CONTRACT DOCUMENTS
AND
SPECIFICATIONS
FOR
PROJECT NO. TMUA-W 18-27
TIAWAH TUNNEL REPAIRS AND BIRD CREEK PUMP STATION IMPROVEMENTS

Prepared for:
TULSA METROPOLITAN UTILITY AUTHORITY
CITY OF TULSA, OKLAHOMA

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END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section includes requirements for health and safety of workers and providing a safe environment.

B. The Contractor is solely responsible for the enforcement of safe methods and procedures prescribed by the references indicated herein.

C. Review of the Health and Safety Plan by the Engineer shall not impose any liability upon the Engineer, nor shall any such review relieve the Contractor of any responsibilities under the Contract or applicable local, state, or federal safety statutes and regulations.

D. The Contractor shall provide and maintain a written Health and Safety Plan for review by the Engineer, in general accordance with COT 112 - Safety.

1.2 MEASUREMENT AND PAYMENT:

A. No separate measurement or payment shall be made for the requirements and restrictions noted in this Section.

B. The costs of meeting these requirements shall be included in the Contract prices.

1.3 SAFETY REGULATIONS

A. Applicable Standards include all Local, State and Federal Regulations for working in an underground environment in effect at the time of construction.

1.4 ASSISTANCE TO SAFETY INSPECTORS

A. Contractor shall provide assistance to the Engineer or Regulatory Safety Inspectors in the performance of their duties by furnishing labor, access to work locations, and materials needed to complete their tasks.

1.5 GENERAL SAFETY REQUIREMENTS

A. The Contractor’s Health and Safety Plan shall define the appropriate engineering control methods and personal protection equipment for the health and safety of the Contractor’s workers and to mitigate potential hazards for underground work.
1.6 SUBMITTAL

A. Submit Health and Safety Plan to the Engineer within 10 days of Notice to Proceed.

PART 2 - MATERIALS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION
SECTION 02 41 00

DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section specifies demolition, removal, and disposal of surface and subsurface structures and related ancillary components, including removal of a portion of the Tiawah Tunnel existing lining (Replacement Section), and demolition for modifications to the existing East Access Structure.

B. Work specified includes where care must be exercised to prevent damage to existing utilities or portions of structures that are to remain.

1.2 RELATED SECTIONS

A. Current City of Tulsa Standard Specifications and Standard Details govern, unless modified herein. Refer to the following City of Tulsa (COT) Standard Specifications for Related Work:
   1. COT 113 – Removal of Condemned Materials and Structures
   2. COT 115 – Clean-Up
   3. COT 302 – Excavation and Backfill, Unclassified
   4. COT 330 – Erosion Control Measures

B. Refer to Volume II – Technical Specification (SPECIAL) for related work:
   1. Section 31 41 00 – Shoring, Sheeting and Bracing

1.3 MEASUREMENT

A. Demolition of the existing Tiawah Tunnel lining will be measured on a per lineal foot of tunnel as the actual horizontal measurement along the centerline of the tunnel. Demolition beyond the limits shown on the Plan will not be included for payment, unless as directed by the Engineer.

B. Demolition for modifications to the existing East Access Structure will be measured on a lump sum basis, per the Plans. Demolition beyond the limits shown on the Plan will not be included for payment, unless directed by the Engineer.

1.4 PAYMENT

A. Demolition of the existing tunnel lining (Replacement Section) in accordance with the Plans and Specifications will be paid at the unit prices stated in the Bid Schedule. Demolition will include sawcutting, demolition and removal, temporary bracing, lighting and ventilation, surveying, disposal, utilities and any incidentals required for the work. Work does not include excavation.
support systems, which are covered in Section 31 41 00. Work does not include excavation around the lining, which is covered in other Pay Items.

B. Demolition for modifications of the existing East Access Structure in accordance with the Plans and Specifications will be paid at the lump sum stated in the Bid Schedule. Demolition will include sawcutting, demolition and removal, preparing and cleaning the sawcut surfaces for installation of the access hatches, temporary bracing, lighting and ventilation, surveying, disposal, utilities and any incidentals required for the work.

1.5 SUBMITTALS

A. Demolition and Removal Construction Work Plan within 14 days of starting work:
   1. Methods of demolition, temporary support, and removal of each Structure, including sequencing of work. Coordinate demolition with layout of the excavation support system, in accordance with Section 31 41 00.
   2. Waste Management Plan
   3. Waste Management Progress Reports

B. Permits
   1. Demolition
   2. Hauling and debris disposal
   3. Groundwater discharge

C. Permit from Underground Service, if applicable

D. As-Built Drawing(s) of surveyed locations and dimensions of demolition limits.

1.6 SITE CONDITIONS

A. Unknown Conditions
   1. The Contract related documents may not represent all surface and subsurface conditions at the site and adjoining areas. Verify the actual conditions and utilities before commencing work.
   2. Protect existing structures not subject to demolition from damage.

1.7 DEMOLITION AND REMOVAL CONSTRUCTION WORK PLAN

A. Include the following items in the Demolition and Removal Construction Work Plan:
   1. Demolition schedule for both existing lining removal and modifications to the existing access structure
2. Description of the proposed sequence
3. Description of demolition methods
4. Description of equipment to be used in the demolition process
5. Salvageable items
6. Description of proposed disposal of materials including provisions for maximizing recycling and reuse of materials
7. Description of haul routes and access points
8. Description of cleanup methods

B. Submit Waste Management Plan in accordance with COT 115.

PART 2 - PRODUCTS

2.1 MATERIALS, EQUIPMENT, AND FACILITIES

A. Backfill: COT 302, unless directed otherwise by the Engineer.

B. Products for patching, extending and matching: Same type as those in existing facility.

PART 3 - EXECUTION

3.1 PERMITS

A. Obtain all special permits and licenses and give all notices required for performance and completion of the demolition and removal work, hauling, and reuse, salvage, recycling, and/or disposal of debris, and other permit requirements identified in this Section.

3.2 PROTECTION

A. Protection of Persons and Property

1. Install temporary chain link fencing around the area of work, and shown on the Plans, and in accordance with ODOT R-68.

2. Erect and maintain temporary bracing, shoring, lights, barricades, signs, and other measures as necessary to protect the public, workers, and adjoining property from damage from demolition work, in accordance with applicable codes and regulations. Coordinate work with requirements of Section 31 41 00.
3.3 DEMOLITION
   A. Perform demolition in accordance with the approved Demolition and Removal Construction Work Plan.
   B. Blasting is not permitted.
   C. Backfill depressions caused by excavations, demolition, and removal with materials placed and compacted in accordance with COT 302 and restore to pre-construction conditions.
   D. Exercise pollution controls as specified in COT 330.
   E. Demolish and remove invert/foundations for existing tunnel lining.

3.4 DEBRIS AND MATERIAL SALVAGE, RECYCLING, AND DISPOSAL
   A. Perform salvage, recycling and disposal-related work in accordance with COT 113.
   B. Remove materials, waste, and debris from the site at frequent intervals so that its presence will not delay the progress of the work or create unsafe or unsanitary conditions.
   C. Contain runoff so drainage through concrete spalls or debris remains on-site and does not go off site.

3.5 CLEANUP
   A. Refer to COT 115.

END OF SECTION
SECTION 03 10 80
SHOTCRETE

PART 1 GENERAL

1.1 DESCRIPTION

A. Shotcrete conforming to the requirements hereinafter specified shall be applied and bonded to concrete, rock, soil, expanded metal or stayform, welded wire fabric (WWF), grouted surfaces, or previously placed shotcrete, in the tunnel as provided in these Specifications and shown on the Plans. Shotcrete shall be of the dry-mix type as approved by the Engineer. The various ACI 506 Guides shall be used as a guide for obtaining quality shotcrete.

B. The Work covered by this Section also consists of furnishing all labor, equipment, and materials, and performing all work required to scale the existing concrete liner and install WWF with epoxy dowel steel studs to the existing concrete tunnel liner in accordance with the Contract Documents.

C. Unreinforced dry-mix shotcrete (DMS) shall be a sprayed concrete mix consisting of cement, sand, coarse aggregate, admixtures, and water.

D. All materials used shall be ANSI/NSF Standard 61 potable water approved compliant.

E. Shotcrete thickness shall be as indicated on the Plans, specified in this Section, or as directed by the Engineer, for Type II and IV repairs. Multiple layers may be necessary to provide the final thickness indicated. The time interval between successive applications of shotcrete must be sufficient to allow initial set to develop.

1.2 RELATED SECTIONS

A. Current City of Tulsa Standard Specifications and Standard Details govern, unless modified herein. Refer to the following City of Tulsa (COT) Standard Specifications for Related Work:

1. COT 111 – Dewatering
2. COT 113 – Removal of Condemned Materials and Structures
3. COT 115 – Clean-Up

B. Refer to Volume II – Technical Specification (SPECIAL) for related work:

1. Section 01 04 40 – Underground Safety
1.3 MEASUREMENT

A. Unreinforced dry-mix shotcrete (DMS) placed as support in the tunnel will be measured as the number of cubic feet of shotcrete forming a permanent part of the lining. Shotcrete rebound, spillage and wastage will not be measured for payment, and will be subtracted from the sprayed quantity.

B. Welded wire fabric (WWF) required per the Plans will be measured in square footage (SF).

1.4 PAYMENT

A. Unreinforced dry-mix shotcrete (DMS) placed as lining repairs in the tunnel in accordance with the Plans and Specifications or at the direction of the Engineer will be paid at the unit prices stated in the Bid Schedule. Shotcrete work will include furnishing equipment, labor, and dry-mix shotcrete mix; placing the DMS; DMS quality assurance measures; maintaining the tunnel in a clean condition; ventilation and lighting; scaling of loose or deteriorated concrete, removal from the tunnel and disposal; preparing and cleaning surfaces for placement of additional layers; expanded metal support or stayform used in Type IV repairs including installation; surveying; utilities; disposing of DMS rebound and wastage; and all incidentals necessary to complete the work.

B. Welded wire fabric (WWF) placed as part of lining repairs in the tunnel in accordance with the Plans and Specifications or at the direction of the Engineer will be paid at the unit prices stated in the Bid Schedule. WWF will include materials; equipment and labor for installation; supply and installation of epoxy dowel steel studs for holding the WWF in place during placing DMS; and all incidentals necessary to complete the work.

1.5 REFERENCES


B. ASTM International (ASTM)

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<th>Subject</th>
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<tr>
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<td>A1064</td>
<td>Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete</td>
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<tr>
<td>ASTM</td>
<td>C 33</td>
<td>Specification for Concrete Aggregates</td>
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ASTM C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C 42 Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

ASTM C 94 Specification for Ready-Mixed Concrete

ASTM C 150 Specification for Portland Cement

ASTM C 494 Specifications for Chemical Admixtures for Concrete

ASTM C 685 Specification for Concrete Made by Volumetric Batching and Continuous Mixing

ASTM C 1141 Specification for Admixtures for Shotcrete

C. American Concrete Institute (ACI) publications:

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<th>Subject</th>
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<tbody>
<tr>
<td>ACI</td>
<td>201.2R</td>
<td>Guide to Durable Concrete</td>
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<td>ACI</td>
<td>506.4R</td>
<td>Guide for the Evaluation of Shotcrete</td>
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<td>ACI</td>
<td>506.3R</td>
<td>Guide to Certification of Shotcrete Nozzlemen</td>
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<td>Guide to Shotcrete</td>
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<tr>
<td>ACI</td>
<td>506.2</td>
<td>Specification for Shotcrete</td>
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1.6 DEFINITIONS

A. Defective Shotcrete: Shotcrete that does not meet strength or toughness requirements or that lacks uniformity; exhibits segregation, honeycombing, or lamination; shows open cracking; lacks watertightness; contains any dry patches, voids, or sand pockets or is hollow; or in the Engineer’s opinion fails to meet the Project requirements.

B. Dry-mix shotcrete: Shotcrete to which most of the mixing water is added at the nozzle.

C. Rebound: Shotcrete constituents that fail to adhere to the surface to which shotcrete is being applied.

D. Shotcrete: Portland cement concrete forced through a nozzle by compressed air, and containing admixtures to provide quick set and high strength.

E. Tier 1, 2 and 3 Priority: A system set up to prioritize repairs in the tunnel, with Tier 1 being the highest priority, Tier 2 being the next highest priority, and Tier 3 being the lowest priority. The intent is to complete all repairs indicated on the Plans during the available outage period, but to develop the repair schedule based upon the Tier priority.
1.7 SUBMITTALS

A. Reports and Certifications no less than 14 days prior to commencing shotcrete operations:

1. Contractor Certification
   a. Submit satisfactory evidence of the Contractor's experience and workmanship, as required by the ACI guides listed herein.
   b. Submit ACI CP-60 Shotcrete Nozzleman Certification at least 14 days prior to commencing shotcrete operations.

2. Materials Certification - Submit the manufacturer's notarized Certificate of Compliance that materials meet or exceed the requirements of the contract documents.

3. Product Data - Submit the proposed mix design, materials, and equipment for approval.
   a. Submit mix designs, laboratory test reports, and mill or manufacturer's certificates, certifying that ingredients conform to specified requirements.
   b. Use ingredients in design mixes that are representative samples of materials to be used in the work.
   c. Documentation shall be provided from the manufacturer that all admixtures are compatible with the proposed cement, and do not result in long-term damage or deterioration. Proper safety precautions shall be practiced when handling admixture materials.
   d. In the event that the source, brand, or characteristic properties of ingredients would need to be varied during the work, submit revised laboratory mix reports in accordance with procedures defined for original mix designs in an RFI.

4. Procedures - Submit proposed process and equipment for the shotcrete application, materials, heating and storage, and method for curing of samples and installed shotcrete.

B. Healthy and Safety Plan for all shotcreting work, in accordance with Section 01 04 40.

C. Field Quality Control Progress Reports, on a daily basis:

1. Results of shotcrete quality control tests.
2. Batch Tickets defining weight and mix of bagged shotcrete materials.

D. Design Data no less than 14 days prior to commencing shotcrete operations:
   1. Establish mix designs through an approved laboratory.
   2. During the performance of laboratory and field tests, submit mix designs and descriptions of equipment and methods of application to be used in such tests. The Engineer may inspect tests and materials at any time.

E. Samples no less than 14 days prior to commencing shotcrete operations:
   1. Expanded metal or stayform for Type IV repairs.
   2. Anchorage devices to be used to anchor expanded metal to existing tunnel liner.
   3. Epoxy dowel steel studs to anchor the WWF.

1.8 QUALITY ASSURANCE

A. Inspections shall be made regularly by the Contractor and, as deemed appropriate, accompanied by the Engineer for compliance with contract requirements including, but not limited to, DMS batching requirements, mix proportions and consistency at the job site, and all other tests and inspections specified or required by these Specifications. As a minimum, the following shall be performed:
   1. Record and check mix design proportions at least once per day.
   2. Personnel shall be qualified to make required tests for quality control and shall report all test results on forms approved by the Engineer. A copy of records and tests, as well as the records of corrective action taken, shall be furnished to the Engineer within 24 hours.

1.9 QUALIFICATIONS

A. DMS work shall be performed by personnel who have experience in DMS shotcrete application in tunnels. The work experience shall be documented by supplying the names of the personnel along with their work experience to the Engineer for approval 14 days prior to any work. DMS shall be applied by nozzlemen having at least three years of documented previous satisfactory experience in the application of dry-mix shotcrete of the type to be used on the project, on at least two comparable tunnel projects. These nozzlemen shall work under the immediate supervision of a foreman or underground superintendent having at least 5 years of such experience, two of which shall be as a nozzleman. In no case shall inexperienced or unapproved workers be allowed to perform the nozzling of DMS.
B. Applicants for shotcrete nozzlemen shall have successfully completed the ACI CP-60 Shotcrete Nozzleman Certification Program 14 days before the start of the work.

C. Each crew shall demonstrate, to the satisfaction of the Engineer, acceptable proficiency in the application of DMS to vertical test panel surfaces in field tests 14 days prior to beginning production work. Crews and/or individuals lacking acceptable proficiency, as determined by the Engineer, shall not be permitted to work on the project.

1.10 DELIVERY, STORAGE AND HANDLING

A. Materials storage facilities, delivery, and handling shall be the sole responsibility of the Contractor.

B. All materials shall be stored in a weather-tight structure such that the physical, chemical, and dimensional properties specified herein are not altered or otherwise adversely affected prior to their placement.

C. Cement and bagged shotcrete mix shall be stored in a dry place with a floor raised not less than 1 foot above the ground. Cement shall be used within six months of its manufacture. Broken packages and packages subjected to moisture shall be wasted at the Contractor's expense.

D. Special Storage: Bulk materials, cement, aggregate, and water shall be at least 40°F prior to batching. Colder weather conditions will require special storage arrangements to maintain temperatures.

1.11 PROJECT CONDITIONS

A. Safety:

1. Alkali hydroxides and other chemicals contained in shotcrete admixtures are moderately toxic and can cause skin and respiratory irritation. Take full safety measures to prevent injury to personnel.

2. Maintain safety in accordance with all applicable local, state, and federal regulations in all areas where shotcrete is to be applied. Causticity of cement and accelerating hardening admixtures may cause skin and respiratory irritation unless safety measures are implemented and proper ventilation provided.

B. Environmental Requirements:

1. Ensure shotcrete, rock or soil surface, and surrounding air temperature, are a minimum 35°F prior to, during, and three days after completion of work.

2. During freezing or near-freezing weather, provide equipment and cover to maintain minimum 35°F and to protect work completed or work in progress.
3. Suspend shotcrete operations during high winds or near-freezing temperatures when work cannot be protected.

4. Shotcrete shall not be placed on any deteriorated, frozen or spongy surface, or where free-standing water exists.

5. Areas of tunnels to receive DMS shall be lighted by flood lights so that all portions of area to be shotcreted are clearly visible to the nozzleman and inspector.

PART 2 PRODUCTS

2.1 MATERIALS

A. Type II Portland cement: ASTM C150

B. Aggregate:

1. Normal weight fine aggregate shall conform to the requirements set forth in ASTM C 33. The combined gradation of fine and coarse aggregate used in the shotcrete shall meet the following grading requirements:

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<th>Sieve Size</th>
<th>Percent Passing By Weight</th>
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<tbody>
<tr>
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2. Specific gravity: 2.55 minimum

C. The mixing water used for this work shall be clear, free from loam, clay, oil, acid, alkali, sulphate, sewage, decayed vegetable matter, organic matter, or any other impurities, and shall be subject to the prior approval of the Engineer. Turbidity of the water shall not exceed 2,000 ppm. Total chloride content shall be within the limits specified in ACI 201.2R. Unless water is obtained from a municipal drinking water supply, the Contractor shall perform the testing necessary, including a program of comparative strength tests, to verify that water meets the requirements of these Specifications. All testing shall be performed by the Contractor at no additional cost to the Owner.

D. Admixtures:
1. Accelerator shall contain no water-soluble chlorides or materials corrosive to steel and shall not cause other detrimental effects such as cracking or spalling. Accelerator shall be in liquid form. Compatibility of accelerator, water reducing agents or plasticizers, and microsilica with cement, aggregate, and fibers shall be demonstrated by the Contractor to the satisfaction of the Engineer.

2. Admixtures which reduce sulfate resistance of shotcrete, such as aluminum, salts, chlorides, or nitrates, or are corrosive to steel shall not be used. Admixture shall conform to the applicable requirement of ASTM C 494 and ASTM C 1141. The brands of admixture agents are the responsibility of the Contractor and shall be such as will produce shotcrete meeting requirements of these Specifications.

3. Provide certification showing that admixtures have a documented minimum five-year history of satisfactory performance in similar applications.

E. Expanded Metal: ¼-inch by 20 gauge or heavier raised expanded metal.

1. Anchorage for expanded metal: Contractor shall submit samples and descriptions of methods proposed for securing expanded metal as a backing form for Type IV repairs.

F. Welded Wire Fabric (WWF): Galvanized 6x6xW4.0/W4.0 WWF, conforming to requirements of ASTM A1064.

2.2 MIXES

A. DMS:

1. The exact proportions of cement, fine aggregate, coarse aggregate and water shall be determined by the Contractor, subject to approval by the Engineer, prior to shotcreting and subject to adjustments in the field. Mixture proportions shall be selected during preconstruction testing on the basis of compressive strength tests of specimens continuously moist-cured until testing. Mix and accelerator portion of DMS shall be adjusted as required to provide necessary immediate ground support and control of the ground while maintaining 28-day compressive strength development requirements.

2. The required compressive strength development for DMS shall be 1,000 psi (24 hours), 2,500 psi (3 days), 3,600 psi (7 days), and 5,000 psi (28 days). DMS core testing shall conform to ASTM C 39 and ASTM C 42.

3. The shotcrete manufacturer shall certify compliance with these Specifications. Dry-mix shotcrete shall be a standard product of a company regularly engaged in its manufacture.
PART 3 EXECUTION

3.1 PREPARATION

A. Prioritization of repairs is indicated on the Plans, and as defined herein, for Tier 1, 2 and 3 priorities. Schedule repair work to complete Tier 1 repairs first, followed by Tier 2 repairs, and then Tier 3 repairs.

B. Protection:

1. Protect drainage structures, and temporary utility lines from shotcrete equipment and rebound, by a method approved by the Engineer.

2. Under no circumstances shall shotcrete encroach into the profile of the existing tunnel adjacent to the repaired section.

3. Prior to shotcrete application, control groundwater inflows and seepage as required by the Contract Documents, or as directed by the Engineer, to prevent dissolution of cement and fine aggregates in fresh shotcrete, and to assure bond between the surface and shotcrete.

C. Surface Preparation:

1. When a layer of shotcrete is to be covered by a succeeding layer at a later time, it shall be allowed to develop its initial set. Then all laitance, loose materials, and rebound shall be removed by air and/or water spray or other approved methods.

D. Proportioning and Mixing:

1. Accelerator shall be added at the nozzle in such a way that the quantity can be measured and regulated as required by the nozzleman, and the material dispersed uniformly through the shotcrete as it is applied. Accelerator quantities shall be measured and reported for each load. Demonstrate the calibration of the accelerator dispensing equipment, when requested by the Engineer.

2. The shotcrete shall be air-jetted from the nozzle at a suitably high velocity to develop maximum adherence and density and to minimize rebound.

3. Batches of material containing cement which have been in contact with damp aggregate or mixing water for more than 2 hours shall not be applied unless the Contractor can demonstrate that a suitable and compatible set retardant is utilized, but shall be wasted in an approved manner at no cost to the Owner. Shorter times may be necessary to achieve early set and strength-gain requirements. Rebound material shall not be recycled, but shall be collected and wasted in an approved manner.
4. Batching and mixing shall be accomplished in accordance with the applicable provisions of ASTM C 94 or C 685. Volumetric batching must be strictly controlled. The mixing equipment shall be capable of thoroughly mixing the specified materials in sufficient quantity to maintain continuous placing. Ready-mix shotcrete complying with ASTM C 94 may be used.

3.2 APPLICATION

A. Shotcrete shall be placed using suitable pumping and application equipment and procedures. The equipment shall be capable of delivering the premixed materials accurately, uniformly, and continuously through the delivery hose.

