended valve use is to provide flow control and energy dissipation for breaking head from 367 psi static pressure down to 222 psi at the Woodland Hills turnout as follows:

1. Normal Operating Range: 2 to 20 cubic feet per second (cfs).
2. Maximum Operating Flow: 25 cubic feet per second (cfs).
3. Maximum Inlet Pressure: 367 psi (at 0 cfs = static).
4. Minimum Inlet Pressure: 236 psi (at 25 cfs).

5. Maximum Outlet Pressure: 222 psi.
6. Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

F. 12-inch, Type SZ 30-20, Flow Control Plunger Valve Operation Data: Intended valve use is to provide flow control and energy dissipation for breaking head from 327 psi static pressure down to 215 psi at the Mapleton High Pressure turnout as follows:

1. Normal Operating Range: 2 to 10 cubic feet per second (cfs).
2. Maximum Operating Flow: 10 cubic feet per second (cfs).
3. Maximum Inlet Pressure: 327 psi (at 0 cfs = static).
4. Minimum Inlet Pressure: 226 psi (at 10 cfs).
5. Maximum Outlet Pressure: 215 psi.
6. Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

G. 12-inch, Type SZ 40, Flow Control Plunger Valve Operation Data:

1. Intended valve use is to provide flow control and energy dissipation for breaking head from 371 psi static pressure down to 129 psi at the Salem East turnout as follows:
   a. Normal Operating Range: 1 cubic feet to 10 cubic feet per second (cfs).
   b. Maximum Operating Flow: 10 cubic feet per second (cfs).
   c. Maximum Inlet Pressure: 371 psi (at 0 cfs = static).
   d. Minimum Inlet Pressure: 241 psi (at 10 cfs).
   e. Maximum Outlet Pressure: 129 psi.
   f. Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

H. 12-inch, Type SZ 30-20, Flow Control Plunger Valve Operation Data:

1. Intended valve use is to provide flow control and energy dissipation for breaking head from 367 psi static pressure down to 222 psi at the Woodland Hills turnout as follows:
   1) Normal Operating Range: 2 cubic feet to 10 cubic feet per second (cfs).
   2) Maximum Operating Flow: 10 cubic feet per second (cfs).
   3) Maximum Inlet Pressure: 367 psi (at 0 cfs = static).
   4) Minimum Inlet Pressure: 237 psi (at 10 cfs).
   5) Maximum Outlet Pressure: 222 psi.
   6) Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

I. 12-inch, Type SZ 30-20, Flow Control Plunger Valve Operation Data:

1. Intended valve use is to provide flow control and energy dissipation for breaking head from 344 psi static pressure down to 55 psi at the Payson East turnout as follows:
    1) Normal Operating Range: 2 cubic feet to 10 cubic feet per second (cfs).
    2) Maximum Operating Flow: 15 cubic feet per second (cfs).
    3) Maximum Inlet Pressure: 344 psi (at 0 cfs = static).
    4) Minimum Inlet Pressure: 196 psi (at 10 cfs).
    5) Maximum Outlet Pressure: 200 psi.
    6) Minimum Outlet Pressure: 55 psi.
    7) Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

J. 12-inch, Type SZ 40, Flow Control Plunger Valve Operation Data:

1. Intended valve use is to provide flow control and energy dissipation for breaking head from 338 psi static pressure down to 97 psi at the Payson Main turnout as follows:
    a. Normal Operating Range: 1 cubic feet to 15 cubic feet per second (cfs).
    b. Maximum Operating Flow: 15 cubic feet per second (cfs).
    c. Maximum Inlet Pressure: 338 psi (at 0 cfs = static).
    d. Minimum Inlet Pressure during flow control: 191 psi (at 15 cfs).
    e. Minimum Inlet Pressure when draining to atmosphere: 0 psi (when fully drained).
    f. Maximum Outlet Pressure: 97 psi.
    g. Minimum Outlet Pressure: 0 psi (when draining)
    h. The valve must come with a venting device as described in Article Aeration Devices.
    i. Operating Function: Flow control (or isolation) valve modulating up to 365 days per year. Drain valve that operates up to 20 hours per year.

K. 12-inch, Type SZ 40, Flow Control Plunger Valve Operation Data:

1. Intended valve use is to provide flow control and energy dissipation for breaking head from 361 psi static pressure down to 119 psi at the Payson South turnout as follows:
    a. Normal Operating Range: 1 cubic feet to 10 cubic feet per second (cfs).
    b. Maximum Operating Flow: 10 cubic feet per second (cfs).
    c. Maximum Inlet Pressure: 361 psi (at 0 cfs = static).
    d. Minimum Inlet Pressure: 210 psi (at 10 cfs).
    e. Maximum Outlet Pressure: 120 psi.

f. Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

L. 6-inch, Type SZ 30-20, Flow Control Plunger Valve Operation Data:

1. Intended valve use is to provide flow control and energy dissipation for breaking head from 330 psi static pressure down to 175 psi at the Santaquin North turnout as follows:
   a. Normal Operating Range: 0.3 cubic feet to 3 cubic feet per second (cfs).
   b. Maximum Operating Flow: 3 cubic feet per second (cfs).
   c. Maximum Inlet Pressure: 330 psi (at 0 cfs = static).
   d. Minimum Inlet Pressure: 175 psi (at 3 cfs).
   e. Maximum Outlet Pressure: 176 psi.
   f. Minimum Outlet Pressure: 168 psi.
   g. Operating Function: Flow control (or isolation) valve modulating up to 365 days per year.

2.02 PLUNGER VALVE OPERATING REQUIREMENTS

A. Valve Assembly Components: Each plunger valve assembly shall consist of a flanged short conical inlet section having an internal cone to divert the water flow into the annular chamber of the body section.

B. An oval body section with an inner annular chamber shall be formed by the body shell. The plunger with custom designed cylinder control trim is part of internal slider-crank mechanism and is driven by an outside 90 degree AWWA worm gear. The control trim cylinder shall be field removable and replaceable with alternate control trim when hydraulic conditions change or new operating parameters are required.

C. The plunger shall move in an axially flow direction to reduce or enlarge the annular flow cross-section through slots in a degressive manner, and the medium will flow through the customized regulating cylinder from the outer annular chamber to the inner chamber of the plunger, shall be provided for flow control.

D. The seals of the plunger valve shall allow the valve to be drip and bubble tight in both flow directions for the long term and without the need for premature seal replacement. The outside of the plunger shall seat against a quad-oring sealing ring. The quad-oring shall deflect and seal in both axial directions. The quad O-ring will provide the best available design for both modulating and for open close service in the prevention of twist, roll and point loading of the plunger seal. The seal shall be insensitive to debris. The elastomeric profile sealing ring shall seat leak tight at the downstream end of the plunger. The elastomeric profile sealing ring shall be mechanically retained in the downstream flange of the valve body by a stainless steel seat ring. Valve shaft seals shall prevent the long term potential of water entering into the gear case. The valve operating shaft shall have five O-ring seals; two on the shaft at the crank mechanism and three on the shaft at the gear box. The O-ring seals shall maintain a drip tight seal regardless of modulation cycles or inactivity. The O-ring seals will prevent corrosion of the shaft body bore.

E. The minimum closure time of the 24-inch diameter and 16-inch diameter plunger valves from full open to full close shall be 5 minutes. The minimum closure time of the 12-inch diameter and 6-inch diameter plunger valves shall be 5 minutes from full open to full close.

F. Valves shall be provided with 4 integral feet per each 180 degree circumference. There shall be four total lifting lugs, one per each foot. The four lifting lugs shall be factory drilled and taped. They shall be sufficiently broad in placement to assist with rigging of an unbalanced load.

G. The valve shall function properly and without issue within any 180 degree flange rotation.

2.03 PLUNGER VALVE DESIGN FEATURES

A. Plunger valve shall be a one-part-body design with interior geometry that provides water flow that is guided around a streamlined internal body. The design shall feature a geometrically optimized design, a continuous annular cross-sectional reduction from inlet to throttle cross-section, and continuous rise of flow velocity to the exit without producing cavitation.

B. Plunger valve design shall feature a customized designed plunger with tailored anti- cavitation trim with slots or orifice holes to minimize cavitation. Slots or orifice shall be fully closed when the valve is placed in the closed position. The plunger shall be seated against the upstream quad O-ring and an elastomeric seat located in body downstream flange with the valve in the closed position. The elastomeric seat shall be properly kept in position in a groove in the body and the downstream stainless steel seat ring shall secure the elastomeric profile sealing ring from displacement. The profile seat ring shall not be penetrated by fasteners, exposed to the flow stream in the open position and shall not be subject to cold flow of the elastomer.

C. Plunger valve design, when open during operation, shall feature plunger assembly movement in the upstream side direction to release water through the slots or orifice holes.

D. Plunger valve design shall feature advance and retract axial strokes of the plunger, guided in the internal body by an internal slider-crank mechanism of stainless steel. The crank and push rod mechanism shall have an industry standard 90 degree angle of rotation stroke from open to close matching the travel for AWWA waterworks quarter turn valves. The provided actuator shall include a mechanical stop in the open and closed positions which will prevent attempts of actuator to hyper extend the plunger or place undesired stresses on the internal linkage system. The plunger shall slide and be contained in the axial position by guide rails. To prevent possible corrosion between the guide rails and the valve body, the guide rails shall be completely fused to the valve body in an overlay weld process to prevent any gaps or corrosion pathways. Guide rails which are riveted or bolted to the valve body are not acceptable for long-term operability and corrosion protection. The guide rails shall be bronze and shall be positioned around the plunger in an uneven quantity to reduce the potential for damaging harmonic vibration, clogging or excessive wear. The guide rails shall be low to no lead and very low zinc content to prevent dezincification.

E. Motion shall be controlled by means of electric actuator attached to the body section.

F. The design of the annular throat cross section in any position of the plunger shall ensure linear regulation of flow.

G. Actuate plunger valve as specified and described in Section 40 27 03, Electric Motor Actuators.

H. Flanged connections shall mate with adjacent flanges per Section 33 05 01, Conveyance Piping—General.

I. The movement of the plunger shall be controlled by means of maintenance free irreversible, self-locking, quarter turn, 90 degree AWWA worm gear unit with externally adjustable mechanical stops to limit valve travel in both the open and closed positions. The valve stroke shall equal 90 degrees plus or minus 2 degrees, whereby the mechanical stops of the worm gear shall be engaged before the full extension or retraction of the plunger. In no instance shall the full output torque of actuator be allowed to be transmitted to the valve at its end of travel, either open or closed, without engaging the travel stops of the worm gear first. The AWWA worm gear unit shall be operated by a hand wheel or electric actuator. Only pneumatic or hydraulic cylinder actuators may utilize scotch yoke linkages to change linear piston force to rotational torque. As scotch yoke output torques are inconstant through their complete stroke, the submittals shall mathematically validate the actuator output torques exceed the required valve input torque, inclusive of AWWA safety factors, through the full stroke of the valve.

2.04 VALVE SUPPORT

A. The valve supplier shall design and provide the valve baseplate, a plastic sliding plate and a foundation plate. The installation contractor shall be responsible for the design and supply of the anchor bolts to anchor the valve to the concrete pedestal. Both plates shall be made of carbon steel. The baseplate shall be unbolted to remove the valve from the adjacent piping. The baseplate shall secure the valve to a foundation plate which is cast into a reinforced concrete pedestal. Provide pedestal anchors and all fasteners for mounting baseplate and foundation plate.

B. The anchoring system shall allow for field adjustment for final valve installation. The installation contractor shall provide the final valve support and anchoring calculations and have the drawings to be stamped by a professional engineer registered in the State of Utah.

C. Provide the valve body with integral supporting feet designed for transmitting the full vertical load, including the weight of any contained water and thrust from the valve operating mechanism to base plates secured in the concrete pedestal.

D. Plunger Valve Base Plates for Valves 12 Inches and Larger: Submit and obtain approval for, and provide, base plates for plunger valve. Base plates must be able to be unbolted to remove the valve from the adjacent process piping by sliding the valve up to 3 inches horizontally away from the upstream flange before it is lifted vertically. Base plates shall secure valve to a reinforced concrete base (by installation contactor) so that the plunger valve does not vibrate.

E. Plunger Valve Base Plates for Valves 10-Inches and Smaller: Submit and obtain approval for, and provide, base plates for plunger valve. Base plates must be able to be unbolted to remove the valve from the adjacent process piping by sliding the valve up to 1.5 inches horizontally away from the upstream flange before it is lifted vertically. Base plates shall secure valve to a reinforced concrete base (by installation contactor) so that the plunger valve does not vibrate.

2.05 MATERIAL REQUIREMENTS

A. Principal Component Parts Materials of Valve Construction:

Item	Size	Material	Specification
Valve Body	All	Cast Steel	ASTM A216 WCB
Plunger	All	Stainless Steel	AISI 304
Regulating Cylinder	All	Stainless Steel	AISI 304
Shaft Bushing		Bronze	ASTM C90800/CuSn12

Item	Size	Material	Specification
Crank Shaft	All	Stainless Steel	AISI 420
Crank Mechanism (sizes 6” – 78”)	All	Stainless Steel	AISI 304
Seat / Retaining Ring	All	Stainless Steel	AISI 304
Plunger Guide Rails	All	Bronze welded overlay	CuAl8 (lead <0.0020% Zinc < 0.008%
Quad-Sealing-Ring	All	EPDM	hardness A:80, (=/- 5). Elongation >200%, Tensile >12 N/mm, Elasticity >25%
Profile Sealing Ring	All	EPDM	hardness A:80, (=/- 5). Elongation >200%, Tensile >12 N/mm, Elasticity >25%
O-Rings, Actuator Shaft	All	EPDM	hardness A:80, (=/- 5). Elongation >200%, Tensile >12 N/mm, Elasticity >25%
Worm Gearbox			Housing: Ductile Iron GGG-40 Worm Wheel: GGG-60 or bronze Coupling: Quenched and tempered steel acc. to 10083-2 Input Drive Shaft (Secondary Gear): Stainless steel 10088-3

B. Fasteners: All studs, bolts, washers, and nuts in contact with water shall be Type 304 or Type 316 stainless steel.

C. All materials of moving components in contact with each other shall be of dissimilar hardness to prevent galling. The valve shall be moved through an open-close-open cycle three times after final assembly and prior to shipment to ensure this requirement.

D. The valve manufacturer coating process shall include post preparation and coating application assurances of targeted performance. The manufacturer shall utilize and incorporate a QC process that includes Coating thickness Testing, Holiday Free Testing, Cross Linkage Testing, Impact Resistance Testing, Coating Adhesion Testing and Cathodic Disbonding Testing. The Quality Compliance testing shall remain on record with the manufacturer and available for review and approval.

E. The valve shall be blast coated to near white metal. The blast cleaned body shall be then thoroughly cleaned to remove all dust, grease, oil or other negative adhesion potentials. It shall meet the coating manufacturers recommended duration for humidity and temperature and at coating application. Coating shall take place within 12 hours of the blast cleaning process.

F. The applied coating shall be tested and signed and dated-verified holiday free with a dry film thickness of a minimum of 12 mils DFT or as specifically stated in the coatings section.

2.06 AERATION DEVICES

A. Where specifically indicated, the anti-cavitation venting device shall be mounted directly downstream of the plunger valve with air intake connecting piece on the top of venting system. The venting shall be in annular flow shape directly at the outlet of the plunger valve.

B. The anti-cavitation venting device shall be manufactured out of ASTM A283 steel with one flat faced ANSI/ASME B16.5, Class 300 at upstream side, flanges with one flat faced ANSI/ASME B16.5, Class 300 at downstream side, flange on the top of anti-cavitation venting device.

2.07 PLUNGER VALVE MANUFACTURER

A. VAG-Armaturen GmbH, Carl-Reuther-Str. 1, Mannheim, Germany.

B. Armacon Systems GmbH, Magdeburg, Germany.

C. ERHARD GmbH & Co. KG, Heidenheim, Germany.

D. “Or-equal.”

PART 3 EXECUTION

3.01 INSTALLATION

A. Valve installation shall be in strict accordance with the manufacturer's printed recommendations, and the Contract Documents.

B. Four bound copies, and one CD of the Operations and Maintenance Manual are to be provided with the valve. The manuals shall include installation instructions, maintenance procedures and operation parameters.

3.02 WORKMANSHIP

A. Valves shall be free from manufacturing defects and shall be manufactured in a workmanlike manner. Valves shall be manufactured under the direction of a registered professional engineer.

B. Painting shall be per Section 09 90 00, Painting and Coating. Grease and scale shall be completely cleaned from the valve prior to painting per Society for Protective Coatings (SSPC) standards.

C. All carbon steel components shall be painted with fusion epoxy paint per Section 09 90 00, Painting and Coating. A Certificate of Compliance with the purchaser’s material specifications, and the manufacturer’s quality assurance program shall be furnished with each valve.

3.03 FIELD TESTING AND PERFORMANCE

A. Manufacturer shall furnish all required startup assistance and inspection of installed valve at the Owner’s facility.

B. Valves supplied under this Specification shall be field leak tested by the Contractor to the specified operating pressure in the closed position and shall not leak. Field leakage relevant to the plunger valve shall be corrected by the manufacturer at the manufacturer’s expense. Field leakage test results shall be certified by the Construction Manager, manufacturer’s onsite representative, and Contractor.

C. Plunger valves shall be subjected to onsite performance testing as part of the commissioning activities in accordance with a written performance test plan. To the extent possible, the valve shall be subjected to variable flow conditions, and the resulting control settings, flow, upstream and downstream pressures, noise levels, and vibration levels shall be documented and compared to the manufacturer’s shop test results. Operational flow testing shall be performed on each valve to verify the following:

1. Simulate valve operation using local and remote control.
2. Operate valve at maximum flow demonstrating maximum allowed pressure drop across the valve.
3. Operate valve from minimum to maximum flow. Using their specified electric motor actuators, operate valve–actuator assemblies demonstrating the ability to adjust flows at increments of 5 percent of peak design flow throughout their full stroke range.

This testing and valve cycling need not occur at the full heads the valves will experience when operating within their normal system operations. For all tests record flow, upstream and downstream pressure, valve position set points and actuator motor inrush current. Submit all test results of forecasted operating curves and actual test results.

4. Demonstrate successful “high-pressure” cavitation control operations without damage to the valve or downstream piping facilities. Demonstrate the valve will meet specified noise requirements and not be damaged by cavitation in the specified design ranges.
5. In-place (Field) Leakage Test: Contractor shall perform in-place (Field) Leakage Test regardless of which operational flow test method is selected: Field leak test all valves to the specified system tests pressure in the closed position with zero leakage. After verifying zero leakage to Construction Manager satisfaction, exercise each valve through its full stroke at least two times during the second phase of pressure testing and system disinfection.
6. All Operational Flow Testing and In-place (Field) Leakage Tests performed during the construction period (not the 5 year warranty period) shall be witnessed by the Construction Manager and manufacturer's representative. Test results shall be jointly certified by Construction Manager or its representative, manufacturer’s onsite representative, and the Contractor.
7. If the valve fails any of the tests, it shall be corrected by the manufacturer within 7 days at the manufacturer’s expense.

D. Upon completion of the necessary field testing, the shop test results and field test results comparison shall be discussed and resolved during a meeting or teleconference, as determined by the Owner.

3.04 WARRANTY

A. The plunger valve manufacturer shall warrant its products, including actuators incorporated in the work, to be free from defects in materials, workmanship and performance for a period of 5 years from the date of recording the Notice of Completion. Upon notice by the Owner, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no cost to the Owner.

END OF SECTION

SECTION 40 27 08
FULL PORT ISOLATION BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. This section includes materials, design features, testing, and operating requirements for fusion bonded lined and coated resilient metal-seated, full port, flanged isolation valve assemblies. Furnish full port ball valves ANSI Class 300, each, complete with electric actuator capable of closing and opening with differential pressures of 400 psi and under flow velocities up to 23 feet per second. Primary purpose of valve is for isolation and ability to close during emergency situations. Valves shall be factory tested, and operable, as shown on the drawings and as specified herein.

1.02 RELATED WORK

A. Section 40 27 03, Electric Motor Actuators.

1.03 REFERENCE

A. American National Standards Institute (ANSI): B1.20.1, Pipe Threads, General Purpose (inch).

B. American Petroleum Institute (API):

1. 6D, Specification for Pipeline Valves (Seat Leakage).
2. 598, Valve Inspection and Testing.
3. 609, Butterfly Valves: Double-Flanged, Lug- and Wafer-Type.

C. American Society of Mechanical Engineers (ASME):

1. B16.1, Gray Iron Pipe Flanges and Flanged Fittings.
2. B16.10, Face-to-Face and End-to-End Dimensions of Valves.
3. B16.34, Valves – Flanged, Threaded, and Welding End.
4. B16.47, Large Diameter Steel Flanges.
5. B31.1, Power Piping.
6. B31.3, Process Piping.
7. B46.1, Surface Texture (Surface Roughness, Waviness, and Lay) Standards Materials of Construction.

D. American Society for Testing and Materials (ASTM):

1. A27, Standard Specification for Steel Castings, Carbon, for General Application.
2. A148, Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
3. A182, Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
4. A216, Carbon Steel Castings.
5. A322, Specification for Steel Bars, Alloy, Standard Grades.
6. A351, Stainless Steel Castings.
7. A395, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
8. A536, Standard Specification for Ductile Iron Castings.
9. A564, Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
10. A609, Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof.
11. B62, Specification for Composition Bronze or Ounce Metal Castings.
12. B427, Specification for Gear Bronze Alloy Castings.
13. D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
14. E125, Standard Reference Radiographs for Magnetic Particle Indications on Ferrous Castings.
15. E186, Standard Reference Radiographs for Heavy-Walled (2-in to 4 1/2-in. (50.8-mm to 114-mm)) Steel Castings.
16. E709, Standard Guide for Magnetic Particle Testing.
17. S316000, UNS Specification for Stainless Steel.
18. S31803, UNS Specification for Stainless Steel.

E. American Water Works Association (AWWA):

1. C207, Standard for Steel Pipe Flanges for Waterworks Service.
2. C210, Liquid Epoxy Coatings and Linings for Water Pipe and Fittings.
3. C213, Fusion-Bonded Epoxy coating for the Interior and Exterior of Steel Water Pipelines.
4. C507, Ball valve, 6 inch. Through 60 inch (150mm through 1,500mm).

F. International Organization for Standardization (ISO):

1. 3506, Mechanical Properties of Corrosion Resistant Stainless Steel Fasteners.
2. 5211/1, Part-Turn Valve Actuator Attachment.
   a. Part 1: Flange Dimension.
   b. Part 2: Flange and Coupling Performance Characteristics.
3. 9001, Quality Management Standard.

G. Manufacturers Standardization Society (MSS):

1. SP-6, Standard Finishes for contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings.
2. SP-25, Standard Marking System for Valves, Fitting, Flanges, and Unions.
3. SP-55, Quality Standard for Steel Castings for Valves, Flanges, and Fittings, and Other Piping Components.

H. National Sanitation Foundation (NSF): 61, Drinking Water System Components – Health Effects

I. Occupational Safety and Health Act of 1970, as amended (OSHA).

J. UL.

K. American Welding Society (AWS): D1.1, Structural Welding Code, Steel.

L. The Society for Protective Coatings (SSPC): SP-10, Near White Metal Blast Cleaning.

1.04 SUBMITTALS

A. Submit the following before manufacturing:

1. Manufacturer’s data and descriptive literature including catalog data, calculations for all valve parts, and descriptions of materials of construction with their applicable material specifications such as AISI, ANSI, ASME, ASTM, AWWA, American Society of Automotive Engineers, or the Copper Development Association. Identify each valve by tag number to which the catalog data and detail sheets pertain.
2. If a company other than the valve manufacturer completes the valve casting and machining, provide the company name, contact person, and location of mill used for casting, and the company name, contact person, and location of where the machining of the casting shall be performed.

3. Inspection certificates that certify quality of all metallic products (such as, plates, sheets, bars, forgings, castings) are in compliance with the requirements of the order per ISO 10474/EN 10204.
4. Inspection documents and test reports that certify quality of all metallic products (such as, plates, sheets, bars, forgings, castings) are in compliance with the requirements of the order as defined in ISO 10474/EN 10204. Include at a minimum data for the following items:
   a. Heat treatment.
   b. Chemical analysis.
   c. Mechanical tests.
   d. Non-destructive test procedures and results.
5. Foundry and Manufacturing Quality Control and Quality Assurance Plan including at a minimum:
   a. ISO 9001 certification.
   b. Quality control recordkeeping.
   c. Sources of materials and material quality control procedures.
   d. Physical testing methods and procedures.
   e. Coating materials and procedures.
   f. Repair methods and procedures.
   g. Detailed inspection test plan with inspection witness and hold points.
   h. Product control procedures documenting the manufacture of the valve throughout the manufacturing and fabrication process.
6. Fabrication and production schedule.
7. Production drawings showing valve dimensions, laying lengths, port sizes, component parts, materials of construction, 3D model or stp file of the valve and actuators, and computer modeling results of estimated noise and cavitation levels.
8. Shop assembly drawings showing dimensions and orientation of valve actuators as installed on the valves and location of internal stops for gear actuators.
9. Shop coating and lining specifications, application instructions, and descriptive literature, including NSF 61 lining certification, and which clearly identifies all valve linings and coatings.
10. NSF 61 certification of valve.
11. A valve summary data sheet that provides the type, manufacturer, size, pressure rating, drilling pattern, and model number of each valve; and type, and manufacturer and model number of the valve actuator.
12. Shop performance test plan including all testing and inspection datasheets to demonstrate compliance with specified industry standards.
13. Field performance test plan including all initial testing and inspection after valve installations, and proposed inspections and

tests to demonstrate valve conformance with the specifications after one year of operation.

