STANDARD CONSTRUCTION SPECIFICATION

FOR

ELECTRIC STATIONS
This document provides the specifications for the construction of electric stations.

**TABLE OF CONTENTS**

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIVISION 1  GENERAL REQUIREMENTS</td>
<td></td>
</tr>
<tr>
<td>1A (100000) General Description and Scope of Work</td>
<td>3</td>
</tr>
<tr>
<td>1B (100000) Drawings</td>
<td>3</td>
</tr>
<tr>
<td>1C (100000) Construction Schedule</td>
<td>6</td>
</tr>
<tr>
<td>1D (100000) Construction Services</td>
<td>7</td>
</tr>
<tr>
<td>1E (100000) Material Receiving, Handling and Storage</td>
<td>12</td>
</tr>
<tr>
<td>1F (100000) Quality Assurance and Quality Control</td>
<td>16</td>
</tr>
<tr>
<td>1G (210000) Fire Prevention Procedures for Contractors</td>
<td>17</td>
</tr>
<tr>
<td>DIVISION 2  SITE WORK</td>
<td></td>
</tr>
<tr>
<td>2A (310000) Earthwork</td>
<td>20</td>
</tr>
<tr>
<td>2B (033000) Cast In-Place Concrete</td>
<td>29</td>
</tr>
<tr>
<td>2C (050000) Miscellaneous Metals</td>
<td>41</td>
</tr>
<tr>
<td>DIVISION 3  ELECTRICAL CONSTRUCTION</td>
<td></td>
</tr>
<tr>
<td>3A (260000) Contractor Furnished Equipment and Materials</td>
<td>50</td>
</tr>
<tr>
<td>3B (260000) Owner Furnished Equipment and Materials</td>
<td>51</td>
</tr>
<tr>
<td>3C (260529) Electrical Equipment Erection</td>
<td>52</td>
</tr>
<tr>
<td>3D (260526) Grounding</td>
<td>62</td>
</tr>
<tr>
<td>3E (260533) Raceways</td>
<td>67</td>
</tr>
<tr>
<td>3F (260513) Conductors</td>
<td>80</td>
</tr>
<tr>
<td>3G (265100) Interior/Exterior Lighting</td>
<td>93</td>
</tr>
<tr>
<td>3H (265600) Power Circuit Breakers</td>
<td>94</td>
</tr>
<tr>
<td>3I (261200) Power Transformers</td>
<td>96</td>
</tr>
<tr>
<td>3J (260525) Medium Voltage Switchgear</td>
<td>98</td>
</tr>
<tr>
<td>3K (260000) Battery and Battery Chargers</td>
<td>100</td>
</tr>
<tr>
<td>3L (260000) Disconnect Switches</td>
<td>102</td>
</tr>
<tr>
<td>3M (265000) Testing and Commissioning</td>
<td>104</td>
</tr>
<tr>
<td>DIVISION 4  UNDERGROUND CONSTRUCTION</td>
<td></td>
</tr>
<tr>
<td>4A (260000) Contractor Furnished Materials</td>
<td>105</td>
</tr>
<tr>
<td>4B (260000) Owner Furnished Materials</td>
<td>105</td>
</tr>
<tr>
<td>REVISION HISTORY</td>
<td>106</td>
</tr>
</tbody>
</table>

(Note: Associated AIA sections listed in parenthesis as references)

APPENDIX A  INDUSTRY CODES AND STANDARDS ................................. 107
**DIVISION 1 - GENERAL REQUIREMENTS**

**Section 1A (100000) - GENERAL DESCRIPTION AND SCOPE OF THE WORK**

1A.1 **GENERAL**

This general construction specification is intended for use by outside Contractors, as well as for in-house construction personnel. Where this specification is used in the latter form, the term Contractor shall refer to the in-house construction personnel performing the job. Refer to the Substation Field Issue which covers the scope of work as follows: A general description of the scope of the work and supplementary requirements for the construction work for the project including all Additions and Removals.

1A.2 **WORK INCLUDED UNDER THIS SPECIFICATION**

The work under this Specification shall include: furnishing all equipment and materials, except those specified in the Material List of the Substation Field Issue as furnished by the Owner; furnishing care and protection of Owner-furnished equipment; furnishing all construction equipment, vehicles, on-site facilities, tools and supplies; and furnishing all labor, supervision, administration, management; and services all necessary to perform the construction complete conforming in all respects to the details and requirements in accordance with the Specifications, Drawings, and Contract Documents.

The principle components of the work include, but are not limited to the following. This listing is intended to give a general outline of the scope of work under this specification and shall not be construed to be an itemized listing of each element of work required.

The Contractor is responsible for the handling, removal, and containerization of all environmentally sensitive materials at the jobsite. The summary of work detailed in the Substation Field Issue will typically include the installs, upgrades, and removals. It will also cover the requirements with respect to job specific disposals (including environmentally sensitive materials) and/or leaving equipment at the site for use as spares by the Owner.

If called out in the Substation Field Issue, the Contractor shall provide an upfront labor cost for man-hours allowances for wiremen and test support personnel if required during the testing & commissioning by the Owner.

1A.3 **CONTRACTOR FURNISHED EQUIPMENT & MATERIALS**

Refer to Section 3A and Substation Field Issue.
1A.4 OTHER WORK INCLUDED UNDER THIS SPECIFICATION

1A.4.1 Owner-Furnished Equipment and Materials. Equipment and materials to be furnished by the Owner are described on the Drawings and associated Material Lists as contained in the Substation Field Issue. All equipment and materials not indicated as furnished by the Owner but required for the completion of the work, shall be provided by the Contractor. The term “BY FIELD” as referenced on the drawings or material lists is defined as “BY CONTRACTOR” and these items have to be furnished by the Contractor.

a. All equipment and materials shall be transported to the job site from the designated storage locations by the Contractor. The Contractor shall deliver and receive the equipment into its custody until final acceptance of the work, and shall handle, securely store, protect and install it in its final location. The Contractor shall inspect the major electrical equipment at the storage facility for any damage prior to moving it to the jobsite and should inform the Owner of any defects found in writing prior to starting the moving procedure.

1A.4.2 Work by Others. Any items of work that will be furnished by the Owner, will also be called out in the Summary of Work section in the Substation Field Issue. Any portions of this work may be performed concurrently with the Contractor’s work. The Contractor shall coordinate its actions and cooperate with the Owner in the best interest of the project. In addition, the Substation Field Issue may also include any interface work being performed by the Owner’s Transmission Line dept., Distribution dept., and any exclusions of major equipment installations or equipment testing by the Owner or the Owner’s representatives.

1A.5 WORK UNDER SEPARATE CONTRACTS

The Owner reserves the right to self-perform or contract with others for any work at the site not included in the Contractor’s scope of work.

1A.6 CONSTRUCTION MANAGEMENT SYSTEM

The Contractor and its Sub-contractors shall participate in the construction management system established by the Owner. The information shall be submitted in the form of a daily report. Under this system, the Contractor and its Subcontractors shall provide, to the Owner, specific and accurate person-hours, quantity and schedule information, and other information as required by the Owner. Such information shall be provided in the detail and format required by the Owner.
1A.7 PROJECT MANAGEMENT REQUIREMENTS

The Contractor shall comply with the Milestone Dates shown in the Construction Schedule – refer to the Substation Field Issue. The Contractor and its Subcontractors shall attend project management meetings or other meetings when deemed necessary by the Owner. The Contractor and its Subcontractors shall actively participate in and adhere to the Owner's project management requirements, job rules and conduct, fire protection and safety procedures, and all other procedures initiated by the Owner for the purpose of maintaining job site administrative control. The Contractor and its Subcontractors shall fully adhere to the Owner's safety and environmental guidelines. The successful contractor will be responsible preparing a “Waste Management Plan” to detail the proposed management activities for all wastes generated during the work. This plan shall be submitted to the Owner for approval with initial submittals within ten days after award.”

1A.8 LINES AND GRADES

Initial bench marks and centerlines shall be provided by the Owner. All lines and grades necessary for the proper construction of the project shall be established by the Contractor in accordance with the Drawings. Bench marks and base lines shall be as indicated on the Drawings. Bench marks, reference points, line stakes, and/or grade stakes shall be carefully protected by the Contractor, and such marks or points disturbed by the Contractor shall be replaced at the Contractor’s expense.

1A.8.1 It shall be the responsibility of the Contractor to verify all lines and grades shown on the Drawings or established in the field and the Contractor shall report any apparent discrepancy to the Owner before work on any such section may commence.

1A.8.2 The Owner shall establish offsets for station centerlines and an elevation bench mark for construction purposes at the beginning of the construction project. The Contractor shall be responsible for preserving all offsets and bench marks as established by the Owner and, in the case of destruction thereof by the Contractor or resulting from his negligence, the Contractor shall be responsible for all delays, all mistakes, and all damages that may be caused by such loss or disturbance of the established lines, base lines and bench marks. The total cost incurred for relocating survey due to actions of the Contractor shall be at the Contractor’s expense. This shall include all property line stakes and monuments of the Owner and others.

1A.9 OUTAGES

The dates and time durations for the outages required for the work have been established and the work shall be done within the outage time duration. The construction planning and sequence shall be developed to minimize outages and outage durations. The outage durations shall be kept to an absolute minimum by completing all the preparatory work in advance of the outage. All required outages shall be shown on the project schedule. In the scope and planning of work, the Contractor shall take into consideration that the availability of outages are dependent on system conditions and ISO-Owners granting approval. System conditions permitting, spring and fall periods are more conducive for obtaining outages.
1A.10 COST UNITIZATION

The Contractor shall provide the Owner with filled-in Substation Work Order Summary sheets (refer to the Substation Field Issue) to meet cost unitizing requirements under the Federal Power Act and relevant regulations. This shall include all units of plant added and removed by the Contractor. The completed summary sheets shall be furnished by the Contractor to the Owner within two weeks following the completion of the work and prior to final acceptance.

1A.11 CONSTRUCTION SUPERVISOR

The Owner’s Construction Supervisor shall be designated as the direct contact between the Contractor and the Owner and the Owner’s Engineering Department. All correspondence including requests for information (RFI) and change order requests (COR) shall go thru the Construction Supervisor to all other Owner organizations. Approval of the COR in writing by the Owner’s Construction Supervisor including the dollar amounts is a prerequisite prior to the Contractor submitting and including the dollar amount on the Contractors monthly progression invoicing.

1A.12 ADDITIONAL REQUIREMENTS

Refer to the Substation Field Issue which may also cover any additional requirements such as permit conditions to comply including environmental licensing, oil handling, oil spills, asbestos/lead abatement, and waste management requirements to be performed by the Contractor. Other typical items may include some of the following: the construction sequence, any work hours or access restrictions for trucks/construction equipment, degassing of circuit breakers, gas top-up for circuit breakers, construction equipment, vehicles, trailers, or storage parking/location restrictions, optional works like man-hours allowance for wireman support during testing & commissioning, etc.

Section 1B (100000) - DRAWINGS

1B.1 GENERAL

The Bid Drawings which have been prepared for the Work under this Specification are found in the Substation Field Issue. The term “FIELD TO” or “BY FIELD”, as referenced on the Drawings and/or Material Lists, is defined as “CONTRACTOR TO” or “BY CONTRACTOR” and shall be furnished by the Contractor.

1B.2 PROJECT DRAWINGS

The drawings listed and included in the Substation Field Issue are part of the Agreement and may be listed as “for bidding purposes”. They show the work covered by this contract but shall not be used for construction purposes. These will be replaced by three sets of “Issued for Construction” full size drawings prior to the onset of construction. Existing “As Was” Drawings may also be supplied by the Owner in electronic format.
1B.3 SUPPLEMENTS AND STANDARDS

The supplements and standards listed in Appendix A and the Substation Field Issue are part of the Agreement. These supplements and standards are for general reference to define construction methods and details and they complement the “Issued for Construction” drawings and this specification.

1B.4 VENDOR DRAWINGS (TRADE PRINTS)

One set of each of these drawings and instruction manuals will be furnished by the Owner to the Contractor prior to construction, as applicable.

1B.5 AS-BUILT RECORDS

The Contractor shall prepare and submit all as-built documentation in duplicate to the Owner. The as-built documentation shall be submitted to the Owner immediately on completion of work and prior to final acceptance.

1B.5.1 Removals and/or deletions shall be indicated in green ink/pencil and additions shall be indicated in red ink/pencil.

1B.5.2 The Contractor is responsible for documenting the final As-Built condition by marking up the Construction drawings and supplying them back to the Owner. Any corrections made to the Vendor Drawings shall be noted and returned to the Owner for documenting the As-Built conditions.

1B.5.3 Drawings with no “as-built” changes shall be returned with a noting “NO FIELD CHANGES”.

1B.5.4 The marked-up drawings shall comply with the Owner’s Engineering Document PR.02.00.005 Engineering Drawing As-Buils.

Section 1C (100000) - CONSTRUCTION SCHEDULE

1C.1 GENERAL

This section covers the schedule and scheduling requirements for performance and completion of the work included under this Agreement.
1C.2 CONSTRUCTION SCHEDULE

The time of completion is a basic part of the Agreement. The Contractor shall comply with the Milestone Dates shown in the Construction Schedule in the Substation Field Issue.

1C.2.1 Milestone Dates. The milestone dates listed in the Milestone Schedule are established only for the major items of work. It is not intended to be a complete or detailed listing of all work under this Agreement or of all interfaces with the work of others. They indicate key interface dates with work by the Owner. The completion dates indicated are essential to the work under this Agreement and to the coordination and continuity of all work at the site.

a. It is understood and agreed that the dates shown in the Milestone Schedule are the latest feasible completion dates and that earlier dates may be attained as agreed to by the Owner and the Contractor.

1C.2.2 Contractor’s Schedule. The Contractor is responsible to develop and adhere to the Construction Schedule in accordance with the requirements of the Agreement.

1C.3 COORDINATION

The Contractor shall coordinate its work with that of others and shall cooperate fully with the Owner in maintaining orderly progress towards completion of the work as scheduled. The Owner's decision regarding priority between the Contractor's work and the work of others at the project site shall be final and shall not be cause for extra compensation or extension of time, except where extension of time is granted as provided for in the Agreement.

1C.3.1 The dates shown in the Substation Field Issue for delivery of Owner-furnished equipment and materials represent the best information available at this time. It should be recognized that these dates may vary due to causes beyond the Owner's control and appropriate allowance should be made in the Contractor's planning of the work.

1C.3.2 Failure of Owner-furnished equipment and materials to arrive as scheduled or failure of others to meet their schedule shall not be justification for an extension of time, except where such failure causes, in the opinion of the Owner, an unreasonable delay in the Contractor's work, in which case the provisions of the Agreement regarding changes shall apply.

1C.3.3 The Contractor shall keep itself and its Subcontractors advised at all times during the course of construction as to the delivery status of Owner-furnished equipment and materials and of the progress of construction work being performed by others.

1C.3.4 The Owner will, upon written request by the Contractor, furnish information which may be available to the Owner regarding the status of the Owner-furnished equipment and materials or construction work being performed by others.
Section 1D (100000) - CONSTRUCTION SERVICES

1D.1 GENERAL

This section covers the requirements for construction services to be provided by the Contractor and the Owner in the execution of the work.

1D.1.1 All construction plant, temporary facilities, and construction utilities provided by the Owner for the Contractor's use shall remain the property of the Owner and shall be returned to the Owner in satisfactory condition when the work is completed. The Contractor shall be responsible for the repair of damage to Owner-furnished construction plant and temporary facilities when such damage has resulted from the construction activities under this Agreement.

1D.2 CONSTRUCTION PLANT AND TEMPORARY FACILITIES

The Contractor shall furnish all construction plant, utilities, temporary facilities, equipment, materials, and supplies required for execution of the work but which will not be incorporated in the completed work, unless otherwise specified herein.

1D.2.1 Prior to installation of any Contractor-furnished temporary facilities on the job site, proposals for such facilities shall be submitted to and written approval received from the Owner.

1D.2.2 All temporary structures and facilities furnished by the Contractor shall remain the property of the Contractor and shall be maintained throughout the work. Any materials, equipment, or temporary structures installed or erected on the job site or within permanent buildings by the Contractor shall be removed by it when so directed by the Owner to permit the execution of other work in connection with the project or at the completion of the Contractor's work.

1D.2.3 All Contractor-furnished construction plant and facilities shall be in first-class condition and shall be of the proper type and size to perform the work. The plant and facilities shall be regularly and systematically maintained throughout the work to ensure proper, efficient operation. Plant and facilities which are inadequate or improperly maintained shall be promptly modified, repaired, or removed from the site and replaced as directed by the Owner, and at the Contractor's expense.

1D.2.4 When the work is completed, all Contractor-furnished temporary structures and facilities shall be removed from the site and the area shall be restored to its original condition to the maximum extent practicable.

1D.2.5 All construction plant and temporary facilities requiring use of wood shall be constructed of Class A Fire Retardant Pressure Impregnated Wood.
1D.2.6 Temporary structures for offices, change houses, warehouses, and other uses for the Contractor or its Subcontractors shall be provided by the Contractor. Suitable construction trailers may be used in lieu of temporary structures. Such structures or trailers shall be placed only in the locations assigned by the Owner.

1D.2.7 The Owner will, at its expense, arrange for, develop, and maintain the utilities and services specified as Owner-furnished in the work area to meet the overall requirements of the project construction program. The Owner-furnished facilities will be concurrently used by others, and the Contractor shall not make unreasonable demands on such utilities and services. While reasonable efforts will be made to maintain supply continuity, continuity cannot be guaranteed. The Contractor shall have no claim against the Owner for any loss or inconvenience the Contractor may suffer because of supply interruption.

1D.3 CONSTRUCTION UTILITIES

Construction utilities required for the execution of the work shall be provided by the Contractor or the Owner as herein specified.

1D.3.1 Telephones and Other Site Communication Requirements. The Contractor shall provide its own telephone and other site communications to meet its needs and shall pay all costs associated with such services.