B. Recommendations of the equipment manufacturer shall be followed on the type and size of nozzle to be used, and on cleaning, inspection, and maintenance of equipment. The delivery machine shall be provided with an operating and frequently-calibrated measuring device that can be directly correlated to production (cubic yards) either by direct volume or a machine constant. The temperature of surface to receive shotcrete shall not be less than 35°F. The temperature of the shotcrete, as placed, shall not exceed 85°F.

C. If in the opinion of the Engineer, the application thickness is too great for good quality shotcrete, then individual layer thickness shall be reduced. In this case, the optimum layer thickness shall be determined in a series of field tests performed in the presence of the Engineer, at no additional cost to the Owner.

D. The shotcrete shall be dense, impermeable, low shrinkage, uniform, and non-laminated.

E. Thickness, air pressure, accelerator proportioning, and water content of shotcrete shall be controlled to eliminate sagging or sloughing off.

F. Shotcreting shall be discontinued or suitable means shall be provided to screen the nozzle stream if wind or air currents cause separation of the nozzle stream during placement.

G. The nozzle shall be positioned within an approximate range of 4 to 6 feet of the surface in such a manner as to compact the shotcrete onto the wall with a minimum of rebound, with the stream of material impinging as nearly as possible at right angles to the surface to be covered. Irregularities in the rock or lining surface shall be filled with sufficient shotcrete to form a fairly smooth, regular surface. The surface of each shotcrete layer shall be uniformly free of sags, drips, and runs.

H. Succeeding layers of shotcrete shall be applied no sooner than 15 minutes, or after initial set of the shotcrete, after the application of the previous layer. Previous layers shall be sounded with a hammer to detect and remove voids, rebound, or aggregate pockets, and unbonded areas prior to application of the next layer.
I. Shotcreting in the tunnel shall proceed from bottom of the repair to the top to prevent the encasement of rebound material,

J. If sand pockets occur, the nozzle shall be directed away from the affected area until the faulty work is cut out and repaired. Horizontal and vertical corners and any areas where rebound cannot escape or be blown free shall be filled with shotcrete first.

K. The nature of the shotcrete application should be adjusted to meet actual conditions encountered, such as overbreak or unstable ground, to stabilize the ground or existing tunnel lining, and to improve safety for construction operations.

3.3 REPAIR

A. If at anytime the DMS mix, the placement procedures, or the finished product are defective according to these Specifications, the shotcreting operation shall be discontinued, any defective shotcrete removed and repaired, and changes made as approved by the Engineer.

B. Shotcrete which does not meet strength criteria, lacks uniformity, exhibits segregation or variable density, honeycombing, lamination, shows cracking, contains any dry patches, voids, or sand pockets, or is drummy when sounded with a hammer shall be regarded as defective.

C. The Engineer reserves the right to order the removal of defective shotcrete and replacement with acceptable shotcrete at no cost to the Owner.

D. Surface defects shall be repaired as soon as possible after initial placement of the shotcrete. The repaired surface shall be flush with surrounding shotcrete or existing tunnel lining surface.

3.4 FIELD QUALITY CONTROL

A. All equipment used by the Contractor for applying shotcrete shall be subject to approval by the Engineer, and shall be capable of handling and applying shotcrete containing the specified maximum size coarse aggregate, and accelerating admixture.

B. Delivery equipment shall be capable of batching and delivery within the accuracy specified in ASTM C 94.

C. Equipment which fails to operate to the satisfaction of the Engineer shall be repaired or replaced by and at the expense of the Contractor.

D. The following precautions shall be taken during placement:

1. Do not place shotcrete if drying or stiffening of the mix takes place at any time prior to delivery to the nozzle.
2. The area to which shotcrete is to be applied shall be clean and free of rebound or overspray.

3. In areas of heavy groundwater seeps, drain holes may be required around the repair location. After the repair is completed, drain holes shall be grouted and filled per Section 31 73 13.

E. Preconstruction Testing:

1. A field testing program shall be carried out in the presence of the Engineer at least 14 days prior to beginning production work for the purpose of evaluating the Contractor's equipment, mix design, and application techniques. The test shall consist of applying trial mixes of DMS to vertical test panels. Shotcrete shall be applied in 2-inch layers to a total thickness of 8 inches using the identical equipment, mix designs, and personnel to be used in production work.

2. Eight-inch-long, 2 or 3-inch-diameter cores shall be taken from the DMS test panels in accordance with ASTM C 42. Cores shall be tested by an approved laboratory in accordance with ASTM C 42 and ASTM C 39 at 3 days, at 7 days, and at 28 days.

3. Upon receipt of satisfactory test results, the Engineer will give written approval of acceptable mix designs. No mix shall be used for production work without such written approval. All mixes used for production work shall be proportioned and mixed as tested and approved by the Engineer.

F. Mixture Acceptance:

1. For mixture acceptance purposes, average core compressive strength during testing shall be at least 1.2 times the required compressive strength.

2. The homogeneity of aggregate shall also be in accordance with the requirements for a well bonded, dense, uniform tight shotcrete lining.

G. Testing of Shotcrete During Construction:

1. Core testing shall be performed routinely from vertical test panels produced during construction from the same DMS used for the tunnel repairs, at the direction of the Engineer. Cores from production sections shall be taken and tested in the same manner as in the preconstruction testing. A set of 6 cores (2 tests) shall be collected at least once per week. If samples taken from production sections fail to show adequate bond, show obvious defects or show less than the required strength, two additional cores shall be taken. If either of the additional cores fails to show adequate bond, shows obvious defects, or shows less than the required strength, the shotcrete in the tunnel applied during the same shift as the test panels as determined by the Engineer shall be
considered defective and shall be removed and replaced with new, acceptable DMS at no cost to the Owner.

H. Evaluation and Acceptance - The average compressive strength from three cores shall be considered one test. The average values of the compressive strength from each group of three consecutive tests for the 3-day age, 7-day age, and the 28-day age shall meet or exceed the required properties specified with no individual sample less than 85 percent of the required value.

3.5 CLEANUP

A. Overspray, spillage, fallout or rebound material produced by the DMS application shall be cleaned from the tunnel and disposed of. Cleaning of the pump, agitator, or other shotcrete equipment shall not foul drainage elements. Rebound and wastage shall be disposed of in a manner and to a site approved by the Engineer, and in accordance with COT 115.

END OF SECTION
PART 1 GENERAL

1.1 DESCRIPTION

A. The Work covered by this Section consists of furnishing all labor, equipment, and materials, and performing all work required to clean the existing concrete liner and scale damaged sections of the existing concrete liner, and transportation and disposal of material generated from the cleaning and scaling operations to the designated temporary staging areas shown on the Plans, and disposal to final approved off-site depositories, all in accordance with the Plans and Specifications.

B. The Work covered by this Section also consists of furnishing all labor, equipment, and materials, and performing all work required to repair minor defects (Type I and III defects) in the existing concrete tunnel liner with concrete repair mortar in accordance with the Plans and Specifications.

C. Loose and unsound concrete will be scaled throughout the tunnel and as requested by the Engineer. Liner scaling will be accomplished using mechanical methods that will not damage or over-excavate the adjacent sound concrete liner. Scaling work will include removal and transport of removed material for disposal.

1.2 RELATED SECTIONS

A. Current City of Tulsa Standard Specifications and Standard Details govern, unless modified herein. Refer to the following City of Tulsa (COT) Standard Specifications for Related Work:

1. COT 111 – Dewatering
2. COT 113 – Removal of Condemned Materials and Structures
3. COT 115 – Clean-Up

B. Refer to Volume II – Technical Specification (SPECIAL) for related work:

1. Section 01 04 40 – Underground Safety
2. Section 03 10 80 – Shotcrete

1.3 MEASUREMENT

A. Repair Types I and III will be measured as a unit price (EA), and will include all cleaning and scaling required to prepare the lining for the repair.
1.4 PAYMENT

A. Repair Types I and III shall be installed in accordance with the Plans and Specifications or at the direction of the Engineer, and will be paid at the unit prices stated in the Bid Schedule. Type I and III repairs include equipment, labor, and patching materials; installing the repairs including preparation and cleaning of surfaces; quality assurance; maintaining the tunnel in a clean condition; ventilation and lighting; scaling of loose concrete; surveying; utilities; disposal of excess materials; and all incidentals necessary to complete the work.

1.5 REFERENCES


1.6 SUBMITTALS

A. Submit the plan and schedule for tunnel liner cleaning and scaling a minimum of 7 days prior to starting the Work. The plan shall include descriptions of the cleaning and excavation methods, methods of scaling, loading, hauling, and disposal of the debris, water and scaled liner materials.

B. Submit a work plan for repairing minor defects a minimum of 7 days prior to starting the Work. The plan shall include descriptions of the repair method and proposed materials.

C. Submit a Health and Safety Plan in accordance with Section 01 04 40.

D. Submit copies of all current licenses and permits required by local, state, and federal agencies a minimum of 7 days prior to starting the Work described in this Section.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Transport, store, and handle materials in accordance with the Manufacturers’ and Suppliers’ instructions. Protect the materials from mechanical damage and damage caused by environmental exposure.

B. Materials storage facilities, delivery, and handling shall be the sole responsibility of the Contractor.

C. Clean up material spills and dispose of clean up materials in accordance with the Manufacturers’ instructions.

D. Post copies of Material Safety Data Sheets (MSDS) and warnings as appropriate at all locations where materials are stored or handled.

E. Ensure each package of materials is marked with an expiration date either by the Manufacturer or per the Manufacturer’s recommendations.
PART 2 PRODUCTS

A. Concrete Repair Mortar shall be ANSI/NSF Standard 61 potable water approved compliant and suitable for vertical and overhead repairs, such as SikaTop-123 Plus by Sika Corporation of Lyndhurst, New Jersey; MasterEmaco by BASF Corporation of Shakopee, Minnesota; or approved equivalent.

B. Water: Only potable water shall be used.

PART 3 EXECUTION

3.1 GENERAL

A. Prioritization of repairs is indicated on the Plans, and as defined in Section 03 10 80, for Tier 1, 2 and 3 priorities. Schedule repair work to complete Tier 1 repairs first, followed by Tier 2 repairs, and then Tier 3 repairs.

B. Cleaning of the concrete liner shall be accomplished with equipment, methods, and workmanship that will minimize disturbance or damage to the remaining lining. Cleaning shall utilize high pressure air (a blowpipe), pressure washing or scraping with hand tools, or a combination of these methods as approved by the Engineer.

C. Scaling of the concrete liner shall utilize mechanical methods such as hand-scaling, and shall be accomplished with equipment, methods, and workmanship that will minimize disturbance or damage to the remaining lining. Test the liner by tapping it with a scaling bar prior to scaling an area.

D. Follow local, state and federal safety regulations for underground construction.

E. Loose material shall be scaled or supported and the tunnel maintained in a safe condition during construction. Appropriate measures shall be taken to protect personnel and equipment from falling material. Loose lining slabs shall be scaled and supported prior to exposing personnel and equipment to fall hazard.

F. The Contractor's excavation methods shall be such that after completion of excavation, all peripheral surfaces are sound and not cracked or loosened, and overexcavation is within the specified overbreak tolerance.

G. The Contractor shall limit overbreak due to its operations to less than one (1) inch into sound concrete liner. Overbreak resulting in excessive raveling or slabbing of the concrete liner surface shall be repaired by the Contractor at no additional expense to the Owner.

H. Concrete repair mortar shall be installed in accordance with the Manufacturer’s instructions, including requirements for curing.
I. Prior to applying the concrete repair mortar, confirm that the application surface is clean, free from loose aggregate, dirt, laitance, oil and grease, and other substances that are likely to damage or affect the concrete repair mortar.

3.2 CORRECTION OF DEFECTIVE WORK

A. Defective work for the concrete repairs shall include repairs that lack uniformity, exhibit lamination or cracking, lack adequate bonding, or fail to meet the specified requirements.

B. Areas deemed defective shall be removed, cleaned, and re-applied.

3.3 DISPOSAL OF REMOVED MATERIALS

A. Materials produced by tunnel liner cleaning and scaling may be stored temporarily by the Contractor in the designated staging areas. Concrete shall be separated out and disposed of at approved off-site disposal facilities. Owner will not be responsible for any waste related to the Contractor's operations.

B. All wastewater generated by the tunnel liner cleaning shall be captured and removed from the tunnel by the Contractor, in accordance with COT 111.

C. All biofilm and treatment solids shall be collected by the Contractor and hauled to a location to be determined by the Owner. The Contractor shall coordinate with the Owner for the proper disposal of the treatment solids.

3.4 FINAL CLEANUP

A. All liner repair materials, including excavated liner material, shall be captured and removed from the tunnel by the Contractor, and work performed in accordance with COT 115.

END OF SECTION
SECTION 08 31 20
FLOOR ACCESS HATCHES

PART 1    GENERAL

1.1   DESCRIPTION

A. Factory-fabricated single or double leaf aluminum floor access hatches and frames with water drainage. Include gasket, safety chain, telescoping ladder, safety post and slip resistant surface coating at all floor access doors.

1.2   RELATED SECTIONS

A. Current City of Tulsa Standard Specifications and Standard Details govern, unless modified herein. Refer to the following City of Tulsa (COT) Standard Specifications for Related Work:

1. COT 113 - Removal of Condemned Materials and Structures
2. COT 115 – Clean-Up

1.3   MEASUREMENT

A. Access hatches will be measured on a unit price basis for each hatch (EA) for the size indicated in Floor Access Hatch Schedule.

1.4   PAYMENT

A. Access hatches in accordance with the plans and specifications will be paid at the unit prices stated in the bid schedule. Hatches will include equipment and labor to install the hatches; all materials, including structural supports for holding the hatches into the concrete; quality assurance and control; maintaining the access structure in a clean condition; ventilation and lighting; preparing and cleaning demolished surface prior to hatch installation; surveying; utilities; disposal of waste materials; and all incidentals necessary to complete the work.

1.5   REFERENCES

A. ASTM International (ASTM) Organization Number Subject

<table>
<thead>
<tr>
<th>Organization</th>
<th>Number</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM</td>
<td>A240</td>
<td>Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications</td>
</tr>
<tr>
<td>ASTM</td>
<td>B221</td>
<td>Aluminum and Aluminum-Alloy Extruded</td>
</tr>
</tbody>
</table>

TMUA-W 18-27 08 31 20-1 Floor Access Hatches and Doors
Bars, Rods, Wire, Profiles, and Tubes

<table>
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<tr>
<th>ASTM</th>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>B632</td>
<td></td>
<td>Aluminum-Alloy Rolled Tread Plate</td>
</tr>
<tr>
<td>F593</td>
<td></td>
<td>Stainless Steel Bolts, Hex Cap Screws, and Studs</td>
</tr>
<tr>
<td>F594</td>
<td></td>
<td>Stainless Steel Nuts</td>
</tr>
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</table>

B. B. Occupational Safety and Health Association (OSHA): 29 CFR 1910.23 – Ladders

1.6 SUBMITTALS

A. Statement of experience for both manufacturer and installer.

B. Fabrication drawings showing layouts, connections to structure, and anchoring details.

C. Erection and installation drawings showing construction details, reinforcement, anchorage, and installation with relation to the building construction.

D. Drain pipe layout from the drain coupling to the discharge point.

E. Manufacturer's product data showing conformance to the specification.

F. Structural calculations for the floor access hatch design provided by the manufacturer and sealed by a registered professional engineer registered in the State of Oklahoma.

G. Instructions for the storage, handling, installation, and operation.

H. Manufacturer’s warranty.

1.7 QUALITY ASSURANCE

A. Manufacturer: Minimum of 5 years’ experience manufacturing similar products.

B. Installer: Minimum of 2 years’ experience installing similar products.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in manufacturer’s original packaging, stored in a dry, protected, well-ventilated area. Inspect product upon receipt and report damage to carrier and manufacturer.
1.9 SPECIAL WARRANTY

A. Materials shall be free of defects in material and workmanship for a period of 5 years from the date of purchase. Should a part fail to function in normal use within this period, manufacturer shall furnish a new part at no charge.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. The following manufacturers are acceptable. The manufacturer’s standard product may require modification to conform to specified requirements.

1. The Bilco Company.
2. Babcock Davis.
3. Halliday Products.
4. Approved Equal.

2.2 PERFORMANCE/DESIGN CRITERIA

A. Access hatch leafs shall be reinforced to support a minimum live load of 300 psf; with a maximum deflection of 1/150th of the span. See Floor Access Hatch Schedule at the end of this section, which indicates loading criteria required at each location.

B. Nominal opening sizes and hinge opening side shall be as noted on the Drawings and in the Floor Access Hatch Schedule.

2.3 MATERIALS

A. Access hatches, single or double leaf: 1/4 inch minimum aluminum with diamond tread pattern; ASTM B632, 6061-T6.

B. Access hatches subject to pedestrian loading shall include a slip resistant surface per ADA curb ramp requirements. Slip resistant surface shall be SlipNOT metal safety flooring (a Division of W.S. Molnar Company).

C. Channel frame shall be 1/4 inch minimum extruded aluminum with bent down anchor tabs around the perimeter: ASTM B221, 6061-T6.

D. Hardware: ASTM A240 Type 316 stainless steel throughout.

E. Fasteners:
1. Bolts: ASTM F593
2. Nuts: ASTM F594

2.4 COMPONENTS/ FEATURES

A. Manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled hatch leaf operation throughout the entire arc of opening; and to act as a check in retarding downward motion of the cover when closing. Maximum lift effort to open hatch shall be 30 pounds.

B. Spring tubes shall be constructed of a reinforced nylon 6/6-based engineered composite material. The upper tube shall prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe fastened to a formed 1/4 inch gusset support plate.

C. Hatch leafs shall be equipped with a hold-open arm which automatically locks the hatch in the open position.

D. A removable exterior turn/lift handle with a spring loaded ball detent shall be provided to open the hatch and the latch release shall be protected by a flush, gasketed, removable screw plug. A stainless steel snap lock with fixed handle shall be mounted on the underside of the hatch. Include a recessed padlock hasp.

E. Provide heavy forged aluminum hinges with 1/4 inch minimum diameter stainless steel pins.
   1. Hinges must operate in such a manner to prevent the hatch leafs from protruding into the channel frame.
   2. Design hinges specifically for horizontal installation.
   3. Hinges shall be through-bolted to the cover with tamperproof stainless steel lock bolts and through-bolted to the frame with stainless steel bolts and locknuts.

F. A continuous ethylene propylene diene monomer (EPDM) gasket shall be mechanically attached to the aluminum frame to create a barrier around the entire perimeter of the cover and significantly reduce the amount of dirt and debris that may enter the channel frame.

G. A 1.5 inch drain coupling shall be provided.

H. Provide a continuous EPDM gasket along the inside edge of the frame. This gasket is in addition to the perimeter debris gasket.

I. Provide safety chain made of non-corrosive material that will span across the corners of double leaf access hatch when open.
J. Provide telescoping ladder safety posts for easy, safe ladder access through the access hatch openings.
   2. Telescoping post to be permanently mounted to the top two rungs of fixed ladders.
   3. Post must automatically lock in the fully raised position to provide the user with a firm and steady hand-hold.
   4. Post to have release lever that allows the post to be easily lowered to its retracted position.

K. Provide a fall protection grating system where indicated in the Floor Access Hatch Schedule. Manufacturer shall install the grating system when the hatch is fabricated.
   2. Grating panel material: Aluminum with powder coat paint finish.
   3. Grating panel color: High visibility OSHA safety yellow or orange.
   4. Grating panel shall lock automatically in the full open position.
   5. Grating panel shall lift open in the opposite direction as the hatch(es).
   6. Hold open feature: Stainless steel hold open device shall be provided to lock the cover in the fully open 90 degree position.
   7. Lift mechanism and hardware: Stainless steel lifting mechanisms as specified above for all fall protection panels that weigh over 50 pounds.

2.5 FINISHES

A. Hatch and frame: Mill finish aluminum with heavy bituminous coating where in contact with concrete.

B. Telescopic safety post: aluminum or stainless steel.


PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings for compliance with requirements for installation tolerances and other conditions affecting performance.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Installation shall conform to the manufacturer’s recommendations.
   B. Frame shall be securely anchored to concrete.
   C. Set frame level, plumb and in proper alignment with adjacent work.
   D. Contractor shall field route a 1.5 inch Schedule 80 PVC drain pipe from the 1.5 inch drain coupling on all access hatches to the water level, sump or drainage trench at the floor level below. Place drain pipe clear of the access area below the hatch and as approved by the Engineer.

3.3 REPAIR/RESTORATION
   A. Repair finishes damaged during installation.
   B. Remove and replace hatches that are warped, bowed, or otherwise damaged.

3.4 ADJUSTING
   A. Adjust hatches and hardware after installation for proper operation.

3.5 CLEANING
   A. Clean exposed surfaces using methods acceptable to the manufacturer that will not damage finish.
# 3.6 FLOOR ACCESS HATCH SCHEDULE

<table>
<thead>
<tr>
<th>Mark</th>
<th>Location</th>
<th>Frame Opening Size [Concrete Rough Opening] (north/south x east/west)</th>
<th>Minimum Clear Opening Size (north/south x east/west)</th>
<th>Leafs</th>
<th>Loading</th>
<th>Pedestrian Traffic</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-01</td>
<td>East Access Structure Roof</td>
<td>4’-0”x6’-0”</td>
<td>3’-6”x5’-0”</td>
<td>Single or Double</td>
<td>300 psf</td>
<td>Yes</td>
<td>Modify existing 2’-0”x6’0” opening to accommodate larger access hatch</td>
</tr>
<tr>
<td>E-02</td>
<td>East Access Structure Intermediate Level</td>
<td>4’-0”x6’-0”</td>
<td>3’-6”x5’-0”</td>
<td>Single or Double</td>
<td>300 psf</td>
<td>Yes</td>
<td>New access hatch, requires cutting opening in floor</td>
</tr>
</tbody>
</table>

**Note:**
1. Clear opening is defined as the dimensions such that objects can pass through the floor access hatch (note that depth of the access hatch structure typically reduces clear opening size to a dimension less than the frame opening [concrete rough opening]- see sketch below). Lifting and other hardware shall be outside of the clear opening dimensions.
END OF SECTION
SECTION 26 05 00

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1  GENERAL

1.1  SUMMARY

A. Section Includes: General requirements for providing basic electrical materials and methods.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Certain equipment, control devices, conduit and wiring are shown on electrical drawings, but are specified in other sections pertaining to plumbing, valves, process control systems and instrumentation. Install and connect these items to the electrical system as indicated or required in accordance with the Contract Documents.

C. Overall Application of Specifications: This Section applies to all Division 26 sections and to other sections that include requirements for electrical equipment. Irrespective of where the electrical requirements are specified, provide and install all materials necessary for a complete operational system.

1.2  SYSTEM DESCRIPTION

A. Design Requirements: Design requirements are specified in the applicable sections.

B. Performance Requirements: Performance requirements are specified in the applicable sections.

1.3  SUBMITTALS

A. General: Furnish all submittals, including the following,

B. Product Data and Information: Furnish a complete list of electrical equipment and materials to be furnished that shows the manufacturer, catalog number, size, type, capacity, voltage rating and other pertinent information related to each item on the list.

1. Furnish catalog data for the manufacturer's standard equipment and materials. Clearly identify the equipment and devices specifically being proposed on manufacturers’ catalog data sheets.
2. Identification: Furnish a complete schedule or listing of system and equipment identification labels with legends.