14. Valve support anchor calculations and shop drawings, signed by a California Registered Professional Engineer, for equipment design and equipment anchorage layout and details per California Building Code requirements.
15. Calculations demonstrating the valve body and components are designed for the rated pressures and the valve will perform under the specified operating conditions.

B. Submit the following for approval during manufacturing:

1. A complete descriptive report of defects, supplemented with sketches, photographs, and metallurgical test reports, as the case may warrant, and the proposed repair procedure before any repair of minor defects.
2. Inspection reports, photographs and other test documentation demonstrating the valve is repaired in accordance with the approved repair procedure.

C. Submit the following for approval before shipping:

1. Certified shop hydrostatic test reports, seat leakage test reports, performance test reports, mil thickness and holiday free coating and lining test repots, and any other required test reports. Test reports shall be presented to reflect the requirement of the test procedures specified herein. Performance test reports shall show all relevant test parameters of the valve and actuator assembly as tested in the manufacturer’s facility, and shall indicate valve position, flow rate, and inlet/outlet pressures at a minimum. Report shall include handwheel rotation direction, valve full stroke calibration data, pilot pressure settings, operating times, and visual inspection notes.
2. Coating and lining test reports that verify the valve interior lining condition has been tested for an absence of holidays and for lining thickness. Describe test results and repair procedures for the valve. Do not ship valve to project site until the reports have been accepted.
3. Operation and Maintenance data for each valve.
4. Factory export packaging specifications, applicable to overseas shipping via surface carrier.
5. Manufacturer’s required and recommended storage conditions, storage maintenance requirements, and storage, handling, and storage maintenance instructions.
6. Warranty certification.

1.05 QUALITY ASSURANCE

A. Manufacturer of valve shall have a minimum of 5 years of recent continuous product history in the waterworks industry, 5 years of experience manufacturing a minimum of 10 valves of comparable size, capacity, and complexity, as specified herein, and five years of successful, continuous service in water service facilities. The burden of proof to the comparative quality and suitability of equipment and material supplied shall be the responsibility of the manufacturer who shall furnish a list and contact information of water service facilities that includes service details, performance data, equipment type, and quality of the materials offered to those listed as a reference.

B. Manufacturer and foundry shall be ISO 9001 certified.

C. Perform design calculations for each pressure class and valve size range showing the valve body, rotor, and components are designed in accordance with the specified requirements.

D. All butt welds on skinplates and main beam flanges shall be given complete nondestructive examination by ultrasonic method. All welds on other components shall be given complete nondestructive examination by ultrasonic and either dye penetrant or magnetic particle methods, supplemented by radiographic examination where necessary. Provide supplemental radiographic examination for all areas where interpretations by other methods are unclear, or where the integrity of the weld is doubtful.

E. Engineer may request random spot-check examination or welds, including radiographic examination, as part of the equipment inspection.

F. Examination of welds shall be in accordance with the technique and acceptance standard of section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code; ultrasonic examination in accordance with paragraph UW53; and radiographic examination in accordance with paragraph UW51 unless otherwise approved.

G. Give major forgings an ultrasonic examination with liberal overlap and other applicable non-destructive tests to the extent necessary to determine they are sound. Conduct non-destructive examination of minor forgings in accordance with accepted good practice to ensure their soundness, and indicate the type of examination on the shop drawings. The structure of forgings shall be homogeneous and free from excessive nonmetallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a forging shall be cause for its rejection.

H. All castings shall be given a complete ultrasonic examination and a radiographic examination insofar as practicable. No casting will be accepted having defects in any category A through E with severity levels four or five when evaluating defects in accordance with ASTM E186. Where radiographic examination is not practicable due to configuration or accessibility, give castings a nondestructive examination by dye penetrant or magnetic particle methods in addition to an ultrasonic examination.

I. Inspect castings visually at the foundry after they are cleaned and while defects are being removed. Inspect castings after repairs and after heat treatment. Radiographic or other nondestructive tests are required as specified and as directed when repairs to major defects are required. Nondestructive tests may be required to determine:

1. The full extent of defects;
2. That the area is properly prepared for welding; and
3. That the repairs are satisfactory.

J. Inspect castings of valve parts by magnetic particle examination in accordance with ASTM E125. Remove defects exceeding the following limits:

Type	Degree
Linear Discontinuities (hot tears and cracks)	All
Shrinkage	2
Inclusions	3
Chills and Chaplets	1
Porosity	1

K. Defects:

1. Minor defects, that will not impair the strength or serviceability of the castings, may be repaired by welding in accordance with accepted foundry practice without review by the Engineer. Defects shall be considered minor when the depth or cavity properly prepared for welding is not greater than 25 percent of the actual wall thickness but in no case greater than 0.75 inches and when the area to be welded is smaller than eight square inches.
2. Major defects are an accumulation of minor defects, or defects greater than any minor defect. If removal of defects reduces the stress-resisting cross-section of the casting by more than 30 percent, the casting may be rejected. All castings repaired by welding of major defects after heat treatment shall be heat-treated again.

3. Dimensions of castings shall not be reduced due to shop or foundry practices by an amount sufficient to impair the strength of castings by more than 10 percent (calculated from drawing dimensions). Dimensions shall not be oversized to the extent that a casting interferes with processing operations or proper fit with other parts. Warped or otherwise distorted castings shall not be used without submitting complete details for the Engineer's review.

L. Coating Inspections:

1. Measure coating thickness with a calibrated magnetic-type or electronic dry-film thickness gauge. Provide dry-film thickness gauge as manufactured by Mikrotest, Elcometer, or equal. Check each for the correct dry-film thickness. Do not measure within eight hours after application of the coating.
2. Dry Film Thickness of applied coating shall not exceed NSF 61 certification requirements.

M. Perform shop assembly, tests, and inspections before shipment to verify design, construction, lining, and coatings were manufactured as specified in the presence of the Engineer.

1. Test each valve before shipment in accordance with API 598 and the following minimum standards:
   a. Hydrostatic test: Pressure test the valve body and leakage test the valve seat, to demonstrate zero leakage (0 drops per minute) in both flow directions according to the pressures and procedures described in API 598. Criteria for acceptance shall be as specified in API 598.
   b. Leakage test: After the hydrostatic test is satisfactorily completed, close the valve and remove the test bulkhead from the downstream end of the valve and reduce the internal hydrostatic pressure to 1.1 times the valve pressure rating for a period of 60 minutes to verify zero drop per minute leakage.
   c. Functional Test: Test valve through three complete cycles of operation with the valve actuator settings in place, including but not limited to switches, torque switches, and pilot pressure settings. Verify the pull required to operate the handwheel, confirm the valve travel time is not less than specified, and the valve operates without sticking or binding.

N. Inspect shop assembled components for accurate fit, correctness of dimensions, accuracy of alignment, and ease of movement. Correct errors and misalignments.

O. Correct all defects, distortion, and leakage detected during shop testing to the satisfaction of the Engineer. Repeat tests if, in the opinion of the Engineer, further tests are warranted. Provide all necessary parts and perform adjustments and re-testing.

P. Prepare a complete test report showing in detail all results of shop tests, including dimensional checks. The test report shall include a detailed tabulation showing values of measurements and all adjustments recorded during the tests including certified shop test reports.

Q. Align and matchmark components to ensure proper field alignment. Provide templates, photos, dowels, and setting plates where applicable to assist with field installation.

R. The Owner will witness and require successful on-site shop inspection and testing of the axial flow control prior to shipment from the manufacture's facilities. The manufacturer shall provide a minimum of 8-week advance notice to the Owner prior to performing tests, and shall allow full access to designated Owner's representatives for inspection of manufacturing facilities and processes, and any specified testing. The manufacturer shall perform all testing at manufacturer's cost, unless such testing is specifically indicated to be provided by the Owner. The manufacturer is not responsible to cover travel cost for the Owner and their representatives to witness the shop testing and inspections. However, all testing shall occur on the agreed upon dates established 8 weeks prior to actual testing. Should the agreed upon dates need to be modified or changed then the manufacture is responsible to reimburse the Owner for any additional travel costs due to schedule changes or delays.

S. The Owner and Engineer will perform in-plant fabrication inspection. Owner and Engineer may inspect, observe testing and observe manufacturer inspections during all phases of the manufacture process. The following are witness and inspection hold points required by the Engineer. The Engineer reserves the right to perform additional hold point inspections if manufacturing issues arise during fabrication.

In-plant Fabrication Inspection Requirements		
Item	Quality Assurance	Remarks
Visual inspection of Castings for Defects at Foundry	Hold Point	MSS SP-55
Material Test Report verification to ASTM standards	Review	ASTM A216 ASTM A536

In-plant Fabrication Inspection Requirements		
Item	Quality Assurance	Remarks
Radiographic and ultrasonic testing of the whole valve body as practicable	Hold Point	Section 15106, ASTM
Ultrasonic Testing of Flanges	Hold Point	ASTM A609 Level 4 Procedure A
Magnetic Particle Testing on Inner and Outer surface of body casting	Hold Point	ASTM E125, ASTM E709
Welding of Casting-Forging repairs	Hold Point	AWS D1.1, and Approved Procedure
NDE of Casting-Forging repairs	Hold Point	Section 15106, ASTM
Hydrostatic Testing of Body before assembly	Hold Point	
Visual Review of Cast parts after abrasive blasting	Hold Point	SSPC SP-10, MSS SP-55
Dimensional and visual inspection of parts after machining	Witness	Approved Drawing
Hydrostatic Testing of Body after assembly	Hold Point	API 598
Rotor strength tests	Hold Point	In both directions
Hydrostatic seat tests	Hold Point	API 598
Functional Test	Hold Point	Approved Procedure
Verification of Product Marking	Review	MSS SP-25
Fusion Bonded Epoxy and Paint Application	Witness	
Visual Inspection of Fusion Bonded Epoxied and Painted Surfaces	Witness	
Verification of Paint Thickness	Hold Point	NSF 61

In-plant Fabrication Inspection Requirements		
Item	Quality Assurance	Remarks
Adhesion Testing of painted surfaces	Witness	ASTM D4541, AWWA C210
Holiday Testing of wetted surfaces	Hold Point	
Packing Inspection	Witness	
Legend Hold Point – Requires 48-hour notification prior to starting the Work. Work can proceed after Engineer approves the item. Witness Points – Requires 48-hour notification prior to starting the Work.		

T. Notify the Owner and Engineer eight weeks in advance of valve testing. Allow the Owner and Engineer full access for inspection as specified herein.

1.06 SHIPPING AND STORAGE

A. Package valves, actuators, and associated equipment to prevent damage during shipping, and for storage after delivery in accordance with the manufacturer’s recommendations.

B. Before shipping flanged valves, clean flanges by wire brushing and coat unpainted machined surfaces of the flange with strippable, rust-preventative compound. Fasten full-face flange protectors of waterproof plywood or weather-resistant pressboard, of a diameter at least that of the outside of the flange, to each flange to protect both the flange and the interior of the valve.

C. Valves may be fully packaged at the manufacturer’s option. Bolt or otherwise fasten valves to skids or other supports, so as to preclude damage in subsequent handling.

1.07 SERVICE RESPONSE

A. The valve manufacturer shall provide 24-hour manufacturer’s response for any field service requirement during construction, testing and start-up. Approved service agents, licensee(s), or representatives of the manufacturer shall be permitted as long as the valve manufacturer is present. The valve manufacturer shall be responsible for its authorized agents and licensees. A detailed manufacturers signed service call write up, inclusive of photo-documentation, shall be provided without exception, by the valve manufacturer. The valve manufacturer shall be required to know and keep data files on all work performed, modifications and remediation's as well as the agents performing the work. This data shall be permanently kept with the manufacturer regardless of licensee.

PART 1 PRODUCTS

2.01 GENERAL

A. Supply valves complete with operating handwheels or levers, gear actuators, operating nuts, and wrenches required for operation.

B. Provide lifting and handling eyes.

2.02 MARKING

A. Each valve shall have the manufacturer name, address, catalog number, pressure rating, valve size, and if identified the valve ID number cast or molded onto the valve body or bonnet shown on a permanently attached plate.

B. Cast or stamp the preferred high pressure side on the valve body, if applicable.

2.03 VALVE ACTUATORS

A. Provide enclosed worm and gear type actuators and handwheel. Gear actuators shall be enclosed, lubricated with oil or grease, and provided with seals on shafts to prevent entry of dirt and water into the actuator.

B. Worm and gear actuators shall permit operation of the valve under full differential pressure rating of the valve with a maximum rim pull of 80 pounds on the handwheel and a maximum input of 150 foot-pounds on wrench nut. Design gear actuators assuming the differential pressure across the rotor is equal to the pressure rating of the valve.

C. Provide stop limiting devices in the actuators in the open and closed positions. Design actuator components between the input and the stop-limiting devices to withstand without damage a pull of 200 pounds for handwheel or chainwheel actuators, and an input torque of 300 foot-pounds for operating nuts when operating against the stops.

D. Actuators shall be self-locking type, one-piece design made of gear bronze material (ASTM B427), accurately machine cut. The worm shall be hardened alloy steel (ASTM A322, Grade G41500; or ASTM A148, Grade 105-85), with thread ground and polished. Helix angle of worm and gear shall be designed and cut at 3.5 degrees or less to prevent creep, unless other means to prevent creep are employed and are approved by the Engineer. The actuator shall prevent creeping of the valve under all flow conditions. Support worm gear shaft at each end by ball or tapered roller bearings. Provide reduction gearing to meet maximum torque and pull design requirement. The reduction gearings shall run in a proper lubricant. Worm gear actuators shall be Auma Model GS "or-equal."

E. Provide open and close limit switches with one normally open and normally closed contact for valves. Mount switches on the valve such that the corresponding switch transfers when the valve is fully open and fully closed. Limit switches shall be Square D Class 9007, HA 1 arm, C54B2 switch, "or-equal."

F. Provide a dial indicating the position of the valve rotor.

2.04 OPERATIONAL REQUIREMENTS

A. Valves are used for pipeline isolation and are operated year-round primarily either in the open or closed position.

B. The maximum flow velocity through each valve is 10 feet per second.

C. Valves shall be pressure rated to minimum 400 psi and operate without cavitation, vibration, or excessive noise in the 100 percent open position for flow velocities up to 10 feet per second.

D. Ball Valves and Operating Conditions under this Contract Include:

1. 60-inch Ball Valve:
   a. Pressure Rating 400 psi.
   b. Normal Operating Flow Range: 0 cubic feet to 120 cubic feet per second (cfs).
   c. Maximum Operating Flow: 120 cubic feet per second (cfs).
   d. Minimum Operating Flow: 3 cubic feet per second (cfs).
   e. Maximum Inlet Pressure: 330 psi (at 0 cfs = static).
   f. Minimum Inlet Pressure: 175 psi.
   g. Operating Function: Continuous year round operation at Normal Operating Flow and Head ranges listed above.

E. Material stresses shall not exceed 1/5 of the ultimate, or 1/3 of the yield strength of the material.

F. Design and protect valve body and components so they last 25 years in continuous operation with normal manufacturer recommended maintenance.

G. Design the valves to be lifted and lowered into place through roof hatches as shown on Drawings.

2.05 DESIGN FEATURES

A. Valves shall be double-flanged, non-rubbing, non-jamming, torque-seated, resilient metal-to-metal seating fusion bonded lined and coated, quarter turn full port type valve capable of zero leakage (0 drops per minute) service.

B. Valves shall operate without cavitation, vibration, or excessive noise for the operating conditions and pressures stated in Article Operational Requirements of this section.

C. Valves shall be, at minimum, in accordance with ASME B16.34 pressure and temperature ratings.

D. Valve body and flanges shall withstand induced pipe loads without distortion and effect on the movement of the valve rotor and seating operation. Design flange thickness in accordance with ASME Boiler and Pressure Code Section VIII flange design requirements and they shall be suitable for mating to the connecting pipe flanges.

E. Valve sealing design shall incorporate “inclined conical sealing” using three geometrical offsets (such as, “triple offset”), providing torque seating system. Position seated and “interference fit” sealing designs shall not be used. The valve shall be designed so that the rotor can never be rotated through the seat.

F. Valves shall be capable of bi-directional seating against pressures up to the valve pressure rating applied to one side of the rotor, with zero pressure applied to the other side of the rotor in the CLOSED position, with zero leakage (0 drop per minute), and without damage or permanent deformation to any part of the valve body, seat, rotor, shaft, bearings, or actuator.

G. Valves shall have a field replaceable “laminated” seal ring retained in the body or rotor. The seal ring shall be constructed of laminates of stainless steel and graphite. No elastomers shall be used in the sealing system. Seal ring design shall also include the following parameters:

1. The seal ring shall be accessible (replaceable) by positioning the rotor in a proper orientation and removing an adjacent pipe spool piece without removing or disassembling the valve.
2. The seal ring shall be machined in an inclined conical shape to match the companion surface (in the body or on the rotor, as appropriate). The geometry of the seal ring shall be formed to provide resilient seating.
3. Each seal ring shall be identical and interchangeable for valves of the same size.

4. The seal ring shall be mechanically retained in place by a bolted, stainless steel retaining ring.
5. A spiral wound or flat static gasket shall be provided to prevent leakage around the seal ring.
6. The seal ring shall be indexed and keyed to ensure exact and proper installation or reinstallation without shims.
7. No special tools shall be required to install the seal ring.
8. Valve seating surface for the seal ring shall be integral to the valve body or on the rotor edge. Overlay seating surfaces on the valve body with 2.5 mm with hardened Type 316 stainless steel or StelliteTM Gr.21 in the finished condition, without exception. Valve seating shall be achieved by applying a pre-determined and calculated torque value to the valve rotor. This value shall be consistent for all valves of the same size. Valve seat leakage shall be zero (0 drop per minute) in both high pressure water and low pressure air according to API 598.
9. Seal shall be bi-directional.

H. Rotor attachment to the shaft shall be by means of parallel keys made of material consistent with shaft. Pins of any kind shall not be used for torque transmission.

I. Each valve shaft shall be two piece stainless steel with long length stainless steel bearings conforming to API 609 anti-blowout protection. Valve with two-piece shafts will not be accepted. Allowable stresses shall be limited to 33 percent of Ultimate Tensile Strength and 67 percent of Yield Strength in accordance with ASME Boiler and Pressure Code, Section. III, Case N62.6. The shaft diameter shall be reduced at the actuator connections so as to put the weakest point outside the valve, outside the packing.

J. Valves shall be press-fit shaft bearings with replacement inboard bearing protectors. Top and bottom bearing flush taps shall be provided to prevent ingress of particulates or contaminants to the bearing area.

K. Valve shaft seal shall be by adjustable packing box. Packing gland shall have minimum of four retaining bolts for even packing compression.

L. Operator mounting bracket shall be centered with machined register and minimum of two dowel pins shall be used in addition to bracket bolting to absorb torsional load from operator.

2.06 MATERIALS

A. Valve body: Cast steel complying with A216 Grade WCB as a minimum conforming to applicable ASME B16.34 specifications.

B. Valve rotor: Cast steel A216 Grade WCB as a minimum conforming to applicable ASME B16.34 specification. The overlay seating surfaces on the rotor edge with minimum 2.5 mm thickness hardened Type 316 stainless steel or StelliteTM Gr.21 in the finished condition, the overlay surface hardness is 350HB minimum..

C. Valve shaft: High strength stainless steel material with exceptional corrosion resistance capable of withstanding torque loads from intended use.

D. All materials of moving components in contact with each other shall be of dissimilar hardness to prevent galling.

E. Valve seal ring: Laminate type duplex stainless steel or Type 316 stainless steel and graphite.

F. Valve packing: Combination of graphite die-formed rings and braided graphite rope anti-extrusion rings.

G. Packing gland and end-cap: Stainless steel.

H. Rubber parts: Rubber parts exposed to water shall be made of a rubber compound that is resistant to free chlorine and monochloramine concentrations up to 10 mg/l in the fluid conveyed.

I. Valve bearings: Ni-Resist alloy or Type 316 stainless steel with nitriding treatment. Bearings shall be sealed from the ingress of particulates and contaminants. Wetted bronze parts shall be in conformance with ASTM B62, containing not more than: 5 percent zinc, 2 percent aluminum, 8 percent lead, and 83 percent copper plus nickel, plus silicon.

J. Trunnion flange bolting: Bolting shall comply with ASME B31.1 and ASME B31.3, and shall use at least four retaining bolts. Material of bolting to be ISO 3506 A4 Grade. Type 316 Stainless Steel, “or-equal.”

2.07 FLANGES

A. Flanged connections shall mate and be compatible with adjacent flanges that are ASME B16.5, Class 300 Series A raised face flanges for diameters 24-inches and smaller. For diameters 26-inches and larger, adjacent flanges are ASME B16.47, Class 300 Series A raised face flanges.

B. Provide flat faced flanges coated without projection or raised face. Raised face flanges will not be accepted. Use a serrated concentric finish having at least a four groove finish to aid in gasket retention. Serrations shall be V-shaped at an angle of 60 degrees, and 0.04-inch to 0.06-inch deep.

2.08 VALVE SUPPORT

A. Design and provide the valve baseplate, a foundation plate, and anchor bolts to anchor the valve to the concrete pedestal. Both plates shall be made of carbon steel. The baseplate shall be unbolted to remove the valve from the adjacent piping by sliding the valve up to 3-inches horizontally away from the downstream flange before it is lifted vertically. The baseplate shall secure the valve to a foundation plate which is cast into a reinforced concrete pedestal. Provide pedestal anchors and all fasteners for mounting baseplate and foundation plate.

B. Design the valve support and anchoring system per the 2016 California Building Code based on actual loads, design, and layout of equipment supplied. The anchoring system shall allow for field adjustment for final valve installation. The final valve support and anchoring calculations and drawings shall be stamped by a professional engineer registered in the State of Utah.

C. Provide the valve body with integral supporting feet designed for transmitting the full vertical load, including the weight of any contained water and thrust from the valve operating mechanism to base plates secured in the concrete pedestals. The valve supporting feet shall have slotted holes for the anchor bolts to permit any slight lateral movement, which may be experienced due to elongation of the exposed portion of the penstock immediately upstream of the valve during closure, and the mating surfaces shall be finished smooth to facilitate such lateral movement.

2.09 PAINTING AND COATING

A. Valves shall be fusion-bonded epoxy (FBE) lined and coated in accordance with AWWA C231 and as specified herein.

B. The valve shall be blast coated to near white metal. The blast cleaned body shall be then thoroughly cleaned to remove all dust, grease, oil or other negative adhesion potentials. It shall meet the coating manufacturers recommended duration for humidity and temperature and at coating application. Coating shall take place within 12 hours of the blast cleaning process.

C. The applied coating shall be tested and signed and dated-verified holiday free with a dry film thickness of a minimum of 12 mils DFT or as specifically stated in the coatings section.

D. Coat metal valves and accessories, excluding actuators, with FBE. Line the interior metal parts of valves, excluding seating areas and bronze and stainless-steel pieces, with FBE.

E. Interior valve surfaces, except stainless steel, monel, machined, or bearing surfaces shall be NSF 61 certified.

2.10 WORKMANSHIP

A. Like parts and spare parts shall be interchangeable wherever possible. Surface finish of machined parts shall be adequate for their functional requirements. Machining of fits on renewable parts shall be accurate and to specified dimensions so that replacements made to drawing sizes may be readily installed.

B. Valves shall be free from manufacturing defects and shall be manufactured in a professional manner.

C. Provide a certificate of compliance with the requirements of this section, and the manufacturer's quality control program.

D. Electric Welding:

1. Make all welds continuous and watertight. All butt welds shall be full penetration welds welded from both sides.
2. Members to be joined by welding shall be cut to shape and size by mechanical or thermal means to suit the conditions. Design of welded joints and selection of weld filler metal shall allow thorough penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound metal free of visible defects, such as laminations or defects caused by cutting operations, and free from rust, oil, grease, and other foreign matter.
3. The qualification of welding procedures, welders, and welding operators for all welding including weld repairs shall conform to the AWS D1.1.
4. Treat welds so they display good appearance and have a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. Dress all welds which require nondestructive examinations by chipping and grinding, as required, for good interpretation by the selected weld examination methods.

E. Steel and Iron Castings:

1. Castings shall be free from injurious defects as determined by visual inspection in accordance with MSS SP-55 requirements and shall be satisfactorily cleaned for their intended use. Dress surfaces of castings which do not undergo machining for good appearance and for painting. Determine the location of existing defects, and remove

all defects which impair the strength or utility of the casting to sound metal and repaired by welding. The structure of the castings shall be homogeneous and free from excessive nonmetallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a casting will be cause for its rejection.

F. Correct all defects, distortion, and leakage detected during shop testing to the satisfaction of the Engineer.

2.11 MANUFACTURER

A. Armacon GmbH; Triple Offset Ball Valve.

PART 3 EXECUTION

3.01 INSTALLATION

A. Valve installation shall be in strict accordance with the manufacturer's printed recommendations, and the Contract Documents. Manufacture shall assist the Owner and selected Construction Contract with installation and startup of the valves. Manufacture shall provide two full time person days during installation and three full time person days during start-up and testing.

B. Four bound copies, and one CD of the Operations and Maintenance Manual are to be provided with the valve. The manuals shall include installation instructions, maintenance procedures and operation parameters.

3.02 WORKMANSHIP

A. Valves shall be free from manufacturing defects and shall be manufactured in a workmanlike manner. Valves shall be manufactured under the direction of a registered professional engineer.