1D.3.2 Compressed Air. The Contractor shall provide all air compressors, fuels, lubricants, hoses, piping, and other apparatus required for supplying compressed air required for execution of the Contractor's work.

1D.3.3 Construction Power. The Contractor may use existing 120 volt outlets in the substation for small portable hand tools and lighting only, if available. All significant construction power shall be furnished by the Contractor. The Contractor shall request the local power utility for the installation of a temporary 120/240 volts, single phase, power supply through a Contractor-provided temporary meter loop and disconnect. The Contractor shall pay for all costs associated with such services.

a. The Contractor shall provide all disconnect switches, breakers, transformers, wiring, and other devices required to distribute power for its use and for the use of its Subcontractors.

b. Temporary power facilities shall conform to applicable safety and code requirements, shall be constructed to provide proper clearances and minimum interference with construction, and shall be acceptable to the Owner.

c. All temporary wiring shall conform with Article 305 - TEMPORARY WIRING of the National Electrical Code.
1D.3.4 Water. The Contractor shall furnish its own water for construction uses and shall provide piping, valves, and hoses as required.

   a. The Contractor shall provide its own source of drinking water and sanitary drinking water facilities for its employees including coolers, ice, disposable cups, and a trash barrel at each water cooler. Each dispenser shall be emptied, cleaned, and refilled at the start of each day, and personnel shall be assigned to assure maintenance of the water supply.

1D.3.5 Heat. The Contractor shall provide all temporary enclosures and all heating facilities required for the efficient execution of the work and to prevent freeze damage during construction. Heating methods shall be submitted to the Owner for acceptance prior to use.

   a. Salamanders, open fires, or other methods which constitute a hazard to personnel or property shall not be used. All heating equipment shall be provided with adequate safeguards.

1D.3.6 Sanitary Facilities. The Contractor shall furnish and maintain sanitary facilities, including chemical toilets, for the use of its personnel. Chemical toilets shall be furnished in numbers and locations as required to adequately and conveniently serve the needs of all of the Contractor's personnel and shall meet the requirements of applicable regulations of the appropriate federal, state, and local health agencies. Maintenance of the chemical toilets shall include weekly inspection, cleaning, and replenishment of chemicals.

1D.3.7 Access Roads, Parking, and Storage Areas. Roadbeds and drainage facilities damaged by the Contractor’s operations shall be promptly repaired by the Contractor at its own expense.

   a. The Contractor is responsible for compliance with local and state traffic regulations applicable to the site.

   b. The Contractor shall return to its original state any areas used for parking vehicles, storing equipment or supplies, or any other purposes during the execution of the work.

   c. The Contractor is responsible for all snowplowing required to complete the execution of the work.

1D.3.8 Environmental. The Contractor and all of his Subcontractors shall fully adhere to the Owner’s Environmental Protection Policy contained in the associated purchasing documents supplied by the Owner.

1D.3.9 Security. The Contractor shall be responsible for all security at the site, relating to their work.

1D.3.10 First Aid. The Contractor shall provide for all first aid requirements at the site, relating to their work.
1D.3.11 Fire Protection. The Contractor shall be responsible for all fire protection at the site, relating to their work.

1D.3.12 Trash Collection and Disposal. The Contractor shall be responsible for the cleanliness of the site. The Contractor shall provide its own trash collection and disposal services. Trash shall be hauled to an offsite landfill area, acceptable to the Owner, for disposal.

a. All petroleum products, thinners, solvents, or other items considered as hazardous materials shall be disposed of by the Contractor by means of a hazardous material process meeting state and federal requirements and the requirements of the Owner’s Environmental Protection Policy. This shall be done in a manner acceptable to the Owner.

1D.3.13 Welding Facilities. The Contractor shall furnish all welding machines and other welding facilities required for its work. The Contractor may furnish portable welding machines at its option.

Section 1E (100000) - MATERIAL RECEIVING, HANDLING, AND STORAGE

1E.1 GENERAL

The Contractor shall provide all required storage facilities. The Contractor shall promptly receive, unload, and place into storage all equipment, materials, and supplies arriving at the project site for the work under this Agreement, including equipment and materials furnished by the Owner and specified to be erected and installed under this Agreement.

1E.2 HAZARDOUS MATERIALS

As required under Federal Hazardous Communications Standards and certain state and local laws, the Contractor shall provide Material Safety Data Sheets covering all hazardous materials furnished under or otherwise associated with the work under this Agreement. The Contractor shall provide the Owner with either copies of the applicable Material Safety Data Sheets or copies of a document certifying that no Material Safety Data Sheets are required under any federal, state, or local law, regulation, statute, or ordinance in effect at the job site.

1E.2.1 Hazardous materials are defined in the applicable statute which may use the terminology "toxic substances" instead of "hazardous materials." The Contractor is responsible for determining if any substance or material furnished, used, applied, or stored under this Agreement is within the provisions of any applicable statute.

1E.2.2 The Contractor shall provide written notice of the presence of hazardous materials to local fire, medical, and law enforcement agencies as required with a copy of such notice to the Owner.

1E.2.3 The Contractor shall provide labeling of hazardous materials and training of employees in the safe usage of such materials as required under any applicable federal, state, or local law, regulation, statute, or ordinance.
1E.2.4 The Contractor shall provide proper hazardous materials storage areas in accordance with all applicable federal, state, or local laws, requirements, regulations, statutes, or ordinances.

1E.3 RECEIVING

The Contractor shall examine all shipments of Owner-furnished equipment and material, including spare parts and maintenance tools, and shall notify the Owner immediately of any shortages, discrepancies, or damage.

1E.3.1 The Contractor shall prepare a listing of the equipment or materials received and acknowledge receipt of such items from the Owner. The Contractor shall take immediate custody of all equipment and materials received in good condition and shall thereafter be solely responsible for any damage or shortage until Final Acceptance of the Contractor's work.

1E.3.2 The Contractor shall be responsible for the prompt uploading and unloading of all equipment and materials and shall pay any demurrage. The Contractor shall assign personnel to receive, inspect, unload and store these shipments. Delivery shall be made between the hours of 8:00 A.M. and 2:00 P.M. Monday-to-Friday only.

1E.3.3 The Contractor shall replace all Owner-furnished equipment and materials which are lost or damaged while in the custody of the Contractor. Replacement equipment and materials shall be of a type and quality equal to the original equipment and materials, shall be acceptable to the Owner, and shall be obtained expeditiously to prevent delay of the work. Extensions of time will not be granted for delays caused by failure to receive replacement equipment and materials at the time required for their installation.

1E.3.4 The Contractor shall maintain a current, accurate inventory and record of location for all equipment and materials in its custody.

1E.4 HANDLING

The Contractor shall handle all equipment and materials carefully to prevent damage or loss, shall store them in an orderly manner in accordance with the manufacturer’s instructions, shall keep adequate and convenient records of their location, and shall keep a continuously accurate inventory.

1E.4.1 The use of bare wire rope slings for unloading and handling equipment and materials is prohibited except with the specific permission of the Owner.

1E.4.2 The Contractor shall re-handle and reload, if required, all Owner-furnished equipment and materials which have been rejected.
1E.4.3 The Contractor shall handle and load all returnable packing boxes, special handling devices, and cable reels for Owner-furnished equipment and materials and shall prepare shipping papers, if required. All such equipment and materials shall be returned to the locations as directed by the Owner, as promptly as possible. Unused cables should have their ends sealed, and the reels should be tagged with the remaining footage, date, contractor, and foreman’s name.

1E.5 STORAGE

Stored equipment and materials shall be adequately supported and protected to prevent damage. Equipment and materials shall be moved into the permanent building or onto its permanent foundation as soon as construction will permit.

1E.5.1 Stored equipment and materials shall not be allowed to contact the ground. In warehouses that do not have dry concrete or suspended floors, equipment and materials shall be stored on platforms or shoring.

1E.5.2 Strip heaters and similar heating devices furnished with electrical equipment shall be electrically connected to provide protection during storage. Heaters shall be energized immediately upon placement of the equipment in storage, and maintained in an energized condition until they can be energized from a permanent electrical connection. If permanent electrical power is not available when the equipment is installed in its permanent location, electrical equipment requiring strip heaters and similar heating devices shall be suitably connected to a reliable temporary power source. Contractor shall inspect such heating devices daily to insure their proper function and shall note this inspection on its daily report. If temporary power is not available, this requirement is waived, until power is provided.

1E.5.3 All openings in equipment not stored under weatherproof covers shall be closed to prevent entrance of dirt or moisture during storage.

1E.5.4 All platforms, enclosures, shoring, and weatherproof coverings for storage use shall remain the property of the Contractor and shall be removed upon completion of the work.

1E.5.5 Indoor Storage Facilities. Indoor storage furnished by the Contractor shall consist of suitable construction trailers or portable enclosures and shall be weather tight, well ventilated, and secure against theft and vandalism.

a. Equipment and materials shall be placed on shoring to permit air circulation under the stored item. Access doors shall be adequate to accommodate the movement and handling of equipment and materials to be stored and shall be equipped with secure locks.

b. Indoor storage facilities shall be acceptable to and accessible by the Owner.
1E.5.6  Open Platforms. Open platforms shall be Contractor-constructed from sound lumber not less than 2 inches nominal thickness. Open platforms shall be adequately constructed to support the loads imposed by the stored equipment and materials. Platforms shall be level, shall be supported on concrete block piers, and shall be not less than 18 inches above grade.

a. Shoring for storage of equipment and materials shall utilize sound timbers not less than 4 inches by 4 inches nominal size. Shoring shall be arranged to provide 8 inches of clearance above grade.

1E.5.7  Coverings. Weatherproof coverings for outdoor storage shall utilize waterproof flame resistant type sheeting. Sheeting widths shall be the maximum practicable and, if necessary, widths may be built up by using waterproof taped splices. The sheeting shall be carefully placed and tied down to prevent moisture from entering the laps and to prevent wind damage to the coverings.

1E.5.8  Storage Methods. Except as otherwise specified, the storage method to be used for various equipment and materials shall be determined as follows:

a. All storage methods shall be acceptable to the Owner.

b. Equipment and materials which incorporate electrical equipment or which have finish painted surfaces, and other items which would be damaged by outdoor exposure, shall be stored indoors. When such storage would present an unreasonable building space or volume requirement, the equipment or materials may, when acceptable to the Owner, be stored under weatherproof coverings on shoring or platforms. The coverings shall cover the top and sides of the equipment, shall be lapped to shed water, and shall be fastened securely around the base of the equipment.

c. All small loose items which could be easily lost, stolen, broken, or misused shall be stored indoors. All other equipment and materials shall be stored on open platforms or shoring.

d. Combustible and flammable materials shall be handled and stored in a safe manner to prevent the potential of fires.

e. In addition to complying with all requirements specified herein all materials and equipment shall be stored in accordance with the manufacturer’s recommendations. In case of a conflict the more stringent requirement shall apply.

f. No Materials or equipment shall be stored at the site until site security is established.
Section 1F (100000) - QUALITY ASSURANCE AND QUALITY CONTROL

1F.1 GENERAL

As a means of assuring that the performance of the work fulfills the requirements of the Agreement, the Contractor shall establish and implement a program for quality assurance and quality control.

1F.2 INSPECTIONS AND AUDITS

The Contractors and the Contractor’s associated equipment vendor’s work and related records shall be subject to inspection and audit by the Owner to assure compliance with applicable requirements. A request for corrective action may be issued by the Owner upon detection of a noncompliance with the requirements of the Agreement, the accepted quality assurance manual when a manual is required, and/or control procedures. The Contractor shall correct in a timely manner all such deficiencies so identified. The Contractor shall keep documented records of these findings, including records for all subcontractors and associated equipment vendors.

1F.3 INSPECTION AND REJECTION

All materials or equipment furnished and delivered under this Agreement shall be subject to inspection. If any items or articles are found not to meet the requirements of the Specification, the lot, or any faulty portion thereof, may be rejected. Before offering a lot for inspection, the manufacturer shall, by its own inspection, eliminate any items which, in its opinion, are defective or do not meet the requirements of the Agreement. The fact that the materials or equipment have been successfully inspected, tested, and accepted shall not relieve the Contractor of responsibility in the case of later discovery of flaws or defects.

1F.4 INSPECTION PRIOR TO DELIVERY

When the Specification requirements provide for inspection at the Contractor's mill, factory, yard, or warehouse, the conditions shall be as follows.

1F.4.1 Access. The Owner shall have the right to inspect the Contractor's and Subcontractor's work in the course of manufacture and require such tests from time to time as it may deem advisable, providing no delay in production of acceptable materials or equipment is caused thereby. The Contractor shall furnish, at its own expense, reasonable facilities including tools and instruments for so doing and for obtaining such information as the Owner desires respecting the progress and manner of the work and the character of the materials used.

1F.4.2 Witness Tests. Mill or factory witness tests, if called for in the Specification requirements, shall be made in the presence of the Owner. The Contractor shall bear all expense of such tests except the compensation and expense of the Owner.
1F.5 RECEIPT INSPECTION

Materials or equipment purchased under this Agreement may be inspected at the specified receiving points and there accepted or rejected. Inspection will include the necessary testing for determining compliance with the Specification. All expense of initial acceptance tests will be borne by the Owner. The expense of subsequent tests due to failure of materials or equipment first offered will be charged against the Contractor.

1F.6 QUALITY ASSURANCE

The Contractor shall maintain a quality assurance program that provides that equipment, materials, and services under this Specification whether manufactured or performed within the Contractor's plant or at any other source shall be controlled at all points necessary to assure conformance to contractual requirements. The program shall provide for the prevention and ready detection of discrepancies and for timely and positive corrective action. If required, the Contractor shall make objective evidence of quality conformance readily available to the Owner. Instructions and records for quality assurance shall be controlled.

1F.7 FIELD PROJECT QUALITY CONTROL

The Contractor's organization shall be responsible for all of the field project quality control. It shall be the Contractor’s responsibility to assure that all tests, examinations, qualifications, and recordkeeping requirements of this Agreement are being implemented by the Contractor's organization. The Owner has the authority to monitor this quality control and to reject any defective work.

Section 1G (210000) - FIRE PREVENTION PROCEDURES FOR CONTRACTORS

1G.1 GENERAL

It is the intent of the Owner that all reasonable and appropriate precautions are taken to prevent fires on this construction project and to assure prompt extinguishment of any accidental fires which may occur. All Contractors and subcontractors are expected to cooperate fully to achieve this end.

1G.2 PRACTICES

The suggested good practices of the National Fire Protection Association form the basis of the fire safety requirements for the project. The word "approved" in the following rules refers to approval by the Owner, and when referring to articles of equipment, will normally call for an Underwriters' Laboratories, Inc. or Factory Mutual label.
1G.3 FIRE SAFETY RULES

The fire safety rules include but may not be limited to the following:

1G.3.1 FIRE EQUIPMENT. Within Contractor’s work areas, extinguishers of approved types shall be provided by Contractors. Contractors’ shanties & equipment, such as trucks, motor cranes, cats, etc., must be individually equipped with the proper fire extinguishers by the Contractor. Fire equipment provided by Contractor is expected to be maintained in proper operating condition at all times.

1G.3.2 FLAMMABLE LIQUIDS. Handling of all liquids having a flash point below 140 degrees Fahrenheit on the job site will normally require the use of properly identified safety cans. Bulk storage in tanks, drums or other containers will be in a manner acceptable to the Owner. Combustible solvents used for cleaning purposes will be required to have a minimum flash point of 100 degrees Fahrenheit. Refueling of gasoline or diesel driven mobile equipment in enclosed areas is prohibited. Precautions to be followed when refueling fixed or semi-fixed equipment such as compressors, pumps, welding generators, etc. will be established. Equipment having an attached fuel tank will not be refueled while the engine is running.

1G.3.3 CUTTING AND WELDING. Operations involving the use of a torch or welding equipment require the issuance of either a permanent or temporary permit which will specify the special precautions to be observed for the particular job involved. Fire watchers may be required.

1G.3.4 HEATING DEVICES. All heating devices must be an approved type. Solid fuel devices are not permitted in enclosed areas. The preferred fuel source is a propane tank to be stored outdoors. All such equipment shall be installed and used in a safe manner. Temporary space heaters shall be supervised by a competent employee when in use. Refueling of portable space heaters shall be done in a safe location and not while the unit is in operation.

1G.3.5 COMPRESSED GASES. Containers of compressed gases in use on the site shall be installed in an approved manner. They shall be properly supported to prevent upset. Charged containers not in use shall have safety caps in place. Storage of bulk quantities of gases shall be in an approved manner. Unloading of gas cylinders by dropping from a truck bed is prohibited.

1G.3.6 ELECTRICAL. All electrical installations will be in accordance with the requirements of the National Electrical Code and the National Electric Safety Code. Only UL approved equipment and devices will be used. Particular care is necessary in protecting and supporting temporary light and power wiring. Lighting units shall be properly guarded against mechanical damage where necessary. Portable cables for welding sets, power tools, lights, etc. shall be maintained in good condition and protected against pedestrian or vehicle damage insofar as possible.
1G.3.7 PAINTING. Painting operations using combustible materials shall be conducted in a safe manner. No sparking or open flame devices shall be permitted in the area. Bulk supplies of finishing materials shall be stored in approved manner. In general, no more than one day's supply should be stored in the work area.

1G.3.8 SCAFFOLDING AND FORMS. Scaffolding and forms may be required to be non-combustible or of approved pressure impregnated wood construction.

1G.3.9 TARPAULINS. Only approved flame-proofed tarpaulins shall be used on the job site. Plastic drop cloths shall be of an approved slow burning type.

1G.3.10 SMOKING. Smoking will be prohibited in those areas deemed to be hazardous by the Owner. These areas will be adequately placarded. Cigarette butts shall not be discarded on the ground. All areas shall be kept clean of cigarette butts.

1G.3.11 MATERIAL STORAGE. Storage of combustible building materials or materials with combustible packaging will be so arranged as to offer a minimum exposure to permanent construction. Combustible storage in areas where hazardous operations such as welding and cutting are being conducted will be avoided insofar as possible.

