

**COLORADO
DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISIONS
HANGING LAKE TUNNEL BACKUP GENERATOR REPLACEMENT**

The 2011 Standard Specifications for Road and Bridge Construction controls construction of this project. The following special provisions supplement or modify the Standard Specifications and take precedence over the Standard Specifications and plans.

PROJECT SPECIAL PROVISIONS

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STANDARD SPECIAL PROVISIONS**

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On the Job Training	(July 29, 2011)	3
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Required Contract Provisions – Federal-Aid Construction Contracts	(October 20, 2016)	14
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NOTICE TO BIDDERS

The proposal guaranty shall be a certified check, cashier's check, or bid bond in the amount of 5 percent of the Contractor's total bid.

Pursuant to subsections 102.04 and 102.05, it is recommended that bidders on this project review the work site and plan details with an authorized Department representative. Prospective bidders shall contact one of the following listed authorized Department representatives at least 12 hours in advance of the time they wish to go over the project.

Program Engineer -	Martha Miller P.O. Box 2107 Eagle, CO 81631 Office Phone: 970-328-9933
Resident Engineer -	Pete Lombardi P.O. Box 2107 Eagle, CO 81631 Office Phone: 970-328-9962
Project Engineer -	David Tedrow P.O. Box 2236 Frisco, CO 80443 Office Phone: 303-512-5611 Cell Phone: 970-485-2527

The above referenced individuals are the only representatives of the Department with authority to provide any information, clarification, or interpretation regarding the plans, specifications, and any other contract documents or requirements.

A mandatory pre bid conference will be held on **Friday, xxx xth, 2017 beginning at 10:00 am at the CDOT Hanging Lake Tunnel Complex, location??**. Bids will be accepted only from pre-qualified bidders who attend the mandatory pre-bid conference.

Questions received from bidders along with CDOT responses will be posted on the following CDOT web site as they become available: <https://www.codot.gov/business/bidding/future-bidding-opportunities>

If the bidder has a question or requests clarification that involves the bidder's innovative or proprietary means and methods, phasing, scheduling, or other aspects of construction of the project, the Project Engineer will direct the bidder to contact the Resident Engineer directly to address the question or clarification. The Resident Engineer will keep the bidder's innovation confidential and will not share this information with other bidders.

The Resident Engineer will determine whether questions are innovative or proprietary in nature. If the Resident Engineer determines that a question does not warrant confidentiality, the bidder may withdraw the question. If the bidder withdraws the question, the Resident Engineer will not answer the question and the question will not be documented on the CDOT web site. If the bidder does not withdraw the question, the question will be answered, and both the question and CDOT answer will be posted on the web site. If the Resident Engineer agrees that a question warrants confidentiality, the Resident Engineer will answer the question, and keep both question and answer confidential. CDOT will keep a record of both question and answer in their confidential file.

All questions shall be directed to the CDOT contacts listed above no later than 7:00 A.M. Monday of the week of bid opening. Final questions and answers will be posted no later than Tuesday morning of bid opening week. Questions and answers shall be used for reference only and shall not be considered part of the Contract.

**COMMENCEMENT AND COMPLETION OF WORK
CALENDAR DATE**

The Contractor shall commence work under the Contract on or before the 15th day following Contract execution or the 30th day following the date of award, whichever comes later, unless such time for beginning the work is changed by the Chief Engineer in the "Notice to Proceed." The Contractor shall complete all work within 170 calendar days in accordance with the "Notice to Proceed."

Stockpiling of materials before the beginning date is subject to the Engineer's approval. If such approval is given, stockpiled material will be paid for in accordance with Sections 109 and 626.

The Generator shall not be out of service for more than 30 total consecutive days, and the Generator replacement work shall fall within the period from June 1 to September 30. This includes removing the existing Generator and connections, installing the new Generator and installing the piping and electrical connections for the new Generator. Short duration outages for preparation prior to this 30 day allowance are subject to engineer approval.

Section 108 of the Standard Specifications is hereby revised for this project as follows:

Subsection 108.03 shall include the following:

Salient features for this project are:

- (1) Mobilization
- (2) Generator Procurement
- (3) Structure Modifications
- (4) Remove/Install Exhaust Piping
- (5) Remove/Install Remote Radiator
- (6) Remove/Install Remote Radiator Piping
- (7) Remove/Install Fans and HVAC Ductwork
- (8) Remove/Replace Generator
- (9) Testing and Acceptance
- (10) Punch list, Cleanup

DISADVANTAGED BUSINESS ENTERPRISE (DBE) CONTRACT GOAL

This is a federally-assisted construction project. As described in the CDOT DBE Standard Special Provision, the Bidder shall make good faith efforts to meet the following contract goal:

xxx Percent DBE participation.

ON THE JOB TRAINING CONTRACT GOAL

The Department has determined that On the Job Training shall be provided to trainees with the goal of developing full journey workers in the types of trade or classification involved. The contract goal for On the Job Trainees working in an approved training plan in this Contract has been established as follows:

Minimum number of total On the Job Training required **xxxx** hours

**REVISION OF SECTION 102
PROJECT PLANS AND OTHER DATA**

Section 102 of the Standard Specifications is hereby revised for this project as follows:

Subsection 102.05 shall include the following:

After the proposals have been opened, the low responsible bidder may obtain electronic sets of plans and special provisions at no cost from CDOT. If they are available for the project, the low responsible bidder may also obtain cross sections, major structure plan sheets, and computer output data. This material may be obtained on a CD from the Visual Communications Center or by file sharing. The Visual Communications Center is located in the southeast building of the CDOT Headquarters Complex, 4201 East Arkansas Avenue, Denver, Colorado 80222. Subcontractors and suppliers may obtain plans and other data from the successful bidder.

**REVISION OF SECTION 104
MAINTAINING TRAFFIC**

Section 104 of the Standard Specifications is hereby revised for this project as follows:

Subsection 104.04 shall include the following:

The Department intends to minimize the impact of construction operations to the traveling public on I-70 and various side roads and accesses. Special scheduling, coordination, and traffic control not usually associated with highway construction will be necessary to accomplish work on this project and to maintain traffic flow. Traffic control operations must have the approval of the Engineer. Unless otherwise allowed by this specification, the Contractor shall abide by the provisions for maintaining traffic to meet the Department's intention of minimizing the impact to the traveling public.

- (a) *General.* Construction activities that affect traffic on the traveled roadway shall not commence prior to establishment of traffic control operations for these activities. Construction activities shall be discontinued and all materials and equipment removed from the traveled roadway in time to allow for a safe removal of traffic control devices within the time limits defined in Subsection 104.01(c) – Periods of No Interference.
- (b) *Traffic Control Requirements for Specific Construction Activities.* In addition to the above, the following restrictions shall apply. In all cases, the Contractor shall schedule and coordinate his work such that the minimum delay to the traveling public will result and all requirements and restrictions are met.
- (c) *Periods of No Interference.* During the periods listed below, the Contractor shall not interfere with traffic, other than what is identified in the plans, on the traveled roadway:
 - 1. I-70 Eastbound & Westbound (two lane traffic each way): 7 am to 7 pm all days of the week.
 - 2. Lane closures in the Eastbound lanes shall not be allowed until after Mother's Day, May 14, 2017.
 - 3. Lane closures shall not be allowed on holiday weekends: Memorial Day (May 26-29, 2017); Independence Day (June 30 – July 4, 2017); and Labor Day (September 1-4, 2017).

For all other periods not stated above, traffic delays and interruptions by the Contractor will only be allowed as described in the Traffic Control Plan – General. Unauthorized delays and traffic interruptions will be considered a violation of this provision and shall be subject to price reductions as described in Revision of Section 105 – Violation of Working time Limitation.

If any approved variation from the two-lane traffic results in unsafe conditions or undue delays for the traveling public, the approval of the MHT will be rescinded, and the two-lane traffic operation shall be immediately re-established. If the Engineer finds that any closures result in unsafe conditions or undue delays, construction activities causing the situation and/or delay shall immediately cease, and the two-lane traffic operation shall be immediately re-established.

- (d) *Construction Operations.* Traffic control shall be the responsibility of the Contractor within the provisions of the Contract and CDOT standards. Traffic control shall be coordinated by the Contractor such that the delays to the traveling public will not exceed 20 minutes, with enough time between each interval to clear traffic.

Traffic stops of up to 20 minutes will only be allowed between 12 am and 5 am.

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**REVISION OF SECTION 104
MAINTAINING TRAFFIC**

All traffic operations shall be completed in close coordination with CDOT Hanging Lake Tunnel Operations and active adjacent projects. Safety plans shall be developed with CDOT to take into consideration emergency response and ingress and egress plans.

- (e) *Adverse Weather Conditions.* The Contractor shall cease any operation that affects traffic when the Engineer determines that slippery roads, poor visibility, or other adverse weather conditions make traffic control hazardous to the traveling public. Operations shall not re-start until the Engineer determines that the traveled roadway is safe.
- (f) *Maintaining Other Access.* The Contractor shall provide and maintain access to the Hanging Lake Tunnel facility entrances at all times throughout the duration of the project except for one work zone at a time. Additional emergency operation procedures shall be developed in coordination with Hanging Lake Tunnel staff to provide access for emergency vehicles at a minimum of one entrance to the Cinnamon Creek Complex.
- (g) *Costs.* All costs incidental to the foregoing requirements will not be paid for separately, but shall be included in the work.

Delays or impacts to the Contractor due to the requirements of this provision shall not be a basis for an extension of time or additional compensation, or both. Any denial or revocation of prior approval for traffic-handling requests shall not be the basis for any claim for additional time or compensation.

The Contractor shall communicate with CDOT Hanging Lake Tunnel Operations for coordination of staging area(s) and access to the facility. Tunnel Operations will assist with lane closures for delivery of materials with three-week prior notice in order to adequately schedule appropriate staff.

Hanging Lake Tunnel – Tunnel Control
970-945-3840

Hanging Lake Tunnel Contact:
Todd Anselman
970-945-3854

**REVISION OF SECTION 107
PERFORMANCE OF SAFETY CRITICAL WORK**

Section 107 of the Standard Specifications is hereby revised as follows:

Subsection 107.06(c) shall include the following:

Prior to any work on site, the Contractor's Project Safety Manager shall coordinate with Hanging Lake Tunnel staff to provide a mandatory site-specific fire-life-safety instruction course to all construction staff. The course shall include information on responsible Tunnel staff, the Tunnel emergency procedures during a fire event, evacuation of the Cinnamon Creek Complex and the Tunnel for a fire event, and locations and operation of fire extinguishers. Attendance at the fire-life-safety instruction course shall be recorded with an attendance sheet that will be provided to the Tunnel staff. The Project Safety Manager shall ensure that any Contractor staff that do not attend the pre-work fire-life-safety instruction course are advised of its content and shall track their instruction with a sign-up list that will be shared with Tunnel staff. Any Contractor personnel whose fire-life-safety instruction cannot be corroborated by the Project Safety Manager will not be allowed on the work site.

Add subsection 107.061 immediately following subsection 107.06 as follows:

107.061 Performance of Safety Critical Work. The following work elements are considered safety critical work for this project:

- a. Removal of Portions of Present Structure (Building)
- b. Removal of Electrical Equipment
- c. Modify Building

The Contractor shall submit, for record purposes only, an initial detailed Construction Plan that addresses safe execution of each of the safety critical elements. The Construction Plan shall be submitted two weeks prior to the safety critical element conference described below. The Construction Plan shall be stamped "Approved for Construction" and signed by the Contractor. The Construction Plan will not be approved by the Engineer.

The Construction Plan shall include the following:

- (1) Safety Critical Element for which the plan is being prepared and submitted.
- (2) Contractor or subcontractor responsible for the plan preparation and the work.
- (3) Schedule, procedures, list of equipment, and sequence of operations, that comply with the working hour limitations.
- (4) Temporary works required: falsework, formwork, bracing, shoring, etc.
- (5) Additional actions that will be taken to ensure that the work will be performed safely.
- (6) Names and qualifications of workers who will be in responsible charge of the work:
 - A. Years of experience performing similar work
 - B. Training taken in performing similar work
 - C. Certifications earned in performing similar work
- (7) Names and qualifications of workers operating cranes or other lifting equipment:
 - A. Years of experience performing similar work
 - B. Training taken in performing similar work
 - C. Certifications earned in performing similar work

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**REVISION OF SECTION 107
PERFORMANCE OF SAFETY CRITICAL WORK**

- (8) The construction plan shall address how the Contractor will handle contingencies such as:
 - A. Unplanned events (storms, traffic accidents, etc.)
 - B. Structural elements that don't fit or line up
 - C. Work that cannot be completed in time for the roadway to be reopened to traffic
 - D. Replacement of workers who don't perform the work safely
 - E. Equipment failure
 - F. Other potential difficulties inherent in the type of work being performed
- (9) Name and qualifications of Contractor's person designated to determine and notify the Engineer in writing when a route is safe to open to traffic after it has been closed for safety critical work.
- (10) Plan requirements that overlap with above requirements may be submitted only once.

A safety critical element conference shall be held two weeks prior to beginning construction on each safety critical element. The Engineer, the Contractor, the safety critical element subcontractors, and the Contractor's Engineer shall attend the conference. Required pre-erection conferences may be included as a part of this conference.

After the safety critical element conference, and prior to beginning work on the safety critical element, the Contractor shall submit a final construction plan to the Engineer for record purposes only. The final construction plan shall be stamped "Approved for Construction" and signed by the Contractor.

The Contractor shall perform safety critical work only when the Engineer is on the project site. The Contractor's Engineer shall be on site to inspect and give written approval of safety critical work for which he provided signed and sealed construction details. Unless otherwise directed or approved, the Contractor's Engineer need not be on site during the actual performance of safety critical work, but shall be present to conduct inspection for written approval of the safety critical work.

When ordered by the Engineer, the Contractor shall immediately stop safety critical work that is being performed in an unsafe manner or that will result in an unsafe situation for the traveling public. Prior to stopping work, the Contractor shall make the situation safe for work stoppage. The Contractor shall submit an acceptable plan to correct the unsafe work process before the Engineer will authorize resumption of the work.

When ordered by the Engineer, the Contractor shall remove workers from the project that are performing the safety critical work in a manner that creates an unsafe situation for the public in accordance with subsection 108.05.

Should an unplanned event occur or the safety critical operation deviate from the submitted plan, the Contractor shall immediately cease operations on the safety critical element, except for performing any work necessary to ensure worksite safety, and shall provide proper protection of the work and the traveling public. If the Contractor intends to modify the submitted plan, he shall submit a revised plan to the Engineer prior to resuming operations.

All costs associated with the preparation and implementation of each safety critical element construction plan will not be measured and paid for separately, but shall be included in the work.

Nothing in the section shall be construed to relieve the Contractor from ultimate liability for unsafe or negligent acts or to be a waiver of the Colorado Governmental Immunity Act on behalf of the Department.

**REVISION OF SECTION 202
REMOVAL OF ELECTRICAL EQUIPMENT**

Section 202 of the Standard Specifications is hereby revised for this project as follows:

Subsection 202.01 shall include the following:

This work consists of the removal and disposal of existing electrical equipment and wiring systems that are taken out of active service permanently where indicated on the Contract Drawings or that interfere with work of other trades and contracts involved in this project. The Contractor shall perform all work required to remove or safely abandon existing systems.

Subsection 202.02 shall include the following:

- (a) *Removal of Equipment.* The Contractor shall remove existing electrical equipment, including but not limited to the emergency generator and controls, combination motor starters, conductors, exhaust silencer, exhaust pipe and supports, coolant pipe, remote radiator assembly, fuel day tank, switches, conduits, boxes, fittings, wire and cable, raceway, light fixtures, and all other equipment marked for removal by the Contract Drawings or as directed by the Engineer. All existing equipment removed in connection with the work under this Section and not reinstalled as indicated on the Contract Drawings with the exception of the existing generator, exhaust silencer, remote radiator, and the fuel day tank shall become the property of the Contractor and shall be disposed of properly. The Contractor shall maintain in service all lighting circuits disrupted by the installation of the emergency generator. The Contractor shall supply all conduit, boxes and wire required by the Contract Drawings.
- (b) *Removals.* As indicated on the Contract Drawings and herein, for those equipment and wiring systems to be permanently taken out of active service, the Contractor shall perform all work required to remove or safely abandon existing systems. The Contractor shall visit the site and estimate the extent of removal work prior to bidding the job. The following describes the intended work for removals.
1. The Contractor shall arrange for the safe de-energization of all electrical equipment affected by the Contract work.
 2. Feeder and branch wiring, conduits, and boxes shall be removed in their entirety by the Electrical Contractor in areas where the equipment is not reused or as shown on the Contract Drawings.
 3. Feeder and branch wiring and conduits in earth, concrete slabs, or masonry shall be abandoned in place, except that wiring ends shall be cut off (or removed) at the conduit mouth by the Electrical Contractor. When feeder and branch wiring and conduits interfere with the installation of any new project work, they shall be removed in their entirety by the Electrical Contractor. Conduits which exit concrete floor slabs and walls shall be cut or hammered down one inch below floor level or wall and filled with cement mortar to the extent possible.
 4. The Contractor shall fill voids with epoxy concrete or other patching material from CDOT's Approved Products List, to floor or wall adjacent surface level to match the surrounding concrete finish. Any exposed anchor bolts or other fasteners shall be ground to a minimum of 1 inch below the adjacent surface, and the remaining holes shall be filled as above.
 5. Generally, all equipment, boxes, fixtures, etc., unused and abandoned shall be removed from the site and disposed of at the Contractor's expense, or delivered to an on-site storage area where the Engineer directs.

Subsection 202.03 shall include the following:

The existing diesel engine generator (rated at 350kW, 4160 V), exhaust silencer, fuel day tank assembly, and remote radiator shall be removed in reusable condition by the Contractor and transported to a designated CDOT facility for storage. The expected CDOT storage facility will be at the CDOT Dotsero barn or at the CDOT Siloam storage yard, both of which are less than 10 miles from the work site.

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**REVISION OF SECTION 202
REMOVAL OF ELECTRICAL EQUIPMENT**

The Contractor shall place the removed generator, exhaust silencer, fuel day tank assembly, and remote radiator on leveled, durable blocks, off the ground, at the designated location in the storage site. The equipment shall be covered with weatherproof tarps and secured with straps as approved by the Engineer, after coordination for any pre-storage preparation or maintenance of the equipment to be done by CDOT.

All other materials removed from the existing structure shall become the property of the Contractor and shall be properly disposed of offsite at the Contractor's expense, unless otherwise stated in the plans.

Existing structures, facilities, and surrounding areas shall not be damaged by the removal operations. Damage that does occur shall be repaired immediately at the Contractor's expense.

Subsection 202.12 shall include the following:

Payment will be made under:

Pay Item	Unit
Removal of Electrical Equipment	Lump Sum

Payment for Removal of Electrical Equipment will be full compensation for all labor and materials required to complete the work, including preparation and implementation of the Removal Plan, inspection, equipment, debris handling and disposal, salvaging, handling and storage of salvable materials, handling and disposal of all hazardous materials, and disposal of non-salvable materials.

Removal, transport, blocks, and secured protective coverings of the existing generator, exhaust silencer, day tank assembly, and remote radiator will not be measured and paid for separately, but shall be included in the work.

Lighting that is required for removal operations in areas that are not directly lit will not be measured and paid for separately, but shall be included in the work.

**REVISION OF SECTION 202
REMOVAL OF PORTIONS OF PRESENT STRUCTURE (BUILDING)**

Section 202 of the Standard Specifications is hereby revised for this project as follows:

Subsection 202.01 shall include the following:

This work consists of the removal and disposal of a portion of the existing concrete wall between the interior parking area and the emergency generator room at the Hanging Lake Tunnel complex, and enlargement of existing openings in concrete floors and walls where indicated in the Contract Drawings. Wall removal consists of the complete removal of an existing metal double door and door frame and enlargement of a wall opening area as shown in the plans, to facilitate removal and replacement of equipment in the generator room. Enlarged openings in concrete floors and walls will be used for installation of a new generator exhaust system, piping for a remote radiator, and for other system requirements.

Subsection 202.02 shall include the following:

The removal of the existing concrete shall be performed in a safe manner.

The Contractor shall submit a Removal Plan to the Engineer, for record purposes only, at least 20 working days prior to the proposed start of removal operations. The Removal Plan shall detail procedures, sequences, and all features required to perform the removal in a safe and controlled manner. The Removal Plan shall be stamped "Approved for Construction" and signed by the Contractor. The Removal Plan will not be approved by the Engineer.

The Removal Plan shall provide complete details of the removal process, including:

- (1) The exact location of the enlarged opening. The location shall be determined with the Engineer to minimize disturbance of existing electrical or mechanical appurtenances near the door area, and to facilitate the removal of the existing emergency generator and related components and the installation of a larger emergency generator, day tank, exhaust system, and related components.
- (2) The removal sequence, including a detailed schedule that complies with the working hour limitations.
- (3) Complete descriptions of equipment to be used during removal operations. Saw-cutting or coring of concrete is likely to be the method of choice to ensure edges that are most compatible with the eventual use of the enlarged door opening for the generator room and to enlarge openings for the exhaust and radiator piping.
- (4) Shoring that exceeds 5 feet in height, including all bracing necessary to temporarily support the wall area above the door lintel.
- (5) Details for temporarily and safely maintaining electrical outlets and switches that are currently located within or near the enlarged opening.
- (6) Details, locations, and types of protective coverings to be used. The protective covering shall prevent any materials, equipment or debris from falling onto facilities below the removal area. Additional width of protective covering shall be sufficient to assure that people, property, and utilities near removal areas will not be endangered.
- (7) Detailed methods for mitigation of fugitive dust resulting from the demolition.
- (8) Details for removing, loading, and hauling concrete pieces.

Where rebar in the existing walls or floors is exposed by concrete removal to enlarge the openings, the rebar shall be ground down to a minimum of 1" below the adjacent concrete surface and the hole shall be patched with an epoxy grout product found on CDOT's Approved Products List.

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**REVISION OF SECTION 202
REMOVAL OF PORTIONS OF PRESENT STRUCTURE (BUILDING)**

A Pre-Removal Conference shall be held at least seven days prior to the beginning of removal operations. The Engineer, the Contractor, and the Removal Subcontractor shall attend the Pre-Removal Conference. The Removal Plan shall be agreed upon and finalized at this Conference.

The Contractor's Engineer shall sign and seal (1) through (4) listed above in the final Removal Plan.

The final Removal Plan shall be stamped "Approved for Construction" and signed by the Contractor. The Contractor shall submit a final Removal Plan to the Engineer prior to any removal work, for record purposes only.

The Contractor shall not begin the removal process without written confirmation of the receipt of the Removal plan by the Engineer.

Submittal of the final Removal Plan to the Engineer and field inspection performed by the Engineer, shall not relieve the Contractor and the Contractor's Engineer of full responsibility for the removal plan and procedures.

Unless otherwise directed, the Contractor's Engineer need not be on site when removal operations are in progress, but shall be available if requested by the Engineer to conduct timely inspections for written approval of the work.

The Contractor shall have all necessary workers, materials, and equipment at the site prior to closing any Tunnel Complex areas to accommodate removal operations. Work shall be pursued promptly and without interruption until the area is re-opened for typical use by Tunnel Maintenance forces.

Removal of hazardous material shall be in accordance with Section 250 of the Standard Specifications.

Should an unplanned event occur or the removal operation deviate from the submitted removal plan, the removal operations shall immediately cease after performing any work necessary to ensure worksite safety. The Contractor shall submit to the Engineer the procedure or operation proposed by the Contractor's Engineer to correct or remedy the occurrence of this unplanned event or to revise the final Removal Plan. The Contractor shall submit his Engineer's report in writing, within 24 hours of the event, summarizing the details of the event and the procedure for correction.

Before removal of the protective covering, the Contractor shall clean the protective covering of all debris and fine material.

Removal operations may be suspended by the Engineer for the following reasons:

- (1) Final Removal Plan has not been submitted and written confirmation of the receipt of this plan has not been provided by the Engineer.
- (2) The Contractor is not proceeding in accordance with the final Removal Plan, procedures, or sequence.
- (3) The Contractor's Engineer is not available to conduct inspections for the written approval of the work.
- (4) Safety precautions are deemed to be inadequate.
- (5) Existing neighboring facilities are damaged as a result of removal activity.

Suspension of removal operations shall in no way relieve the Contractor of his responsibility under the terms of the Contract. Removal operations shall not resume until modifications have been made to correct the conditions that resulted in the suspension, as approved in writing by the Engineer.

Prior to reopening the removal work areas to typical CDOT Maintenance activity, all debris, protective pads, materials, and devices shall be removed and the work areas vacuumed clean.

Explosives shall not be used for removal work without the written approval of the Engineer.

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**REVISION OF SECTION 202
REMOVAL OF PORTIONS OF PRESENT STRUCTURE (BUILDING)**

Subsection 202.12 shall include the following:

Payment will be made under:

Pay Item	Unit
Removal of Portions of Present Structure (Building)	Lump Sum

Payment for Removal of Portions of Present Structure (Building) will be full compensation for all labor and materials required to complete the work, including, preparation and implementation of the Removal Plan, inspection, equipment, debris handling and disposal, salvaging, handling and storage of salvable materials, handling and disposal of all hazardous materials and disposal of non-salvable materials.

Lighting required for removal operations in areas that are not directly lit will not be measured and paid for separately, but shall be included in the work.

**REVISION OF SECTION 601
STRUCTURAL CONCRETE**

Section 601 of the Standard Specifications is hereby revised for this project as follows:

Subsection 202.01 shall include the following:

This work includes preparation of existing concrete surfaces and placement of concrete to enlarge the existing generator pad area and to add height to the existing containment wall at the generator day tank.

Subsection 601.02 shall include the following:

Concrete with compressive strength, materials, air content, and water/cementitious material ratio equivalent to Class D concrete shall be used in this application.