C. Contractor's Shop Drawings: Furnish shop drawings on items manufactured for the Contract.

1. Furnish connection and schematic diagrams for each piece of electrical equipment where applicable. A manufacturer's standard connection or schematic diagram showing more than one method of wiring is not acceptable unless, the intended method is clearly marked.

2. Furnish diagrams that show connections to field equipment. Clearly differentiate between manufacturer's and field wiring.

3. Furnish raceway layout drawings that show conduits, boxes, and panels which contain the conductors to be provided. Include schedules listing conduit sizes, conductor content and identification.

4. Where additions and modifications are made to existing equipment, furnish drawings which clearly identify remaining existing equipment and the new Work.

D. Record Documents: Furnish record documents indicate installed conditions for:

1. Interior and exterior major raceway systems’ sizes and locations; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker sizes and arrangements.

2. Exposed equipment locations dimensioned from prominent building lines.

3. Approved substitutions, and actual equipment and materials installed.

E. Maintenance Manuals: Furnish maintenance manuals, include the following information for equipment items:

1. Functional description, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and catalog numbers of replacement parts. Where a Bill of Materials is provided, include a manufacturers’ data sheet for each component and device listed therein.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

1.4 QUALITY ASSURANCE

A. Codes: Provide all electrical Work in accordance with applicable local codes, regulations and ordinances. If there is a conflict between the requirements specified in the Contract Documents and the codes, follow the more stringent requirements as determined and approved.

B. Testing: As a minimum, provide standard factory and field tests for each type of equipment.

C. Labeling: Provide electrical equipment and materials that are listed and approved by Underwriters Laboratories or other OSHA recognized testing laboratories with the testing agency’s label attached.

D. Standard Products: Unless otherwise indicated, provide electrical materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standard design that conforms to these Specifications. Provide the products of the same manufacturer when two or more units of the same class of material and equipment are required.

1.5 DELIVERY, STORAGE AND HANDLING

A. Shipping and Packing: Provide materials and equipment suitably boxed, crated or otherwise completely enclosed and protected during shipment, handling, and storage. Clearly label such boxes, crates or enclosures with manufacturer's name, and name of material or equipment enclosed.

B. Acceptance at Site:

1. Repair or replace all materials and equipment damaged by handling and storage as directed at no additional cost to Owner

C. Storage and Protection: Protect materials and equipment from exposure to the elements and keep them dry at all times. Handle and store to prevent damage and deterioration in accordance with manufacturer's recommendations. Provide temporary power to space heaters where provided with equipment to prevent condensation from developing.
1.6 PROJECT CONDITIONS

A. General: The Drawings indicate the extent and general arrangement of the principal electrical elements, outlets, devices and circuit layouts. Install and connect all electrical elements and devices to form a complete workable system as required by the Contract Documents. Provide necessary materials and installation wherever required to conform to the specific requirements of the furnished equipment and for proper installation of the Work.

B. Physical Layouts: In general, the routing of feeders show general arrangement and are not intended to show exact routing and locations of raceways. Verify actual and final arrangement, equipment locations, and prepare circuit and raceway layouts before ordering materials and equipment. Equipment locations are approximate and are subject to modifications as determined by approved equipment dimensions and existing conditions.

C. Coordination of Work: Coordinate the Work so that the electrical equipment may be installed without altering building components, other equipment or installations.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 ROUGH-IN

A. Final Location: Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by taking field measurements.

3. Arrange for chases, slots, and openings in other building components as construction progresses to provide for electrical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in cast-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum possible headroom. Detailed dimensions to be submitted for approval to Engineer.

7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services.

8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, submit RFI to the Engineer for resolution.

9. Where installed exposed in finished spaces, install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.

10. Provide electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Install systems, materials, and equipment providing right-of-way priority to systems required to be installed at a specified slope.

12. All wiring specified, scheduled, noted or shown is to be installed in conduit unless identified otherwise.

3.3 CUTTING AND PATCHING

A. General: Perform cutting and patching as required including the following requirements:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:

   a. Uncover Work to provide for installation of ill-timed Work.

   b. Remove and replace defective Work.
c. Remove and replace Work not conforming to requirements of the Contract Documents.

d. Remove samples of installed Work as specified for testing.

e. Install equipment and materials in existing structures.

f. Locate existing structural reinforcing with a pachometer where core drilled penetrations are required so as not to cut the steel reinforcing.

2. Cut, remove, and properly dispose of selected electrical equipment, components, and materials as indicated. Deliver all removed serviceable apparatus to the Owner as directed.

3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

4. Provide and maintain adequate temporary partitions or dust barriers that prevent the spread of dust and dirt to adjacent areas.

5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

6. Patch finished surfaces and building components using new materials that are compatible with the original installation and applied by experienced installers.

END OF SECTION

(NO TEXT FOR THIS PAGE)
PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing all wires and cables rated at 600 volts and below for electrical installation as shown.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 00 - Basic Electrical Materials and Methods
2. Section 26 05 53 - Electrical Identification

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM B 3 - Standard Specifications for Soft or Annealed Copper Wire
2. ASTM B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
3. TIA/EIA 568-B - Commercial Building Telecommunications Cabling Standard
4. NFPA 70 - National Electrical Code (NEC)

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Section 26 05 00.

B. Product Data and Information: Furnish manufacturer's catalog data for each type of wire and cable furnished.

1.4 QUALITY ASSURANCE

A. General: Furnish wire and cable in accordance with applicable IEEE and NEMA standards and meeting the applicable requirements of the NEC and UL.
B. Tests: Furnish factory tested cables prior to shipment in accordance with ICEA standards for the insulation specified.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle wire and cable in accordance with the manufacturer's instructions.

B. Storage: Store cable reels on concrete, 2x4 wood laggings or other hard surface.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Wire and Cable
   a. Southwire Company
   b. The Okonite Company
   c. General Cable Corporation

2. Instrumentation Cable
   a. Belden
   b. Dekoron Wire and Cable
   c. The Okonite Company

3. Multiconductor Cable
   a. The Okonite Company
   b. Southwire Company

4. Wire Connectors
   a. Thomas & Betts/ABB Group
   b. 3 M/Electrical Products Division
   c. Ideal Industries

5. Color Coding Marker
   a. W. H. Brady Company
b. Thomas & Betts/ABB Group

2.2 MATERIALS

A. Conductors: Provide soft drawn or annealed copper conductors with 98 percent minimum conductivity, meeting requirements of ASTM B 3 (solid) or ASTM B 8 (stranded). Use stranded conductors except solid No. 12 and No. 10 AWG may be used in lighting fixture and convenience outlet wiring.

B. Insulation: Provide wires and cables with insulation as follows:

1. Power, control and lighting wiring
   a. Single Conductor: Provide insulation as follows:

<table>
<thead>
<tr>
<th>NEC Type</th>
<th>Insulation Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>XHHW</td>
<td>Cross-linked Polyethylene</td>
</tr>
</tbody>
</table>

   b. Multiconductor Cables: Insulate individual conductors with 15 mils of polyethylene or PVC and 4-mil nylon jacket. Wrap the conductors with type binder and an outer jacket not less than 45 mils of PVC. Use ICEA Method 1 for color coding wires.

2. Instrumentation Wiring: The manufacturers’ name and catalog number shown below are for the purpose of establishing quality and general configuration.

   a. Two conductor or single pair: Stranded No. 16 AWG wire, 600 volt polyethylene insulation, twisted conductors, tinned copper drain wire, overlapped metalized tape overall shield providing 100 percent shield coverage and outer jacket of PVC. Belden Cat. No. 8719.

C. Printed Data on Covering: Provide the following information printed on the surface of all wires and cables at regular intervals throughout the entire length.

   1. Manufacturer or trade name.
   2. Size of conductor.
   3. Type of insulation.
   4. Voltage classification.

2.3 WIRE CONNECTIONS AND CONNECTING DEVICES

A. Connectors for No. 10 AWG and Smaller: Provide insulated compression type butt connectors.
B. Connectors for No. 8 AWG and Larger: Provide UL, Inc. listed compression type tube connectors for parallel or butt splices. Provide companion preformed plastic insulating covers or tape to provide insulation equal to conductor insulation.

C. Miscellaneous Connectors: Provide preinsulated spring connectors for lighting and receptacle splices and pigtailed.

D. Solderless Lugs: Provide solderless terminal lugs for stranded and multiple solid conductors at connection to terminals or use UL listed crimp tool compression style lugs.

E. Control Wire Terminations: Provide spade lug or pressure type control conductor connection terminations for control wiring terminations. Provide lug bolting at devices or bus bars with a flat washer, a Belleville washer and a locknut.

2.4 COLOR CODING

A. General: Use a vinyl impregnated cloth tape resistant to oil, dirt and heat for conductor color coding.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Swab new and existing conduits to be used to clear debris and remove moisture before conductor installation. Install conductors in raceways with no splices between boxes.

B. Pulling Equipment: Pull conductors using proper equipment without exceeding manufacturer's recommendation for maximum pulling tension. Protect conductor insulation jacket at all times from twists, kinks, scrapes, punctures and other damage. Replace damaged conductors. Pull wires and cables into ducts and conduit without the use of lubricants, except where such use is necessary and approved by the cable manufacturer and the Engineer. Use UL listed lubricating compound compatible with the conductor insulated jacket and with the raceway.

Use lines of nylon or polypropylene, propelled by carbon dioxide, or compressed air, to snake or pull wire and cable into conduits. Do not use flat steel tapes or steel cables.

C. Conductor Support: Support conductors in vertical risers with woven grips to prevent loading on conductor connectors.
D. Seals: Provide a seal between the conductor and conduit for conduits entering buildings or from areas where the temperature change may cause condensation or moisture. Seal the conduits after the conductors are in place.

E. Identification: Identify all cables as specified in Section 26 05 53.

F. Color Coded Tape: Apply color coding tape at all terminations and splices with overlapping turns for a minimum length of two inches, starting two inches back from the termination point. Provide color code tape in all boxes and manholes.

Provide color coding throughout the entire network for service, feeder, branch, control and low energy signal circuit conductors. Use the following color code for conductors.

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>PHASE A</th>
<th>PHASE B</th>
<th>PHASE C</th>
<th>NEUTRAL</th>
<th>GROUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>480/277 three phase</td>
<td>Brown</td>
<td>Orange</td>
<td>Yellow</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Control and low-energy signal</td>
<td>Red</td>
<td>---</td>
<td>---</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>Gray</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

G. Terminations: Leave a minimum of six inches of free conductor at each connected outlet and a minimum of nine inches at unconnected outlets.

H. NEC Requirements: Install wiring in accordance with applicable provisions of National Electrical Code, local codes having jurisdiction and as indicated.

I. Conductor Sizing: Size conductors in accordance with the NEC, local codes having jurisdiction and the following:

1. Size conductors to limit the maximum conductor temperature to less than 75 degrees C, except where specifically stated otherwise.

2. Use minimum conductor sizes as follows:
   a. Power and lighting branch circuits, No. 12 AWG.
b. 120-volt control circuits, No. 14 AWG.

c. Instrumentation and signal wiring, 2 or 3 conductors No. 16 AWG stranded shielded.

3. Size conductors as shown or as required by the actual load to be served, whichever is larger.

J. Splicing: Install continuous cables without splices in all duct systems.

K. Instrumentation wiring: Install instrumentation wiring as follows:

1. Wherever possible provide continuous instrumentation wiring without splices from field device to instrument. Where connections are required, make all connections in terminal boxes.

2. Terminate instrumentation wiring at terminal blocks only.

3. Where instrumentation wire is required to be connected in a terminal box, provide an isolated terminal for each shield.

4. Ground instrumentation shields and drain wires only at the panel end of loop.

5. Install clear, heat-shrink, seamless tubing over exposed shields and drain wires in all terminal boxes, junction boxes, panels and field devices.

3.2 CONDUCTOR IDENTIFICATION

A. Labeling: Label each wire at both termination points and at each splice point in junction boxes. Carry individual conductor or circuit identification throughout, with circuit numbers or other identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panelboards.

B. Identification: Where the total number of control and signal wires is three or more and no terminal board is provided, identify each wire in junction boxes and cabinets by means of plastic slip-on wire marker.

C. Plastic Tags: In manholes, identify each wire by laminated plastic tag located so it can be easily seen.

D. Color Coordination: Connect circuit conductors of the same color to the same phase throughout the installation.
3.3 WIRE AND CABLE CONNECTIONS TO EQUIPMENT

A. General: Provide electrical connections to all equipment in strict accordance with the manufacturer's approved wiring diagrams, the Plans, or as approved. Repair or replace any damaged equipment resulting from erroneous connections.

3.4 CONNECTOR AND TERMINAL LUG INSTALLATION

A. UL Requirements: Install all connectors and terminal lugs in accordance with UL requirements and manufacturer's recommendations.

3.5 QUALITY ASSURANCE

A. Field Tests: Test the following 600-volt wires and cables after installation but before final connections are made up:

1. For the above listed cables, apply a test voltage of 1,500 volts AC for a period of 1 minute between all conductors in the same conduit, and between each conductor and ground.

B. Test Results: Make all tests and submit certified test results. Replace any cables that fail the tests.

C. Continuity Test: Perform continuity test to demonstrate proper cable connection.

END OF SECTION
(NO TEXT FOR THIS PAGE)
PART 1  GENERAL

1.1  SUMMARY

A. Section Includes: Requirements for providing a complete grounding system as specified and shown. Grounding includes but is not limited to: electric equipment enclosures and raceway systems,

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 00 - Basic Electrical Materials and Methods
2. Section 26 05 33 - Electrical Raceway Systems
3. Section 26 05 19 - Wires and Cables - 600 Volts and Below

1.2  REFERENCES

A. Codes and Standards: The following codes and standards are referred to in this Section:

1. NFPA 70 - National Electrical Code (NEC)

1.3  SUBMITTALS

A. General: Furnish all submittals, including the following.

B. Product Data and Information: Furnish manufacturer's catalog data for the following:

1. Grounding and grounded conductors
2. Grounding connectors, clamps and bushings
3. Bonding jumpers

1.4  QUALITY ASSURANCE

A. Codes and Standards: Construct a complete grounding system in accordance with applicable ANSI, IEEE Standards, the NEC and local codes.
1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in the City of Tulsa Standard Specifications.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Grounding and Grounded Conductors
   a. Okonite Company
   b. Southwire Company

2.2 MATERIALS

A. General: Provide conductor sizes as shown or required.

B. Materials: Provide conductors in accordance with the requirements specified in Section 26 05 19 – wires and cables.

C. Bare conductors: Provide bare copper conductor where buried in earth, embedded in concrete or exposed.

D. Insulated Conductors: Provide copper conductor with green color insulation rated at 600 volts where installed in conduits or other enclosed raceways.

2.3 CONNECTORS

A. Grounding Clamps and Bolted Connectors: Provide grounding clamps and bolted connectors suitable for devices or cables being connected.

B. Bolted Connectors: Provide bolted connectors for grounding to ground buses and equipment.

C. Pipe Grounding: Provide copper, brass, or bronze grounding clamps for grounding pipes. Do not provide strap type clamps.

D. Grounding Bushings: Provide grounding bushings for conduits where conduits are not effectively grounded by firm contact to the grounded enclosure.
PART 3 EXECUTION

3.1 INSTALLATION

A. General:

1. Install conductors to preclude exposure to physical damage.

2. Install connections firm and tight.

3. Arrange conductors and connectors without placing strain on the connections.

4. Bury equipment grounding conductors as shown, or at a minimum of 12 inches below grade.

5. Install an insulated grounding conductor in all conduits.

6. When raceways are used to contain and protect grounding conductors, install in accordance with Section 26 05 33 and NEC.

B. Equipment Grounding: Ground each piece of electrical equipment using a conductor in the raceway feeding the equipment in accordance with NEC.

C. Grounding Conductors: Connect the grounding conductor between the equipment and the grounding system. Where a ground bar is furnished with the panelboard, connect the grounding conductor to the bar.

D. Miscellaneous Grounding: Provide grounding for the following:

Ground racks, supports, frames, covers and metal parts in valve vaults exposed noncurrent carrying metal, mechanical equipment.

END OF SECTION
SECTION 26 05 33
ELECTRICAL RACEWAY SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing electrical raceway systems as indicated, in accordance with the Contract Documents.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 00 - Basic Electrical Materials and Methods
2. Section 26 05 43 - Underground Electrical Distribution System

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ANSI C80.1 - Rigid Steel Conduit
2. ANSI/NFPA 70 - National Electrical Code
3. UL 6 - Standard for Rigid Metal Conduit-Steel
4. UL 360 - Standard for Liquid-Tight Flexible Steel Conduit
5. NFPA 70 - National Electrical Code (NEC)

1.3 SUBMITTALS

A. General: Furnish all submittals as specified in Section 26 05 00.

1.4 QUALITY ASSURANCE

A. Codes: Provide all materials and workmanship in accordance with the requirements of the National Electrical Code and local codes having jurisdiction.

B. Regulatory Requirements: Provide UL listed components.

C. Installers of PVC coated rigid steel conduit are to be factory certified.
1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials per 26 05 00

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Rigid steel and intermediate metal conduits and electrical metallic tubing:
   a. Allied Tube and Conduit
   b. Wheatland Tube Company/JMC Steel Group
   c. Republic Conduit Manufacturing

2. Liquidtight and flexible steel conduit:
   a. Electri-Flex Company
   b. The International Metal Hose Co.
   c. Southwire
   d. Anamet Electrical, Inc.
   e. Thomas & Betts/ABB Group

3. Conduit Fitting and Connectors
   a. Appleton/Emerson Industrial Automation
   b. Thomas & Betts/ABB Group
   c. Eaton’s Cooper Crouse-Hinds
   d. O-Z Gedney/Emerson Industrial Automation
   e. Hubbell - Killark
   f. AdaletPLM/Scott Fetzer Company

4. Boxes and Enclosures:
   a. Appleton/Emerson Industrial Automation
   b. Raco/A Hubbell Company
   c. Eaton’s Cooper Crouse-Hinds
   d. Thomas & Betts/ABB Group
   e. Hoffman
   f. Hope Electrical Products Company/O-Z Gedney/Emerson Industrial Automation
5. Strut Channel and Fittings
   a. Allied Tube and Conduit
   b. Eaton’s Cooper B-Line Systems, Inc.
   c. Thomas & Betts /ABB Group-SuperstrutEnduro Composites Inc.
   d. Strut Tech Systems
   e. Unistrut

6. Fire Stop System
   a. 3M/Electrical Products Division
   b. Acoustical Solutions Inc.
   c. Nelson Fire Stop Products/Emerson Industrial Automation

7. Terminal Blocks
   a. Phoenix Contact
   b. ABB - Entrelec
   c. Weidmuller

2.2 RACEWAYS
   A. General: Provide minimum 3/4-inch raceways.
   B. Raceway Requirements: Provide raceways meeting the following requirements:
      1. Provide rigid steel, heavy wall, hot-dip galvanized in accordance with the requirements of UL-6 and ANSI C80.1.

2.3 FITTINGS
   A. General: Provide fittings of similar material as raceways.
   B. Fittings Requirements: Provide fittings meeting the following requirements:
      1. Set screw or indenter type fittings are not acceptable. Provide threaded connectors for all rigid or intermediate metal conduits.
      2. Provide insulated connectors for liquid tight flexible conduit.
      3. Expansion/Deflection Fittings:
         a. Provide a deflection and expansion coupling for rigid and intermediate metal conduits that have a 3/4 inch movement in all directions from normal and a 30 degree angular deflection. Provide coupling that includes internal bonding jumper. Provide at building walls.
b. Provide a nonmetallic expansion coupling for nonmetallic conduits that have a 4-inch maximum expansion.

4. Bushings

a. Provide insulated nonmetallic bushing rated 105 degrees C for all installations where bonding is not required.

b. Provide insulated metallic grounding and bonding bushing rated 150 degrees C where bonding is required.

2.4 WALL AND FLOOR PENETRATIONS

A. Watertight:

1. For conduit penetrations in new exterior walls or floors provide watertight sealing sleeves consisting of a steel sleeve with pressure ring and clamps.

2. For conduit penetrations in existing walls or floors, provide watertight sealing bushing consisting of a neoprene sealing ring between two PVC coated steel pressure discs. Provide stainless steel captive screws for sealing ring compression.

B. Fire-proofing Through Fire Rated Construction:

1. Provide a permanent fire stop system for all penetrations through fire-rated walls, partitions and floors.

2. Design fire stop system to maintain the integrity of the wall or floor assembly for its rated time period.

3. Arrange fire stop system to allow normal pipe movement without being displaced.

4. Do not utilize asbestos in fire stop systems.

2.5 BOXES AND CABINETS

A. Junction and Pull Box Requirements:

1. Provide cast aluminum boxes with mounting lugs, threaded hubs and gasket covers for surface mounted boxes

2. Provide fabricated sheet metal boxes when cast metal box weight exceeds 50 pounds. Construct box from 1/8-inch thick galvanized sheet steel or aluminum with sides return channel flanged around cover opening. Provide
angle or channel supporting frame. Provide continuously welded and ground smooth seams. Provide mounting lugs and threaded conduit hubs.

3. Provide watertight gasketed covers held with stainless-steel captive screw slot bolts.

4. Provide steel barriers in all boxes that isolates instrumentation wiring from all other wiring systems.

5. Provide all boxes located outdoors, in corrosive areas or where otherwise indicated meeting NEMA 4X, 316 stainless steel requirements.

B. Terminal Box Requirements:

1. Provide minimum 12 gauge stainless steel fabricated box with mounting lugs, floor stand, and hinged doors.

2. Provide the door with continuous piano hinge and 3 point lockable latch. Provide print pocket on inside of door.

3. Provide back plate fabricated from 12 gauge minimum steel with white enamel finish for mounting terminals and wire troughs.

4. Provide wire troughs consisting of plastic ducts with snap slot design and removable covers. Run all wiring within wire troughs.

5. Furnish a schedule of terminals with the following information
   a. Source
   b. Type of Signal
   c. Function

6. Provide removable jumpers to allow operation of the equipment.

7. Separate analog terminals from all other terminals.

8. Provide number of terminals shown. Where the number of terminals are not shown, provide sufficient terminals for each wire entering the terminal box plus 20 percent but not less than 10 spare terminals.

9. Terminals:
   a. All catalog numbers refer to Phoenix Contact Type for the purpose of establishing the standard of quality and general configuration desired.
   b. Provide symmetrical type steel mounting rails, NS-35.
c. Analog Signals: Provide terminals in enclosed housing suitable for wires from 22 to 12 AWG rated 600 volts with gray body, knife disconnect and test connection socket on both sides of disconnect, Phoenix Contact Type UK 5-MTK-P/P.

d. Control and Alarm Signals: Provide terminals suitable for wires from 24 to 10 AWG rated 18 amperes at 600 volts, blue body, Phoenix Contact Type UK5N BU.

e. 120-Volt Power Wiring: Provide terminals suitable for wires from 18 to 10 AWG rated 30 amperes at 600 volts, hot (black body), neutral (white body), ground (green body), Phoenix Contact Type UK5N BK, UK5N WH & UK5N GN, respectively.

10. Enclosures: Provide enclosures meeting the same NEMA criteria for the various areas as specified under Junction and Pullboxes.

2.6 SUPPORTING DEVICES

A. Raceway Supports: Provide raceway supports meeting the following requirements:

1. Do not use perforated straps or plumbers tape for conduit supports.

2. Provide expansion bolts or inserts for fasteners in concrete, toggle bolts for hollow masonry or frame construction, and preset inserts for prestressed concrete.