1G.3.12 HOUSEKEEPING. Combustible scrap, debris, packaging materials, etc., must be removed to designated collection points at appropriate intervals to prevent accumulation in work or storage areas. Burning of such materials is prohibited. Containers which have been used for combustible liquids shall be kept separate and not mixed with other combustible refuse.

1G.3.13 GENERAL. Contractors and subcontractors are expected to be alert to the hazards of fire. Special cases not covered by these procedures or exceptions will be referred to the Owner for instructions.
DIVISION 2 - SITE WORK

Section 2A (310000) - EARTHWORK

2A.1 GENERAL

General earthwork shall include the necessary preparation of the construction areas; removal and disposal of all debris; excavation and trenching as required; the handling, storage, and transportation of all excavated material per 2A.21; all necessary sheeting, shoring, and protection work; preparation of subgrades; pumping and de-watering as necessary or required; protection of adjacent construction; backfilling; pipe embedment; construction of fills and embankments; surfacing and grading; and other appurtenant work. The Contractor shall ensure that all imported fill materials consist entirely of clean fill materials (virgin excavated natural materials).

All excavations shall be constructed and maintained under the supervision of a competent person.

2A.2 SHEETING AND SHORING

The stability of previously constructed structures and facilities shall not be impaired or endangered by excavation work. Previously constructed structures and facilities include both structures and facilities existing when this construction began and structures and facilities already provided under this Specification.

Adequate sheeting and shoring shall be provided as required to protect and maintain the stability of previously constructed structures and facilities and the sides of excavations and trenches until they are backfilled. Sheet ing, bracing, and shoring shall be designed and built to withstand all loads that might be caused by earth movement or pressure, and shall maintain the shape of the excavation under all circumstances.

2A.3 REMOVAL OF WATER

The Contractor shall provide and maintain adequate de-watering equipment to remove and dispose of all surface and ground water entering excavations and other parts of the work. Each excavation shall be kept dry during subgrade preparation and thereafter until the construction to be provided therein is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result. Discharging of pumped water shall be in accordance with all applicable project permits/approvals, and the Owner’s Environmental Protection Policy.

2A.4 BLASTING

Blasting or other use of explosives for excavation will not be permitted unless authorized in writing by the Owner.
2A.5 CLASSIFICATION OF EXCAVATED MATERIALS

No classification of excavated materials will be made except for identification purposes. Excavation work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the contract work, regardless of the type, character, composition, or condition thereof. All excavated material shall be managed in accordance with the Owner’s Environmental Protection Policy included in Schedule F and in a manner acceptable to the Owner.

2A.6 MAINTENANCE OF TRAFFIC

The Contractor shall conduct its work with as little interference as possible with the Owner's operations, the work of others, and the public. Whenever it is necessary to cross, obstruct, or close roads, driveways, parking areas, and walks, the Contractor shall provide and maintain suitable and safe bridges, detours, or other temporary expedients at his own expense, including police protection or flag person as applicable. In making open cut road crossings, the Contractor shall not block more than one half of the road at any time.

2A.7 PROTECTION OF UNDERGROUND CONSTRUCTION

The Contractor shall locate, protect, shore, brace, support, and maintain all existing underground pipes, conduits, drains, and other underground construction which may be uncovered or otherwise affected by the work.

2A.8 PRESERVATION OF TREES

Trees shall be preserved and protected as much as possible. Consideration will be given to the removal of additional trees only where essential, in the opinion of the Owner, for the effective execution of the work.

Trees left standing shall be adequately protected from permanent damage by construction operations. Trimming of standing trees, where required, shall be as directed by the Owner.

2A.9 UNAUTHORIZED EXCAVATION

Except where otherwise authorized, indicated, or specified, all material excavated below the bottom of concrete structures which will be supported by the sub-grade shall be replaced with concrete placed monolithic with the concrete above.
2A.10 TESTING

All field and laboratory testing required to determine compliance with the requirements of this section shall be provided by the Contractor. All laboratory testing shall be done by an independent testing laboratory acceptable to the Owner and retained and paid by the Contractor. Field sampling shall be done by the testing laboratory.

At least one field density determination shall be performed for each 50 cubic yards of compacted material for trenches and each 300 cubic yards for roadway fill and site leveling operations. Field samples shall be taken at locations selected by the Owner. If additional field control tests are necessary, in the opinion of the Owner, such tests shall be made.

Maximum density for cohesive compacted materials shall be determined in accordance with ASTM D698. The terms "maximum density" and "optimum moisture content" shall be as defined in ASTM D698.

2A.10.1 The following tests will be required for the earthwork:

a. Two gradation tests (ASTM C136) for each type of granular embedment or backfill material.

b. Two tests for laboratory density (ASTM D698) for each type of embedment or backfill material proposed.

c. Two tests for moisture content test (ASTM D2216) for each type of backfill material.

2A.10.2 A copy of each test result shall be promptly furnished to and accepted by the Owner prior to use on the Site.

2A.11 STRUCTURE EXCAVATION

Excavation for structures shall be done to lines and elevations indicated on the Drawings and to the limits required to perform the construction work. Machine excavation shall be controlled to prevent undercutting the proper subgrade elevations and shall not be used within 5 feet of permanent structures and facilities. Only hand tools shall be used for excavation around permanent structures and facilities.

Work shall be done so the construction areas will be as free as possible from obstructions and from interference with the transportation, storage, or handling of materials. Excavated materials free of trash, rocks, roots, and other foreign materials, and which meet the specified requirements, may be used as required for the fills, embankments, and backfills constructed under this Specification.
2A.12 STABILIZATION

Subgrades for structures and the bottom of trenches shall be firm, dense, and thoroughly compacted to at least 90 percent of maximum density at optimum moisture content for trenches and 95 percent for structures as determined by ASTM D698; shall be free from mud and muck; and shall be sufficiently stable to remain firm and intact under the feet of the workmen.

Trench subgrades which run beneath roads, or pass through structural backfill, shall be compacted to 95 percent of maximum density as determined by ASTM D698. The moisture content shall be ±2 percent of optimum.

Subgrades for structures and trench bottoms which are otherwise solid but which become mucky on top due to construction operations shall be reinforced with one or more layers of crushed rock or gravel per Section 2A.14.

The finished elevation of stabilized structure subgrades shall not be above the subgrade elevations indicated on the Drawings.

All stabilization work shall be performed by and at the expense of the Contractor.

2A.13 STRUCTURE BACKFILL

Backfill around and outside of structures, including the substation yard, shall be deposited in layers not to exceed 8 inches in uncompacted thickness and mechanically compacted, using acceptable compaction techniques, to at least 98 percent of maximum density at optimum moisture content as determined by ASTM D698. Compaction of structure backfill by rolling will be permitted provided the desired compaction is obtained and damage to the structure is prevented. Compaction of structure backfill by inundation with water will not be permitted.

Material for structure backfill shall be composed of earth only and shall contain no wood, grass, roots, broken concrete, stones, trash, rocks larger than 1 inch, or debris of any kind. The gradation shall meet the following:

| Table 2A-1 |
|---|---|
| Sieve Size | % by Weight Passing |
| 1/2" | 50 - 85 |
| No. 4 | 40 - 74 |
| No. 50 | 8 - 28 |
| No. 200 | 0 - 10 |

No tamped, rolled, or otherwise mechanically compacted backfill shall be deposited or compacted in water.
2A.13 STRUCTURE BACKFILL (continued)

All backfill material shall consist of loose earth having moisture content such that the required density of the compacted soil will be obtained with the compaction method used. Moisture content shall be distributed uniformly and water for correction of moisture content shall be added sufficiently in advance so proper moisture distribution and compaction will be obtained.

Particular care shall be taken to compact structure backfill which will be beneath precast trenches, conduits, drives, roads, or other surface construction or structures.

2A.14 COMPACTED SAND FILL

Compacted sand fill material shall consist of clean natural sand. The sand shall conform to ASTM C33 and not less than 75 percent shall pass a No. 4 sieve. Not more than 10 percent shall pass a No. 200 sieve.

Inundated sand fills shall be placed on a suitable subgrade and shall be placed with suitable arrangements for retention of water until compaction is completed and water is disposed of after compaction. The sand shall be deposited in, or simultaneously with the application of, clean water so that the sand is kept inundated at all times. During placement and inundation, the sand shall be compacted to 70 percent relative density as determined by ASTM D4253 and D4254 using mechanical probe type vibrators.

Tamped sand fills shall be placed on a suitable subgrade. The sand shall be wet, not just damp, when placed and moisture content shall be adjusted for maximum density. Compaction shall be performed with vibrating platform type compactors.

If concrete is to be placed on the compacted sand fill, a polyethylene film moisture barrier shall be placed over the sand as specified in the section titled CAST-IN-PLACE CONCRETE.

2A.15 TRANSFORMER DRAINAGE FILL

Transformer drainage fill shall be uniformly graded washed crushed stone of 3 inch size. Unwashed drainage material is unacceptable. A minimum void ratio of 40 percent is required.

Drainage material shall be placed to the approximate limits indicated on the Drawings, and shall be lightly compacted to minimize settlement without sacrificing permeability.
2A.16 TRANSFORMER OIL SUMP SYSTEM

The transformer oil sump system shall be in accordance with the following.

2A.16.1 Geotextile Fabric. Geotextile fabric shall be a non-woven fabric consisting of continuous chain polymeric filaments or yarns of polyester, or polypropylene formed into a stable network by needle punching.

The geotextile fabric shall be inert to commonly encountered chemicals and hydrocarbons. It shall be resistant to mildew and rot, ultraviolet radiation, insects, and rodents. The geotextile shall conform to the properties in table 2A-2. The average roll minimum value for strength properties shall be in excess of the average roll minimum value stipulated below. The average roll minimum value is defined as the sampling average, in the weakest principal direction, of the designated physical properties for the roll within a production lot designated first quality.

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Average Roll Minimum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab tensile strength (lb) ASTM D4632-86</td>
<td>200</td>
</tr>
<tr>
<td>Elongation at failure (percent) ASTM D4632-86</td>
<td>50</td>
</tr>
<tr>
<td>Thickness (mils) ASTM D1777-64 (1975)</td>
<td>90</td>
</tr>
<tr>
<td>Puncture strength (lb) ASTM D4833-88</td>
<td>80</td>
</tr>
<tr>
<td>Weight (oz/yd²) ASTM D3776-85</td>
<td>16</td>
</tr>
</tbody>
</table>

The geotextile shall be 16 oz./yard² polypropylene fabric, Philips ASUPAC@ 16 NP or Owner approved equal.

The geotextile shall be furnished in rolls wrapped with a covering to protect the fabric from mud, dirt, dust, and debris. The fabric shall be free of defects or flaws that affect its physical properties. Each roll of fabric shall be labeled to identify its production run.

a. Inspection and Testing. The following tests and documentation shall be submitted to the Owner for review before beginning liner installation.
b. **Quality Control.** A competent laboratory shall be retained at the point of manufacture to provide quality control in accordance with the specified ASTM testing procedures and ASTM D4759-88. Records of the quality control tests shall be provided to the Owner, in the form of a manufacturer's certificate that includes the following:

- Name of manufacturer
- Chemical composition
- Product description
- Physical Properties
- Statement of compliance with specification requirements
- Signature of legally authorized official attesting to the information required

c. The geotextile shall be tested and certified to be in accordance with this Specification by an independent laboratory. This data, along with a sample of the material, shall be submitted to the Owner.

d. **Installation.** Two layers of geotextile shall be installed in accordance with the manufacturer's recommendations, as indicated on the Drawings included in the Substation Field Issue and as specified.

Installation work shall not begin until all required data have been submitted and the acceptability of the subgrade reviewed by the Owner.

The bottom layer of geotextile shall be installed, in accordance with the manufacturer's requirements, on the prepared subgrade. All seams shall overlap 12 inches minimum.

A 12 inch layer of fill material consisting of 1" minus processed gravel compacted to 92% dry density as determined by ASTM D698 shall be installed on the bottom layer of geotextile.

The second layer of fabric shall be installed, in accordance with the manufacturer's requirements, on the processed gravel fill to the limits indicated on the Drawings. All seams shall overlap 12 inches minimum.

**2A.16.2 Oil Sump Clean Out.** To facilitate oil removal from the sump in the event a transformer leak occurs, a 6 inch perforated schedule 40 PVC drain pipe shall be installed vertically in each of the four corners of the sump. The pipes shall have 1 inch diameter holes placed in rows (4 per row at the quarter points) spaced 3 inches apart to within 6 inches of the top of the pipe. Holes in adjacent rows shall be staggered. The pipes shall extend from top layer of the geotextile to finished grade level and capped with a threaded plug to keep out debris. Care must be taken to insure that no overhanging part of the transformer will block insertion of the suction hose.
2A.16.3 **Soil Liner Material.** The soil liner shall be deposited in layers not to exceed 8 inches in uncompacted thickness and mechanically compacted, using acceptable compaction techniques, to at least 98 percent of the maximum density at optimum moisture content as determined by ASTM D698. Compaction of structure backfill by inundation with water will not be permitted.

Material for the soil liner shall be composed of earth only and shall not contain wood, grass, roots, broken concrete, stones, trash, rocks or debris of any kind. The gradation shall meet the following:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% passing by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4</td>
<td>100</td>
</tr>
<tr>
<td>#8</td>
<td>95</td>
</tr>
<tr>
<td>#16</td>
<td>91</td>
</tr>
<tr>
<td>#30</td>
<td>89</td>
</tr>
<tr>
<td>#50</td>
<td>88</td>
</tr>
<tr>
<td>#100</td>
<td>82</td>
</tr>
<tr>
<td>#200</td>
<td>53</td>
</tr>
<tr>
<td>0.05 mm</td>
<td>50</td>
</tr>
<tr>
<td>0.03 mm</td>
<td>37</td>
</tr>
<tr>
<td>0.01 mm</td>
<td>21</td>
</tr>
<tr>
<td>0.005 mm</td>
<td>11</td>
</tr>
</tbody>
</table>

2A.17 **CONDUIT TRENCH EXCAVATION**

No more trenches shall be opened in advance of conduit laying than is necessary to expedite the work.

All trench excavation shall be open cut from the surface except where tunneling is required.

2A.17.1 **Alignment and Grade.** The alignment and grade or elevation of each conduit shall be fixed and determined by means of laser beam equipment or surveying instruments unless otherwise accepted.

2A.17.2 **Limiting Trench Widths.** Trenches shall be excavated to a minimum width which will provide adequate working space and clearance for proper conduit installation.
2A.18 TRENCH BACKFILL

All trench backfill above conduit encasement shall conform to the following requirements.

2A.18.1 Compacted Backfill. Compacted backfill will be required for the full depth of the trench above the embedment.

a. Compacted backfill material shall meet the requirements specified hereinafter. Compacted backfill material shall be either suitable job excavated material or suitable material furnished by the Contractor from his own sources.

b. Compacted backfill material shall be finely divided and free from debris, organic material, and stones larger than 4 inches in greatest dimension. Compacted backfill material shall be placed in uniform layers not exceeding 8 inches in non compacted thickness. The method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the conduit. Trench backfill shall be compacted to not less than 95 percent of maximum density.

c. Backfill for trenches traversing subgrades of roads, parking areas, underground electrical ducts and conduit, and other facilities subject to damage by settlement shall be compacted to not less than 95 percent of maximum density. Moisture content of backfill material shall be adjusted as required to obtain the specified density with the compaction equipment used.

d. Backfill material shall be compacted to the densities specified hereinbefore as determined by ASTM D698.

2A.19 MAINTENANCE & RESTORATION OF FILLS, EMBANKMENTS, & BACKFILLS

Fills, embankments, and backfills that settle or erode before Final Acceptance of the work, and pavement, structures, trenches, and other facilities damaged by such settlement or erosion, shall be repaired. The settled or eroded areas shall be refilled, compacted, and graded to conform to the elevation indicated on the Drawings or to the elevation of the adjacent ground surface. Damaged facilities shall be repaired in a manner acceptable to the Owner.

Earth slopes of the roads constructed under this Specification shall be maintained to the lines and grades indicated on the Drawings until the final acceptance of the road slopes by the authorities having jurisdiction.
2A.20 FINAL GRADING

After all construction work has been completed, all ground surface areas disturbed by this construction shall be graded. The grading shall be finished to the contours and elevations indicated on the Drawings or, if not indicated, to the matching contours and elevations of the original, undisturbed ground surface. The final grading shall provide smooth uniform surfacing and effective drainage of the ground areas.

2A.21 DISPOSITION OF MATERIALS

Excavated earth material shall be used to construct fills, embankments, and backfills to the extent required. Surplus earth, if any, and materials which are not suitable for fills, embankments, and backfills shall be removed from the site by and at the expense of the Contractor. This work shall be done in accordance with the Owner’s Environmental Protection Policy and in a manner acceptable to the Owner.

If additional material is required, it shall conform to Section 2A.13

Section 2B (033000) - CAST IN-PLACE CONCRETE

2B.1 GENERAL

This section covers all cast-in-place concrete and includes reinforcing steel, forms, finishing, curing, and other appurtenant work.

Cast-in-place concrete shall be in accordance with the latest applicable requirements of Specifications, ACI, ASTM, and CRSI, except as modified by this Specification.