B. Painting shall be per AWWA C213 and as specified herein. Grease and scale shall be completely cleaned from the valve prior to painting per Society for Protective Coatings (SSPC) standards.

C. All carbon steel components shall be painted with fusion bonded epoxy paint per AWWA C213 and as specified herein. A Certificate of Compliance with the purchaser's material specifications, and the manufacturer's quality assurance program shall be furnished with each valve.

3.03 FIELD TESTING AND PERFORMANCE

A. Manufacturer shall furnish all required startup assistance and inspection of installed valve at the Owner's facility.

B. Valves supplied under this Specification shall be field leak tested by the Contractor to the specified operating pressure in the closed position and shall not leak. Field leakage relevant to the plunger valve shall be corrected by the manufacturer at the manufacturer's expense. Field leakage test results shall be certified by the Owner, manufacturer's onsite representative, and Contractor.

C. Ball valves shall be subjected to onsite performance testing as part of the commissioning activities in accordance with a written performance test plan. To the extent possible, the valve shall be subjected to variable flow conditions, and the resulting control settings, flow, upstream and downstream pressures, noise levels, and vibration levels shall be documented and compared to the manufacturer's shop test results. Operational flow testing shall be performed on each valve to verify the following:

1. Simulate valve operation using local and remote control.
2. In-place (Field) Leakage Test: Contractor shall perform in-place (Field) Leakage Test regardless of which operational flow test method is selected: Field leak test all valves to the specified system tests pressure in the closed position with zero leakage. After verifying zero leakage to Owner satisfaction, exercise each valve through its full stroke at least two times during the second phase of pressure testing and system disinfection.
3. All Operational Flow Testing and In-place (Field) Leakage Tests performed during the construction period (not the warranty period) shall be witnessed by the Owner and manufacturer's representative. Test results shall be jointly certified by Owner or its representative, manufacturer's onsite representative, and the Contractor.
4. If the valve fails any of the tests, it shall be corrected by the manufacturer within 7 days at the manufacturer's expense.

D. Upon completion of the necessary field testing, the shop test results and field test results comparison shall be discussed and resolved during a meeting or teleconference, as determined by the Owner.

3.04 WARRANTY

A. The valve manufacturer shall warrant each valve to be free from defects in materials, workmanship, and performance for five years from the valve delivery date. Upon notice, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no additional cost.

B. The valve manufacture shall warrant each valve to be free from cavitation damage under normal operating conditions and defects in material, workmanship and performance for a period of 10 years from the data of recording the Notice of Completion. Upon notice by the Owner, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no cost to the Owner.

C. The valve actuator manufacturer shall warrant the actuators to be free from defects in materials, workmanship and performance for five years from the valve delivery date. Upon notice, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no additional cost.

END OF SECTION

SECTION 40 90 01
INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   b. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
   c. A312, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
   d. B32, Standard Specification for Solder Metal.
   e. B88, Standard Specification for Seamless Copper Water Tube.
2. International Society of Automation (ISA):
   a. S5.1, Instrumentation Symbols and Identification (NRC ADOPTED).
   b. PR12.6, Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations.
   c. S5.4, Standard Instrument Loop Diagrams.
   d. S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
   e. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 1, General Standards for Industrial Control and Systems.
4. National Institute of Standards and Technology (NIST).
5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
6. UL: 508A, Standard for Safety, Industrial Control Panels.

1.02 SUMMARY

A. Materials, equipment, and work included in this specification shall be performed by APCO. APCO is the Owner’s preferred automation subcontractor and shall be the selected subcontractor for this portion of the Contract.

B. Work Includes:

1. Engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and Owner training for complete Process Instrumentation and Control (PIC) for plant.
2. Major parts are:
   a. Primary elements, transmitters, and control devices.
   b. Wall-mounted control panels.
   c. One freestanding control panel.
   d. One programmable logic controller.
   e. Interfaces with existing control systems.

C. Detailed Design: PIC as shown and specified includes functional and performance requirements and component specifications. Complete detailed PIC design.

1.03 DEFINITIONS

A. Abbreviations:

1. LCP: Local Control Panel.
2. MCC: Motor Control Center.
3. PAT: Performance Acceptance Test.
4. PIC: Process Instrumentation and Control.
5. PLC: Programmable Logic Controller.
6. RTU: Remote Telemetry Unit.

B. Rising/Falling: Terms used to define actions of discrete devices about their setpoints.

1. Rising: Contacts close when an increasing process variable rises through setpoint.
2. Falling: Contacts close when a decreasing process variable falls through setpoint.

C. Signal Types:

1. Analog Signals, Current Type:
   a. 4 mA dc to 20 mA dc signals conforming to ISA S50.1.
   b. Unless otherwise indicated for specific PIC Subsystem components, use the following ISA 50.1 options:
      1) Transmitter Type: Number 2, two-wire.
      2) Transmitter Load Resistance Capacity: Class L.
      3) Fully isolated transmitters and receivers.

2. Analog Signals, Voltage Type: 1V dc to 5V dc within panels where a common high precision dropping resistor is used.
3. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.
4. Pulse Frequency Signals:
    a. Direct current pulses whose repetition rate is linearly proportional to process variable.
    b. Pulses generated by contact closures or solid-state switches as indicated.
    c. Power source less than 30V dc.
5. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

1.04 SUBMITTALS

A. Action Submittals:

1. General:
    a. Shop Drawings, full-scaled details, wiring diagrams, catalog cuts, and descriptive literature.
    b. Identify proposed items and options. Identify installed spares and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
    c. Legends and Abbreviation Lists: Complete definition of symbols and abbreviations used on this Project (for example, engineering units, flow streams, instruments, structures, and other process items used in nameplates, legends, and data sheets).
2. Bill of Materials: List of required equipment.
    a. Group equipment items as follows:
        1) I&C Components: By component identification code.
        2) Other Equipment: By equipment type.
    b. Data Included:
        1) Equipment tag number.
        2) Description.
        3) Manufacturer, complete model number, and all options not defined by model number.
        4) Quantity supplied.
        5) Component identification code where applicable.
3. Catalog Cuts:
    a. I&C Components, Electrical Devices, and Mechanical Devices:
        1) Catalog information, mark to identify proposed items and options.
        2) Descriptive literature.
        3) External power and signal connections.

4) Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.

4. Component Data Sheets: Data sheets for I&C components.
   a. Format and Level of Detail: In accordance with ISA-S20.
   b. Include component type identification code and tag number on data sheet.
   c. Specific features and configuration data for each component:
      1) Location or service.
      2) Manufacturer and complete model number.
      3) Size and scale range.
      4) Setpoints.
      5) Materials of construction.
      6) Options included.
   d. Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
5. Sizing and Selection Calculations for the following equipment:
   a. Uninterruptible power supply.
   b. DC power supplies.
6. Panel Construction Drawings:
   a. Scale Drawings: Show dimensions and location of panel mounted devices, doors, louvers, and subpanels, internal and external.
   b. Panel Legend: List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
   c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
   d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners, and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.
   e. Construction Notes: Finishes, wire color schemes, wire ratings, wire and terminal block, numbering, and labeling scheme.
7. Panel Control Diagrams: For discrete control and power circuits.
   a. Diagram Type: Ladder diagrams include devices, related to discrete functions, that are mounted in or on the panel and that require electrical connections. Show unique rung numbers on left side of each rung.
   b. Item Identification: Identify each item with attributes listed.
      1) Wires: Wire number and color. Cable number if part of multiconductor cable.
      2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.

3) Discrete Components:
    a) Tag number, terminal numbers, and location (“FIELD”, enclosure number, or MCC number).
    b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
4) Relay Coils:
    a) Tag number and its function.
    b) On right side of run where coil is located, list contact location by ladder number and sheet number. Underline normally closed contacts.
5) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).

c. Show each circuit individually. No “typical” diagrams or “typical” wire lists will be permitted.
d. Ground wires, surge protectors, and connections.
e. Circuit Names: Show names corresponding to Circuit and Raceway Schedule for circuits entering and leaving a panel. Refer to Division 26, Electrical.

8. Panel Wiring Diagrams: Show point-to-point and terminal-to-terminal wiring within panel.
9. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for: Pipes and Tubes: Thickness, pressure rating, and materials.
    a. Components: Valves, regulators, and filters.
    b. Connections to panel mounted devices.
    c. Panel interface connections.
10. Installation Details: Include modifications or further details required to adequately define installation of I&C components.
11. List of spares, expendables, test equipment and tools.
12. Additional Equipment Recommended: List of, and descriptive literature for, additional spares, expendables, test equipment and tools recommended. Include unit prices and total costs as specified in Section 01 29 00, Payment Procedures.

B. Informational Submittals: For PIC equipment, provide Manufacturer’s Certificate of Proper Installation and readiness for operation.

1. Owner Training Plan. Reference Section 01 43 33, Manufacturers’ Field Services.

2. Operation and Maintenance (O&M) Manuals: In accordance with Section 01 78 23, Operation and Maintenance Data, unless otherwise specified in this section.
    a. Content and Format:
        1) Complete sets O&M manuals.
        2) Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PIC component.
        3) Final versions of Legend and Abbreviation Lists.
        4) Manual format in accordance with Section 01 78 23, Operation and Maintenance Data.
    b. Include:
        1) Process and Instrumentation Diagrams: One reproducible copy of revised P&ID to reflect as-built PIC design.
        2) Refer to Article Submittals for the following items:
            a) Bill of Materials.
            b) Catalog Cuts.
            c) Component Data Sheets.
            d) Panel Control Diagrams.
            e) Panel Wiring Diagrams, one reproducible copy.
            f) Panel Plumbing Diagrams, one reproducible copy.
            g) Loop Diagrams, one reproducible copy.
            h) Interconnecting Wiring Diagrams, one reproducible copy.
            i) Application Software Documentation.
        3) Device O&M manuals for components, electrical devices, and mechanical devices include:
            a) Operations procedures.
            b) Installation requirements and procedures.
            c) Maintenance requirements and procedures.
            d) Troubleshooting procedures.
            e) Calibration procedures.
            f) Internal schematic and wiring diagrams.
            g) Component Calibration Sheets from field quality control calibrations.
        4) List of spares, expendables, test equipment and tools provided.
        5) List of additional spares, expendables, test equipment and tools recommended.
3. Performance Acceptance Tests (PAT) Submittals:
    a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.
    b. Final Test Procedures: Proposed test procedures, forms, and checklists.
    c. Test Documentation: Copy of signed off test procedures when tests are completed.

1.05 QUALITY ASSURANCE

A. Calibration Instruments: Each instrument used for calibrating PIC equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the NIST.

B. Coordination Meetings:

1. In accordance with Section 01 31 13, Project Coordination.
2. Location: Owner’s office.
3. Attended By: Engineer, Owner, and Contractor.
4. Minimum of four are required. Specific dates will be established in Progress Schedule.
5. First Meeting: Within 36 days after. Notice to Proceed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Provide Site and warehouse storage facilities for PIC equipment.

B. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.

C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.

D. Cover panels and other elements that are exposed to dusty construction environments.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Standard Environmental Requirements: Unless otherwise noted, design equipment for continuous operation in these environments:

1. Freestanding Panel and Consoles:
   a. Inside, Air Conditioned: NEMA 1.
   b. Inside: NEMA 12.
2. Smaller Panels and Assemblies (that are not Freestanding):
   a. Inside, Air Conditioned: NEMA 12.
   b. All Other Locations: NEMA 4X Type 316 stainless steel.
3. Field Elements: Outside.

B. Environmental Design Requirements: Following defines the types of environments referred to in the above.

1. Inside, Air Conditioned:
   a. Temperature:
      1) Normal: 60 degrees F to 80 degrees F.
      2) With Up to 4-Hour HVAC System Interruptions: 40 degrees F to 105 degrees F.
   b. Relative Humidity:
      1) Normal: 10 percent (winter) to 70 percent (summer).
      2) With Up to 4-Hour HVAC System Interruption: 10 percent to 100 percent.
   c. NEC Classification: Nonhazardous.
2. Inside:
   a. Temperature: 20 degrees F to 104 degrees F.
   b. Relative Humidity: 10 percent to 100 percent.
   c. NEC Classification: Nonhazardous.
3. Inside, Corrosive:
   a. Temperature: Minus 20 degrees F to 104 degrees F.
   b. Relative Humidity: 10 percent to 100 percent.
   c. Corrosive Environment: As noted on Drawings.
   d. NEC Classification: Nonhazardous.
4. Outside:
   a. Temperature: Minus 20 degrees F to 104 degrees F.
   b. Relative Humidity: 10 percent to 95 percent noncondensing, rain, snow, freezing rain.
   c. NEC Classification: Nonhazardous.
5. Outside, Corrosive:
   a. Temperature: Minus 20 degrees F to 104 degrees F.
   b. Relative Humidity: 10 percent to 95 percent noncondensing, rain, snow, freezing rain.
   c. Corrosive Environment: As noted on Drawings.
   d. NEC Classification: Nonhazardous.

1.08 SEQUENCING AND SCHEDULING

A. Activity Completion:

1. The following is a list of key activities and their completion criteria:
   a. Shop Drawings: Reviewed and approved.
   b. Quality Control Submittals: Reviewed and accepted.
   c. Hardware Delivery: Hardware delivered to Site and inventoried by Owner.
   d. PAT: Completed and required test documentation accepted.

B. PIC Substantial Completion: When Engineer issues Certificate of Substantial Completion.

1. Prerequisites:
   a. All PIC Submittals have been completed.
   b. PIC has successfully completed PAT.
   c. Owner training plan is on schedule.
   d. All spares, expendables, and test equipment have been delivered to Owner.

C. PIC Acceptance: When Engineer issues a written notice of Final Payment and Acceptance.

1. Prerequisites:
   a. Certificate of Substantial Completion issued for PIC.
   b. Punch-list items completed.
   c. Final revisions to O&M manuals accepted.
   d. Maintenance service agreements for PIC accepted by Owner.

D. Prerequisite Activities and Lead Times: Do not start the following key Project activities until the prerequisite activities and lead times listed below have been completed and satisfied:

Activity	Prerequisites and Lead Times
Submittal reviews by Engineer	Engineer acceptance of Submittal breakdown and schedule.
Hardware purchasing, fabrication, and assembly	Associated shop drawing Submittals completed.
Shipment	Completion of PIC Shop Drawing Submittals and preliminary O&M manuals.
Owner Training	Owner training plan completed
PAT	Startup, Owner training, and PAT procedures completed; notice 4 weeks prior to start.

PART 2 PRODUCTS

2.01 GENERAL

A. PIC functions as shown on Drawings and as required for each loop. Furnish equipment items as required. Furnish all materials, equipment, and software, necessary to effect required system and loop performance.

B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment and materials.

1. If an item is proposed from other than first named manufacturer, obtain approval from Owner for such changes in accordance with Article Submittals.
2. If using proposed item requires other changes, provide work and equipment to implement these changes. Changes that may be required include, but are not limited to: Different installation, wiring, raceway, enclosures, connections, isolators, intrinsically safe barriers, software, and accessories.

C. Like Equipment Items:

1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s services.
2. Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

D. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 LOOP SPECIFICATIONS

A. Location: Article Supplements.

B. Organization: By unit process and loop number.

C. Functional Requirements for Control Loops:

1. Shown on Drawings, in Panel Control Diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on Drawings.
2. Supplemented by Control Specifications.

D. Subheadings for Each Loop:

1. Functions: Clarifies functional performance of loop, including abstract of interlocks.
   a. Components: Lists major components for each loop. Information listed include tag numbers.

2.03 I&C COMPONENTS

A. Components for Each Loop: Major components for each loop are listed in Instrument List referenced in Article Supplements. Furnish all equipment that is necessary to achieve required loop performance.

B. Component Specifications: Generalized specifications for each type of component are located in Article Supplements.

2.04 NAMEPLATES AND TAGS

A. Panel Nameplates: Enclosure identification located on the enclosure face.

1. Location and Inscription: As shown.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 1/2-inch white on black background, unless otherwise noted.

B. Component Nameplates—Panel Face: Component identification located on panel face under or near component.

1. Location and Inscription: As shown.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

C. Component Nameplates—Back of Panel: Component identification located on or near component inside of enclosure.

1. Inscription: Component tag number.
2. Materials: Adhesive backed, laminated plastic.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.

1. Inscription:
   a. Refer to:
      1) Table under Paragraph Standard Pushbutton Colors and Inscriptions.

2) Table under Paragraph Standard Light Colors and Inscriptions.
3) P&IDs on Drawings.

2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
3. Letters: Black on gray or white background.

E. Service Legends: Component identification nameplate located on face of component.

1. Inscription: As shown.
2. Materials: Adhesive backed, laminated plastic.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

F. Nametags: Component identification for field devices.

1. Inscription: Component tag number.
2. Materials: 16-gauge, Type 304 stainless steel.
3. Letters: 3/16-inch imposed.
4. Mounting: Affix to component with 16-gauge or 18-gauge stainless steel wire or stainless steel screws.

2.05 ELECTRICAL REQUIREMENTS

A. In accordance with Division 26, Electrical.

B. I&C and Electrical Components, Terminals, Wires, and Enclosures: UL recognized or UL listed.

C. Wires within Enclosures:

1. ac Circuits:
   a. Type: 300-volt, Type MTW stranded copper.
   b. Size: For current to be carried, but not less than 18 AWG.
2. Analog Signal Circuits:
   a. Type: 300-volt stranded copper, twisted shielded pairs.
   b. Size: 18 AWG, minimum.
3. Other dc Circuits.
   a. Type: 300-volt, Type MTW stranded copper.
   b. Size: For current carried, but not less than 18 AWG.
4. Special Signal Circuits: Use manufacturer’s standard cables.
5. Wire Identification: Numbered and tagged at each termination.
   a. Wire Tags: Machine printed, heat shrink.
   b. Manufacturers:
      1) Brady PermaSleeve.
      2) Tyco Electronics.

D. Wires entering or leaving enclosures, terminate and identify as follows:

1. Analog and discrete signal, terminate at numbered terminal blocks.
2. Special signals, terminated using manufacturer’s standard connectors.
3. Identify wiring in accordance with Section 26 05 05, Conductors.

E. Terminal Blocks for Enclosures:

1. Quantity:
   a. Accommodate present and spare indicated needs.
   b. Wire spare RTU I/O points to terminal blocks.
   c. One wire per terminal for field wires entering enclosures.
   d. Maximum of two wires per terminal for 18-WG wire for internal enclosure wiring.
   e. Spare Terminals: 20 percent of all connected terminals, but not less than five per terminal block.
2. General:
   a. Connection Type: Screw compression clamp.
   b. Compression Clamp:
      1) Complies with DIN-VDE 0611.
      2) Hardened steel clamp with transversal groves that penetrate wire strands providing a vibration-proof connection.
      3) Guides strands of wire into terminal.
   c. Screws: Hardened steel, captive and self-locking.
   d. Current Bar: Copper or treated brass.
   e. Insulation:
      1) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
      2) Two funneled shaped inputs to facilitate wire entry.
   f. Mounting:
      1) Standard DIN rail.
      2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
      3) End Stops: Minimum of one at each end of rail.
   g. Wire preparation: Stripping only permitted.
   h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
   i. Marking System:
      1) Terminal number shown on both sides of terminal block.
      2) Allow use of preprinted and field marked tags.
      3) Terminal strip numbers shown on end stops.
      4) Mark terminal block and terminal strip numbers as shown on Panel Control Diagrams and Loop Diagrams.
      5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

3. Terminal Block, General-Purpose:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 30 amp.
    c. Wire Size: 22 AWG to 10 AWG.
    d. Rated Wire Size: 10 AWG.
    e. Color: Grey body.
    f. Spacing: 0.25 inch, maximum.
    g. Test Sockets: One screw test socket 0.079-inch diameter.
    h. Manufacturer and Product: Entrelec; Type M4/6.T.
4. Terminal Block, Ground:
    a. Wire Size: 22 AWG to 12 AWG.
    b. Rated Wire Size: 12 AWG.
    c. Color: Green and yellow body.
    d. Spacing: 0.25 inch, maximum.
    e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
    f. Manufacturer and Product: Entrelec; Type M4/6.P.
5. Terminal Block, Blade Disconnect Switch:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 10-amp.
    c. Wire Size: 22 AWG to 12 AWG.
    d. Rated Wire Size: 12 AWG.
    e. Color: Grey body, orange switch.
    f. Spacing: 0.25 inch, maximum.
    g. Manufacturer and Product: Entrelec; Type M4/6.SN.T.
6. Terminal Block, Fused, 24V dc:
    a. Rated Voltage: 600V dc.
    b. Rated Current: 16-amp.
    c. Wire Size: 22 AWG to 10 AWG.
    d. Rated Wire Size: 10 AWG.
    e. Color: Grey body.
    f. Fuse: 0.25 inch by 1.25 inches.
    g. Indication: LED diode 24V dc.
    h. Spacing: 0.512 inch, maximum.
    i. Manufacturer and Product: Entrelec; Type M10/13T.SFL.
7. Terminal Block, Fused, 120V ac:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 16-amp.
    c. Wire Size: 22 AWG to 10 AWG.
    d. Rated Wire Size: 10 AWG.
    e. Color: Grey body.
    f. Fuse: 0.25 inch by 1.25 inches.
    g. Indication: Neon Lamp 110V ac.
    h. Leakage Current: 1.8 mA, maximum.
    i. Spacing: 0.512 inch, maximum
    j. Manufacturer and Product: Entrelec; Type M10/13T.SFL.

8. Terminal Block, Fused, 120V ac, High Current:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 35 amps.
   c. Wire Size: 18 AWG to 8 AWG.
   d. Rated Wire Size: 8 AWG.
   e. Color: Grey.
   f. Fuse: 13/32 inch by 1.5 inches.
   g. Spacing: 0.95 inch, maximum.
   h. Manufacturer and Product: Entrelec; Type MB10/24.SF.

F. Grounding of Enclosures:

1. Furnish isolated copper grounding bus for signal and shield ground connections.
2. Ground bus grounded at a common signal ground point in accordance with National Electrical Code requirements.
3. Single Point Ground for Each Analog Loop:
   a. Locate at dc power supply for loop.
   b. Use to ground wire shields for loop.
   c. Group and connect shields in RTU cabinet.
4. Ground terminal block rails to ground bus.

G. Analog Signal Isolators: Furnish signal isolation for analog signals that are sent from one enclosure to another. Do not wire in series instruments on different panels, cabinets, or enclosures.

H. Power Distribution within Panels:

1. Feeder Circuits:
   a. One or more 120V ac, 60-Hz feeder circuits as shown on Drawings.
   b. Make provisions for feeder circuit conduit entry.
   c. Furnish terminal board for termination of wires.
2. Power Panel: Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
   a. Locate to provide clear view of and access to breakers when door is open.
   b. Breaker sizes: Coordinate such that fault in branch circuit will blow only branch breaker but not trip the main breaker.
      1) Branch Circuit Breaker: 15 amps at 250V ac.
   c. Breaker Manufacturers and Products: Square D, Type QO.
3. Circuit Wiring: P&IDs and Control Diagrams on Drawings show function only. Use following rules for actual circuit wiring:
   a. Devices on Single Circuit: 20, maximum.
   b. Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.

c. Branch Circuit Loading: 12 amperes continuous, maximum.
d. Panel Lighting and Service Outlets: Put on separate 15-amp, 120V ac branch circuit.
e. Provide 120V ac plugmold for panel components with line cords.

4. Provide Uninterruptible Power Supply UPS unit to provide power to all instruments, PLC, and network equipment in control panel. See Supplement Component Specifications for UPS requirements.

I. Signal Distribution:

1. Within Panels: 4 mA dc to 20 mA dc signals may be distributed as 1V dc to 5V dc.
2. Outside Panels: Isolated 4 mA dc to 20 mA dc only.
3. All signal wiring twisted in shielded pairs.

J. Signal Switching:

1. Use dry circuit type relays or switches.
2. No interruption of 4 mA to 20 mA loops during switching.
3. Switching Transients in Associated Signal Circuit:
   a. 4 mA dc to 20 mA dc Signals: 0.2 mA, maximum.
   b. 1V dc to 5V dc Signals: 0.05V, maximum.

K. Relays:

1. General:
   a. Relay Mounting: Plug-in type socket.
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: Rail.
   e. Provide holddown clips.
2. Signal Switching Relay:
   a. Type: Dry circuit.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 0 amps to 5 amps at 28V dc or 120V ac.
   d. Contact Material: Gold or silver.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 0.9 watts (dc), 1.2VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.
   h. Expected Electrical Life at Rated Load: 100,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Seal Type: Hermetically sealed case.
   k. Manufacturer and Product: Potter and Brumfield; Series KH/KHA.
3. Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general-purpose plug-in.
   b. Contact Arrangement: 3 Form C contacts.

c. Contact Rating: 10A at 28V dc or 240V ac.
d. Contact Material: Silver cadmium oxide alloy.
e. Coil Voltage: As noted or shown.
f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
g. Expected Mechanical Life: 10,000,000 operations.
h. Expected Electrical Life at Rated Load: 100,000 operations.
i. Indication Type: Neon or LED indicator lamp.
j. Push to test button.
k. Manufacturer and Product: Potter and Brumfield; Series KUP.

4. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
   g. Expected Mechanical Life: 500,000 operations.
   h. Expected Electrical Life at Rated Load: 50,000 operations.
   i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
5. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 240V ac.
      1) Contact Material: Silver cadmium oxide alloy.
   d. Coil Voltage: As noted or shown.
   e. Operating Temperature: Minus 10 degrees C to 55 degrees C.
   f. Repeatability: Plus or minus 2 percent.
   g. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
   h. Time Delay Setpoint: As noted or shown.
   i. Mode of Operation: As noted or shown.
   j. Adjustment Type: Integral potentiometer with knob external to dust cover.
   k. Manufacturer and Products: Potter and Brumfield:
      1) Series CB for 0.1 second to 100-minute delay time ranges.
      2) Series CK for 0.1 second to 120-second delay time ranges.

L. Power Supplies:

1. Furnish to power instruments requiring external dc power, including two-wire transmitters and dc relays.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that

instruments being supplied can operate within their required tolerances.

3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1 in accordance with NEMA 250.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.

M. Internal Panel Lights for Freestanding Panels:

1. Type: Switched 120V, 400 Lumen LED panel light.
2. Quantity: One light for every 4 feet of panel width.
3. Mounting: Inside and in the top of back-of-panel area.
4. Protective shield for lights.

N. Service Outlets for Freestanding Panels:

1. Type: Three-wire, 120-volt, 15-ampere, GFCI duplex receptacles.
2. Quantity:
   a. For panels 4 feet wide and smaller: One.
   b. For panels wider than 4 feet: One for every 4 feet of panel width, two minimum per panel.
3. Mounting: Evenly spaced along back-of-panel area.

O. Internal Panel Lights and Service Outlets for Smaller Panels:

1. Internal Panel Light: Switched 120V, 400 Lumen LED panel light.
2. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle:
3. Required for following panels: RTU Panel.

P. Standard Pushbutton Colors and Inscriptions: Use following color code and inscriptions for pushbuttons, unless otherwise noted in Article Supplements.

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black

Tag Function	Inscription(s)	Color
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

1. Lettering Color:
   a. Black on white and yellow buttons.
   b. White on black, red, and green buttons.

Q. Standard Light Colors and Inscriptions: Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted in Instrument List, Article Supplements.

Tag Function	Inscription(s)	Color
ON	ON	Green
OFF	OFF	Red
OPEN	OPEN	Green
CLOSED	CLOSED	Red
LOW	LOW	Green
FAIL	FAIL	Amber
HIGH	HIGH	Red
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow

1. Lettering Color:
   a. Black on white and amber lenses.
   b. White on red and green lenses.

2.06 MECHANICAL SYSTEMS

A. Manifold, Three-Valve Equalizing:

1. Type: For isolation and equalization of differential pressure transducers.
2. Materials: Stainless steel.
3. Manufacturers and Products:
   a. Anderson, Greenwood and Co.; Type M1.
   b. Evans.

B. ON/OFF Valves:

1. Type: Ball valve.
2. Materials: Stainless steel.
3. Manufacturers and Products:
   a. Whitey; Series 41 through Series 43.
   b. Hoke; Flomite 7100 Series.

C. Regulating Valves:

1. Type: Needle valves, with regulating stems and screwed bonnets.
2. Materials: Stainless steel.
3. Manufacturers and Products:
   a. Whitey; Catalog No. RF or RS.
   b. Hoke; 3100 through 3300 Series.

D. Valve, Three-Way:

1. Type: Ball valve.
2. Materials: Stainless steel with nylon handle.
3. Manufacturers and Products:
   a. Whitey; Series 41 through Series 43.
   b. Hoke; Selecto-Mite Series.

E. Solenoid Valve, Two-Way:

1. Type: Globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation.
2. Materials:
   a. Body: Brassed globe valves.
   b. Valve Seat: Buna-N.
3. Size: As noted and normally closed or opened, as noted.
4. Coil: 115V ac, unless noted otherwise.
5. Solenoid Enclosure: NEMA 4.
6. Manufacturer and Product: ASCO; Red Hat Series 8260.

F. Pressure Regulator, Air:

1. Provide air at reduced pressures, as shown, constant to within plus or minus 10 percent for flows from 0 to 300 scfh with 100 psi supply pressure.
2. Setscrew for outlet pressure adjustment.
3. Integral filter and relief valve.
4. Manufacturers and Products:
    a. Masoneilan; Series 77-4.
    b. Fisher; Series 67FR.

G. Pressure Regulator, Water:

1. Materials:
    a. Body: Bronze.
    b. Spring Case: Cast iron.
    c. Seat Rings: Brass.
    d. Valve Disk and Holder: Buna-N and bronze.
    e. Diaphragm: Buna-N diaphragm.
2. Sizing: For maximum of 7 psi offset pressure.
3. Manufacturers and Products:
    a. Fisher; Controls Type 95H or 95L.
    b. Masoneilan; Series 17.

H. Copper Tubing and Fittings:

1. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
2. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on the Drawings.
3. Manufacturers:
    a. Parker-Hannifin.
    b. Swagelok tube fittings.

I. Stainless Steel Tubing: ASTM A312, Type 316, seamless, soft annealed, as shown on Drawings, 0.065-inch wall.

J. Stainless Steel Fittings:

1. Compression Type:
    a. Materials: Stainless steel, ASTM A182 forged bodies or ASTM A276 barstock bodies, Type 316, flareless.
    b. Manufacturers and Products:
        1) Parker Flodar; BA Series.
        2) Swagelok tube fittings.

3) Parker CPI tube fittings; Parker A-LOK dual ferrule tube fittings.

2. Socket Weld Type:
   a. Materials: Stainless steel, ASTM A182 forged bodies or ASTM A276 barstock bodies, Type 316 for 3,000 psi maximum working pressure, safety factor 4:1.
   b. Manufacturers:
      1) Cajon.
      2) Swagelok.
      3) Parker WELDLOK.

K. Air Set: Consist of a shutoff valve, pressure regulator, discharge pressure gauge, and interconnecting tubing.

L. Tubing Raceways:

1. Cable tray systems complete with tees, elbows, reducers, and covers.
2. Size in accordance with manufacturer's recommendations for the intended service.
3. Materials: Aluminum.
4. Manufacturers:
   a. Globetray.
   b. Cope.

M. Air Supply Sets:

1. Parts: Integrally Mounted:
   a. Pressure Controls: Automatic START/STOP, factory set at 30 psig to 50 psig.
   b. Valves: Manual drain, manual shutoff, pressure relief, and check valve.
   c. Pressure gauge.
   d. Inlet filter muffler.
   e. Power: 120V ac.
   f. Compressor: Oilless, single cylinder, rated for at least 1 scfm at 50 psig.
   g. Manufacturers and Products:
      1) ITT Pneumotive; GH Series.
      2) Gast.
2. Simplex Air Supply Sets:
   a. Air Receiver: 2 gallons.
   b. Compressors: One.
3. Duplex Air Supply Sets:
   a. Air Receiver: 20-gallon.
   b. Compressors: Two.
   c. Automatic Failover Control: Factory set at 20 psig.

2.07 SPARE PARTS

Description	Percent of Each Type and Size Used	No Less Than
Fuses	20	5
Relays	20	3
Terminal Blocks	10	10

2.08 FABRICATION

A. General:

1. Panels with external dimensions and instruments arrangement as shown on Drawings.
2. Panel Construction and Interior Wiring: In accordance with the National Electrical Code, state, and local codes, NEMA, ANSI, UL, and ICECA.
3. Fabricate panels, install instruments, wire, and plumb, at the PIC factory.
4. Electrical Work: In accordance with Division 26, Electrical.

B. Factory Assembly: Assemble panels at the manufacturer’s factory. No fabrication other than correction of minor defects or minor transit damage shall be done on panels at Site.

C. UL Listing Mark for Enclosures: Mark stating “Listed Enclosed Industrial Control Panel” per UL 508A.

D. Wiring Within PIC Panels:

1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so that bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Abrasion protection for wire bundles which pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
   a. Locking-fork-tongue or ring-tongue lugs.
   b. Use manufacturer’s recommended tool with required sized anvil to make crimp lug terminations.
   c. Wires terminated in a crimp lug, maximum of one.
   d. Lugs installed on a screw terminal, maximum of two.

6. Connections to Compression Clamp Type Terminals:
    a. Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.
    b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
11. Plastic Wire Ducts Fill: Do not exceed manufacturer's recommendation.

E. Temperature Control:

1. Freestanding Panels:
    a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel or on panel.
    b. Ventilated Panels:
        1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel or on panel.
        2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
        3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
        4) Louver Construction: Stamped sheet metal.
        5) Ventilation Fans:
            a) Furnish where required to provide adequate cooling.
            b) Create positive internal pressure within panel.
            c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
        6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
2. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel or in panel face.

3. Space Heaters:
   a. Thermostatically controlled to maintain internal panel temperatures above dew point.
   b. Required for following panels: V16-RTU-0001.

F. Freestanding Panel Construction:

1. Materials: Sheet steel, unless otherwise shown on Drawings with minimum thickness of 10-gauge, unless otherwise noted.
2. Panel Fronts:
   a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
   b. No seams or bolt heads visible when viewed from front.
   c. Panel Cutouts: Smoothly finished with rounded edges.
   d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.
3. Internal Framework:
   a. Structural steel for instrument support and panel bracing.
   b. Permit panel lifting without racking or distortion.
4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.
5. Adjacent Panels: Securely bolted together so front faces are parallel.
6. Doors: Full height, fully gasketed access doors where shown on Drawings.
   a. Latches: Three-point, Southco Type 44.
   b. Handles: “D” ring, foldable type.
   c. Hinges: Full length, continuous, piano type, steel hinges with stainless steel pins.
   d. Rear Access Doors: Extend no further than 24 inches beyond panel when opened to 90-degree position.
   e. Front and Side Access Doors: As shown on Drawings.
7. Manufacturers:
   a. Saginaw Control and Engineering.
   b. Eaton B-Line.
   c. Hoffman Engineering Co.
   d. Rittal.

G. Nonfreestanding Panel Construction:

1. Based on environmental design requirements required and referenced in Article Environmental Requirements, provide the following:
   a. For panels listed as inside, air conditioned:
      1) Enclosure Type: NEMA 12 in accordance with NEMA 250.
      2) Materials: Steel.

b. For all other panels:
   1) Enclosure Type: NEMA 4X in accordance with NEMA 250.
   2) Materials: Type 316 stainless steel.
2. Metal Thickness: 14-gauge, minimum.
3. Doors:
   a. Rubber-gasketed with continuous hinge.
   b. Stainless steel lockable quick-release clamps.
4. Manufacturers:
   a. Saginaw Control and Engineering.
   b. Eaton B-Line.
   c. Hoffman Engineering Co.
   d. Rittal.

H. Factory Finishing:

1. Enclosures:
   a. Stainless Steel and Aluminum: Not painted.
   b. Nonmetallic Panels: Not painted.
   c. Steel Panels:
      1) Sand panel and remove mill scale, rust, grease, and oil.
      2) Fill imperfections and sand smooth.
      3) Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
      4) Sand surfaces lightly between coats.
      5) Dry Film Thickness: 3 mils, minimum.
      6) Color: Light gray.
2. Manufacturer’s standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with light gray color.

2.09 ELECTRICAL TRANSIENT PROTECTION

A. General:

1. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
2. Implementation:
   a. Provide, install, coordinate, and inspect grounding of surge suppressors at:
      1) Connection of ac power to PIC equipment including panels, consoles assemblies, and field mounted analog transmitters and receivers.

2) At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.

3. Construction: First-stage high energy metal oxide varistor and second-stage bipolar silicon avalanche device separated by series impedance. Includes grounding wire, stud, or terminal.
4. Response: 5 nanoseconds maximum.
5. Recovery: Automatic.
6. Temperature Range: Minus 20 degrees C to plus 85 degrees C.

B. Suppressors on 120V ac Power Supply Connections:

1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE 587 Category B test waveform.
2. First-Stage Clamping Voltage: 350 volts or less.
3. Second-Stage Clamping Voltage: 210 volts or less.
4. Continuous Operation:
    a. Power supplies for one four-wire transmitter or receiver: 5 amps minimum at 130V ac.
    b. All other applications: 30 amps minimum at 130V ac.

C. Suppressors on Analog Signal Lines:

1. Test Waveform: Linear 8 microsecond rise in current form 0 amps to a peak current value followed by an exponential decay of current reaching one half the peak value in 20 microseconds.
2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
    a. dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
    b. dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
    c. Maximum Loop Resistance: 18 ohms per conductor.

D. Physical Characteristics:

1. Mounted in Enclosures: Encapsulated inflame retardant epoxy.
2. For Analog Signals Lines: EDCO PC-642 or SRA-64 Series.
3. For 120V ac Lines: EDCO HSP-121.
4. Field Mounted at Two-Wire Instruments: Encapsulated in stainless steel pipe nipples. EDCO SS64 Series.
5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
    a. Enclosure: NEMA 4X fiberglass or Type 316 stainless steel with door.
        1) Maximum Size: 12 inches by 12 inches by 8 inches deep.
    b. Manufacturer and Product: EDCO; SLAC Series.

E. Installation and Grounding of Suppressors: As shown. See Surge Suppressor Installation Details. Grounding equipment, installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.

2.10 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:

1. Northern Instruments; Model Zerust VC.
2. Hoffmann Engineering Co; Model A-HCI.

2.11 SOURCE QUALITY CONTROL

A. Scope: Inspect and test entire PIC to ensure it is ready for shipment, installation, and operation.

B. Location: Manufacturer’s factory or Engineer approved staging Site.

C. Test: Exercise and test all functions.

D. Temporary PLC software configuring to allow PLC testing.

PART 3 EXECUTION

3.01 EXAMINATION

A. For equipment not provided by PIC, but that directly interfaces with the PIC, verify the following conditions:

1. Proper installation.
2. Calibration and adjustment of positioners and I/P transducers.
3. Correct control action.
4. Switch settings and dead bands.
5. Opening and closing speeds and travel stops.
6. Input and output signals.

3.02 INSTALLATION

A. Material and Equipment Installation: Retain a copy of manufacturers’ instructions at Site, available for review at all times.

B. Electrical Wiring: As specified in Division 26, Electrical.

C. Mechanical Systems:

1. Drawings for PIC Mechanical Systems are diagrammatic and not intended to specifically define element locations or piping and

tubing run lengths. Base materials and installations on field measurements.

2. Copper and Stainless Steel Tubing Support: Continuously supported by an aluminum tubing raceway system.
3. Install tubing conduit for plastic tubing and tubing raceways parallel with, or at right angles to, structural members of buildings. Make vertical runs straight and plumb.
4. Tubing and Conduit Bends:
    a. Tool-formed without flattening, and all of same radius.
    b. Bend Radius: Equal to or larger than conduit and tubing manufacturer’s recommended minimum bend radius.
    c. Slope instrument connection tubing in accordance with installation details.
    d. Do not run liquid filled instrument tubing immediately over or within a 3-foot plan view clearance of electrical panels, motor starters, or mechanical mounting panel without additional protection. Where tubing must be located in these zones, shield electrical device to prevent water access to electrical equipment.
    e. Straighten coiled tubing by unrolling on flat surface. Do not pull to straighten.
    f. Cut tubing square with sharp tubing cutter. Deburr cuts and remove chips. Do not gouge or scratch surface of tubing.
    g. Blow debris from inside of tubing.
    h. Make up and install fittings in accordance with manufacturer’s recommendations. Verify makeup of tube fittings with manufacturer’s inspection gauge.
    i. Use lubricating compound or TFE tape on stainless steel threads to prevent seizing or galling.
    j. Run tubing to allow, for example, clear access to doors, controls, and control panels; and to allow for easy removal of equipment.
    k. Provide separate support for components in tubing runs.
    l. Supply expansion loops and use adapters at pipe, valve, or component connections for proper orientation of fitting.
    m. Keep tubing and conduit runs at least 12 inches from hot pipes.
    n. Locate and install tubing raceways in accordance with manufacturer’s recommendations. Locate tubing to prevent spillage, overflow, or dirt from above.
    o. Securely attach tubing raceways to building structural members.
5. Enclosure Lifting Rings: Remove rings following installation and plug holes.

D. Removal or Relocation of Materials and Equipment:

1. Remove from Site materials that were part of the existing facility but are no longer used, unless otherwise directed by Engineer to deliver to Owner.
2. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

3.03 FIELD FINISHING

A. Refer to Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY CONTROL

A. Startup and Testing Team:

1. Thoroughly inspect installation, termination, and adjustment for components and systems.
2. Complete onsite tests.
3. Complete onsite training.
4. Provide startup assistance.

B. Operational Readiness Inspections and Calibrations: Prior to startup, inspect and test to ensure that entire PIC is ready for operation.

1. Loop/Component Inspections and Calibrations:
   a. Check PIC for proper installation, calibration, and adjustment on a loop-by-loop and component-by-component basis.
   b. Prepare component calibration sheet for each active component (except simple hand switches, lights, gauges, and similar items).
      1) Project name.
      2) Loop number.
      3) Component tag number.
      4) Component code number.
      5) Manufacturer for elements.
      6) Model number/serial number.
      7) Summary of functional requirements, for example:
         a) Indicators and recorders, scale and chart ranges.
         b) Transmitters/converters, input and output ranges.
         c) Computing elements' function.
         d) Controllers, action (direct/reverse) and control modes (PID).
         e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
      8) Calibrations, for example:
         a) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.

b) Discrete Devices: Actual trip points and reset points.
c) Controllers: Mode settings (PID).
9) Space for comments.
c. These inspections and calibrations will be spot checked by Engineer.
2. Leak Test: Provide instrument tubing leak test.

C. Performance Acceptance Tests (PAT): These are the activities that Section 01 91 14, Equipment Testing and Facility Startup, refers to as Performance Testing.

1. General:
a. Test all PIC elements to demonstrate that PIC satisfies all requirements.
b. Test Format: Cause and effect.
1) Person conducting test initiates an input (cause).
2) Specific test requirement is satisfied if correct result (effect) occurs.
c. Procedures, Forms, and Checklists:
1) Conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
2) Describe each test item to be performed.
3) Have space after each test item description for sign off by appropriate party after satisfactory completion.
d. Required Test Documentation: Test procedures, forms, and checklists. All signed by Engineer and Contractor.
e. Conducting Tests:
1) Provide special testing materials, equipment, and software.
2) Wherever possible, perform tests using actual process variables, equipment, and data.
3) If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.
4) Define simulation techniques in test procedures.
f. Coordinate PIC testing with Owner and affected Subcontractors.
1) Excessive Test Witnessing: Refer to Supplementary Conditions.
2. Test Requirements:
a. Once facility has been started up and is operating, perform a witnessed PAT on complete PIC to demonstrate that it is operating as required. Demonstrate each required function on a paragraph-by-paragraph and loop-by-loop basis.
b. Perform local and manual tests for each loop before proceeding to REMOTE and AUTOMATIC modes.

c. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
d. Make updated versions of documentation required for PAT available to Engineer at Site, both before and during tests.
e. Make one copy of O&M manuals available to Engineer at the Site both before and during testing.
f. Refer to referenced examples of PAT procedures and forms in Article Supplements.

3.05 MANUFACTURER'S SERVICES

A. Specialty Equipment: For following equipment, provide the services of a qualified manufacturer's representative during installation, startup, and demonstration testing and Owner training. Provide original equipment manufacturer's services as noted in Project Specific Requirements Table.

3.06 TRAINING

A. General:

1. Provide an integrated training program to meet specific needs of Owner's personnel.
2. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
3. Provide instruction on for working shift(s) as needed to accommodate the Owner's personnel schedule. See Project Specific Requirements Table.
4. Owner reserves the right to make and reuse video tapes of training sessions.

B. Operations and Maintenance Training:

1. Include a review of O&M manuals and survey of spares, expendables, and test equipment.
2. Use equipment similar to that provided or currently owned by Owner.
3. Provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics or instrumentation.

C. Operations Training:

1. Training Session Duration: See Project Specific Requirements Table.
2. Number of Training Sessions: See Project Specific Requirements Table.
3. Location: Site.
4. Content: Conduct training on loop-by-loop basis.
    a. Loop Functions: Understanding of loop functions, including interlocks for each loop.
    b. Loop Operation: For example, adjusting process variable setpoints, AUTO/MANUAL control transfer, AUTO and MANUAL control, annunciator acknowledgement and resetting.
    c. Interfaces with other control systems.

D. Maintenance Training:

1. Training Session Duration: See Project Specific Requirements Table.
2. Number of Training Sessions: See Project Specific Requirements Table.
3. Location: Project Site.
4. Content: Provide training for each type of component and function provided.
    a. Loop Functions: Understanding details of each loop and how they function.
    b. Component calibration.
    c. Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
    d. Troubleshooting and diagnosis for components.
    e. Replacing lamps, chart paper, fuses.
    f. Component removal and replacement.
    g. Periodic maintenance.

3.07 CLEANING/ADJUSTING

A. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

B. Cleaning:

1. Prior to closing system using tubing, clear tubing of interior moisture and debris.
2. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.08 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. Periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules just prior to Final Payment and Acceptance

3.09 PROJECT SPECIFIC REQUIREMENTS TABLE

A. This is a master specification and all products and materials described in specification may not apply to this Project. Table below helps clarify products and work required for this specific Project. Provide all products and work as specified unless noted otherwise in the table below.

Products or Work	Comments
Environmental Design Requirements	Vault interior shall be defined as inside. Outside the vault shall be defined as outside.
Mechanical Systems	Not Applicable.
Freestanding Panels	Not Applicable.
Nonfreestanding Panels	One new panel. See Control Panel Schedule.
Manufacturer's Services	Not Applicable.
Operations Training	Provide instruction for one working shift. Instruction Duration: 3 hours. Training Sessions: One.
Operations Training	Provide instruction for one working shift. Instruction Duration: 3 hours. Training Sessions: One.
Maintenance Training	Provide instruction for one working shift. Instruction Duration: 3 hours. Training Sessions: One.
Control Specifications Supplement	Not included in this Contract. Provide standard controls for turnout vault. Details not included in P&IDs and specification will be coordinated during construction.

3.10 SUPPLEMENTS

A. Supplements listed below, following “End of Section,” are part of this specification.

1. Component Specifications.
2. Instrument List.
3. Control Panel Schedule.
4. Control Specifications: Not included. Controls are typical for turnout vaults. Details will be worked out during coordination meeting, during construction.
5. PLC Input and Output List: Not included. Reference P&IDs of I/O quantity and type.
6. Instrument Calibration Sheet: Provides detailed information on each instrument (except simple hand switches, lights, and similar items).
7. I&C Valve Adjustment Sheet: Each sheet shows detailed information for installation, adjustment, and calibration of a given valve.
8. Performance Acceptance Test Sheet: Describes the PAT for a given loop. The format is mostly free form.
    a. Lists the requirements of the loop.
    b. Briefly describes the test.
    c. Cites expected results.
    d. Provides space for check off by witness.

END OF SECTION

COMPONENT SPECIFICATIONS

A. A16 Chlorine Analyzer:

1. General:
   a. Function: Measure, indicate, and transmit chlorine residual from sample water flow.
   b. Parts:
      1) Flow Cell Module.
      2) Electronic Control Unit.
   c. Flow Cell Module:
      1) Includes electrode sensor.
      2) Range: As noted.
      3) Shall maintain consistent sample flow with an inlet pressure range of 3 psi to 60 psi.
      4) Maximum Sample Temperature: 50 degrees C.
      5) Minimum Sample Conductivity: 200 microsiemens/cm.
   d. Electronic Control Unit:
      1) Display: Back-lit LCD display.
      2) Digital Inputs: Three.
         a) Monitoring sampling water.
         b) External stop.
         c) Operator defined.
      3) Digital Outputs: Eight.
         a) Contact Ratings: 150W, 220V dc.
      4) Analog Outputs: Four.
         a) Rating: 4 mA to 20 mA.
      5) Power Supply: 100V ac to 120V ac, 60-Hz, 30 VA.
      6) Ambient Temp: 0 degrees C to 50 degrees C.
   e. Manufacturer and Model:
      1) Evoqua; MFC-Depolox 5.
      2) “Or-equal.”

B. F4 Flow Element and Transmitter, Electromagnetic:

1. General:
   a. Function: Measure, indicate, and transmit the flow of a conductive process liquid in a full pipe.
   b. Type:
      1) Electromagnetic flowmeter, with operation based on Faraday’s Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
      2) Full bore meter with magnetic field traversing entire flow-tube cross-section.
      3) Unacceptable are insert magmeters or multiple single point probes inserted into a spool piece.

c. Parts: Flow element, transmitter, interconnecting cables, and mounting hardware. Other parts as noted.

2. Service:
   a. Stream Fluid:
      1) As noted.
      2) Suitable for liquids with a minimum conductivity of 5 microS/cm and for demineralized water with a minimum conductivity of 20 microS/cm.
   b. Flow Stream Descriptions: If and as described below.
3. Operating Temperature:
   a. Element:
      1) Ambient: 14 degrees F to 140 degrees F, typical, unless otherwise noted.
      2) Process: 14 degrees F to 140 degrees F, typical, unless otherwise noted.
   b. Transmitter:
      1) Ambient: Minus 4 degrees F to 140 degrees F, typical, unless otherwise noted.
      2) Storage: 15 degrees F to 120 degrees F, typical, unless otherwise noted.
4. Performance:
   a. Flow Range: As noted.
   b. Accuracy: Plus or minus 0.5 percent of rate for all flows resulting from pipe velocities of 2 feet to 30 feet per second.
   c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
5. Features:
   a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
   b. No obstructions to flow.
   c. NSF 61 certification.
   d. Very low-pressure loss.
   e. Measures bi-directional flow with a discrete signal for reverse flow.
6. Process Connection:
   a. Meter Size (diameter inches): As noted.
   b. Connection Type: Flanges compatible with adjacent piping and matching or exceeding adjacent piping pressure rating as specified in Section 33 05 01, Conveyance Piping—General, unless otherwise noted.
   c. Flange Material: Carbon steel, unless otherwise noted.
7. Power (Transmitter): 120V ac, 60-Hz, unless otherwise noted.
8. Element:
   a. Meter Tube Material: Type 304 or Type 316 stainless steel, unless otherwise noted.
   b. Liner Material: Polyurethane.

c. Liner Protectors: Covers (or grounding rings) on each end to protect liner during shipment.
d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid. Self-cleaning.
e. Electrode Material: Type 316 stainless steel.
f. Grounding Ring:
    1) Required, unless otherwise noted.
    2) Quantity: Two, unless otherwise noted.
    3) Material: Type 316 stainless steel, unless otherwise noted.
g. Enclosure: NEMA 4X, minimum, unless otherwise noted.
h. Submergence:
    1) Temporary: If noted.
    2) Continuous (up to 10 feet depth), NEMA 6P/IP68: If noted.
i. Hazardous Area Certification: Unclassified.