Subsection 601.05 shall include the following:

The Contractor may choose to use a bagged concrete mix where the concrete quantity needed does not warrant delivery by truck mixers or self-contained mobile mixers. The manufacturer of the mix shall provide certification that the resulting concrete product is equivalent to typical Concrete Class D.

Subsection 601.07 shall include the following:

The concrete shall be mixed with a portable mixer that meets the mix manufacturer's recommendations for small batch production, including mixing time, amount of water per batch, and time of deposition.

Subsection 601.12 (j) shall include the following:

For the enlargement of the existing generator pad and the vertical extension of the containment wall, where new concrete is will be cast against existing concrete surfaces, the vertical and horizontal surfaces of the existing concrete shall be thoroughly cleaned of all paint and other foreign material. Cleaning shall be done by abrasive blast methods or by mechanical chipping, so that the surface to be joined is roughened to a minimum 1/4-inch amplitude.

The roughened surface shall be coated with an approved bonding agent before the new concrete is placed.

When the new concrete for the generator pad is thoroughly cured, the Contractor shall paint the exposed surfaces and any adjacent surfaces that were damaged during preparation for the concrete placement to match the existing concrete surfaces in the generator room. Paint meeting requirements for application on exterior concrete surfaces shall be provided by the Contractor and included in the cost of the work.

Similarly, when the concrete for the containment wall extension is thoroughly cured, the Contractor shall paint the exposed surfaces and any adjacent surfaces that were damaged during preparation for the concrete placement to match the surface of the existing containment wall, except that the interior of the containment basin shall be coated to be leakproof. A leakproof coating or lining for the basin interior shall be supplied by the Contractor. The coating or lining shall be impervious to petroleum products, a 100% solids plural system with no VOCs, 80 to 125 mils in final thickness, with minimum 750 psi adhesion to concrete and a rapid cure time. The Contractor shall test the containment area for leaks before final acceptance.

Subsection 601.20 shall include the following:

Payment for Concrete Class D will be full compensation for all labor, equipment, and materials required to complete the work, including preparation of existing concrete surfaces, debris handling and disposal, small batch concrete production, and provision and application of paint, bonding, and sealing agents.

Painting the exposed surfaces of the new concrete to match the adjacent existing concrete surfaces and coating for the interior of the containment basin will not be measured and paid for separately, but shall be included in the work.

**REVISION OF SECTION 622
GENERATOR**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is the installation of diesel-fueled generator sets that are rated at 1750.0 kW and operate up to 15,000 VAC. Digital controls which are optimized for paralleling applications are included. The paralleling features described are appropriate for automatic paralleling with other generator sets on an isolated bus, as well as for utility paralleling applications. The codes and standards that are referenced are typical for North American applications and in accordance with these specifications and in conformity with the details shown on the plans or established.

MATERIALS

- (a) *Manufacturers*. The basis for this specification is Cummins Power Generation equipment; approved equals may be considered if equipment spatially fits and performance is shown to meet the requirements herein.
- (b) *Engine-Generator Set*.
1. Factory-assembled and -tested, engine-generator set.
 2. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 - A. Rigging Information: Indicate location of each lifting attachment, generator-set center of gravity, and total package weight in submittal drawings.
 3. Capacities and Characteristics:
 - A. Power Output Ratings: Electrical output power rating for standby operation of not less than 1750.0 kW, at 80 percent lagging power factor, 2400/4160, Wye, Three phase, 3-wire, 60 hertz.
 - B. Alternator shall be capable of accepting maximum 7926.0 kVA in a single step and shall be capable of recovering to a minimum of 90 percent of rated no load voltage, following the application of the specified kVA load at near zero power factor applied to the generator set.
 - C. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component. The engine-generator nameplate shall include information of the power output rating of the equipment.
 4. Generator-Set Performance:
 - A. Steady-State Voltage Operational Bandwidth: 0.5 percent of rated output voltage from no load to full load.
 - B. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 5 seconds. On application of a 100 percent load step, the generator set shall recover to stable voltage within 10 seconds.
 - C. Steady-State Frequency Operational Bandwidth: 0.25 percent of rated frequency from no load to full load.

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**REVISION OF SECTION 622
GENERATOR**

- D. **Steady-State Frequency Stability:** When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
- E. **Transient Frequency Performance:** Not more than 15 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within 5 seconds. On application of a 100 percent load step, the generator set shall recover to stable frequency within 10 seconds.
- F. **Output Waveform:** At full load, harmonic content measured line-to-line or line-to-neutral shall not exceed 5 percent total and 3 percent for any single harmonic. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50.
- G. **Sustained Short-Circuit Current:** For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 8 seconds without damage to generator system components. For a 1-phase, bolted short circuit at system output terminals, system shall regulate both voltage and current to prevent over-voltage conditions on the non-faulted phases.
- H. **Start Time:** Comply with National Fire Protection Association (NFPA) 110, Level 1, Type 10, system requirements.
- I. **Ambient Condition Performance:** Engine generator shall be designed to allow operation at full rated load in an ambient temperature under site conditions, based on highest ambient condition. Ambient temperature shall be as measured at the air inlet to the engine generator for enclosed units, and at the control of the engine generator for machines installed in equipment rooms.

(c) Engine.

- 1. **Fuel:** ASTM D975 #2 Diesel Fuel
- 2. **Rated Engine Speed:** 1800 RPM.
- 3. **Lubrication System:** The following items are mounted on engine or skid:
 - A. **Lube oil pump:** Shall be positive displacement, mechanical, full pressure pump.
 - B. **Filter and Strainer:** Provided by the engine manufacturer of record to provide adequate filtration for the prime mover to be used.
 - C. **Crankcase Drain:** Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- 4. **Engine Fuel System:** The engine fuel system shall be installed in strict compliance to the engine manufacturer's instructions.
- 5. **Main Fuel Pump:** Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.

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**REVISION OF SECTION 622
GENERATOR**

6. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and performance.
 - A. Designed for operation on a single 208 VAC, single phase, 60Hz power connection. Heater voltage shall be shown on the project drawings.
 - B. Installed with isolation valves to isolate the heater for replacement of the element without draining the engine cooling system or without allowing significant coolant loss.
 - C. Provided with a 24VDC thermostat, installed at the engine thermostat housing
7. Governor: Adjustable isochronous, with speed sensing. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate as appropriate to the state of the engine generator. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous states.
8. Cooling System: Closed loop, liquid-cooled, with remote radiator and integral engine-driven coolant pump.
 - A. The generator set manufacturer shall provide prototype test data demonstrating that the machine will operate at rated standby load in an outdoor ambient condition of 50 deg C.
 - B. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - C. Size of radiator overflow tank: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - D. Expansion tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - E. Temperature control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - F. Duct flange: Generator sets installed indoors shall be provided with a flexible radiator duct adapter flange.
9. Muffler/Disk Silencer: Selected with performance as Critical Grade Silencer for operation in a relatively quiet environment that requires a high level of silencing Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements. Miratech DCK2-Disk Critical Grade Silencer Typical Attenuation 22-36dB(A). Or Approved Equal.
10. Air-Intake Filter: Engine-mounted air cleaner with replaceable dry-filter element and restriction indicator.
11. Starting System: 12 or 24V, as recommended by the engine manufacturer; electric, with negative ground.
 - A. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum of 120 degrees Fahrenheit..
 - B. Cranking Cycle: As required by NFPA 110 for level 1 systems.

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**REVISION OF SECTION 622
GENERATOR**

- C. Battery Cable: Size as recommended by engine manufacturer for cable length as required. Include required interconnecting conductors and connection accessories.
- D. Battery Compartment: Factory-fabricated of metal with acid-resistant finish.
- E. Battery-Charging Alternator: Factory-mounted on engine with solid-state voltage regulation. The battery charging alternator shall have sufficient capacity to recharge the batteries with all parasitic loads connected within 4 hours after a normal engine starting sequence.
- F. Battery Chargers: Unit shall comply with UL 1236, provide fully regulated, constant voltage, current limited, battery charger for each battery bank. It shall include the following features:
 - (1) Operation: Equalizing-charging rate based on generator set manufacturer's recommendations shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - (2) Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 20 deg C to plus 40 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - (3) Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - (4) Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of AC input or DC output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - (5) LED indication of general charger condition, including charging, faults, and modes. Provide a LCD display to indicate charge rate and battery voltage. Charger shall provide relay contacts for fault conditions as required by NFPA110.
 - (6) Enclosure and Mounting: NEMA, Type 1, wall-mounted cabinet.

(d) *Fuel Oil Storage.*

- 1. Comply with NFPA 30.
- 2. Day Tank : Comply with UL 142, freestanding, factory-fabricated fuel tank assembly and the following features:
 - A. Allocation: A separate day tank shall be provided for each engine generator.
 - B. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - C. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day tank leak.
 - D. Tank Capacity: 150 gallon(s).

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REVISION OF SECTION 622
GENERATOR**

- E. Pump Capacity: Minimum 2 GPM with 20-foot lift, driven by ¼ HP, 120/240V 1-phase motor.
- F. Control: Provided with On/Off/Emergency run switch, Test/Reset Switch, AC Circuit Breaker, DC Circuit Breaker, and the following indicator lamps:
 - (1) Ready (Green) – AC Supply and DC Control Power Available.
 - (2) High Fuel (Red) – Latching fault, indicates fuel level near overflow, shuts down pump, and closes N/O dry contacts.
 - (3) Low Fuel (Red) – Latching fault, indicates pump failure or operating float switch failure, closes N/O dry contacts.
 - (4) Low Fuel Shutdown (Red) – Latching fault, indicates near empty tank, closes N/O contacts which may be used to shutdown engine generator to avoid air in the injection system.
 - (5) Overflow To Basin (Red) – Latching fault, indicates fuel in overflow/rupture basin, shuts down pump, closes N/O dry contacts.
 - (6) Spare (Red) – with N/O and N/C dry contacts.
 - (7) Pump Running (Green).
- G. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, and vent lines in compliance with NFPA 37 requirements for venting aboveground inside fuel storage tanks.

(e) Control and Monitoring.

1. Engine generator control shall be microprocessor-based and provide automatic starting, monitoring, protection and control functions for the unit.
2. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator set shutdown. (Switches with different configurations but equal functions are acceptable.) When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of the local (generator set-mounted) and/or remote emergency-stop switch also shuts down generator set.
3. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of the local (generator set-mounted) and/or remote emergency-stop switch also shuts down generator set.
4. Configuration: Operating and safety indications, protective devices, system controls, engine gages and associated equipment shall be grouped in a common control and monitoring panel. Mounting method shall isolate the control panel from generator-set vibration. AC output power circuit breakers and other output power equipment shall not be mounted in the control enclosure.

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REVISION OF SECTION 622
GENERATOR**

5. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
- A. AC voltmeter (3-phase, line-to-line and line-to-neutral values).
 - B. AC ammeter (3-phases).
 - C. AC frequency meter.
 - D. AC kW output (total and for each phase). Display shall indicate power flow direction.
 - E. AC kVA output (total and for each phase). Display shall indicate power flow direction.
 - F. AC Power factor (total and for each phase). Display shall indicate leading or lagging condition.
 - G. Ammeter-voltmeter displays shall simultaneously display conditions for all three phases.
 - H. Emergency Stop Switch: Switch shall be a red “mushroom head” pushbutton device complete with lock-out/tag-out provisions. Depressing switch shall cause the generator set to immediately stop the generator set and prevent it from operating.
 - I. Fault Reset Switch: Supply a dedicated control switch to reset/clear fault conditions.
 - J. DC voltmeter (alternator battery charging).
 - K. Engine coolant temperature gauge.
 - L. Engine lubricating oil pressure gauge.
 - M. Running-time meter.
 - N. Generator-voltage and frequency digital raise/lower switches. Rheostats for these functions are not acceptable. The control shall provide adjustment of these parameters in a range of plus or minus 5 percent of the voltage and frequency operating set point (not nominal voltage and frequency values). The voltage and frequency adjustment functions shall be disabled when the paralleling breaker is closed.
 - O. Fuel tank derangement alarm.
 - P. Fuel tank high-level shutdown of fuel supply alarm.
 - Q. AC Protective Equipment: The control system shall include over/under voltage, reverse kVAR, reverse kW, overload (kW) short circuit, over-current, loss of voltage reference, and over-excitation shut down protection. There shall be a ground fault alarm for generator sets rated over 1000 amps, overload warning, and over-current warning alarm.
 - R. Status LED indicating lamps to indicate remote start signal present at the control, existing shutdown condition, existing alarm condition, not in auto, and generator set running.
 - S. A graphical display panel with appropriate navigation devices shall be provided to view all information noted above, as well as all engine status and alarm/shutdown conditions (including those from an integrated engine emission control system). The display shall also include integrated provisions for adjustment of the gain and stability settings for the governing and voltage regulation systems.

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**REVISION OF SECTION 622
GENERATOR**

- T. Panel lighting system to allow viewing and operation of the control when the generator room or enclosure is not lighted.
- U. Data Logging: The control system shall log the latest 20 different alarm and shut down conditions, the total number of times each alarm or shutdown has occurred, and the date and time the latest of these shutdown and fault conditions occurred.
- V. DC control Power Monitoring: The control system shall continuously monitor DC power supply to the control, and annunciate low or high voltage conditions. It shall also provide an alarm indicating imminent failure of the battery bank based on degraded voltage recover on loading (engine cranking).

(f) Generator Overcurrent and Fault Protection.

1. Generator Overcurrent Protection: The generator set shall be provided with a UL Listed/CSA Certified protective device that is coordinated with the alternator provided to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine. The protective device shall be listed as a utility grade protective device under UL category NRGU. The control system shall be subject to UL follow-up service at the manufacturing location to verify that the protective system is fully operational as manufactured. Protector shall perform the following functions:
 - A. Initiates a generator kW overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator set malfunction alarms.
 - B. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110 percent of rated current for more than 10 seconds.
 - C. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator.
 - D. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.
 - E. Senses clearing of a fault by other over-current devices and controls recovery of rated voltage to avoid overshoot greater than 120 percent of nominal voltage.
 - F. The protective system provided shall not include an instantaneous trip function.

(g) Generator, Exciter, and Voltage Regulator.

1. Comply with NEMA MG 1.
2. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
3. Electrical Insulation: Class H.
4. Temperature Rise: 125 / Class H environment.
5. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over-speed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
6. Permanent Magnet Generator (PMG) shall provide excitation power for optimum motor starting and short circuit performance.

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REVISION OF SECTION 622
GENERATOR**

7. Enclosure: Drip-proof.
 8. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified. The voltage regulation system shall be microprocessor-controlled, 3-phase true RMS sensing, full wave rectified, and provide a pulse-width modulated signal to the exciter. No exceptions or deviations to these requirements will be permitted.
 9. The alternator shall be provided with anti-condensation heater(s) in all applications where the generator set is provided in an outdoor enclosure, or when the generator set is installed in a coastal or tropical environment.
 10. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding. Alternators operating at voltage higher than 690 VAC shall be provided with form-wound stator coils.
 11. Subtransient Reactance: 13 percent maximum, based on the rating of the engine generator set.
- (h) *Vibration Isolation Devices.* Generators installed on grade shall be provided with elastomeric isolator pads integral to the generator, unless the engine manufacturer requires use of spring isolation.
- (i) *Finishes.* Components: Powder-coated and baked over corrosion-resistant pretreatment and compatible primer. Manufacturer's standard color or as directed on the drawings.
- (j) *Source Quality Control.*
1. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - A. Tests: Comply with NFPA 110, Level 1 Energy Converters. In addition, the equipment engine, skid, cooling system, and alternator shall have been subjected to actual prototype tests to validate the capability of the design under the abnormal conditions noted in NFPA110. Calculations and testing on similar equipment which are allowed under NFPA110 are not sufficient to meet this requirement.
 2. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 - A. Test engine-generator set manufactured for this Project to demonstrate compatibility and functionality.
 - B. Full load run.
 - C. Maximum power.
 - D. Voltage regulation.
 - E. Steady-state governing.
 - F. Single-step load pickup.
 - G. Simulated safety shutdowns.
 - H. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.

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REVISION OF SECTION 622
GENERATOR

CONSTRUCTION REQUIREMENTS

(a) *Installation.*

1. Installation shall comply with packaged engine-generator manufacturers' written installation, application, and alignment instructions and with NFPA 110.
2. Equipment shall be installed by the Contractor in accordance with final submittals and Contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.
3. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The Contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
4. Equipment shall be installed on concrete pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer's instructions and seismic requirements of the site.
5. Equipment shall be initially started and operated by representatives of the manufacturer. All protective settings shall be adjusted as instructed by the consulting engineer.
 - A. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to initial operation and final testing of the system.
 - B. On completion of the installation by the electrical Contractor, the generator set supplier shall conduct a site evaluation to verify that the equipment is installed per manufacturer's recommended practice.

(b) *On-Site Acceptance Test.*

1. The complete installation shall be tested to verify compliance with the performance requirements of this specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests. The generator set manufacturer shall provide a site test specification covering the entire system.
2. Prior to start of active testing, all field connections for wiring, power conductors, and bus bar connections shall be checked for proper tightening torque.
3. Installation acceptance tests to be conducted on site shall include a "cold start" test, a two hour full load (resistive) test, and a one-step rated load pickup test in accordance with NFPA 110. Provide a resistive load bank and make temporary connections for full load test, if necessary.
4. A power failure test shall be performed on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.

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REVISION OF SECTION 622
GENERATOR**

- (c) *Training.* The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the facility owner.
- (d) *Field Quality Control.* Manufacturer's Field Service: The Contractor shall engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- (e) *Service and Support.*
 - 1. The generator set supplier shall maintain service parts inventory for the entire power system at a central location which is accessible to the service location 24 hours per day, 365 days per year. The inventory shall have a commercial value of \$3 million or more. The manufacturer of the generator set shall maintain a central parts inventory to support the supplier, covering all the major components of the power system, including engines, alternators, control systems, paralleling electronics, and power transfer equipment.
 - 2. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical power system replacement parts in the local service location. Service vehicles shall be stocked with critical replacement parts. The service organization shall be on call 24 hours per day, 365 days per year. The service organization shall be physically located in Colorado within a 200 mile radius of Hanging Lake Tunnel.
 - A. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

METHOD OF MEASUREMENT

The Generator will be measured by the unit as shown in the Plans, complete and accepted.

BASIS OF PAYMENT

The accepted quantities of generators will be paid for at the contract unit price for the pay item listed below.

Payment will be made under:

Pay Item	Pay Unit
Generator	Each

Payment for Generator will be full compensation for providing, transporting, and installing the generator set described in the this special provision, including the engine and all components (day tank, remote radiator, day tank piping, generator controls, installation, testing, operator training, service).

**REVISION OF SECTION 622
TESTING**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is testing in accordance with these specifications and in conformity with the details shown on the plans or established.

All equipment furnished and installed under this Contract shall be tested as indicated in the Contract Drawings, or specified herein.

The Contractor shall perform all tests as may be necessary to demonstrate that the installed equipment complies with the Contract requirements. The Contractor shall provide all labor, instruments, and apparatus required for the tests. If testing indicates that the equipment fails to meet the Contract requirements or to function properly, the defects shall be rectified by readjusting or removing and replacing the faulty equipment until testing indicates the Contract requirements are met. The Engineer may check the Contractor's instruments or furnish his own instruments.

All tests shall be performed in conformity with the standard test codes of the applicable association(s) specified in paragraph 1.2 Factory Tests, and shall be witnessed by the Engineer.

All measuring instruments shall be of the precision type and be calibrated immediately before and immediately after the tests. All instruments and other facilities, including labor, for the tests shall be provided by the Contractor. The Engineer may check the Contractor's instruments or furnish his own instruments.

The Contractor shall furnish and install all necessary testing apparatus including but not limited to: calibrated meters, gauges, fittings, and thermometers. All apparatus supplied by the Contractor for these tests shall remain his property and shall be removed by him after the tests.

The Contractor shall submit test procedures for the approval of the Engineer, showing in complete detail the manner in which it proposes to perform each test.

The Contractor shall provide full documentation and certifications of all tests performed.

Subsection 622.03 shall include the following:

(a) Factory Tests.

1. All equipment, emergency generator, remote radiator, apparatus and materials of construction, shall be tested at the place of manufacture.
2. All necessary ratings, capacities, calibration, temperature in operation, and other characteristics shall be obtained by methods in accordance with the standard test codes of the applicable associations including but not limited to the Air Movement and Control Association, the Air Conditioning and Refrigeration Institute, the American Society of Heating, Refrigerating and Air Conditioning Engineers, the American National Standards Institute, Underwriters Laboratories, the Institute of Electrical and Electronics Engineers. Six copies of these certified ratings, etc., shall be submitted for the approval of the Engineer. No material or apparatus shall be shipped to the work unless approved by the Engineer.

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REVISION OF SECTION 622
TESTING**

(b) *Field Tests.*

1. Field tests shall be conducted on all electrical equipment which are not assembled at the shop to demonstrate the soundness and suitability of the materials and the adequacy of the workmanship of the installation work. In addition, performance tests shall be conducted on the plant as a whole, upon its major subdivisions as required by the Engineer, in conformity with the standard test codes of the applicable association(s) specified in Paragraph 1.2, Factory Tests. All measuring instruments shall be of the precision type and shall be calibrated immediately before and immediately after the tests. All instruments and other facilities, including labor, for the tests shall be provided by the Contractor.
2. The Contractor shall furnish and install all necessary testing apparatuses including but not limited to calibrated electrical meters, gauges, fittings, and thermometers. All the foregoing apparatuses supplied by the Contractor for these tests shall remain the property and shall be removed by him after the tests are completed to the satisfaction of the Engineer.
3. The Contractor shall submit, for the approval of the Engineer, test procedures showing in complete detail the manner in which it proposes to perform each test.
4. All defects in the new systems shall be corrected to the satisfaction of the Engineer. All equipment shall be re-tested after the correction of defects.
5. The Contractor shall make insulation resistance and ground tests of all wiring installed under this Contract in conformity with the requirements of this section and elsewhere specified herein during the progress of the work, and at the time specified by the Engineer. These tests shall be conducted in the presence of the Engineer prior to connection to equipment.
6. Apparatus such as but not limited to circuit breakers, contactors, motor starters, and push-button stations shall be checked for free movement and alignment of parts and contacts.
7. The grounding system shall be tested and verified with accepted methods and standards by actual measurements in the field. The proposed method of measurement shall be submitted for approval.
8. A performance test shall be made to verify proper electrical operation of all power and control circuits and electrical apparatus.
9. After installation, performance tests shall be made on the plant as a whole, upon its major subdivisions, and as required by the Engineer. The tests shall be performed with all rated loads connected.
10. Similar tests shall be performed on the emergency equipment with all rated emergency loads connected.
11. Motors shall be checked for proper rotation and for balancing of the currents in all three phases.
12. All tagging shall be verified as meeting all relevant specifications as listed in the Contract Documents.
13. All electrical bolted connections shall be tightened by the calibrated torque method in compliance with the manufacturer's requirements. Where the manufacturer has no requirements the connections shall be torqued as required by the NEC. Torqueing shall be witnessed and verified by the Engineer.
14. After splicing wiring but before the application of insulation, the Contractor shall perform a resistance test across the splice, using a minimum ten (10) ampere DC test current. Resistance shall be within 5 percent of the equivalent conductor DC resistance.

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REVISION OF SECTION 622
TESTING**

(c) Electrical Tests after Installation.

1. All electrical equipment, including wire and cable, shall be tested after completion of installation in accordance with the following:
 - A. All wiring shall be installed such that when completed, the system shall be free from shorts, crosses or grounds.
 - B. All cables sizes larger then AWG #10 shall be tested for insulation as per NETA, Inc. The tests shall be performed on each conductor with respect to ground and adjacent conductors. All cables shall be tested with 1000 volts DC. Test duration shall be one minute.
 - C. The insulation resistance values shall be as per manufacturer's published data. If manufacturer's data is not available, the insulation resistance values shall not be less than the following:
 - (1) For 208V Equipment: 25 Megohms at 500V DC
 - (2) For 480V up to 1000V: 100 Megohms at 1000V DC
2. The above values shall be measured with all switchboards, panel boards, cutouts, and other safety devices installed.
3. The Contractor shall make tests as necessary, including polarity test of the sockets, to demonstrate that all installed equipment complies with the Contract requirements. The Contractor shall provide all labor, calibrated instruments and apparatus required for tests. If any of the equipment fails under test to meet the Contract requirements or to function properly, the defects shall be rectified by readjusting, or removing and replacing, the faulty equipment until under test, the requirements are met. The Engineer may check the Contractor's instruments or furnish its own instruments.

(d) Acoustical Testing.

1. Equipment: All data shall be obtained and derived using a calibrator, sound level meters, tape recorders, octave band analyzer and a graphic level recorder. Tape recording of minimum two-minute duration shall be made in the field through a sound level meter for all tests. Subsequently, the tape recording shall be replayed in the laboratory, where a graphic record shall be made on a graphic level recorder. For octave band analysis, a graphic record of at least a fifteen-second duration shall be made for each of eight octave bands. Other equipment and test methods shall be used only if they have received the written approval of the Engineer.
2. Test Procedures and Laboratory Work: Prior to conducting acoustical tests, the Contractor shall submit full details of the proposed field test methods, laboratory work, and a complete list of all equipment to be used both in the field and in the laboratory. Each item of equipment listed shall include the manufacturer's name, model number, input and output sensitivity, accessories and other pertinent data.
3. Test Data: The following data shall be obtained and submitted for each test.
 - A. Sound Level, dB(A) Re .0002 microbar.
 - B. Octave Band Analysis, sound pressure level, dB Re .002 microbar versus frequency in eight octave bands; center frequencies shall be from 63 hertz to 8,000 hertz inclusive. The Octave Band Analysis shall be plotted on NC graph paper.

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REVISION OF SECTION 622
TESTING**

Subsection 622.27 shall include the following:

Testing of equipment will not be measured and paid for separately, but shall be included in the price of the Generator.

**REVISION OF SECTION 622
ELECTRICAL MODIFICATIONS**

Section 622 of the Standard Specifications is hereby revised for this project as follows:

Subsection 622.01 shall include the following:

This work is Electrical Modifications in accordance with these specifications and in conformity with the details shown on the Contract Drawings or herein.