The Contractor shall inform the Owner at least 24 hours in advance of the times and places at which it intends to place concrete.
2B.2 MATERIALS

Materials shall be in accordance with the following requirements:

<table>
<thead>
<tr>
<th>Material</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>ASTM C150, Type II.</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>Clean natural sand, ASTM C33.</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>Crushed stone or worked gravel conforming to ASTM C33, Size 467 or 57, Class 3S</td>
</tr>
<tr>
<td>Water</td>
<td>Clean and free from mud, oil, organic matter, or other deleterious substances</td>
</tr>
<tr>
<td>Admixtures</td>
<td></td>
</tr>
<tr>
<td>Plasticizer</td>
<td>ASTM C494, Type A; Grace &quot;WRDA17,&quot; Master Builders &quot;Pozzolith 300N,&quot; Sika Chemical &quot;Plastocrete 161,&quot; or acceptable equal</td>
</tr>
<tr>
<td>Plasticizing retarder</td>
<td>or acceptable equal</td>
</tr>
<tr>
<td>Reinforcing steel bars</td>
<td>ASTM A615-90 Grade 60. Yield strength shall be determined by full size bar tests.</td>
</tr>
<tr>
<td>Welded wire fabric</td>
<td>ASTM A185 or A497.</td>
</tr>
<tr>
<td>Water Stops</td>
<td></td>
</tr>
<tr>
<td>Flexible</td>
<td>PVC ribbed or serrated, 9 inches by 3/8 inch, with AO@ bulb closed center sections unless otherwise indicated on the Drawings. Grace ADurajoint Type 7&quot;, W.R. Meadows ASealtight Type 9380&quot;, or Vinylex ARB9-38&quot;</td>
</tr>
<tr>
<td>Forms</td>
<td></td>
</tr>
<tr>
<td>Form coating</td>
<td>Nox-Crete &quot;Nox-Crete FormCoating,&quot; L &amp; M &quot;Debond,&quot; Protex &quot;Pro-Cote,&quot; or Richmond ARich Cote.</td>
</tr>
<tr>
<td>Polyethylene film</td>
<td>Fed Spec L-P-378, Type I; 6 mil.</td>
</tr>
<tr>
<td>Expansion Joint Materials</td>
<td>Filler Preformed, ASTM D1752, Type I (sponge rubber) or closed cellplastic foam (PVC or polyethylene)</td>
</tr>
<tr>
<td>Urethane sealant</td>
<td>Two component, Fed Spec TT-S- (self-leveling) 00227, Type 1, Class A; Pecora &quot;NR-200 Urexpan&quot; or Tremco&quot;TCH-900,&quot; gray color</td>
</tr>
<tr>
<td>Primer</td>
<td>As recommended by sealant manufacturer</td>
</tr>
<tr>
<td>Epoxy bonding compound</td>
<td>Sika Chemical &quot;Sikadur Hi-Mod,&quot; U.S. Grout &quot;Five Star Epoxy,&quot; or acceptable equal</td>
</tr>
<tr>
<td>Membrane Curing Compound</td>
<td>Styrene-acrylate or styrene-butadiene; minimum and 18 percent solids, non-yellowing, unit moisture floor sealer loss 0.039 g/sq cm maximum, Gifford-Hill &quot;Sealc0800,&quot; ProSoCo &quot;Kure and Seal,&quot;Protex &quot;Acryseal,&quot; Sonneborn &quot;Kure-N-Form,&quot; or L&amp;M &quot;Dress &amp; Seal.&quot;</td>
</tr>
</tbody>
</table>
2B.3 PRELIMINARY REVIEW

The source and quality of concrete materials and the concrete proportions proposed for the work shall be submitted to the Owner for review before the concrete work is started. Complete certified reports covering the materials and proportions shall be prepared by an independent testing laboratory and submitted to the Owner for each concrete class.

2B.4 LIMITING REQUIREMENTS

These requirements shall apply to concrete containing either the specified plasticizer or plasticizing retarder. A plasticizer or plasticizing retarder shall be included in all concrete mixes.

Table 2B-2

<table>
<thead>
<tr>
<th>Aggregate size range</th>
<th>Minimum cement content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inch to No. 4 sieve</td>
<td>585 lb/cu yd</td>
</tr>
<tr>
<td>3/4 inch to No. 4 sieve</td>
<td>600 lb/cu yd</td>
</tr>
<tr>
<td>Maximum water/cement ratio</td>
<td>0.45</td>
</tr>
<tr>
<td>Coarse aggregate size</td>
<td>Refer to Table 2B-3</td>
</tr>
<tr>
<td>Consistency</td>
<td>Workable, without</td>
</tr>
<tr>
<td></td>
<td>segregation, with</td>
</tr>
<tr>
<td></td>
<td>slump not more than 2</td>
</tr>
<tr>
<td></td>
<td>inches 1 inch when</td>
</tr>
<tr>
<td></td>
<td>concrete is placed</td>
</tr>
</tbody>
</table>

Table 2B-3 Concrete Mixes

<table>
<thead>
<tr>
<th>Mix Number</th>
<th>Strength Minimum 28 Day Lbs/Square Inch</th>
<th>Aggregate Max. Size Nominal</th>
<th>Slump Not More Than</th>
<th>Air-Entraining Content</th>
<th>Typical Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>2,000</td>
<td>1/2&quot;</td>
<td>6&quot;</td>
<td>--</td>
<td>Duct Lines - Unit Method</td>
</tr>
<tr>
<td>M2</td>
<td>4,000</td>
<td>1&quot;</td>
<td>2&quot;</td>
<td>6.0% +/- 1.0%</td>
<td>Piers, Slabs and Walls</td>
</tr>
</tbody>
</table>
2B.5 STORAGE OF MATERIALS

Reinforcing steel shall be carefully handled and shall be stored on supports which will keep the steel from contact with the ground.

2B.6 BATCHING AND MIXING

Batching and mixing shall be performed by an acceptable ready-mix concrete supplier. Personnel at the batching and mixing plant shall be qualified and experienced.

2B.6.1 Batching. The measurement of aggregates and cement shall be by weight. Aggregate weights shall be adjusted for the moisture content.

Each admixture shall be dispensed by a mechanical device that will ensure accurate and automatic measurement.

The minimum amount of water required to produce the desired slump shall be batched automatically. Slump shall be kept uniform. Aggregates shall float uniformly throughout the mass and the concrete shall flow sluggishly when vibrated.

2B.6.2 Mixing. Concrete shall be mixed until all ingredients are uniformly distributed throughout the batch. Mixers shall not be loaded in excess of their rated capacities. Each batch shall be completely discharged before the mixer is recharged.

2B.6.3 Ready-Mixed Concrete. Ready-mixed concrete shall conform to ASTM C94, except as otherwise specified herein.

A delivery ticket shall be prepared for each load of ready-mixed concrete delivered. A copy of each ticket shall be handed to the Owner by the truck operator at the time of delivery. Tickets shall indicate the mix identification, the number of yards delivered, the quantities of each material in the batch, the outdoor temperature in the shade, the time at which the cement was added, and the numerical sequence of the delivery.

When a truck mixer or agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within 1-1/2 hours, or before the drum has been revolved 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to the aggregates, unless a longer time is specifically accepted by the Owner. In hot weather, or under conditions contributing to quick stiffening of the concrete, a time less than 1-1/2 hours may be required by the Owner. When a truck mixer is used for the complete mixing of the concrete, the mixing operation shall begin within 30 minutes after the cement has been intermingled with the aggregates. Truck mixers shall be revolving drum type and shall be equipped with a mixing water tank. Only the prescribed amount of mixing water shall be placed in the tank for any one batch, unless the tank is equipped with a device by which the amount of water added to each batch can be readily verified by the Owner.
2B.7 FIELD CONTROL TESTING

Field control tests, consisting of aggregate gradation tests, slump tests, air content tests, and the securing of compression test cylinders, shall be made by an independent testing laboratory. The independent testing laboratory shall provide all equipment and supplies and the services of one or more employees as necessary for the field control testing.

All tests required for preliminary review, field quality control and compression tests for the entire project shall be tested by an acceptable independent testing laboratory at the expense of the Contractor.

The frequency hereinafter specified for each field control test is a minimum. If additional field control tests are necessary, in the opinion of the Owner, such tests shall be made.

2B.7.1 Aggregate Gradation. It is not anticipated that aggregate gradation tests will be required after the tests made for the initial acceptance of the materials. However, if directed to do so by the Owner, the Contractor shall sample and test the fine and coarse aggregate in accordance with ASTM D75 and C136.

2B.7.2 Slump. A slump test shall be made from each of the first three batches mixed each day. An additional slump test shall be made for each additional 25 cubic yards of concrete placed in any one day. Slump shall be determined in accordance with ASTM C143.

Each set of compression test cylinders shall be marked or tagged with the slump.

2B.7.3 Air Content. An air content test shall be made from one of the first three batches mixed each day and from each batch of concrete from which concrete compression test cylinders are made. Air content shall be determined in accordance with ASTM C231.

Each set of compression test cylinders shall be marked or tagged with the air content.

2B.7.4 Compression Tests. A set of three compression test cylinders shall be made each day concrete is placed. An additional set of three compression test cylinders shall be made for each additional 25 cubic yards of concrete placed in 1 day. One cylinder of each set shall be tested at an age of 7 days and the other cylinder of each set shall be tested at an age of 28 days. The third cylinder will be kept as a spare for additional testing, if required.

Concrete test cylinders shall be made, cured, stored, and delivered to the laboratory in accordance with ASTM C31 and tested in accordance with ASTM C39.

Each set of compression test cylinders shall be marked or tagged with the date and time of day the cylinders were made, the location in the work where the concrete represented by the cylinders was placed, the delivery truck or batch number, the air content, and the slump.

2B.7.5 Test Reports. The Contractor shall promptly furnish the Owner, and all other persons designated by the Owner, certified reports of all tests made by the testing laboratory.
2B.8 REINFORCEMENTS

Reinforcements shall be accurately formed. Unless otherwise indicated on the Drawings or specified herein, the details of fabrication shall conform to ACI 318-95.

2B.8.1 Accessories. The Contractor shall provide all bar supports, ties, spacers, bolsters, inserts, screeds, and other concrete accessories required to maintain reinforcing in its proper position and permit proper placement of concrete.

The Contractor shall be responsible for the design of all bar support systems.

2B.8.2 Certification. The Contractor shall furnish the Owner with a certification that the reinforcing steel furnished complies with the requirements specified in the article titled MATERIALS. The certification shall be signed by the Contractor and the reinforcing steel fabricator.

2B.8.3 Welding. Except where indicated on the Drawings, welding of reinforcement for any purpose, and tack welding in particular, is expressly prohibited. Reinforcements upon which unauthorized welding has been done shall be presumed to be damaged and such reinforcing shall be removed and replaced at the Contractor's expense. Replacement materials shall conform to all applicable requirements of this Specification.

Welded chairs and supports may be used provided they are clamped or wired to the reinforcement.

2B.8.4 Concrete Cover. Except as otherwise indicated on the Drawings, metal reinforcement for concrete shall have a minimum concrete protective cover of 3 inches.

2B.8.5 Placement. Reinforcements shall be accurately positioned on supports, spacers, hangers, or other reinforcements, and shall be secured in place with wire ties or suitable clips. Bare metal supports shall not be used in contact with forms for exposed surfaces.

2B.8.6 Splices. Unless otherwise required by this Specification or Drawings, splices shall conform to ACI 318-95. Splices in horizontal reinforcement placed in vertical wall sections shall be detailed in accordance with the top reinforcement requirements of ACI 318-95.

Splices shall not be used in regions of maximum bending stress. Welded splices shall not be used.

2B.9 FORMS

Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions indicated on the Drawings. Forms shall be constructed and maintained in proper position and accurate alignment. Forms shall conform to ACI 347.
2B.9.1 Design. Forms shall be substantial and sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied so that they will maintain the desired position, shape, and alignment during and after placing concrete therein.

2B.9.2 Form Ties. Form ties shall be of the removable end, permanently embedded body type, and shall have sufficient strength, stiffness, and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders. Outer ends of the permanently embedded portions of form ties shall be at least 1 inch back from adjacent outer concrete faces. Permanently embedded portions of form ties which are not provided with threaded ends shall be constructed so that the removable ends can be broken off by twisting, without chipping or spalling the concrete surface. The type of form ties used shall be acceptable to the Owner.

Form ties in exposed surfaces shall be uniformly spaced and aligned in horizontal and vertical rows.

2B.9.3 Edges and Corners. Chamfer strips shall be placed in forms to bevel all salient edges and corners except edges which are to be buried and edges which are indicated on the drawings with a special treatment. Equipment bases shall have formed beveled salient edges for all vertical and horizontal corners unless specifically indicated otherwise on the drawings. Bevel dimensions shall be 3/4 by 3/4 inch unless indicated otherwise on the Drawings.

2B.9.4 Form Removal. Forms shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead and live loads to be imposed thereon. Supports beneath beams or slabs shall be left in place and reinforced as necessary to carry any construction equipment or materials placed thereon. Care shall be taken in form removal to avoid surface gouging, corner or edge breakage, or other damage to the concrete.

2B.10 EMBEDMENTS

Anchor bolts, castings, steel shapes, conduit, sleeves, masonry anchorages, and other materials that are to be embedded in the concrete shall be accurately positioned and securely anchored.

Anchor bolts shall be provided with sufficient threads to permit a nut to be installed on the concrete side of the form or template. A second nut shall be installed on the other side of the form or template and the two nuts shall be adjusted so the bolt will be held rigidly in proper position.

Embedments shall not be welded to reinforcement.

Embedments shall be clean when they are installed. After concrete placement, surfaces not in contact with concrete shall be cleaned of all concrete spatter and other foreign substances.
2B.11 PLACEMENT

The handling, depositing, and compacting of concrete shall conform to this Specification subject to adjustment by the Owner for weather or placement conditions.

Concrete shall not be pumped through aluminum pipe or aluminum alloy pipe.

Concrete placement shall be coordinated such that construction joints are not required.

Before concrete is placed, forms, reinforcements, water stops, anchor bolts, and embedments shall be rigidly secured in proper position; all dirt, mud, water, and debris shall be removed from the space to be occupied by the concrete; all surfaces which may have become encrusted with dried mortar or concrete from previous placement operations shall be cleaned; and the entire installation shall be acceptable to the Owner.

2B.11.1 Bonding to Hardened Concrete. The surface of hardened concrete against which fresh concrete is to be placed shall be rough, clean, and damp. Surface mortar shall be removed to expose the aggregate. The hardened surface shall be cleaned of all foreign substances (including curing compound), washed with clean water, and kept saturated during the 24 hour period preceding placement of fresh concrete.

2B.11.2 Conveyance and Distribution. Concrete shall be conveyed to the point of final deposit by methods which will prevent the separation or loss of the ingredients. Concrete shall be deposited in its final position without moving it laterally in the forms for a distance in excess of 5 feet.

2B.11.3 Depositing Concrete. Horizontal and vertical construction joints shall be provided as necessary and as accepted by the Owner to comply with these requirements.

Plastic concrete is defined as concrete which can be re-vibrated at least to the extent that an immersion type vibrator spud will penetrate the concrete at least 1 inch by vibration action and its own weight. Concrete shall remain plastic to this extent for at least 2-1/2 hours after initial contact of cement and water. Concrete which is no longer plastic but which must be covered by an additional lift shall be immediately chipped back to well consolidated concrete, slushed with mortar puddle as specified in the article titled Bonding to Hardened Concrete, and otherwise treated as accepted by the Owner to ensure that a cold joint will not occur. If the pour requirements do not exceed the Contractor's placing ability, these measures should not be necessary.

Concrete shall be thoroughly settled when top finished. All laitance, debris, and surplus water shall be removed from concrete surfaces at top of forms by screeding, scraping, or other effective means. Wherever the top of a wall will be exposed to weathering, the forms shall be overfilled and after the concrete has settled the excess shall be screeded off.
2B.11.4 Compaction. During and immediately after depositing, all concrete shall be thoroughly compacted, worked around reinforcements and embedments, and worked into the corners of the forms. Compaction shall be in accordance with ACI 309 and the following requirements.

All concrete shall be compacted by means of mechanical vibrating equipment, except duct bank concrete shall also be rodded or spaded and concrete slabs 6 inches or less in thickness may be either vibrated or tamped. Unless otherwise accepted by the Owner, mechanical vibrators shall be spud type immersion vibrators which will maintain at least 9,000 cycles per minute when immersed in the concrete. The number and type of vibrators shall be subject to the acceptance of the Owner.

2B.11.5 Hot Weather Concreting. Except as modified herein, hot weather concreting shall comply with ACI 305. At air temperatures of 90°F or above, special procedures shall be adopted to keep the concrete as cool as possible during placement and curing. The temperature of the concrete when it is placed in the work shall not exceed 90°F.

Whenever the air temperature exceeds 95°F, membrane cured slabs shall be kept wet to promote cooling of the concrete during the curing period.

2B.11.6 Cold Weather Concreting. Except as modified herein, cold weather concreting shall comply with ACI 306. The temperature of concrete at the time of mixing shall be not less than that indicated in the following table for corresponding outdoor temperature (in shade) existing at the time of placement:

<table>
<thead>
<tr>
<th>Outdoor Temperature</th>
<th>Concrete Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 30°F</td>
<td>70°F</td>
</tr>
<tr>
<td>Between 30°F and 45°F</td>
<td>60°F</td>
</tr>
<tr>
<td>Above 45°F</td>
<td>45°F</td>
</tr>
</tbody>
</table>

When deposited, the temperature of heated concrete shall be not over 80°F.

When freezing temperatures may be expected during the curing periods, suitable means shall be provided for maintaining the concrete at temperatures of not less than 50°F for 5 days or 70°F for 3 days after the concrete is placed. Concrete and adjacent form surfaces shall be kept moist at all times. Sudden cooling of concrete will not be permitted.

The use of calcium chloride will not be permitted.

2B.12 CONSTRUCTION JOINTS

Construction joints will not be permitted.
2B.13 FINISHING FORMED SURFACES

All fins and other surface projections shall be removed from all formed surfaces from which the forms are stripped except exterior surfaces that will be in contact with earth backfill. In addition, exterior surfaces which will be exposed above grade and all interior surfaces, except interior surfaces which are not usually exposed to view, shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed and the resulting recesses shall be cleaned, wetted, and filled with patching mortar. For rubbed surfaces, patches shall match the texture of the adjacent concrete. Rubbing shall be performed within 24 hours of removing forms.

2B.14 FINISHING UNFORMED SURFACES

No surface treatment will be required for buried or permanently submerged concrete not forming an integral part of a structure except that required to obtain the surface elevations or contours and surfaces free of laitance. The unformed surfaces of all other concrete shall be screeded and given an initial float finish followed by additional floating and troweling where required.