3. Conduit Straps and Backs:

   a. For metallic conduits, provide steel or malleable iron.

4. Conduit Hangers

   a. For metallic conduits, provide steel adjustable conduit hangers or clevis hangers.

5. Beam Clamps:

   a. For metallic conduits, provide malleable iron with steel bolt.

6. Trapeze Hangers:

   a. For metallic conduits provide 12 gauge 1-1/2-inch square steel channels with steel channel straps to secure conduits.
b. Provide addition channels welded together to limit the deflection to 1/240th of span.

7. Threaded Rod
   a. Provide threaded rod with the minimum size as follows:
      (1) Conduit Hangers
          (a) 3/4-inch to 1-1/2-inch conduit: 1/4-inch thread rod
          (b) 2-inch to 3-1/2-inch conduit: 3/8-inch thread rod
          (c) 4-inch and larger: 1/2-inch thread rod
      (2) Trapeze Hangers: Provide thread rod of sufficient size to support the load. Provide a minimum of 3/8-inch thread rod.
   b. For Metallic Conduit Systems: Provide continuous threaded galvanized steel rod.

PART 3 EXECUTION

3.1 PREPARATION
   A. General: Install electrical equipment and material of the size, type and general routing as shown or required.
   B. Coordination with Reinforcing: Install raceway, fittings, boxes and cabinets free from direct contact with reinforcing steel.
   C. Alignment: Provide fasteners, anchor bolts, anchorage items and supports as required to insure proper and rigid alignment. Attach equipment with fasteners sized according to size and weight of the equipment and the thickness of the supporting surface.
   D. Grounding: Make metallic raceways electrically and mechanically continuous and ground as required. Install conduits continuous between outlets, boxes, cabinets and panels.

3.2 INSTALLATION
   A. General: Unless otherwise indicated, install conduits exposed, parallel or perpendicular to building floors, ceilings and walls, to avoid interference with other work. In architecturally finished areas, conceal conduits within finished walls, ceilings and floors. Cut conduits square and deburr the cuts to the same degree as
the conduit manufacturer. Fasten conduit securely to outlets, junction, pull and terminal boxes. Provide caps and seals to prevent the entrance of foreign material and moisture during installation and before pulling wire.

1. Where conduit size is not shown, provide conduits one size larger than indicated in Table 4, Chapter 9 of the NEC.

2. Keep conduit at least six inches away from piping, ducts and surfaces. For mounting on concrete and masonry surfaces provide a minimum of 1/4 inch air space between conduit and mounting surface. Support and fasten conduit to building structural members spaced in accordance with electrical codes. Support conduit at least every eight feet or less in accordance with NEC requirements.

3. When two or more exposed conduits are in the same general routing, provide parallel installation with symmetrical bends and for three or more provide trapeze hangers. Size trapeze hangers with space for 25 percent additional conduits.

4. Make changes in direction with bends or fittings. Use factory-made bends or elbows wherever possible. Make field bends and offsets with a hand bender or conduit-bending machine.

5. Run conduit in buildings with no more than the equivalent of three 90 degree bends between pull points. Provide no more than 125 feet of conduit runs between pull points. Provide pull boxes where shown, specified or wherever required to install conductors and to meet the above requirement.

6. Install pull and junction boxes in accessible locations with working space in front of and around the installation.

7. Install an expansion fitting when a conduit crosses a structural expansion joint.

8. Unless otherwise approved, install conduits to cross at right angles to building structural expansion joints.

9. Where approved for encased installation, install conduits in slabs as close to the middle of concrete slabs as practicable without disturbing reinforcement. Do not use conduit with an outside diameter exceeding one-third of the slab thickness. Do not place conduits closer than three diameters on centers, except at cabinet locations where the slab thickness is increased.

10. Pitch conduits to outlet boxes to avoid trapping moisture. Where dips are unavoidable in exposed conduit runs, install drain fitting at low point.

B. Conduit Material Types: Provide conduit as follows:
1. Provide rigid steel conduits in all installations concealed in structures, concrete encased within structures or under structures.

2. Provide rigid steel conduits for all instrumentation, and electronic equipment signal wiring in all exposed or concealed noncorrosive installations.

C. Connections to Equipment

1. Provide double locknuts and bushing for all boxes, enclosures and cabinets located in dry areas.

2. Provide watertight hub fittings for all boxes, enclosures and cabinets located below grade or in wet, damp or corrosive areas.

3. Provide rigid conduit connection where equipment is fixed and not subject to adjustment, mechanical movement or vibration. Provide union fittings to permit removal of equipment without cutting or breaking conduit.

4. Provide liquid tight flexible conduit connection where equipment is subject to adjustment, mechanical movement or vibration.

5. Coat all threads in steel conduit runs with zinc dust in oil or other corrosion-preventive compound before making connections.

D. Underground Conduits: Provide underground conduits meeting the requirements of this Section.

E. Penetrations: Make concealed penetrations for single conduits not more than 1/4-inch larger than the diameter of the conduit. Make penetrations through walls, ceilings and floors other than concrete for exposed conduits not more than 1/4-inch larger than the diameter of the conduit. Fill the voids around conduit with caulking compound and finish the surface the same as the wall, ceiling or floor.

1. Where a conduit enters through a concrete roof or membrane waterproofed wall, floor or ceiling, provide a watertight sealing sleeve that can be tightened from one or both sides. If the sealing sleeve is not placed with the concrete, core drill the proper size hole to provide a mechanically watertight installation.

2. Where a conduit enters through a concrete non-waterproofed wall, floor or ceiling, provide a galvanized steel sleeve and fill the space between the conduit and sleeve with a plastic expandable compound. If the sleeve is not placed with the concrete, drill the hole not less than 1/2-inch and not more than one inch larger than the sleeve, center the sleeve and grout the sleeve for the total depth of penetrated concrete with non-shrink grout, polyurethane or silicone sealant.
F. Boxes: Provide boxes of the proper dimensions for the size and quantity of conductors enclosed.

1. For boxes mounted on steel, concrete and masonry surface, provide a minimum 1/4-inch non-metallic spacer to hold the box away from the surface.

2. Provide separate support for boxes and bolt units to buildings with expansion anchors, toggle bolts or appropriate screws. For lighting fixture outlet boxes, provide supports adequate to support the weight of the fixture to be mounted on the box.

3. Remove debris including dust, dirt, wire clippings and insulation from the interior of boxes. Replace boxes with open conduit holes. Repair or replace damaged boxes as directed.

END OF SECTION
PART 1   GENERAL

1.1   SUMMARY

A. Section Includes: Requirements for providing underground electrical raceway system consisting of concrete encased conduits, direct buried conduits, cables, manholes, handholes, and outdoor electrical equipment pads as shown.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 00 - Basic Electrical Materials and Methods
2. Section 26 05 19 - Wire and Cable - 600 Volts and Below
3. Section 26 05 26 - Grounding
4. Section 26 05 33 - Electrical Raceway Systems

1.2   SYSTEM DESCRIPTION

A. Performance Requirements: Arrange and route conduits as shown to allow pulling-in of conductors without exceeding the conductor's tension limits.

1.3   SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Section 26 05 00.

B. Product Data and Information: Furnish manufacturer's data for conduits, manholes, handholes and all accessories.

C. Contractors’ Shop Drawings: Furnish working drawings for underground electrical raceway system showing conduits, concrete encasement. Indicate the designation, type, size, location, elevations and slopes of the system. Provide scaled profile drawings as needed to resolve conflicts among the various disciplines and existing infrastructure. Profile drawings are to be scaled 1”=10’-0” horizontal and 1”=2’-0” vertical.
1.4 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in the City of Tulsa Standard Specifications.

1.5 PROJECT CONDITIONS

A. Existing Conditions: Examine record drawings to determine the location of all obstructions along the conduit or cable route and at the sites of manholes, handholes and outdoor electrical equipment pads. Contact the local underground utility locator service and confirm the location of all existing utilities prior to excavating for new work. Verify prior to commencing work.

B. Field Measurements: Field survey, and in critical areas, excavate test pits to verify locations of probable obstacles along the conduit or cable route and at the sites of manholes, handholes and outdoor electrical equipment pads.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Conduit Spacers
   a. Carlon - Thomas & Betts/ABB Group
   b. Underground Devices, Inc.

2. Buried warning tape
   a. Ezcode - Thomas & Betts/ABB Group
   b. W. H. Brady Company

2.2 MATERIALS

A. Conduit: Provide conduits meeting the requirements of Section 26 05 33.

B. Spacers: Provide rigid plastic, conduit spacers to maintain conduit separation as indicated.
PART 3  EXECUTION

3.1  CONDUIT INSTALLATION

A.  General:  Install underground, concrete encased conduits as indicated.

B.  Conduit Route:  Establish and mark exactly conduit or cable routing.  Resolve routing near existing obstacles and coordinate with other site work.  Maintain a 12-inch minimum longitudinal clearance from the conduit bank encasement or direct buried conduit to adjacent utility lines.  Maintain a 6-inch minimum vertical clearance from the conduit bank encasement or direct buried conduit to utility lines at crossovers.  Adhere to lines, grades, elevations and dimensions as shown.

C.  Trench Excavation:  Perform excavation work in coordinated with the requirements for pipe excavation.

D.  Bedding:  Provide a sand cover on trench bottoms to create a firm and smooth surface for direct buried conduits.

E.  Spacers:  Locate spacers at intervals of approximately four feet and stagger locations at each conduit tier to provide not less than 12-inches of longitudinal separation.

F.  Conduit:  Place conduit in straight lines and with a minimum slope of 0.25 percent (3 inches per 100 feet).  Slope conduit down to handholes and structures.  Install expansion fittings in straight runs exceeding 100-feet.  Secure conduits in place to prevent floating and movement.  Provide innerducts with pull strings installed in all conduits scheduled for the routing of instrumentation wiring (Cat 5E, fiber optic, twisted shielded, etc.)  Provide spare innerducts to the maximum allowable capacity of the conduit size being used.  Spare innerducts are to be of the same size used for the scheduled wiring.

G.  Bends:  Install 12-foot minimum radius bends in horizontal turns and vertical deflections.  For bends used at ends of conduit runs install elbows with 4-foot minimum radius for 6-inch and 5-inch conduits, and elbows with 3-foot minimum radius for 4-inch and smaller conduits.

H.  Inside Cleaning:  Pull a standard flexible mandrel not less than 12-inches long, having a diameter approximately 1/4-inch less than the inside diameter of the conduit, through each conduit, then pull a brush with stiff bristles through each conduit.  Replace conduit runs that do not allow the passage of the mandrel at no increase in Contract Price.  Use the pneumatic method to draw into conduit the nylon or polypropylene pull line.  Plug and seal all conduits after cleaning.

I.  Concrete Reinforcing:  Install concrete reinforcing meeting the requirements of Section 03 20 00.  Provide duct banks with No. 5 reinforcing, spaced 12 inches on centers, top and bottom, with No. 3 ties at 18 inches, unless otherwise shown.
J. Backfilling: Backfill meeting the requirements of Section 31 23 23. Provide a cover layer of sand that is 6 inches deep above direct buried conduits or cables. Provide 4” minimum top soil at surface.

K. Underground Warning Tape: Provide one underground warning tape for each trench up to 18 inches wide. For trenches wider than 18 inches provide two underground warning tapes installed at each edge of the trench. Place the tape or tapes 12 inches below the finished grade.

L. Markers: Provide 4-inch round, 6-inch thick, concrete markers identified with the letter "E" and directional arrows. Place these markers approximately every 200 feet along straight portions of conduit and cable runs, at each change in direction and at the conduit run end. Install markers to protrude 1-inch above adjacent ground. Allow markers to protrude 1/2-inch in finished lawns. Do not place conduit markers at structures and at conduit risers.

M. Surface Finish: Restore existing pavements and curbs with materials and construction to match existing. Restore landscaped/ grass covered areas with top soil, rake smooth to meet existing grade, seed, and protect.

END OF SECTION
PART 1  GENERAL

1.1  SUMMARY

A. Section Includes: Requirements for providing materials for the identification of electrical equipment, components, conduits, cables and wiring, and furnishing and installing safety signs.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:
   
   1. Section 26 05 00 - Basic Electrical Materials and Methods

1.2  REFERENCES

A. Codes and standards referred to in this Section are:

   1. ANSI C2 - National Electrical Safety Code (NESC)
   2. ANSI Z535.1 - Safety Color Code
   3. ANSI Z535.2 - Environmental and Facility Safety Signs
   4. ANSI Z535.3 - Criteria for Safety Symbols
   5. OSHA - Occupational Safety and Health Act

1.3  SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Section 26 05 00.

B. Product Data and Information: Furnish manufacturers’ catalog data for safety signs, nameplates, labels and markers.

   1. Furnish manufacturers’ instructions indicating applicable conditions and limitations of use, storage, handling, protection, examination and installation of product.

1.4  DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in the City of Tulsa Standard Specifications.
PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. W. H. Brady Company
2. Seton
3. Thomas & Betts/ABB Group

2.2 MATERIALS AND COMPONENTS

A. General: Provide identification materials listed and classified by UL or tested by an acceptable Electrical Testing Company certifying the equivalence of the materials to UL listing requirements and OSHA approved.

B. Laminated Plastic Nameplates: Provide engraved three layer laminated plastic nameplates with black letters on white background and fastened with corrosion-resistant screws. Do not use mounting cement for fastening nameplates.

1. Provide nameplates with 1/2-inch high lettering for individual components of a group such as main breakers, switchgear units, switchboard units, motor control center units and similar devices.

2. Provide nameplates with 1/4-inch high lettering for remote motor controllers, control stations, relays and similar equipment.

3. Provide smaller lettering for a neat, legible nameplate where the amount of lettering causes excessively large nameplates.

C. Wire Markers: Identify wire bundles and each individual wire.

1. Wire bundles: Provide a brass or rigid fiber identifying tag attached with nylon self locking "Ty-Raps".

2. Wire identification markers: Provide a printed white, heat-shrink, seamless tubing type with black bold lettering for wires size No. 10 AWG and smaller. Provide a printed self-laminating white, vinyl type with black bold lettering for wires No. 8 AWG and larger.

D. Underground Warning Tape

1. Provide underground warning tape for underground cables, conduits and duct banks.
2. Use 6 inch wide, 0.004 inch thick, polyethylene underground warning tape with black lettering and background colors as follows:
   a. Electric: Red.
   b. Telephone/Data: Orange.

3. Provide lettering that indicates the type of buried service.
   a. Electric: "CAUTION ELECTRIC LINE BURIED BELOW"
   b. Telephone/data: "CAUTION TELEPHONE LINE BURIED BELOW"

4. Manufacturer: Utility Safeguard, LLC.

PART 3 EXECUTION

3.1 PREPARATION

A. Surface Preparation: Degrease and clean surfaces to receive nameplates, labels and marking paint.

3.2 INSTALLATION

A. General: Install nameplates on the front of equipment, parallel to the equipment lines and secured with corrosion resistant screws. Caulk all screw holes with clear silicone caulk prior to attaching nameplates on NEMA 4X enclosures.

1. Install laminated nameplates identifying:
   a. Each electrical equipment enclosure
   b. Individual equipment and devices

B. Wire Markers: Identify wire bundles and each individual wire with identification tags as follows:

1. Wire Bundles: Install an identifying tag engraved with the conduit number where conduits enter motor control centers, switchgear, switchboards, control panels, terminal boxes and the like.
2. Wire identification markers: Provide wire identification markers on each wire at all termination points.
   a. On power and lighting circuits: The branch circuit or feeder number as indicated on drawings
   b. On control circuits terminated in motor control centers, switchgears, control panels and alike: The field device and terminal number of the opposite end connection.
c. On control circuits at each field device: The panel or compartment number and terminal number of the opposite end connection.

3. Oversize wire markers so that after heat shrinking the wire marker can be rotated on the wire. Rotate wire markers so that wire identification number is visible.

C. Underground Warning Tape

1. Install underground warning tape in the trench above underground conduit(s), 1 foot below the finished grade, or as otherwise directed by the Engineer.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Work required for protection of an excavation or structure through shoring, sheeting, and bracing.

B. Work is required for excavation for the Replacement Section of the Tiawah Tunnel, as well as excavation for the Bird Creek Pump Station Valve Vault.

1.2 RELATED SECTIONS

A. Current City of Tulsa Standard Specifications and Standard Details govern, unless modified herein. Refer to the following City of Tulsa (COT) Standard Specifications for Related Work:

1. COT 105 – Protection of Property
2. COT 111 – Dewatering
3. COT 113 - Removal of Condemned Materials and Structures
4. COT 115 – Clean-Up
5. COT 301 – Right-of-Way Clearing and Restoring
6. COT 302 – Excavation and Backfill, Unclassified
7. COT 330 – Erosion Control Measures

B. Refer to Volume II – Technical Specification (SPECIAL) for related work:

1. Section 02 41 00 – Demolition

1.3 MEASUREMENT AND PAYMENT

A. In accordance with COT 302, unless noted otherwise.

B. For the Tiawah Tunnel Replacement Section, shoring and bracing will be measured on a per lineal foot along the tunnel, and included in the Pay Item for Excavation and Backfill, Unclassified – Tunnel Section.
1.4 SUBMITTALS

A. Submit separate Work Plans for the Tiawah Tunnel Replacement Section and the Bird Creek Pump Station Valve Vault, signed and sealed by a Licensed Professional Engineer with a minimum of 5 years of experience in excavation support design and registered in the State of Oklahoma. The Work Plans shall include as a minimum:

1. Complete design calculations and working drawings for the shoring, sheeting and bracing which will be used for excavation support.

2. Methods for monitoring deformations to limit impacts to surrounding features.

3. Methods for controlling and handling groundwater inflows, if encountered, in accordance with COT 111.


5. Contingency measures for handling and remediating localized areas of unstable ground, groundwater inflows, and subgrade conditions unsuitable for pipe or structure placement.

6. Where commercially manufactured trench boxes or other pre-engineered shoring systems are to be used, provide certification from the Contractor’s Licensed Professional Engineer stating the conditions under which the trench boxes or shoring systems will be used.

1.5 REFERENCES

A. Codes and standards referred to in this Section are:

1. All Federal, State and local laws and regulations applying to the design and construction of shoring, sheeting and bracing.


PART 2 PRODUCTS

2.1 MANUFACTURERS AND MATERIALS

A. Use manufacturers and materials for shoring, sheeting and bracing as recommended by the Contractor’s Licensed Professional Engineer who designed the shoring, sheeting, and bracing. Where wood lagging is to be left in place use oak or treated fir or treated pine. Use only environmentally safe treatment for wood lagging.
PART 3   EXECUTION

3.1 SHORING, SHEETING AND BRACING INSTALLATION

A. General: Provide safe working conditions, prevent shifting of material, prevent damage to structures or other work, and avoid delay to the work, all in accordance with applicable laws and regulations and COT 302. Shore, sheet, and brace all excavations that are not cut back to the proper slope, as determined by the Contractor’s Licensed Professional Engineer.

1. Construct shoring, sheeting, and bracing in accordance with the working drawings of the approved Work Plan.

2. Take sole responsibility for the design and adequacy of shoring, sheeting and bracing not shown on the Plans.

3. Take sole responsibility for the methods of installation of the shoring, sheeting and bracing.

4. Take sole responsibility for controlling groundwater inflows into the excavations, either by dewatering or by using watertight excavation support systems. Dewater in accordance with COT 111.

5. Provide clearances to final structures as indicated on the Plans, or as consistent with Contractor’s means and methods if no clearances are indicated on the Plans.

6. Coordinate design and installation of the shoring, sheeting and bracing with existing features as indicated on the Plans, such as at the Bird Creek Pump Station.

B. Arrange shoring, sheeting and bracing so as not to place loads on portions of completed work until the completed works have obtained 70% of design strength.

C. If the Contractor or its Licensed Professional Engineer is of the opinion that at any time the Contractor’s excavation plan, shoring, sheeting or bracing is inadequate or unsuited for the purpose, take immediate and appropriate action. Provide a new Work Plan if the Contractor’s excavation plans, shoring, sheeting or bracing require modifications.

D. Monitoring:

1. Monitor horizontal and vertical deflections of sheeting, shoring and bracing at least twice a week during excavation adjacent to the sheeting, shoring and bracing, or at least once a week if excavation is not currently occurring.
2. The Licensed Professional Engineer shall compare deflections to estimated values and adjust procedures accordingly if deflections exceed estimated values. Results shall be reported to the Engineer on a weekly basis.

E. Accurately locate all underground utilities and take measures necessary to protect them from damage. All underground utilities shall be kept in service at all times in accordance with COT 105.

F. Remove shoring, sheeting and bracing as the excavation is backfilled in a manner to avoid the caving or disturbance to adjacent areas or structures or pipe bedding.

1. Carefully fill voids left by the withdrawal of the shore, sheeting and bracing. No separate payment will be made for the filling of such voids.

2. If pipe bedding is disturbed, re-compact it to meet specified density requirements.

3. Follow requirements per COT 302.

G. Permission for Removal: Obtain permission from the Contractor’s Licensed Professional Engineer before the removal of any shoring, sheeting or bracing. Retain the responsibility for injury to structures or to other property or persons for failure to leave such shoring, sheeting and bracing in place even though permission for removal has been obtained.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. This Section specifies requirements for designing and developing grout mix designs; testing and verifying grout mixes; and batching, transporting, and placing void filling grout behind the existing concrete tunnel lining within the Tiawah Tunnel, including drilling holes to place and verify grout placement. Locations and prioritization for void filling are shown on the Plans, and as specified herein.

B. Related Sections:

C. Current City of Tulsa Standard Specifications and Standard Details govern, unless modified herein. Refer to the following City of Tulsa (COT) Standard Specifications for Related Work:

1. COT 111 – Dewatering
2. COT 113 – Removal of Condemned Materials and Structures
3. COT 115 – Clean-Up

D. Refer to Volume II – Technical Specification (SPECIAL) for related work:

1. Section 03 33 25 – Tunnel Liner Cleaning, Scaling and Repairs
2. Section 01 04 40 – Underground Safety

1.2 REFERENCES

A. Reference Standards:

1. ASTM International:

2. NSF International (formerly National Sanitation Foundation) / American National Standards Institute (NSF/ANSI):

B. Definitions:

1. Grout Hole: Hole drilled through the concrete lining and into rock or surrounding ground to receive the injection of grout between the concrete lining and the excavated ground.

2. Grout Hole Array: Two or more grout holes located at the same station in the tunnel.

3. Primary Holes: First set of grout holes that are drilled and grouted to perform Void Filling Grouting.

4. Probe Hole: An exploratory hole drilled into intact rock beyond the tunnel lining and void to determine lining and ground conditions and size of void behind the lining. Probe holes can subsequently be utilized for grouting or for drainage.

5. Refusal: The point at which grouting of a hole is considered complete. Refusal is achieved when grout injection rate is equal to or less than 1 gallon per minute as measured over 3 continuous minutes at the maximum allowable grouting pressure.

6. Secondary Holes: Grout holes that are drilled and grouted following completion of grouting in the primary holes to perform Void Filling Grouting.

7. Tier 1, 2 and 3 Priority: Per Section 03 10 80.

8. Verification Hole: Similar to grout hole but used to verify the extent of the injected grout.

9. Void: Any opening behind the tunnel lining resulting from the original mining of the tunnel or subsequent erosion. The void may be partially filled with wood backpacking or lagging, soil, rock packing, roof fall material, or a combination of the above.