9. Transmitter:
    a. Mounting: Surface (wall), unless otherwise noted.
    b. Display: Required, unless otherwise noted.
        1) Digital LCD display, indicating flow rate and total.
        2) Bi-directional Flow Display: Required, unless otherwise noted.
            a) Forward and reverse flow rate.
            b) Forward, reverse, and net totalization.
    c. Parameter Adjustments: By keypad or nonintrusive means.
    d. Enclosure: NEMA 4X, minimum, unless otherwise noted.
    e. Empty Pipe Detection: Drives display and outputs to zero when empty pipe detected.
    f. Clock display 45 degrees upwards from the horizontal to be easily viewable by Operator.
10. Signal Interface (at Transmitter):
    a. Analog Output:
        1) Isolated 4 mA dc to 20 mA dc for load impedance from 0 ohm to at least 500 ohms minimum for 24V dc supply.
        2) Supports Superimposed Digital HART Protocol: If noted.
11. Cables:
    a. Types: As recommended by manufacturer.
    b. Lengths: As required to accommodate device locations.
12. Built-in Diagnostic System:
    a. Features:
        1) Field programmable electronics.
        2) Self-diagnostics with troubleshooting codes.
        3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
        4) Initial flow tube calibration and subsequent calibration checks.

13. Factory Calibration:
    a. Calibrated in an ISO 9001 and NIST certified factory.
    b. Factory flow calibration system must be certified by volume or weight certified calibration devices.
    c. Factory flow calibration system shall be able to maintain calibration flow rate for at least 5 minutes for repeatability point checks.
14. Manufacturer and Product:
    a. Endress & Hauser, Inc. Flow Measuring System; Promag 10W.
    b. “Or-equal.”

C. L6 Level Switch, Flood Sensor:

1. Type: Rising stem.
2. Material: Type 316 stainless steel float and stem.
3. Lead Conductors: 24-inch long, #22 AWG
4. Approvals: UL Listed.
5. Switch:
    a. Normally Open.
    b. Single-pole single throw.
    c. Rating: 20 VA.
6. Manufacturer and Product:
    a. Gems; LS-1755.
    b. No “Or-equal.”

D. L7 Level Element and Transmitter, Radar:

1. General:
    a. Function: Continuous level measurement.
    b. Type: Radar, noncontacting.
    c. Loop powered.
    d. Parts: Element/integral transmitter and accessories as noted.
2. Service:
    a. Application: Raw water.
    b. Operating Temperature Range:
        1) Ambient: Minus 40 degrees F to plus 176 degrees F.
        2) At Flange (Inside Vessel):
            a) Dependent on antenna type and O-ring materials.
            b) For PTFE rod with PVDF threaded connection, minus 40 degrees F to plus 176 degrees F.
        3) Pressure Rating:
            a) Dependent on antenna type and process temperature.
            b) For PTFE rod with PVDF threaded connection, minus 14 psig to plus 43.5 psig.

3. Performance:
   a. Process Range: As noted.
   b. Zero Reference: As noted.
   c. Frequency: C-band.
   d. Accuracy (Maximum Measurement Error): Up to 10 meters (23 feet), plus or minus 10 mm (0.39 inch).
   e. Resolution: 0.04 inch (1 mm.)
   f. Transition Zone (Not Recommended for Measurement): 2 inches from lower end of antenna.
   g. Medium Suitability:
      1) Suitable for most liquids with measuring range decreasing for liquids with smaller dielectric constants.
      2) For conductive liquids, (for example, water) maximum possible measuring range is 65 feet.
4. Element/Integral Transmitter:
   a. Enclosure:
      1) Transmitter: NEMA 4X/IP65 watertight.
      2) Antenna: NEMA 6P/IP68.
   b. Display: Integral, unless otherwise noted.
   c. Antenna Type: Horn.
   d. Horn Antenna Parameters:
      1) Size: 3 inches.
      2) Material: Type 316 stainless steel.
      3) Seal: FKM, Viton, unless otherwise noted.
      4) Extension: If noted.
         a) Material: Type 316L stainless steel, unless otherwise noted.
         b) Length: 12 inches, unless otherwise noted.
   e. Process Connection: Type 316 stainless steel wall-mounting bracket.
   f. Approvals: UL or other NRTL.
   g. Element Beam Angle: 10 degrees.
5. Signal and Electrical Interface:
   a. Analog:
      1) 4 mA dc to 20 mA dc HART.
      2) Not furnished when digital interface is noted.
   b. Conduit Type: 1/2-inch NPT, unless otherwise noted.
6. Accessories:
   a. Handheld Programmer:
      1) One per lot of level units provided, if noted.
      2) HART DXR375 Handheld Communicator.
7. Manufacturer and Product: Endress and Hauser; Micropilot M FMR244.

E. M43 Intrusion Switch:

1. General:
   a. Function: Monitor intrusion of entry point such as doors, overhead doors, and vault hatches.
   b. Type:
      1) Magnetic.
      2) Large.
   c. Parts: Magnet, switch, and cabling.
2. Features:
   a. Type: Large magnet, surface-mount suitable for door, unless otherwise noted.
   b. Cable: Armored, 36 inches long.
   c. Mounting Kits:
      1) For doors.
      2) For hatches.
   d. Magnet Length: 3 inches, nominal.
   e. Magnet and Switch Dimensions: Each, 3-inch long by 1-inch wide by 0.5-inch thick, nominal inches.
   f. Housing: Weather-resistant aluminum.
   g. Two holes on switch and magnet for fasteners.
   h. Additional Features: If and as noted.
3. Signal Interface:
   a. Switch: NO (closed loop), unless otherwise noted.
   b. Contact Rating: 70VA ac/50 watts dc, unless otherwise noted.
   c. Maximum Voltage: 24V dc.
   d. Maximum Switching Current: 0.5-amp dc.
   e. Maximum Carry Current: 0.5 amp.
4. Manufacturers and Products:
   a. GE; Security Model 2505A-L.
   b. Sentrol; 25065A-L.

F. P4 Pressure Gauge:

1. General:
   a. Function: Local pressure indication.
   b. Type: Bourdon tube element.
2. Performance:
   a. Scale Range: As noted.
   b. Accuracy: Plus or minus 0.50 percent of full scale.
3. Features:
   a. Dial: 4-1/2-inch diameter.
   b. Pointer Vibration Reduction:
      1) Required, unless otherwise noted. Use the following method:
         a) Liquid filled gauge front, unless otherwise noted.
         b) Glycerine fill, unless otherwise noted.

c. Case Material: Black thermoplastic, unless otherwise noted.
d. Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components):
   1) Stainless steel, unless otherwise noted.
e. Pointer: Adjustable by removing ring and window.
f. Window: Glass or acrylic, unless otherwise noted.
g. Threaded reinforced polypropylene front ring.
h. Case Type: Solid front with blow-out back.

4. Process Connection:
   a. Mounting: Lower stem, unless otherwise noted.
   b. Size: 1/2-inch MNPT, unless otherwise noted.
5. Accessories:
   a. Throttling Device: Required, unless otherwise noted.
      1) Type suitable for the intended service.
      2) Install in gauge socket bore.
6. Manufacturers and Products:
   a. Ashcroft; Duragauge Model 1259/Model 1279/Model 1279 PLUS!
   b. Ametek U.S. Gauge; Solfrunt Model 19XX/1981 Advantage.
   c. WIKA, Type 2XX.34.

G. P8 Pressure Switch, Adjustable Deadband:

1. General:
   a. Function: Monitor pressure.
   b. Type: Bourdon tube actuated switch.
2. Performance:
   a. Setpoint:
      1) As noted.
      2) Repeatability: Plus or minus 1 percent.
   b. Range: Noted setpoint shall fall between 20 percent and 80 percent of range.
   c. Overpressure Proof Pressure: At least 400 percent of rated maximum static pressure.
   d. Operating Temperature Limit: 180 degrees F.
3. Features:
   a. Actuator Seal: Buna-N, unless otherwise noted.
   b. Differential (deadband): Fixed.
   c. Reset: Automatic, unless otherwise noted.
   d. Mounting: Surface, unless otherwise noted.
4. Process Connection:
   a. 1/4-inch NPT female connections, unless otherwise noted.
   b. Materials: Nickel-plated brass, unless otherwise noted.
5. Enclosure: Weatherproof.

6. Signal Interface:
   a. Contact Type:
      1) SPDT, unless otherwise noted.
      2) Rated for 10 amps minimum at 120V ac.
   b. Hermetically Sealed Switch: If noted.
7. Manufacturers and Products:
   a. Mercoid: Model DA-31-3-7.
   b. No “Or-equal.”

H. P9 Pressure Transmitter:

1. General:
   a. Function: Measure pressure and transmit signal proportional to pressure.
   b. Type:
      1) Electronic variable capacitance or silicon strain gauge.
      2) Two-wire transmitter; “smart electronics.”
   c. Parts: Transmitter and accessories.
2. Performance:
   a. Range: As noted.
      1) Select transmitter’s factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL but does not exceed it.
   b. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
   c. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
   d. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
   e. Humidity: 0 percent to 100 percent relative humidity.
   f. Hazardous Location Certifications: Unclassified.
3. Features:
   a. Type: Gauge pressure, unless otherwise noted.
   b. Adjustable damping.
   c. LCD indicator, unless otherwise noted.
      1) Display in engineering units, field configurable.
   d. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
      1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
   e. Wetted O-rings: Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise noted.
   f. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
   g. Fill Fluid: Silicone, unless otherwise noted.

4. Process Connections:
   a. Line Size: 1/2 inch.
   b. Connection Type: FNPT.
   c. Internal diaphragm seal.
   d. Provide bock and blead valve (E+H DA63M).
5. Signal Interface:
   a. 4 mA dc to 20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
      1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.
   b. FOUNDATION Fieldbus Protocol: If noted.
   c. Profibus: If noted.
6. Enclosure:
   a. Type: NEMA 4X.
   b. Materials: Coated aluminum, unless otherwise noted.
   c. Mounting bracket, unless otherwise noted.
      1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
7. Accessories: Two-valve (isolate and vent) stainless steel manifold (E+H DA63M).
8. Manufacturer and Product: E+H; Cerabar S PMP71.

I. P30 Submersible Pressure Transmitter:

1. Accuracy: Plus or minus 1 percent full scale.
2. Internal surge protection.
3. NSF/ANSI 61 and 372 approved.
4. Power: Loop-powered.
5. Output:
   a. 4 mA to 20 mA analog.
   b. RS485 modified-Modbus.
6. Probe:
   a. Submersible.
   b. Maximum Dimensions:
      1) Diameter: 0.9 inches.
      2) Probe Length: 4.5 inches.
7. Cable Length: As noted.
8. Pressure Range: As noted.
9. Operating Temperature: Minus 10 degrees C to plus 60 degrees C.
10. Accessories:
    a. Termination enclosure.
    b. Drying tube assembly.
    c. Stainless steel cable support hanger.
11. Manufacturer and Product: KELLER America; Acculevel.

J. S27 Indicator, Digital Panel:

1. Features:
   a. Display:
      1) LED.
      2) At least 3.5 digits.
      3) 0.56-inch height.
   b. Overrange indication.
   c. Input Impedance: 100 ohms maximum.
2. Enclosure:
   a. 1/8 DIN, high impact plastic.
   b. Nominal Maximum Dimensions: 2.5 inches high by 4.7 inches wide by 4 inches deep.
   c. Nominal Cutout Dimensions: 1.8 inches high by 3.6 inches wide.
   d. Suitable for panel mounting.
   e. Maintains NEMA 4X Panel Rating: If noted.
      1) Furnish accessories as required.
3. Power: 115V ac, unless otherwise noted.
4. Signal Interfaces:
   a. Process Inputs: Field Selectable: 4 mA to 20 mA, 1 volt to 5 volts.
   b. Loop Power Supply: If noted.
      1) 24V dc, at least 25 mA.
5. Manufacturers and Products:
   a. Newport Electronics, Santa Ana, CA; Model 202A-P.
   b. Precision Digital, Natick, MA; Model Trident Model PD765.

K. T3 Room Temperature Element and Transmitter, Resistance:

1. General:
   a. Function: Measure temperature of room or area and transmit analog signal proportional to temperature.
   b. Type: RTD.
2. Service:
   a. Ambient room air.
   b. Temperature Range: 32 degrees F to 158 degrees F.
3. Element:
   a. Type: Platinum 100 ohm RTD.
   b. Performance:
      1) Sensor Accuracy for 900 degrees F and Below: Plus or minus 0.5 degree F or plus or minus 0.25 percent of reading, whichever is larger.

4. Transmitter:
   a. Ambient Operation Conditions:
      1) Temperature: Minus 20 degrees F to 158 degrees F, with display.
      2) Relative Humidity: 0 percent to 100 percent, noncondensing.
   b. Type: Two-wire, powered by remote power supply.
   c. Performance:
      1) Digital Accuracy: Greater of plus or minus 0.09 degrees F or plus or minus 0.1 percent of span.
      2) Response Time: 10 seconds.
   d. Signal Interface: 4 mA dc to 20 mA dc.
   e. Power: 24V dc loop powered.
   f. Enclosure:
      1) Mounting: Wall.
5. Manufacturer and Product: PR Electronics; 2914.

L. T4 RTD Temperature Element, Transmitter, and thermowell, Resistance:

1. General:
   a. Function: Measure temperature.
   b. Type: RTD.
2. Service:
   a. As noted.
   b. Temperature Range: As noted.
3. Element:
   a. Type: Platinum 100 ohm RTD.
   b. Performance:
      1) Sensor Accuracy for 400 degrees F and Below: Plus or minus 0.15 percent of reading at 0 degrees C.
4. Transmitter:
   a. Ambient Operation Conditions:
      1) Temperature: Minus 20 degrees F to 158 degrees F.
      2) Relative Humidity: 0 percent to 100 percent, noncondensing.
   b. Type: Two-wire, powered by remote power supply.
   c. Signal Interface: 4 mA dc to 20 mA dc.
   d. Power: 24V dc loop powered.
   e. RTD Head:
      1) 1/2-inch NPT male connection.
      2) Type 316 stainless steel.
      3) NEMA 250, Type 4X rating.

f. Thermowell:
   1) Connection: Threaded.
   2) Material: Type 316 stainless steel.
   3) Provide union and nipples as needed to fit application and RTD sensor.
   4) See installation detail.

5. Manufacturer and Product: Reotemp RTD.

INSTRUMENT LIST

Column1	Column2	Column3	Column4	Column5	Column6
Tag Number	Component Code	Component Title	Options	P&ID	Installation Detail
MHP-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 12 IN	SANR-10-N-1	2605-213
SE-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 12 IN	SANR-15-N-1	2605-213
SWH-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 16 IN	SANR-20-N-1	2605-213
SWH-FIT-00009	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 12 IN	SANR-20-N-1	2605-213
S2W-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 16 IN	SANR-30-N-1	2605-213
PE-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 12 IN	SANR-40-N-1	2605-213
PMS-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 12 IN	SANR-45-N-1	2605-213
PS-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 16 IN	SANR-50-N-1	2605-213
SN-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 6 IN	SANR-60-N-1	2605-213
SS-FIT-00003	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 20 IN	SANR-70-N-1	2605-213
SS-FIT-00007	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 16 IN	SANR-70-N-1	2605-213
SS-FIT-000013	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 24 IN	SANR-70-N-1	2605-213
SS-FIT-000019	F4	FLOW ELEMENT AND TRANSMITTER, ELECTROMAGNETIC	RANGE: 350-2800 GPM FLUID: RAW WATER METER SIZE: 24 IN	SANR-70-N-1	2605-213
MHP-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-10-N-1	4090-690
MHP-PIT-00006	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-10-N-1	4090-690
SE-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-15-N-1	4090-690
SE-PIT-00006	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-15-N-1	4090-690
SWH-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-20-N-1	4090-690
SWH-PIT-00006	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-20-N-1	4090-690
SWH-PIT-00007	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-20-N-1	4090-690
SWH-PIT-00012	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-20-N-1	4090-690
S2W-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-30-N-1	4090-690
PE-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-40-N-1	4090-690
PE-PIT-00007	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-40-N-1	4090-690
PE-PIT-00008	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-40-N-1	4090-690
PMS-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-45-N-1	4090-690
PMS-PIT-00008	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-45-N-1	4090-690
PS-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-50-N-1	4090-690
PS-PIT-00006	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-50-N-1	4090-690
SN-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-60-N-1	4090-690
SN-PIT-00006	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-60-N-1	4090-690
SS-PIT-00001	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-70-N-1	4090-690
SS-PIT-00005	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-70-N-1	4090-690
SS-PIT-00010	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-70-N-1	4090-690

Tag Number	Component Code	Component Title	Options	P&ID	Installation Detail
SS-PIT-00011	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-70-N-1	4090-690
SS-PIT-00016	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-70-N-1	4090-690
SS-PIT-00017	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-70-N-1	4090-690
SS-PIT-00022	P9	PRESSURE TRANSMITTER	RANGE: 30-250 PSIG	SANR-70-N-1	4090-690
MHP-ZS-99001	M43	INTRUSION SWITCH		SANR-10-N-2	2813-004
MHP-ZS-99002	M43	INTRUSION SWITCH		SANR-10-N-2	2813-004
MHP-ZS-99003	M43	INTRUSION SWITCH		SANR-10-N-2	2813-004
MHP-ZS-99004	M43	INTRUSION SWITCH		SANR-10-N-2	2813-004
MHP-ZS-99005	M43	INTRUSION SWITCH		SANR-10-N-2	2813-004
SE-ZS-99001	M43	INTRUSION SWITCH		SANR-15-N-2	2813-004
SE-ZS-99002	M43	INTRUSION SWITCH		SANR-15-N-2	2813-004
SE-ZS-99003	M43	INTRUSION SWITCH		SANR-15-N-2	2813-004
SE-ZS-99004	M43	INTRUSION SWITCH		SANR-15-N-2	2813-004
SE-ZS-99005	M43	INTRUSION SWITCH		SANR-15-N-2	2813-004
SWH-ZS-99001	M43	INTRUSION SWITCH		SANR-20-N-2	2813-004
SWH-ZS-99002	M43	INTRUSION SWITCH		SANR-20-N-2	2813-004
SWH-ZS-99003	M43	INTRUSION SWITCH		SANR-20-N-2	2813-004
S2W-ZS-99001	M43	INTRUSION SWITCH		SANR-30-N-2	2813-004
S2W-ZS-99002	M43	INTRUSION SWITCH		SANR-30-N-2	2813-004
S2W-ZS-99003	M43	INTRUSION SWITCH		SANR-30-N-2	2813-004
PE-ZS-99001	M43	INTRUSION SWITCH		SANR-40-N-2	2813-004
PE-ZS-99002	M43	INTRUSION SWITCH		SANR-40-N-2	2813-004
PE-ZS-99003	M43	INTRUSION SWITCH		SANR-40-N-2	2813-004
PE-ZS-99004	M43	INTRUSION SWITCH		SANR-40-N-2	2813-004
PMS-ZS-99001	M43	INTRUSION SWITCH		SANR-45-N-2	2813-004
PMS-ZS-99002	M43	INTRUSION SWITCH		SANR-45-N-2	2813-004
PMS-ZS-99003	M43	INTRUSION SWITCH		SANR-45-N-2	2813-004
PMS-ZS-99004	M43	INTRUSION SWITCH		SANR-45-N-2	2813-004
PS-ZS-99001	M43	INTRUSION SWITCH		SANR-50-N-2	2813-004
PS-ZS-99002	M43	INTRUSION SWITCH		SANR-50-N-2	2813-004
PS-ZS-99003	M43	INTRUSION SWITCH		SANR-50-N-2	2813-004
PS-ZS-99004	M43	INTRUSION SWITCH		SANR-50-N-2	2813-004
SN-ZS-99001	M43	INTRUSION SWITCH		SANR-60-N-2	2813-004
SN-ZS-99002	M43	INTRUSION SWITCH		SANR-60-N-2	2813-004
SN-ZS-99003	M43	INTRUSION SWITCH		SANR-60-N-2	2813-004
SS-ZS-99001	M43	INTRUSION SWITCH		SANR-70-N-2	2813-004
SS-ZS-99002	M43	INTRUSION SWITCH		SANR-70-N-2	2813-004
SS-ZS-99003	M43	INTRUSION SWITCH		SANR-70-N-2	2813-004
MHP-LSHH-99007	L6	LEVEL SWITCH, FLOOD SENSOR		SANR-10-N-2	4091-254
SE-LSHH-99007	L6	LEVEL SWITCH, FLOOD SENSOR		SANR-15-N-2	4091-254
S2W-LSHH-99005	L6	LEVEL SWITCH, FLOOD SENSOR		SANR-30-N-2	4091-254
PE-LSHH-99006	L6	LEVEL SWITCH, FLOOD SENSOR		SANR-40-N-2	4091-254
PMS-LSHH-99005	L6	LEVEL SWITCH, FLOOD SENSOR		SANR-45-N-2	4091-254
PS-LSHH-99007	L6	LEVEL SWITCH, FLOOD SENSOR		SANR-50-N-2	4091-254
SN-LSHH-99005	L6	LEVEL SWITCH, FLOOD SENSOR		SANR-60-N-2	4091-254
MHP-TT-99008	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-10-N-2	
SE-TT-99008	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-15-N-2	
SWH-TT-99005	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-20-N-2	
S2W-TT-99006	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-30-N-2	
PE-TT-99007	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-40-N-2	

Tag Number	Component Code	Component Title	Options	P&ID	Installation Detail
PMS-TT-99008	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-45-N-2	
PS-TT-99008	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-50-N-2	
SN-TT-99006	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-60-N-2	
SS-TT-99005	T3	ROOM TEMPERATURE ELEMENT AND TRANSMITTER	TEMPERATURE RANGE: 32 DEGREES F TO 158 DEGREES F	SANR-70-N-2	

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	Dimensions W	Dimensions D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
MHP-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:

FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	Dimensions W	Dimensions D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
SE-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:
- FDT: Functional Demonstration Test required.
- Dimensions: Maximum space available for panel.
- Heat / Cool: Heating system and cooling system requirements.
- SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	Dimensions W	Dimensions D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
SWH-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:

FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	W	D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
S2W-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:

FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	W	D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
PE-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:
- FDT: Functional Demonstration Test required.
- Dimensions: Maximum space available for panel.
- Heat / Cool: Heating system and cooling system requirements.
- SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	Dimensions W	Dimensions D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
RR-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:
FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	W	D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
PM-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:

FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	W	D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
PS-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:

FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	Dimensions W	Dimensions D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
SN-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:
FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL PANEL SCHEDULE

Panel No.	Requirements	Mounting	NEMA	Dimensions H	Dimensions W	Dimensions D	FDT	Heat / Cool	Serv. Lights, Outlets	Environment	SS
SS-RTU-00001	Non-ventilated local control panel for local monitoring and control of equipment. Local control panel shall incorporate: 1. PLC: Owner's Standard 2. UPS: size per Owner's standard 3. Ethernet switch: Owner's standard 4. Fiber optic patch panel: Owner's standard. 5. Wire terminations, power supplies, isolation relays, surge protection and other components required to provide complete PICS. 6. Provide power distribution within control panel using circuit breakers and/or fused terminal blocks. 7. Provide space to house UPS in bottom of enclosure.	Wall mounted	4X	48	36	18	Yes	Heat	Yes	Inside	Yes

Column Descriptions:

FDT: Functional Demonstration Test required.
Dimensions: Maximum space available for panel.
Heat / Cool: Heating system and cooling system requirements.
SS: Stainless Steel.

CONTROL SPECIFICATIONS
(NOT INCLUDED)

PLC INPUT AND OUTPUT LIST
(NOT INCLUDED)

JACOBS INSTRUMENT CALIBRATION SHEET Rev.06.05.92

COMPONENT	MANUFACTURER	PROJECT
Code:	Name:	Number:
Name:	Model:	Name:
	Serial #:	

FUNCTIONS

	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? Y / N	CONTROL? Y / N
Indicate? Y / N	Chart:			Describe:	Action? direct / reverse Modes? P / I / D
Record? Y / N	Scale:				SWITCH? Y / N Unit Range:
Transmit/ Convert? Y / N	Input:				Differential: fixed/adjustable
	Output:				Reset? automatic / manual

ANALOG CALIBRATIONS							DISCRETE CALIBRATIONS					Note No.
REQUIRED			AS CALIBRATED				REQUIRED			AS CALIBRATED		
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	
			Indicated	Output	Indicated	Output		(note rising or falling)		(note rising or falling)		
							1.					
							2.					
							3.					
							4.					
							5.					
							6.					