Float finished surfaces shall be finished to provide a flat profile within 1/4 inch deviation as measured from a 10 foot straightedge. Trowel finished surfaces shall be finished to form a flat plane in which the profile shall not deviate more than 1/8 inch when measured from a 10 foot straightedge.

2B.14.1 Screeding. Screeding shall provide a concrete surface conforming to the proper elevation and contour with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited as required to produce finished surfaces within the tolerances specified. If no further finishing is required, surface irregularities shall not exceed 1/4 inch as measured from a 10 foot straightedge.

2B.14.2 Floating. Screeded surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which may be disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance with no unnecessary working of the surface with the float.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth, uniform, and workmanlike float finish of uniform texture and color. Unless additional finishing is specifically required, the completed finish for all unformed surfaces shall be a float finish as produced by the second floating.

Floating shall be performed with hand floats or suitable mechanical compactor floats.
2B.14.3 **Troweling.** The exposed portions of the tops of equipment bases, the tops of interior curbs, the surfaces of all interior slabs except those which will receive a separate concrete finish, and all other surfaces designated on the drawings to be troweled shall be steel trowel finished. Troweling shall be performed after the second floating when the surface has hardened sufficiently to prevent an excess of fines being drawn to the surface. Troweling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

2B.14.4 **Aggregate Exposure.** All surface mortar shall be removed from surfaces which are to be later covered with mortar, concrete, or grout. The coarse aggregate shall be exposed in all such surfaces to improve bonding. The method employed shall be effective and acceptable to the Owner.

2B.14.5 **Edging.** Unless specified to be beveled, exposed edges of floated or troweled surfaces shall be edged with a tool having a 1/4 inch corner radius.

2B.14.6 **Finishing Mortar.** Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 225 pounds of concrete sand (fine aggregate) to one sack of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 2 inches.

2B.14.7 **Brooming.** Brooming shall follow the float finish specified for those surfaces designated on the Drawings to be broomed. Brooming shall be done with an acceptable steel or fiber broom not less than 18 inches wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1/16 inch and 1/8 inch deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate.

2B.15 **CURING**

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed.

Curing of concrete shall be by methods which will keep the concrete surfaces adequately wet during the specified curing period. Curing shall be by saturation with water unless otherwise specified.

2B.15.1 **Water Curing.** Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water to formed surfaces may be interrupted for surface rubbing only over the areas being rubbed at the time, and the concrete surface shall not be permitted to become dry during such interruption.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap which shall be saturated for the remainder of the curing period.
2B.15.2 Membrane Curing. Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible without damaging the surface. Membrane curing compound shall be spray applied at a coverage of not more than 300 square feet per gallon. Membrane curing shall not be used on surfaces which will be covered at a later date with mortar, concrete, damp proofing, or any coating.

2B.16 LOADING OF CONCRETE

Normal concrete structures shall not be subjected to external loads in less than:

- Four days for foundations and walls.
- Seven days for floors.

Each concrete placement shall be allowed to set 48 hours before addition of a subsequent pour upon it.

Trenches containing concrete encased duct lines constructed on undisturbed original ground shall be backfilled not less than 24 hours after placement. If the concrete is poured on disturbed earth, the trench shall be backfilled not less than 48 hours after placement. Loading of the backfill by heavy equipment or traffic is not permitted until 48 hours after concrete placement.

2B.17 REPAIRING DEFECTIVE CONCRETE

Defects in formed concrete surfaces shall be repaired to the satisfaction of the Owner within 24 hours, and defective concrete shall be replaced within 48 hours after the adjacent forms have been removed. All concrete which is porous, honeycombed, or otherwise defective to a depth in excess of 1 inch shall be cut out and removed to sound concrete, with edges square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the repair concrete is placed.

Concrete repair work shall be performed in a manner that will not interfere with thorough curing of surrounding concrete. Mortar and concrete used in repair work shall be adequately cured and shall be finished to match adjacent surfaces.

2B.18 DUCT BANK CONCRETE

Concrete for duct banks shall be as specified in Table 2B-3. All reinforcing steel and other magnetic materials installed in duct banks shall be parallel to the lengths of the individual ducts unless they enclose all the ducts of the duct bank.

Hardened surfaces that are to receive additional concrete shall be prepared by being cleaned of all loose particles, scum, and laitance so that the aggregate is exposed. The hardened surface shall then be thoroughly wetted and a thin coating of neat cement mortar shall be spread over the entire surface just before the fresh concrete is placed. The fresh concrete shall be puddled and spaded to eliminate any honeycomb or lack of mortar at or near the joint.

Duct bank concrete shall be compacted to ensure concrete is worked around reinforcements and embedments, and worked into the corners of the forms. Care shall be taken during compaction to avoid movement or breaking ducts. High frequency mechanical vibrators may be used.
2B.19  TOLERANCES FOR SUBSTATION FOUNDATIONS

The concrete bases and their embedments for substation yard structures and equipment shall meet the following tolerance requirements in addition to those specified hereinbefore.

Concrete form dimensions and placement shall be within 1/2 inch of the plan dimensions and locations indicated on the Drawings. The top of the forms shall be accurately set to the elevation required to produce finished surfaces within the specified tolerances.

The elevation of all points on all float finished surfaces shall be within 1/4 inch of the elevation indicated on the drawings. The elevation of all points on all trowel finished surfaces shall be within 1/8 inch of the elevation indicated on the Drawings.

Anchor bolts and all other materials that are to be embedded in the concrete shall be accurately positioned and securely anchored. The center of each anchor bolt group or cluster shall be within 1/8 inch of the location indicated on the Drawings. The center-to-center dimensions between the anchor bolts in a group or cluster shall be within 1/16 inch of the dimensions indicated on the Drawings.

Maximum variation of any foundation from its designated location shall not be more than 1 inches at its top elevation. Variation of the foundation location within its specified tolerance shall not be cause for variation of anchor bolt or embedment location beyond their specified tolerance.

Section 2C (050000) - MISCELLANEOUS METALS

2C.1  GENERAL

This section covers the materials, fabrication, and erection requirements for miscellaneous metals.

Except as otherwise specifically noted on the Drawings, or specified herein, all materials furnished and work performed in connection with miscellaneous metals work shall be in conformity with the AISC "Manual of Steel Construction, Ninth Edition or The Aluminum Association Aluminum Design Manual."

2C.2  DRAWINGS

Detailed fabrication and erection drawings for all materials shall be prepared, checked, and submitted to the Owner prior to the beginning of fabrication.
2C.3 MATERIALS

Materials shall be new and undamaged and shall conform to pertinent AISC and ASTM standard specifications and the following requirements:

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural shapes and plates not otherwise</td>
<td>ASTM A36 steel, shop prime painted. Minimum yield point of 36,000 psi</td>
</tr>
<tr>
<td>otherwise noted</td>
<td>including appurtenant materials</td>
</tr>
<tr>
<td>Shapes and plates noted &quot;galv&quot; or &quot;galvanized&quot;</td>
<td>ASTM A36 steel, galvanized</td>
</tr>
<tr>
<td>or &quot;galvanized&quot; on the drawings</td>
<td></td>
</tr>
<tr>
<td>Shim pack</td>
<td>ASTM A36 steel.</td>
</tr>
<tr>
<td>Steel pipe</td>
<td>ASTM A53 Type E or S, Grade B steel pipe with yield strength of 35,000 psi,</td>
</tr>
<tr>
<td></td>
<td>galvanized.</td>
</tr>
<tr>
<td>Aluminum shapes and plates:</td>
<td></td>
</tr>
<tr>
<td>Shapes (rolled sections)</td>
<td>ASTM B308, 6061-T6.</td>
</tr>
<tr>
<td>Extrusions</td>
<td>ASTM B221, Alloy 6063-T5 or T6 tubular sections</td>
</tr>
<tr>
<td>Bolts</td>
<td>ASTM B211, 2024-T4.</td>
</tr>
<tr>
<td>Nuts</td>
<td>ASTM B211, 6061-T6.</td>
</tr>
<tr>
<td>Flat Washers</td>
<td>ANSI B18.22.1.</td>
</tr>
<tr>
<td>Lock Washers</td>
<td>ANSI B18.21.1, helical spring type.</td>
</tr>
<tr>
<td>Checkered floor plates:</td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>ASTM A786; carbon steel, skid resistant pattern as standard with the</td>
</tr>
<tr>
<td></td>
<td>manufacturer, Inland A4-way Floor Plate@, or acceptable equal, galvanized.</td>
</tr>
<tr>
<td>Shop and field bolts</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Flat and beveled washers</td>
<td>ASTM F436, quenched and tempered, compatible with ASTM A325 Type 1 bolts.</td>
</tr>
<tr>
<td></td>
<td>Galvanized if any connection component is galvanized, stainless steel if</td>
</tr>
<tr>
<td></td>
<td>any connection component is stainless steel</td>
</tr>
<tr>
<td>Unfinished bolts</td>
<td>ASTM A307 Grade A with lock washers. Galvanized where either connection</td>
</tr>
<tr>
<td></td>
<td>component is aluminum or galvanized steel</td>
</tr>
<tr>
<td>Threaded inserts for concrete</td>
<td>Dayton Sure-Grip &quot;Type F-5, Gateway &quot;Type J,&quot; or acceptable equal,</td>
</tr>
<tr>
<td></td>
<td>galvanized.</td>
</tr>
<tr>
<td>Continuous inserts</td>
<td>&quot;Unistrut,&quot; &quot;Kindorf,&quot; &quot;Binkley,&quot; or acceptable equal, galvanized</td>
</tr>
<tr>
<td>Pulling eyes</td>
<td>McGraw-Edison No. DU2T3 or acceptable equal</td>
</tr>
<tr>
<td>Anchor bolts ¾ inch and larger</td>
<td>ASTM A36 threaded bars or ASTM A307 Grade B, with nuts conforming to</td>
</tr>
<tr>
<td></td>
<td>ASTM A563 Grade A heavy hexagon; all galvanized after fabrication.</td>
</tr>
</tbody>
</table>
Table 2C-1

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchor bolts smaller than ¾ inch</td>
<td>ASTM A307 Grade A or B with hexagon heads and ASTM A563 Grade A hexagon nuts; all galvanized after fabrication.</td>
</tr>
<tr>
<td>Expansion anchors</td>
<td>Fed Spec FF-S-325, Group II, Type 3, Class 3; Group II, Type 4; Group VIII, Type 1 or Type 2, Hilti Kwik-Bolt II, ITW Phillips Red Head Wedge and Sleeve Anchors, Drillco Device Limited Maxi-Bolt, or acceptable equal.</td>
</tr>
<tr>
<td>Concrete anchors</td>
<td>Welded stud type, 3/8inch by 4inches, Nelson Stud Welding, Erico Products &quot;Blue Arc,&quot; KSM Welding Systems, or acceptable equal, unless otherwise indicated on drawings</td>
</tr>
<tr>
<td>Sleeves</td>
<td>ASTM A53 standard weight pipe or formed ASTM A36 plate, galvanized.</td>
</tr>
<tr>
<td>Welding electrodes</td>
<td>American made including flux.</td>
</tr>
<tr>
<td>Aluminum</td>
<td>ALCOA 6061-T6 alloy AC-102 Tread Plate@ or acceptable equal.</td>
</tr>
<tr>
<td>ASTM A36 steel</td>
<td>Low hydrogen types, AWS D1.1-88 (as specified in Table 4.1.1 &quot;Matching filler metal requirements&quot;). Tensile strength range of 70,000 psi minimum.</td>
</tr>
<tr>
<td>Iron castings</td>
<td>ASTM A48, Class 35 or better.</td>
</tr>
<tr>
<td>Shop applied coatings</td>
<td>System A6P as specified in the Coating System Data Sheet at the end of this section.</td>
</tr>
<tr>
<td>Primer paint</td>
<td></td>
</tr>
</tbody>
</table>

2C.4 FABRICATION

Miscellaneous metals shall be fabricated in conformity with the dimensions, arrangements, sizes, and weights or thicknesses indicated on the Drawings or stipulated in this Specification. Framing and connections of all members shall be detailed and fabricated in accordance with AISC standards, specifications, and details unless otherwise indicated on the Drawings or specified herein.

2C.4.1 Shapes and Plates. Shapes and plates shall be fabricated and assembled in the shop to the greatest extent practicable. Shearing, flame cutting, and chipping shall be done carefully, neatly, and accurately. Holes shall be cut, drilled, or punched at right angles to the surface and shall not be made or enlarged by burning. Holes shall be clean-cut without torn or ragged edges, and burrs resulting from drilling or reaming operations shall be removed with the proper tool.

Shapes and plates shall be fabricated to tolerances that will permit field erection within AISC tolerances except as otherwise specified.
Contact surfaces at all connections shall be free of loose scale, dirt, burrs, oil, and other foreign materials that would prevent solid seating of the parts.

2C.4.2 **Bolting.** High strength bolts and their installation and bolting tools and equipment shall conform to all requirements for A325 bolts of the "Specification for Structural Joints Using ASTM A325 or A490 Bolts" including the commentary given therewith, as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation, and endorsed by AISC, except as otherwise modified and supplemented herein. The Research Council specification is dated November 13, 1995. Bolt length shall be determined in accordance with the Research Council specification and commentary.

High strength bolted connections shall be bearing type connections with threads excluded from the shear planes except where other type connections are required by the Drawings or this Specification. Contact surfaces of bearing type connections may be painted.

Tightening of bolts shall be controlled using the "turn-of-nut" method.

2C.4.3 **Anchor Bolts.** Anchor bolts furnished under this Specification shall be as listed and detailed on the Drawings. Sleeves and anchor plates shall be provided where they are indicated on the Drawings. Unless otherwise indicated on the Drawings, fabrication details for all anchor bolts shall comply with ASTM A307. Anchor bolts, nuts, and washers shall be hot-dip galvanized after fabrication, threads being under-cut to provide a tolerance equal to ANSI Class 2A. Anchor bolts longer than 3 feet shall have the top 18 inches hot-dip galvanized after fabrication, threads being under-cut to provide a tolerance equal to ANSI Class 2A. Each bolt without a sleeve shall be furnished with two nuts and sufficient threads to permit a nut to be installed on each side of the concrete form or template.

2C.4.4 **Iron Castings.** Iron castings shall be made of tough gray pig iron, free from cracks, swells, holes, and cold shuts, and shall have a smooth finish. If galvanizing is specified, casting shall be hot-dipped galvanized in accordance with ASTM A124, A153, and A385.

2C.4.5 **Embedments.** Embedded materials shall be accurately fabricated and assembled. Warped or bent sections, which do not fit into the concrete forms as required, shall be replaced with suitable material. All materials embedded in concrete shall be galvanized after fabrication except steel framing members, reinforcing steel, base plates, and concrete anchors.
2C.5 WELDING

Except as otherwise specified, all welds, welding, and related operations for steel shall be in conformity with the applicable provisions of the AWS Structural Welding Code, AWS D1.1-88 as issued by the American Welding Society.

Except as otherwise specified, welding shall be performed using only those joint details and welding procedures which are pre-qualified in accordance with the referenced AWS code.

All welding procedures shall be submitted to the Owner for review prior to beginning the work.

All welders, welding operators, and tackers shall be tested and examined by an independent testing laboratory in accordance with the applicable provisions of the referenced AWS code. Accurate records of welder, welding operator, and tacker qualifications shall be certified and maintained by the Contractor and shall be made available to the Owner upon request.

Only E71T-1 and E71T-5 electrodes with supplemental shielding gas will be permitted when using the flux cored arc welding process.

Low hydrogen electrodes shall be stored and handled during use in a manner that will maintain their low hydrogen characteristics. The methods used for storage and handling shall be fully explained in the welding procedures submitted or in a separate electrode storage and handling procedure submitted to the Owner for review prior to beginning the work.

All welded joints exposed in exterior locations or subject to submergence in any location shall be provided with continuous welds along all contact edges except as prohibited in Article 8.8.5 of the referenced code.

Welds that are not dimensioned on the Drawings shall be sized to develop the full strength of the least strength component involved in the connection.

All welds shall be properly identified on the detailed shop drawings and shall be subject to acceptance by the Owner.

Components to be welded shall be accurately positioned and shall be rigidly secured during welding.

2C.5.1 General Inspection. The Contractor shall be responsible for inspection of the work to assure conformance to the requirements of these documents. Personnel responsible for visual inspection and acceptance of welding shall be Certified Welding Inspectors qualified and certified in accordance with American Welding Society AWS QC1, Standard for Qualification and Certification of Welding Inspectors.

Personnel performing welding inspection shall be responsible for verifying that all aspects of the welding operation are in accordance with the requirements defined in Section 6 of the referenced edition of AWS D1.1.
2C.5.2 Aluminum Welding. Welding and brazing of aluminum shall be in accordance with the recommendations of the Aluminum Company of America, as contained in its latest publications "Welding of Alcoa Aluminum" and "Brazing of Alcoa Aluminum." All welding rod, filler wire, brazing wire, flux, and other materials used in such welding shall be as recommended by the Aluminum Company of America for use in conjunction with the alloy to be welded in each case.

Welding procedure qualification and welder qualification shall be performed in accordance with ASME B and PVC, Section IX. All welding procedures and procedure qualification reports (PQRs) shall be submitted to the Owner for review prior to beginning the work.

Workmanship standards for the production work for weld size reinforcement, fitting, camber, tilt, defect sizes, etc., shall comply with Sections 3 and 8 of AWS D1.1.

2C.6 GALVANIZING

Metal materials which are specified herein or indicated on the Drawings to be galvanized shall be hot-dip galvanized in accordance with ASTM A123, ASTM A153, and ASTM A385. Materials specified to be galvanized shall be prepared for galvanizing by being properly cleaned, pickled, rinsed, and dried. The cleaned materials shall be immediately galvanized before any rusting can occur.