10. Void Filling Grouting: Injection of cement grout under pressure to ensure the complete infilling of the annulus between the excavated ground and the existing tunnel concrete lining.

11. Water to Cement Ratio: The ratio, as measured by volume, of water to cement in the grout mix.

1.3 MEASUREMENT

A. Grout placed for void filling will be measured per 94 pound sack of dry cement injected for void filling, on a unit price basis.
B. Primary and Secondary Grout Holes will be measured as the number of completed holes drilled through the existing concrete lining, rock backpacking, and collapsed soil/rock adjacent to the lining, on a unit price basis.

C. Probe/Verification Holes that extend up to 8 feet in length from the concrete lining inside surface to verify extent of void, conditions behind the liner, or verify grout placement beyond what is shown on the Plans will be measured per hole, on a unit price basis.

1.4 PAYMENT

A. Grout shall be placed in accordance with the Plans and Specifications or at the direction of the Engineer, and will be paid at the unit prices stated in the Bid Schedule. Grout will include furnishing equipment, labor, and other grout materials; placing the grout; quality assurance measures; maintaining the tunnel in a clean condition; ventilation and lighting; verification of grout placement except for costs of drilling holes covered elsewhere; utilities for placing grout; disposal of excess grout; and all incidentals necessary to complete the work.

B. Grout Holes and Secondary Holes shall be drilled as shown on the Plans and at the direction of the Engineer, and will be paid at the unit prices stated in the Bid Schedule. Grout and Secondary Holes will include equipment and labor; drilling the holes; maintaining the tunnel in a clean condition; ventilation and lighting; stabilizing the hole as necessary; utilities for drilling holes; disposal of materials from drilling; and all incidentals necessary to complete the work. No payment will be made for Grout and Secondary Holes abandoned because of Contractor negligence.

C. Probe and Verification Holes shall be drilled and logged at the direction of the Engineer, and will be paid at the unit prices stated in the Bid Schedule. Probe and Verification Holes include equipment and labor; drilling the holes; maintaining the tunnel in a clean condition; ventilation and lighting; supplying access to allow the Engineer to inspect and obtain measurements from each hole; utilities for drilling the holes; disposal of materials from drilling; and all incidentals necessary to complete the work. No payment will be made for Probe or Verification Holes abandoned because of Contractor negligence.

1.5 SYSTEM DESCRIPTION

A. Design Criteria:

1. Void Filling Grouting to be performed systematically in the crown at designated locations to ensure continuous filling of voids between the rock and the existing lining. All Void Filling Grouting shall proceed from the lowest elevation of the tunnel to the highest.
2. Void Filling Grouting of the existing lining shall be performed at locations and using Grout Hole Arrays as indicated in the Plans.

3. Minimum Compressive Strength: Minimum 28-day unconfined compressive strength of 3,000 psi.

4. Maximum grout pressure shall be 30 psi or 30 psi above hydrostatic pressure as measured at each hole.

B. Performance Requirements:

1. The condition of the existing concrete lining is variable and there is a potential for zones of thin and weak concrete. Modify the grout pressure and procedures in specific areas based on lining observations with approval from the Engineer.

2. Ensure continuous Void Filling Grouting between the tunnel lining and the surrounding ground using Primary and Secondary Holes as show on the Plans, and using Probe and Verification Holes as directed by the Engineer.

3. Do not drill any holes within repair zones in the existing lining. Move holes a minimum of 12 inches away from repaired areas and drill the holes within the existing lining.

4. Proportion and mix grout in a batch plant and pump from inside the tunnel, or from the East Access Structure.

1.6 SUBMITTALS

A. Product Data:

1. Grout and admixture manufacturer’s product data sheets indicating:
   a. Mixing, handling, storage, and waste disposal requirements.
   b. Personal safety equipment and first aid measures.

2. Source of supply for each grout ingredient.

3. For each type of and source of material:
   a. Cement: Standard physical and chemical analysis.
   b. Admixtures: Documentation showing that the proposed admixtures have a history of demonstrable satisfactory performance.

4. Copies of the Safety Data Sheets (SDS) for grout and admixtures materials shall be submitted to the Engineer for information.
5. Calibration procedures for gauges and meters to be used in grouting operations.

B. Working Drawings and Methods Statements:

1. Grouting patterns and details for sequencing and performing grouting, in accordance with general layout on the Plans.

2. Means and methods for cleaning the surface of the existing tunnel lining and invert and disposing of wasted or excess grout.

3. Layout and description of grouting equipment and facilities including:
   a. Supply equipment.
   b. Drilling equipment.
   c. Agitators or holding tanks.
   d. Mixers.
   e. Pumps.
   f. Grout delivery piping and manifolds.
   g. Hookup details including valves, packers, grout meters, and pressure gauges.

4. Safety plan for completing the work while protecting workers from potential spalling of the existing concrete lining during and after grouting, in accordance with Section 01 04 40.

5. Means and methods for:
   a. Measuring for each hole the grout pressure, injection rate, and quantity from the tunnel pump.
   b. Maintaining grout pressure at or below specified limits.
   c. Sequencing grouting.
   d. Repairing methods and materials for sealing cracked concrete tunnel lining that communicate grout. This includes caulking and plugging material to be used in the existing lining.

C. Mix Designs:

1. Furnish for each of the grout operations:
a. Mix design data, including all mix components and test results to meet minimum performance requirements specified herein.

b. Initial and final set times for proposed mixes for the range of water/cement ratios anticipated.

D. Quality Control:

1. Qualifications:
   a. Qualifications of the grouting superintendent.

2. Certifications:
   a. Calibration certificates and field calibration procedures, on a monthly basis or as directed by the Engineer, for gauges and meters to be used in grouting operations.
   b. Certifications that all admixtures satisfy NSF/ANSI 61 potable water standard requirements.
   c. Certifications that admixtures are noncorrosive.
   d. Certificates of chloride content for accelerating admixtures.
   e. Certificates from an approved testing laboratory verifying accuracy of master grouting pressure gauges within 30 days prior to start of Work.

3. Quality Control Plans:
   a. Methods for assuring uninterrupted Void Filling Grouting at the pressures that do not exceed the maximum specified.
   b. Means for assuring that void filling grout holes drilled through existing concrete lining does not damage the concrete lining.
   c. Methods for demonstrating that grout mixes meet design criteria.

4. Recordkeeping:
   a. Submit records of strength test results on grout cylinders within 48 hours after scheduled 24 hour and 28-day testing.
   b. Logs for each shift for each type of grout hole drilling including:
      (1) Start and finish times.
      (2) Name of drillers and inspectors.
      (3) Number and type of equipment used.
(4) Diameter and length of hole drilled.
(5) Station of hole and clock position.
(6) Locations of changes in the drilling rate if applicable.
(7) Locations of changes in water inflow rate and pressure.
(8) Groundwater inflow rate for each hole, if any.
(9) Groundwater pressures in all holes if water is flowing from hole.
(10) Locations of drilling water loss.

c. Grouting Record:

(1) Stationing and clock position for each hole.
(2) Identify hole being grouted.
(3) Identify holes that are communicating grout or serving as an air vent for the hold being grouted.
(4) Amount of cement injected (sacks) and mix design (W/C ratio) for each hole.
(5) Maximum injection gauge pressure (psi) at refusal.
(6) Communication patterns to other holes, cracking of the tunnel lining or existing defects and other reasons to stop injection in each grout hole, as applicable.
(7) Sections of tunnel invert cleaned.

5. Notifications:

a. Within 1 workday of any proposed addition, deletion, or change to the scheduling shift work.

b. Within 1 workday of performing gauge and meter tests.

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Void Filling Grouting shall be performed under the direction of a superintendent having a minimum of 10 years in grouting for underground construction purposes.

B. Acceptance Criteria: Complete filling of voids between the existing tunnel lining and the rock surface to the level of refusal with a mix design meeting the minimum compressive strength, as specified herein or as approved by the Engineer.

C. Preconstruction Meeting:

1. At least 5 days and no more than 30 days before beginning the Void Filling Grouting operation, the grouting superintendent and shift supervisors shall attend a pre-grouting meeting with the Owner and Engineer to discuss the following:
a. Scope of work to be performed.
b. Construction methods and constraints overview.
c. Equipment operating parameters.
d. Safety and first-aid procedures, including protecting workers from potential spall zones.
e. Mix designs and materials.
f. Grouting procedures, crews, and sequencing with other work.
g. Grouting procedures if existing concrete lining becomes cracked or spalls.
h. Available crews and materials for plugging/sealing leaks while grouting.
i. Criteria used to initiate and cease grouting including applicable refusal, grout leakage criteria.
j. Grouting records.
k. Tunnel invert cleanup procedures.
l. Reporting requirements.
m. Other issues that may be raised by either party.

1.8 SEQUENCING AND SCHEDULING

A. Where no lining repairs are required, drill and perform Void Gilling Grouting per Contractor’s option at any time during the outage.

B. Where lining repairs are required, drill and perform Void Filling Grouting after the lining repairs have reached the specified 7-day design compressive strength.

C. Coordinate construction of the Replacement Section if access into the tunnel will be required from the West Access Structure. Equipment access will only be from the East Access Structure.

1.9 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Transport, store, and handle grouting materials in the manner prescribed by the manufacturers of each product.
B. Protect materials from mechanical damage and damage caused by environmental exposure. Clean up spills as prescribed by the manufacturer or directed by the Engineer.

C. Cement:

1. Furnish Portland cement in 94-pound sacks as packaged by the manufacturer or in bulk.

2. Use cement as close as possible to the chronological order in which it was delivered to the job site and within six months of its manufacture.

3. Store bagged cement so that it may be distinguished from other shipments.

4. Cement shall be free from foreign matter and lumps. If cement is found to contain lumps or foreign matter of a nature and in amounts deleterious to the grouting operations, it shall not be used and shall be disposed of in a manner satisfactory to the Engineer. Broken packages and packages subjected to moisture shall be wasted at the Contractor's expense.

5. If bulk cement is used, accurate devices shall be used to measure the quantity of cement delivered and utilized.

PART 2 PRODUCTS

2.1 MATERIALS

A. General:

1. All grouting admixtures shall meet NSF/ANSI 61 potable water standards requirements.

B. Cement:

1. Cement shall conform to ASTM C150.

2. Void Filling Grout shall use Type II cement.

C. Admixtures:

1. Superplasticizers or high range water reducers used for the formulation of grout mixes shall be as approved by the Engineer.

2. Use antiwashout additive, BASF UW450 or equivalent, in areas of heavy water discharge that can erode the void filling grout out during placement.

3. Use granulated perlite as needed for leakage control in cracks or seams in the existing concrete lining.
4. Use admixtures compatible with proposed mixing water. Admixtures containing chlorides shall not be used.

5. Accelerators shall conform to ASTM C494, Type C.

D. Water:

1. Water used for all grout mixes shall meet local drinking water standards.

2. The temperature of the water at the time of mixing shall be less than 80°F.

E. Miscellaneous Materials:

1. Keep caulking materials available for use during the performance of grouting operations. These materials shall include oakum, wooden wedges, burlap, and cement water plug (BASF MasterSeal 590 or an approved equivalent).

2. Nonshrink grout for plugging grout, Probe and Verification holes after the completion of grout injection through concrete linings shall be compatible with the existing lining, with a minimum compressive strength of 2000 psi and no shrinkage. Conform to manufacturer’s recommendations for mixing, placement, and curing.

2.2 EQUIPMENT

A. Drilling Equipment:

1. Drilling equipment for Void Filling Grouting shall be selected to suit proposed methods, and the objectives of grouting specified herein.

   a. Concrete strength evaluated indicated a range of strengths of approximately 2,000 psi to 5,000 psi with a mean of 3,500 psi.

   b. Concrete lining thickness as evaluated by coring small diameter drill holes and GPR had a range of thickness of approximately 3 inches to 15 inches.

2. Provide one spare/standby drill at all times.

B. Cement Grout Mixers and Agitators:

1. Mixers shall be high-speed colloidal type capable of providing a homogenized mix with a tangential return flow from a centrifugal pump.

2. Use a mixer and grout plant capable of delivering a neat cement grout to a colloidal mixer or agitator tank and pump in the tunnel where grouting is to be performed without interruption. The Engineer may direct the addition of
approved particulate matter (Perlite) to the grout mix at the mixer within the tunnel.

3. Provide a means of accurately measuring grout ingredients at all mixers, both in the automated plant and plants within the tunnel.

4. Provide a means for increasing or decreasing the water/cement ratio at the mixer in the tunnel as indicated by the field conditions.

5. Provide a separate agitator serving as a holding tank between the mixer and the pump, both for the automated plants at the top of the access structures and in tunnel plants, that allows continuous pumping.

6. Equip agitators with baffles to induce turbulence and rotating paddles that will promote thorough mixing of the grout prior to and during injection.

C. Cement Grout Pumps:

1. Provide a water connection on the grout pump to facilitate flushing the system and injection of water into the grout recirculation lines and holes.

2. Pumps within the tunnel shall have a maximum pressure capacity of 250 psi, a maximum output of 20 gpm, and utilize a helical screw rotor-type (Moyno pump) that produces uniform flow without pulsation.

3. Provide standby pump of same specifications.

4. Pumps shall be equipped with calibrated flow meters and pressure gauges to monitor grouting flow rates and pressure at the pump.

D. Appurtenances:

1. Packers: Packers shall be capable of sealing the grout holes at the selected locations and depths, such that grouting can be performed at grout pressures equal to the maximum specified without leakage. Packers shall be designed to prevent hydrostatic build-up during placement and seating of the packers. Packers shall be equipped with shutoff valves.

2. Grout piping: Grout lines and pipes to and through the packer shall have a minimum inside diameter of 1 inch. Provide sufficient grout piping to complete all grouting operations from the start to end stationing for each grouting operation.

3. Valves: Void Filling Grout and grout holes that may be communicated to from the connection being grouted shall be provided with a steel ball valve at the collar of the hole for quick closure.
E. Instrumentation:

1. Pressure Gauges:
   a. Pressure gauges shall be accurate within 1.0 psi ± for the entire range of injection pressures, with a measuring range no more than approximately three times the maximum grout pressure used and shall be provided with appropriate gauge savers.
   b. Pressure gauges shall be installed at the collar of the grout hole and at the pump.
   c. Verify accuracy of gauges weekly by use of a set of calibrated master pressure gauges not used in grouting operations.

2. Calibrated Master Pressure Gauges:
   a. Furnish a minimum of one calibrated pressure gauge to be used as a master to check pressure gauges used in the field for grouting. Additional calibrated master pressure gauges are required for each field gauge pressure range used.

3. Flowmeters:
   a. Install a magnetic flow meter between the grout recirculation line in the tunnel and injection grout hole. The flow meter shall have a resettable totalizer and be battery operated.
   b. Verify accuracy of flowmeters meet a maximum measuring error of 0.5%, used to monitor grout injected as required by the Engineer.

F. In-Tunnel Hoses/Piping:

1. Locate a manifold and grout return line consisting of a system of valves and pressure gauge in the line located at the collar of the grout hole to permit continuous circulation, accurate control and monitoring of grouting pressure and regulation of flow.

2. The manifold and grout return line will all the grout pressure to be regulated thru the return line regardless of pump speed. The return line will return grout to the agitator tank.

3. The grout flow meter will monitor flow between the manifold and the injected grout hole.

4. The arrangement of manifold, hoses and pipes used shall allow for reliable recording of injected quantities of grout in each grout hole connection.
5. **Size:**
   a. Inside diameter of the supply lines and manifolds, including valves and fittings, shall be a minimum of 1 inch.
   b. Flexible rubber supply lines shall not exceed 1-1/2 inch inside diameter.
   c. Group pipes placed in grout holes for grouting shall have a minimum internal diameter of 1 inch.

2.3 **MIXES**
   A. The mix design shall meet the minimum strength requirements unless modified under the approval of the Engineer.

PART 3 **EXECUTION**

3.1 **GENERAL**
   A. Prioritization of repairs is indicated on the Plans, and as defined herein, for Tier 1, 2 and 3 priorities. Schedule repair work to complete Tier 1 repairs first, followed by Tier 2 repairs, and then Tier 3 repairs.
   B. All grouting shall be performed with a pressure regulator and a grout return line.
   C. Contractor shall use the East Access Structure for equipment access for Void Filling Grout as appropriate. Personnel access can be staged from either the East or West Access Structures, although the East Access Structure avoids interfacing with work at the Tunnel Replacement Section. Grout for the Void Filling Grouting operations shall be mixed at the access structures or in the tunnel and supplied to the Void Filling Grouting area.
   D. Perform all Void Filling Grouting in a progressive, methodical manner:
      1. Proceed from end of the designated Void Filling Grouting area and systematically progress upstream.
      2. Proceed from lower to higher holes, with respect to elevation around the tunnel circumference and tunnel invert gradient.
      3. Discharge water from grouting operations shall be collected, treated, and disposed of in accordance with COT 111.
      4. Grout and Probe or Verification holes in the vicinity of the Void Filling Grouting shall remain open until grout is observed at the hole to allow the Engineer to monitor the extent of grout penetration.
E. Any grout hole that becomes plugged or obstructed before grouting shall be reopened, redrilled, or plugged with grout and abandoned and a replacement hole drilled. Hookup and verification on every hole is required to confirm it is plugged.

F. Maintain equipment used for mixing and pumping of grout in satisfactory operating condition at all times. Keep equipment and lines clean by constant circulation of grout and by periodic flushing.

3.2 PREPARATION

A. Have equipment and materials on hand for tunnel invert clean up prior to beginning the in-tunnel grouting operations.

B. Drill and clean out each Void Filling Grout hole from the inside tunnel face to the face of the rock surface:
   1. Using a drill equipped with a bit of the same nominal diameter as that for holes to be grouted or to which grout may be communicated.
   2. Do not drill grout holes where the tunnel lining has been repaired. Consult the Plans for locations of repair zones. Move holes as needed to avoid the tunnel lining repair area while maintaining hole spacing.

C. Affix a valve to each hole that has been cleaned and open all valves upstream of the hole to be grouted.

3.3 INSTALLATION

A. General:
   1. Do not pump grout into more than one connection at a time.
   2. Relieve air and groundwater through the valved, open, ungrouted Primary and Secondary Grout Holes upstream of the hole being grouted to the extent possible.
   3. Do not close any valved, open, ungrouted hole until grout return of the same consistency and flow as that being injected occurs.
   4. Grout procedure consists of:
      a. Hook up to each valve.
      b. Begin pumping.
      c. Observe communication from adjacent holes.
      d. Shut off valve in adjacent holes as specified.
e. Move to the adjacent hole after refusal has been reached

f. All drilled Primary and Secondary Grout Holes will be grouted to refusal.

5. Remove grout valves and permanently install repairs to the lining after the grout has reached initial set.

6. Alteration of the mix proportions, grouting pressure, sequence of injection, and pumping rate throughout the grouting operations to achieve the desired results shall be approved by the Engineer.

B. Primary and Secondary Grout Holes:

1. Drill holes for Void Filling Grouting through the concrete tunnel lining and any localized voids to rock.

2. Grout holes shall be located in known high points in the specific area to be grouted. Verify the escape of air/water and grout from the holes during grouting.

3. Install a grout packer or shut-in valve into each grout hole. The packer/vent pipe shall extend to within a minimum of 1 inch of the end (high end) of the hole. Once grout issues from the grout holes, the packer shall be closed off and subsequently used as a grout hole as the grouting operation proceeds towards the grout hole.

4. Drill the diameter of each grout hole to be compatible with grout pipes and packers specified herein.

C. Grouting:

1. Once grouting is started, do not interrupt grouting of a hole until refusal is obtained or with specific approval of the Engineer.

2. Where grout is found to flow from adjacent grout connections and holes in sufficient quantity to cause appreciable loss of grout, valves on such connections may be temporarily closed, and intermittently opened for bleeding and subsequent grout connection.

D. Completion of Grouting:

1. Void Filling Grouting will be considered complete when refusal in the injected hole is met. Refusal for grouting shall occur when the grout hole accepts less than 1 gpm flow rate at the maximum injection pressure.

2. Fill all open Primary and Secondary grout holes with nonshrink grout at completion of the grouting operations to within 6 inches of the tunnel lining.
surface and dry pack the remainder of the hole with sand and cement to have a smooth finished surface.

3.4 FIELD QUALITY CONTROL

A. All grouting operations shall be performed in the presence of the Engineer.

B. Void Filling Grouting: Test three cylinders once a week. Minimum cylinder diameter shall be 3 inches. Tests performed on grout cubes or prisms shall not be accepted for verifying strength.

C. During grouting operations, verify:
   1. Hole location, depth, and spacing satisfy criteria specified herein and as shown on the Plans.
   2. Ensure that grouting is performed from bottom upwards (lowest to highest elevation), and continuously in all aspects.
   3. Grout lines and packers are not plugged or obstructed.
   4. That the pressure gauge at the point of injection and the grout flow meter are accurately working.
   5. Grouting operations are performed in the correct sequence, specified herein.

D. Master Gauges and Meters:
   1. Perform testing of all field gauges and grout flow meters no less often than twice a week, or as directed by the Engineer, using master gauges and spare grout flow meters.
   2. Perform testing of gauges and meters in the presence of the Engineer.
   3. Verify accuracy of master gauges and meters through the use of a test laboratory no less frequently than every two months.

3.5 CLEANUP

A. Prevent the buildup and hardening of wasted or leaked grout in the tunnel invert at all times during grouting.

B. Actively look for and eliminate situations where the in-tunnel equipment or hoses form temporary dams that allow waste grout to accumulate and harden.

C. If leakage of grout or other foreign material occurs, remove and dispose of such material by washing or other suitable means.
D. Do not permit more than one shift’s accumulation of trash, debris, and deposits in the tunnel or allow the grout in the invert to harden.

E. Refer to COT 115 for additional cleanup and recommissioning requirements.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Furnishing and installing reinforced concrete pipe, including joint details, for water conveyance with low internal pressure for the Tiawah Tunnel Replacement Section. Requirements will follow COT 205 and COT 306 except as noted herein.

1.2 RELATED WORK

A. Current City of Tulsa Standard Specifications and Standard Details govern, unless modified herein. Refer to the following City of Tulsa (COT) Standard Specifications for Related Work:

1. COT 109 – Testing
2. COT 111 – Dewatering
3. COT 115 – Clean-Up
4. COT 205 – Reinforced Concrete Pipe and Fittings
5. COT 306 – Pipe, Reinforced Concrete

1.3 MEASUREMENT AND PAYMENT

A. In accordance with COT 306.

B. Payment for this item shall be made at the unit price bid per lineal foot of pipe of the type specified in the Proposal, and placed as shown on the Drawings. Total footage shall be the actual horizontal measurement along the centerline of the pipe. No additional payment shall be made for testing required in this section, nor incidentals to work.

1.4 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM C 76 - Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.
2. ASTM C361 - Specification for Reinforced Concrete Low-Head Pressure Pipe.


1.5 SUBMITTALS

A. Shop Drawings: Submit complete shop drawings for the diameter and class of reinforced concrete pipe, showing dimensions, strength and materials specifications and standards, joint details, and reinforcement position for approval prior to manufacture. Include special joints between the RCP and cast in place transition sections.