The Contractor shall furnish all labor, materials, tools and equipment necessary for electrical work as indicated on the Contract Drawings or specified herein. The work shall include but not be limited to the following:

1. The maintenance of all existing electrical feeders, circuits, and equipment disturbed during the process of construction that will not be removed, relocated or replaced.
2. Making all changes, additions, and connections as indicated or required for a completed electrical system.
3. The furnishing and installation of all material and equipment necessary for a complete emergency generator electrical system including but not limited to the following:
 - A. 1750kW Emergency Generator and controls cabinet.
 - B. Combination Motor Starters SF-1, AH-4, EF-3, and Generator Cooling Fan.
 - C. Adjustment of trip settings of circuit breakers in Switchboard 6C.
 - D. New 3 pole circuit breaker in Panel 6H.
 - E. Receptacles and switches.
 - F. Conduits, boxes, and fittings.
 - G. Wire and Cable. (5kV and 600V)
 - H. Rubber mats.
 - I. Controls integration and testing.
 - J. Any other electrical work indicated or specified.

All wiring shall be placed in rigid steel heavy wall conduit and shall comply with the specifications for conduits, outlet boxes, pull and junction boxes, wires and cables, grounding, etc., as set forth in these specifications and as noted herein.

The electrical work shown on the Contract Drawings and to be performed under this section of the specifications is related but not limited to the following sections:

- Revision of Section 622 - Wires, Cables, Splices, Terminations (600 Volts or Less),
- Revision of Section 622 - Wires, Cables, Splices, Terminations (Medium Voltage: 601 Volts to 34,500 Volts, Inclusive),
- Revision of Section 622 - Boxes and Fittings (Revision of Section 622), and
- Revision of Section 622 - Testing.

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**REVISION OF SECTION 622
ELECTRICAL MODIFICATIONS**

MATERIALS

(a) Wiring.

1. Liquid tight flexible conduit shall be used for final connection to all vibrating electrical equipment such as motors etc. and shall be limited to four feet in length.
2. Separate ground wire (with power wires) shall be provided from switchboard and panelboard to each motor load. The ground wire shall be sized according to the applicable code.

(b) Rubber Mats. Three-foot-wide rubber mats shall be furnished and installed on the floor of generator and mechanical rooms in front of combination starters and adjacent to the combination starter for the generator cooling fan. These mats shall be placed at the front of the aforementioned electrical equipment and be of adequate length to cover the full width of the equipment. Where equipment is mounted along a continuous surface with less than one foot separation, the rubber matting shall provide a continuous strip under the equipment. The mats shall be 1/2-inch thick with beveled edges, canvas back, solid type with corrugations running the long way, and be guaranteed extra quality, free from cracks, blow holes or other defects detrimental to their mechanical or electrical strength. They shall meet the requirements of ASTM D178, "Type 2", "Class 4" with ozone, flame, and oil resistive properties.

(c) Hardware for Mounting Equipment. Hardware for mounting equipment shall be high strength (100 percent rust resistant) and conform to the latest American Standards and Practices. Samples shall be submitted for approval. The Engineer shall decide on one or more types and shall direct the Contractor to guide himself accordingly in the usage at specific locations. All screws and bolts shall be stainless steel with stainless steel nuts where required.

CONSTRUCTION REQUIREMENTS

(a) General.

1. Existing Circuits: Where the Contractor disturbs existing circuits, all wires shall be disconnected in the boxes and the exposed ends taped and tagged.
2. Existing Conditions: The Contractor, before submitting his proposal, shall visit the site and be responsible for having ascertained local conditions such as but not limited to the location, accessibility, and general character of the site, the character and extent of any existing work within or adjacent to the site, and any other work being performed on the site at the time of submitting his proposal. The Contractor shall fully examine all drawings relating to the work and become completely informed as to the extent and character of the work required and prevailing existing conditions. No allowances shall be made for the Contractor's failure to avail himself of information.
 - A. It is anticipated that several branch circuit conduits and lights may have to be rerouted, extended, relocated, or temporarily removed and replaced, to permit the installation or removal of equipment. The Contractor shall review all removal drawings and allow for the rerouting or relocation of wiring systems and devices to remain which shall be relocated or rerouted. The Contractor shall allow for and accomplish these re-work items to suit field requirements and conditions.
 - B. When working with existing equipment or wiring systems, care shall be taken to avoid damage to equipment. Prior to working in an area, the Contractor shall examine existing conditions. Any defects caused by the Contractor shall result in the Contractor being held liable for damage to existing equipment.

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**REVISION OF SECTION 622
ELECTRICAL MODIFICATIONS**

- C. Where new construction involves connecting to or using existing equipment, the Contractor shall include all work and materials required to adapt, extend, or re-work the prevailing existing "As Is" condition, to the new work. Should an existing condition prove to be grossly deteriorated or inadequate for modification, that condition shall be reported to the Engineer for a remedy.
- 3. Locations - Approximate: The locations of equipment, boxes, switches, outlets, and similar objects as shown on the Contract Drawings are approximate only, and exact locations shall be determined in the field. In case of interference with other work or of erroneous locations with respect to equipment or structures, the Contractor shall furnish all labor and materials to complete the work in an approved manner, at no additional cost to CDOT.
- 4. Drawings - Diagrammatic: Conduits and wiring are shown diagrammatically only. The Contractor shall furnish, install, and place in satisfactory condition ready for operation, all conduits, cables, and other material needed for installation and operation of the emergency generator, day fuel tank, supply air fan, combustion air fan, exhaust air fan, associated dampers, and other electrical systems shown or indicated in the Contract Documents. Additional conduits and required wiring shall be installed by the Contractor where necessary to complete the installation of the equipment furnished and to meet NEC requirements at no additional cost to CDOT.
- 5. Painting: All shop painting shall be accomplished at the manufacturer's facilities meeting ANSI standards and shall be included in the bid price for equipment and materials furnished under this division. All scratched or base surfaces of factory-painted equipment shall be touched up with the same color and type of paints as used originally.
- 6. Close out Procedures: General coordination is required. Close out procedures shall be sequenced properly such that work shall not be endangered or damaged, and every required performance shall be fully tested and demonstrated.
 - A. System performance test runs are required. Test runs of electrical systems shall be coordinated with test runs of equipment served.
 - B. During test runs, the Contractor shall make final corrections or adjustments of systems to refine and improve performances where possible, including noise and vibration reductions, elimination of hazards, better response of controls, signals and alarms, and similar system performance improvements.
 - C. Cleaning and lubrication is required. After final performance test run of each electrical system, the Contractor shall clean systems both externally and internally and comply with manufacturer's instructions for lubrication. The Contractor shall remove excess lubrication and touch up minor damage to factory-painted finishes.
- 7. Documentation Procedures: Signed commitments are required. The transfer of electrical system to CDOT for operation shall not proceed until guarantees, warranties, performance certifications, maintenance agreements, and similar commitments to be signed by the Contractor and other entities have been executed and transmitted to the Engineer for placement in records.

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**REVISION OF SECTION 622
ELECTRICAL MODIFICATIONS**

8. The Contractor shall furnish and install all electrical equipment, materials and labor, machinery, tools, transportation, procurement of all necessary permits, certificates, and other incidental services, whether described in these specifications and drawings or not, to provide a satisfactory operating and complete electrical installation.
9. The Contractor shall perform all operations necessary to install, adjust, and put into satisfactory operation all electrical equipment.
10. The Contractor shall provide and install conduits, cable and electrical connections, adjustments, and test of mechanical equipment which requires electrical power.
11. The Contractor shall provide and install all required systems and equipment grounding as required to properly ground all systems and equipment in conformance with the latest requirements of NEC and best modern practice using the existing grounding system.
12. The specifications and Contract Drawings are complementary; items shown in one, but not in the other shall be as binding as if included in both. Where a discrepancy exists between specifications and drawings and/or drawings and drawings, the Contractor shall assume the most expensive material or method of installation for bidding purposes and shall refer the discrepancy to the Engineer for a decision.
13. Before cutting or removing any existing cable, the Contractor shall ensure the cable has been properly identified, de-energized, grounded, or otherwise made safe.
14. All electrical equipment enclosures shall have no knockouts, nor shall they be drilled for more than the actual conduits entering them. All electrical equipment shall be made to minimize equipment size.
15. For existing electrical equipment shown on drawings as relocated and reused, the Contractor shall extend the existing raceways or conduits and wire of the same size, type, and number where required to reach the new location of the equipment.
16. All floor-mounted electrical equipment such as the emergency generator shall be installed on a concrete pad as indicated on the Contract Drawings. The pad shall be extended four inches beyond the base plan of the equipment or as shown on the Contract Drawings.
17. All electrical equipment shall be installed on hot dipped galvanized steel channel 1½" X 1½" 12 gauge thick with holes on the web. All channels installed for mounting lighting fixtures, troughs and conduits shall be 1½" X 1½" 12 gauge thick with rod, fitted with a metallic shroud and painted (color to match fixture, trough and steel channel) with lock washer, and hexagonal nuts.
18. It is anticipated that several branch circuit conduits and/or lights shall have to be rerouted, extended, relocated, or temporarily removed and replaced to permit the installation or removal of equipment. The Contractor shall reconnect and re-feed all lighting fixtures located in the generator room which are disconnected during the work. He shall review removal drawings and allow for the rerouting or relocation of wiring systems and devices which are to remain and be relocated or rerouted. The Contractor shall allow for and accomplish these re-work items to suit field requirements and conditions.
19. All exposed conduit shall run in a neat, inconspicuous, and workmanlike manner. This work shall be performed to the satisfaction of the Engineer.

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**REVISION OF SECTION 622
ELECTRICAL MODIFICATIONS**

20. All feeders shall be in one continuous length without a splice or joint.

The Contractor shall prepare the following shop drawings (scale 1/4" = 1' and size 24" x 36"), based on the one line diagram and electrical distribution and room layouts, and shall submit to the Engineer for approval:

- A. Detailed plan view showing all electrical equipment, ceiling mounted conduits, pull boxes, etc.
- B. Elevation of all walls showing equipment height, clearance between them, pull boxes, and conduit routing.

21. All electrical equipment shall be installed to permit easy access for inspection, operation, maintenance, and repair in accordance with manufacturer's recommendations and as directed by the Engineer.

22. The approval of shop drawings will be general and will not relieve the Contractor of responsibility for the accuracy of the drawings, nor for the proper fitting and construction of the work, nor of the furnishing of materials or work required by the Contract and not indicated on the shop drawings. Approval of shop drawings shall not be construed as approving departures from the Contract Drawings, supplementary drawings, or specifications.

(b) *Surface Raceway and Wireway Installations.* The surface raceway system shall be installed in an approved and workmanlike manner to make the system as inconspicuous as possible. Where standard lengths are required to be cut or mitered to suit the field conditions, proper tools as recommended by the manufacturer shall be used to attain smooth edges, accurate bends, and offsets. Runs shall be parallel or at right angles to walls and partitions. Each surface raceway section shall be independently and securely supported to the structure in an approved manner.

- 1. Connections shall be made to other types of raceways in an approved manner with fittings manufactured for the purpose and application. Flat tees, crosses, or utility boxes shall be installed where required to accommodate branch circuits. Bushings shall be installed where a raceway enters a terminal fitting. Where the surface raceway systems enters the rigid conduit system, conduit connectors as manufactured by the Wiremold Company, or approved equal, together with all necessary fittings shall be installed.
- 2. Detail drawings, showing the various proposed methods of installation of the surface raceways, shall be submitted for the approval of the Engineer. The Contractor shall not proceed with the installation of any surface raceways before approval is obtained.

(c) *Clean Up.* The Contractor shall be responsible for cleaning of the worksite during progress of the work, including periods when work is suspended, and at completion of the work.

- 1. Requirements of Regulatory Agencies: In addition to the requirements herein, the Contractor shall maintain the cleanliness of the work and surrounding premises within the work limits to comply with federal and local fire and safety laws, ordinances, codes and regulations. Comply with all federal and local anti-pollution laws, ordinances, codes and regulations when disposing of waste materials, debris, and rubbish.
- 2. Protection of Painted Surfaces: The Contractor shall schedule cleaning and disposal operations so that dust, wash water, or other contaminants generated during such operations do not damage or mar painted or finished surfaces and to prevent accumulation of dust, dirt, debris, rubbish, and waste materials on or within the work or on the premises surrounding the work.

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**REVISION OF SECTION 622
ELECTRICAL MODIFICATIONS**

3. **Waste Material Disposal:** The Contractor shall dispose of all waste materials, surplus materials, debris and rubbish from the project site. Do not burn or bury rubbish and waste materials on the project site, nor dispose of volatile or hazardous wastes such as mineral spirits, oil, or paint thinner in storm or sanitary drains.
 4. **Cleaning Materials:** The Contractor shall use only cleaning materials recommended by manufacturer of surface to be cleaned. Use each type of cleaning material on only those surfaces recommended by the cleaning material manufacturer. Use only materials which shall not create hazards to health or property.
 5. **During Construction:** The Contractor shall keep the work and surrounding premises within work limits free of accumulations of dirt, dust, waste materials, debris, and rubbish. Keep dust-generating areas wetted down. Provide suitable containers for storage of waste materials, debris and rubbish until time of disposal. Dispose of waste, debris and rubbish off site at legal disposal areas.
 6. **Upon Completion:** The Contractor shall remove and dispose of all excess or waste materials, debris, rubbish, and temporary facilities from the site, structures, and all facilities. Repair all areas affected by the construction and restore them to original condition or to minimum condition specified in the Contract Documents. Remove spatter, grease, stains, fingerprints, dirt, dust, labels, tags, packing materials, and other foreign items or substances from interior and exterior surfaces, equipment, signs, and lettering. Repair, patch and touch-up chipped, scratched, dented, or otherwise marred surfaces to match specified finish. Remove paint, clean, and restore all equipment and material nameplates, labels, and other identification markings. Clean all walls, floors, slabs, pavements, and ground surfaces, and maintain cleaning until substantial completion.
- (d) *Testing.* The Engineer reserves the right to require such tests, after installation, as in his opinion may seem adequate and reasonable to demonstrate that the work has been properly performed. All apparatus, labor, and other facilities necessary to perform tests shall be provided by the Contractor. Any work deemed by the Engineer to be defective shall be replaced. The Contractor is required to submit documents and perform tests as requested by the Engineer. Proper documentation includes but is not limited to: A (certifications), B (visual inspection & mechanical tests), and C (electrical tests) for the systems and system components.

METHOD OF MEASUREMENT

Electrical Modifications will not be measured, but will be paid for on a lump sum basis.

BASIS OF PAYMENT

The completed and accepted work for the Electrical Modifications will be paid for at the contract lump sum price for the pay item listed below.

Payment will be made under:

Pay Item	Unit
Electrical Modifications	Lump Sum

**REVISION OF SECTION 622
ARCPROOFING**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is arcproofing low and medium voltage cables in accordance with these specifications and in conformity with the details shown on the plans or established.

MATERIALS

(a) *Arcproofing Materials.* Material shall meet the following requirements:

1. Fire Resistant Tape shall be Scotch (3M) No. 77 or approved equal.
2. Glass Cloth Tape shall be Scotch (3M) No. 69 or approved equal.
3. Cable Tags
 - A. Stainless steel metal tags, No. 28 gauge and 3/4 inch wide, embossed with letters and numbers 5/16 inch high, fastened to the cable at both ends of tags with nominal 1/16 inch diameter monel metal wire or stainless steel cable ties.

CONSTRUCTION REQUIREMENTS

(a) *Examination.* Tape shall be inspected prior to installation. Defective tape shall be discarded.

(b) *Installation.* Arcproofing shall be installed as follows:

1. Arcproof all wire and cables operating at greater than 600 volts (line to line).
2. Wires and cables shall be grouped by circuit and arcproofing applied over the group of cables comprising one circuit. Splices shall be arcproofed individually and the taping shall join with and be overlapped by the group taping.
3. Arcproofing shall be applied in two wrappings of half-lapped tape, bound with glass cloth tape applied at the ends of the fire resistant tape and at intervals not to exceed 24 inches along the entire length of the cables. The two wrappings shall be wrapped with opposing lays.
4. Arcproofing shall be extended into the conduit opening or end bell of the raceway entering a handhole, manhole or box.
5. Arcproofing tape shall be 1-1/2 inch wide where the diameter of the individual cable, or the circumscribed circle for the circuit group, is less than 1-3/4 inches. For larger diameters, the tape shall be 3 inches wide.

(c) *Identification of Wires and Cables.*

1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, handholes, and other enclosures, and at all terminal points.
2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.
3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.
4. Wires and cables that are arcproofed shall be identified outside of the applied arcproofing.

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**REVISION OF SECTION 622
ARCPROOFING**

(d) *Adjustments.* Prior to final inspection, arcproofing that has been disturbed, for any reason, shall be reinstalled or replaced, as determined by the Engineer, as soon as possible.

METHOD OF MEASUREMENT

Arcproofing will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
BOXES AND FITTINGS**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is installation of electrical boxes and fittings in accordance with these specifications and in conformity with the details shown on the plans or established.

MATERIALS

(a) General.

1. Locations, types and sizes of boxes and fittings are shown on the Contract Drawings.
2. Boxes and fittings shall be metallic, unless otherwise shown on the Contract Drawings, and shall conform to NEMA OS1, NEMA 250, UL 50, UL 514A, UL 514B, and National Fire Protections Association (NFPA) 70.
3. Nonmetallic boxes and fittings shown on the Contract Drawings shall conform to NEMA OS2, NEMA 250, UL 50, UL 514C, and NFPA 70.
4. Boxes and fittings to be located in hazardous (classified) areas as shown by "area plans" on the Contract Drawings shall conform to UL 886 and NFPA 70.
5. All electrical materials and equipment for which there are established UL standards shall bear the UL label.
6. Where the sizes or dimensions of a box are not shown on the Contract Drawings, all boxes, whether for use on power, communications, signaling, control, telephone, or other purposes, shall be sized as follows:
 - A. In straight pulls, the length of the box shall not be less than eight times the trade diameter (nominal inside diameter) of the largest raceway.
 - B. Where angle or "U" pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than six times the trade diameter of the largest raceway. The distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries in any row on the same wall of the box. The distance between raceway entries enclosing the same conductor shall not be less than six times the trade diameter of the larger raceway.
 - C. Where a conduit entry is in the wall of a box opposite a removable cover, the minimum distance between the entry and the cover shall be as follows:

Conduit Size	Distance Between Entry and Cover
Up to 1-1/4 inch	4 inches
1-1/4 inch and 1-1/2 inches	6 inches
2 inches and 2-1/2 inches	8 inches
3 inches and larger	12 inches

- D. The minimum depth of a box shall be not less than two times the trade diameter of the conduit entries in a single row and not less than 1-1/2 times the sum of the trade diameter of the largest raceway in each row for multiple rows.

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**REVISION OF SECTION 622
BOXES AND FITTINGS**

7. Weatherproof cast boxes shall be used for exterior or damp locations. Weatherproof boxes shall be hot-dipped galvanized cast-steel or cast-aluminum. Cast boxes shall be threaded conduit entrance type provided with mounting lugs. Materials shall match the type of conduit i.e., galvanized steel or aluminum, used in the conduit run.
 8. Covers for boxes located in public spaces or where shown on the Contract Drawings shall be furnished with tamper-resistant hardware.
 9. Cover plates for outlet boxes shall be stainless steel grade 302.
- (b) *Interior Outlet and Device Boxes.* Provide galvanized, flat-rolled, sheet-steel interior outlet wiring boxes, of types, shapes and sizes, including box depths, to suit each respective location and installation; construct boxes with stamped knockouts in back and sides and with threaded screw holes with corrosion-resistant screws for securing box covers and wiring devices.

Outlet boxes shall be of proper sizes and shapes for conduits and wires entering them, and equipped with plaster ring or cover as necessary for the wiring devices to be installed. Boxes for switches and receptacles shall be 4-inch square, minimum 2 1/8-inch deep, for up to two devices; solid, ganged boxes for over two devices; and installed so that device covers shall be tight and plumb with wall finish. Provide suitable barrier in boxes where two or more 277-volt switches are to be installed, to isolate each on its own phase. Boxes for lighting fixture installation shall be 4-inch square, minimum 2 1/8-inch deep, and provided with 3/8-inch studs.

Boxes to be installed in ceilings, plenums, or spaces used for supply or return of environmental air shall be UL-listed for such use, without holes, openings or penetrations, and complete with gasketed cover plates. Provide all sheet-steel boxes with suitable knockouts.

(c) *Junction and Pull Boxes*

1. General

- A. Unless otherwise shown on the Contract Drawings, the Contractor shall provide galvanized, code-gauge, sheet-steel junction and pull boxes and covers for interior locations and cast-metal boxes and covers for exterior locations of types, shapes and sizes to suit each respective location and installation, and equipped with stainless steel hinges, nuts, bolts, screws and washers.
- B. Junction or pull boxes having any dimension larger than 36 inches shall contain racks or supports for all cables or conductors.
- C. The Contractor shall provide pull boxes with suitable insulating barriers where shown on the Contract Drawings or required by code. Vertical-offset pull boxes shall contain cable supports at turns to prevent cables from resting on corners.
- D. Where shown on the Contract Drawings, the Contractor shall provide boxes with provisions for padlocking.
- E. Special boxes shall be as shown on the Contract Drawings.
- F. Where shown on the Contract Drawings, catches or vault handles shall be lockable. Locks shall be keyed alike for the same service, such as power, communications, signal or telephone. Each service type shall be keyed differently.
- G. All covers in exposed exterior locations, or other areas as shown on the Contract Drawings, shall be gasketed.

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**REVISION OF SECTION 622
BOXES AND FITTINGS**

- H. For covers heavier than 20 pounds or more than 24 inches in any dimension, the Contractor shall provide two replaceable studs, located on each side of the box flange, to support the cover during installation.
- I. Boxes containing, or designated for, conductors operating at greater than 600 volts (phase-to-phase) shall be constructed of minimum 12-gauge steel.

2. Interior Junction and Pull Boxes

A. Finished Areas

- (1) Junction and pull boxes, located in finished areas and having any dimension larger than 12 inches, shall be furnished with flush-mounting, lockable, hinged covers, similar to adjacent panelboard cabinets. Locks shall be keyed alike for the same service, such as power, communications, signal or telephone. Each service type shall be keyed differently. Hinged covers shall contain catches to keep covers closed. Covers having any dimension larger than 36 inches and all multiple-section doors shall contain three-point vault handles. Covers shall be furnished shop-primed for field painting, and shall be finished with a color as selected by the Engineer.
- (2) Boxes having any cover dimension 12 inches or less shall be furnished with flush-mounting, screw-on covers, unless otherwise shown on the Contract Drawings.

B. Unfinished Areas

- (1) Junction and pull boxes, located in electrical or telephone closets or rooms, in mechanical equipment rooms, in areas above hung or accessible ceilings, or in areas shown on the Contract Drawings as "unfinished," shall be furnished with screw-on covers for boxes having any cover dimension 24 inches or less, and with either single or multiple-section hinged covers for boxes having any cover dimension larger than 24 inches.
- (d) *Conduit Bodies.* The Contractor shall provide galvanized, cast-metal, conduit bodies, of types, shapes and sizes to suit each respective location and installation; construct with threaded-conduit entrance hubs, removable covers, and stainless steel or brass screws.
- (e) *Bushings, Locknuts and Knockout Closures.* The Contractor shall provide corrosion-resistant knockout closures and conduit locknuts, and insulated, malleable iron, conduit bushings and offset connectors, of types and sizes to suit each respective use and installation.
- (f) *Supporting Devices.* The Contractor shall provide inserts, expansion shield lugs, bolts with nuts and washers, shims, or any other type of fastening devices required to secure boxes, in accordance with Supporting Devices (Revision of Section 622). Unless otherwise shown on the Contract Drawings, all fasteners shall be hot-dipped galvanized and of sizes and types recommended by the equipment manufacturer and as approved by the Engineer.

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**REVISION OF SECTION 622
BOXES AND FITTINGS**

CONSTRUCTION REQUIREMENTS

- (a) *General.* Installation of boxes and fittings shall meet the following requirements:
1. Install boxes and conduit bodies at the locations shown on the Contract Drawings and as required by NFPA 70 at any other location where they are required to facilitate the pulling, supporting or connection of wires and cables.
 2. Securely mount all boxes in a manner approved by the Engineer and support the boxes independently of conduits entering them.
 3. Install boxes and conduit bodies in classified (hazardous) locations in accordance with their listing or label requirements. Conduit seal fittings shall be packed and filled only after proper operation of equipment and systems has been demonstrated and approved by the Engineer.
 4. Paint exteriors of boxes exposed in mechanical equipment rooms or in electrical rooms or closets or spaces shown as "unfinished" on the Contract Drawings, and the exteriors of boxes installed above hung or accessible ceilings, as follows:
 - A. Emergency: Orange
 - B. Fire Alarm: Red
 - C. High Voltage: Red with 1-inch, white block letters reading "HIGH VOLTAGE" on each exposed face and cover.
 5. All installations shall conform to NFPA 70.
 6. Dissimilar Metals
 - A. "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data.
 - B. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

METHOD OF MEASUREMENT

Boxes and Fittings will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
GROUNDING**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is installation of grounding in accordance with these specifications and in conformity with the details shown on the plans or established.