2C.7 SHOP PAINTING

Unless specifically exempted, all non galvanized steel materials shall be painted with one coat of metal primer paint after shop fabrication and before moving from the fabricating shop or manufacturing plant. Surfaces shall be dry and of proper temperature when painted, and free of grease, oil, dirt, dust, grit, rust, loose mill scale, weld flux, slag, weld spatter, or other objectionable substance. Surfaces shall be cleaned in accordance with SSPC Surface Preparation Specification No. 6 Commercial Blast Cleaning.

All shop primer paint shall be purchased from the same manufacturer.

Cleaned surfaces shall be kept dry and clean and shall be prime coated within 8 hours after cleaning.

All shop paint shall be applied in a skillful manner by acceptable methods which will provide a closely adhering coating of uniform thickness. Should materials which have been shop coated arrive on the jobsite with an inadequate or damaged coating, or a coating which is not free of sags, blisters, and runs or shows evidence of being handled or loaded before the paint has properly set, the Contractor shall be responsible for removing any rust that has formed, cleaning the surface, and applying an adequate and defect free coat of the primer paint.

No shop paint shall be applied to surfaces within 3 inches of any field welded connection.

During painting, the ambient temperature shall not be below 50°F. During damp or wet weather all painting shall be done in a dry shelter.

Materials shall not be handled in any manner until the shop paint is dry, hard, and able to resist abrasion.
2C.8  **ERECTION**

Metal materials shall be erected in accordance with AISC, the Drawings, and this Specification. Unless specified otherwise, erection tolerances shall be the same as those specified hereinbefore under the article titled FABRICATION.

All parts shall be assembled accurately and match marks shall be carefully followed. Light drifting to draw the parts together will be acceptable, but drifting to match unfair holes will not be acceptable. Any enlargements of holes necessary to make connections in the field shall be done by reaming with twist drills, care being taken not to weaken the adjoining metal. Enlarging of holes by burning is prohibited. Connections requiring extensive hole enlargements or adjustments, other than provided for by shop fabricated slotted holes, shall be brought immediately to the Owner's attention. The necessary adjustments shall be made under the direction of the Owner.

Anchor bolts and other materials embedded in concrete shall be installed as specified in the section titled CAST-IN-PLACE CONCRETE.

Installation of high strength bolts, bolting tools and equipment, and tightening of high strength bolts shall be the same as specified hereinbefore under the article titled BOLTING.

2C.8.1  **Field Welding**  Field welding shall conform to the requirements specified under the article titled WELDING, and to these additional requirements. Each welding operator shall be qualified for all welding positions required in a joint that he welds. The entire weld of any structural joint shall be made by one operator.

It shall be the responsibility of the Contractor to have all welders, welding operators, and tackers tested and examined by an independent testing laboratory in accordance with applicable code requirements before work is begun. Qualification shall be made in accordance with the AWS Structural Welding Code, AWS D1.1--88.

2C.9  **TOUCHUP PAINTING**

Damaged or inadequate paint films of shop painted miscellaneous metal materials, and all accessible surfaces of field welds and connection bolts, shall be cleaned and prime painted as specified in the Coating System Data Sheet, System A6P at the end of this section.

2C.10  **SPECIAL COATINGS FOR ALUMINUM SHAPES AND PLATES**

Aluminum surfaces which will be in contact with dissimilar metals shall be heavily coated with zinc chromate pigment, synthetic resin type paint. Aluminum surfaces which will be in contact with concrete or mortar shall be given a heavy coat of alkali resistant bituminous paint. Bituminous paint shall be Koppers "Bitumastic No. 50" coal tar paint.
2C.11 TOUCH-UP GALVANIZING

Galvanized surfaces scratched or otherwise damaged during delivery, unloading, or erection shall be thoroughly cleaned. Galvanizing touch-up shall be gray in color. Cleaned areas shall be painted with galvanizing repair paint System A19 as specified in the Coating System Data Sheet at the end of this section.

<table>
<thead>
<tr>
<th>DESCRIPTION: Structural Steel and Miscellaneous Metals Environmental Zones 1A (interior, normally dry), 1B (exterior, normally dry)</th>
<th>SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SURFACE PREPARATION</td>
<td>A6P</td>
</tr>
<tr>
<td>SSPC-SP6 Commercial Blast Cleaning</td>
<td>Profile depth 1.5 mils maximum</td>
</tr>
<tr>
<td>COATING</td>
<td>DRY FILM THICKNESS</td>
</tr>
<tr>
<td>FIRST COAT</td>
<td>2-3 mils</td>
</tr>
<tr>
<td>TOUCHUP</td>
<td>2-3 mils</td>
</tr>
<tr>
<td>SECOND COAT</td>
<td></td>
</tr>
<tr>
<td>THIRD COAT</td>
<td></td>
</tr>
<tr>
<td>TOTAL SYSTEM</td>
<td>2-3 mils</td>
</tr>
<tr>
<td>COATING MANUFACTURER</td>
<td>PRODUCT IDENTIFICATION</td>
</tr>
<tr>
<td>Ameron</td>
<td>FIRST COAT</td>
</tr>
<tr>
<td>Carboline</td>
<td>5105</td>
</tr>
<tr>
<td>Glidden</td>
<td>GP-18</td>
</tr>
<tr>
<td>Porter</td>
<td>5202</td>
</tr>
<tr>
<td>Tnemec</td>
<td>297FD</td>
</tr>
<tr>
<td>Valspar</td>
<td>10-99</td>
</tr>
<tr>
<td></td>
<td>13-R-28</td>
</tr>
</tbody>
</table>

COATING SYSTEM DATA SHEET

Date: 03/20/91
### DESCRIPTION:
Structural Steel and Miscellaneous Metals
Touchup for galvanized surfaces not to be painted

### SYSTEM
A19

<table>
<thead>
<tr>
<th>SURFACE PREPARATION</th>
<th>DRY FILM THICKNESS</th>
<th>SPECIAL NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSPC-SP1 Solvent Cleaning and SSPC-SP3 Power Tool Cleaning</td>
<td>2-3 mils</td>
<td>Organic zinc rich (light gray color)</td>
</tr>
<tr>
<td>SSPC-SP1 Solvent Cleaning</td>
<td>2-3 mils</td>
<td></td>
</tr>
<tr>
<td>SSPC-SP3 Power Tool Cleaning</td>
<td>2-3 mils</td>
<td></td>
</tr>
<tr>
<td>Remove Oil and Loose Rust</td>
<td>2-3 mils</td>
<td></td>
</tr>
</tbody>
</table>

### PRODUCT IDENTIFICATION

<table>
<thead>
<tr>
<th>COATING MANUFACTURER</th>
<th>FIRST COAT</th>
<th>TOUCH UP</th>
<th>SECOND COAT</th>
<th>THIRD COAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboline</td>
<td>676</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subox</td>
<td></td>
<td></td>
<td>Galvanox</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Type 1</td>
<td></td>
</tr>
<tr>
<td>Tnemec</td>
<td></td>
<td></td>
<td>90-93</td>
<td></td>
</tr>
<tr>
<td>Valspar</td>
<td></td>
<td></td>
<td>13-F-22</td>
<td></td>
</tr>
<tr>
<td>ZRC</td>
<td></td>
<td></td>
<td>ZRC Cold</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Galvanizing Compound</td>
<td></td>
</tr>
</tbody>
</table>

### COATING SYSTEM DATA SHEET
Date: 03/20/91
DIVISION 3 – ELECTRICAL CONSTRUCTION

Section 3A (260000) - CONTRACTOR FURNISHED EQUIPMENT AND MATERIALS

3A.1 GENERAL

The Contractor shall furnish all equipment and materials, except those specified herein to be furnished by the Owner or other contractors, as required for the complete erection of the equipment.

3A.2 MATERIAL LISTS

The Contractor shall furnish all the items labeled or noted as “By Field” on the drawings and material Lists contained in the Substation Field Issue. All Contractor-supplied material shall be furnished in accordance with this Specification. No substitutions are allowed without the written authorization of the Owner. Contractor shall be responsible for determining the quantities of material required.

3A.3 ENGINEERING DATA

The Contractor shall submit a minimum of two sets of drawings to the Owner for acceptance on all major items of material they are required to furnish by this Specification. The Contractor shall submit drawings which adequately indicate the general arrangement of major items of material, principles of operation, sizes, general appearance, and materials of construction.

3A.4 CORRECTION OF MANUFACTURING ERRORS

The materials shall be complete in all respects within the limits herein outlined as determined by the Owner. All manufacturing errors or omissions required to be corrected in the field shall be done by the Contractor at his expense, or if done by the Owner, the cost of the same shall be deducted from the contract price. Any changes shall be reflected on the As-built drawings.

3A.5 MISCELLANEOUS

The Contractor shall furnish all miscellaneous materials described in section 3C.2. The contractor is also responsible to furnish all wiring materials including STAKONS, wire markers/sleeves, wire ties, and cable identification tags.

3A.6 OPERATING POSITIONS AND CONTROL ROOM PANELBOARD LABELS

The Contractor shall furnish and install Operating Position Labels for all substation yard equipment installed by the Contractor including Owner-furnished equipment. Contractor shall also furnish and install Control Room device labels, if not previously identified and mounted by equipment manufacturer.

3A.6.1 Switchyard Operating Positions. Switchyard Operating Position labels shall be assembled from replaceable letter/number blocks or Owner-approved equal consisting of black characters on a white or yellow background. The letter blocks shall be approximately 1 ¾” wide by 2 7/8” inches high. The letter blocks shall be fade resistant and shall be assembled on aluminum panels of 3” high by 12” wide.
3A.6.2 In addition, the Contractor shall provide and install all Transmission lines, feeder termination structures, and riser poles with the appropriate line and feeder numbers and phase designations. Phase designations (PH1, PH2, PH3 or A, B, C as agreed upon by the Owner) shall also be installed on the load side of all disconnect switch structures, power cable terminating structures, main bus structures, power transformers and at all VT structures.

3A.6.3 All switchyard Operating Position labels shall be attached to the equipment or structures with stainless steel hardware.

3A.6.4 Control Room Devices. The Contractor shall provide and install all adhesive backed labels for all control room panelboards, cabinets, junction boxes, etc. unless previously identified and labeled by the device manufacturer. Adhesive labels shall be 1/2” high by 3” long, fabricated of laminated Bakelite having black surfaces and a white core, engraved in bold letters, in Arial Font, captions shall be device designation, unless stated otherwise by Owner.

3A.6.5 Additionally, adhesive backed labels using the buyer letter and/or number designations per the drawings are required for the rear of all devices, as well as terminal blocks, AC circuit breakers, fuses, etc., mounted on the control wiring compartment.

3A.6.6 Each front of control or relay panelboard shall be identified with and adhesive backed label mounted on the top center or each panelboard unit. The adhesive label shall be 1½” high by 5” long, fabricated of laminated Bakelite having black surfaces and a white core, engraved in bold letters, in Arial Font, caption shall be the panelboard designation, unless stated otherwise by Owner.

Section 3B (260000) - OWNER-FURNISHED EQUIPMENT AND MATERIALS

3B.1 GENERAL

Owner-furnished equipment and materials are identified in the Substation Field Issue. Delivery dates for major pieces of Owner-furnished electrical equipment and materials are included in the Substation Field Issue. All other material and equipment not supplied by the Owner shall be supplied by the Contractor and approved by the Owner.
Section 3C (260529) - ELECTRICAL EQUIPMENT ERECTION

3C.1 GENERAL

The Contractor shall install electrical equipment as specified herein. Erection work for all electrical equipment installed or furnished and installed under this Specification shall include receiving, unloading, care, storage, removal from storage, hauling, cleaning, erection on foundations, and all other work necessary to place all equipment into successful operation. In addition, erection work shall include complete assembly of equipment shipped unassembled; dismantling and reassembly of equipment to make adjustments; and provision of personnel, equipment, and assistance to the Owner in testing and placing the equipment into operation. Erection procedures shall be in accordance with this specification and manufacturer’s recommendations and drawings. In the event of a conflict, stringent requirements shall prevail.

3C.2 MISCELLANEOUS MATERIAL

The Contractor shall furnish all tools and miscellaneous materials as required for the complete erection of the equipment. These materials shall include, but shall not be limited to, grout, shims, wedges, dowels, anchors, supports, bolting, gaskets, packing, welding rod, and consumable gases.

3C.3 EQUIPMENT PROTECTION

The Contractor shall protect all equipment from damage of any kind from the time it is unloaded until it is ready for initial operation.

3C.3.1 During the erection period, all electrical equipment having drive motors or rotating parts shall be protected with weatherproof flame resistant sheeting which completely covers the exposed parts of the equipment.

3C.3.2 Equipment shall be suitably protected from weld spatter during construction.

3C.3.3 Equipment housed or covered with glass or equipped with easily broken components shall be protected as required to prevent damage throughout the construction period.

3C.4 CLEANING

The Contractor shall clean the exterior and interior surfaces of each equipment item of sand, dirt, and other foreign materials after its removal from storage and immediately before its movement to its final location.

3C.4.1 Before initial operation of individual items of equipment, the Contractor shall remove all dirt, mortar, and other material which has been spilled, misplaced, or otherwise has been allowed to mar the finish surfaces.

3C.4.2 The interior of all electrical equipment, including relays and electrical contacts, shall be thoroughly wiped and vacuumed clean before the equipment is energized.

3C.4.3 All debris shall be removed from the site and disposed of as directed by the Owner.
3C.5  MAINTENANCE TOOLS

The Contractor may use special tools furnished with equipment only when authorized by the Owner. The Contractor shall store all special tools furnished with equipment for maintenance as directed by the Owner.

3C.6  MANUFACTURERS' INSPECTION AND SUPERVISION

The services of a trained manufacturer's representative to inspect and advise during the installation of Owner-furnished equipment will be supplied as required by the Owner. The Contractor shall furnish all necessary labor to perform tests or inspections as required by the manufacturer's representative.

3C.6.1  When field labor is needed to correct errors in Owner-furnished equipment, the Contractor shall furnish such labor when so requested by the manufacturer or the manufacturer's representative. The cost of such remediation labor will not be included in the payment for the work to be performed under this Specification. The Contractor shall obtain payment for this labor from the manufacturer who requests the labor.

3C.7  LOCATION TOLERANCES

Equipment shall in general, be located within 1/8 inch of the dimensional location indicated on the Drawings unless otherwise indicated or permitted by the Owner.

3C.8  ALIGNMENT

The Contractor shall align and connect rigid components such as bus and enclosures with special care to prevent excessive stress in joints, supports, and connections. Equipment with moving parts such as switches, circuit breakers, and switch operating mechanisms shall be carefully aligned to assure free mechanical operation.

3C.9  BOLTED ELECTRICAL CONNECTIONS

It shall be the Contractor's responsibility to certify that the tightness of each bolt in all bolted electrical connections, factory or field, is in accordance with the manufacturer's recommendations. The Contractor shall check the tightness of each bolt in each factory made bolted electrical connection during erection and connection of the equipment.

3C.9.1  Where bolted connections are made to aluminum, the aluminum surface shall be thoroughly cleaned with a wire brush, then coated with joint compound and thoroughly brushed again through the compound. Additional compound shall then be added and the joint bolted together. Joint compound shall be Alcoa No.2.

3C.9.2  Where bolted connections are made between copper or brass surfaces, the metal surfaces shall be thoroughly cleaned and coated with Penetrox A as manufactured by Burndy Corp., Norwalk, Connecticut or No-Ox-Id A compound as manufactured by Sanchem Inc., Chicago, Illinois.
3C.9.3 Bolted electrical connections made with Belleville spring washers shall be tightened until the Belleville washer is completely flat. Tightening of connections with Belleville washers shall stop when the Belleville washers go flat. These connections shall not be over-tightened.

3C.9.4 Bolted electrical connections shall be tightened with manual torque wrenches. Torque wrenches shall be constructed so that they will visually or audibly indicate when the proper torque is reached. The accuracy of each torque wrench shall be checked by a testing laboratory acceptable to the Owner immediately prior to its use on equipment erected under this Specification.

3C.9.5 Torque Values. If the equipment manufacturer's erection instructions do not include recommended torque values for bolt tightening or specify an alternate method for tightening bolted electrical connections, torque values shall be in accordance with those listed in table 3C-1.