B. Materials Compliance: Submit notarized affidavits of all materials compliance with ASTM C 76.

C. Product Compliance: Submit notarized affidavit of pipe compliance with ASTM C 76 and these specifications.

D. Joint Compliance: Submit notarized affidavit of joint compliance with ASTM C 361 and these specifications.

E. Quality Control: Submit certified results of all shop tests for approval.

1.6 QUALITY ASSURANCE

A. General: Provide concrete water pipe in accordance with COT 205.

B. Reinforced Concrete Pipe: Provide reinforced concrete pipe meeting the requirements of ASTM C 76, ASTM C 361 and COT 205.

C. Joints: Provide joints for pipe and joints with cast in place transition sections meeting the requirements of ASTM C 361 and these specifications.

PART 2 PRODUCT

2.1 REINFORCED CONCRETE PIPE

A. General: Manufacture all reinforced concrete pipe in lengths of not more than 16 feet and not less than 7-1/2 feet, except where shorter lengths are required for junctions with transition structures. Do not use admixtures or blends in concrete without prior approval.

B. Design: Provide the classes of reinforced concrete sewer pipe as shown or specified. Conform pipe designs with the following requirements.
1. Use diameter, wall thickness, compressive strength of concrete and area of circumferential reinforcement as prescribed for Classes I to IV in Tables 1 to 5 in ASTM C 76, except do not use Wall A thickness, elliptical reinforcing cages or quadrant reinforcing mats. Do not substitute modified designs for designs shown in the Tables.

2.2 JOINTS

A. Manufacture all reinforced concrete sewer pipe, fittings and specials with watertight joints using rubber gaskets in accordance with the requirements of ASTM C 361, to take internal pressures up to one bar (14.7 psi). Provide a bell and spigot of sufficient depth to hold the gasket securely in place and produce the proper gasket compression. Provide special details between the RCP and cast in place transition sections, as shown on the Plans.

2.3 CURING

A. Cure all pipe by steam or membrane curing. Water curing is not permitted.

2.4 SHOP TESTING

A. General: Test concrete sewer pipe in accordance with the applicable provisions of ASTM C 497, as required by the ASTM Specification for the pipe and as specified herein.

B. Basis of Acceptance: Conform the basis of acceptance for reinforced concrete pipe with Section 5.1.1 of ASTM C 76 and these specifications.

C. Joint Adequacy Tests: Prior to manufacturing production run pipe, conduct all tests required by ASTM C 361 for the pipe.

D. Finished Pipe Tests: Test one pipe section of the total pipe sections manufactured, by the three-edge-bearing method in accordance with Section 11.3 of ASTM C 76.

E. Test Witnessing: Arrange for a qualified representative of an independent testing laboratory to witness all tests and provide certified test results.

F. Costs of Tests: Pay all costs associated with tests and test witnessing.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install all reinforced concrete pipe in accordance with the manufacturer's recommendations and approved shop drawings and as specified in COT 306.
3.2 LEAKAGE TESTS

A. Test the reinforced concrete pipes for leakage after completion in accordance with COT 109.

END OF SECTION
SECTION 40 05 20
BALL VALVE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for furnishing the New Control Valve at the Bird Creek Pump Station, as shown on the Contract Drawings. Provide valve operators as specified complete, including a suitable enclosure, with all appurtenances necessary for the operator to perform its intended function. Such appurtenances include, but are not limited to, anchor bolts and other mounting hardware, control switches, limit switches, pressure switches, torque switches, gauges, control valves, electrical supply connections, internal electric wiring and controls, terminal blocks, regulating controls, push button controls, miscellaneous controls, extension stems, local and remote indicators.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 40 90 50 – Process Control System Description

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings
2. ASTM A 27/A27M- Specification for Steel Castings, Carbon, for General Application
3. ASTM A 29/A29M- Specification for Steel Bars, Carbon and Alloy, Hot Wrought and Cold-Finished, General Requirements
4. ASTM A 48 - Specifications for Gray Cast Iron Castings
6. ASTM A 536 - Specification for Ductile Iron Castings
7. ASTM B 30 - Specification for Copper Base Alloys in Ingot Form
8. ASTM B 62 - Specification for Composition Bronze or Ounce Metal Castings
9. ASTM B 148 - Specification for Aluminum-Bronze Castings
10. ASTM B 584 - Specification for Copper Alloy Sand Castings for General Applications
11. AWWA C507 - Ball Valves, 6-inch through 60-inch
12. AWWA C540 - Power-Actuating Devices for Valves and Sluice Gates

1.3 SUBMITTALS

A. General: Provide all submittals, including the following:

B. Shop Drawings: Submit the following:
   1. Complete detailed drawings of all valves
   2. Working drawings, including arrangement and erection drawings of the operators and control equipment; schematic control diagrams, electrical connection diagrams, and complete description of the control system; and operating characteristics

C. Quality Control Submittals: Submit the following:
   1. Manufacturer's certified performance and material records.
   2. Complete calculations for each size of motor operator indicating the force required to operate the valve, the operator force provided, full load and locked rotor current, and horsepower.

D. Operation and Maintenance: Submit operation and maintenance manuals for the valve and operators to include the following:
   1. One copy of equipment start-up reports for each item of equipment.
   2. One copy of the manufacturer's operating and maintenance instructions. Operating instructions include equipment start-up, normal operation, shutdown, emergency operation and troubleshooting. Maintenance instructions include equipment installation, calibration and adjustment, preventive and repair maintenance, lubrication, troubleshooting, parts list and recommended spare parts.
   3. List of electrical relay settings and control and alarm contact settings.
4. Electrical interconnection wiring diagram for equipment furnished including all control systems.

5. All information provided in the manual shall be modified so that it ONLY includes information pertaining to the approved equipment and shall accurately depict the equipment provided. All “optional” and non-pertinent materials and information shall be excluded from the manual or noted as such.

6. Furnish all O&M Manual material on 8-1/2 by 11 commercially printed or typed forms or an acceptable alternative format. Organize each manual into sections paralleling the equipment specifications. Identify each section using heavy section dividers with reinforced holes and numbered plastic index tabs. Use 3-ring, slant ring, hard-back binders Type No. AVE-VS11 as manufactured by Avery Company, or equal. Binder size shall be 3-inch maximum. Punch all loose data for binding. Arrange composition and printing so that punching does not obliterate any data. Print on the cover and binding edge of each manual the project title, and manual title, as furnished and approved by the Engineer.

1.4 DELIVERY, STORAGE AND HANDLING

A. Tests: Furnish a letter confirming that all valves have been satisfactorily tested as specified, prior to shipment.

B. Storage and Erection: Pack and store all valves in satisfactory operating condition. Carefully erect all valves in their respective positions, free from all distortion and strain.

1.5 SPARE PARTS

A. For electric motor operators:

1. One motor
2. One torque switch of each size
3. One limit switch assembly
4. Six push buttons
5. Six color caps of each color
6. Twenty indicating lamps
7. One solid state reversing starter matching unit
8. One overload relay of each size
PART 2  PRODUCT

2.1  MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Double Rubber Seated Ball Valve:
   a. Pratt

2. Electric Motor Operator - Modulating:
   a. Limitorque Corporation

2.2  MATERIALS

A. General:

1. Fabricate valves of materials resistant to corrosion for the required service.

2. Fabricate valves that are to be installed in metal pipelines and that are 2-1/2 inches in diameter and larger of the materials specified herein.

3. Fabricate operators of materials resistant to corrosion for the required services. Provide operator materials as specified.

4. Operator housings and pedestal handwheels:
   a. Cast iron  
      ASTM A 126, Class B
      ASTM A 48, Class 30 or 35
   b. Ductile iron  
      ASTM A 395
      ASTM A 536, Grade 65-45-12
   c. Cast steel  
      ASTM A 27/A27M

5. Operator worms, steel  
   ASTM A 29/A29M Grade
   Designation 8620

6. Operator gears, steel  
   (spur & helical)  
   ASTM A 572/A572M

7. Worm gears, bronze  
   ASTM B 148, Alloy C95400 or C95500
   ASTM B 584, Alloy C86300

B. Valve Joints
1. Provide flanges that are faced accurately at right angles to the axis of the casting. Face and drill flanges and shop coat with a rust-preventive compound before shipment.

2. Provide flanges whose dimensions and drillings meet the requirements of ASME B16.1, 125 pounds as a minimum. Provide flanges whose pressure ratings equal or exceed the specified test pressure of the pipeline. Furnish special drillings where required. For valves having flanges that do not conform with the thickness requirements of ASME B16.1, test each valve in accordance with the hydrostatic shell test pressure requirements of ASME B16.1.

2.3 DOUBLE RUBBER SEATED BALL VALVE

A. Provide a double rubber seated ball valve for the New Control Valve at the Bird Creek Pump Station. Valve body shall be three pieces comprised of two end pieces and one center section. Resilient seat shall be located in the valve body.


C. Provide each valve, actuator and positioner assembled, adjusted, and tested as a unit by the valve manufacturer or an authorized automation facility. Conduct performance testing on each valve and tie test results to the valve serial number.

D. Valve manufacturer is to warrant the valve to be free of defects in material and workmanship for a period of three years from date of installation.

E. Provide valve complying with NSF/ANSI Standard 61 and certified lead free to NSF/ANSI 372 as a safe drinking water system component.

F. The Valve shall be bubble tight at rated pressure with flow in either direction.

2.4 FLOOR STANDS

A. General: Provide stands for 24-inch and larger valves of single crank, single speed or 2-speed operated as specified.

B. Materials: Use materials in floor and bench stands meeting the applicable requirements of the "General" specifications subsection. Provide frames of cast iron or fabricated steel of heavy and substantial design with smooth exterior and neat appearance. Make adequate provision for lubrication and protect all operating parts.
C. Nameplate and OPEN Indication Marking: Equip each stand with a nameplate stating the valve controlled by the stand and also stamp the operator with an arrow and the word OPEN to indicate the direction of rotation.

D. Rising Stems: Fit rising stem floor and bench stands with ball or roller bearings designed to take the thrust. Equip rising stem stands with a transparent plastic cover to protect the stem. Provide the cover with labels and other attachments that will facilitate its use as an indicator of valve position.

E. Operating and Lift Nuts: Provide operating nuts or lift nuts of bronze meeting the requirements of ASTM B 62, finished all over, suitably splined to connect with the handwheel or gear and with threads which will engage smoothly with those of the lifting shaft.

F. Handwheel-Operated Stands: Provide handwheel-operated stands with handwheels that open the valve when the wheel is turned counterclockwise. Locate the center of the handwheel approximately 36 inches above the operating floor. Provide a handwheel of sufficient diameter so that the stand will operate the valve with a maximum pull on the handwheel of 40 pounds.

2.5 ELECTRIC MOTOR OPERATORS

A. General: Provide electric motor operators of the close-coupled, electric motor-driven, worm gear type, complete with motor, gearing, limit switches and auxiliary contacts, torque switches, position indicator, handwheel, integral controller, and all required appurtenances. Design the operators to rotate valve discs through 90 degrees from the fully open to the fully closed position and back, as in butterfly, ball or plug valves. Provide operators that complete each operation in the time specified. Provide operators that hold the discs in any position from fully open to fully closed without vibration.

B. Operator Mounting: Design the operator to be mounted in the position shown or specified.

C. Standard: Except as otherwise specified, provide operators meeting AWWA C540.

D. Open and Close Time Periods: Provide valve operators that fully open the valve from the closed position in approximately 100 seconds and fully close it in approximately 100 seconds when the differential pressure and flow are at the values specified for the valve and the voltage at the terminals is within 15 percent of the nominal voltage. Design the operator to operate the valve through three consecutive opening and closing cycles or for a period of 15 minutes, whichever is longer, during every 60-minute period, at specified ambient temperature conditions under full differential pressure.

E. Temperature Range: Design the operator for outdoor operation and for an ambient temperature range of -20 to 140 degrees F in full sunlight.
F. Torque: Design the operator to exert an unseating torque of at least 50 percent in excess of the required disc seating torque at the specified voltage, neglecting hammer-blow effect.

G. Power Gearing: Provide power gearing consisting of helical or spur gears and worming gearing. Fabricate helical and spur gears of accurately machined hardened alloy steel. Provide a hardened alloy steel worm with threads ground and polished after heat treating. Provide a nickel or manganese bronze worm gear. Use antifriction bearings throughout. Grease pack or oil bath lubricate the operator. Provide lubricants suitable for the ambient temperatures specified.

H. Lost-Motion Device: Design operators for gate valves to include a lost-motion device that will permit the motor to attain full speed, and then impart a hammer blow to the stem nut to start movement of the disc in both the opening and closing directions. Do not include this feature if the valve is for modulating service.

I. Handwheel - Manual Operation: Provide a handwheel for manual operation with a maximum rim pull of 40 pounds. Design the handwheel so that it does not rotate during electrical operation and the motor does not rotate during manual handwheel operation. Provide an operator that is arranged so that motor or motor gearing failure does not prevent manual operation. Arrange the operator to automatically change from manual operation to electrical operation when its motor is energized and to continue electric operation until the operator is reset to manual operation. Provide a means for locking the drive in either manual or motor operation. Provide removable handwheels. Provide an adaptor key or drive nut to permit operation by a portable operator.

J. Declutching Mechanism: Provide a declutching mechanism to disengage the motor mechanically but not electrically from motor to handwheel operation. If the clutch is of the external lever type, arrange it such that the lever does not move when the motor is energized.

K. Position Indication: Provide an operator-mounted disc position indicator of the mechanical or indicating light type. For OPEN-CLOSED service, indicate the fully open, fully closed and intermediate disc position either mechanically or by lights. For modulating or throttling service, provide continuous disc position indication between the fully open and fully closed positions. Provide electrical contacts as required for remote indication of disc position.

L. Electric Motor Design: Provide manufacturer selected, integral operator motor of the high torque, ball or roller bearing, squirrel-cage type designed for continuous valve duty. Provide motor rated for 5 minute duty cycle or ten complete opening and closing valve strokes, whichever is longer during a 60 minute period under full differential pressure at 40 degrees C ambient. Design the motor for use on a nominal 480 volts, 3-phase, 60-hertz electrical service. Provide motor windings and leads
with Class F or better insulation with built-in thermal overload protection. Provide motor meeting torque requirements of the valve.

M. Housing: Provide housings for controls, gears, and motors with integrally cast flanges. Fully machine and template drill the flanges and their mating surfaces. Provide joints which are metal-to-metal or gasket or O-ring sealed as required.

N. Control and Motor Enclosures: Provide NEMA 4 control and motor enclosures, except as otherwise specified. Provide the controller with mechanical interlocks and mount as an integral part of the operator.

O. Electrical Compartment Heater: Provide electrical compartment heaters, unless other means can be proven effective for moisture elimination.

P. Electrical Requirements: Provide electrical controls for the operator as shown or specified. Design operators for 480-volt, 3-phase, 60-hertz service. Design all control circuits for 120-volt, single-phase, 60-hertz ac. Provide an integral 480/120-volt control transformer with fused secondary.

Q. Reversing Controller, Overload Protection and Internal Wiring: Provide a NEMA rated reversing controller, or an approved special duty rated reversing controller, complete with mechanical interlocks and controls as an integral part of the operator. Provide adequate overload protection in the controller or embedded in the motor windings. Install an overload device in each phase. If overload devices are installed in the motor windings, provide devices of the manual reset type with remote-indication with the contacts in the control circuit. Arrange the internal wiring in the operator so that the opening and closing coils cannot be energized simultaneously at any time, regardless of external wiring conditions.

R. Push Buttons and Selector Switches: Provide remote operator inside the Bird Creek Pump Station in an accessible location, mount OPEN-STOP-CLOSE push buttons or a selector switch as shown on the operator housing. Also mount red and green position indicator lights and, where shown or required, an amber ready light or MANUAL-AUTO mode selector on the operator housing. Connect all internal control and indication wiring to a terminal block within the valve operator enclosure and provide a separate control station for remote mounting. Provide the remote control station with the same NEMA rating as the operator.

S. Limit and Torque Switches: Provide the operator with limit and torque switches, either direct or gear driven. Provide adjustable limit and torque switches with auxiliary contacts that are operative in either direction of travel. Provide limit switches that are "in step" with torque switches at all times, whether in motor or manual operation. Equip the operator with limit switches to stop movement in each direction and torque switches for protection against mechanical overload and to stop movement in either direction if an obstruction is encountered. Provide the number, function and arrangement of limit switches as shown, specified or required.
T. Additional Accessories: Provide additional limit switches, indicating lights, position transmitters and remote position indicators, remote operating controls and other accessories and controls as shown, specified or required.

2.6 ELECTRIC MOTOR OPERATORS - MODULATING

A. General: Provide modulating motor operators that meet the requirements for in paragraph 2.5, Electric Motor Operators, except as specified herein. In addition, provide an electronic control module and a solid state reversing starter.

B. Control Module: Provide a solid-state type control module with a comparator circuit which senses the error between the input command signal and the position feedback signal. Mount the control module within the operator switch compartment.

1. Accept a 4-20 mA dc input command signal. Provide zero and span adjustments to align minimum and maximum valve position with zero and 100 percent values of the input command signal. Provide deadband adjustment from 0.16 to 1.0 percent to eliminate excessive motor movement due to minor variation in the process variable signal.

2. Activate the solid state reversing starter to drive the actuator in the proper direction necessary to reduce the error to zero. Provide proportional band adjustment from 5-40 percent. When the error is outside the proportional band, run the actuator motor continuously toward set point. When the error is within the proportional band, pulse the actuator motor toward set point to prevent overshoot.

3. Provide actuator to open the valve when command input signal increases.

4. On loss of command input signal, have valve fail in last position. On loss of feedback signal, have valve fail in last position.

C. Selector Switch and Push Buttons: Where the operator is 7 feet or less from the floor and in an accessible location, integrally mount a 3-position AUTO-OFF-MANUAL selector switch plus two push buttons marked OPEN and CLOSE on the operator housing. Provide local control station remote from valve inside Bird Creek PS in an accessible location, connect all internal control and indication wiring to a terminal block and provide a separate control station for remote mounting.

D. Auto and Manual Operations: Provide operators that, when in the AUTO position, will respond to the automatic signal as described above. Provide operators that, when in the MANUAL position, will be operable by either push buttons or handwheel.

E. Motor Design: Design the motor specifically for valve operator service and to be continuous rated for continuous modulating duty. Provide motor insulation of at least Class H.
2.7 EXTENSION STEMS, VALVE BOXES AND FLOOR BOXES

A. Equip valve in vault with operating nuts and extended shafts to grade, unless otherwise shown or specified. Provide two tee wrenches for each size and type of operating nut.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install valves in accordance with the manufacturer's recommendations and approved shop drawings and as specified in the City of Tulsa Standard Specifications.

B. Floor Stands: Accurately center floor and bench stands over the valve. Solidly bolt stands to the floor or support structure, with through-bolts wherever possible. Place approximately 3/4 inch of nonshrink cement grout beneath stands mounted on concrete or similar construction to assure uniform support. For stands installed within the area of a removable type floor, platform, or grating, securely mount them on their own support structure independent of the removable element, unless otherwise shown or specified.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Furnish the services of a qualified representative of each of the various manufacturers to provide inspect the completed installation, direct the Contractor to make any necessary adjustments, participate in the startup of the equipment, participate in the field testing of the equipment and place the equipment in trouble-free operation, as specified in the City of Tulsa Standard Specifications.

B. Tests: After installation of the valves, control equipment and all appurtenances, subject the units through field calibration testing. Operate each valve under each Control Philosophy as provide in Specification Section 40 90 50. Update the Control Philosophy as determined in the field. For each operating mode, the maximum transfer rate to Mohawk Water Treatment Plant is when the water surface level in the downstream Mingo Test Tower reaches 6-inches below the existing weir elevation. For each operating mode, the minimum transfer rate to the Mohawk Water Treatment Plant is when the valve begins to operate under minor cavitation as defined in Specification Section 40 90 50.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. Provide all labor, materials, equipment and incidentals as shown, specified, and required to furnish and install all equipment and coordinate all activities necessary to perform check-out and start-up of the equipment installed as part of the Tiawah Tunnel And Bird Creek Pump Station Improvements project.

B. Contractor: retain the services of a System Integrator, with substantial documented experience, to supervise and perform check-out and start-up of all Process Control System components. Provide the services of an authorized manufacturer's representative to check the equipment installation and place the equipment in operation. The manufacturer's representative shall be thoroughly knowledgeable about the installation, operation, and maintenance of the equipment.

C. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:
   1. Section 40 05 20 - Ball Valve
   2. Section 40 90 50 - Process Control System Descriptions
   3. Section 40 91 00 - Process Control System Instrument

1.2 SUBMITTALS

A. General: Furnish all submittals as specified herein.

B. Action Submittals
   1. Prior to beginning commissioning activities, submit the following for Owner approval, meeting the sequence and schedule established by the Contractor for facilities impacted by the Contract, as well as overall commission. Submit to meet requirements for commissioning:
      a. Test Plan
      b. Test Forms
      c. Test Schedule
d. Testing Tools

e. Test results

f. Test Logs

g. Loop Check List

h. Point to Point Wiring Diagrams

i. Preliminary Testing Results

j. Approved O&M Manual List

k. Certification that the Test Engineer has reviewed all data and the system and certifies that it is ready for operation

l. Submit certification that all appropriate Operator Component training has been completed.

2. Forms

a. Submit sample test forms and test logs for review.

C. Closeout Submittals: Furnish submittals as required below.

1. Project Record Documents: Provide the following:

a. Program documentation: Provide paper copies of all software development and configuration including listing of all register tables.

b. Include functional narrative description of the developed ladder logic to describe each control system. Ladder logic is to be annotated to include functional alphanumeric description of logic elements to assist Owner in understanding the ladder logic for troubleshooting and future modification.

c. Program copies: Provide two digital copies in CD-ROM format and USB storage drive format of fully configured systems.

d. Operator interface program copies: Provide hard copy printouts and digital copies in CD-ROM format and USB storage drive format of new or modified OIT screens and database listings.

2. Programming Software:
a. Provide a licensed copy of the latest version of PLC, OIT, and instrumentation programming software for the project related programming platforms.

b. Provide system capable of adapting to program changes without impacting the hardware, with programs protected from accidental changes by use of passwords and/or key lock switches or Cryptographic Controller Engineering Key Lock.

c. Provide capability for logic programming and I/O configuration printout.

d. Programming software to be turned over to the Owner at the completion of the project.

e. Provide with the programming software any external security product used. Turn over licensing to the Owner as part of the project.

3. System Validation:

a. Provide updated Transfer Valve Operating Parameters table after testing, calibration, and validation is completed. The table shall be signed by authorized representatives of Contractor, System Integrator, and Engineer.

4. Operation and Maintenance Data: Provide operation and maintenance manuals. Include the following information:

a. Recommended spare parts list.

b. Manufacturer approved repair and service centers list.

c. Replacements part sources.

d. Recommended maintenance procedures and frequencies.

1.3 SYSTEM CHECKOUT AND START-UP

A. System Integrator: perform the following, as witnessed by the Owner, as applicable:

1. Check and approve the installation of all Process Control System components and all cable and wiring connections between the various system components.

2. Conduct a complete system testing, calibration, and validation of the Transfer Valve Operating Parameters specified in the Control Philosophy section of Section 40 90 50 - Process Control System Description.
3. Conduct a complete system checkout and adjustment, including checking each component functions, and testing of final process control system instrument, device, computer, and network functions. Promptly correct all problems encountered to prevent any delays in start-up of the equipment.