CONTROL MODE SETTINGS:	P:	I:	D:		7.					

#	NOTES:	Component Calibrated and Ready for Startup
		By:
		Date:
		Tag No.:

JACOBS INSTRUMENT CALIBRATION SHEET Rev.06.05.92

EXAMPLE - ANALYZER/TRANSMITTER

COMPONENT	MANUFACTURER	PROJECT
Code: *A7*	Name: *Leeds & Northrup*	Number: *WDC30715.B2*
Name: *pH Element & Analyzer / Transmitter*	Model: *12429-3-2-1-7* Serial #: *11553322*	Name: *UOSA AWT PHASE 3*

FUNCTIONS					
	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? N	CONTROL? N
Indicate? Y Record? N	Chart:			Describe:	Action? direct / reverse Modes? P / I / D
	Scale:	*1-14*	*pH units*		SWITCH? N Unit Range: Differential: fixed/adjustable Reset? automatic / manual
Transmit/ Convert? Y	Input:	*1-14*	*pH units*		
	Output:	*4-20*	*mA dc*		

ANALOG CALIBRATIONS							DISCRETE CALIBRATIONS					Note
REQUIRED			AS CALIBRATED				REQUIRED			AS CALIBRATED		No
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	
			Indicated	Output	Indicated	Output		(note rising or falling)		(note rising or falling)		
1.0	*1.0*	*4.0*	*1.0*	*4.0*	*1.0*	*3.9*	1.	*N.A.*		*N.A.*		
2.3	*2.3*	*5.6*	*2.2*	*5.5*	*2.3*	*5.6*	2.					*1.*
7.5	*7.5*	*12.0*	*7.5*	*11.9*	*7.5*	*12.0*	3.					
12.7	*12.7*	*18.4*	*12.7*	*18.3*	*12.6*	*18.3*	4.					
14.0	*14.0*	*20.0*	*14.0*	*20.0*	*14.0*	*20.0*	5.					
							6.					

CONTROL MODE SETTINGS:	P: *N.A.*	I:	D:		7.					

#	NOTES:	Component Calibrated and Ready for Startup
	1. Need to recheck low pH calibration solutions.	
		By: *J.D. Sewell*
		Date: *Jun-6-92*
		Tag No.: AIT-12-6[pH]

JACOBS I&C VALVE ADJUSTMENT SHEET Rev.06.05.92

PARTS	Project Name:	Project Number:
Body	Type:	Mfr:
	Size:	Model:
	Line Connection:	Serial #:
Operator	Type:	Mfr:
	Action:	Model:
	Travel:	Serial #:
Positioner	Input Signal:	Mfr:
	Action:	Model:
	Cam:	Serial #:
Pilot Solenoid	Action:	Mfr:
	Rating:	Model:
		Serial #:
I/P Converter	Input:	Mfr:
	Output:	Model:
	Action:	Serial #:
Position Switch	Settings:	Mfr:
	Contacts:	Model:
		Serial #:
Power Supply	Type:	Air Set Mfr:
	Potential:	Model:
		Serial #:

ADJUSTMENTS	Initial	Date	VERIFICATION	Initial	Date
Air Set			Valve Action		
Positioner			Installation		
Position Switches			Wire Connection		
I/P Converter			Tube Connection		
Actual Speed					

REMARKS:	Valve Ready for Startup
	By:
	Date:
	Tag No.:

JACOBS I&C VALVE ADJUSTMENT SHEET Rev.06.05.92
EXAMPLE

PARTS	Project Name: *SFO SEWPCP*	Project Number: *SFO10145.G2*
Body	Type: *Vee-Ball*	Mfr: *Fisher Controls*
	Size: *4-inch*	Model: *1049763-2*
	Line Connection: *159 # ANSI Flanges*	Serial #: *1003220*
Operator	Type: *Pneumatic Diaphragm*	Mfr: *Fisher Controls*
	Action: *Linear - Modulated*	Model: *4060D*
	Travel: *3-inch*	Serial #: *2007330*
Positioner	Input Signal: *3-15 psi*	Mfr: *Fisher Controls*
	Action: *Direct - air to open*	Model: *20472T*
	Cam: *Equal percentage*	Serial #: *102010*
Pilot Solenoid	Action:	Mfr:
	Rating: *None*	Model:
		Serial #:
I/P Converter	Input: *4-20 mA dc*	Mfr: *Taylor*
	Output: *3-15 psi*	Model: *10-T-576-3*
	Action: *Direct*	Serial #: *1057-330*
Position Switch	Settings: *Closed / Open 5 deg, rising*	Mfr: *National Switch*
	Contacts: *Close / Close*	Model: *1049-67-3*
		Serial #: *156 &157*
Power Supply	Type: *Pneumatic*	Air Set Mfr: *Air Products*
	Potential: *40 psi*	Model: *3210D*
		Serial #: *1107063*

ADJUSTMENTS	Initial	Date	VERIFICATION	Initia l	Date
Air Set	*JDS*	*Jun-06-92*	Valve Action	*JDS*	*Jun-03-92*
Positioner	*JDS*	*Jun-06-92*	Installation	*JDS*	*Jun-03-92*
Position Switches	*JDS*	*Jun-06-92*	Wire Connection	*JDS*	*Jun-04-92*
I/P Converter	*JDS*	*Jun-07-92*	Tube Connection	*JDS*	*Jun-04-92*
Actual Speed	*JDS*	*Jun-07-92*			

REMARKS: *Valve was initially installed backwards.*	Valve Ready for Startup
Observed to be correctly installed May-25-92	By: *J.D. Sewell*
	Date: *Jun-07-92*
	Tag No.: *FCV-10-2-1*

JACOBS PERFORMANCE ACCEPTANCE TEST SHEET
Rev.06.05.92

Project Name:	Project No.:

Demonstration Test(s): For each functional requirement of the loop: (a) List and number the requirement. (b) Briefly describe the demonstration test. (c) Cite the results that will verify the required performance. (d) Provide space for signoff.

<table>
<tr><td>Forms/Sheets Verified</td><td>By</td><td>Date</td><td>Loop Accepted By Owner</td></tr>
<tr><td>Loop Status Report</td><td></td><td></td><td>By:</td></tr>
<tr><td>Instrument Calibration Sheet</td><td></td><td></td><td>Date:</td></tr>
<tr><td>I&C Valve Calibration Sheet</td><td></td><td></td><td rowspan="3"></td></tr>
<tr><td>Performance Acceptance Test</td><td>By</td><td>Date</td></tr>
<tr><td>Performed</td><td></td><td></td></tr>
<tr><td>Witnessed</td><td></td><td></td><td>Loop No.:</td></tr>
</table>

JACOBS PERFORMANCE ACCEPTANCE TEST SHEET Rev.06.05.92

EXAMPLE

Project Name: *SFO SEWPCP Plant Expansion*	Project No.: *SFO12345.C1*

Demonstration Test(s): For each functional requirement of the loop:
(a) List and number the requirement. (b) Briefly describe the demonstration test.
(c) Cite the results that will verify the required performance. (d) Provide space for signoff.

1. MEASURE EFFLUENT FLOW	
1.a With no flow, water level over weir should be zero and	
FIT indicator should read zero.	*Jun-20-92 BDG*
2. FLOW INDICATION AND TRANSMISSION TO LP & CCS	
With flow, water level and FIT indicator should be related by expression	
*Q(MGD) = 429*H**(2/3) (H = height in inches of water over weir).*	
Vary H and observe that following.	
2.a Reading of FIT indicator.	*Jun-6-92 BDG*
2.b Reading is transmitted to FI on LP-521-1.	*Jun-6-92 BDG*
2.c Reading is transmitted and displayed to CCS.	*Jun-6-92 BDG*

H(measured)	*0*	*5*	*10*	*15*
Q(computed)	*0*	*47.96*	*135.7*	*251.7*
Q(FIT indicator)	*0*	*48.1*	*137*	*253*
Q(LI on LP-521-1)	*0*	*48.2*	*138*	*254*
Q(display by CCS)	*0*	*48.1*	*136.2*	*252.4*

Forms/Sheets Verified	By	Date	Loop Accepted By Owner
Loop Status Report	*J.D. Sewell*	*May-18-92*	By: *J.D. Smith*
Instrument Calibration Sheet	*J.D. Sewell*	*May-18-92*	Date: *Jun-6-92*
I&C Valve Calibration Sheet	*N.A.*		
Performance Acceptance Test	By	Date	
Performed	*J. Blow MPSDC Co.*	*Jun-6-92*	
Witnessed	*B.deGlanville*	*Jun-6-92*	Loop No.: *30-12*

SECTION 40 95 80
FIBER OPTIC COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide all tools, supplies, materials, equipment, and all labor necessary for furnishing, constructing, installing, terminating, and testing fiber optic (FO) system.

B. Route FO system as shown on Drawings. Install conduits straight, within the tolerances called for in Drawings and Specifications.

1.02 RELATED WORK

A. Section 26 05 33, Conduit and Boxes.

B. Section 31 23 16, Excavation.

C. Section 31 23 23.15, Trench Backfill.

1.03 REFERENCES

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

1. ASTM: F2160 Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD).
2. Electronic Components, Assemblies, and Materials Association (ECA): 310-E, Cabinets, Racks, Panels, and Associated Equipment.
3. Institute of Electrical and Electronic Engineers, Inc. (IEEE): 802.3, Telecommunications and Information Exchange Between Systems—Local and Metropolitan Networks.
4. Insulated Cable Engineers Association (ICEA):
   a. S-83-596, Optical Fiber Premises Distribution Cable.
   b. S-87-640, Optical Fiber Outside Plant Communications Cable.
   c. S-104-696, Indoor-Outdoor Optical Fiber Cable.
5. International Organization for Standardization (ISO): 9001, Quality Management Systems—Requirements.
6. International Telecommunication Union (ITU): T G.652, Characteristics of a Single-mode Optical Fibre and Cable.
7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
8. QuEST Forum (QF): TL 9000, Quality Management Systems.

9. Rural Development Utilities Programs (RDUP):
    a. 7 CFR 1755.902, Minimum Performance Specification for Fiber Optic Cables.
    b. 7 CFR 1755.903, Fiber Optic Service Entrance Cables.
10. Telecommunications Industry Association (TIA):
    a. 526-7, OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
    b. 526-14, OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
    c. 568-C.1, Commercial Building Telecommunications Cabling Standards.
    d. 568-C.3, Optical Fiber Cabling Components Standard.
    e. 598, Optical Fiber Cable Color Coding.
    f. 606, Administration Standard for Commercial Telecommunications Infrastructure.
11. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
    a. 455-78, FOTP-78 - IEC 60793-1-40 Optical Fibres Part 1-40: Measurement Methods and Text Procedures – Attenuation.
    b. 455-133, FOTP-133 IEC-60793-1-22 Optical Fibres Part 1-22: Measurement Methods and Test Procedures Length Measurement.
    c. 492AAAA, Detail Specification for 62.5-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
    d. 492AAAB, Detail Specification for 50-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
    e. 492AAAC, Detail Specification for 850-nm Laser-Optimized, 50-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
    f. 492CAAA, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers.
    g. 492CAAB, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak.
    h. 604-2, FOCIS-2 Fiber Optic Connector Intermateability Standard, Type ST.
    i. 604-3, FOCIS-3 Fiber Optic Connector Intermateability Standard, Type SC and SC-APC.
    j. 604-12, FOCIS-12 Fiber Optic Connector Intermateability Standard, Type MT-RJ.
    k. 942, Telecommunications Infrastructure Standard for Data Centers.
    l. TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems-Contains Color.
12. UL: 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.04 DEFINITIONS

A. ATM: Asynchronous Transfer Mode.

B. AUI: Attachment Unit Interface.

C. dB: Decibel.

D. EMB: Effective Modal Bandwidth.

E. ETL: Electrical Test Laboratories.

F. Flux Budget: Difference between transmitter output power and receiver input power required for signal discrimination when both are expressed in dBm.

G. Fusion Splice: Connecting ends of two fibers together by aligning fiber ends and applying electric arc to fuse ends together.

H. FOS: Fiber Optic System.

I. Hybrid Cable: Cable containing more than one type of fiber.

J. LAN: Local Area Network.

K. LIU: Lightguide Innerconnect Unit (patch panel).

L. m: Micrometer.

M. Mbps: Megabits per Second.

N. Mechanical Splice: Connecting ends of two fibers together by means other than fusion.

O. Megahertz (MHz): One million cycles per second.

P. MHz: Megahertz.

Q. micro: x 10^{-6}.

R. Micron: Micrometer or one millionth meter.

S. MIS: Management Information System.

T. n, nano: x 10^{-9}.

U. N: Newton.

V. nm: Nanometer—unit of measure equal to one billionth meter.

W. OFNP: Nonconductive Optical Fiber Plenum Cable.

X. OFNR: Nonconductive Optical Fiber Riser Cable.

Y. OLTS: Optical Loss Test Sets.

Z. OTDR: Optical Time Domain Reflectometer.

AA. PIC: Process Instrumentation and Control.

BB. Plenum: Air return path of central air handling system, such as open space above suspended ceiling.

CC. UPC: Ultra Physical Contact.

DD. UPS: Uninterruptible Power Supply.

EE. V ac: Volts Alternating Current.

FF. WAN: Wide Area Network.

1.05 SUBMITTALS

A. Action Submittals:

1. Site Layout Diagrams Showing:
    a. Location of all splices and pull boxes with references to pipeline station numbers.
    b. Log of duct markings, pull box locations and duct splices. The log will be used to calculate distances between pull boxes.
    c. Belowgrade conduit routings between access holes and buildings, with conduit counts and identification.
    d. Belowgrade innerduct routings through conduits, with innerduct counts and identification.
2. Cable Schedule Showing:
    a. Cable identification.
    b. Fiber counts for each cable.
    c. Cable length and attenuation, with two connector pairs and planned number of splice(s), based on TIA 568-C.3, Annex H.
3. Component Data:
    a. Manufacturer and model number.
    b. General data and description of each component.
    c. Engineering specifications and data sheet for each component including:
        1) Duct, connectors.
        2) Duct sealing devices.
        3) Duct sealants.
        4) Closures.

5) Pull rope.
6) Identification tape.
7) Pulling equipment.
8) Testing equipment.
9) Splicing hardware and equipment.

B. Informational Submittals:

1. Testing and acceptance plan, 30 days prior to beginning of testing.
2. Fiber test results. Documentation covering fiber facility testing, not later than 2 days after testing, showing:
   a. Manufacturer’s tag of attenuation per fiber as recorded from OTDR reading before shipment.
   b. Attenuation of each fiber upon delivery to Site.
   c. Attenuation of each fiber plus connector after installation as recorded from OTDR with tracing.
   d. Flux Budget calculations with comparison to measured attenuation for each run verifying adequate optical signal strength.
3. Manufacturer’s Certificate of Compliance.
4. Manufacturer’s suggested installation practice.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Optical Fiber Cable and Cable Splice Centers:

1. Outside, Underground/Submerged: Minus 20 degrees C to 40 degrees C.
2. Outside, Overhead: Minus 40 degrees C to 80 degrees C.
3. Outside, Aboveground in Conduit: Minus 40 degrees C to 80 degrees C.
4. Inside: 0 degree C to 40 degrees C.

B. Equipment:

1. Outside, Aboveground: Minus 40 degrees C to 80 degrees C.
2. Control Rooms, Equipment Rooms, and Telecommunications Closets: 30 percent to 55 percent relative humidity, 18 degrees C to 24 degrees C.
3. Other Interior Areas: 0 percent to 100 percent relative humidity, 5 degrees C to 35 degrees C.

1.07 QUALITY ASSURANCE

A. Contractor Qualifications:

1. Use qualified personnel, possessing the necessary equipment and having experience in similar installations. Evidence of qualification shall include the following:
   a. Written evidence that the Contractor has a minimum of 3 consecutive years' recent experience with all aspects of the fiber optic cable system as specified, including the installation of conduit and pull boxes, pulling of fiber optic cable in conduit, splicing and testing of fiber optics, and the installation and testing of all other components of the fiber optic cable system. Such experience shall include a minimum of three projects with installation and testing of no less than 5,000 feet of continuous fiber optic cable. Retain specialty workers or subcontractors meeting this experience requirement.
   b. Provide a list of completed installations similar to this Project including the name, address, and phone number of the owner, the name of the project, type of cable with model number, and the date of completion. Provide separate lists for the Contractor, supplier, and cable manufacturer.
   c. The name and qualifications of the supervisory personnel that will be directly responsible for the installation of the fiber optic duct system.

PART 2 PRODUCTS

2.01 HDPE FIBER OPTIC CABLE DUCT

A. Conduit and Fittings: High Density Polyethylene (HDPE) SDR11, meets requirements of ASTM F2160.

2.02 SCHEDULE 40 PVC OR RGS CONDUIT

A. See Section 26 05 33, Raceways and Boxes.

2.03 CABLE SEAL FITTINGS

A. Function: Keep water from flowing through conduits into pull boxes, enclosures, and rooms.

B. PVC or HDPE Conduit: CAL AM; Wedge Seal.

C. Other Conduit: See Section 26 05 33, Raceways and Boxes.

2.04 DUCT SEAL FITTINGS

A. Function: Provides a watertight seal between the outside of a conduit a concrete wall. Keeps water from leaking into boxes, vaults, or other below grade structures through conduit penetrations.

B. Manufacturers and Products:

1. OZ Gedney; FSK.
2. “Or-equal.”

2.05 CONDUIT PLUGS

A. Function: Plugs empty or spare conduits so that water, debris, or animals cannot go into empty raceways.

B. Manufacturer and Product: CAL AM/JackMoon; Kwikie Blank Duct Plugs.

2.06 FIBER OPTIC CABLE

A. Provide armored fiber optic cable unless noted otherwise.

1. Quantity of strands per cable as shown on Drawings.
2. If no quantity is shown on Drawings, provide 24 strand fiber cable.

B. Single-Mode: 8.3/125-micron Class IVa dispersion-unshifted optical fibers for use in the backbone distribution subsystem shall meet or exceed requirements of TIA 568-C.3, including the following specifications:

1. Chromatic Dispersion:
   a. Zero-Dispersion Wavelength: Between 1,302 nm and 1,322 nm.
   b. Maximum value of dispersion slope at zero dispersion wavelength shall be no greater than 0.093 ps per km-nm^2.
2. Mode Field Diameter: Nominal 8.7 microns to 10 microns, with a tolerance of plus or minus 0.5 micron at 1,300 nm.
3. Maximum Attenuation:
   a. Outside and Indoor-Outdoor Optical Fiber Cable:
      1) 0.5 dB per km at 1,310 nm.
      2) 0.5 dB per km at 1,550 nm.
   b. Inside Optical Fiber Cable:
      1) 1 dB per km at 1,310 nm.
      2) 1 dB per km at 1,550 nm.
4. Cutoff Wavelength of Cabled Fiber: Less than 1,260 nm.
5. TIA 492 CAAB (OS2) low water peak and complies with ITU T G.652 (A to D).

C. Type 8.3/250, Backbone for Underground Conduit Installation:

1. Individual Fibers: 8.3/125/250 microns.
2. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-87-640 and RDUP 7 CFR 1755.902 for backbone, feeder and distribution cables and RDUP 7 CFR 1755.903 for service entrance or drop cable with 12 strands or less used having a distance of 100 m or less.
3. NEC/UL Listing: None; not approved for general use within building, except when installed in metallic conduit.
4. Protective Covering: Black, antifungus, UV-resistant, polyethylene jacket with rip-cord.
5. Minimum Short Term Pull Strength: 600 lbf.
6. Manufacturers and Products:
   a. Corning Cabling Systems; ALTOS loose-tube dielectric cable.
   b. Mohawk; Outdoor loose-tube cable.

D. Type 8.3/250, Backbone for Underground Conduit and Building Riser Installation:

1. Individual Fibers: 8.3/125/250 microns.
2. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-104-696.
3. NEC/UL Listing: OFNR.
4. Protective Covering: Black, flame and UV-resistant, thermoplastic jacket with rip-cord.
5. Minimum Short Term Pull Strength: 600 lbf.
6. Manufacturers and Products:
   a. Corning Cabling Systems; FREEDM cable.
   b. Mohawk; RiserLite loose-tube cable.

E. Type 8.3/900, Backbone for Building Installation:

1. Individual Fibers: 8.3/125/250/900 microns.
2. Assembly:
   a. Distribution style with core of individually tight-buffered fibers surrounded by nonmetallic sheath.
   b. Cable: Comply with ICEA S-83-596.
3. Protective Covering: Flame retardant outer jacket with pull string.
   a. NEC/UL Listing: OFNR.

4. Manufacturers and Products:
   a. Corning Cabling Systems; (MIC) cable.
   b. Mohawk; Distribution Riser cable.

2.07 MULTIMODE FIBER OPTIC CABLE

A. 50/125 and 62.5/125-micron, graded-index for use in backbone and horizontal distribution subsystems, meets or exceeds the requirements of TIA 568-C.3, including the following specifications:

1. Maximum Mean Fiber Loss:
   a. 3.5 dB per km at 850 nm.
   b. 1.5 dB per km at 1,300 nm.
2. Minimum OFL Bandwidth:
   a. OM3-1500 MHz•km minimum at 850 nm; TIA 492AAAC.
   b. OM4-3500 MHz-km.
   c. 500 MHz•km minimum at 1,300 nm.
3. Distance Capacity per IEEE 802.3:
   a. 100Mbit Ethernet: OM3 or OM4 300m at 850 nm and 2,000m at 1,310 nm.
   b. 1 Gbit Ethernet:
      1) OM3: 1,000m at 850 nm and 600 at 1,310 nm.
      2) OM4: 550m at 1,310 nm.
   c. 10 Gbit Ethernet—10km at 850 nm and 40km at 1,310 nm:
      1) OM3: 300m at 850 nm and 300 at 1,310 nm.
      2) OM4: 400m at 1,310 nm.

B. Type 50/250 OM4, Backbone for Underground Conduit Installation:

1. Individual Fibers: 50/125/250 microns.
2. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-87-640.
3. NEC/UL Listing: None; not approved for general use within building except when installed in metallic conduit.
4. Protective Covering: Black, antifungus, UV-resistant, polyethylene jacket with rip-cord.
5. Minimum Short Term Pull Strength: 600 lbf.
6. Manufacturers and Products:
   a. Corning Cabling Systems; ALTOS loose-tube dielectric cable.
   b. Mohawk; Outdoor loose-tube cable.

C. Type 50/250 OM4, Backbone for Underground Conduit and Building Riser Installation:

1. Individual Fibers: 50/125/250 microns.
2. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-104-696.
3. NEC/UL Listing: OFNR.
4. Protective Covering: Black, flame and UV-resistant, thermoplastic jacket with rip-cord.
5. Minimum Short Term Pull Strength: 600 lbf.
6. Manufacturers and Products:
   a. Corning Cabling Systems; FREEDM cable.
   b. Mohawk; RiserLite loose-tube cable.

2.08 INNERDUCT

A. Function: Installs into conduit system provided by others, to provide smooth, low-friction path through conduit, with only one cable per path to facilitate changing individual cables.

B. Features:

1. Size and Count, in 4-inch Conduit: As shown on Drawings.
2. Type: Annular, corrugated innerduct.
3. Material: HDPE.
4. Color Code: Orange, blue, green, brown, white, or grey.
5. Strength: Minimum 600-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
6. Lubrication: Prelubricated.

C. Manufacturers:

1. Endocor.
2. Dura-Line.

2.09 ETHERNET FIBER OPTIC REPEATERS

A. Function: Extends ethernet communications range beyond 1,000 meters.

B. Features:

1. In accordance with IEEE 802.3.
2. Attaches into ethernet segment and repeats signals bidirectionally.
   a. Regeneration: Retimes packets, regenerates preamble, extends collision fragments, partitions problem segments, and reconnects nonproblem segments.
   b. Media: Support fiber optic type specified.
   c. Wavelength: 1,300 nm.
   d. Fiber Optic Connectors: SC.
3. Mounting: Stackable in 19-inch rack.
4. Power: 120V ac.

C. Segments per Repeater, Maximum: As shown on Drawings.

D. Fiber Signal: Minimum distance 2,000m at 100 Gbit Ethernet.

E. Manufacturers:

1. Black Box Corporation.
2. Hewlett-Packard.
3. Newbridge.
4. 3Com.

2.10 ETHERNET FIBER-TO-COPPER TRANSCEIVERS

A. Function: Convert half/full-duplex fiber optic ethernet signal to copper ethernet signal and vice versa.

B. Speed: Auto-negotiating 10/100/1000 Mbps.

C. Features:

1. Support fiber optic type specified.
2. Fiber Optic Connectors: SC.
3. Copper Connector: RJ45 unshielded.
4. Power:
   a. Powered by signal.
   b. 120V ac.
5. Mounting: Suitable for permanent mounting.
6. Fiber Signal Distance: 2,000m at 100 Gbit Ethernet at 1,310 nm minimum.

D. Manufacturers:

1. ATI Centre.
2. Hewlett-Packard.
3. Black Box Corporation.

2.11 FIBER DISTRIBUTION FRAME

A. Function: Provides industry-standard rack mounting system for interface between fiber optic backbone and equipment cables.