### Table 3C-1

<table>
<thead>
<tr>
<th>Bolt Size</th>
<th>18-8 Stainless Steel</th>
<th>Brass</th>
<th>Silicon Bronze</th>
<th>Aluminum 24ST-4</th>
<th>316 Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.-lb</td>
<td>in.-lb</td>
<td>in.-lb</td>
<td>in.-lb</td>
<td>in.-lb</td>
</tr>
<tr>
<td>1/4&quot; - 28</td>
<td>94</td>
<td>77</td>
<td>87</td>
<td>57</td>
<td>99</td>
</tr>
<tr>
<td>5/16&quot; - 24</td>
<td>132</td>
<td>107</td>
<td>123</td>
<td>80</td>
<td>138</td>
</tr>
<tr>
<td>3/8&quot; - 16</td>
<td>236</td>
<td>192</td>
<td>219</td>
<td>143</td>
<td>247</td>
</tr>
<tr>
<td>3/8&quot; - 24</td>
<td>259</td>
<td>212</td>
<td>240</td>
<td>157</td>
<td>271</td>
</tr>
<tr>
<td>7/16&quot; - 14</td>
<td>376</td>
<td>317</td>
<td>349</td>
<td>228</td>
<td>393</td>
</tr>
<tr>
<td>7/16&quot; - 20</td>
<td>400</td>
<td>327</td>
<td>371</td>
<td>242</td>
<td>418</td>
</tr>
<tr>
<td>1/2&quot; - 13</td>
<td>517</td>
<td>422</td>
<td>480</td>
<td>313</td>
<td>542</td>
</tr>
<tr>
<td>1/2&quot; - 20</td>
<td>541</td>
<td>443</td>
<td>502</td>
<td>328</td>
<td>565</td>
</tr>
<tr>
<td>9/16&quot; - 12</td>
<td>682</td>
<td>558</td>
<td>632</td>
<td>413</td>
<td>713</td>
</tr>
<tr>
<td>9/16&quot; - 18</td>
<td>752</td>
<td>615</td>
<td>697</td>
<td>456</td>
<td>787</td>
</tr>
<tr>
<td>5/8&quot; - 11</td>
<td>1110</td>
<td>907</td>
<td>1030</td>
<td>715</td>
<td>1160</td>
</tr>
<tr>
<td>5/8&quot; - 18</td>
<td>1244</td>
<td>1016</td>
<td>1154</td>
<td>798</td>
<td>1301</td>
</tr>
<tr>
<td>3/4&quot; - 10</td>
<td>1530</td>
<td>1249</td>
<td>1416</td>
<td>980</td>
<td>1582</td>
</tr>
<tr>
<td>3/4&quot; - 16</td>
<td>1490</td>
<td>1220</td>
<td>1382</td>
<td>958</td>
<td>1558</td>
</tr>
<tr>
<td>7/8&quot; - 9</td>
<td>2328</td>
<td>1905</td>
<td>2140</td>
<td>1495</td>
<td>2430</td>
</tr>
<tr>
<td>7/8&quot; - 14</td>
<td>2318</td>
<td>1895</td>
<td>2130</td>
<td>1490</td>
<td>2420</td>
</tr>
<tr>
<td>1&quot; - 8</td>
<td>3440</td>
<td>2815</td>
<td>3185</td>
<td>2205</td>
<td>3595</td>
</tr>
<tr>
<td>1&quot; - 14</td>
<td>3110</td>
<td>2545</td>
<td>2885</td>
<td>1995</td>
<td>3250</td>
</tr>
</tbody>
</table>
3C.9.6 Connection Bolt Tightness Check. The Contractor shall check the tightened bolts in electrical connections at random as selected by and in the presence of the Owner. The Contractor shall provide calibrated hand torque wrenches and the necessary platforms, equipment, and personnel for the random check.

a. The number of bolts checked shall be acceptable to the Owner based upon his observance of the quality and completeness of the tightening operations. A minimum of 10 per cent of the bolts in each connection, but not less than two bolts in each connection, shall be checked.

b. The Contractor shall be responsible for coordinating the checking of bolt tightness so that minimum interference with equipment erection and connection will be experienced. Removal of covers and similar dismantling of equipment to permit the Owner to witness the testing of bolt tightness of enclosed connections shall be part of the work included under this Specification.

c. Checking of tightness of electrical connections in the presence of the Owner is intended to assist the Contractor in avoiding the expense of repairing costly connection failures. This check shall not relieve the Contractor of complete responsibility for the integrity of the electrical connections.

d. After torquing connections (Refer to Table 3C-1), each bolted connection shall be marked with a black, indelible (waterproof, permanent) marker from the nut body to the material being bolted, to indicate that proper torque has been achieved.

3C.10 WELDER QUALIFICATION

All workmen performing ferrous and aluminum welding of any kind shall be qualified according to the American Welding Society Publication AWS D1.1 and AWS D1.2, latest revisions, Structural Welding Code. The qualification testing shall be conducted by an independent testing laboratory acceptable to the Owner. The conditions of test welding shall be similar to those for the work.

3C.11 LUBRICATION

The Contractor shall furnish all oils, greases, and other lubricants required to place equipment in operation. The Contractor shall apply lubricants in accordance with the manufacturer's recommendations. The lubricants used shall be acceptable to the Owner.
3C.12 EQUIPMENT FINISH

Surfaces of most electrical equipment, such as panels, transformers, and circuit breakers, are finished at the factory. The Contractor shall exercise great care to prevent damage to this original finish during installation of the equipment and during construction work.

3C.12.1 If the factory finish is damaged during the course of construction, the entire surface of the damaged component shall be refinished by and at the expense of the Contractor. The refinished surface shall be equivalent in every respect to the original surface, including color, texture, and smoothness. Refinishing paint, if furnished with the equipment, may be used; otherwise, the paint shall be obtained from the equipment manufacturer.

3C.13 GALVANIZED SURFACE COATINGS

All galvanized surfaces on which the galvanizing is removed by cutting, drilling, or by any other operation shall be re-galvanized with "Galvanizing Powder M-32l" as manufactured by the American Solder and Flux Company of Philadelphia, Pennsylvania; with "Zincilate 810" as manufactured by Industrial Metal Protectives, Inc., of Dayton, Ohio; with "Zinc Rich" coating as manufactured by ZRC Chemical Products Company, Quincy, Massachusetts; or acceptable equal. The Contractor shall furnish this protective material and shall apply it in the field to any surface where the galvanized coating is broken or removed.

3C.14 RESERVED

3C.15 RESERVED

3C.16 ERECTION OF SUBSTATION STRUCTURES

The Contractor shall erect substation structures in accordance with AISC and Aluminum Association standards, the Drawings, and this Specification.

Except as specifically indicated otherwise on the Drawings, or specified herein, all work performed in connection with substation structures under this Specification shall be in accordance with the AISC "Manual of Steel Construction", latest revision, and the applicable provisions of the Aluminum Association "Standard for Aluminum Structures".

3C.16.1 Tolerances. All galvanized steel structures, including each vertical component thereof, shall be erected plumb within a tolerance of 1:1000. Horizontal components shall be level.

a. Structural aluminum shall be erected so that individual pieces are plumb, level, and aligned within a tolerance of 1:500. The elevation of horizontal members shall be within 1/16 inch of the elevation indicated on the Drawings.
b. The limit of tolerance in vertical component plumbness shall be based on the height from the baseplate to the point being plumbed and shall be measured from the true center line of the vertical component.

3C.16.2 Assembly. Components for steel or aluminum structures shall be assembled accurately as indicated on the Drawings and match marks shall be followed carefully. Light drifting will be permitted to draw the parts together, but drifting to match unfair holes will not be permitted.

a. Slight enlargement of holes necessary to make connections shall be done by reaming with twist drills; enlarging of holes by burning is prohibited. Connections requiring extensive enlargements or enlargements which would adversely affect the strength of the member or connection shall be brought immediately to the Owner’s attention and the necessary adjustments shall be made in accordance with the Owner’s instructions.

b. Before making permanent field connections, all joints shall be assembled and drawn up snugly and the structure shall be checked for alignment, plumb, and level in accordance with the specified tolerances.

c. During the assembly, fit-up, and adjustment, the structure shall be braced, guyed, and otherwise secured as required to prevent collapse or damage resulting from wind, construction operations, or other stresses.

d. Materials which become bent, warped, or otherwise damaged so that they are unsuitable for installation, in the opinion of the Owner, shall be replaced with suitable materials without expense to the Owner.

e. Where the galvanized coating of any structure component has been damaged and parent metal is exposed as a result of shipping, handling, drilling, reaming, welding, or any other cause, the damaged or exposed area shall be cleaned to white metal and repaired with a zinc rich coating, depositing not less than 2 ounces of zinc per square foot. The zinc rich coating shall be as specified in the section titled GALVANIZED SURFACE COATINGS.

3C.16.3 Bolting. The work shall be done by competent and experienced bolting crews. All methods, tools, and equipment shall be subject to the acceptance of the Owner. Bolts will be furnished by the Owner, except as otherwise indicated on the Drawings or as otherwise specified in this Specification.

a. Connection bolts for galvanized steel structures will be high strength galvanized per ASTM A325 with washers and locking devices.

b. Connection bolts and flat washers for aluminum structures will be aluminum alloy 2024-T4 and bolts will have #205 Alumilite finish. Nuts and beveled washers for aluminum structures will be aluminum alloy 6061-T6.
c. All connections shall be bearing type connections with threads excluded from the shear planes of the connected materials. Bolt length shall be selected in accordance with the Research Council specification and commentary specified hereinafter. Bolt length shall provide for washers, nuts, and locking devices. Where clearance permits, nuts shall be placed so they will be on the least visible side of each connection.

d. High strength bolts and their installation and bolting tools and equipment shall conform to all requirements for A325 bolts of the "Specifications for Structural Joints Using ASTM A325 or A490 Bolts" including the commentary given therewith, as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation and endorsed by AISC, except as otherwise modified or supplemented herein. The Research Council specification is dated November 13, 1985.

e. Tightening of all bolts shall be done by the "turn-of-nut" method only. A washer shall be used under the element turned in tightening. Smooth beveled washers shall be used when the bearing faces of the bolted parts have a slope of 1:20 or greater with respect to a plane normal to the bolt axis.

f. Bolted connections shall be drifted to proper position and the holes inspected to ensure that bolt threads will not be damaged by forcing the bolts in place. Connections shall be tightly drawn together using two bolts or 25 per cent of the total number of bolts in the completed joint, whichever is greater. Bolts for initial tightening shall be distributed uniformly about the joint. Either fitting-up bolts or high strength bolts may be used for this purpose.

g. Any ASTM A325 bolt which has been tightened more than one-third turn beyond "snug tight" shall not be loosened and re-tightened. All such bolts shall be discarded and new bolts shall be used in their place.

h. The Contractor shall make a thorough inspection to ensure that all bolts are tightened and that a locknut has been installed and tightened on each bolt. The bolts shall be marked in place.

i. The tightened bolts shall be checked at random as directed by and in the presence of the Owner. A calibrated hand torque wrenches and the necessary platforms, equipment, and personnel shall be provided for the random check. The wrench shall be calibrated to indicate a torque equivalent to bolt tension of 18,000 pounds or 5/8 inch bolts. The number of bolts checked shall be acceptable to the Owner based upon his observance of the quality and completeness of the tightening operations. A minimum of 10 percent of the bolts in each connection, but not less than two bolts in each connection, shall be checked.

3C.16.4 Erection of Shielding Masts. Except as modified or supplemented by this article, substation shielding masts shall be erected in accordance with the requirements for substation structures in this Specification.
a. Two sets of nuts will be furnished for the mast anchor bolts. One set shall be installed on the anchor bolts and leveled before the masts are set on the bolts.

b. Each mast shall be checked with a transit for alignment and plumb. Each mast shall be plumb within 1/4 inch in 10 feet of height.

c. Masts shall be grounded as soon as practicable after they are erected.

3C.17 STRUCTURAL AND MISCELLANEOUS ALUMINUM

Unless otherwise noted, all materials and work shall conform to applicable provisions of the Aluminum Association "Standard for Aluminum Structures." All members shall be Aluminum Association standard structural shapes. Fabrication work shall be in accordance with current industry practice.

3C.17.1 Connections. Connections not specifically detailed on the Drawings shall develop the full strength of the least strength member of the connection. Unless otherwise noted, connections shall be all-bolted, bearing type, utilizing 3/4 inch bolts equipped with a helical spring lock washer under the stationary element (bolt head or nut) and a flat washer under the turned element. A sufficient number of bolts shall be provided in each connection to develop the shear strength of the members. Unless otherwise noted, welded connections will not be acceptable.

3C.17.2 Field Erection. Structural aluminum shall be erected so that individual pieces are plumb, level, and aligned within a tolerance of 1:500. The elevation of horizontal members shall be within 1/16 inch of the elevation indicated on the Drawings.

3C.18 SUBSTATION ALUMINUM BUS

The Contractor shall unpack, clean, and check all aluminum bus immediately upon receipt from the carrier or Owner. The Contractor shall remove all materials which might damage the bus finish and shall store the bus in such a manner that the finish will be protected. All costs associated with the cleaning of minor black marks, abrasions, and scratches shall be included in the lump sum price.

Bus delivered by the carrier or Owner with unsatisfactory finish shall be rejected. The Contractor shall be responsible for maintaining the finish on bus accepted from the carrier. Defective bus finish discovered after initial unpacking and inspection shall be the responsibility of the Contractor. Any stored or erected bus found to have unsatisfactory finish shall be refinished or replaced by the Contractor at the option of the Owner. All expense for such refinishing or replacement shall be borne by the Contractor.

All bus shall be carefully handled and erected to provide a complete bus system without dents, abrasions, discolorations, or other structural or surface damage. Any bus so damaged shall be replaced by the Contractor at his expense.

Prior to the installation of fittings for the bus, conductor for vibration dampening, as required by the Drawings, shall be installed within all horizontal buses for the full length of each bus. The conductor for this application will be furnished by the Owner.
3C.18.1 Field Bends. All field bends of bus shall be made with a hydraulic type bender which is acceptable to the Owner. Each bend shall be smooth and uniform and shall retain the original inside bus diameter. Bend radii shall be as indicated on the Drawings. Each bend in 2 inch bus shall have a center line radius of at least 9-1/2 inches. Each bend in bus larger than 2 inches shall have a center line radius of at least five times the inside diameter of the bus.

3C.18.2 Alignment. All bus components shall be aligned and supported prior to and during the welding operation. Support and alignment shall be as required to provide a finished bus arrangement with center lines of adjacent sections coincident. Bus shall be aligned for welding in such a manner that the welded bus remains essentially straight after removal of erection supports. During splicing operations, each piece of bus shall be supported at not less than three points in approximately equal spans of 12 feet or less.

3C.18.3 Fittings. The joint components to be welded shall be fitted to allow for expansion and contraction during welding without loss of alignment. The joint design shall be in accordance with manufacturers’ recommendations. Connections shall be positioned and located to prevent the retention of water or drainage from copper or copper alloys to aluminum surfaces. Drain holes shall be provided as required. The location and size of drain holes shall be acceptable to the Owner.

3C.18.4 Connections. Connections shall be made using Deutsch or DMC compression connectors for bus assemblies, where indicated on the drawings and material list. The Contractor is responsible for providing proper training for his field personnel in making these compression connections, as well as providing all the associated tooling, dies, and equipment necessary to perform the work.

3C.18.5 Cleaning. Immediately prior to welding, each surface to be joined by the weld shall be thoroughly cleaned. Greases, oils, waxes, etc., shall be removed by standard degreasing solutions as recommended by the manufacturer. Oxides shall be removed from the areas to be welded by vigorous scrubbing of the surfaces with stainless steel wire brushes.
3C.18.6 Welding. Welding processes and methods shall be subject to code qualification and acceptance by the Owner. Only the following welding methods will be permitted for joining bus sections and fittings:
   Gas metal arc welding.
   Gas tungsten arc welding.

Shielding gas for each process shall be welding grade argon when welding material is less than ¾ inch thick. A combination of helium and argon shall be used for each process when the welding material is ¾ inch thick and greater. Welding energy and filler metal requirements shall be as recommended by AWS D10.7-86, "Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe."

The following from AWS D10.7 shall apply:
   Filler rod Table 1
   Rod size, gas flow, and welding current Table 2 through Table 11

3C.18.7 Welding Qualifications. The Contractor shall prepare written welding procedure specifications. The procedure shall be qualified as defined below. Welding procedure specifications, procedure qualification reports, and welder qualification reports shall be submitted to the Owner for review. Welding shall not begin until the Owner's review is complete.

   a. All procedure qualification testing and welder qualification testing shall be in accordance with the methods defined in AWS D10.9-80, "Specification for Qualification of Welding Procedures and Welders for Piping and Tubing."

   b. Testing shall be conducted to the requirements of AR-1 qualification level under the following conditions:
      Materials P-Number 23, aluminum base alloys.
      Weld Groove.
      Position 6G.

   c. All qualification testing shall be performed by an acceptable independent testing laboratory. Report formats shall be similar to the examples in AWS D10.9-80 for the following:
      Typical Welding Procedure Specification (WPS).
      Typical Contractor's Procedure Qualification Test Record (PQR).
      Typical Contractor's Welder Qualification Tests Record.

   d. All costs for testing, including material costs, shall be paid by the Contractor.

   e. Welders, after qualification, shall not be replaced on this welding duty unless such action is acceptable to the Owner.
3C.18.8 Painting. If indicated on the drawings or specified in the work summary, aluminum angle, tubular and integral web busses insulated for less than 69 kV, shall be painted to ensure that they will be distinguishable from structural members. The sole purpose of the paint is to provide color identification of the bus and maintain a consistent appearance for all energized current-carrying bus conductors in a structure. It is neither necessary nor desirable to cover all connections, joints, etc., so long as coverage is sufficient for the purpose.

a. While tubular and integral-web busses are readily distinguished from structural angles, their close proximity to the structure at lower voltages makes color identification necessary. The Contractor shall furnish Rust-Oleum R #K7764 – “Safety Red” and Rust-Oleum # V7769 “Rusty Metal Primer”. The Contractor shall apply the paint in accordance with the manufacturer’s surface preparation and application instructions as printed on the container.

Section 3D (260526) - GROUNDING

3D.1 GENERAL

The Contractor shall install grounding materials as indicated on the Drawings and in the Substation Field Issue and as required for a complete grounding system. The Contractor is also responsible for providing all tools, dies, and other equipment required for his crews to perform all grounding work.

3D.2 INSTALLATION

The Contractor shall install grounding system materials according to the Drawings and as specified herein. The ground grid materials shall consist of copper or copperweld as directed by the drawings or specified in the work summary within.

3D.2.1 Ground Grid. Ground grid conductors under buildings or structures shall be buried with at least 6 inches of earth cover. Buried grounding conductors extending beyond the foundations of buildings or structures shall have at least 18 inches of earth cover.

3D.2.2 Ground Rods. All ground rods shall be located as indicated on the Drawings and installed to the depth indicated. Except as otherwise indicated on the Drawings, all buried ground rods shall be installed with not less than 18 inches of earth cover.

a. The Contractor shall measure the ground resistance of a typical ground rod after each section of rods has been installed into the ground prior to connection of the ground rods to the grounding system. The resistance values measured shall be recorded on the Grounding Report. These data shall be obtained, identified, and recorded under the supervision of the Owner and records of the results sent to the Owner within 5 days.

b. Where rock is located at a depth less than the required ground rod depth below the ground surface, the Contractor shall contact the Owner, who will advise the Contractor on how to proceed.
3D.2.3 Conductors. Exposed conductors shall be installed inconspicuously in vertical or horizontal positions on supporting structures. When located on irregular supporting surfaces or equipment, the conductors shall run parallel to or normal to dominant surfaces. Conductors routed over concrete, structures, or equipment surfaces shall be kept in close contact with those surfaces by using fasteners located at intervals not to exceed 3 feet. Damaged ground system conductors shall be repaired or replaced by the Contractor as directed by the Owner. Except as otherwise indicated on the Drawings, all buried ground conductors shall be installed with not less than 18 inches of earth cover.