MATERIALS

- (a) *General.* The Contractor shall furnish grounding elements for emergency generator, cabinets, starters, and miscellaneous electrical equipment for all non-current-carrying metallic portions of the entire electrical system and for exposed non-electrical systems located in electrical substations or switchgear rooms as required by ANSI C2, National Fire Protection Association (NFPA) 70 and building codes which would be applicable if CDOT were a private corporation. All receptacles, switches, disconnects, individual motor controllers, etc., shall be provided with a grounding terminal connected to the device frame or enclosure. Refer to each individual equipment Specification section for additional grounding requirements. All conduit, cable tray, raceways, junction boxes, pull boxes, etc., shall be made electrically continuous by means of grounding conductors, bonding jumpers, grounding brushings, couplings, fittings, etc., as required by the NEC and the authority having jurisdiction.
- (b) *Grounding Conductors.* The Contractor shall provide grounding conductors in accordance with the requirements of NFPA 70, this Revision of Section 622 as applicable, and as specified on the Contract Drawings. Equipment grounding conductors shall be green insulated. Isolated grounding conductors shall be green insulated with yellow striping. All bonding conductors shall be flexible copper bonding jumpers sized in accordance with the NEC for grounding electrode conductors.
- (c) *Above Grade Connections.* Connectors to piping, fencing, and conduit systems shall be listed and labeled as grounding connectors for the materials used.
- (d) *Grounding Bushings.* Grounding bushing shall be insulated type.

CONSTRUCTION REQUIREMENTS

- (a) *Installation.* The Contractor shall install grounding elements for emergency generator, cabinets, panelboards, starters, and miscellaneous electrical equipment, for all metallic non-current carrying portions of the entire electrical system and for exposed non-electrical systems located in electrical substations or switchgear rooms as required by ANSI C2, NFPA 70 and building codes which would be applicable if CDOT were a private corporation.
 - 1. Each system or electrically continuous metallic piping and ductwork shall be electrically grounded in accordance with the requirements of NFPA for “bonding” as they apply to the “bonding of piping systems.” Isolated metallic piping and duct systems shall be bonded to the building equipment grounding system.
 - 2. Bonding and grounding conductors shall be sized, run in conduit and connected to various services in accordance with the requirements of NEC and NFPA 70.
 - 3. Grounding shall be done in accordance with the requirements of and subject to the approval of the Engineer. Approved materials, devices and workmanship shall be utilized. All conductor terminations shall be in accordance with Revision of Section 622 - Wires, Cables, Splices, Terminations.

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**REVISION OF SECTION 622
GROUNDING**

4. All ground connectors, shall be protected from mechanical injury by rigid conduit to which the conductor shall be bonded at each end.
 - A. All exposed non-current-carrying metal parts of permanently mounted electrical equipment, all terminal devices, and the conduit system shall be effectively grounded and securely bonded to the reference ground point of its separately derived service ground. The equipment ground path from conduit, equipment, and metal enclosures shall be continuous and permanent, and shall have the capacity to safely conduct any fault currents imposed on it with sufficiently low impedance to facilitate the operation of the circuit protective devices.
 - B. All conduits 2 inches and larger entering distribution switchboards and distribution or power panels shall be provided with grounding bushings and connected to the respective equipment ground bus by means of bare copper wire.
 - C. Flexible metal conduit and liquid-tight flexible metal conduit, where permitted by other sections of this Specification, shall be provided with a separate, copper equipment grounding conductor. The equipment grounding conductor shall be sized in accordance with NFPA70, and if insulated, the color of the insulation shall be green for the conductor's entire length. The equipment grounding conductor shall be bonded at both ends of the flexible conduit using an approved fitting or bonding screw.
 - D. Motor frames that are not directly clamped to the supply conduit shall be bonded and grounded to the conduit by means of a suitably-sized ground conductor and ground clamp. No soldered connections shall be used in leads. All connections shall be made with an approved solderless connector.
 - E. A separate insulated (green) equipment grounding conductor shall be installed in all branch circuits.
 - F. When a separate insulated equipment grounding conductor is provided with a branch circuit, it shall be connected to a ground bus in the panelboard from which it is served. The panelboard ground bus shall be of sufficient size to accommodate all devices served, including space for future expansion, as well as lugs of appropriate size for connection of an equipment grounding conductor to the grounding electrode of the derived source.
5. Flexible Bonds
 - A. All expansion joints, points of electrical discontinuity, or connections in conduit where firm mechanical bond is not possible shall be bonded with OZ-Gedney Type "BJ" or approved equal bonding jumper.
 - B. A flexible bonding jumper shall be provided around isolating couplings and isolating nipples, and shall be similar and approved equal to OZ-Gedney Type "BJ." All mechanical piping requires isolating couplings or isolating nipples when the piping material is changed.

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REVISION OF SECTION 622
GROUNDING**

(b) *Emergency Generator System Grounding.* Grounding shall meet the following requirements:

1. The neutral point of the emergency generator system shall be grounded in a manner identical to that used for service entrance equipment except that the system will require connection to only one of the grounding electrode means. The ground bus in the generator output and control switchboard shall be used as the reference point of the emergency system and shall be grounded to the grounding electrode. Connect the neutral leads from the generator to the reference point using a full size neutral run with the phase conductors, to the switchboard neutral bus, and a bonding jumper between the switchboard neutral and ground bus. Provide a grounding electrode conductor, without splice or joints, of a minimum of 250 MCM copper conductor, or 12.5 percent of the circular mil area of the phase conductors, whichever is larger, between the reference ground point and the grounding electrode. Connect the generator frame to the reference ground point using a minimum No. 4/0 AWG copper conductor.
2. Grounding shall be installed as shown on the Contract Drawings.
3. Grounding and bonding equipment for use in connection with interior wiring systems shall conform to UL 467.
4. Separate insulated equipment grounding conductors shall be installed with circuit conductors to maintain grounding system at equipotential. Raceway system shall not be utilized as the equipment ground.
5. All non-current-carrying metallic enclosures of electrical conductors, or exposed non-current-carrying metallic parts of electrical equipment, or of power apparatus shall be grounded.
6. Connections:
 - A. General
 - (1) Make connections in such a matter as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - (2) Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
 - B. Make connections with clean bare metal at points of contact.
 - C. Make all connections of grounding connector cables to ground rods by exothermic welding method. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
 - D. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.
 - E. Tighten grounding and bonding conductors and terminals, including screws and bolts, in accordance with manufacturer's published torque-tightening values for connectors and bolts.
 - F. Where insulated grounding conductors are connected to ground rods or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

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**REVISION OF SECTION 622
GROUNDING**

- (c) *Field Tests.* Upon completion of the electrical system, including all grounding, the Electrical Contractor shall test the system for stray currents, ground shorts, etc. These tests shall be performed in a manner acceptable to the Engineer. Approved instruments, apparatus, services and qualified personnel shall be utilized. If stray currents, shorts, etc., are detected, eliminate or correct as required. The test procedure shall be as follows:
1. All main disconnects shall be opened for the system being tested.
 2. A DC ohmmeter shall be connected across the system neutral and equipment ground.
 3. An ohmmeter reading in excess of 100 ohms shall indicate that the system neutral and equipment ground are properly isolated.
 4. An ohmmeter reading less than 100 ohms shall indicate that the system contains ground shorts (stray currents) at some point along the system neutral.
 5. Grounded neutrals may be identified by disconnecting individual neutral conductors from the system one at a time while monitoring the ohmmeter.
 6. The systems shall be retested after correction of all ground shorts is complete. Final readings shall be tabulated for review by the Engineer.

METHOD OF MEASUREMENT

Grounding will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
MEDIUM VOLTAGE SYSTEM COMMISSIONING TESTS**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is required testing for commissioning the medium voltage equipment shown on the Contract Drawings in accordance with these specifications and in conformity with the details shown on the plans or established. These tests shall be performed in addition to the specified tests outlined in other sections of these Specifications.

CONSTRUCTION REQUIREMENTS

- (a) *General*. In addition to the tests outlined in this Section, the Contractor shall perform all tests recommended by the manufacturer in manufacturer's instructions, shop drawings, as described in various sections of these Specifications and as outlined on the Contract Drawings. All tests must be witnessed by the Engineer. A written notice shall be given to the Engineer at least 14 days prior to the tests. Test values shall be considered acceptable as specified by the manufacturer and approved by the Engineer.
- (b) *Electrical Tests*. Testing shall meet the following requirements:
1. General
 - A. Prior to the energization of any medium voltage equipment, all tests outlined above and those outlined below in accordance with NETA ATS, shall have been performed by the Contractor and approved by the Engineer.
 - B. No voltage other than Megger output shall be applied to control voltage transformers during the performance of any tests, so that no high voltage can be induced on the primary of these transformers or into the high voltage system.
 - C. All safety precautions shall be exercised per OSHA regulations to avoid personal injury and damage to equipment under test.
 2. Medium Voltage Circuit Breaker A24
 - A. The following tests shall be performed on the Medium Voltage Circuit Breaker A24. The term "Breaker" in the following tests represents Medium Voltage Circuit Breaker.
 - (1) Measure contact resistance by a Digital Low Resistance Ohmmeter (DLRO). Any contact resistance over 100 micro-ohms should be investigated and remedial action shall be performed.
 - (2) Perform minimum pick-up voltage tests on the trip and close coils.
 - (3) Breaker A24 shall be given a Megger test in the racked-out and closed position. A 1000-Volt, motor-driven Megger shall be used. Megger tests shall be applied between each phase to ground, between phases and between Line and Load sides. All test readings shall be recorded.
 - (4) Perform an Over-Potential Test, at a voltage recommended by the breaker manufacturer, in the closed position. Test each phase to ground with all other phases grounded and across open contacts of each phase.
 - (5) Perform insulation resistance test at 1000 volts DC on the breaker control wiring. (Do not perform the test on wiring connected to solid state components.)

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**REVISION OF SECTION 622
MEDIUM VOLTAGE SYSTEM COMMISSIONING TESTS**

(6) With the breaker in the test position, perform the following tests:

Trip and close the breaker with the control switch at least 10 times. All indication lights, annunciators, alarms and targets shall be observed to determine correct operation. The breaker mechanism shall be observed for correct alignment, freedom of binding and good contact.

Trip Breaker A24 by manually operating each of its protective relays.

Test the breaker anti-pump circuit as recommended by the manufacturer.

B. Breaker A24 shall be operated through at least three Open-Close cycles in the racked-in position by manual operation and via control circuits, from each control point. All indication lights, annunciators, alarms and targets shall be observed to determine correct operation. The Breaker mechanism shall be observed for correct alignment, freedom of binding and good contact.

3. Medium Voltage Insulated Power Cables

- A. All medium voltage cables should be Hi-Potential tested by the following method outlined herein at a voltage recommended by the manufacturer. It should be noted that these tests shall be performed with all safety precautions and proper preparation of the cable ends.
- B. Each phase conductor of the cable shall be subjected to the Hi-Potential test to ground with the other two phases grounded together with the ground shields. Applied potential shall be increased in steps of 5KV by holding the voltage for one minute at each step. At the end of each minute, leakage current shall be recorded.
- C. After reaching the intended voltage level, the voltage shall be held for at least 10 minutes and the leakage current shall be recorded at the end of each minute. If the test indicates excessive leakage current, discontinue the test and notify the Engineer.
- D. Discharge each cable of the capacitive charge by grounding the cable until the cable is completely discharged and remains discharged.
- E. Check continuity of the cable shield and measure its resistance for the entire length of the cable.

METHOD OF MEASUREMENT

Medium Voltage System Commissioning Tests will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
MOTOR POWER AND CONTROL WIRING**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is furnishing, installation, connection and testing of motor power and control wiring in accordance with these specifications and in conformity with the details shown on the plans or established.

MATERIALS

The Contractor shall provide all conduits, wires, and accessories as shown on the Contract Drawings and as required to perform the Work.

The Contractor shall provide all conduits and wires in accordance with Revision of Section 622 – Raceways, and Revision of Section 622 – Wires, Cables, Splices, Terminations. PVC-insulated wiring and cables shall not be used in areas subject to the requirements of National Fire Protection Association (NFPA) 130 or NFPA 502.

The Contractor shall provide angle iron supports, brackets or hangers for mounting starters, control panels and control devices in accordance with Revision of Section 622 – Supporting Devices.

All fuses and circuit breakers provided under this Section shall be of the ratings and types as shown on the Contract Drawings or, if not shown on the Contract Drawings, shall be as recommended by equipment manufacturers. Fuses and circuit breakers shall be in accordance with Revision of Section 622 - Over-Current Protective Devices.

All motor control equipment shall be manufactured in compliance with NEMA ICS2, NEMA ICS4, ANSI/UL 65, ANSI/UL486E, ANSI/UL486A-486B, ANSI/UL 969, ANSI/UL 467, ANSI/UL 508, and UL 1059.

CONSTRUCTION REQUIREMENTS

- (a) *Examination.* Prior to making electrical connections, the Contractor shall check all electrical equipment furnished under other sections of the Specifications for the specified voltages and directions of rotation. Prior to energizing motors, verify the specified overload rating of all heater elements and relay settings, furnished with the motor starters under other Sections of the Specifications, so that the proper running protection will be provided for the motors. Should the overload ratings not be correct, notify the Engineer.
- (b) *Installation.* All motor starters, control devices, conduits, wires and accessories shall be installed in accordance with the requirements of NFPA 70 and the manufacturers' installation procedures. Make final connections in accordance with approved shop drawings. Install all conduits, wires, accessories and supports in accordance with the requirements of this Section.
- (c) *Field Tests.* The Contractor shall perform tests, in the presence of the Engineer, to demonstrate the following, and give the Engineer 24-hours advance notice of tests.
 - 1. That each control device and its related motor starter operate as designed.
 - 2. That each overload protective and safety device functions as designed.

Tests shall be performed in accordance with the equipment manufacturers' start-up and field test instructions and made jointly with all affected trades. Should the tests reveal any defects, promptly correct such defects and rerun the tests until the entire installation is satisfactory in all respects.

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**REVISION OF SECTION 622
MOTOR POWER AND CONTROL WIRING**

METHOD OF MEASUREMENT

Motor Power and Control Wiring will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
OVER-CURRENT PROTECTIVE DEVICES (600 VOLTS OR LESS)**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is installation of Over-current Protective Devices (6000 Volts or Less) in accordance with these specifications and in conformity with the details shown on the plans or established. The types of over-current protective devices specified in this Revision of Section 622 are: Low Voltage Power Air Circuit Breakers, Molded Case Circuit Breakers, Safety Switches, and Fuses.

MATERIALS

- (a) *Manufacturers.* Subject to compliance with the requirements of this Section, the Contractor shall provide low voltage power circuit breakers, molded case circuit breakers, safety switches and fuses of one of the manufacturers specified herein.
1. Circuit Breakers and Safety Switches
 - A. Square D Company
 - B. General Electric Company
 - C. Siemens Energy Automation, Inc.
 - D. Cutler – Hammer
 2. Fuses
 - A. Commercial Enclosed Fuse Company (CEFCO)
 - B. Cooper Industries Inc./Bussman Division
 - C. Gould Incorporated/Circuit Protection Division
 - D. Ferraz/Shawmut
- (b) *General.* Location, types, sizes, ratings and enclosures for over-current protective devices are shown on the Contract Drawings. Over-current protective devices mounted in their own enclosures as shown on the Contract Drawings shall conform to the requirements of NEMA, UL, and National Fire Protection Association (NFPA). Over-current protective devices to be installed as part of an assembly unit shall be installed in accordance with the manufacturer's requirements for the specified assembly or as shown on the Contract Drawings. Over-current protective devices and enclosures for which there are established UL standards, shall bear the UL label.
- (c) *Molded Case Circuit Breakers.*
1. Molded case circuit breakers for panel or individual mounting shall be molded-case type, quick-make and quick-break on manual or automatic operation. The handle mechanism shall be trip-free to prevent holding contacts closed on a fault. Tripping shall be indicated by the handle automatically assuming a position between the manual "off" and "on" positions.
 2. Molded case circuit breaker contacts shall be of the high-pressure type and shall be made of a silver composition material. Arc shields shall be provided to confine, cool, and quench the arc drawn at interruption.

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**REVISION OF SECTION 622
OVER-CURRENT PROTECTIVE DEVICES (600 VOLTS OR LESS)**

3. Continuous ampere ratings and number of poles shall be as shown on the Contract Drawings.
4. Molded case circuit breakers shall be bolt-on type. Unless otherwise shown on the Contract Drawings or as required by the system interrupting rating, all 120V or 208V circuit breakers shall have a minimum short circuit interrupting rating of not less than 10,000 amperes (RMS symmetrical) and all 277V or 480V breakers shall have a minimum short circuit interrupting rating of not less than 18,000 amperes (RMS symmetrical).
5. All molded case circuit breakers feeding 120V or 277V lighting circuits that are not controlled by local wall switches shall be UL approved type "SWD" circuit breakers.
6. Each molded case circuit breaker shall be suitable for the circuit on which it is applied and the load that it controls.
7. Accessories including, but not limited to, auxiliary switches, shunt trips, under-voltage trips, ground fault sensing and tripping shall be as shown on the Contract Drawings.

(d) *Thermal-Magnetic Circuit Breakers*

1. Circuit breakers up to, but not including 400 amperes shall be thermal magnetic trip. Electronic trip circuit breakers rated 100 amperes or higher may be provided in lieu of thermal magnetic type.
2. Automatic operation of the molded case circuit breaker shall be obtained by means of calibrated thermal and magnetic tripping devices for each pole of the breaker. The thermal device shall provide time-delay tripping on overloads, and the magnetic device shall provide instantaneous tripping on short circuits. The instantaneous magnetic trip shall be adjustable and accessible from the front of the breaker on frame sizes above 100 amperes.

(e) *Safety Switches*. Safety switches shall conform to NEMA KS-1, UL 98 and Federal Specifications (FS) FSW-S-865. Safety switches shall conform to the NEMA classification and shall be rated, as shown on the Contract Drawings. Safety switches shall be of the quick-make, quick-break type with terminals suitable for copper conductors, shall be padlock-able in the "off" position and shall be equipped with defeatable door interlocks.

(f) *Fuses*. Fuses shall be of the class, size and ratings (current, voltage, interrupting capacity, type, NEMA class) as shown on the Contract Drawings. Fuses shall conform to ANSI C97.1 for low voltage fuses. Unless otherwise shown on the Contract Drawings, fuses used in conjunction with motor protection shall be current limiting, dual element, time-delay type.

CONSTRUCTION REQUIREMENTS

- (a) *General*. Unless otherwise shown on the Contract Drawings, over-current protective devices shall be installed in conformance with NFPA 70, and UL 98, in accordance with the manufacturer's instructions and in accordance with the requirements of this Section.
- (b) *Fuses*. All fuses rendered inoperative during the Work shall be replaced before the issuance of the Certificate of Final Completion. All replacement fuses shall be provided in addition to the spare fuses specified in Section Spare Parts herein.
- (c) *Spare Parts*. Furnish a minimum of three but not less than 10 percent spare of the number of fuses of each type and rating required and shown on the Contract Drawings.

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**REVISION OF SECTION 622
OVER-CURRENT PROTECTIVE DEVICES (600 VOLTS OR LESS)**

(d) *Delivery, Storage and Handling.* Over-current protective devices to be installed in an assembly, as shown on the Contract Drawings, shall be mounted in the assembly and delivered in accordance with the manufacturer's specifications for such assembly. Over-current protective devices to be installed in their own enclosures, as shown on the Contract Drawings, shall conform to the following requirements:

1. Enclosures shall be packaged with material to prevent damage to components due to vibration or jarring during transportation and handling.
2. Enclosures shall be delivered in the manufacturer's original, unopened, protective packaging and shall be identified with suitable non-corrosive tags.
3. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of the final cleanup.

METHOD OF MEASUREMENT

Over-Current Protective Devices (600 Volts or Less) will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
RACEWAYS**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is installation of raceways in accordance with these specifications and in conformity with the details shown on the plans or established in the Contract Documents.

Related Work specified elsewhere: Revision of Section 622 - Supporting Devices.

MATERIALS

- (a) *General*. Locations, types, and sizes of raceways are shown on the Contract Drawings. Minimum size of conduit shall be 3/4 inch. Conduit shall be supplied in a minimum of 10-foot lengths and accordance with UL.
- (b) *Rigid Metal Conduit (RGS)*. Conduit shall be rigid galvanized steel heavy-wall conduit, hot-dip galvanized inside and out, with hot-dip galvanized threads, and shall conform to UL 6 and ANSI C80.1. All preformed elbows shall be the same in construction to and of a type designed for use with the appropriate conduit and shall conform to UL 6. All fittings shall be threaded and shall conform to NEMA FB1. If threads are cut after the zinc coating has been applied, the threads shall be treated with protective coating of zinc equivalent to hot-dip process.
- (c) *Flexible Metal Conduit (FSC)*. Flexible steel galvanized conduit shall conform to ANSI/UL 1. Liquid-tight flexible metal conduit (LSC) shall conform to ANSI/UL 360. Fittings shall be of a type designed for use with the respective conduit and shall conform to ANSI/UL 514B.
- (d) *Surface Metal Raceways*. Surface raceways shall conform to ANSI/UL 5. Surface metal raceways shall come complete with all necessary accessories for installation.
- (e) *Fire Stops, Through Penetrations of Conduits*. Where raceways penetrate wall or floor, fire stops with a fire rating equal or greater than the rating of the penetrated wall or floor shall be provided. All fire stops shall conform to the UL 1479.
- (f) *Wireways*. Wireways shall be seamless galvanized steel construction, cover to be locked with captive screws and shall conform to ANSI/UL 870. Wireways shall come complete with all necessary accessories for installation.
- (g) *Fastening Devices*. Provide inserts, clamps, bolts and washers, or any other type of fastening devices conforming to the requirements of Revision of Section 622 - Supporting Devices required to secure conduits to walls or above hung ceilings. Unless otherwise shown on the Contract Drawings, all fasteners shall be hot-dip galvanized and of the size and type recommended by the equipment manufacturer.

CONSTRUCTION REQUIREMENTS

- (a) *General*. Material shall be delivered in manufacturer's original, unopened, protective packaging. Protective caps shall be removed only upon installation of conduit. Store materials in a clean, dry space and protect them from weather. Handle in a manner to prevent damage to finished surfaces.

All conduit bends shall be accomplished with a trade approved bending tool and in accordance with the manufacturer's recommendations and National Fire Protection Association (NFPA) 70. Ream conduit ends free from burrs prior to installation, and draw joints up tight. Make transitions in conduit from one metal to a dissimilar metal only at boxes or other enclosures, unless otherwise shown on the Contract Drawings.

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REVISION OF SECTION 622
RACEWAYS

Concealed conduits or tubing shall be installed in as direct a line as possible. Install exposed raceways, located above hung or accessible ceilings, parallel with or at right angles to the lines of buildings and as close to the ceiling as possible, unless otherwise shown on the Contract Drawings. Install expansion fittings in all conduits that cross expansion joints, where conduits attach to independent structures, or where exposed to large temperature changes.

Threaded conduits entering enclosures, other than threaded cast boxes, shall be securely fastened by means of two lock-nuts, one on each side of the enclosure. Terminate the conduits in insulated bushings. Cap all free ends of empty conduit to prevent water entrance. Conduit through roofs and external walls of buildings, manholes, and other structures shall be watertight.

The Contractor shall submit detailed shop drawings for the Engineer's approval. Where portions of an interior raceway system are exposed to widely different temperatures, make provisions to prevent circulation of air from a warmer to a colder section through the raceways. Apply zinc-rich paint to all exposed threads after joints have been made up clean and tight. Support all conduits as required in Revision of Section 622 – Supporting Devices.

All conduit runs shall leave or enter structures perpendicularly. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

(b) *Rigid Metal Conduit*. RGS shall be used.

(c) *Flexible Metal Conduit*. The Contractor shall install FSC for motor connections and for other equipment connections where subject to movement and vibration. Conduit shall be installed to permit maximum flexibility, without crushing or permanent deformation, and shall not exceed 18 inches in length, without approval of the Engineer. Use LSC for the same installation conditions as FSC above, and where also subjected to one or more of the following conditions: Exterior locations, condensation, moist, wet, or humid conditions, corrosive atmospheres, water spray, dripping oil, grease, or water.

1. LSC installed within tunnel facilities, ventilation buildings, railroad/subway tunnels, and stations shall have a galvanized steel core with a low smoke, halogen-free, polyurethane outer jacket. PVC jacketing may be substituted for the low smoke, halogen-free, polyurethane outer jacket only for non-tunnel, outdoor installations. PVC jacketing shall not be accepted as a substitute for installation within the tunnels, ventilation buildings, railroad/subway tunnels and stations. Install FSC and LSC with a separate, insulated copper, code-sized, equipment grounding conductor, installed inside the flexible conduit.

(d) *Surface Metal Raceways*. Only metallic surface metal raceways will be permitted, unless otherwise shown on the Contract Drawings. Installation shall be in accordance with manufacturer's written recommendations and instructions accompanying the raceways. Provide surface raceway system with means for assuring a continuous ground path throughout. Use fittings without sharp edges introduced into any part of the raceway system.

(e) *Dissimilar Metals*. "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

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**REVISION OF SECTION 622
RACEWAYS**

- (f) *Conduit Cleaning and Testing.* After installation of conduits and accessories and completion of all concreting operations, if any, carefully clean and clear all conduit runs of all obstructions and foreign matter to the satisfaction of the Engineer. Test conduits, in the presence of the Engineer, by pulling through each conduit a flexible cylindrical mandrel having an outside diameter not more than 1/4 inch smaller than the inside diameter of the conduit, but nominally 85 percent of the trade diameter, whichever is larger. Only nylon cable of adequate strength shall be used to pull the mandrel through the conduit system. The use of rope will not be permitted.
- (g) *Connections to Existing Conduits.* Where conduits installed under this Contract are connected to existing conduits or conduits installed by others, the Contractor shall test the entire run to the nearest box, manhole, handhole, or equipment enclosure as specified in this Section. Report immediately to the Engineer any defect or stoppage found in portions of the conduit system not installed under this Contract. Do not attempt to rectify any defect or stoppage found in conduit not installed under this Contract unless specifically instructed to do so by the Engineer. The Contractor's compensation for the rectifying of such defects or stoppages at the direction of the Engineer will be determined in accordance with Section 109.04 of the Standard Specifications. The Engineer shall be the sole judge as to whether a defect or stoppage exists. Perform all tests required by the Engineer to enable the engineer to make a decision.