B. System Integrator: furnish all test equipment necessary to perform the testing during system checkout and start-up.

C. System Integrator: assume responsibility of the operation of the process control system. Make any required changes, adjustments, or replacements necessary to the system to perform the intended functions.

D. System Integrator: furnish Engineer an installation inspection report certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by authorized representatives of Contractor, System Integrator, and equipment Supplier.

1.4 INTEGRATED SYSTEM FIELD TEST

A. System Integrator: perform a complete system test, as witnessed by the Owner, as applicable, to verify that all instrumentation and controls equipment, network hardware, and software is operating properly as a fully integrated system, and that the intended network functions are fully implemented and operational. Complete this integrated test after all process areas are demonstrated as operational and tested individually, and after individual facilities are tested and proven operational.

B. System Integrator: correct any defects or problems found during the test and then retest to demonstrate proper operation.

C. Refer to Part 2 of this specification for detailed Integrated System Field Test (SAT & Start-up) requirements.

1.5 7-DAY TEST

A. The 7-Day Test is a period of time during which the equipment shall be utilized by the Owner in day-to-day operations. The purpose of the 7-Day test is to test the equipment and control system stability and completeness over time. The intent of the test is for the system to operate without modification or repairs.

B. Contractor: start the 7-Day Test upon written approval from the Owner / Engineer.

C. 7-Day Test shall continue until a time frame has been achieved wherein the system (both hardware and software) availability meets or exceeds 99.7 percent for 7 consecutive days and no system failures have occurred which result in starting the 7-Day Test over. During the 7-Day Test the system shall be available to facility operating personnel for use in normal operation of the facility.
D. For the purpose of the 7-Day Test, the system shall be defined as all new control system work installed under this Contract, as well as any modifications made to the existing control system.

E. The 7-Day Test shall be terminated if one or more of the following occur. Following correction of the problem, a new 7 consecutive day 7-Day Test shall begin.

1. Failure to repair a hardware or software problem, causing one or more processes halt execution, within 24 consecutive hours from the time of notification failure(s).

2. Recurrent hardware or software problems: If the same type of problem occurs three times or more.

3. Programming or configuration changes shall reset the 7-Day clock.

4. Valve or instrument failure.

F. The following conditions shall constitute a system failure in determining the system availability based on the equation specified in Paragraph 1.5.G, below:

1. Loss of communications between devices on the process control system network.

2. Failure of one or more network devices

3. Failures of any device impacting two or more process control system components simultaneously.

4. Failure of Power Supply: Where redundant power supplies are provided, failure of one power supply will not constitute a system failure provided the backup power supply operates properly and maintains power supply. Failure of the backup supply to operate properly and maintain supply power shall constitute a system failure.

5. The system shall be considered down if the system cannot generate the periodic reports, alarm log, or event log. The report and logs need not appear on the printer originally selected for the report.

6. Downtime caused by primary utility power failure will not count as downtime.

7. Loss of any microprocessor shall be considered downtime.

8. Loss of any inputs or outputs per processor shall be considered downtime.
9. The accuracy and precision of all of the analog inputs and outputs must be within the limits specified, or the system shall be considered down.

10. The time between notifying the Contractor of a system failure and the time it has been corrected and back on line shall be considered downtime.

11. Shutdown of the critical systems from a software fault shall be considered downtime.

G. The system availability shall be calculated based on the following equation:

\[ A = \frac{TTO}{TTO + TTR} \times 100 \text{ percent} \]

where,

- \( A \) = system availability in percent
- \( TTO \) = total time in operation
- \( TTR \) = total time to repair

H. Time to repair shall be the period between the time that Contractor is notified of a system failure and the time that the system has been restored to proper operation in terms of hours with an allowance for the following dead times which shall not be counted as part of the time to repair period.

1. Actual travel time for service personnel to get to the Site up to four hours per incident from the time Contractor is notified of a system failure.

2. Time for receipt of replacement parts to the Site once identified up to 8 hours per incident. Work done on the system while waiting for delivery of replacement parts does not stop the failure clock.

3. Dead time shall not be counted as part of the system available period. The dead time shall be logged and the duration of the 7-Day Test extended for an amount of time equal to the total dead time. Dead time shall be totalized.

I. Contractor: furnish all parts and maintenance materials required to repair the system prior to completion of the 7-Day Test at no additional cost to Owner. Immediately replace parts that are obtained from the Contract spare parts inventory.

1.6 SPARE PARTS

Not Used
PART 2 SITE ACCEPTANCE TESTING

2.1 GENERAL

A. The Site Acceptance Test (SAT) shall be focused on verifying that all instrumentation, equipment, PLC/OIT/HMI, and controller hardware and software is working properly and that all software configurations match the requirements identified in the detailed process narratives. Successful completion of the SAT shall be considered to be a critical project milestone.

B. Contractor: test the software under all possible process conditions in order to demonstrate the robustness of the software. The software test shall be witnessed by Owner / Engineer.

C. The SAT shall consist of testing using the actual field inputs/outputs once all field equipment has been installed and successfully tested.

D. SAT testing shall be carried out for all PLC/OIT/HMI and controller software including packaged and vendor supplied products as a whole system.

2.2 PREREQUISITES

A. Complete equipment start-ups with manufacturer representatives including all mechanical equipment required to fully test the operation of the software. Complete process area start-ups prior to overall SAT

B. Install, calibrate, and test all required instrumentation prior to starting SAT.

C. Install and test all required network equipment prior to starting the first facility SAT.

D. Submit the SAT & Start-Up Test plan for approval by the Owner / Engineer no later than four (4) weeks in advance of the SAT.

E. Wire, test, and sign off 100% all process area and packaged system panel I/O prior to commencing SAT unless otherwise approved by Owner / Engineer. Submit a request to defer I/O testing until after the SAT for review and approval at the same time when the SAT & Start Up test plan is submitted for review and I/O is not available. Identify the reason for deferring I/O testing in the request along with a proposed date when the I/O shall be tested.

2.3 START-UP TEAM

A. The Start-Up Team shall consist of individuals from the Owner, Engineer, Contractor, System Integrator, and Equipment Manufacturers.

B. The Start-Up Team shall review the testing plan, SAT, & Start-Up Plan and revise,
if necessary, at a pre-SAT & Start-Up meeting to be scheduled no later than six (6) weeks in advance of the proposed SAT period.

C. Furnish details for the SAT & Start-Up Plan to clearly identify the proposed test procedure for the equipment and software.

D. The SAT testing shall be witnessed by the Start-Up Team.

E. Members of the Start-Up Team shall be identified at the pre-SAT & Start-Up meeting. These team members will be involved throughout the process and shall be changed only with the approval of the Engineer.

2.4 PURPOSE AND SCOPE

A. Goal of software testing: to verify that the system released for use by the Facility’s Staffs meets the contract requirements, and is error-free, and does not adversely affect other systems. Software installed or modified under the project shall not adversely affect the operation of other systems currently in operation at existing Owner facilities. All functionality that is currently available within the system must remain available at the completion of the testing.

B. Test all software installed as part of the project to confirm that the software developed, tested, and installed under the project conforms to the approved process control narratives.

C. All software shall meet the requirements of the project specifications including all operational control, monitoring, and alarming. Software shall integrate all vendor packaged systems as defined within the contract documents.

D. Testing shall demonstrate that all software developed works throughout Owner SCADA workstations. Conduct all system-wide testing concurrently with the local testing to confirm operation throughout the system.

2.5 DEFINITIONS

A. Software Testing: defined as the execution of a program to find its faults, and not just a process to verify its correctness.

B. Other definitions are:

1. Verification: The process of proving the program’s correctness.

2. Validation: An attempt to find errors by executing a program in the controllers, Control nodes, and Monitoring nodes.

3. Debugging: Diagnosing the precise nature of a known error then correcting
it. Debugging is a “fix” activity, not strictly a testing activity.

4. Errors: Human mistakes; errors in design definition or interpretation of the design by the programmer.

5. Defects: Improper program conditions that are generally the result of an error. Not all errors produce defects (as with incorrect program comments, for example).

6. Bugs: A fault that is a program defect found when the program is being tested or is in operational use. Bugs result from defects, but all defects do not necessarily produce bugs.

2.6 OBJECTIVES

A. The following identifies the overall objectives of the PCS Site Acceptance Test:

1. Confirm and document that the PLC I/O matches the panel shop drawings in terms of input/output configuration, tagging, and function.

2. Confirm and document that the individual device logic operates all field equipment correctly and safely, as described in the detailed process control description.

3. Confirm and document that the control logic operates the facility correctly and safely, as described in the detailed process control description.

2.7 APPROACH

A. As part of the testing process regression, incorporate testing into all test plans to demonstrate that any changes made to the software do not impact other areas of the logic. This approach shall ensure that corrections/modifications have not adversely affected the previously tested (and debugged) systems and system components.

B. Testing is to be both progressive and regressive.

1. Progressive testing introduces and tests new functions and uncovers problems in the newly added or modified modules and in their interfaces.

2. Regressive testing concerns the effects of newly introduced changes or system components on all previously integrated (tested) code.

2.8 TEST SUCCESS CRITERIA

A. Test success shall be based on the number of defects and the defect severity encountered during the testing period. The Owner / Engineer, at their discretion, shall determine to restart a new SAT.
2.9 COMPLETION CRITERIA

A. Testing of software is deemed to be complete when all features, functions and information required in contract drawings, and the complete functionality as described in the contract documents has been verified as present and functioning, and documented as accurate within the anticipated operating range for the process being monitored and controlled.

2.10 PARTICIPANT AND RESPONSIBILITIES

A. SAT & Start-Up Test Planner (Contractor / System Integrator / Equipment Manufacturer):

1. Develops the complete SAT & Start-Up test plan
2. Develops the schedule
3. Coordinates all meetings identified in the contract documents to develop and implement the test plan
4. Coordinates the involvement of all team members and equipment manufacturers required to be present during testing
5. Develops/compiles the test data
6. Oversees the test planning and test plan execution of the process control system
7. Obtains approval for test plan and schedule from Engineer.

B. Owner / Engineer:

1. Reviews and approves test plan
2. Documents test results and classifies defect severity
3. Identifies system “design” defects (where the design does not match the specification) and coding defects (where the system does not behave as specified)
4. Reviews test results
5. Assigns fault severity. Logs action required and taken in the Software Action Log
6. Maintains Software Action Log

7. Maintains Deficiency Log related to other trades: electrical, instrumentation, vendor packages, and others

8. Presents Correction Requests to the Owner for prioritization

9. Schedules approved Correction Request work

10. Maintains Correction Request Log

11. Coordinates with City operations staff to avoid conflicts and minimize impact to operations of construction activities

12. Participates and assists in the acceptance testing

13. Responsible for signing-off on the acceptance testing that the system is fully functional as defined within the detailed process control narrative

14. Oversee the integration of the software into the existing SCADA network

C. System Integrator

1. Responsible for defining the procedure required to complete the SAT & Start-Up tests

2. Responsible for directing the SAT and start-up testing and for providing input to the Contractor as to which trades are required to complete the tests identified within the test plan

3. Installs and tests all software for functionality as per the detailed process control description

4. Fixes all defects

5. Documents test results and forwards to Contractor

D. Contractor / System Integrator

1. Responsible for conducting complete system testing, calibration, and validation of the Transfer Valve Operating Parameters specified in the Control Philosophy section of Section 40 90 50 - Process Control System Description.
PART 3  EXECUTION

3.1  GENERAL

A. Part 3 provides an outline of the work to be carried out by the Owner / Engineer / Contractor / System Integrator / Equipment Manufacturer as part of the PCS Site Acceptance Test(s).

3.2  TEST SUB-PHASE

A. The types of software tests are:

1. Individual instruments, equipment, and process units: these sub-phases test/verify that devices and their larger system parts (e.g. process units and duty tables) perform as specified.

2. Intra-system Integration: tests/verifies the interfaces between units and the associated process logic related to multiple units, and facility-wide operating strategies.

3. Function: tests/verifies the functions the program is to perform as set out in the detailed process control narratives.

4. Performance/Operational: tests/verifies the system’s performance under a variety of conditions (normal/abnormal) and verifies these results against the detailed process control narratives. Includes testing of the system’s configuration, security, backup/recovery, and reliability in the planned network architecture.

5. System Wide Integration: tests/verifies the operation of all control areas from all OITs and HMI operator workstations.

3.3  DEFECT HANDLING

A. During testing, identify the need for corrections to the system. This shall be as a result of a test failure or as a result of an incorrectly implemented requirement (test did not fail, but the requirement is incorrectly implemented).

B. For test failures, record the defect in the SAT test document. Immediately review and resolve all defects during the SAT period.

C. If Correction Requests are required, they will be prepared by the Engineer. Possible implications of not proceeding should also be identified. The Owner will authorize the work to be done under any correction request. Prior to implementing, Contractor shall schedule correction request work based on the project priorities.
3.4 SUCCESSFUL COMPLETION

A. The SAT is deemed successful when the following items have been completed:

1. SAT Test plan has been completed and signed-off

2. All faults identified during the SAT have been corrected and verified for correct operation

3. The completed SAT plan has been reviewed and signed off by the Engineer, Contractor, and System Integrator.

3.5 FACILITY STARTUP PERIOD

A. Following successful completion of the SAT testing, the startup period may commence. Owner, Engineer, Contractor, System Integrator, and Equipment Manufacturers, are to be present during the startup period.

B. Engineer maintains a log of faults/deficiencies encountered during the startup period. The Contractor / System Integrator / Equipment Manufacturer is to immediately correct faults/deficiencies at the request of the Owner, or Engineer. If any fault occurs during the startup period, the test period shall be restarted from Day 1 after completion of the software modifications and testing by the System Integrator.

C. Following completion of the startup period, the fault/deficiency log is submitted to the Engineer for review. Sign-off by Owner, Engineer, Contractor, and System Integrator is required at the completion of the facility startup period.

3.6 TRAINING

A. Provide training on new valve and modified controls in accordance with the requirements contained in Contract Documents and Drawings.

3.7 MANUFACTURER’S FIELD SERVICES AND TRAINING

A. During the 7-Day Test, the Contractor shall include the services and training time of factory trained personal, as required, from each manufacturer listed. This time shall be utilized at the discretion of the Owner. Field services shall be based on an eight (8) hour day, Monday through Friday, during the Facility’s normal working hours. All travel and living related costs are the responsibility of the Contractor.

1. Valve manufacturer

2. System Integrator

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. Section 40 90 50 includes requirements for furnishing and installing instrumentation and control systems including all work and materials necessary to perform control and monitoring functions as illustrated on drawings, and as specified in this document.

B. Related work specified in other sections includes, but is not limited to the following:

1. Section 40 05 20 – Ball Valve
2. Section 40 80 50 - Process Control System Commissioning
3. Section 40 91 00 - Process Control System Instruments

1.2 SYSTEM SUPPLIERS

A. The Contractor shall furnish all labor, materials, equipment, and incidentals as shown, specified, and required to furnish, install, calibrate, test, start-up, and place in satisfactory operation a process control system as specified herein and in Contract Documents and Drawings.

1.3 SYSTEM DESCRIPTION

A. General Description of Work

1. The Instrumentation and Control documents are requirements to assist the Contractor with the detailed design of control system including networks and communication with existing facilities’ Process Control System (PCS).

   a. Provide process control applications for the Bird Creek Pump Station No. 1 (BCPS-1) control system as shown on drawings and as specified in this document to provide a completely functioning control system including networking and software development.

   b. Conduct a complete system testing, calibration, and validation of the Transfer Valve Operating Parameters specified herein, and as specified in Section 40 05 20 – Ball Valve.
c. Perform the Site Acceptance Testing for each equipment individually and with other equipment as a system.

B. The Control Descriptions provide the functional requirements of the Control represented in the Contract Documents.

C. The Control Descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions, but are rather intended to supplement and complement the Drawings and other Specification Sections. The Control Descriptions will be the base document for the Contractor creation of the Control Strategies. Identification of required elements, documentation, and coordination between loops are to be developed during shop drawings. Finalizing and tuning of strategies, as required by process characteristics, are to be completed during start-up.

D. The project scope includes the following facilities and areas:

1. Bird Creek Pump Station No. 1:
   a. Addition of a new 36-inch motor-operated ball valve (MOV) to increase the hydraulic capacity of BCPS-1.
   b. Addition of new process instrumentation as specified herein, and as specified in the Contract Documents and Drawings.

2. System Integration:
   a. Integration of the new 36-inch MOV and all new process instrumentation into existing pump station Pump B2 PLC as required to accomplish valve controls as specified herein, and as specified in the Contract Documents and Drawings.
   b. Modification of existing Pump B1 PLC Operator Interface Terminal (OIT) and Pump B2 PLC OIT to integrate to operation of the new 36-inch MOV and the new process instrumentation, as well as existing instrumentation as needed.

3. System Validation:
   a. Testing, calibration, and validation of the Transfer Valve Operating Parameters specified in herein, and as specified in Section 40 05 20 – Ball Valve.

1.4 SUBMITTALS

A. Contractor: furnish all submittals as specified herein.
B. Action Submittals

1. Product Data: Submit manufacturer’s official and published product data, specifications, and installation recommendations for each item.

2. Shop Drawings: Submit shop drawings as required below. Include the following information in each submittal:
   a. I/O List complete with Instrument Ranges, Alarm levels, and setpoints.
   b. Each detailed control logic permissive and interlock.
   c. Complete control description/strategies further developed from the control descriptions provided in this Specification, with a breakdown on each control mode, based on requirements of Part 3 of this Specification.
      (1) Include sufficient detail for a complete understanding of each Operator controllable setpoint, failure mode, and alarm.
      (2) Include detailed ranges, setpoints, and operator adjustments for each detailed control strategy.
      (3) Provide modified screen layouts for OIT/Human-Machine Interface (HMI) applications including navigation, graphic standards, alarms, popups, and animation. Match existing graphics and color codes.
   d. Complete and include in the submittal all graphics and process screens for all PLC control strategies and PCS control strategies.
   e. Ladder logic focused diagrams, functional blocks as approved by the Owner, and messages to carry out the program. The messages shall be within the program to explain how the control program will carry out the required functions. The use of “structured text” type programing shall not be an acceptable alternative to ladder logic programing.
   f. Configuration and data register assignments.

C. Closeout Submittals

1. Contractor: furnish submittals as required below:
a. Project Record Documents: Provide the following:

(1) Provide record documents and program copies as specified in Section 40 80 50 - Process Control System Commissioning.

b. Programming Software:

(1) Provide licensed copies of PLC and OIT/HMI programming software as specified in Section 40 80 50 - Process Control System Commissioning.

c. System Validation:

(1) Provide updated Transfer Valve Operating Parameters table as specified in Section 40 80 50 - Process Control System Commissioning.

d. Operation and Maintenance Data: Furnish operation and maintenance manuals as specified in Contract Documents, including the following information:

(1) Recommended spare parts list

(2) Manufacturer approved repair and service centers list

(3) Replacements part sources

(4) Recommended maintenance procedures and frequencies

1.5 QUALITY ASSURANCE


B. The purpose of contract drawings and specifications is to convey information required for complete and functioning systems. System Integrator shall be responsible for all details necessary to properly install, adjust, and place in operation intended systems. Preliminary Input and Output points will be provided to the Contractor on the Contract Drawings for convenience; however, their accuracy will not be guaranteed.

C. Meetings

1. Meetings shall be scheduled as necessary at the Engineer’s designated office to jointly review control requirement submittals. This shall also serve to coordinate and resolve any issues or discrepancies in regard to the operator interface software programming and implementation, and detailed PLC
programming. Plan to attend meetings of one-day duration to jointly review all control requirements with the Owner’s representative and Engineer.

2. At a minimum, meetings to review progress of test plan, schedule, training, and software graphics shall include:
   a. Kick-Off Meeting
   b. Controls development at 60% development
   c. Controls development at 100% development

D. When requested by Contractor, Owner, and/or Engineer, System Integrator will attend Monthly Progress Meetings and Weekly Meetings as required and specified.

1.6 APPLICATION SOFTWARE PROGRAMMING

A. System Integrator: provide application software programming as specified herein and in the Contract Documents and Drawings. Modify existing PLC and OIT software, test application software programming to demonstrate operation as part of the Process Control System Commissioning, as specified in Section 40 80 50.

B. Training services, and equipment testing and start-up shall not begin until System Integrator has successfully completed application software programming, downloading, and testing.

1.7 DELIVERY, STORAGE, AND HANDLING

Not Required

1.8 PROJECT/SITE CONDITIONS

A. Equipment is subject to humidity, dust, noise, and elevated and reduced temperatures.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.1 SITE MONITORING AND CONTROL

A. Monitoring and control functions to be programmed under this Contract are outlined in the narratives described below.
B. All settings shall be adjustable based on log-in credentials.

C. All alarms and trips shall have time delay dampening.

3.2 BIRD CREEK PUMP STATION NO. 1

A. General

1. Refer to the Contract Drawings for point of connection and equipment locations.

B. BIRD CREEK FLOW TRANSFER CONTROL

1. The new transfer control valve allows for the reliable Transfer of raw water from Lake Oologah to the Mohawk Water Treatment Plant (WTP). As part of the improvements to the Bird Creek Pump Station operation, the new transfer control valve is to mitigate the risk of water shortage due to potential compromise of the Tiawah Tunnel, and provide the City with a more resilient conveyance system during routine maintenance.

2. Provide the necessary modifications to the existing PLC and existing B1 PLC OIT and B2 PLC OIT to allow for the operation of valve D19 from both OITs, as specified below.

3. Bird Creek Transfer Control Valve (Valve D19):

   a. Provide system integration as specified below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related Drawing:</td>
<td>CN1</td>
</tr>
<tr>
<td>Process Description:</td>
<td>BCPS-1 contains two (2) pumps and two Venturi type flow meters located downstream of the pumps. The new 36-inch ball type MOV (D19) will be housed in a new valve vault located outside of the pump station, as shown on Contract Drawings. The existing flow instrumentation measurement located downstream of each of the existing pumps shall be used to control the operation of the new valve when operating in REMOTE AUTO mode. The position of the valve shall be adjusted in order to control the flow based on predetermined setpoints as defined herein. New pressure indicating transmitters shall be used to provide...</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pressure Measurement</td>
<td>pressure measurement upstream and downstream of the valve for valve protection.</td>
</tr>
</tbody>
</table>
| Components              | Valve manufacturer supplied Local Control Station (LCS) integral to the actuator located above the valve vault to provide local control capabilities, and control transfer capability for remote control from SCADA.  
                         | Valve manufacturer supplied duplicate LCS located within the BCPS-1 to provide local control capabilities, and control transfer capability for remote control from SCADA.                                |
| Local Controls          | LOR (LOCAL/OFF/REMOTE) selector switch at each LCS  
                         | - Local: Valve is controlled from the LCS  
                         | - Off: Valve does not operate under any condition  
                         | - Remote: Valve is PLC controlled  
                         | OPEN/CLOSE selector switch at each LCS  
                         | VALVE POSITION INDICATOR at each LCS  
                         | OPEN/CLOSED/FAULT status indicating lights at each LCS |
| MCC/VFD Functions       | Not applicable.                                                                                                                                                                                               |
| HMI Functions           | OPEN/CLOSE (digital buttons)  
                         | VALVE POSITION (indication)  
                         | OPEN/CLOSED/FAULT (status indication)  
                         | Existing flow measurement (indication)  
                         | New valve upstream and downstream pressure measurement (indication)  
                         | Differential pressure (DP) across the valve as calculated based on upstream and downstream pressure measurements from the new pressure transmitters (indication)  
                         | Operating Pumps at Oologah Pump Station:  
                         | - Pump No. 1 In Operation (operator input)  
                         | - Pump No. 2 In Operation (operator input)  
                         | - Pump No. 3 In Operation (operator input)  
                         | Spavinaw Flow Lines in Service at Spavinaw:  
                         | - Spavinaw Flowline No. 1 in Service (operator input)  
                         | - Spavinaw Flowline No. 2 in Service (operator input)  
                         | Transfer Flowrate Setpoint (operator input)  
                         | PLC Functions           | The new valve shall be controlled by existing B2 PLC located within BCPS-1, in either LOCAL, REMOTE MANUAL, or REMOTE AUTO, and shall include hardwired interlocks.  
                         | Provide valve control from the PLC when the LOR selector switches at both valve LCSs are in the REMOTE position.  
                         | Provide AUTO/MANUAL mode selections at the existing OITs on B1 PLC panel and B2 PLC panel.  