B. Features:

1. Used in either cross-connect or interconnect configuration.
2. 23-inch (584-mm) rack for mounting 19-inch (483-mm) rack mount units.
   a. Accommodates up to 576 fiber terminations per frame.
   b. Accepts connector module housing and splice housing within same rack.
   c. Fiber Optic Connectors: SC Optic.
3. Fiber/Wire Management System:
   a. Vertical: 75-mm by 100-mm supports on 200-mm centers vertically on four sides (front LHS, back LHS, front RHS, back RHS).
   b. Horizontal: Supports on 100-mm centers horizontally above and below each termination frame front and back. Support may serve frames immediately above and below.
4. Mounting Hardware: Accepts standard 19-inch (483-mm) rack for integrated fiber optic system (for example, hubs, routers, patch panels).
5. Splice Trays with Coil Former: Former to wind slack cable around, provides controlled long radius bends.
   a. Doors: Pivot down lockable.
   b. Foot and End Caps: Included in final, assembled unit.
   c. Ancillaries: Jumper troughs and covers, cable tie brackets.

C. Manufacturers:

1. Ortronics.
2. Siecor.

2.12 FIBER CENTERS (PATCH PANELS)

A. Function: Provides secure place to terminate fiber optic cables.

B. Features:

1. Compartments: Two; one for fiber optic cable, one for jumpers to individual equipment.
2. Coil Former: Former to wind slack cable around, provides controlled long radius bends.
3. Connectors: Minimum 24 SC connectors for entry and exit.
4. Size: Maximum 450 mm by 300 mm by 100 mm.
5. Mountings: Suitable for permanent attachment as shown, or provide separate mountings that do not obscure covers and doors.
6. Doors: Separate doors for cable and jumper terminations and lockable.

C. Manufacturers:

1. Leviton.
2. Ortronics.
3. Siecor.

2.13 HOUSINGS

A. Termination Housing:

1. Rack mountable connector housing.
2. Mountable in ECA 310-E compatible 465-mm or 592-mm rack.
3. Available in several sizes, including 1U, 2U, 3U, and 4U.
   a. One ECA rack space or panel height (denoted as U) is defined as being 44.45 mm in height.
4. In accordance with design requirements of TIA 568-C.3 and polymer compounds flammability requirements of UL 94.
5. Manufactured using 16-gauge aluminum or equivalent for structural integrity.
6. Finished with wrinkled black powder coat for durability.
7. Provide black installation fasteners.

8. Available sizes with their corresponding fiber capacities are noted below:

Termination Housing Sizes and Fiber Capacities				
Unit Size	Panel Capacity	Fiber Capacity with 6f Panels	Fiber Capacity with 12f Panels	Fiber Capacity with 24f Panels
1U	2	12	24	48
2U	4	24	48	96
3U	6	36	72	144
4U	12	72	144	288

B. Splice Housing:

1. Mountable in ECA 310-E compatible 465-mm or 592-mm rack.
2. Available in two rack mount sizes of 3U and 5U.
   a. One ECA rack space or panel height (denoted as U) is defined as being 44.45 mm in height.
3. Provide individual tray access with minimal disturbance to neighboring trays and fibers.
4. In accordance with design requirements of TIA 568-C.3 and polymer compounds flammability requirements of UL 94.
5. Manufactured using 16-gauge aluminum or equivalent for structural integrity.
6. Finished with wrinkled black powder coat for durability.
7. Front and rear doors shall be lockable.
8. Brackets shall allow wall mounting of rack-mounted hardware.
9. Provide black installation fasteners.
10. Available sizes with their corresponding fiber capacities are noted below:

Splice Housing Sizes and Splice Capacities			
Unit Size	Tray Height (inches)	Tray Capacity	Splice Capacity
3U	0.2	12	144
3U	0.4	7	84
5U	0.2	22	264
5U	0.4	14	168

C. Combination Termination/Splice Housings:

1. In accordance with design requirements listed in TIA 568-C.3, TIA/EIA-942, and polymer compounds flammability requirements of UL 94.
2. Mountable in ECA 310-E compatible 465-mm rack or 592-mm rack.
3. Available in 1U and 4U sizes.
   a. One ECA rack space or panel height (denoted as U) is defined as being 44.45 mm in height.
   b. 1U shall have removable top lid.
   c. 4U shall have integrated jumper routing guides.
4. Depth: 16 inches deep for extra cable routing.
5. Manufactured using 16-gauge aluminum or equivalent for structural integrity.
6. Finished with rustic gun-metal grey powder coat for durability.
7. Joints shall be welded and finished in a workman-like manner.
8. Provide installation fasteners that match housing color.
9. Provide clamshell-type cable clamping mechanism to provide cable strain relief.
10. Front and rear doors shall be lockable.
11. Connector housings shall have a labeling scheme that complies with TIA-606.
12. Available with factory-installed connectorized cable stubs in multiple cable and connector types.
13. Able to accommodate fusion splicing with additional hardware.

2.14 PANELS (MOUNTING PLATES)

A. Closet Connector Housing Panel:

1. Manufactured from 16-gauge cold rolled steel or injection-molded polycarbonate for structural integrity.
2. Designed to accommodate applications requiring specified labeling.
3. Offered in 6-fiber, 8-fiber, 12-fiber, 16-fiber, and 24-fiber versions.
   a. 6-fiber panels shall be offered in ST compatible, FC, SC simplex.
   b. 8-fiber and 12-fiber versions shall include ST Compatible Connector, FC, LC duplex, SC duplex and simplex, and MT-RJ multifiber connectors.
   c. For high-density applications, MT-RJ and LC duplex panels shall be available in 16-fiber and 24-fiber versions.
      1) When MT-RJ adapters are used, adapter shall be a style that has a polarity adjustment knock-out keyway tab that shall be oriented on inside of panel so that it is not accessible to user once system is installed.

4. Capable of being used with field-installable connectors or in applications where preconnectorized cables are routed directly from equipment to interconnect hardware.
5. Capable of accepting interchangeable connector panel.
6. Panel shall be attached with two push-pull latches to allow quick installation and removal.
7. Blank Connector Panel:
    a. Available to fill unused space within housing.
    b. Attached with at least two push-pull latches to allow quick installation and removal.
    c. Manufactured from injection-molded polycarbonate.

2.15 SPLICE TRAY

A. General:

1. Compatible with hardware connector/splice housings.
2. Securely organize and provide physical protection without stress on fibers for both single-mode and multimode individual and ribbonized fiber splices.
3. Splice enclosures to include various lengths and depths for a variety of splicing methods.

B. Features:

1. Shall not induce attenuation of signal at operational wavelengths up to 1,550 nm.
2. Consist of rugged aluminum base and aluminum cover with crimpable metal tabs that provide buffer tube strain-relief on both ends of tray.
3. Hold up to 24 single-fiber splices and up to six mass fusion splices.
4. Splice Organizer:
    a. Accommodate fusion splice, fusion splice with heat-shrink sleeve or mechanical sleeve, and mechanical splice part.
    b. High-precision molded construction that holds and protects actual splice thus eliminating need for extra splice protection parts.
    c. Provide positive holding action for maximum splice protection during installation and operation.
5. Strain-relief Points: Tie-wrap buffer tubes or pigtails to metal tray.
6. Finish: Black powder coating for ease of fiber identification and protection.

2.16 UNDERGROUND SPLICE CLOSURES

A. Function: Enclose branch and inline splices in aerial and underground applications.

B. Available in canister (butt) and in-line styles to fit most applications.

C. Sizes:

1. Small: Accommodate up to 72 single-fiber splices or 144 ribbon-fiber splices using 12-fiber ribbons.
2. Medium: Accommodate up to 288 single-fiber splices or 432 ribbon-fiber splices.
3. Large: Accommodate up to 480 single-fiber splices or 864 ribbon-fiber splices.

D. Housing:

1. Nonmetallic, resistant to solvents, stress cracking, and creep.
2. Material shall be compatible with chemicals and other materials to which they might be exposed in normal applications.

E. End Caps:

1. Feature two express ports for uncut feeder cables.
2. Capable of accepting additional cables without removal of sheath retention or strength-member-clamping hardware on previously installed cables or disturbing existing splices.

F. Quick-seal mechanical seal drop ports.

G. Optical Fiber Closure:

1. Capable of accepting optical fiber cable commonly used in interoffice, outside plant, and building entrance facilities.
2. Provide clamping mechanism to prevent pistoning of central member or strength members, and to prevent cable sheath slip or pullout.
3. Ability to double cable capacity of installed canister splice closure by use of a kit. Such a conversion shall not disturb existing cables or splices.

H. Encapsulation shall not be required to resist water penetration.

I. Re-enterable.

J. Bonding:

1. Provide hardware to facilitate bonding and grounding of metal components in closure and armored cable sheath.
2. Cable bonding hardware shall be able to accommodate a copper conductor equal to or larger than 6 AWG.

K. Installation shall not require specialized tools or equipment other than those normally carried by installation crews.

2.17 CONNECTORS

A. General:

1. Comply with TIA/EIA 604-2, TIA/EIA 604-3, TIA/EIA 604-12, and TIA 568-C.3.
2. SC connectors.
3. Pull Strength: 0.2 N minimum.
4. Durability: Sustain minimum 500 mating cycles without violating other requirements.
   a. Ferrules: Free-floating low loss ceramic.
   b. Polarizing key on duplex connector systems.
5. Attenuation:
   a. In accordance with TIA 568-C.3.
   b. Maximum of 0.75 dB per connector pair.
6. Manufacturer: AMP.

2.18 PATCHCORDS

A. General:

1. In accordance with TIA 568-C.3.
2. Function: Connect fiber centers to network nodes, such as computer workstations.
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.
4. Cable Configuration:
   a. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.
   b. Protected with kevlar strength members and enclosed in thermoplastic jacket.
5. Length: Standard, to meet requirements shown, plus minimum 3 meters at workstations.
6. Connectors: As required by Article Connectors.
7. Cable Rating: OFNR or OFNP.
8. Color: Per standards or as indicated.

2.19 ACCESSORIES

A. Hardware: Provide cable clamps, strain reliefs, blocking and grommet kits, closures, and fan outs for complete installation.

2.20 CABLE IDENTIFICATION TAPE

A. Cable identification (or marking) tape shall be a nondetectable plastic orange tape not less than 6 inches in width. The tape shall have a continuous legend reading “CUWCD FO ” in black lettering. Tape splices shall be per tape manufacturer’s recommendations to be sure tape continuity for locating purposes. The tape shall be Panduit, Terra Tape, Brady and Blackburns, “or-equal.”

2.21 CABLE PULL ROPE AND TRACER WIRE

A. Provide cable pull rope in all conduits. The cable pull rope shall be constructed of a solid braid polyethylene jacket with a polyester core. The duct manufacturer shall certify that the cable pull rope is compatible for use with pulling fiber optic cable and fiber optic cable with extruded high tensile strength duct.

B. Provide tracer wire in conduit per Standard Details and Section 31 23 23.15, Trench Backfill. Keep tracer wire conduit within 3 inches of FO conduits.

   1. If fiber optic work is provided as part of a piping project that includes cathodic protection, provide terminal posts with boxes (match Ca Stations) per Section 26 42 00, Cathodic Protection, Article Cathodic Protection Test Stations.

2.22 DUCT SPACER

A. For use in trenches with conduits only. See Section 26 05 33, Raceways and Boxes.

B. For conduit systems that are in the same trench with parallel pipelines:

   1. Donut Spacer:
      a. Function: Bundles conduits into a multi-duct system while maintaining proper spacing.
      b. Material: Virgin High Impact Polystyrene.
      c. Manufacturer: Underground Devices Incorporated, Duct Donut Spacer.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Underground Installation:

1. The multi-duct system shall be installed in the trench as shown on Drawings and backfilled with flowable fill (CLSM) to encase the conduits with a minimum of 3 inches of cover all around.
2. Manufactured sweeps shall be used to limit bending of the conduits to a minimum radius of 10 feet.
3. For change in direction exceeding 45 degrees in either the horizontal or vertical direction, use a duct bend radius of at least 10 feet, or install a pull box if bend radius must be less than 10 feet.
4. The tracer wires for CUWCD are exclusive and care shall be taken to be sure the tracer wire conduits begin and end at the correct pull boxes. Marking or coloring shall be required to maintain accurate identification. Place the identification tape and tracer wire or identification tape/tracer wire above the top of the duct.
5. The multi-duct system shall be anchored in the trench to prevent displacement of the ducts during the placement of the flowable fill.
6. The tracer wires and the pulling tapes, shall be installed after the conduits are secured and have been proofed with an approved mandrel.
7. The ducts shall be kept sealed at all times to prevent water and foreign material from enter the ducts.
8. For duct that will not be immediately used, seal duct at both ends with conduit plugs to prevent moisture from entering. Repair any damaged duct immediately to keep water from entering duct.
9. At duct splicing locations, provide sufficient cable pull rope beyond the ends of the duct to allow for splicing of cable pull rope.
10. Use manufacturer approved methods and materials to splice the cable pull rope and duct. Spliced sections of rope are to withstand the maximum pull tension available by the pulling equipment used without damaging the integrity of the duct while pulling.
11. Provide duct seal fittings at each below grade penetration through pulbox wall or below grade wall to keep water from leaking into box or structure from conduit penetration.
12. Provide cable seal fittings at pull boxes, junction boxes, below grade vaults, buildings, and other location noted on drawings for conduits that have cables to prevent water ingress from conduit system.

B. Aboveground Installation: See Section 26 05 33, Raceways and Boxes.

3.02 LOCATION OF FO SYSTEM COMPONENTS

A. The Drawings diagrammatically indicate the desired location and arrangement of pull boxes, cable runs, and other elements of the fiber optic cable system. Determine exact locations in the field based on the size and arrangement of specified materials, capabilities of installation equipment, finished elevations, allowable cable pulling tensions and obstructions.

3.03 PREPARATION

A. Conduit:

1. Ensure installed conduit system conforms to fiber optic system requirements, including:
   a. Conduits and Innerducts: Size and quantity.
   b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts may be installed without exceeding manufacturer’s limitations.
   c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.
2. Ensure duct bank, conduit, and other confined routing is free and clear of debris before cable placement.
   a. Clean and test the duct prior to installing the cable pull rope. As a clearance test, pass through the duct a rigid mandrel with a length not less than 6 inches and a diameter 1/4 inch less than the inside diameter of the duct. Remove foreign materials, earth, sand, and gravel from the duct. The Construction Manager’s field representative shall be present to observe and approve duct testing.
   b. Install cable pull rope in all fiber optic conduits in accordance with the manufacturer’s recommendations. All installation equipment and methods shall be reviewed and allowed by the Owner prior to installation. All installation of cable pull rope shall be witnessed by the Owner’s field representative.
3. Spare Conduit: No cables shall be pulled into spare conduit.
4. Expansion Plugs: Seal spare or empty conduits to stop ingress of water and grit with conduit plugs.
5. Existing Conduit: Test and prepare existing conduit the same as new conduit prior to installing pull rope or cables.
6. Cabled Conduit: Cable seals for all conduit entering pullboxes or other structures that have cables in them to stop ingress of water.

B. Innerduct:

1. In accordance with manufacturer’s recommendations.
2. Identify innerducts at both ends by methods such as color-coding or waterproof tags wired through innerduct wall.

3. Sealing:
   a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
   b. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.
   c. Empty Innerducts: After installation, seal with fabricated expansion plugs to stop ingress of water and grit. Remove plugs as required to install cables.

3.04 INSTALLATION

A. Fiber Optic Cable:

1. Specified fiber counts, routing, origination, and terminating points are indicated on Drawings.
2. Installation by manufacturer's certified installer.
3. Install cables in accordance with manufacturer's requirements.
4. Install cable directly from shipping reels. Ensure that cable is:
   a. Not dented, nicked, or kinked.
   b. Not subjected to pull stress greater than manufacturer's specification.
   c. Not bent to a radius below manufacturer's minimum bend radius.
   d. Not subjected to treatment that may damage fiber strands during installation.
5. Cables per Conduit or Innerduct: As indicated on Drawings.
6. If calculation indicates cable will attenuate signals more than 8 dB, reroute may be allowed if approved by Engineer.
7. Splices:
   a. Install fiber optic cables in unspliced lengths from fiber source to destination as shown on Drawings.
   b. If splices are required and approved by Engineer indoor splices shall be in splice housings and outside splices shall be in access boxes or above grade pedestals protected by splice enclosures.
   c. Fusion splice fibers using apparatus applicable to type and size of fiber being spliced. Insert loss of splicing unit shall not exceed 0.2 dB on single-mode fibers and 0.25 dB on multimode fibers.
8. Connector: Insertion loss on multimode connections exceeding 0.5 dB and 0.4 dB on single-mode connections not permitted.
9. Identification:
   a. Identify cable on both ends, in access holes, and pull points.
   b. In accordance with TIA 606.
10. Arrange cable, equipment, and hardware to provide neat appearance and accessibility for servicing.

11. Access Holes:
    a. Provide supports for cables in access and handholes as shown on Drawings.
    b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.
    c. Coil up 50 feet of additional cable length in each handhole for each fiber optic cable in each manhole, handhole, large junction box, or pull box. Coiled cable shall be restrained into a neat bundle. Restrain cable with electrical tape, or zip ties. Restrained cable coil shall be supported on cable racks or laid flat on the floor of handhole or manhole.

B. Fiber Center, Fiber Distribution Frame, Housing, Panel, Splice Tray: Install securely in field panels or enclosures as shown on Drawings.

C. Cable Terminations:

1. In accordance with TIA 568-C.3.
2. Fan out fiber cable to allow direct connectorization of connectors.
    a. Sleeve over individual fibers with transparent furcation tubes.
    b. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.
3. Break-out Kits:
    a. Terminate cables using manufacturer-supplied break-out kits.
    b. Terminate in accordance with manufacturer’s recommendations.
4. Slack:
    a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
5. Connectors:
    a. Terminate 100 percent of fibers in each cable to specified connector.
    b. Connect into fiber management system.

D. Ethernet Fiber Optic Repeaters:

1. Install repeaters in accordance with manufacturer’s instructions.
2. Location: Install transceivers securely in enclosures as shown on Drawings.
3. Power: As indicated on Drawings.

E. Ethernet Fiber-to-Copper Transceivers:

1. Install transceivers in accordance with manufacturer’s instructions.
2. Location: Install transceivers securely in field panels, close to network nodes and fiber centers.

3. Power: Energize each transceiver from its field panel's UPS, if applicable.
4. Connections:
   a. Connect transceiver to fiber optics and network node.
   b. Lace fiber optics neatly in place, routed through wireways.

F. Conduit: Install in accordance with Section 26 05 33, Raceway and Boxes, Section 31 23 23.15, Trench Backfill, and Drawings

3.05 LABELING CONVENTIONS

A. Conform to TIA 606 or to requirements specified by Owner or Owner's representative.

B. Backbone (Riser) Cables: Coordinate labeling convention with Owner.

3.06 FIELD QUALITY CONTROL

A. General:

1. Advise Engineer at least 24 hours in advance of each test. Engineer shall have option to witness and participate actively in tests.
2. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.
3. Provide equipment, instrumentation, supplies, and skilled staff necessary to perform testing.
4. Outlets, cables, patch panels, and associated components shall be fully assembled and labeled prior to field testing.
5. Testing performed on incomplete systems shall be redone on completion of the Work.
6. Document Test Results: Confirm each cable has at least specified number of fibers that meet standards, in accordance with As-Built Fiber Optic Cable Installation form included as Supplement to this section.
7. Confirm quantities and sizes of conduit and innerduct, in accordance with As-Built Conduit/Innerduct Installation form included as Supplement to this section.

B. Test Equipment:

1. Field test instruments shall have latest software and firmware installed.
2. Optical Fiber Cable Testers:
   a. Field test instrument shall be within calibration period recommended by manufacturer.

b. Optical Loss Test Set (OLTS):
   1) Single-mode Optical Fiber Light Source:
      a) Provide dual laser light sources with central wavelengths of 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
      b) Output Power: Minus 10 dBm, minimum.
      c) Manufacturer: Fluke Networks.
   2) Multimode Optical Fiber Light Source:
      a) Provide dual LED light sources with central wavelengths of 850 nm (plus or minus 30 nm) and 1,300 nm (plus or minus 20 nm).
      b) Output Power: Minus 20 dBm minimum.
      c) Meet launch requirements of TIA/EIA 455-78. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap, as described in Clause 11 of TIA 568-C.3, with Category 1 light source.
      d) Manufacturer: Fluke Networks.
   3) Power Meter:
      a) Provide 850 nm, 1,300/1,310 nm, and 1,550 nm wavelength test capability.
      b) Power Measurement Uncertainty: Plus or minus 0.25 dB.
      c) Store reference power measurement.
      d) Save at least 100 results in internal memory.
      e) PC interface (serial or USB).
      f) Manufacturer: Fluke Networks.
   4) Optional Length Measurement: Capable of measuring optical length of fiber using time-of-flight techniques.

3. Optical Time Domain Reflectometer (OTDR):
   a. Bright, color transmissive LCD display with backlight.
   b. Rechargeable for 8 hours of normal operation.
   c. Weight with battery and module of not more than 4.5 pounds and volume of not more 200 cubic inches.
   d. Internal nonvolatile memory and removable memory device with at least 16 MB capacity for results storage.
   e. Serial and USB ports to transfer data to PC.
   f. Single-mode OTDR:
      1) Wavelengths: 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
      2) Event Dead Zone: 2 meters maximum at 1,310 nm and 2 meters maximum at 1,550 nm.
      3) Attenuation Dead Zone: 15 meters maximum at 1,310 nm and 15 meters maximum at 1,550 nm.
      4) Distance Range: Minimum 10,000 meters.
      5) Dynamic Range: Minimum 10 dB at 1,310 nm and 1,550 nm.

g. Multimode OTDR:
1) Wavelengths: 850 nm (plus or minus 20 nm) and 1,300 nm (plus or minus 20 nm).
2) Event Dead Zone: 1 meter maximum at 850 nm and 2 meters maximum at 1,300 nm.
3) Attenuation Dead Zone: 6 meters maximum at 850 nm and 15 meters maximum at 1,300 nm.
4) Distance Range: 2,000 meters minimum.
5) Dynamic Range: Minimum 10 dB at 850 nm and 1,300 nm.

h. Manufacturer: Fluke Networks.

4. Integrated OLTS, OTDR, and Fiber Microscope:
a. Test equipment that combines into one instrument such as OLTS, OTDR, and fiber microscope may be used.
b. Manufacturer: Fluke Networks.

C. Conduit Test:

1. Test and seal spare conduits.
2. Conduit and Innerduct Testing:
a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
b. If conduit is restricted over full length, advise Engineer.
3. Documentation: Confirm conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.

D. Cable Testing:

1. Test procedures and field test instruments shall comply with applicable requirements of:
a. LIA Z136.2.
b. TIA/EIA 455-78.
c. TIA/EAI 455-133.
d. TIA 526-7.
e. TIA 526-14.
f. TIA 568-C.1.
g. TIA 568-C.3.
h. TIA TSB 140.
2. Test attenuation and polarity of installed cable plant with OLTS and installed condition of cabling system and its components with OTDR.
3. Verify condition of fiber end face.
4. Perform on each cabling link (connector to connector).
5. Perform on each cabling channel (equipment to equipment).
6. Do not include active devices or passive devices within link or channel other than cable, connectors, and splices. For example, link

attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

7. Document Tests:
   a. OLTS dual wavelength attenuation measurements for single-mode and multimode links and channels.
   b. OTDR traces and event tables for single-mode and multimode links and channels.

E. Fiber Testing Parameters:

1. Each cabling link shall be in compliance with the following test limits:
   a. Optical Loss Testing:
      1) Backbone (single-mode and multimode) Link:
         a) Calculate link attenuation by the formulas specified in TIA 568-C.1.
         b) Values for Attenuation Coefficient (dB/km) are listed in the table below:

Attenuation Coefficient				
Type of Optical Fiber	Wavelength (nm)	Attenuation Coefficient (dB/km)	Wavelength (nm)	Attenuation Coefficient (dB/km)
Single-mode (Inside plant)	1,310	1.0	1,550	1.0
Single-mode (Outside plant)	1,310	0.5	1,550	0.5
Multimode 62.5/125 µm	850	3.5	1,300	1.5
Multimode 50/125 µm	850	3.5	1,300	1.5

   b. OTDR Testing:
      1) Reflective Events: Maximum 0.75 dB.
      2) Nonreflective Events: Maximum 0.3 dB.
   c. Magnified Endface Inspection:
      1) Visually inspect fiber connections for end-face quality.
      2) Scratched, pitted, or dirty connectors shall be diagnosed and corrected.

F. Diagnosis and Correction:

1. Installed cabling links and channels shall be field tested and pass test requirements and analysis as described herein.
2. Link or channel that fails these requirements shall be diagnosed and corrected.

3. Document corrective action and follow with new test to prove corrected link or channel meets performance requirements.
4. Provide final and passing result of tests for links and channels.

G. Acceptance: Acceptance of test results shall be given in writing after Project is tested and completed in accordance with Contract Documents and satisfaction of Owner.