METHOD OF MEASUREMENT

Raceways will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
SUPPORTING DEVICES**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is installation of hangers and supports, sleeves, and fasteners used to support electrical raceways and equipment in accordance with these specifications and in conformity with the details shown on the plans or established, except as specified within this section.

Supporting devices, furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Sections of the Specifications.

MATERIALS

- (a) *Manufacturers.* Subject to compliance with requirements of this Section, the Contractor shall provide supporting devices of the acceptable manufacturers as shown on Contract Drawings.
- (b) *General Hangers and Supports.* Unless otherwise shown on the Contract Drawings, the Contractor shall provide hangers and supports as specified in this Section. Where more than one type of hanger or support is suitable for the intended use, selection is at the Contractor's option, subject to approval by the Engineer. Hangers and supports for which there are established Underwriters Laboratories Inc. (UL) standards shall bear the UL label.
- (c) *Raceway Support.*
 - 1. Clevis hangers for supporting horizontal conduit shall be of galvanized steel with hole provided for a threaded steel rod.
 - 2. Riser clamps for supporting vertical conduits shall be of galvanized steel with two or three bolts and nuts and 4-inch ears.
 - 3. Steel rod reducing couplings shall be sized as required and constructed of galvanized or plated steel.
 - 4. C-Clamps shall be of black malleable iron, galvanized, or plated steel with a hole for threaded rod.
 - 5. I-Beam clamps shall be galvanized or plated steel out of 1-1/4-inch by 3/16-inch stock with a 3/8-inch cross bolt and a 2-inch flange width.
 - 6. Right-angle and parallel beam clamps shall be constructed of galvanized steel clamps for supporting or fastening conduit up to 2-inch trade size.
 - 7. One-hole conduit straps for supporting up to 1-inch conduit or electrical metallic tubing (EMT) shall be of galvanized steel.
 - 8. Two-hole conduit straps for supporting conduit or EMT larger than 1-inch shall be 3/4 - inch in width and of galvanized steel.
 - 9. Hexagon nuts shall be of galvanized steel
 - 10. Round steel rod shall be of galvanized or plated steel.
 - 11. Threaded trapeze hangers shall be the same as specified in this section. The following types of hangers and supports shall not be used: perforated metal strapping, slotted/perforated angles, spring pressure or torsion clips, hangers or supports.

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**REVISION OF SECTION 622
SUPPORTING DEVICES**

- (d) *Equipment Supports.* U-channel strut system shall be 12-gauge, hot-dipped galvanized steel. Provide with drilled or slotted holes as required for the application and with the following fittings which mate and match with U-channel:
1. Fixture hangers
 2. Channel hangers
 3. End caps
 4. Beam clamps
 5. Wiring stud
 6. Thin wall conduit clamps
 7. Rigid conduit clamps
 8. Conduit hangers
 9. U-bolts
- (e) *Supporting Steel Sections and Channels.* Supporting steel sections and channels shall be fabricated of ASTM A36 steel in accordance with the appropriate requirements of the AISC, AISI, and AWS publications specified in this Section, and shall be hot-dip galvanized after fabrication.
- (f) *Cable Supports.* The Contractor shall provide cable supports with insulating wedging plug for non-armored type electrical cables in risers. Assembly shall include body of galvanized malleable iron with insulating wedging plug. Provide cable supports for armored type electrical cables in risers. Assembly shall include body and pressure plates of galvanized steel.
- (g) *General Sleeves and Seals.* Unless otherwise shown on the Contract Drawings, the Contractor shall provide sleeves and seals as specified below. Where more than one type of sleeve or seal is suitable for the intended use, selection is at the Contractor's option, subject to approval by the Engineer. Sleeves and seals for which there are established UL standards shall bear the UL label.
- (h) *Pipe Sleeves.* Pipe sleeves for conduits penetrating concrete or masonry floor and walls shall be provided as follows:
1. Steel Pipe: Fabricate from schedule 40 galvanized steel pipe; remove burrs.
 2. Iron Pipe: Fabricate from cast iron or ductile iron pipe; remove burrs.
 3. Plastic Pipe: Fabricate from either fiberglass or schedule 40 PVC plastic pipe; remove burrs. Fiberglass sleeves may be utilized for interior or exterior usages, but PVC sleeves shall be utilized for exterior usage only.

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REVISION OF SECTION 622
SUPPORTING DEVICES**

4. Sleeves shall have a minimum inside diameter as shown, based on the installed raceway diameter.

Raceway Diameter (inches)	Sleeve Inside Diameter (inches)
1 or less	2
1-1/4 to 2	3
2-1/2 to 3	4
3-1/2 to 4	5
5	6
6	7

5. Where sleeve encloses only one conductor, phase or polarity, or ground wire or cable, the sleeve shall be non-ferrous.

- (i) *Interlocking Modular Seals.* Provide interlocking modular type seals for conduit access located in exterior foundation and pit walls. The seals shall be multi-link, stainless steel bolted connection, high-temperature fittings.
- (j) *Sealing Bushings.* Provide sealing bushings for conduit access core-drilled through foundation walls or floors. The bushings shall be molded, one-piece neoprene sealing rings with PVC-coated steel or uncoated aluminum pressure plates, stainless steel hex socket head cap screws, and flat washers.
- (k) *Fire Seals.* Provide UL-listed, three-hour rated, silicone-based foam, fire-resistive, waterproof joint sealing system to prevent the passage of hot gases and fire.
- (l) *Wall and Floor Seals.* Provide watertight and pressure-tight wall and floor seals suitable for sealing around conduit passing through exterior concrete floors and walls. Assembly shall include steel sleeves, galvanized malleable iron body, neoprene sealing grommets and rings, metal pressure rings, membrane clamp where required by foundation design, and pressure clamps with Type 316 stainless steel hex head cap screws. Seal sizes shall be maximum published size for conduit to be installed therein.
- (m) *General Fasteners.* Unless otherwise shown on the Contract Drawings, provide fasteners as specified below. Where more than one type of fasteners is suitable for the intended use, selection is at the Contractor's option, subject to approval by the Engineer.
- (n) *Toggle Bolts.* Toggle bolts shall be spring head, galvanized or plated steel, 1/4-inch to 1/2-inch sizes, and of length as required.
- (o) *Expansion Anchors.* Expansion anchors shall be metallic expansion anchors or shields, including drop-in anchors, wedge and sleeve anchors, and two-piece and three-piece shields for lag screws or machine screws or bolts.
- (p) *Powder Activated Fasteners.* Powder-activated fasteners shall be steel-, pin-, or stud-type, selected for proper length and penetration for the equipment, clamp or strap to be installed, and the base material.

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**REVISION OF SECTION 622
SUPPORTING DEVICES**

- (q) *Bolts, Nuts, Lockwashers and Washers.* All hardware shall be galvanized or plated steel, unless otherwise shown on the Contract Drawings. Bolts and nuts, 1/4-inch trade size and larger, shall be hex head or hex socket type, standard American sizes. Lockwashers shall match the finish of the furnished bolts and nuts, and generally be installed one-per-bolt, at the nut end of the assembly. Washers shall be standard-or fender-type, as required, and sized to match the installed bolts or screws. The following types of fasteners shall not be used:
1. Lead anchors or studs;
 2. Wooden plugs or anchors;
 3. Plastic anchors;
 4. "Nail-in" anchors, either of plastic or metal type.

CONSTRUCTION REQUIREMENTS

- (a) *Examination.* The Contractor shall verify that electrical installations, structural, mechanical and other related Work satisfy the requirements for performance of the Work of this Section in accordance with the Contract Documents. Report immediately to the Engineer any electrical, structural or related construction defects in areas where supporting devices are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Engineer.
- (b) *Installation.* Before installation the supporting devices, the Contractor shall investigate the site condition to determine what preparatory work, if any, is needed.
1. Install hangers and supports, sleeves, and fasteners in accordance with approved printed manufacturer's installation procedures and as specified.
 2. Coordinate all affected trades and all aspects of the electrical work, including installation of raceways and wiring as necessary to interface installation of supporting devices with other work.
 3. Install hangers, supports, and attachments to properly support raceways, equipment, and accessories from building structure. Arrange for grouping of parallel runs of horizontal conduits to be supported together on trapeze hangers where possible. Install hangers and supports with maximum spacing not to exceed that permitted by NFPA 70 and NECA Standard of Installation, as applicable, unless otherwise shown on the Contract Drawings.
 4. Secure threaded rod couplings, trapeze hangers, supports, or similar horizontal elements using lock washers and jam nuts to prevent loosening.

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REVISION OF SECTION 622
SUPPORTING DEVICES**

(c) *Conduit and Raceway Supports.* Raceways shall not be supported from hung ceiling supports or members or metal roof deck. Do not support raceways from mechanical ductwork, ductwork supports, piping, or piping supports. Threaded rod used for the support of conduits, raceways, or trapeze hangers of the given size, shall be not less than the following:

Conduit, Raceway, Hanger Size (inches)	Threaded Rod Size (inches)
2 or less	3/8
2-1/2 to 3-1/2	1/2
4 to 5	5/8
6	3/4

1. Where trapeze hangers are used, bolt or clamp the raceways in place to at least every third hanger and to the first hanger on each side of a bend, fitting, junction or pull box, or change in direction.

- (d) *Sleeves.* Unless otherwise shown on the Contract Drawings, sleeves for raceways and risers shall be extended one inch beyond top of finished floor, curb, or building element being penetrated. Install sleeves level and plumb, accurately located, and positioned to conform to the requirements of the equipment and in accordance with the approved layout drawings. Interlock modular seals in tandem, one at the interior and one at the exterior face of the pipe sleeve. Tighten sleeve seal nuts until sealing grommets have expanded to form watertight seal.
- (e) *Fasteners.* Wood screws, lag screws, carriage bolts, or machine screws shall be utilized for wood or materials of similar fibrous nature. Welded or blazed threaded studs, bolts or machine screws, or clamps shall be utilized for structural and miscellaneous steel, iron, or other metals. Metallic expansion shields, wedge anchors, or drop-in anchors with lag screws, bolts, or machine screws shall be utilized for solid masonry or concrete. Sleeve anchors, drop-in anchors, or toggle bolts shall be utilized for concrete masonry units (CMU). Do not use powder-activated fasteners in CMU.
- (f) *Dissimilar Metals.* "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

METHOD OF MEASUREMENT

Supporting Devices will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is installation of wires, cables, splices, terminations, and appurtenances for electrical systems of 600 volts or less in accordance with these specifications and in conformity with the details shown on the plans or established in the Contract Documents.

MATERIALS

- (a) *Manufacturers*. Subject to compliance with requirements of this Section, the Contractor shall provide wires, cables, wire and cable splicing, terminating, and arcproofing materials of manufacturers as shown on the Contract Drawings.
- (b) *Wires and Cables*.
1. Wire shall be defined as a solid or stranded conductor smaller than No. 6 AWG with or without insulation. Cable shall be defined as a single conductor No. 6 AWG or larger, or two or more conductors of any size wire under a common covering.
 2. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings. Where not indicated, provide proper wire and cable selection to comply with this section and National Fire Protection Association (NFPA) 70 Standards.
 3. The wires and cables must be suitable for use in wet and dry locations, as applicable for the installation, with temperature ratings that correspond to the conditions of application. Wires and cables shall be suitable for installation indoors or outdoors, in conduits, trays, and underground ducts or direct burial in earth, as applicable for the installation shown on the Contract Drawings and as allowed by applicable codes and this Section.
 4. Unless otherwise indicated on the Contract Drawings, cable insulation shall be rated for conductor temperatures not exceeding 90 degrees C for normal operation, 130 degrees C for emergency overload conditions and 250 degrees C for short circuit conditions in accordance with Insulated Cable Engineers Association (ICEA) standards S-95-658 and S-73-532. Temperature ratings shall be for both wet and dry locations.
 5. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft or annealed copper, conforming to ASTM B33 (tinned) or ASTM B3 (uncoated). Unless otherwise specified in this Section or unless otherwise shown on the Contract Drawings, stranded copper conductors shall be concentric stranding conforming to ASTM B8.
 6. Polyvinyl Chloride (PVC): PVC-insulated power wiring and items containing PVC shall not be installed in subway areas, railroad or vehicular tunnels, railroad stations, and areas defined on the Contract Drawings as subject to NFPA 130 or NFPA 502 jurisdiction.
 7. Unless otherwise shown on the Contract Drawings, cable insulations and jackets designated as Low-Smoke, Zero-Halogen (LSZH) shall be thermoset, low-smoke, low-toxicity, non-halogen, flame retardant type and shall meet the following performance characteristics:
 - A. Cables shall pass the flame propagatory and smoke release criteria according to the test method of UL 1685.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- B. The halogen content of cable jackets shall not exceed 0.2 percent according to the test method of MIL-DTL-24643.
 - C. The toxicity index of cable jackets shall not exceed 2.0 according to the test method of Naval Engineering Standard NES 713.
 - D. The cable jackets shall comply with ICEA T-33-655 for smoke generation.
 - E. The acid gas content of cable jackets shall not exceed a maximum of 3.0 percent according to the test method of MIL-DTL-24643.
8. The following additional performance characteristics shall be used for wires and cables that will be installed in subway areas, railroad or vehicular tunnels, railroad stations, and areas defined on the Contract Drawings as being under the jurisdiction of NFPA 130 or NFPA 502, where stringent flame retardant, low-smoke, low-toxicity, zero-halogen, and good circuit integrity during a fire are required.
- A. All insulated conductors shall be UL listed as type XHHW-2, in accordance with UL 44. In addition, all one-conductor cables shall be listed for and marked with the following UL designations: "VW-1," "LS" or "ST1" (limited smoke), "Oil and Gas Resistant," and for 1/0 and larger, "CT USE."
 - B. Single conductor wire and cable shall utilize thermoset Low-Smoke, Zero-Halogen, Cross-Linked Polyolefin insulation conforming to ICEA S-73-532 and S-95-658. The insulation shall be comprised of a single layer of homogeneous material. Jackets or other additional coverings shall not be allowed for single conductors because of the increase in cable size. All single conductor wires and cables shall follow the dimensional requirements of NFPA 70, Table 5.
 - C. Wires shall pass the flame propagatory criteria according to the test method of UL 1581 (VW-1).
 - D. The halogen content of both the wire and cable insulation and cable jacket(s) shall not exceed 0.2 percent according to the test method of MIL-DTL-24643.
 - E. The toxicity index of both the wire and cable insulation and cable jacket(s) shall not exceed 2.0 according to the test method of Defence Standard DEF STAN 02-713.
 - F. The acid gas content of both wire and cable insulation and cable jacket(s) shall not exceed a maximum of 2.0 percent according to the test method of MIL-DTL-24643.
 - G. The wire and cable insulation materials shall pass the smoke generation test in accordance with ASTM E662. All wires and cables shall pass the smoke release criteria according to the test method in UL 1685 for "LS" or "ST1" classification as "limited smoke." Wire and cable insulation when tested on a specimen of 80 mils thick slab shall not exceed the following values:
 - (1) Flaming Avg. Ds (4 minutes) 50
 - (2) Flaming Avg. Dm (20 Minutes) 200
 - (3) Non-Flaming Avg. Ds (4 minutes) 50
 - (4) Non-Flaming Avg. Dm (20 minutes) 200

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- H. All single conductor wires shall provide a minimum of 15-minute circuit integrity when tested in accordance with UL 2196. UL qualification is required and shall be predicated upon a No. 12 AWG sample in conduit without the water spray.
- I. Wires and cables shall pass the following flame propagation requirements:
 - (1) All single conductor wires and cables shall pass the “UL VW-1” vertical flame test, according to UL 1581.
 - (2) All single conductor wires and cables shall pass the vertical flame test stated in AAR RP583, paragraph 5.9.4.
- J. Water Resistance
 - (1) All wires and cables shall be rated for wet applications at 90 degrees C as defined by the requirements for type “XHHW-2” stated in UL 44 when tested in accordance with UL 1581.
 - (2) The mechanical water absorption of the insulation shall not be greater than 4 mg/sq. in. when tested in accordance with UL 1581.
- K. All wires shall be suitable for prolonged exposure to water by evidence of long term insulation resistance qualification testing in 90 degree C water. Testing shall be in accordance with UL 44 and UL 1581. After a minimum of one year exposure to 90 degree C water, the insulation resistance measurements must exceed an insulation resistance reading of 4.0 megohms/1000 ft. sample used for testing shall be either 14 or 12 AWG with a nominal 30 mils of LSZH insulation.
- L. Overload Stability: To ensure overload stability, all wires and cables shall pass the following tests defined in AAR Standard RP585:
 - (1) Electrical Overload – Single Conductor (paragraph 5.9)
 - (2) Bundle Overload (paragraph 5.9.1)
 - (3) 125 degrees C Penetration Test (paragraph 5.9.2)
- M. The insulation shall demonstrate heat stability by retaining 95 percent of its original tensile strength and elongation values after aging seven days at 158 degrees C, as per AAR Standard RP585.
- N. Multi-Conductor Cables: Where multi-conductor cables are utilized, use the following additional criteria:

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- (1) Multi-conductor control cables shall utilize stranded class “B” or “C” conductors in accordance with ASTM B8. All conductors shall utilize thermoset low-smoke, zero-halogen cross-linked polyolefin insulation, conforming to ICEA standard S-95-658 and S-73-532, and be listed as type “XHHW-2.” Insulated conductors shall be cabled with a suitable binder tape and covered with a low-smoke, zero-halogen cross-linked polyolefin jacket. All cables shall be UL-listed Type TC in accordance with UL 1277. All individual insulated conductors utilized in multi-conductor cables shall meet all of the requirements set forth in this Section for single conductor cables for subway areas, railroad or vehicular tunnels, railway stations and areas defined on the Contract Drawings as under the jurisdiction of NFPA 130 or NFPA 502, except that UL print is not required on the individual conductor insulation.
- (2) The halogen content of the cable jacket(s) shall comply with this Section.
- (3) The toxicity index of the cable jacket(s) shall comply with this Section.
- (4) The acid gas content of the cable jacket(s) shall comply with this Section.
- (5) The cable jacket materials shall pass the smoke generation test in accordance with ASTM E662. Cable jacket when tested on a specimen of 80 mils thick slab shall not exceed the following values:
 - Flaming avg. DS (4 minutes): 50
 - Flaming avg. DM (20 minutes): 150
 - Non-Flaming avg. DS (4 minutes): 50
 - Non-Flaming avg. DM (20 minutes): 250
- (6) All multi-conductor wire and cables shall provide a minimum of 15-minute circuit integrity when tested in accordance with International Electrotechnical Commission (IEC) IEC-331. Qualifications shall be predicated on a 2/C No.14 AWG sample tested at 240 Volts.
- (7) All multi-conductor cables shall pass the UL vertical flame test criteria according to the test methods stated in UL 1685 for IEEE 1202 type of flame exposure. Test sample used shall be 2/c No.14 AWG.
- (8) All multi-conductor wires and cable shall be listed for, and be marked with, the following UL designations on the cable jacket: “Type TC” (Tray Cable), “LS” or “ST1” (Limited Smoke), “Sun Res” (Sun Resistant) or “XHHW-2”/“90 degrees C Wet and Dry,” “IEEE 1202.”

9. Color-Coding for Power and Lighting Conductors

- A. Insulation or covering of wires and cables shall be factory color-coded by the use of colored compounds or coatings. The color-code shall be followed consistently throughout the performance of the Work.
- B. Circuit identification for multi-conductor cable shall be accomplished by either Method 1 (colored compounds) or Method 3 (printed color designations) per ICEA with a K2 scheme, unless otherwise stated on the Contract Drawings.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- C. Upon written request of the Contractor, the Engineer may permit the use of the following methods in lieu of the wire or cable manufacturer's color-coding, when limited quantities of wire and cable are involved, for sizes No. 8 AWG and larger.
- (1) For dry locations only, spiral application of 3/4 inch wide, colored, pressure-sensitive plastic tape, half-lapped for a distance of not less than six inches may be used. To prevent unwinding, the last two wraps of tape shall be applied with no tension.
 - (2) For wet or dry locations, application of three, 3/16 inch wide, colored, fungus-inert, self-extinguishing, self-locking, nylon cable ties spaced 3 inches apart may be used. The ties shall be snugly applied with a special tool or pliers, and any excess removed.
 - (3) Each wire and cable shall be color-coded at all terminal points, in all manholes, boxes, or other similar enclosures.
 - (4) Color markings shall be applied so as not to obliterate the manufacturer's identification markings.
- D. Color code chart shall be as follows:

System Voltage	Conductor	
	208Y/120V	480Y/277V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green

- (c) *General-Purpose Wires and Cables.* Unless otherwise shown on the Contract Drawings, general-purpose wires and cables shall be as follows:
1. General-purpose wires and cables shall be single conductor, ASTM B8, Class B stranded for all sizes AWG.
 2. Select from the following list of UL wire and cable types:
 - A. Type XHHW: Flame retarding, Cross-linked-polyolefin insulation, conforming to UL 44, for dry locations only.
 - B. Type XHHW-2: Flame retardant, Cross-linked-polyolefin insulation, conforming to UL 44, 90 degrees C wet and dry.
 - C. Type THWN: Flame retardant, moisture and heat-resistant thermoplastic insulation with a nylon jacket or equivalent; double-rated THHN-THWN gasoline-oil resistant II; conforming to UL 83. The use of this cable shall be in accordance with the requirements of this Section.
 3. Type USE: Unless otherwise indicated, Type USE shall be the only wire and cable used for underground installations. Select from one of the following:

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- A. Heat- and moisture-resistant ethylene-propylene-rubber insulation with jacket of either cross-linked polyolefin or heavy duty thermosetting chlorosulphanated polyethylene or heavy-duty neoprene; multiple rated "USE-RHH-RHW"; conforming to ASTM D2802, ICEA S-95-658, UL 44 and UL 854.
 - B. One layer of low-smoke, zero-halogen thermosetting cross-linked polyolefin, Type RHW-2, 90 degrees C wet and dry.
- (d) *Lighting Fixture Wires.* Unless otherwise shown on the Contract Drawings, lighting fixture wires shall be stranded only, and shall be Type SF-2, silicone rubber insulated conforming to UL 62.
- (e) *Grounding Wires and Cables.* Unless otherwise shown on the Contract Drawings, grounding wires and cables shall be as follows:
- 1. Insulated
 - A. ASTM B8, Class B stranded for all sizes; and of the same insulation type as the power conductors.
 - B. Covering shall be a continuous green color and conforming to ASTM B 33 and UL 44.
 - 2. Uninsulated
 - A. General: ASTM B8, Class B stranded for all sizes AWG.
 - B. In raceways soft-drawn and conforming to ASTM B3.
 - C. Direct buried or encased in concrete
 - 3. Soft-drawn, medium-hard-drawn, or hard-drawn and conforming to ASTM B1, B2 or B3, respectively.
- (f) *Control Wires and Cables.* Unless otherwise shown on the Contract Drawings, control wires and cables shall be as follows:
- 1. Single conductor wires and cables shall be ASTM B8, Class B stranded, type XHHW or XHHW-2 flame retardant, cross-linked-polyolefin insulation. Both shall conform to UL 44 and ICEA S-73-532.
 - 2. Multiconductor cables shall be ASTM B8, Class B or Class C stranded, Control Cable Type B, conforming to ICEA S-73-532. Color-coded as per ICEA S-73-532. Method No. 1 for NFPA 70 applications (with white and green) or ICEA S-73-532 for paired conductor cables. Select from the following list of cable types.
 - A. Individual ethylene-propylene rubber insulation with overall flame retardant, cross-linked-polyolefin jacket; conforming to ICEA S-73-532, UL 44 and UL 1581.
 - B. Individual flame retardant, cross-linked-polyolefin insulation with overall flame retardant, cross-linked-polyolefin jacket; conforming to ICEA S-73-532.
 - 3. Single conductor wires and cables shall be ASTM B3 stranded soft drawn bare copper conductor, Type MTW (machine tool wire), resistant to acids, alkalis, grease, chemicals, abrasion, and moisture. Wire shall be UL-recognized as AVM, and shall meet or exceed all applicable requirements of VW-1 flame test per UL44, UL 1015, CSA FT-1 flame test, NEC Article 30, and NFPA Standard 79.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- (g) *Switchboard Wires and Cables.* Unless otherwise shown on the Contract Drawings, switchboard wires and cables shall be as follows:
1. Switchboard wires and cables shall be single conductor, ASTM B8, Class B stranded, except that for wires and cables crossing hinged joints and swinging panels and where "Extra Flexible" wire or cable is shown on the Contract Drawings, conductors shall be ASTM B174, Class K stranded.
 2. Wires and cables shall be Type SIS, cross-linked-thermosetting-polyethylene insulation, conforming to ICEA S-73-532 or ICEA S-95-658, IEEE 383 and UL 44.
- (h) *Cable Tags.*
1. Dry Locations
 - A. Fiberglass tags, 1/16 inch thick and 3/4 inch wide, indented with letters and numbers 5/16 inch high, with No. 14 AWG copper or nylon, weather-resistant cable ties.
 - B. Lighting branch circuit wiring and single conductor signal and control wiring may be identified with "Quik" labels manufactured by W. H. Brady Company, or approved equal.
 2. Wet Locations
 - A. Brass or stainless steel metal tags, No. 28 gauge and 3/4 inch wide, embossed with letters and numbers 5/16 inch high, with No. 14 AWG copper or nylon, weather-resistant cable ties, or stainless steel cable ties.
- (i) *Splicing, Terminating and Arcproofing Materials.* All splicing, terminating and arcproofing materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other or of the wire or cable itself. All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation, installation, and operating conditions of the specific application.
1. Connectors
 - A. Subject to compliance with requirements of this Section, provide connectors of the following types:
 - (1) Solderless, uninsulated, high conductivity, corrosion-resistant, compression connectors conforming to UL 467 and IEEE 837;
 - (2) Insulated, indenter type compression butt connectors;
 - (3) Insulated, integral self-locking flexible shell, expandable spring connectors;
 - (4) Uninsulated, indenter type compression pigtail connectors;
 - (5) Welded type connectors.
 - B. For installations in subway areas, railroad stations, railroad or vehicular tunnels, or areas defined as subject to NFPA 130 or NFPA 502 jurisdiction, use flame-retardant type connectors.
 2. Terminals
 - A. Subject to compliance with requirements of this Section, provide terminals of the following types:

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- (1) Solderless, uninsulated, high conductivity, corrosion-resistant, compression terminals conforming to UL 467 and IEEE 837;
- (2) Insulated, compression terminals;
- (3) Solderless, high conductivity, corrosion-resistant, hex screw type, bolted terminals;
- (4) Welded type terminals.