TMUA-W 18-27 40 90 50-7 Process Control System Description
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
|      | Provide ‘Cavitation Index Sigma’ calculation based on the following definition:  
Sigma = \[
\frac{\text{(Downstream Pressure)} - \text{(Water Vapor Pressure)}}{\text{(Upstream Pressure)} - \text{(Downstream Pressure)}}, \text{ where:}
\]
- Downstream Pressure: in psia as measured by the downstream pressure transmitter (PIT-D19B)
- Upstream Pressure: in psig as measured by the upstream pressure transmitter (PIT-D19A)
- Water Vapor Pressure: -14.44 psig at 60 degF |

### Control Philosophy:
Transfer Valve Operating Parameters are limited to predetermined ranges as defined herein:

<table>
<thead>
<tr>
<th></th>
<th>Minimum Transfer to Mohawk WTP</th>
<th>Maximum Transfer to Mohawk WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating three (3) pumps at Oologah Pump Station and Spavinaw Flow lines No. 1 and 2 in Service:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Rate:</td>
<td>37 MGD</td>
<td>64 MGD</td>
</tr>
<tr>
<td>Valve Position:</td>
<td>33 %</td>
<td>56 %</td>
</tr>
<tr>
<td>Differential Pressure (DP) Across Valve:</td>
<td>27.0 psi</td>
<td>4.0 psi</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th></th>
<th>Minimum Transfer to Mohawk WTP</th>
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<tbody>
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<td><strong>Operating two (2) pumps at Oologah Pump Station and Spavinaw Flow lines No. 1 and 2 in Service:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Rate:</td>
<td>32 MGD</td>
<td>64 MGD</td>
</tr>
<tr>
<td>Valve Position:</td>
<td>31 %</td>
<td>66 %</td>
</tr>
<tr>
<td>DP Across Valve:</td>
<td>26.0 psi</td>
<td>1.0 psi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Minimum Transfer to Mohawk WTP</th>
<th>Maximum Transfer to Mohawk WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating one (1) pump at Oologah Pump Station and Spavinaw Flow line No. 2 in Service:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Rate:</td>
<td>29 MGD</td>
<td>40 MGD</td>
</tr>
<tr>
<td>Valve Position:</td>
<td>29 %</td>
<td>30 %</td>
</tr>
<tr>
<td>DP Across Valve:</td>
<td>25.0 psi</td>
<td>20.0 psi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Minimum Transfer to Mohawk WTP</th>
<th>Maximum Transfer to Mohawk WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating one (1) pump at Oologah Pump Station and Spavinaw Flow line No. 1 in Service:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Rate:</td>
<td>20 MGD</td>
<td>23 MGD</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| Valve Position | 23 %  
|               | 27 %  
| DP Across Valve | 25.0 psi  
|               | 22.0 psi  
| Notes:        | 1. Valve Center Line = Elevation (EL) 567.90  
|               | 2. Oologah Lake = Water Surface (W.S.) EL 638.00  
|               | 3. Mohawk Suction Wet Well = W.S. EL 610.00  
|               | 4. AB Jewell Reservoir = W.S. EL 673.00  
|               | 5. One Pump in Operation = Pump No. 1  
|               | 6. Two Pumps in Operation = Pumps No. 1 and No. 2  
|               | 7. Three Pumps in Operation = Pumps No. 1, No. 2, and No. 3  
| Remote Controls (Manual Mode) | When the LOR selector switches at both LCSs are in the REMOTE position, the valve is operated manually via the HMI when in MANUAL mode.  
| Remote Controls (Auto Mode) | When the LOR selector switches at both LCSs are in the REMOTE position, the valve operates automatically when in AUTO mode, based on logic interlocked with flow and pressure measurements.  
| Controls Signals | Position Command (analog output)  
|               | Position Feedback (analog input)  
|               | In Remote (discrete input)  
|               | Opened status (discrete input)  
|               | Closed status (discrete input)  
|               | Fault status (discrete input)  
|               | Control Valve Upstream Pressure (analog input)  
|               | Control Valve Downstream Pressure (analog input)  
|               | Valve Vault Flooded (discrete input)  
| Protection Interlocks | Valve operation time is approximately 106 seconds from Fully Open position to Fully Closed position, and vice versa.  
|               | The valve shall not be allowed to continue to open if the DP across the valve reaches the Maximum Transfer to Mohawk WTP DP based on the operating conditions listed above.  
|               | The valve shall not be allowed to continue to close if the DP across the valve reaches the Minimum Transfer to Mohawk WTP DP based on the operating conditions listed above.  
| Alarms:       | Valve Fault (based on valve fault status)  
|               | Valve Vault Flooded (based on high level switch activation)  
|               | Severe Cavitation (Sigma ≤ 1.0)  
|               | Minor Cavitation (1.0 < Sigma ≤ 1.5)  

C. CALIBRATION

1. Settings and calculations described above shall be calibrated as part of section 40 80 50 - Process Control System Commissioning. Contractor shall make adjustments to programmed elements to demonstrate successful calibration as directed by the Engineer.

2. Settings, ranges, and alarms shall be adjustable based on login permission.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. Section 40 91 00 specifies the requirements for furnishing, installing, and placing into operation field-mounted instrumentation.

B. It is the Contractor’s responsibility to provide a complete functional system. Provide all instrument devices that are necessary for a complete system. This includes, but is not necessarily limited to, terminal blocks, fuses, signal conditioners, power supplies, transient and surge protection, special wires/cables and connectors, and any other electronics that may be necessary to properly interface with the instrumentation provided.

C. It is the Contractor’s responsibility to verify the type, state, and condition of all existing signals required to interface to the Process Control System (PCS). Information concerning these signals given in these Contract Documents is provided for the Contractor’s reference and is deemed reliable but is not guaranteed to be accurate or true. Acceptance by the Contractor without field verification of the information contained herein regarding existing instrumentation and associated signals is done at the Contractor’s risk.

D. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 40 80 50 - Process Control System Commissioning

2. Section 40 90 50 - Process Control System Description

1.2 SUBMITTALS

A. General: Provide all submittals as specified herein.

B. Action Submittals

1. Provide Shop Drawings as required below. Organize the submittal in a logical manner and have a schematic diagram for each system.

   a. Provide complete and detailed system schematic drawings showing all
components with the electrical point to point connections of each system (wiring and piping diagrams). Include a description of the operation of the system and equipment.

b. Provide instrumentation equipment specifications: Include manufacturer’s catalog information showing product data, outlines, dimensional drawings, and instructions for installation, storage, handling, and protection. Duplicate equipment may be covered by one set of literature.

2. Include the following for each model instrument provided under Division 40:

   a. Manufacturer's design and performance specification data and descriptive literature (catalog cutsheets)

   b. Equipment dimensioning and installation requirements and recommendations.

   c. Electrical signal and power connection diagrams.

   d. Required accessories lists.

3. For each instrument specified in the sections which follow, include the following information in the submittal for that section:

   a. Tag number and description.

   b. Complete model number.

   c. Data sheets and catalog literature edited to indicate specific items provided.

   d. Mounting details for all typical installation requirements and special details for non-typical applications.

   e. Methods and materials required for installation. Include power and signal connection details.

   f. List of spare parts provided.

   g. Other specific submittal information as specified in the particular instrument specification.

C. Closeout Submittals

1. Include the following for each model instrument provided under Division 40:

   a. Operations and maintenance manuals for each type of instrument after
product approval.

b. Calibration certifications from the manufacturer for each calibrated instrument.

c. Provide written loop-calibration report as specified in Part 3 of this document.

d. List of recommended spare parts

2. Instruction Manuals

a. Operation and maintenance information: provide complete descriptive literature/shop drawings for each piece of equipment, including a list and description of all parts of each piece of equipment and instructions for calibration, testing, and maintenance requirements.

b. Project Record Documents: provide revisions from the Approved shop drawings and previous submittals. This includes as built records such as instrument ranges and actual component/instrumentation locations, including sources of control power.

c. Provide revised or updated Instrument Data Sheets, P&IDs (I&C series drawings), and process flow diagrams showing location of instrumentation and equipment including calibration data.

3. Maintenance Material Submittals:

a. Provide list of recommended spare parts

b. Provide list of special tools necessary for normal operation, maintenance, and calibration.

1.3 QUALITY ASSURANCE

A. Provide instrumentation of rugged construction designed for the site conditions. Provide only new, standard, first-grade materials throughout, conforming to standards established by Underwriter’s Laboratories (UL), Inc., and so marked or labeled, together with manufacturer’s brand or trademark.

B. Use single source manufacturer for each instrument type. Use the same manufacturer for different instrument types whenever possible.

C. Coordinate instrumentation to assure proper interface and system integration. Provide signal processing equipment, to include, but not be limited to, process sensing and measurement, transducers, signal converters, conditioners, transmitters,
receivers, and power supplies. Coordinate the various subcontractors, equipment suppliers, and manufacturers.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Each manufacturer or supplier to provide and securely attach the tag number and instructions for proper field handling and installation to each instrument prior to packaging.

B. Each manufacturer or supplier package instrumentation to provide protection against shipping damage, dust, moisture, and atmospheric contaminants. Include a shipping label which contains the following information:

1. Tag number and description
2. Instructions for unloading, transporting, storing, and handling at the site

C. Contractor to provide for unloading, transporting, storing, and handling instrumentation at the site. Inspect instrumentation for damage in shipment and return damaged instrumentation to the manufacturer.

D. Do not store instrumentation out-of-doors. Provide dry, permanent storage facilities.

1.5 WARRANTY

A. Warranty the instrumentation, materials, workmanship, and installation to be free from defects for a period of one year from the date of Final Acceptance of the Work. Extend standard manufacturer’s warranties as necessary to ensure coverage. Document warranty coverage immediately prior to Final Acceptance.

B. Furnish and install replacement parts during the warranty period for any defective component at no additional cost. Replace spare parts consumed during the warranty period with new equipment at no additional cost, immediately after use, to restore the spare parts inventory. A complete contingent of unused spare parts should exist one year after Final Acceptance.

1.6 MAINTENANCE

A. Provide spare parts as specified in the individual instrument sections.

B. Provide special tools necessary for normal operation, maintenance, and calibration.

C. Package spare parts in a manner suitable for long term storage and adequately protected against corrosion, humidity, and temperature.
PART 2 PRODUCTS

2.1 GENERAL INSTRUMENTATION REQUIREMENTS

A. Provide instruments which operate on 115 VAC, single phase, 60 Hertz electrical service, unless otherwise specified, and which return automatically and immediately to accurate measurement upon restoration of power after a power failure, except where specifically noted.

B. Provide open and short circuit protection except for two-wire transmitters.

C. Provide two-wire transmitter power supplies in local panels or enclosures with receiver/indicator/transmitter as required. Loop power supplies are to be installed in the PLC cabinets complete with a separate fuse and blown fuse indicator for each analog circuit.

D. Provide fuses or switches for equipment as recommended by the instrument manufacturer.

E. Provide instrument transmitters which produce isolated 4-20 mA DC analog signals. Follow ISA-S50.1. Process transmitters shall be smart electronic type devices capable of driving a load of at least 1000 ohms with non-interacting zero and span adjustments and remote recalibration features.

F. Each transmitter shall be supplied with an integral junction box with terminal strip, integral test jacks, and conduit connection, and shall be complete with all mounting accessories.

G. Provide signal isolators as necessary to resolve interface problems between field instruments, final control elements, panel instruments, and PCS components. Signal isolation may require the inclusion of one or more isolated signal converters for analog circuits and one or more interposing relays for discrete circuits.

H. Where interposing relays are required to provide proper contact rating from devices interfacing to the PLCs, install the relays in the PLC cabinets.

I. For each field mounted instrument (transmitter, analyzer, gauge, etc.) requiring 120 VAC, provide an individual non-fused disconnect switch with auxiliary contact (switch position indication) to allow for remote monitoring and indication functionality. Provide Pass & Seymour PS30SSAX, Square D Class 2510-Type KW1, or NEMA rated disconnect as required, or equal. Provide disconnect switch cover, Crouse Hinds Model DS185 or equal.

J. Provide instruments with printed circuit boards suitably coated to prevent damage by dust, moisture, fungus, and airborne contaminants. All spare boards shall be conformal coated.
K. Provide instruments complete with mounting hardware, floor stands, wall brackets, or instrument racks. Provide all stainless steel mounting hardware for surface, panel or handrail mounting as required by location. Mounting hardware shall meet the requirements of the area.

L. Provide instrument enclosures NEMA rated for the environment. In areas subject to flooding, provide submergence rated enclosures.

M. Provide sun shields for all outdoor enclosures and indicators.

N. Provide tool kits and test equipment, as recommended by the manufacturer, necessary for assembling, calibrating, and maintaining equipment.

O. Provide each instrument with engraved phenolic nametag, white with black letter, 1/2-inch tall minimum showing device ID.

2.2 LEVEL SWITCH – FLOAT TYPE

A. Type: Potential-free switching reed contact, magnetic float trigger, displacement type liquid level sensor.

B. Construction Features

1. Provide mercury free float switches.

2. Float Body: Hollow hermetically sealed, 316 stainless steel cylinder or sphere containing permanent built triggering magnet.

3. Switch: Potential-free reed contact built into the guide tube, rated 1 amp resistive at 120 VAC.

4. Electrical cable:
   a. Heavy duty, three conductor, flexible, and submersible cable, sheathed in PVC and connected to float and switch with watertight seal.
   b. Length provided to be sufficient to extend to junction box.

5. Ambient Temperature Limits: -22 degF to 176 degF

6. Medium Temperature Limits: -22 degF to 176 degF

7. Safety Classification: As required by process area.

C. Manufacturers:
1. Flygt, Model ENM-10
2. Rotofloat
3. Or approved equal

### 2.3 PRESSURE AND DIFFERENTIAL PRESSURE TRANSMITTERS

A. Differential capacitance cell type. Two-wire, 4-20 mA DC output signal. Loop powered from 24V DC nominal. Output load impedance of at least 550 ohms.

B. Microprocessor based "smart" electronics. HART protocol compatible.

C. Accuracy: +\- 0.10 percent of calibrated span.

D. Span and zero continuously adjustable, either locally or via hand-held digital interface.

E. NEMA 4 housing. Suitable for operation over ambient temperature range of -22 degF to 176 degF.

F. Ceramic or stainless steel wetted parts. Stainless steel bleed and drain fittings. All metal external parts.

G. Integral 4-digit LCD output indicator graduated 0-100 percent. Provide integral mounting bracket suitable for wall, pipestand, or unistrut mounting.

H. NPT process connections.

I. Manufacturers:

1. Siemens SITRANS P series (no substitution)

### 2.4 SIGNAL LINE TRANSIENT PROTECTION

A. All signal lines for solid state electronic equipment shall be equipped with line voltage surge suppressors to protect the equipment from damage due to electrical transients induced in the interconnecting lines from lightning discharges or nearby equipment.

B. This shall include, but is not be limited to digital inputs, analog inputs, analog outputs, flow transmitters, and level transmitters. The signal line transient protection shall be provided on any signal lines which are outside of the building structure housing the PLC control panel.

C. The signal line transient protection shall include gas discharge tubes, varistors, and
suppressor diodes.

D. The unit shall be Phoenix Contact terminal block type consisting of protective plug and base element, with integrated multi-stage status indicator, Model PT-IQ-1X2+F, or approved equal.

E. Terminal block shall be DIN rail type, mounted in the vertical position.

F. Provide lightning protection termination for all digital and analog signals, plus a minimum of 10 percent spares per panels.

G. Field instruments, for 24V DC analog signals
   1. Manufacturers: Phoenix Contact PIPETRAB series.
   2. Conduit Mounted: Protection circuit mounted ¾ inch (19 mm) stainless steel pipe nipple.
   3. Provide surge protection for analog and digital I/O designed to withstand a 10kA test current of a (8/20) microseconds waveform according to IEC 1024 Application Guide A and ANSI/IEEE C62.41 Category C Area.
   4. Surge protection shall consist of a multistage hybrid circuit utilizing only diodes and gas discharge tubes but no Metal Oxide Varistors (MOVs).
   5. Resistance: Less than 10 ohms of series resistance.
   6. Surge protection shall have a response time less than 1 microsecond.
   7. Maximum Continuous Operating Voltage: Not to exceed 28V DC.
   8. Cutoff Frequency: Less than 400 kHz (for a 600 ohm system) to allow HART protocol and other superimposed smart digital signals to function.

PART 3  EXECUTION

3.1 INTERFACE WITH OTHER PRODUCTS
   A. Coordinate installation of transmitters and switches with piping and equipment installers.
3.2 **EXAMINATION**

A. Examine the Drawings and the site for placement of instrumentation. Investigate the space in the buildings through which the equipment must pass to reach its final location. Make provisions to move the instrumentation into place.

B. The instrument installation details show general intent. They are not to scale. Secure and utilize instrument mounting details from the manufacturer or supplier for installation purposes.

3.3 **INSTALLATION**

A. Provide labor, materials, tools, equipment, supplies, and services, and auxiliary devices including, but not limited to, brackets and mounting hardware to install the instrumentation. Install all devices as specified and shown on the Contract Drawings in accordance with manufacturer’s requirements. The Contractor shall be responsible for any problems resulting from any deviation from manufacturer installation instructions.

B. Install all transmitters vertically, with the integral indicators facing front or sides. Install on instrument racks or stands or in enclosures near the sensor at a level that permits viewing from floor elevation. For pipe mounted instruments, provide sufficient clearance to permit 360° access to the units.

C. Install the instrumentation and auxiliary devices to be accessible for maintenance. Provide space between instruments and other equipment and piping for ease of removal and servicing. Install instrumentation to be accessible from floor level or grade.

D. Attach a durable stainless steel tag using stainless steel wire or stainless steel drive screws to each primary element, transmitter, and field mounted readout device. Permanently engrave the tag with the instrument tag number and description as given in the Instrument List for each instrument. Include manufacturer’s name and model number if not discernible on the instrument. Provide tags which are a minimum of 1”x 3” size, 1/16” thick, with characters 1/4” high (minimum).

E. Seal all conduit and wiring entries into all instruments installed below ground or in vaults with non-setting transparent potting material. Seals shall be water tight, suitable for accidental submergence in 30 feet of water.

F. Follow additional installation requirements as specified in the individual instrument sections and as recommended by the manufacturer.
3.4 FIELD QUALITY CONTROL

A. Provide instrument manufacturer services for installation assistance, field calibration, startup, and training as specified in the individual instrument sections.

B. Remove shipping stickers, paint splatters, dirt, grease, and other contaminants to restore the instrumentation to a clean and like new condition prior to Final Acceptance.

3.5 MANUFACTURER’S SERVICES

A. An authorized manufacturer’s representative shall inspect the installation of all work provided under this Section and shall provide a certificate of proper installation.

B. The Contractor shall provide the services of an experience, authorized manufacturer’s representative (Salesperson does not qualify) for the equipment specified herein who shall be present at the jobsite and/or classroom designated by the City for the minimum man-days listed for the services shown below, time travel excluded:

1. One (1) man-day for inspection, start-up, functional testing, and certificate of proper installation.

2. One (1) man-day for Training and Commissioning.

3.6 DEMONSTRATION

A. Prepare an instrumentation installation and calibration certification sheet for each primary element sensor and electronic indicator/analyzer/transmitter for each instrument uniquely specified. Use these sheets for documenting installation and testing. Copies of completed instrument certification sheets need to be provided to the Owner’s Maintenance Group.

B. Calibrate each instrument, including its complete instrument loop. Indication at remote receiving instruments, including any SCADA system operator interface screens, shall be equal to readings at local transmitter indicators.

C. Provide written loop-calibration report for each instrument loop, which shall include, but not limited to the following:

1. Project Name

2. Tag Number and Service Description

3. Manufacturer
4. Model and Serial Number

5. Date, time, and names and signatures of factory trained personnel performing calibration

6. Weather conditions at the time the final calibration was performed

7. Comparison of readings at the local transmitters with readings at the remote receiving instruments.

8. Verification of operation of all contact outputs, including those at the receiving instruments.


10. Calibration data to include:
   a. Table showing calculated and measured values at 0%, 25%, 50%, 75%, and 100%.
   b. Input, output, and error at 0, 25, 50, 75, and 100 percent of span for analog instruments.
   c. Switch setting, contact action, and deadband, if applicable, for discrete elements.

11. Space for comments.

12. Certification by installer and acknowledgment by Contractor and date.

13. Names and signatures of Owner representative witnessing calibration process.

3.7 INSTRUMENT LIST

A. The Instrument List included herein indicates all minimum required instruments for the project, and shall not be considered a complete list, and shall be used as reference material.

B. The Instrument List does not include all details that must be coordinated during project implementation. However, columns have been provided in the attached Instrument List to facilitate inclusion of this information as the project installation progresses.

C. See list below:
<table>
<thead>
<tr>
<th>INST TAG</th>
<th>SERVICE DESCRIPTION</th>
<th>P&amp;ID</th>
<th>TYPE</th>
<th>SCALE</th>
<th>RANGE</th>
<th>AREA CLASS</th>
<th>VENDOR</th>
<th>MODEL NO.</th>
<th>SPEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIT-D19A</td>
<td>Control Valve</td>
<td>CN1</td>
<td>Pressure Indicating Transmitter</td>
<td>4-20 mA</td>
<td>0 – 60 PSI</td>
<td>N/A</td>
<td>SIEMENS</td>
<td>By Vendor</td>
<td>40 91 00 2.3</td>
</tr>
<tr>
<td>PIT-D19B</td>
<td>Control Valve</td>
<td>CN1</td>
<td>Pressure Indicating Transmitter</td>
<td>4-20 mA</td>
<td>0 – 60 PSI</td>
<td>N/A</td>
<td>SIEMENS</td>
<td>By Vendor</td>
<td>40 91 00 2.3</td>
</tr>
<tr>
<td>LSH-D19</td>
<td>Valve Vault Level Switch</td>
<td>CN1</td>
<td>Level Switch – High</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>TBD</td>
<td>By Vendor</td>
<td>40 91 00 2.2</td>
</tr>
</tbody>
</table>

END OF SECTION