H. Test Execution:

1. Optical Fiber Cable Testing:
   a. Tests performed that use laser or LED in test set shall be carried out with safety precautions in accordance with LIA Z136.2.
   b. Link and channel test results from OLTS and OTDR shall be recorded in test instrument upon completion of each test for subsequent uploading to a PC in which administrative documentation may be generated.
      1) Record end-face images in memory of test instrument for subsequent uploading to a PC and reporting.
   c. Perform Testing:
      1) On each cabling segment (connector to connector).
      2) On each cabling channel (equipment to equipment).
      3) Using high-quality test cords of same fiber type as cabling under test.
         a) Test cords for OLTS testing shall be between 1 meter and 5 meters in length.
         b) Test cords for OTDR testing shall be approximately 100 meter for launch cable and at least 25 meters for receive cable.
2. Optical Loss Testing (OLTS):
   a. Backbone Link:
      1) Test single-mode at 1,310 nm and 1,550 nm in accordance with TIA 526-7, Method A.1, One Reference Jumper or equivalent method.
      2) Test multimode at 850 nm and 1,300 nm in accordance with TIA 526-14A, Method B, One Reference Jumper or equivalent method.
      3) Perform tests in both directions.
3. OTDR Testing:
   a. Test backbone, horizontal, and centralized links at appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
      1) Single-mode: 1,310 nm and 1,550 nm.
      2) Multimode: 850 nm and 1,300 nm.
   b. Test each fiber link and channel in one direction.

c. Install launch cable between OTDR and first link connection.
d. Install receive cable after last link connection.

4. Length Measurement:
   1) Record length of each fiber.
   2) Measure optical length using OLTS or OTDR.
5. Polarity Testing:
   a. Test paired duplex fibers in multifiber cables to verify polarity in accordance with subclause 10.3 of TIA/EIA 568-C.1.
   b. Verify polarity of paired duplex fibers using OLTS.
6. Test Results Documentation:
   a. Test results saved within field-test instrument shall be transferred into Windows-based database utility that allows for maintenance, inspection, and archiving of test records. These test records shall be uploaded to the PC unaltered. For example, "as saved in the field-test instrument." The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
   b. Available for inspection by Owner or Owner's representative during installation period. Submit within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling.
   c. Database for Project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD-ROM prior to Owner acceptance of building. CD-ROM shall include software tools required to view, inspect, and print test reports.
   d. Circuit IDs reported by test instrument shall match specified label identification.
   e. Provide in electronic database for each tested optical fiber with the following information:
      1) Identification of Site.
      2) Name of test limit selected to execute stored test results.
      3) Name of personnel performing test.
      4) Date and time test results were saved in memory of tester.
      5) Manufacturer, model, and serial number of field test instrument.
      6) Version of test software and version of test limit database held within test instrument.
      7) Fiber identification number.
      8) Length for Each Optical Fiber: Optionally the index of refraction used for length calculation when using a length capable OLTS.
      9) Test results to include OLTS attenuation link and channel measurements at appropriate wavelength and margin; difference between measured attenuation and test limit value.

10) Test results to include OTDR link and channel traces, and event tables at appropriate wavelength.
11) Length for each optical fiber as calculated by the OTDR.
12) Overall pass/fail evaluation of link-under-test for OLTS and OTDR measurements.

I. Drawings:

1. Record Copy: Provide at end of Project on CD-ROM.
   a. CAD format and include notations reflecting as-built conditions of additions and variations from Drawings provided, such as to cable path and termination point.
   b. CAD drawings are to incorporate test data imported from test instruments.
2. As-built Drawings:
   a. Include, but not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts, and frame installation details.
   b. Include field changes made up to construction completion:
      1) Field directed changes to pull schedule.
      2) Field directed changes to cross connect and patching schedule.
      3) Backbone cable routing or location changes.
      4) Associated detail drawings.

3.07 TRAINING

A. Train Owner's staff in the following skills:

1. Connectorizing fibers.
2. Testing quality of connectors, splices and fibers.

B. Schedule: Provide two 8-hour training sessions on consecutive weekdays, to suit Owner's schedule.

C. Materials: Provide hardware for training, including fibers, connectors, and splice kits.

3.08 SUPPLEMENTS

A. Supplements listed below, following "End of Section," are part of this Specification.

1. As-Built Fiber Optic Cable Installation Form.
2. As-Built Conduit/Innerduct Installation Form.

END OF SECTION

PROJECT: [*INCLUDE YOUR PROJECT'S NAME HERE*]

Contractor:

Signed by:

AS-BUILT FIBER OPTIC CABLE INSTALLATION

Sheet 1 of 2

Cable Identification:
Routing: From: In:
(Identify field panel, control room, and others in building)

Through: 1
(Identify access hole, building, gallery, etc.)
Through: 2 Through: 5
Through: 3 Through: 6
Through: 4 Through: 7
To: In:
See As-Built Conduit/Innerduct Installation forms for identification of conduits/innerducts cable is routed through.

Acceptable Attenuation:
Multimode Fibers

		cable length*	
850 nm:	3.5 dB/km x	km + 1.5 dB =	dB
1300 nm:	1.0 dB/km x	km + 1.5 dB =	dB

*Contractor to provide actual length installed, within ±0.1 km.

Fiber ID	Use/Spare	Measured Attenuation (dB)			
		Hub-to-Node		Node-to-Hub	
		850 nm	1,300 nm	850 nm	1,300 nm

Sheet 2 of 2

Single-mode Fibers

		cable length*		
1310 nm:	[1.0] [0.5] dB/km x		km + 1.5 dB =	dB
1550 nm:	[1.0] [0.5] dB/km x		km + 1.5 dB =	dB

*Contractor to provide actual length installed, within ±0.1 km.

		Measured Attenuation (dB)			
		Hub-to-Node		Node-to-Hub	
Fiber ID	Use/Spare	1,310 nm	1,550 nm	1,310 nm	1,550 nm

PROJECT: [*INCLUDE YOUR PROJECT'S NAME HERE*]

Contractor:

Signed by:

AS-BUILT CONDUIT/INNERDUCT INSTALLATION

From: To:

(Identify building, access hole, field panel, etc.) Sheet 1 of 1

Conduits:
Used: 4 inches; 2 inches
Spare: 4 inches; 2 inches Confirm all spares unrestricted: Yes/No
(Provide number of conduits in each category)

Innerducts:

Conduit ID*	Innerduct ID	Cable ID / Spare

(Continued overleaf delete if not applicable)

*Provide conduit ID if required to identify innerduct uniquely in the access hole, if for example, color-coded innerduct is used in more than one conduit. If innerducts are tagged uniquely, leave this column blank.

END OF SUPPLEMENT

SECTION 41 22 13.13
OVERHEAD CRANES

PART 1 GENERAL

1.01 REFERENCES

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

1. American Society of Mechanical Engineers (ASME):
   a. B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist).
   b. B30.10, Hooks.
   c. B30.11, Monorails and Underhung Cranes.
   d. B30.17, Overhead and Gantry Cranes (Top Running, Single Girder).
   e. HST 1M, Performance Standard for Electric Chain Hoists.
   f. HST 2M, Performance Standard for Hand Chain Manually Operated Chain Hoists.
   g. HST 4M, Overhead Electric Wire Rope Hoists.
2. Crane Manufacturer's Association of America (CMAA):
   a. 70, Electric Overhead Traveling Cranes.
   b. 74, Top Running & Under Running Single Girder. Electric Overhead Traveling Cranes.
3. National Electrical Manufacturer's Association (NEMA):
   a. MG 1, Motors and Generators.
   b. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Occupational Safety and Health Act (OSHA).
6. UL: 674, Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.02 DESIGN REQUIREMENTS

A. Top-Running Multiple-Girder Overhead Traveling Crane: CMAA No. 70 and ASME B30.2 and B30.17.

B. Top-Running and Underhung Single-Girder Overhead Traveling Cranes: CMAA No. 74, and ASME B30.11.

C. Trolley Service Class: CMAA No. 70.

D. Wire Rope Hoist Service Class: ASME HST 4M and CMAA No. 70 or CMAA No. 74.

E. Chain Hoist Service Class: ASME HST 1M and CMAA No. 70 or CMAA No. 74.

F. Hook: ASME 30.10.

G. Building Clearances: CMAA No. 70 and CMAA No. 74. Where bridge span exceeds 40 feet, increase clearance to 6 inches.

H. Stress and Safety Factors: CMAA No. 70 and CMAA No. 74. Properly select materials of construction for stresses to which subjected.

I. Safety of Operation, Accessibility, Interchangeability, and Durability of Parts: ASME B30.2.0 and OSHA requirements. Design equipment for environment operated.

J. Provide system, equipment, and components, including supports and anchorages, designed in accordance with Section 01 61 00, Common Product Requirements.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Make, model, weight, and horsepower of each equipment assembly.
    b. Complete catalog information, descriptive literature, materials of construction, and specifications on bridge drive system, end trucks, runway stops, footwalks and platforms, wheels, shafting, drive motor, gears and bearing, steel framing, trolley drive system, hoist motor and assemblies, hook, brakes, starting system, variable speed drive system, conductors (bus bar, festoon, cable reel), controls, remote control system, and accessories.
    c. Structural design calculations for runway beams and support system and calculations of deflection and loads on building steel stamped by a professional engineer registered in the State of Utah.
    d. Detail Shop Drawings of crane runways, brackets, hangers, and their attachments to building structural steel.
    e. Power and control wiring diagrams, including terminals and numbers.
    f. Motor nameplate data in accordance with NEMA MG 1 and include any motor modifications.
    g. Factory finish system.

B. Informational Submittals:

1. Special shipping, storage and protection, and handling instructions.
2. Manufacturer's printed installation instructions.
3. Manufacturer's Certification of Compliance that the factory finish system is identical to the requirements specified herein.
4. Suggested spare parts list to maintain the equipment in service for a period of 1 year and5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
5. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Indoors in heated and ventilated, but not air-conditioned, building in Santaquin, UT.

B. Temperature: Maximum 115 degrees F; minimum 5 degrees F.

C. Humidity: 20 percent.

1.05 EXTRA MATERIALS

A. Furnish for each remote control crane:

1. One transmitter.
2. One battery.

PART 2 PRODUCTS

2.01 GENERAL

A. Crane manufacturer to coordinate equipment requirements with steel structures, panels, drive motor, control panel, trolley and hoist, hoisting cable or chain, hook, crane mounted conductors, rails, stops, and electrical equipment controls.

B. Where adjustable speed drives or remote control systems are required, crane manufacturer to furnish a coordinated operating system.

2.02 SUPPLEMENTS

A. See supplements to this section for additional requirements.

2.03 RUNWAY

A. Runway beams, brackets, and associated framework furnished under Section 05 12 00, Structural Steel Framing.

B. Runway rails shall conform to cross-sections and weights per yard as specified in CMAA No. 70 or CMAA No. 74. Furnish rails, crane stops, and conductors by crane manufacturer. Floating rails are not acceptable.

C. Support underhung crane runway rails by a suspension system of hanger rods and joints which will permit runway rails to adjust to normal fluctuations of weight occurring as crane travels along rails. Design suspension system for minimal support rod bending stresses. Furnish slotted holes and shims for lateral and vertical rail adjustment. Brace one rail laterally to prevent excess motion of runway. Brace both rails longitudinally.

2.04 BRIDGE

A. Furnish girders from structural shapes proportioned to resist vertical, lateral, and torsional forces.

B. Construct bridge end trucks in accordance with CMAA No. 70 or CMAA No. 74. Furnish end trucks with rail sweeps and impact-absorbing bumpers.

C. Furnish runway stops attached to resist force applied when contacted and locate at limit of travel of bridge. Runway stops shall not engage the wheels.

D. Provide bridge travel limit switches, located approximately 10 feet to 15 feet from each end of bridge runway, or as required such that bridge travel speed is reduced to low speed prior to bridge engaging runway end-stops. Bridge drive speed past the limit switch locations shall be limited to low speed.

E. Wheels: Rolled or forged steel with treads and flanges heat treated, or cast iron wheels with chilled tread. Minimum tread hardness 200 Brinell. Clearances, wheel loads, and tolerances in accordance with CMAA No. 70 or CMAA No. 74. Wheel axles of alloy steel, machined and ground to receive inner bearing races. Use rotating axles and wheels mounted by press fit and keys.

F. Bridge driving machinery consisting of a cross shaft driven by an electrical motor through a gear speed reducer unit. Cross shaft, high-grade steel, turned, ground, polished, and adequately supported with self-aligning bearings. Shaft diameter to resist torsional strains when bridge is traveling under full load, or when stopped suddenly. Furnish oil-tight speed reducer gear case and support on common base with bridge brake.

G. Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.

H. Bearings: Combination radial and thrust type, double row, spherical ball, either prelubricated and sealed or fitted for pressure lubrication. Pressure lubrication fittings for maintenance accessibility.

I. Brakes: Electrically operated, adjustable, suitable for the service class indicated, with rated torque capacities as specified in CMAA No. 70 or CMAA No. 74.

2.05 TROLLEY

A. Frame: Welded steel, cast steel, or ductile iron construction, or a combination thereof. Design to control deflection of trolley assembly while transmitting the carrying load to bridge rails.

B. Drive shall consist of trolley drive shaft, driven by an electric motor through a gear reduction unit.

C. Furnish roller assembly stabilizers on single-girder trolley units to prevent tipping during load pickup.

D. Wheels: Rolled or forged steel, accurately machined and ground to receive inner bearing races. Furnish alloy steel axles. Rotating axles with wheels mounted press fit and keys, or with keys alone. Minimum tread hardness 210 Brinell.

E. Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.

F. Bearings: Combination radial and thrust type, double row, angular contact ball bearings or single-row tapered roller bearings. Bearings prelubricated and sealed, or fitted for pressure lubrication. Locate pressure lubrication fittings for accessibility during maintenance.

G. Brakes: Suitable for service class and rated torque capacities as specified in ASME B30.11. Furnish stops on trolley rails or beams.

H. For bridge spans greater than 40 feet provide trolley travel limit switches, located approximately 6 feet to 8 feet from each end of trolley rails/beams, or as required such that trolley travel speed is reduced to low speed prior to trolley engaging the trolley end-stops. Trolley drive speed past the limit switch locations shall be limited to low speed.

2.06 HOIST

A. Hoisting machinery shall consist of rope drum driven through gear reductions, load blocks, hook, hoisting rope, sheaves, and hoist braking. Drum size and length sufficient for minimum two turns of cable remaining on drum when hook is at lowest position. Furnish reeving as specified on supplement located at end of section. Provide right and left-hand grooved drum when two-part double reeving is specified.

B. Rope drum and surrounding members constructed to minimize abrasion, crushing or jamming of hoist rope. Load blocks enclosed type. Hoisting rope extra flexible, improved plow steel wire rope, made especially for hoist service.

C. Hook: Construct with sufficient ductility to open noticeably before hook failure, equipped with safety latch, free to rotate 360 degrees with rated load and positively held in place with locknuts, collars or other devices.

D. Brakes: Mechanical and electric load brake and controls, designed in accordance with ASME 4M, and adjustable to compensate for wear.

2.07 ELECTRICAL

A. Furnish electrical equipment including motors, motor starters, pendant control, control systems, wire, and conduit. Bridge conductors may be removed for shipment. Crane wiring by crane supplier.

B. Electrical: In accordance with NFPA 70, NEC Article 610.

C. Furnish motors compatible with adjustable frequency, variable speed, drive system, 40 to 1 speed range, suitable for hoist, trolley, and bridge drive applications. Controls with 120-volt ac, microprocessor based, pulsed width modulation design, withstand 45 degree C temperatures, housed in NEMA 250, Type 12 enclosure, and supplied with 200 percent overcurrent protection.

D. Bridge and trolley conductor voltage drops from runway supply taps shall permit the crane motors to operate within voltage tolerances of plus or minus 10 percent, when building supply voltage is at plus or minus 5 percent of design voltage.

E. Enclosed Bus Bar Conductors: steel strip enclosed in insulation. Collector sliding shoe type, with adjustable spring tension arms for contact between bus bar and controls.

F. Festooned Flat Cable Conductors: Flexible cable, carried by heavy-duty roller, permanently lubricated roller bearings, with monorail support system that will dispense and retrieve flexible cable without twisting or tangling, and 20 percent spare conductor in each cable assembly.

G. Grounding: External in accordance with NFPA 70, NEC Article 250.

2.08 CONTROLS

A. Furnish electric cranes with pendant control having momentary contact pushbuttons with a device which will disconnect motors from line on failure of power. Device shall not permit any motor to be restarted until controller handle is brought to the OFF position, or a reset switch or button is operated. Furnish with undervoltage protection as a function of each motor controller, or by magnetic main line contactor.

B. Controls: Fully magnetic, plain reversing type, housed in NEMA 250, Type 12 enclosure, with contactors of sufficient size and quantity for starting, accelerating, reversing, and stopping duty for specified crane service class.

C. Bridge and Trolley Drives: Soft start controls, 120/240-volt ac series device, installed in between drive motor and motor starter with torque and acceleration rate adjustable, suitable for crane service, and work in conjunction with crane controls.

D. Pushbutton Control Stations: Heavy-duty, oil-tight, suspended from bridge with control transformers to supply 120-volt ac power to pushbutton control station. Pushbutton enclosure supported with chain or wire rope. Control wire cable attached to support chain or wire rope at not more than 6-foot intervals. Furnish control station buttons for control of bridge, trolley, and hoist, ON/OFF main line contactor power switch which removes all power from crane and controls.

E. Remote Control System: Infrared, line-of-sight system, handheld and capable of operating all crane functions.

F. Control motions indicate direction of resultant crane motion. Furnish spring-loaded switch motions, with return to OFF position when switch is released and designed to prevent runaway crane situations.

G. Crane motions shall stop automatically when crane can no longer receive remote signals and designed to stop when control signal for any motion becomes ineffective.

H. Remote Control Crane Motions: Hook raise and lower, trolley movement, bridge movement, and crane power up and power. Furnish an EMERGENCY OFF pushbutton station which will disconnect main line power via a remote switch, and manual reset function to activate all motions after an EMERGENCY OFF event.

2.09 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location. Mounted on separate components of each crane assembly, to facilitate assembly in the field.

B. Lifting Lugs: Equipment weighing over 100 pounds.

2.10 FACTORY FINISHING

A. Prepare and prime coat in accordance with manufacturer’s standard.

2.11 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels and equipment for required construction, electrical connection, and intended function.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s printed instructions.

B. Provide lubrication and lubrication fittings.

3.02 FIELD FINISHING

A. Touch up any coatings damaged during shipment and installation using paint supplied by the manufacturer.

3.03 FIELD QUALITY CONTROL

A. Functional Test: Conduct on each crane.

1. Alignment: Test complete assemblies for proper alignment, connection, and quiet operation.

B. Performance Test:

1. Conduct on each crane.
2. Load tests in compliance with OSHA, ASME B30.11, and ASME B30.16.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:
   a. 3 person-days for installation assistance and inspection.
   b. 3 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for prestartup classroom or Site training.
   d. 1 person-day for facility startup.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Crane Data Sheet Santaquin South/Pigging Structure.
2. Crane Dimension Sheet Santaquin South/Pigging Structure.
3. **[E: Induction Motor Data Sheet.]**

END OF SECTION

CRANE DATA SHEET SANTAQUIN SOUTH/PIGGING STRUCTURE

Project: Spanish Fork Santaquin Pipeline—Santaquin Reach	Manufacturer.:________
Owner: Central Utah Water Conservancy District	Model No.:________
Service: Santaquin South Turnout/Pigging Structure	Number of Units: 1________
Equip. Tag Number(s): SS-CRN-00023	Rev/Date/By: ____/____/____

GENERAL REQUIREMENTS

Equipment Capacity: 3______tons	Factory Testing:	Power Supply:________
Method of Control: ________	☐Required ☒Not Required	Voltage________
Location of Control:________	Field Testing: ☐Not required	Phase 1________
Equipment Location:	☒Required, functional and	Frequency 60________
☒Indoors ☐Outdoors	Performance	

BRIDGE	TROLLEY	HOIST
Type:	Type:	Type:
☒Single Girder ☐Double Girder	☐Top Running ☒Underhung	☒Electric, Wire Rope
☒Top Running ☐Underhung		☐Hand Operated, Chain
Service Class (ANSI):	Service Class (ANSI):	Service Class (ANSI):
☒A (standby) ☐B (light)	☒A (standby) ☐B (light)	☒H1 (standby) ☐H2 (light)
☐C (moderate) ☐D (heavy)	☐C (moderate) ☐D (heavy)	☐H3 (standard ☐H4 (heavy)
☐E (severe) ☐F (continuous)	☐E (severe) ☐F (continuous)	☐H5 (severe)
Speed (fpm): ____ to ____	Speed (fpm): ____ to ____	Speed (fpm): ____ to ____
☒Constant Speed	☒Constant Speed	☐Constant Speed ☐Two Speed
☐Variable Speed ☐Hand Operated	☐Variable Speed ☐Hand Operated	☐Variable Speed
Motor hp:________	Motor hp: ________	Motor hp:________
Main Runway Electric Conductors:	Electric Conductors:	Hook: See Crane Dimension Sheet
☐Bus Bar ☐Festoon	☐Bus Bar ☐Festoon ☐______	Hook Manufacturer: Mfr Strd
Bridge Drive System (CMAA):	☐Cable Reel	Reeving: ________
☐A1 ☐A2 ☐A3		
☐A4 ☐A5 ☐A6		

SPECIAL REQUIREMENTS

Accessories:	Remote Controls:	Special Electrical Requirements:
☐Service Platform	☐Infrared, line-of-sight	
☐Central Lubrication System	☐Frequency Modulated (FM)	
☐OSHA Operating and Safety Devices	Manufacturer:________	
	☐Extended Grease Fittings	

See Crane Dimension Sheet for clearances, lift distances, and details.

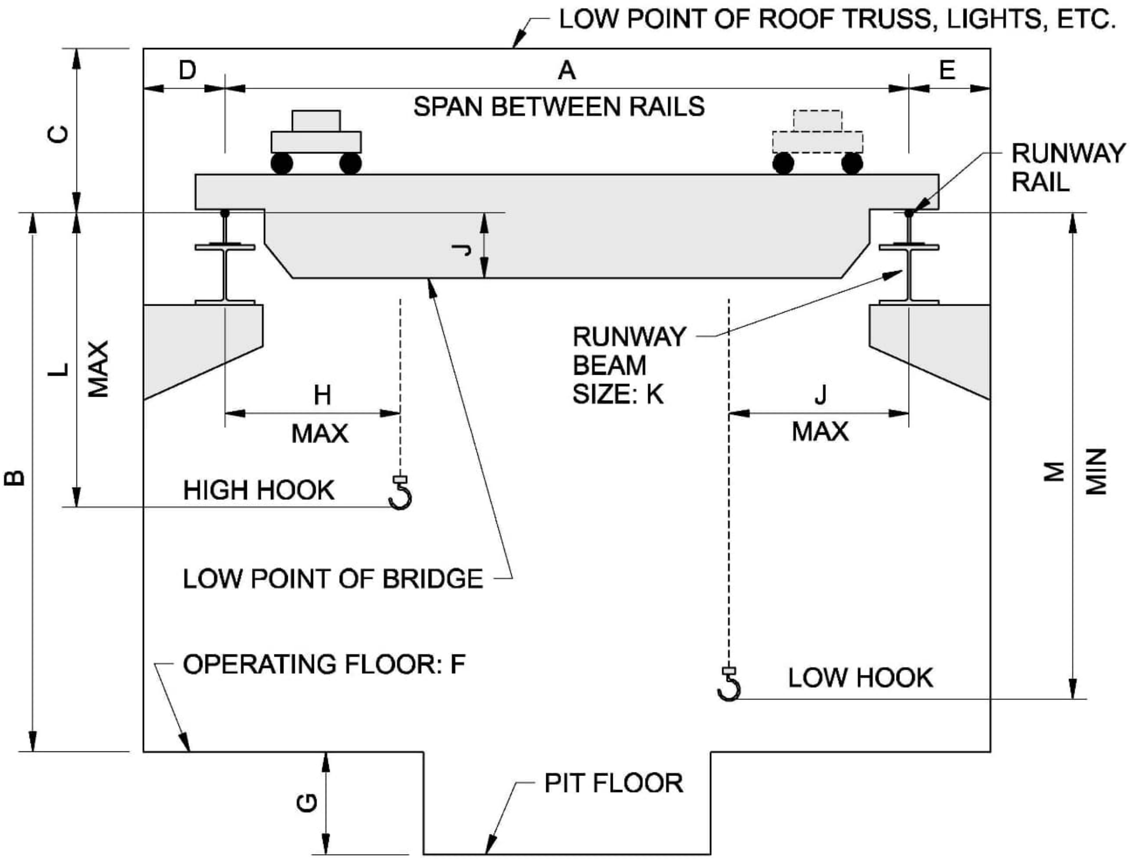
CRANE DIMENSION SHEET SANTAQUIN SOUTH/PIGGING STRUCTURE

Building Clearances for Top-Running Cranes

Project: Spanish Fork Santaquin Pipeline—Santaquin Reach

Owner: Central Utah Water Conservancy District

Equip. Tag No.: SS-CRN-00023



A: 37'-3"	E: 0'-9"	I:
B: 11'-3"	F: El. 4,915.25 feet	J:
C: 3'-0"	G: 8'-9"	K: See Drawings
D: 0'-9"	H: 18'-7.5"	L: 18'-0"

Notes:

1. Runway Length: 64'-6"
2. Minimum Stop Clearance from North Wall : 4'-7"

INDUCTION MOTOR DATA SHEET

Project:____________________

Owner:____________________

Equipment Name:____________________

Equipment Tag Number(s):____________________

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower:____________

Voltage:____________

Phase:____________

Frequency:____________

Synchronous Speed:_____ rpm

☐ Thermal Protection: ________

☐ Space Heater: _____ volts, single-phase

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☐ 1.0 ☐ 1.15

Enclosure Type:____________________

☐ Multispeed, Two-Speed: _____ / _____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☐ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ to _____% of Rated Speed

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☐ See Section 26 20 00, Low-Voltage AC Induction Motors.

Special Features:____________________

____