3. Shrinkable Tubing

A. Subject to compliance with requirements of this Section, provide shrinkable tubing of the following types:

- (1) Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing;
- (2) Cold shrinkable tubing.

4. Tapes and Sealers

A. Vinyl Tapes:

- (1) Flame-retardant, cold- and weather-resistant, 3/4 inch or 1-1/2 inches wide, as required, and conforming to UL 510 and ASTM D3005.

For interior, dry locations, provide 7 mil, conforming to ASTM D3005 (Type I); Scotch (3M) No. 33, or approved equal.

For exterior or damp and wet locations, provide 8.5 mil, conforming to ASTM D3005 (Type II); Scotch (3M) No. 88, or approved equal.

B. Rubber Tapes:

- (1) Ethylene-propylene, rubber-based, 30-mil splicing tape, rated for 130 degrees C operation; 3/4 inch and wider (1, 1-1/2, 2 inches) as shown on the Contract Drawings or approved by the Engineer, conforming to (Grade A); Scotch (3M) No. 130C, or approved equal.

C. Insulating Putty

- (1) Rubber-based, 125-mil elastic filler putty; 1-1/2 inches wide; Scotch (3M) Scotchfil, or approved equal.

D. Silicone Rubber Tapes

- (1) Inorganic silicone rubber, 12 mil, 130 degrees C rated, anti-tracking, self-fusing tape; 1 inch wide; Scotch (3M) No. 70, or approved equal.

E. Sealer

- (1) Liquid applied fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

5. Resin Filled Splices

A. Epoxy Molded Type

- (1) Two-piece, snap-together molded bodies, sized for wire or cable, with two-part low viscosity polyurethane insulating and sealing compound, rated for 600 volts, using crimp-type wire connector; Scotch (3M) No. 82-A1, 82-A2 or 82-A3 compound, or approved equal.

B. Re-Enterable Type

- (1) Transparent, molded bodies clamped with stainless steel strain-relief bar and shield continuity connectors, sized for wire or cable, with loosely woven polyester spacer web and jelly-like urethane formulation for permanent re-entry capability; Scotch (3M) Nos. 78-R1 through 78-R5, with No. 2114 compound, or approved equal.

6. Arcproofing Materials

A. Fire-resistant tapes shall be Scotch (3M) No. 77, or approved equal.

B. Glass cloth binding tapes shall be Scotch (3M) No. 69, or approved equal.

7. Special splicing materials and methods shall be as shown on the Contract Drawings.

(j) Factory Tests.

1. For quantities as shown on the Contract Drawings, regular dielectric-withstand and insulation-resistance in water tests for wires and cables shall be performed in accordance with UL44.
2. Flame tests for wires and cables shall be performed in accordance with UL 1685, UL 2196, and AAR RP-585.
3. The test results shall be certified for each reel/coil/box of wire or cable.
4. Factory inspection and witnessing of tests by the Engineer shall be required for all wires and cables furnished under this Contract. The Engineer reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify the Engineer 14 days in advance of the scheduling of such factory tests.

CONSTRUCTION REQUIREMENTS

(a) *Preparation.* Prior to pulling wires and cables, raceway systems shall be cleaned of all foreign matter and all operations necessary shall be performed so as not to cause damage to wires and cables while pulling. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

(b) *Wire and Cable Installation.*

1. General

A. Keep wires and cables dry at all times.

B. Seal wire and cable ends with water tight end seals if splicing or terminating does not follow at once.

C. Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

D. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

2. General Purpose Wires and Cables

A. Minimum wire or cable size shall be No. 12 AWG for light and power service.

B. Wires or cables shall be at least No.10 AWG for the entire length of branch circuits, where distances to first outlets are as follows:

(1) 100 feet or more on 480Y/277 Volt systems.

(2) 70 feet or more on 208Y/120 Volt systems.

3. Lighting Fixture Wires

A. For wiring within lighting fixtures only, where sizes No. 14 AWG or smaller are required, use Type SF-2 fixture hookup wire. Type SF-2 wire shall not be used for wiring end-to-end connected fluorescent fixtures.

B. For connecting lighting fixtures to branch circuit conductors, use low-smoke, zero-halogen XHHW for dry and XHHW-2 90 degrees C wet and dry for indoor applications. For outdoor applications, use RHW-2 or RHH-RHW-2, VW-1, 90 degrees C wet and dry.

(c) *Splicing and Terminating.*

1. General

A. Splices shall be permitted with the Engineer's approval. Splicing and terminating shall be as specified in this Section. Details of special splicing and terminating shall be as shown on the Contract Drawings. Any splicing or terminating methods other than those specified below, for which the components are in accordance with the requirements of this Section, shall be submitted to the Engineer for approval.

2. General Purpose Wires and Cables

A. Splices in dry locations for sizes No. 10 AWG and smaller: Splicing shall be completed using one of the following:

(1) Insulated, integral, self-locking flexible shell, expandable spring connectors shall be applied to the twisted conductors. Two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

(2) Compression type, insulated butt connectors shall be applied to the butted conductors by means of an appropriate crimping tool, providing controlled indentation. Two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

(3) Compression type, pigtail connectors shall be applied to the conductors by means of an appropriate crimping tool, providing controlled indentation. The connector shall be covered with a polyamide cap and two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

B. Splices in dry locations for sizes No. 8 AWG and larger, splicing shall be completed using all of the following:

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REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

- (1) Connectors shall be split sleeve solderless type or solderless compression type.
 - (2) Fill indents of connectors with Scotchfil insulation putty.
 - (3) Apply rubber splicing tape equal to the original insulation rating.
 - (4) Apply two, half-lapped layers of vinyl tape, or a shrinkable tubing.
- C. Splices in wet locations
- (1) Same as dry locations specified in this Section, except that after vinyl tape is applied, cover with two coats of sealer or shrinkable tubing.
 - (2) Resin-filled splice shall be covered with two, half-lapped layers of vinyl tape and two coats of sealer or shrinkable tubing.
- D. Terminations in dry locations for sizes No. 10 AWG and smaller:
- (1) Terminations shall be compression terminals, insulated or uninsulated.
- E. Terminations in dry locations for sizes No. 8 AWG through No. 3/0 AWG.
- (1) Ring tongue terminals shall be solderless, uninsulated compression crimp-type.
 - (2) Ring tongue lugs shall be bolted hex screw type.
- F. Terminations in dry locations for sizes No. 4/0 AWG and larger:
- (1) Ring tongue terminals shall be solderless, uninsulated compression crimp-type.
- G. Terminations in wet locations:
- (1) In addition to the dry location terminations specified in this Section, cover the entire termination area with two, half-lapped layers of vinyl tape and apply two coats of sealer over the tape.
3. Overhead Service Cables
- A. Splices and terminations in overhead service cables shall be the same as specified in this Section, as appropriate for overhead service conductor size.
4. Portable Cords
- A. Splices shall not be made in portable cords.
- B. Terminations shall be made only at apparatus to be served or at branch circuit connection by means of any of the following:
- (1) Insulated, integral, self-locking flexible shell, expandable spring, or crimp-type connectors;
 - (2) Insulated, crimp-type, compression connectors;
 - (3) Uninsulated, ring tongue terminals for connection to wire terminal strip block.
5. Lighting Fixture Wires
- A. Connections to branch circuit and to fixture wiring shall be made by either insulated, integral, self-locking flexible shell, expandable spring, or crimp-type connectors.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

6. Grounding Wires and Cables

- A. Splices and terminations shall be installed in accordance with the manufacturer's recommendations.
- B. In hazardous or classified locations, splices and terminations shall be solderless high conductivity, corrosion-resistant, compression type connectors and terminations shall be clamp-type pressure connectors, suitable for such use.
- C. All underground connections shall be covered with two coats of asphalt base paint.

7. Control Wires and Cables

- A. Splices shall be made in accordance with the requirements specified in this Section, and shall be enclosed in a re-enterable splicing case. Where shielded cable is shown on the Contract Drawings, the shielding shall be continued through the splice. Shields shall be grounded at one location only unless otherwise shown on the Contract Drawings.
- B. Terminations shall be insulated, indenter-type ring tongue terminals.

8. Switchboard Wires

- A. No splices are permitted.
- B. Terminations shall be insulated, indenter-type ring tongue terminals.

(d) *Arcproofing.*

- 1. Arcproofing shall be applied where shown on the Contract Drawings.
- 2. Arcproofing, which has been disturbed for any reason, shall be reinstalled as soon as possible after the disturbance.
- 3. Arcproofing shall be installed as follows:
 - A. Wires and cables shall be grouped by circuit and arcproofing applied over the group of wires and cables comprising one circuit. Splices shall be arcproofed individually and the taping shall join with and be overlapped by the group taping.
 - B. Arcproofing shall be applied in two wrappings of half-lapped tape, bound with glass cloth tape applied at the ends of the fire-resistant tape, and at intervals not to exceed 24 inches along the entire length of the cables. The two wrappings shall be applied with opposing lays.
 - C. Arcproofing shall be extended into the conduit opening or end bell of the raceway entering a handhole, manhole, or box.
 - D. Arcproofing tape shall be 1-1/2 inches wide where the diameter of the individual cable, or of the circumscribed circle for the circuit group, is less than 1-3/4 inches. For larger diameters, the tape shall be 3 inches wide.

(e) *Identification of Wires and Cables.*

- 1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, handholes, wireways, other enclosures and access locations, and at all terminal points.
- 2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)**

3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.
 4. Wires and cables that are arcproofed shall also be identified outside the applied arcproofing.
- (f) *Field Tests.* Test all wires and cables up to equipment installed under this Contract with a 1000-volt Megohmmeter. Furnish the Engineer with a copy of the "Megger" readings together with an outline of the method used. If, in the opinion of the Engineer, any reading is lower than that required by applicable codes, the Contractor shall promptly replace the materials involved, at his expense, and retest.

METHOD OF MEASUREMENT

Wires, Cables, Splices and Terminations (600 volts or less) will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

REVISION OF SECTION 622

**WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work is installation of wires, cables, splices, terminations and appurtenances for electrical systems of medium voltage: 601 volts to 34,500 volts, inclusive, in accordance with these specifications and in conformity with the details shown on the plans or established.

Related Work specified elsewhere: Revision of Section 622 – Supporting Devices.

MATERIALS

(a) *Manufacturers.* The Contractor shall provide materials from the manufacturers listed on the Contract Drawings, or equal, as approved by the Engineer.

(b) *Materials.*

1. Wires and Cables

A. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings.

B. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft or annealed copper, conforming to ASTM B33 (tinned), ASTM B189 (lead-coated or lead alloy-coated), or ASTM B3 (uncoated).

C. Pulling Devices and End Seals

(1) Wires and cables shall be provided with factory-fitted pulling devices and end caps unless otherwise shown on the Contract Drawings. Shop drawings showing the pulling devices and end caps to be used shall be submitted to the Engineer for approval.

(2) For pulling tensions up to 1000 pounds per grip, basket grips may be utilized.

(3) All wires and cables shall be end-sealed, at both ends of each length. Lead cable shall be solder-wiped sealed with a heat-shrinkable cap, to prevent the entrance of moisture.

(4) Lead-sheathed cables shall be provided with either compression type or solder-wiped style pulling bolts or eyes on the leading end of each conductor, or on the overall assembly. The pulling device shall be installed and fitted with either solder-wipe or heat-shrinkable sleeve to prevent the entrance of moisture.

D. Wires and cables shall be identified in accordance with the Association of Edison Illuminating Companies (AEIC) AEIC CS6. Outer jacket shall be printed with manufacturer's identification, type of insulation, size of conductor, rated voltage, year of manufacture, insulation thickness, and UL listing. Each reel shall carry a tag identifying manufacturer, cable type, size, voltage and length of cable on reel. In addition, on each single conductor cable when shipped triplexed or paralleled, there shall be a unique series of "111" or "222" or "333" respectively per phase or leg to identify the phase connection.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

E. Grounding Wires and Cables: Unless otherwise shown on the Contract Drawings, grounding conductors shall be as follows:

(1) Insulated

Stranded for sizes No. 8 AWG and smaller, Class B stranded for sizes No. 6 AWG and larger, 600 volt rated, XHHW or RHW.

Covering shall be a continuous green color and conform to UL 44.

(2) Uninsulated

Stranded for sizes No. 8 AWG and smaller, Class B stranded for sizes No.6 AWG and larger.

In raceways: soft-drawn and conforming to ASTM B3.

Direct buried or encased in concrete: Soft-drawn, medium-hard-drawn or hard-drawn and conforming to ASTM B1, B2 or B3, respectively.

F. Medium Voltage Cables (For interior use as shown on Contract Drawings)

(1) Jacketed, Single Conductor Cable

Voltage rating and size shall be as shown on the Contract Drawings. Cables shall be Type MV-105, EPR, insulation-shielded, jacketed conforming to AEIC CS8, NEMA WC74, and UL 1072.

Insulation shall be ethylene-propylene-rubber (EPR) and shall conform to AEIC CS8, NEMA WC74 and UL 1072.

General Construction: Single conductor cable shall consist of the following:

Copper conductor, uncoated, Class B stranded or if shown on the Contract Drawings, compact strand or sector.

Extruded conductor shielding.

Insulation shall be EPR, 133 percent insulation level.

Extruded EPR semi-conducting insulation shielding.

Tinned copper braided shield, 85 percent minimum coverage, or copper shielding tape, 5-mil, spirally wrapped with a minimum 20 percent overlap.

Jacket of LLDPE, (linear low density polyethylene) or as shown on the Contract Drawings. In NFPA 130 areas and road tunnels and other areas covered by NFPA 502, cable jackets shall be low smoke, zero halogen (LSZH) type.

Maximum outside diameter shall be as shown on the Contract Drawings.

(2) Jacketed, Three Conductor Cable

Voltage rating and size shall be as shown on the Contract Drawings.

Insulation

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

EPR insulated cables shall conform to AEIC CS8, NEMA WC74 and UL 1072.

General Construction: Three conductor cable shall be type MV-105, consisting of the following: Three insulated, shielded conductors, each with copper conductor, uncoated, Class B stranded; extruded conductor shielding; insulation shall be EPR, 133 percent insulation level; extruded, semi-conducting, insulation shielding; and tinned copper braided shield, 85 percent minimum coverage, or copper shielding tape, 5-mil, spirally wrapped with a minimum 20 percent overlap.

Ground conductors and fillers as necessary to provide an overall round cross section.

Tape binder over the three insulated, shielded conductors.

Jacket of LLDPE (linear low density polyethylene) or as shown on the Contract Drawings. In the National Fire Protection Association (NFPA) code NFPA 130 areas and road tunnels or other areas covered by NFPA 502, cable jackets shall be low smoke, zero halogen (LSZH) type.

G. Cable Tags

- (1) Stainless steel metal tags, No. 28 gauge and 3/4-inch wide, embossed with letters and numbers 5/16-inch high, fastened to the cable at both ends of tags with nominal 1/16-inch diameter Monel metal wire or stainless steel cable ties.

H. Splicing, Terminating, and Arcproofing Materials

(1) General

All splicing, terminating, and arcproofing materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other or of the wire or cable itself.

All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation, installation and operating conditions of the specific application.

Splices and terminations shall be supplied as complete kit assemblies with all components and detailed installation instructions. Unless otherwise shown on the Contract Drawings, splices and terminations for medium voltage cables shall be heat-shrink polymeric type as manufactured by Raychem.

Connectors used with conductors with strand-filled semiconducting blocking compound shall be crimp type. Otherwise, connectors shall be solder type.

- (2) Subject to compliance with requirements of this Section, provide connectors of the following types:
Split-sleeve, solder, high conductivity, corrosion-resistant connectors;

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

Solderless, uninsulated, high conductivity, corrosion-resistant, compression connectors conforming to UL 467 and IEEE 837;

Welded-type connectors.

(3) Terminals

Subject to compliance with requirements of this Section, provide terminals of the following types:

Solder terminals shall be high conductivity, corrosion-resistant-type;

Solderless, uninsulated, high conductivity, corrosion-resistant compression terminals conforming to UL 467 and IEEE 837;

Welded-type terminals.

Shrinkable Tubing: Subject to compliance with requirements of this Section provide shrinkable tubing of the following types:

Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing.

Cold, shrinkable tubing.

Tapes and Sealers

Vinyl Tapes: Flame-retardant, cold- and weather-resistant, 3/4 inch and 1-1/2 inches wide, as required, and conforming to UL 510 and ASTM D3005.

For interior, dry locations, provide tape 7 mils thick, conforming to ASTM D3005 (Type I).

For exterior or damp and wet locations, provide tape 8.5 mil thick, conforming to ASTM D3005 (Type II).

Rubber Tapes: Ethylene-propylene, rubber-based, 30-mil splicing tape, rated for 130 degrees C operation; 3/4 inch and wider (1, 1-1/2, 2 inches) or as shown on the Contract Drawings, or as approved by the Engineer.

Insulating Putty: Rubber-based, 125-mil elastic filler putty; 1-1/2 inches wide; Scotch (3M) Scotchfil, or approved equal.

Silicone Rubber Tapes: Inorganic silicone rubber, 12-mil 130 degrees C rated, anti-tracking, self-fusing tape; 1 inch wide.

Sealer: Liquid applied fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

(4) Binding wire shall be uninsulated, tinned copper.

(5) Lead sleeve shall be 5/32 inches thick, commercially and chemically pure, and shall conform to the Insulated Cable Engineers Association (ICEA) ICEA S-97-682 and ASTM B29.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

(6) Solder

Solder used on the shielding braids of any cable shall be 50 percent tin/50 percent lead.

Solder used for wiping the lead splice sleeve to the lead sheath of any cable shall be 40 tin/60 lead, Class A.

Flux used when soldering conductor connectors or shielding tapes and shielding braids shall be of a non-corrosive and non-acid type.

(7) Insulating compound shall be installed in all lead-covered splices and all potheads.

(8) For arcproofing materials, refer to Arcproofing (Revision of Section 622).

(9) Ground Straps Flexible, tinned copper braid, equivalent to No. 6 AWG.

(10) Special splicing materials and methods shall be as shown on the Contract Drawings.

CONSTRUCTION REQUIREMENTS

(a) *Examination.* All wire, cables, equipment and accessories shall be inspected prior to installation. Replace any damaged items.

(b) *Preparation.* Prior to pulling wires and cables, raceway systems shall be cleaned of all foreign matter and all operations necessary shall be performed so as not to cause damage to wires and cables while pulling. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

(c) *Installation.*

1. Wire and Cable Installation

A. General

(1) Keep wires and cables dry at all times.

(2) Seal wire and cable ends with watertight end seals if splicing or terminating does not follow at once.

(3) Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.

(4) Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

2. Splices and Terminations

A. General

(1) All medium voltage wires and cables shall be spliced in each manhole through which they pass.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

- (2) Any splicing or terminating methods other than those required by this Section, for which the components are in accordance with the requirements of this Section, shall be submitted to the Engineer for approval.
- (3) All cables shall be checked for phase identification before and after terminations have been made. All phase discrepancies shall be corrected.

B. Insulated Wires and Cables

- (1) Splices and terminations shall be completed by workmen trained and experienced in the type of cable and the voltage class specified in this Section, with no less than three years of experience in this specialty type of work, and who perform similar splices and terminations on a regular basis.
- (2) Where required by the Engineer, sample splices shall be demonstrated to the Engineer by each splicer performing the Work of this Section. The sample shall be provided to the Engineer after completion of the demonstration.
- (3) Terminations using stress-relief cones, which conform to Class 1, IEEE 48, shall be made in accordance with the cable manufacturer's recommendations.
- (4) Splices shall conform to IEEE 404 and shall:
 - Meet the full electrical and physical integrity of the wire and cable construction, including voltage rating, ampacity, BIL, and type of waterproofing.
 - Conform to the wire and cable manufacturer's requirements and recommendations.
- (5) For cable where moisture is present, each such cable shall be nitrogen-purged to remove all moisture. The purging procedure shall be submitted to the Engineer for approval.
 - All terminators shall include a lead-wiping collar or adaptor and all splices shall be lead-sleeve, wiped construction.
 - For each splice using filling compound shall be air-tested, prior to filling with insulating compound. The air-testing procedure shall be submitted to the Engineer for approval.
 - All splices shall be inspected and approved by the Engineer prior to pouring insulating compound into sleeve casing and overall vinyl taping.
 - Where cable is jacketed over the lead sheath, apply two half-laps of vinyl tape over other complete splice.
- (6) Where splices or terminations are on the Electrical Utility Company (Utility) side of incoming service equipment, the splices or terminations shall be of the type and style approved by the Utility and shall be submitted to the Utility for approval.

C. Grounding Wires and Cables

- (1) Splices and terminations shall be installed in accordance with the manufacturer's written recommendations.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

- (2) In hazardous or classified locations, splices and terminations shall be solderless, high conductivity, corrosion-resistant, compression-type connectors.
 - (3) All underground connections shall be covered with two coats of asphalt base paint.
 - (4) Each splice shall be bonded to ground, using a flexible ground strap, 2 feet long, not less than No. 6 AWG or equivalent size.
3. For arcproofing of cables, see Arcproofing - Revision of Section 622.
4. Identification of Wires and Cables
- A. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, handholes, wire ways, and other enclosures, and at all terminal points.
 - B. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.
 - C. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.
 - D. Wires and cables that are arcproofed shall be identified outside the applied arcproofing.
5. Field Tests
- A. Medium Voltage Shielded Cables
 - (1) After installation and before they are placed in service, direct current voltage tests shall be run in accordance with AEIC CS8.
 - (2) A copy of all test reports, together with an outline of the test method used, shall be submitted to the Engineer for review.
 - B. Ground Wires and Cables
 - (1) Ground wires and cables shall be tested to prove continuity and proper connections to equipment and ground rods.
 - (2) The Contractor shall certify all field testing and shall submit the test results to the Engineer for approval.
6. Factory Tests
- A. For quantities as shown on the Contract Drawings, regular dielectric-withstand and insulation-resistance in water tests for wires and cables shall be performed in accordance with UL 44.
 - B. The following tests for wires and cables shall be performed and certified reports of these tests shall be submitted to the Engineer:
 - (1) Flame tests in accordance with IEEE 383 (where applicable).
 - (2) Jacket tests in accordance with ICEA S-97-682.
 - (3) Cable tests in accordance with AEIC CS8, and ICEA.

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**REVISION OF SECTION 622
WIRES, CABLES, SPLICES, TERMINATIONS
(MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)**

- C. The test results shall be certified for each shipping reel of wire or cable.
- D. Factory inspection and witnessing of tests by the Engineer shall be required for all wires and cables furnished under this Contract. The Engineer reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify the Engineer 14 days in advance of the scheduling of such factory tests.

7. Independent Laboratory Test

- A. Unless otherwise shown on the Contract Drawings, submit a 2 foot-0 inch sample from 25 percent of the shipping reels to an independent laboratory for the following tests, which shall be performed in accordance with AEIC and ICEA standards:

- (1) AC voltage breakdown tests
- (2) Adhesion of insulation shield to insulation
- (3) Volume resistivity of conductor shield to insulation shield
- (4) Dissection and dimensional analysis
- (5) Microscopic examination for voids, contaminants, and protrusions
- (6) Hot Creep Test to determine state of cure of insulation
- (7) Partial Discharge (DC) measurements
- (8) Dissipation factor of cable insulation
- (9) Impulse breakdown tests

(d) *Delivery, Storage and Handling.*

- 1. Where multiple single conductor cables are to be installed as one cable, single conductor cables shall be multiplexed by cable manufacturer prior to shipment. Cable assembly overall diameter shall be kept to a minimum.
- 2. Store material in a clean, dry space and protect it from the weather.

METHOD OF MEASUREMENT

Wires, Cables, Splices, Terminations (medium voltage: 601 volts to 34,500 volts, inclusive) will not be measured and paid for separately, but shall be included in the lump sum price for Electrical Modifications.

**REVISION OF SECTION 622
FANS**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

Subsection 622.23 shall include the following:

This work consists of removal and replacement including procurement and installation of the supply fan SF-1, the exhaust fan EF-3, and the air handling fan AH-4 to accommodate a new diesel backup generator. This includes replacement of a section of ductwork from the generator room to EF-3, increasing the size as shown in the plans, and replacement of the existing damper in this ductwork.

Related work specified elsewhere:

- Revision of Section 622 – Ductwork
 - Revision of Section 622 – Insulation
 - Revision of Section 622 – Piping Systems
 - Revision of Section 622 – Vibration Isolation
- (a) *General Requirements.* In design and purchase of equipment, the Contractor shall provide for interchangeability of items for equipment, subassemblies, parts, motors starters and relays. Requirements of this section apply to fans which are not a component part of air-handling units designed as complete units by the manufacturer. Fan rating shall be based on tests performed in accordance with Air Movement and Control Association (AMCA) 210. Fans shall be statically and dynamically balanced and quiet in operation. Fans shall be designed to ensure that resonance frequency of blade assembly is not within 15 percent of harmonics of rotational frequency. Finished parts of fans, such as shafts and bearings, shall be protected from rust prior to operation by means of wrappings or protective grease or plastic coatings. Exhaust fans shall be provided with firestats to stop fan when temperature of air being handled reaches 125°F. Firestat shall have adjustable range from 100°F to 200°F and manual reset. Fan construction shall be suitable for operating conditions defined in AMCA 99-2408.
- (b) *Centrifugal Fans.*
1. Class I or II, non-overloading.
 2. Fan blades:
 - A. Fan wheels larger than 30 inches: Backward-inclined air-foil section.
 - B. Fan wheels 30 inches or less: Backward-inclined plate-type blades.
 - C. Fans with wheels less than 12 inches in diameter, and utility fans operating at less than 0.75 inches WG may have forward-curved blades.
 3. Air entering fan uniformly over inlet area.
 4. Fan housing: Fabricated of steel sheets, manufacturer's standard heavy-gauge construction, except for those of low-pressure fans of less than 5,000-cfm capacity which may be fabricated of aluminum, 0.080-inch thick or heavier.
 5. Fan wheel rims and blades: Fabricated of steel, manufacturer's standard heavy-gauge construction, with back plates of steel, 3/16 inch, except for those of low-pressure fans of less than 5,000 cfm which may be fabricated of aluminum, 0.080-inch thick or heavier.
 6. Fan wheels: Aluminum or steel provided with manufacturer's standard corrosion-resistant coating.
 7. Fan scroll attached to the side plates by means of continuous lock-seam or welded-seam construction.

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REVISION OF SECTION 622
FANS**

8. Fan wheels and sheaves splined or keyed and fastened to the shafts with set screws.
 9. Shaft constructed solid or hollow of SAE 1035 or SAE 1040 ground and polished steel.
 10. One layer of corrosion-resistant coating on nonworking surfaces of shafts, factory-applied.
 11. Inspection openings provided for fan housing having wheels larger than 22 inches in diameter.
 - A. Cover plate having pressure latches on fan housing located opposite outlets.
 12. Large fan housings provided in sections to permit installation or removal through openings available in structure.
 13. Field joints: Flanged and bolted.
 14. Fans designed to provide self-limiting, non-overloading power characteristics.
 15. Two bearings for double-inlet and single-inlet fans having wheels larger than 36 inches in diameter, one on each side of wheel, with overhung sheaves.
 16. Inside and outside of fan housings factory-painted with baked-enamel primer; exterior surfaces given additional factory finish-coat of enamel.
 17. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
 - A. Adjustable sheaves furnished on motor, capable of 20-percent adjustment in fan speed, with design fan-capacity setting at approximately midpoint of adjustment.
 - B. Drives provided with belt guard of expanded-metal wire mesh or belt guards with solid-metal side panels with tachometer opening.
 18. Motors:
 - A. One-half horse power and above: Totally enclosed, fan-cooled and guarded.
 - B. Less than 1/2 horsepower: Manufacturer's standard for intended use.
 19. Vibration isolators: In accordance with Revision of Section 622 – Vibration Isolation.
- (c) *Tubular Centrifugal Fans.*
1. Class I or II, belt-driven, non-overloading, designed for straight through airflow.
 2. Housing: Manufacturer's standard heavy-gauge steel construction.
 - A. Flanged inlet and outlet for connection to ductwork, with inlet and outlet identical in size.
 - B. Welded, cylindrical construction, braced to prevent vibration.
 - C. Fan bearings and drive enclosed and isolated from air stream.
 3. Fan wheels:
 - A. Welded construction, centrifugal wheel, with backward-inclined blades.
 - B. Fan wheels 27 inches in diameter or larger supplied with double thickness, air-foil blades.
 - C. Fan wheels less than 27 inches in diameter supplied with plate-type blades.
 - D. Fan wheels statically and dynamically balanced.

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REVISION OF SECTION 622
FANS**

4. Fans supplied with stationary conversion vanes on discharge side of wheel designed to reduce turbulence.
 5. Fan bearings:
 - A. Heavy-duty, self-aligning ball bearings.
 - B. Lubrication fittings extended to fan casing and provided with covers to effectively exclude water and dirt.
 6. Fan shaft accurately machined and ground for proper fit to wheel hub and bearing and designed to operate well below first critical speed.
 7. Inside and outside of fan housing factory-painted with baked-enamel primer. Exterior surfaces given an additional factory-coat of corrosion-resistant finish enamel.
 8. One coat of corrosion-resistant coating on nonworking surfaces of shafts, factory-applied.
 9. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.
 - A. Adjustable sheaves furnished on motor allowing 20-percent adjustment in fan speed, with design-capacity setting at approximately midpoint of adjustment.
 10. Fan wheels and sheaves splined or keyed and fastened to the shaft with set screws.
 11. Internal and external belt guards as necessary for complete protection with tachometer opening.
 12. Motors:
 - A. One-half horsepower and above: Totally enclosed, fan-cooled and guarded in accordance with electrical specifications (Revisions to Section 622).
 - B. Less than 1/2 horsepower: Manufacturer's standard for intended use.
- (d) *Axial Fans.*
1. Direct-driven or belt-driven as shown.
 2. Welded tubular-steel casings, except for low-pressure fans of less than 5,000-cfm capacity, which may have aluminum casings.
 3. Equipped with stationary discharge conversion blades and adjustable motor mounts.
 4. Air-foil blades: High-strength cast aluminum or steel.
 5. Blade pitch:
 - A. Fans with wheels 18 inches or larger: Blades field-adjustable without removing wheel from casing.
 - B. Fans with wheels less than 18 inches in diameter: May be equipped with stationary blades.
 6. Flanged-type for fan-casing connections to ductwork.
 7. Internal and external belt guards, as appropriate.
 8. Inlets with smooth, rounded edges.

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REVISION OF SECTION 622
FANS**

10. Belt-driven fans:

- A. Provide with high-grade, open-hearth steel fan shaft accurately machined and ground for proper fit to wheel hub and bearings.
- B. Fan bearings and drive shafts enclosed and isolated from the air stream.
- C. Bearings sealed mechanically against dust and dirt, self-aligning and grease-lubricated.
- D. Fan driven by V-belt rated at 150 percent of driving-motor brake horsepower.

11. Motors:

- A. 1/2 horsepower and above:
 - (1) Belt-driven fans: Totally enclosed, fan-cooled and guarded in accordance with electrical specifications (Revisions of Section 622).
 - (2) Direct-driven fans: Totally enclosed, air-over, fully guarded in accordance with electrical specifications (Revisions of Section 622).
- B. Less than 1/2 horsepower: Manufacturer's standard for intended use.

(e) *Nameplates.*

- 1. Fans: Securely attached on each fan showing manufacturer's name, model number and serial number.
- 2. Motors: As required in electrical specifications (Revisions of Section 622).

The Contractor shall fit fans and appurtenances within space provided and make readily serviceable. Provide support beams, concrete pads, support legs, platforms, hangers and anchor bolts required for proper installation of equipment as recommended by manufacturer. Vibration isolation for fans and concrete pads shall be as specified in Revision of Section 622 – Vibration Isolation. For axial and tubular centrifugal fans, provide service access as specified in Revision of Section 622 – Ductwork.

Subsection 622.27 shall include the following:

Fans will not be measured, but shall be included in the lump sum price for HVAC.

Subsection 622.28 shall include the following:

The completed and accepted work for the fans will be paid for at the contract lump sum price for the pay item listed below.

Payment will be made under:

Pay Item	Pay Unit
HVAC	Lump Sum

**REVISION OF SECTION 622
VIBRATION ISOLATION**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

Subsection 622.23 shall include the following:

This work is installation of vibration isolation for mechanical equipment and piping in accordance with these specifications and in conformity with the details shown on the plans or established.

Related work specified elsewhere: Revision of Section 622 – Piping Systems, Revision of Section 622 – Fans.

(a) *General Requirements.* Vibration isolators shall be selected to produce uniform loading and deflection even when equipment weight is not evenly distributed; steel components shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

For floor-mounted equipment, provide spring isolators. For ceiling-suspended piping, provide suspension-type isolators.

(b) *Spring Isolators.* Spring isolators for floor-mounted equipment shall have the following properties:

1. Free-standing, laterally stable without housing, complete with minimum 1/4-inch thick neoprene, acoustical friction pad in series with spring element.
2. Leveling bolts and adequate facilities for bolting to equipment and supporting structure using isolation washers.
3. Coil outside diameter: Not less than 0.8 of operating height of spring.
4. Horizontal stiffness: Not less than 0.8 of vertical stiffness.
5. Springs designed to have additional 50 percent capacity beyond rated load.
6. Springs designed so that ends remain parallel during and after spring deflection to operating height.
7. Vibration isolators selected for lowest operating speed of equipment.
8. Built-in adjustable limit stops with isolators provided for equipment of operating weight different from installed weights, to prevent rising of equipment when weight is removed. Limit stops not to be in contact during normal operating conditions.
9. Welding of springs to load plate assembly for vibration isolators with capacities of 6,000 pound or less is prohibited.
10. Vibration isolators with capacities of 6,000 pounds or less are permitted use of cups or other positive means for restraining springs.

(c) *Suspension-type isolation hangers.* Suspension-type isolation hangers for ceiling-suspended equipment shall have the following properties:

1. Combination of spring and neoprene in series.
2. Spring made of stable steel.
3. Encased in structurally stable steel bracket.
4. Spring diameter large enough to permit 15-degree angular misalignment of rod connecting hanger to equipment without rubbing on box.
5. Designed to provide complete support for suspended units upon failure or rupture of isolator.

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**REVISION OF SECTION 622
VIBRATION ISOLATION**

- (d) Concrete equipment subbases (housekeeping pads) shall have the following properties:
 - 1. Concrete subbases not less than four inches high provided for floor-mounted equipment. Subbases resting on structural floor and reinforced with steel anchor rods into existing floor.
 - 2. Clearance between subbases and inertia bases: Two inches minimum.
 - 3. Subbase concrete: CDOT Class B.
- (e) Isolation unit types and deflection for air handling equipment shall be as follows:
 - 1. Fans: Floor-mounted and ceiling-suspended.
 - 2. Spring isolators designed for a minimum of 1.5 inches deflection.
- (f) Self-contained air-conditioning units shall be provided with spring-isolators designed for a minimum of one-inch deflection except through-wall units.
- (g) Ceiling-suspended piping shall include:
 - 1. Combination spring and neoprene in shear element hangers as specified for ceiling-suspended equipment.
 - 2. Springs designed for 1.5-inch minimum deflection.
 - 3. First two isolation hangers of each pipe connected to equipment shall have deflection equal to equipment isolation-support deflection.
- (h) Floor-mounted piping shall include:
 - 1. Spring isolators with one-inch minimum static deflection.
 - 2. First two spring isolators of each pipe connected to equipment to have deflection equal to equipment isolation-support deflection.
- (i) Grout shall be premixed shrinkage-compensating grout.

The Contractor shall install vibration isolators where shown as recommended by the equipment manufacturer. Mechanical equipment shall be mounted on vibration isolators to isolate equipment from structure. Bases and equipment shall be jacked into position and wedged or blocked before vibration isolators are loaded. Isolator leveling bolts shall be used for final leveling of equipment after equipment is in operation. Springs shall be installed so that ends remain parallel during and after deflection to operating height.

Remote Radiator water piping shall be connected to equipment, mounted on vibration isolators or suspended with vibration hangers, isolated for a distance of 50 feet from equipment. Piping with installed length less than 50 feet shall be isolated in its entirety only when connected to equipment provided with vibration isolators.

Subsection 622.27 shall include the following:

Vibration Isolation will not be measured and paid for separately, but shall be included in the lump sum price for HVAC.

**REVISION OF SECTION 622
DUCTWORK**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

Subsection 622.23 shall include the following:

This work includes removal and replacement of ductwork on Level 2 to accommodate the larger piping network and removal and replacement of ducts as needed for new fans. This work is installation of ductwork and accessories in accordance with these specifications and in conformity with the details shown on the plans or established.

Related work specified elsewhere:

- Revision of Section 622 – Fans,
- Revision of Section 622 – Insulation,
- Revision of Section 622 – Piping Systems,
- Revision of Section 622 – Vibration Isolation.

(a) *General.*

1. Galvanized sheet steel: ASTM A653.
2. Steel plate: ASTM A36, Grade A.
3. Steel pipe: ASTM A53, Grade A.
4. Flexible material:
 - A. Fibrous-glass cloth, 32 ounces per square yard, UL-listed.
 - B. Tensile strength: 450-psi minimum.
 - C. Coated on both sides with fire-resistant neoprene.
 - D. Suitable for opening temperature of 200F and meeting requirements of the National Fire Protection Association (NFPA) 90A.
5. Paint:
 - A. Zinc-rich gray, No. 721, Detroit Graphite or equal.
 - B. Bituminous, AASHTO M81, Grade RC-250.

(b) *Fabrication.*

1. Duct construction:
 - A. Fabrication in accordance with Sheet Metal and Air Conditioning Contractors (SMACNA) “HVAC Duct Construction Standards – Metal and Flexible.”
2. Access doors in ducts:
 - A. Provide access doors as shown to gain access to resistance heaters, fans, fan motors, dampers, filters, coils, and controls.
 - B. Doors: Of same material thickness as ducts.
 - C. Gasketed doors: Secured to duct.

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REVISION OF SECTION 622
DUCTWORK**

3. Plenums:

- A. Field-fabricated and reinforced consistent with class of ductwork in which used.
- B. Outward-opening access doors to plenums provided where necessary for equipment access and as shown.

4. Dampers.

- A. Splitter or butterfly damper provided in duct leading to air terminal as shown.
- B. Butterfly dampers:
 - (1) Balanced-type with flat blades.
 - (2) Rigid blades fabricated with close-fitting hemmed edges.
 - (3) Damper rods minimum 3/8-inch square at one end passing directly through ducts.
 - (4) Square end of each rod held in self-locking lever device.
 - (5) Where installed in furred ceilings, damper-locking device may be provided with short lever and concealed in box with flush cover in lieu of access panel.
- C. Opposed-blade dampers:
 - (1) Gang-operated multiple blades provided in ducts over 12 inches in dimension.
 - (2) Multiple blades fabricated maximum six inches wide.
 - (3) Fabricated with nonmetallic edges or coating in low-pressure, medium-pressure, or high-pressure ducts.
 - (4) Ends of damper rods sealed to prevent leakage of air.
- D. Damper material:
 - (1) Splitter and damper blades fabricated of same metal and two gauges heavier than ductwork and casings.
 - (2) Fastening details and other items fabricated of metal specified for ductwork and casing branching.
- E. Damper regulators:
 - (1) Self-locking, damper and splitter regulators furnished, labeled SHUT and OPEN.
 - (2) Factory-fabricated damper and splitter hardware furnished with zinc or cadmium protective coating.
- F. Fire dampers:
 - (1) Fabricated to meet requirements of codes and regulations of jurisdictional authorities.
 - (2) Constructed so that, during normal operation, folded blade assembly does not interrupt air stream.
 - (3) Access provided for replacement of links.
 - (4) Sleeve provided for fire damper, 14-gauge hot-rolled steel.

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REVISION OF SECTION 622
DUCTWORK

- (5) Fire dampers remote from fire partitions; connecting ductwork provided between fire damper and fire partition, fabricated of 11-gauge, zinc-coated sheet steel and supported by ½-inch diameter rods.
- (6) Fire dampers constructed to meet requirements of NFPA 90A and UL 555.

5. Flexible-duct connections:

- A. Flexible-duct connections provided between air-handling unit fan and related ductwork and wherever necessary to prevent transmission of vibration to adjacent elements.
- B. Factory-assembled flexible material bordered each side with three-inch wide galvanized-steel edging mechanically attached.
- C. Width of flexible portion: Three to nine inches as necessary for installation conditions and to allow freedom of movement without unnecessary slack.
- D. Fabric parts of flexible connections: Unpainted.

6. Hangers and supports:

- A. Building attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for building materials.
 - (1) Use powder-actuated concrete fasteners for standard-weight aggregate concrete or for slabs more than 4 inches thick.
 - (2) Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Hanger materials: Galvanized, sheet steel or round, threaded steel rod.
- C. Strap and rod sizes: Comply with Sheet Metal and Air Conditioning Contractors (SMACNA) "HVAC Duct Construction Standards – Metal and Flexible," for sheet steel width and thickness and for steel rod diameters.
- D. Duct attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E. Trapeze and riser supports: Steel shapes complying with ASTM A36/A36M.
- F. Supports for galvanized-steel ducts: Galvanized steel shapes and plates.

7. Instrument test holes:

- A. Factory-fabricated, airtight, non-corrosive instrument test hole with screw cap and gasket.
- B. Instrument test holes provided where required by balancing and testing agency.
- C. Cap extended up through insulation.

(c) *Ductwork Installation.*

- 1. Install dampers and splitters so as to permit adjustment after completion of the work.
- 2. Install dampers without strain or distortion of any part of dampers.
- 3. Adjust moving parts to move freely without binding.

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**REVISION OF SECTION 622
DUCTWORK**

4. Caulk dampers airtight around frames.
 5. Adjust damper and splitter adjusting rods to operate freely between open and closed positions.
 - A. Cut off projecting ends of rods after adjustment and bend over two inches from bushings.
 - B. Leave cut ends smooth and free from burrs.
 6. Where diffuser is located at end of rectangular duct, extend duct minimum of one-neck diameter beyond center line of neck.
 7. Fire dampers:
 - A. Install fire dampers in ducts which penetrate fire-rated walls or floors.
 - B. Install fire dampers to conform to SMACNA "Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems."
 - C. Install fire dampers in strict accordance with manufacturers installation manual and in accordance with UL Listing.
 8. Duct penetration through fire-rated partitions to be sealed with approved fireproof sealant in accordance with Section 07841 or as required by the UL listing and manufacturer's installation instructions.
 9. At in-line fans, provide flanged removable transition to permit access to and removal of fan motor.
- (d) *Flexible Connections.* Install flexible connections in accordance with SMACNA "HVAC Duct Construction Standards – Metal and Flexible."
- (e) *Protection of Ductwork.* Protect ductwork, appurtenances and openings from dirt, foreign objects, and damage during construction. Replace damaged ductwork and appurtenances. Provide sheet metal caps on duct ends that are to be connected to future ductwork.
- (f) *Hanging and Supporting.* Install rigid round, rectangular, and flat-oval metal duct with support systems indicated in SMACNA "HVAC Duct Construction Standards – Metal and Flexible." Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection. Support vertical ducts at a maximum interval of 16 feet and at each floor. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load. Install concrete inserts before placing concrete. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
- (g) *Cleaning of Air System.* Before fans are operated, clean inside of air system, including casing, plenums, ductwork used for air supply or return in accordance with the National Duct Cleaning Associations' requirements. Accomplish cleaning by means of industrial vacuum cleaners which will effectively remove dust and foreign materials from surfaces swept by air stream. Clean exposed ductwork and leave in satisfactory condition, free from grease, oil, and foreign material prior to application of insulation or finish painting. Clean ducts after the system has been used for adjusting, testing, or temporary ventilation.

Subsection 622.27 shall include the following:

Ductwork will not be measured and paid for separately but shall included in the lump sum price for HVAC.

A larger opening is required in the generator room wall, and cost of the new grille at that opening shall be included in the lump sum price for HVAC.

**REVISION OF SECTION 622
INSULATION**

Section 622 of the Standard Specifications is hereby revised for this project as follows:

Subsection 622.23 shall include the following:

This work is installation of insulation in accordance with these specifications and in conformity with the details shown on the plans or established.

Related work specified elsewhere: Revision of Section 622 – Piping Systems, Revision of Section 622 - Ductwork.

(a) *Piping Insulation* shall have the following properties:

1. Vapor-permeance resistance:

A. Maximum vapor permeance: 0.5 percent by volume.

B. Vapor-permeance ratings for piping insulation determined in accordance with ASTM C240.

(b) *Remote radiator water piping insulation* shall have the following properties:

1. Rigid premolded cellular glass: Covered with aluminum jacket 0.016-inch thick; ASTM C552.

2. Rigid premolded insulation sleeving: Thermal-pipe and tube covering, mineral fiber, industrial-type covered with aluminum jacket 0.016-inch thick; ASTM C552, all-service jacket.

3. Insulation for buried or embedded pipe: As specified or rigid polyurethane, one-inch thick, ASTM C552.

(c) *Generator exhaust piping insulation* shall have the following properties:

1. Calcium silicate pipe insulation or mineral wool pipe insulation: Covered with 304 stainless steel cladding with 2" minimum radial and axial overlap. Two layers of insulation with minimum total insulation thickness of 3".

(d) *Expansion Joint Insulation*. Expansion joint insulation shall be flexible unicellular, ASTM C534, one-inch thickness, two layers.

(e) *Wire Mesh*. Wire mesh for insulation shall be galvanized wire, 22-gauge, one-inch mesh welded.

(f) *Corner Beads*. Corner beads for insulation shall be galvanized steel, 26-gauge, 2 1/2-inch wings.

(g) *Mastic*. Vinyl-emulsion mastic for insulation shall be as recommended by manufacturer of rigid insulation.

(h) *Pipe Jackets*.

1. Fabric pipe jacket for insulation shall be prefabricated laminate containing 10-by-10 asphalt-impregnated glass fabric and aluminum foil one-mil thick, sandwiched between three layers of bituminous mastic, for use on embedded or inaccessible piping.

2. Metal Pipe Jacket for insulation shall be galvanized sheet steel, 24 gauge (U.S.S.) having Z-type longitudinal joint seam, or aluminum alloy, 0.016-inch thick, mill-finish, having Z-type longitudinal joint seam.

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**REVISION OF SECTION 622
INSULATION**

(i) *Hanger Shields*. Hanger shields for insulation shall be aluminum alloy, minimum 0.050-inch thick, mill-finish, covering bottom 180 degrees of pipe insulation, lengths as follows:

Pipe Sizes/Inclusive	Shield Length
1/2 inch to 2 inches	6 inches
2-1/2 inches to 6 inches	9 inches
6 inches to 12 inches	12 inches
Larger than 12 inches	18 inches

(j) *Installation*. Do not apply insulation until all surfaces to be covered are clean, dry, and free of foreign materials, such as oil, grease, rust, scale, and dirt. Apply only clean and dry insulation. Install insulation in accordance with manufacturer’s recommendations as a minimum requirement. Provide complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors, and other projections through insulation on cold surfaces. Provide continuous insulation through sleeves and openings except pipe sleeves piercing exterior walls, floors, and ceilings below ground level. Stagger joints with respect to adjacent butt joints. Unless otherwise shown, insulate the remote radiator jacket water piping.

(k) *Insulation*. Insulation of remote radiator water piping shall meet the following requirements:

1. Insulation thickness:

A. Rigid premolded cellular glass:

- (1) Pipe sizes four inches and smaller: Install two-inch thick insulation on supply and return piping, valves, and fittings.
- (2) Pipe size five inches and larger: Install one layer of two-inch thick insulation on supply and return piping, valves and fittings.

B. Rigid premolded insulation sleeving: Install one layer of two-inch thick on supply and return piping, valves, and fittings as follows:

- (1) IPS sizes: 1/2 inch through 30 inches.
- (2) Copper tubing: 1/2 inch through 6-1/8 inches.

2. Insulation of embedded or inaccessible-piping insulation shall comply with the following:

- A. Install insulation consisting of layers or thickness specified for usage specified.
- B. Provide inner jacket of prefabricated-fabric pipe jacket.
- C. Coat exposed surface of fabric pipe jacket with protective plastic film and inner surface with special-release paper.
- D. Apply jacket of galvanized steel over inner jacket.
- E. For flanges, valves, and other fittings, apply aluminum jacket with paper backing or asphalt adhesive over galvanized-steel jacket. Secure by means of strap as specified.
- F. Over elbows provide mitered insulation covered with aluminum jacket material.

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REVISION OF SECTION 622
INSULATION**

3. For insulation on pipe saddles, cut two-inch thick piece of premolded pipe insulation of same material as used on piping, slightly larger than void formed by outer pipe circumference and pipe saddle. Press insulation into void by hand pressure, to that both ends project slightly beyond each end of saddle. Cut ends of insulation flush with saddle ends. Use of filter, adhesive or other material to fill voids or imperfections in insulation is prohibited.
4. For expansion joints for piping insulation, install expansion joints in both horizontal insulation and vertical runs of piping on centers not to exceed 50 feet. Install joints one-half inch wide and fill with cushioning material in accordance with insulation manufacturer's recommendations.
5. For insulation for piping anchors, insulate anchors which are secured directly to cold piping as specified for a minimum distance of eight inches from surface of pipe insulation and sufficient to prevent sweating.

Subsection 622.27 shall include the following:

Insulation will not be measured and paid for separately, but shall be included in the lump sum price for HVAC.

**REVISION OF SECTION 622
PIPING SYSTEMS**

Section 622 of the Standard Specifications is hereby revised for this project to include the following:

Subsection 622.23 shall include the following:

This work consists of replacement of the remote radiator piping and generator exhaust piping. Remote radiator piping includes four 3" pipes and one 5" pipe with all fittings, valves, drains, insulation, specialties, and supporting devices in accordance with these specifications and in conformity with the details shown on the plans or established. Generator exhaust piping includes 18" diameter steel pipe with all bends and angles as described in the plans, insulation and firestop, supporting devices, and all elements of the screen panel at the upper exterior end of the exhaust piping.

Related work specified elsewhere: Revision of Section 202 – Removal of Portions of Present Structure (Building), Revision of Section 622 - Insulation, Revision of Section 622 – Vibration Isolation.

(a) *Interchangeability*. In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies and parts.

(b) *Piping*.

1. Steel pipe and fittings:

A. Seamless piping: ASTM A53, Types Grade B, hot-dip galvanized, Schedule 40, provided for the following applications:

a. Remote Radiator water embedded or otherwise inaccessible.

B. Fittings for Remote Radiator water: ASTM A234 and ANSI/ASME B16.9 for dimensions and tolerances but not chemical properties.

C. Flanges: ASTM A105 and ANSI/ASME B16.5 for dimensions and tolerances.

D. Fittings and flanges furnished with properties equal to or greater than that of adjacent pipe.

2. Unpolished stainless-steel drip pans:

A. Provided under water, waste or condensate-drain piping which run over transformer vaults or electric motor starters.

B. Each drip pan provided with one-inch drain.

3. Black-steel seamless pipe and fittings:

A. Exposed Remote Radiator-water supply and return piping: ASTM A53, Schedule 40.

a. Pipes 1-1/2 inch and smaller connected with socket-weld fittings or screwed fittings.

b. Pipes two inches and larger connected with welded fittings.

B. Exhaust piping: Pipes larger than 12 inches in diameter: Minimum 3/8-inch wall.

C. Threaded-pipe fittings: FS WW-P-501, Type I, Class B.

D. Welding fittings made of same schedule or weight classification as the pipe.

E. Factory-made welding fittings.

F. Mitered joint elbows and field-made reducers will not be permitted.

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**REVISION OF SECTION 622
PIPING SYSTEMS**

- G. Butt-welded fittings larger than 1-1/2 inches: ANSI/ASME B16.9.
- H. Socket-welding fittings: ANSI/ASME B16.11.
- I. Flanges for welded piping system: ANSI/ASME B16.5, forged steel, welded-neck type, 150-pressure class.

4. Unions:

- A. 1-1/2 inch and smaller: Threaded, ASME B16.39, Type A or B to match piping.
- B. Two inch and larger unions: ASTM A126, Class B, flanged.
- C. Two, 2-1/2 and three-inch union flanges: Steel, of cast iron, ANSI/ASME B16.1, 125-pound class.
- D. Four inch and larger union: Forged steel, 150-pound class, slip-on weld-neck flanges, ANSI/ASME B16.5.
- E. Nonferrous-piping unions: Brass, FS WW-U-516B.

(c) Valves.

1. Gate valves two inches or smaller:

- A. MSS SP-80, Type 2, Class 150.
- B. Bronze with threaded ends, rough bodies and finished trim.
- C. Materials except handwheels: ASTM B61.
- D. Furnished with malleable-iron hand wheels.

2. Gate valves 2-1/2 inches and three inches:

- A. MSS SP-70, Type 3, Class 125, OS&Y flanged end, Type I, Class 2, cast-iron bodies and bonnets.
- B. Seat rings, disc, disc guide and stem furnished in bronze.
- C. Outside stem and yoke (OS&Y), flanged-end connections and malleable-iron hand wheels.

3. Gate valves four inches and larger:

- A. MSS SP-70, Type 2, Class 125, OS&Y, flanged end, cast-iron bodies and bonnets.
- B. Seat rings, disc, disc guide and stem furnished in bronze.
- C. Outside stem-and-yoke type and cast-iron hand wheels.

4. Globe, angle and check valves:

- A. Two inches and smaller:
 - (1) WW-V-51E, Class B.
 - (2) Bronze with threaded ends, rough bodies and finished trim.
 - (3) Materials except hand wheels: ASTM B61.
 - (4) Globe and angle valves furnished with malleable-iron hand wheels.

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REVISION OF SECTION 622
PIPING SYSTEMS**

5. Check valves four inches and larger:

- A. Swing-type valve seat, with iron or steel body and cap and flanged-end connections.
- B. 150-pound class, renewable arm, disc assembly and seat ring with bronze trim.
- C. Outside arm and weight for pump discharge check valves.

6. Line Strainers:

- A. Water strainers, Y or basket-type, 1-1/2 inches and smaller: ASTM A126, Grade B, iron bodies with screwed connections.
- B. Two inches and larger: ASTM A126, Grade B, iron bodies with flanged-end connections.
- C. Designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
- D. Stainless-steel or Monel screens as follows:

(1) Perforations:

Strainer Size	Perforation Size
3/4" ≤ Ø ≤ 2"	1/32"
2-1/2" ≤ Ø ≤ 6"	1/16"
8" ≤ Ø ≤ 12"	1/8"
Ø ≤ 12"	5/32"

(2) Free area of screen minimum three times area of strainer inlet pipe.

E. Strainer provided with 3/4-inch drain valve.

7. Butterfly valves:

- A. MSS SP-67, sizes as shown.
- B. Provide extended necks or neck extenders to accommodate two inches of insulation.
- C. Provide 10-position latch-lock handles.
- D. Provide enclosed work screw operators, sizes eight inches and larger.
- E. Provide chainwheels when above normal reaching area.
- F. Provide adjustable balance-return stops for balancing service.
- G. Test shell at 225 psi.
- H. Body:
 - (1) Wafer-type, cast iron, ASTM A126, Class B, or lug-type, ductile iron, ASTM A536 grade 60-40-18, or ASTM A395.
 - (2) To fit between ANSI/ASME B16.5 flanges.
 - (3) Bodies with integral flanges or full lugs drilled.

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REVISION OF SECTION 622
PIPING SYSTEMS**

I. Seat:

- (1) Provide ethylene-propylene-terpolymer (EPT) bonded to rigid ring providing noncollapsible and replaceable seat.
- (2) Provide bubble-tight shutoff of 150 psi at temperatures between 25F and 225F.
- (3) Provide O-ring as secondary seal between seat and stem.

J. Disc:

- (1) Aluminum-bronze: ASTM B150.

K. Stem:

- (1) Stainless steel: AISI Type 304, 316, 410 or 416.
Isolate from contact with piped material.

(d) *Portable Flow Meters.*

1. Factory-fabricated case, carrying handle and fitted to hold meter securely to accommodate the following accessories:
 - A. Two 10-foot lengths of connecting hose with female connectors for venturi-tube pressure-tap nipples.
 - (1) Hose designed for minimum of 125 psi or 150 percent of system working pressure, whichever is greater.
 - (2) Completely assembled three-valve manifold with two block valves and vent and drain valves piped and mounted on base.
 - B. Set of curves showing flow versus pressure differential for each orifice or venturi tube.
 - C. Metal instruction plate, secured inside cover, illustrating use of meter.

(e) *Orifices and Venturis.*

1. Stainless steel, square-edge type, mounted between pipe flanges with factory-made pressure taps.
2. Taps with shut-off valves and with quick-connection hose fittings for portable meters.
3. Orifice-throat diameter at specified flow and differential pressure in inches water gauge as follows:
 - A. Fall in 60 to 80 percent of full scale reading for square-root meters.
 - B. Twelve to 40 inches for linear-scale meters.
4. Venturi size selected with design flow rate between 10 and 40 inches of water-pressure differential.
 - A. Permanent pressure loss: 25-percent maximum of indicated flow-rate differential pressure.
 - (1) Flow-metering equipment: Supplied by same manufacturer.

(f) *Thermometers.*

1. Dial-type, chromium-plated case, remote or direct-type bulb with accuracy of plus-or-minus one degree.
 - A. Three-inch minimum dial with white face and black digits, graduated in two-degree increments.

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REVISION OF SECTION 622
PIPING SYSTEMS

2. Liquid-in-glass thermometers.
3. Thermometer ranges suitable for service at not less than 20 degrees above controlled temperature settings.

(g) *Thermometer Wells.*

1. Stainless steel with portions surrounding bulbs not over 1/16-inch thick, designed to hold engraved-stem thermometer.
2. Six inches projecting two inches into pipe with dust-excluding caps with gaskets and chains.
3. Pipe smaller than 2-1/2 inches enlarged where wells are located.
4. Set vertical or at angle to retain oil.

(h) *Gauges.* ASTM F709, Class 1, 2 or 3, Style A, Type I or III with metal case.

(i) *Expansion Joints.*

1. General:

- A. Designed for 150 psi and 200F for systems operating at 100 psi or less.
- B. Provide expansion joint traverse with 150 percent of pipe expansion resulting from temperature variation of 80F.
- C. Provide corrugated-bellows expansion joints for pipe expansion of 1-1/2 inches or less, minimum of 200 percent of expansion.
- D. 1-1/2 inches and smaller, threaded ends; two inches and larger, flanged ends.

2. Flexible ball joints:

- A. Carbon steel, providing 360 degrees rotation plus 15 degrees minimum angular-flexing movement, furnished with EDPM or similar gaskets, steam-molded in steam-heat presses.

3. Corrugated-bellows expansion joints:

- A. Bellows constructed of single-ply or multiple-ply, formed, corrugated stainless steel for pipe sizes smaller than three inches.
- B. Self-equalizing type with equalizing or reinforcing rings, internal-telescoping stainless-steel or Monel sleeves, removable steel housing to protect bellows and support insulation.
- C. Corrugated element: Seamless tubing or of single sheet of metal rolled into cylinder having one longitudinal seam for sizes up to 16 inches.
- D. Joints 2-1/2 inches and smaller: Internal guides and limit stops.
- E. Designed for a minimum life of 5,000 full-rated traverse cycles when tested at specified pressures and temperatures.

(j) *Supporting Devices.*

1. Pipe hangers and supports:

- A. Provide adjustable steel pipe hangers and supports as follows:

- (1) Clevis and clamp, hot dipped galvanized or zinc-plated: MSS SP-58, Type 1 and Type 8 for steel and cast-iron piping.

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PIPING SYSTEMS**

- (2) With cast-iron roller and sockets: MSS SP-58, Type 41 for Remote Radiator -water piping.
 - (3) Spaced not greater than six feet for pipe sizes up to and including 1-1/2 inches; 10 feet for pipe sizes two inches through six inches; 16 feet for pipe sizes eight inches and larger.
 - B. Pipe hangers for copper tubing: Steel, copper-plated, clevis-type, spaced at maximum five feet for tubing sizes through 1-1/2 inches and maximum eight feet for sizes two inches and larger.
 - C. Hanger rods sized in accordance with anticipated loads (dead, live, and impact) with minimum diameter 3/8 inch, constructed of steel, hot dipped galvanized, threaded full-length and diameter required by pipe size and load imposed.
 - D. Hanger rod nuts and washers: Steel, hot dipped galvanized.
 - E. Supported from malleable-iron, hot-dip galvanized inserts in concrete slab: MSS SP-58, Type 18.
 - F. Pipe hangers and supports in tunnels and shafts: MSS-SP-58, stainless steel, ASTM A276, Type 304.
2. Pipe rolls, plates and stands:
- A. Cast iron: MSS SP-58, Types 44, 45, and 46.
 - (1) Adjustable types selected for piping require grading after setting in place.
 - B. Protection saddles for support piping: MSS SP-58, Type 39, welded to pipe.
3. Pipe anchors:
- A. Designed to withstand five times anchor load minimum.
 - B. Vertical pipes anchored by means of clamps welded around pipes and secured to wall or floor construction.
4. Pipe guides:
- A. Factory-made cast semi-steel or heavy fabricated galvanized steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted or welded tight to pipe.
 - B. Designed to clear pipe insulation and to prevent overtravel of spider and cylinder.
 - C. Guides not less than 12 inches long and spiders not less than the following:
- | Nominal Pipe Diameter | Spider Length |
|--------------------------------|---------------|
| $\text{Ø} \leq 1\text{-}1/2''$ | 2'' |
| $2'' \leq \text{Ø} \leq 3''$ | 2-1/2'' |
| $\text{Ø} = 4''$ | 3'' |
| $5'' \leq \text{Ø}$ | 3-1/2'' |
5. Expansion bolt anchors:
- A. Consisting of bolt, expander, star lock washer and nut.
 - B. Fabricated of stainless steel, Type 303, including expander and star lock washer.

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REVISION OF SECTION 622
PIPING SYSTEMS

- C. Anchor assemblies: FS: A-A-1992, Group II, Type 4, Class 1.
- 6. Self-drilling anchors:
 - A. Self-drilling expansion anchors, with self-cutting annular broaching grooves.
 - B. Anchor and expander plug: FS: A-A-1992, Group III, Type 1, double-plated.
- 7. Pipe sleeves:
 - A. Through interior masonry-unit walls: As shown. Sleeve to be large enough to accommodate pipe and covering but not less than two sizes larger than pipe size.
 - B. Through poured-concrete interior walls, floors and ceiling: As shown.
 - (1) Sleeves minimum two sizes larger than pipe. At floors, sleeves to project four inches above finish floor.
 - C. Through exterior structural elements: Minimum two sizes larger than pipe and as shown.
 - D. Sleeves designed to allow expansion/contraction movement of pipe.
- (k) *Installation.* Piping installation includes pipes, valves, insulation, and hangers for remote radiator piping, and generator exhaust piping, supports, silencer supports, and weatherproof exterior exhaust screen panel and rain cap.
- (l) *Welding Procedure.* Perform welding by manual metallic arc-process except for pipe sizes four inches and smaller where gas welding (oxyacetylene) may be used.
 - 1. Use electrodes and rods of composition recommended for pipe by AWS.
 - 2. Heat surface within three inches from point where weld will start to temperature warm to the hand before welding.
 - 3. Weld corrosion-resistant nickel-copper alloy steel pipe by arc-process utilizing low-hydrogen electrodes of AWS E8016 or E8018 types. Leave joint surfaces smooth, uniform, free from fins, tears and other defects which adversely affect proper welding. After each pass of weld on multiple-pass welding, clean weld free of slag and other deposits before applying next pass.
 - 4. Peen with light blows of blunt-nosed peening hammer.
 - A. Do not peen surface layers or first pass in groove welds.
 - 5. For groove welds, have surface pass substantially centered on the seam, smooth and free from depressions. Perform fillet-welds with minimum cutting back of outside pipe.
 - A. Leave throat of full fillet-weld not less than 0.707 of thickness of pipe.
 - B. Repair excess cutting back and undercutting of base metal in pipe adjoining weld.
 - C. Fill up craters to full cross section of weld.
 - 6. Align and position accurately joints to be welded, so that pipe will not project beyond its adjoining pipe by more than 20 percent of pipe wall thickness or 1/8-inch maximum.
 - 7. Install welded pipe in accordance with ANSI/ASME B31.1.

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REVISION OF SECTION 622
PIPING SYSTEMS

- (m) *Steel-Pipe Installation.* Weld embedded pipe and install so that pipe will not penetrate construction joints or structural contraction joints. Install horizontal piping with minimum pitch of one inch in 40 feet and arrange for drains at low points.
1. Install drain valves and hose nipples not smaller than 3/4 inch at low points.
 2. Install high-capacity automatic air vents at high points, designed for 125 psi and suitable for operation on pressures under 125 psi.
 - A. Pipe air-vent outlet to floor drains.
 3. Pipe drip pan to discharge as shown; if not shown, discharge to nearest open drain. Provide flexible connections to coils, pumps and other equipment so as to eliminate undue strains in piping and equipment. Install condensate-drain lines for each air-handling unit with pitch of 1/4 inch per foot in the direction of flow.
 - A. Run drain lines to nearest open drain.
 - B. Do not exceed 400 feet maximum length of pipe between anchor and expansion joint or 90-degree offset.
 4. Do not support embedded pipe from reinforcing bars with metallic means.
- (n) *Expansion-Joint Installation.* Field set expansion joints for position corresponding to ambient temperature at time of installation. Setting based on manufacturer's calibration data furnished with expansion joints. Do not use corrugated-bellows expansion joints where exposed in train tunnels. Install ball joints in accordance with approved published recommendations of manufacturer. Do not use shims or steel spacers.
- (o) *Pipe Anchors.* Securely anchor piping where shown and where necessary for proper installation to force pipe expansion in proper direction.
- (p) *Expansion-Bolt Anchors.* Drill holes and install expansion-bolt anchors as recommended by anchor-bolt manufacturer. Do not locate less than eight inches from concrete edge.
- (q) *Pipe Sleeves.* Install Exterior walls as shown. Install Interior walls as shown. Seal to maintain integrity of walls.
- (r) *Painting.* Exhaust piping that is outside of the HLT Complex shall be painted a USFS-approved brown color.

Subsection 622.27 shall include the following:

Piping systems will not be measured, but will be paid for on a lump sum basis.

Subsection 622.28 shall include the following:

The completed and accepted work for the piping systems will be paid for at the contract lump sum price for the pay item listed below.

Payment will be made under:

Pay Item	Pay Unit
Building Plumbing Piping Systems	Lump Sum

**REVISION OF SECTION 622
MODIFY BUILDING**

Section 622 of the Standard Specifications is hereby revised for this project as follows:

Subsection 622.01 shall include the following:

This work consists of reconstruction of a portion of the existing wall between the interior parking area and the emergency generator room at the Hanging Lake Tunnel complex. Wall reconstruction shall consist of the complete restoration of an interior wall in which a double-wide door system and a portion of the existing concrete wall are removed to temporarily increase the doorway opening area. The restoration shall provide a rigid wall with a man-size double-wide door opening.

Subsection 622.02 shall include the following:

Prior to the removal of a portion of the existing wall, the Contractor shall examine the existing door system to assess what will be required for its replacement with a new double swing door with similar function, strength, and service configuration. The replacement door system shall have an active side that is prepped for a locking device and an inactive door with flush bolts, lock strike, and an astragal to cover the gap between the door edges.

The Contractor shall use metal frame construction to reconstruct the opening area, with the reconstructed portion that abuts the existing wall securely anchored vertically and horizontally to the wall and to the floor adjacent to the doorway, so that the use of the new door will not damage the integrity of the restored wall.

Steel material for wall reconstruction shall meet the requirements of structural carbon steel as described in Subsection 509.03.

Subsection 622.03 shall include the following:

Final design and detailing of the metal frame construction of the opening area shall be provided by the Contractor's Engineer for review and approval by the Engineer prior to procurement of materials for the reconstruction.

Angles and other steel sections for the framework shall have sufficient section to ensure that the frame will secure the door in all positions. They shall be anchored to the opening jambs, floor, and head wall with torque-controlled expansion anchors which are specially suited to seismic and cracked concrete applications, with classification as Category 1 anchors. The anchors shall have carbon steel anchor body, nut, and washer, with electro-plated zinc coating of minimum thickness of 5µm. Plate for the frame covering shall be fastened to the frame with multiple bolts. Anchors shall be set to provide a minimum 3" clear cover to the concrete wall surface.

The framework shall be welded in separate jamb and header pieces, such that each discrete piece can be set in place, securely connected with the other pieces, and anchored to the concrete at all sides of the door opening. The final reconstruction of the doorway area shall be removable at a future date, by removing the door and door frame, removing the cover plates, unbolting the connections between the new opening jamb and header pieces, and unbolting the frame pieces from their anchors to the doorway area jambs, header, and floor.

All exposed edges of the framework shall be ground to remove burrs and sharp edges. The interface between the existing wall and the plate covers of the metal frame for the reconstructed opening shall be sealed with an approved caulk to close air gaps at these locations.

Subsection 622.14 shall include the following:

The Contractor shall provide all new metal door frame elements as needed to make the door frame compatible with new construction of the door opening. The metal door frame shall be secured as needed to the reconstructed opening to enable the same or better door functionality as was present before the opening was temporarily enlarged.

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**REVISION OF SECTION 622
MODIFY BUILDING**

Subsection 622.21 shall include the following:

This work shall include painting all exposed sides of the restored wall portion and any damaged places on both sides of the existing wall surface so that the restored wall's painted surface is the same color and finish as the adjacent existing undamaged wall's painted surfaces. Painting shall include finishing the metal door frame and metal doors.

Subsection 622.24 shall include the following:

The light switch that is currently located inside the generator room shall be removed and replaced with a new switch located to a similar position outside of the generator room. The new switch shall be flush-mounted into the existing wall adjacent to the reconstructed door opening area. The old switch box shall be covered with a suitable cover plate.

Subsection 622.28 shall include the following:

Payment will be made under:

Pay Item	Unit
Modify Building	Lump Sum

Payment for Modify Building will be full compensation for all labor and materials required to complete the work, including, preparation of shop drawings, all electrical work, anchorages and reinforcing, temporary shelter or protection for the wall reconstruction, preparation for painting and painting of wall and doorway elements.

FORCE ACCOUNT ITEMS

DESCRIPTION

This special provision contains the Department's estimate for force account items included in the Contract. The estimated amounts marked with an asterisk will be added to the total bid to determine the amount of the performance and payment bonds. Force Account work shall be performed as directed by the Engineer.

BASIS OF PAYMENT

Payment will be made in accordance with subsection 109.04. Payment will constitute full compensation for all work necessary to complete the item.

Force account work valued at \$5,000 or less, that must be performed by a licensed journeyman in order to comply with federal, state, or local codes, may be paid for after receipt of an itemized statement endorsed by the Contractor.

<u>Force Account Item</u>	Estimated	
	<u>Quantity</u>	<u>Amount</u>
F/A Minor Contract Revisions	F.A.	\$65,000
F/A Partnering	F.A.	\$3,000
F/A Fuel Cost Adjustment	F.A.	\$500
F/A On-The-Job Trainee	F.A.	\$1,000
F/A Towing	F.A.	
F/A Erosion Control	F.A.	
F/A CSP	F.A.	

Force Account Descriptions

F/A Minor Contract Revisions – This work consists of minor work authorized and approved by the Engineer, which is not included in the contract drawings or specifications, and is necessary to accomplish the scope of work of this contract.

F/A Partnering – This work is described in Standard Special Provision – Partnering Program.

F/A Fuel Cost Adjustment – This work is described in the Project Special Provisions.

F/A Towing – This work consists of towing authorized and approved by the Engineer to respond to emergency conditions.

TRAFFIC CONTROL PLAN - GENERAL

The key elements of the Contractor's method of handling traffic (MHT) are outlined in subsection 630.10(a).

The components of the TCP for this project are included in the following:

- (1) Subsection 104.04 and Section 630 of the specifications.
- (2) Standard Plan S-630-1, Traffic Controls for Highway Construction, Case No. 11, 17, 24, 31 and Standard Plan S-630-2.
- (3) Schedule of Construction Traffic Control Devices.
- (4) Manual of Uniform Traffic Control Devices (MUTCD) (2009 Edition).

Unless otherwise approved by the Engineer, the Contractor's equipment shall follow normal and legal traffic movements. The Contractor's ingress and egress of the work area shall be accomplished with as little disruption to traffic as possible.

Special Traffic Control Plan requirements for this project are as follows:

During the construction of this project, traffic shall use the present traveled roadway unless identified on the plans or approved by the Engineer. Two lanes of traffic shall be maintained between 7:00 am and 7:00 pm. The Contractor shall not have construction equipment or materials in the lanes open to traffic at any time, unless approved by the Engineer.

No work that impacts I-70 traffic shall be allowed on weekends from 12:00pm Friday through 7:00am Monday unless previously approved by the Engineer. Holidays/no work days shall include:

Monday, May 29 th	Memorial Day
Monday, July 3 rd and Tuesday, July 4 th	Independence Day
Monday, September 4 th	Labor Day
Monday, October 9 th	Columbus Day

At least one week prior to starting construction, the Contractor shall notify the Project Engineer of the date the Contractor intends to start construction.

All costs incidental to the foregoing requirements shall be included in the original contract prices for the project.

All traffic operations, detours, and associated MHT's shall be submitted to the Engineer for review and approval. The Contractor shall schedule and coordinate all traffic closures and MHT's at least seven days prior to the closure or MHT taking effect.

Workers, Contractor, Suppliers, etc. shall not access the work area by crossing the roadway unless proper traffic control or other necessary precautions are provided. Suitable transportation to the work site shall be provided by the Contractor for personnel whose vehicles are parked off site.

Employee vehicle parking is prohibited where it conflicts with safety, access, or flow of traffic. There is very limited space available within Hanging Lake Tunnel for parking, shuttles to bring workers to/from the site will be required.

The Contractor's superintendent, foreman, traffic control supervisor, erosion control supervisor, and other key staff shall have cell phones with texting capability at all times. A cell phone list shall be provided to the Engineer.

UTILITIES

Known utilities within the limits of this project are:

CDOT – REGION 3 TRAFFIC SECTION	MARC TRAVIS	970-683-7534 Cell: 970-379-9809
CDOT – REGION 3 TRAFFIC SECTION	DONALD OLMSTEAD	970-379-0539
CDOT – HLT (Electronics Specialist)	TODD ANSELMAN	970-945-3854
CDOT – REGION 3 TRAFFIC SECTION	SPENCER DICKEY	970-945-3843
XCEL ENERGY – (Electric)	JON PRICE	970-244-2693
HOLY CROSS ENERGY	RUSS WINDER	970-945-5491
VARIOUS MEMBER UTILITIES – (Utilities Notification Center of Colorado)		1-800-922-1987

The work described in these plans and specifications may require coordination between the Contractor and the utility company(s) in accordance with subsection 105.11 in conducting their respective operations as necessary, so that the utility work can be completed with minimum delay to all parties. The Contractor shall be required to meet with each utility owner impacted by the work a minimum of thirty (30) days in advance of any construction operations to coordinate required utility work with the construction activity.

THE WORK LISTED BELOW SHALL BE PERFORMED BY THE CONTRACTOR IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS, AND AS DIRECTED BY THE ENGINEER.

The Contractor shall keep the utility owner(s) advised of any work being done to their facility, so that the utility owner(s) can coordinate their inspections for final acceptance of the work with the Engineer.

There are no known utility conflicts on this project. However, the Contractor shall request and shall have received locates from the agencies listed above prior to commencing any type of excavations. The Contractor is responsible for protecting all existing utilities from damage due to their construction operations.

THE WORK LISTED BELOW WILL BE PERFORMED BY THE UTILITY OWNERS OR THEIR AGENTS:

Utility locates will be provided by the Utility owners, or their agents, upon proper notification as indicated in the GENERAL section below. For locates of CDOT owned facilities, the Contractor shall contact Marc Travis at the telephone numbers shown above.

GENERAL:

The Contractor shall comply with Article 1.5 of Title 9, CRS ("Excavation Requirements") when excavation or grading is planned in the area of underground utility facilities. The Contractor shall notify all affected utilities at least two (2) business days, (NOT INCLUDING THE DAY OF NOTICE OR THE DAY OF EXCAVATION) prior to commencing such operations. Contact the Utility Notification Center of Colorado (UNCC) at 1-800-922-1987 to have locations of UNCC registered lines marked by member companies. All other underground facilities shall be located by contacting the respective company. For CDOT owned utility facilities the Contractor shall call the Region 3 Traffic Section at 970-683-7534 to request locates. CDOT is not contacted when locates are requested through the UNCC. Utility service laterals shall also be located prior to beginning demolition.

The locations of utility facilities as shown on the plan sheets, and/or herein described, were obtained from the best available information.

All costs incidental to the foregoing requirements will not be paid for separately but shall be included in the work.