3D.2.4 Connections. All connections shall be compression fittings except where otherwise indicated on the Drawings or in this Specification. The manufacturer’s instructions shall be followed in all details. If bolted and screwed connections are called for they shall be securely tightened. The proper dies and presses shall be used and manufacturer’s instructions shall be followed in all details. Bolted connections shall not be used underground, except in some cases for the ground rod clamp. Where bolted connectors are used, all bolted and screwed connections shall be securely tightened, per the manufacturer’s recommendations, unless specified otherwise within.

3D.2.5 Conduit Grounding. Where a conduit run is terminated at tray and the conduit carries a separate grounding conductor, this grounding conductor shall be terminated on the tray grounding cable.

3D.2.6 Tray Grounding. A bare grounding conductor will be provided with each cable tray system and will be installed the entire length of the cable trays, on the outer side of the tray. The Contractor shall connect the cable tray grounding conductor to the station ground grid as indicated on the Drawings.
3D.2.7 Equipment Grounding. Unless otherwise indicated, all electrical equipment and the control house and/or enclosure shall be connected to the ground grid with the specified grounding conductor. The term "electrical equipment," as used in this article, shall include all enclosures containing electrical connections or bare conductors. Most equipment will be furnished with grounding pads and/or grounding lugs which the Contractor shall connect to the ground grid. All ground connection surfaces shall be cleaned immediately prior to connection. The Contractor shall furnish all grounding material required but not furnished with the equipment or furnished by the Owner.

a. Where ground grid extension stingers are indicated on the Drawings to be provided for connection to electrical equipment, the Contractor shall connect the bare grounding conductor to the equipment ground bus, pad, or lug. In addition to the ground grid extension stingers, a ground conductor shall be provided from the substation ground grid to each end of the ground bus in the control house tray ground.

b. Where a ground conductor is included with the phase conductors of power circuits, the ground conductor shall be connected to the equipment grounding facilities and to the source ground bus. Where a ground conductor is not included with the phase conductors, the equipment shall be grounded by connecting a separate ground cable to the equipment grounding facilities and to the tray ground cable or source ground bus.

c. Except where otherwise indicated on the Drawings, all equipment ground conductors which are not an integral part of a cable assembly shall be sized in accordance with the requirements of NEC. All ground conductors installed in conduit shall be insulated.

d. Suitable grounding facilities, acceptable to the Owner, shall be furnished on electrical equipment not so equipped. The grounding facilities shall consist of compression type terminal connectors bolted to the equipment frame or enclosure and providing a minimum of joint resistance.

e. The conduit system is not considered to be a grounding conductor except for itself and for lighting fixtures. No grounding conductor shall be smaller in size than 12 AWG unless it is a part of an acceptable cable assembly.
3D.2.8 Switch Operator Safety Grounding Mat. The Switch operator safety grounding mat shall be installed as shown on the drawings or as specified in the standards listed in the Substation Field Issue. If not specifically called out in the above, the following shall apply.

A ground spiral shall be installed at the interface of the earth and crushed rock surface for all switch operators as indicated on the Drawings. The spiral shall be 4/0 AWG copper or 248.8KCM copperweld, approximately 3 foot radius and shall be connected to the station ground system and to the switch operating mechanism as indicated on the Drawings. A grounding mat is used as follows: A potential equalizing grid (10’ x 6’ x 8” mesh of #6 AWG Copperweld wire with brazed joints) shall be installed 3” below finished grade, in the crushed stone course, in front of each switch operating mechanism location (Refer to design drawings for equalizing grid locations). Two (2) #2 AWG stranded copper conductors of adequate length shall rise from the equalizing grid to a point above the switch operating mechanism and be bonded to the ground grid riser. Each #2 AWG conductor shall run diagonally across the potential equalizing grid and be bonded to the grid in at least three (3) locations before rising above grade, as shown on the design drawings.

3D.2.9 Control/Switchgear Enclosure(s). The Contractor shall connect the control house and/or switchgear enclosure(s) to the ground system as shown on the Drawings.

3D.2.10 Perimeter Fence. The Contractor shall connect the exterior perimeter fence to the station ground system as shown on the drawings.

3D.3 GROUND SYSTEM RESISTANCE

The Contractor shall measure the continuity of the grounding system. The entire metallic grounding system shall have low resistance continuity. After connection of ground rods to the grounding system, the Contractor shall obtain a ground resistance measurement from a selected location on the ground grid, after the grid is covered with the grounding course material. These data shall be obtained, identified, and recorded under the supervision of the Owner and records of the results sent to the Owner within 1 day.

3D.3.1 In the event that the measured value of ground resistance exceeds the calculated value specified on the drawings, the Contractor shall furnish, install, and connect additional grounding facilities as directed by the Owner. The Contractor will be reimbursed for the additional work required.

3D.3.2 The ground resistance measuring and recording procedure shall be repeated after each grounding adjustment has been completed. The Contractor shall not install more than three additional sections of ground rods at any location without prior approval from the Owner.

3D.3.3 The Contractor must receive approval from the Owner, of the grounding system resistance measurement before continuing with construction.
3D.4 GROUND RESISTANCE MEASUREMENTS

All ground resistance measurements shall be made with a three terminal "megger" type ground tester which applies alternating current to the electrodes and which gives a reading in direct current ohms. Two reference ground probes shall be used and all tests shall be made in accordance with the instrument manufacturer's instructions for ground resistance testing. Some of the acceptable instruments are as follows:

- Meg and megger ground testers, Megger Corp.
- Vibroground, Associated Research, Inc. (Limited availability NY)
- Ground-Ohmer, Herman H. Sticht Co., Inc. (Limited availability NY)
- AEMC Instruments Models 4500 & 4600

3D.5 GROUNDING REPORTS

The Contractor shall maintain a record of the condition of the grounding facilities at each location throughout the construction period. A standard form entitled Grounding Report shall be prepared by the Contractor. The form shall provide space to report dimensions, depths, resistance measurements and the date each measurement was taken, revisions to the grounding arrangement indicated on the Drawings, and other pertinent information. A copy of this form shall be completed for each location and shall be turned over to the Owner at the conclusion of the project as an "as built" record.

3D.6 INSTALLATION DETAILS

3D.6.1 The Contractor shall repair as necessary, any portion of the grounding system previously installed, if disturbed during the performance of this Contract.

3D.6.2 At the start and finish of the grounding installation work; The Contractor shall make ground grid measurements and supply this information to the Owner for further use. The Contractor is responsible for ensuring that this information is taken prior to starting the grounding work and for notifying the Owner after finishing the grounding work.

3D.6.3 The Contractor shall store the ground materials properly to prevent theft, damage, deterioration and inclusion of foreign matter. Packaged materials delivered in original unopened containers must be stored in weatherproof enclosures.

3D.6.4 All electrical cabinets, pull boxes, and junction boxes, etc. shall be grounded.

3D.6.5 The Contractor shall comply with the provisions of the following codes and standards, unless more stringent requirements are specified in this document or on the drawings.


b. The Owner’s compilation of grounding standards which are part of the Electric Station Standards for the Owner’s jurisdiction.
3D.6.6 When not called out specifically on the Bill of Materials, and/or the drawings the Contractor shall adhere to the following minimum grounding material requirements.

   a. Ground Grid Risers & Ground Cables. Wire #4/0 AWG bare 19 str. copper single uncoated conductor with concentric lay Class B round stranding in accordance with the current ASTM Std. B8. Temper shall be soft or annealed drawn in accordance with ASTM B3. Standard shipping quantity shall be 100 lb. (app. 153 feet) coil.

   b. Connector, (above grade) mechanical 2 bolt type for #4/0 stranded copper.

   c. Conduit clamp, steel, ground 1½” to 4” heavy duty, corrosion resistant with silicon bronze hardware, furnished with a mechanical grounding cable connector permitting the grounding cable to be attached parallel with or at right to angles to the steel conduit having a range of #4 solid to #4/0 stranded awg., in accordance with UL standards.

   d. Connector, copper, compression type, Cross and Tee connection for use with copper conductor. Range #4/0 – 250kcmil cable to same or to ground rod. Used for connectors (underground) for #4/0 to #4/0 ground grid cable and #4/0 to ground rod connections.

   e. Wire, copper, #2 stranded. Used for conduit bonding, equipotential grid bonding, etc.)

   f. Connector copper C-Type range taking compression tap connection for use with copper conductor Range 3/0 solid - 4/0 stranded run 6 solid -2 stranded tap.

   g. Connector #2 solid - 250 kcmil copper cable to flat cast copper alloy body. Bolt nut and lock washer made of silicone bronze.

   h. Connector, cable to flat, for two #2 sol. - 250 kcmil copper cables. Cast copper alloy body. Bolt, nut and lockwasher, silicone bronze.

Section 3E (260533) - RACEWAYS

3E.1 GENERAL

The Contractor shall install a complete raceway system in accordance with this Specification, the Conduit & Cable Schedule, and the Drawings.

3E.1.1 The raceway system is defined to include conduit, flexible conduit, continuous rigid cable supports called "cable tray" herein, underground duct, cable trench wire-way, cabinets and boxes, and all materials and devices required to install, support, secure and provide a complete system for support and protection of electrical conductors.
3E.2 CODES AND STANDARDS

Raceway system materials and devices furnished will be in accordance with applicable standards of ANSI, NEMA, and UL. Raceway system components shall be installed in accordance with applicable requirements of the NEC. In case of conflict between the requirements of any of the above referenced codes and standards and the requirements of this Specification, the requirements of this Specification shall govern. All materials and devices will be in accordance with the applicable requirements of the Federal "Occupational Safety and Health Standards."

3E.3 GENERAL INSTALLATION REQUIREMENTS

The installation requirements included herein apply to all raceway system components.

3E.3.1 Routing of Above-Grade Raceway. Electrical cable tray shall be routed as indicated on the Drawings. The Contractor shall field route conduit according to the general routing indicated on the Drawings and shall coordinate conduit locations with other equipment and structures.

3E.3.2 Insulation. All supports for raceway connected to equipment, raceways, etc., that have been electrically insulated from contact with other conducting structures shall be properly installed to prevent shunting of the insulation.

3E.3.3 Sleeves and Openings. The Contractor shall be responsible for making all required openings for cables and raceways. The Contractor shall be responsible for finishing all openings for cables and raceways. Openings shall not be closed until all the cables through the openings have been installed and tested. Installation of materials shall be in accordance with the manufacturer's recommendations. The materials shall be finished to provide a smooth, neat appearance.

a. Control/Switchgear Enclosures. Required openings not provided during the control/switchgear enclosure fabrication shall be provided by the Contractor using a hacksaw, a hole saw, or a core drill subject to acceptance by the Owner. Openings in metal floors and walls for single conduit shall be cut by the Contractor and the conduit sealed in place after being installed.

b. Finishing Conduit Openings Beneath Equipment. Where the cables are in conduits and the conduits project through the openings, openings beneath equipment shall be closed with Carboline Pyrofoam 700 or acceptable equal.
c. Finishing Cable Openings Beneath Equipment. Where the cables entering the equipment are not in enclosing raceways, the openings shall be closed with Dow Corning 3-6548 silicone RTV foam, Manville Type 103 Cera Form board, or acceptable equal flame retardant materials. The Cera Form boards shall be not less than 1 inch thick and shall be cut to fit closely around the outside surfaces of the cable where the cable passes through the boards. The boards shall be securely placed in the floor opening and all openings around the cables and the boards shall be sealed with Manville Cerablanket or acceptable equal and all exposed surfaces of the board and Cerablanket shall be covered with a 1/8 inch thick coating of Carboline Intumastic 285.

d. Unused openings beneath equipment shall be closed with Carboline Pyrofoam 700, Manville Cera Form board coated with a 1/8 inch thick coating of Carboline Intumastic 285, Dow Corning 3-6548 silicone RTV foam, or acceptable equal flame retardant materials.

3E.3.4 Extensions of Building Metal to Support Raceway. Extensions of building structures to support raceway shall be of the same material as the structure being extended and shall be finished to match the finish of the extended structure.

3E.3.5 Beam Clamps. Beam clamps for attachment of hanger rods to structural metal shall be electro-galvanized steel as manufactured by Unistrut, Globe Strut, or acceptable equal.

3E.3.6 Welding. All welding shall completely fuse the welded member to the supporting metal and shall be neat in appearance. All welds shall be made by welders whose quality of work is equivalent to that of welders certified by the American Welding Society.

a. Clamps shall be used for making attachments to structural metal for installation purposes wherever possible. Welded lugs will be permitted only when acceptable to the Owner. The Contractor will apply a protective primer paint equal to that which was initially applied in the shop.

b. All temporary supports which have been welded to the building metal shall be removed as promptly as possible. After removal, the roughened surface of the building metal shall be ground smooth and a protective primer paint applied equal to that which was initially applied in the shop.

3E.3.7 Use of Unfinished Raceway. Unfinished runs of raceway shall not be used. Supports and connections for each raceway run shall be completed prior to the pull-in of any pulling line or conductor.
3E.4 ELECTRICAL CONDUIT SYSTEM

The Contractor shall install an electrical conduit system in accordance with the Drawings and this Specification. The Contractor shall be responsible for the sizing and routing of all conduits including but not limited to indoor and outdoor lighting, power, fire, & heating conduits. Conduit layout and conduit riser details are shown on the detailed design drawings.

3E.4.1 Above Grade Conduit Installation. Conduit installation shall be as indicated on the Drawings and as described in this Specification.

a. Routing. Except as otherwise specified or indicated on the Drawings, all conduit shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical bends or fittings. Except where prevented by the location of other work, a single conduit or a conduit group shall be centered on structural members. All conduit field routing shall be acceptable to the Owner. Routing which is not acceptable shall be rerouted and replaced without expense to the Owner. All conduits shall be tagged at both ends. A tag numbering system shall be provided and installed by the Contractor that is consistent with the Owner’s drawings.

b. Moisture Pockets. Moisture pockets shall be eliminated from conduits.

c. Couplings and Unions. Metal conduit shall be joined by threaded conduit couplings with the conduit ends butted. The use of running threads will not be permitted. Where metal conduit cannot be joined by standard threaded couplings, conduit unions or split couplings may be used if their location is acceptable to the Owner. Only ground seat type watertight unions shall be used outdoors. Where Erickson type couplings or similar unions which do not have ground seats are used in vertical or inclined conduit runs, the coupling nut shall be installed uppermost to prevent the entrance of water into the union. Couplings, unions and fittings should be threaded-type, galvanized steel, B17.

d. Bends and Offsets. A run of conduit shall not contain more than the equivalent of four quarter bends, including those immediately at outlets or fittings. Bends in conduit shall be made without reducing the internal diameter of the conduit. The use of a pipe tee or vise for bending conduit will not be permitted. The inside radius of conduit bends shall be not less than six times the inside diameter of the conduit. Conduits deformed or crushed in any way shall be removed from the job site. All conduit Bend Radii shall be in accordance with the NEC.

e. Cutting and Threading. The plane of all conduit ends shall be square with the center line. Where threads are required, they shall be cut and cleaned prior to conduit reaming. The ends of all conduit shall be reamed to remove all rough edges and burrs. A cutting oil shall be used in threading operations. The dies shall be kept sharp and provisions shall be made for chip clearance.
f. Connections to Boxes and Cabinets. Conduit shall be securely fastened to all boxes and cabinets. Threads on metallic conduit shall project through the wall of the box to allow the bushing to butt against the end of the conduit. The locknuts both inside and outside shall then be tightened sufficiently to bond the conduit securely to the box. Conduit entering some devices, boxes and enclosures shall enter through hubs or threaded openings.

g. Cleaning. Precautions shall be taken to prevent the accumulation of water, dirt, or concrete in the conduit. Conduit in which water or other foreign materials have been permitted to accumulate shall be thoroughly cleaned or, where such accumulation cannot be removed by methods acceptable to the Owner, the conduit shall be replaced.

h. Flexible Conduit. Flexible conduit inserts shall be installed in accordance with the Drawings and the manufacturer’s recommendations.

i. Plastic Conduit. Polyvinyl chloride conduit shall be installed in accordance with the installation requirements specified for metallic conduit except that joints will be unthreaded solvent cement type as recommended by the conduit manufacturer. The contact surfaces of the conduit and fitting socket shall be cleaned with Stoddard solvent, methyl ethyl ketone, or acetone, liberally coated with solvent cement, promptly and fully engaged, and either conduit or fitting rotated approximately 1/4 turn to dispel air and evenly distribute solvent cement over contact surfaces. For proper connection, total elapsed time between the start of the cement application to the surfaces being joined and final assembly of the joint should not exceed 60 seconds. The initial strength of the joint will permit continuous conduit installation; however, additional stress at the joint shall be avoided for at least 24 hours after joining.

j. Spacing and Attachment of Supports. All conduit runs shall be rigidly supported. Each conduit shall be supported within one foot of junction boxes and fittings. Support spacing along conduit runs shall be a minimum of every 3 feet or as required to provide a sturdy support. Conduit clamps shall be bolted to metal structures using drilled and tapped screw holes.

k. Codes and Standards. Comply with the provisions of the following codes, specifications and standards, except where more stringent requirements are shown or specified.
   1. The Owner’s Above Ground Standards for Conduit

l. ID Numbers. Conduit ID Numbers per the conduit and cable schedule shall be securely affixed at both ends of the conduit with aluminum stamped ID tags; or engineering approved equivalents.
m. **Conduit Sizing.** Conduits shall be sized in accordance with the NEC code requirements and as shown on the drawings.

n. **Rigid Steel Conduit.** The conduit risers and below grade bends shall be in accordance with the Owner’s drawings. Other requirements are as follows:

1. **Material:** GRC or Mild steel with continuous welded seam.
2. **External protective coating:** Metallic zinc applied by hot-dip galvanizing or electrogalvanizing; coating shall not flake or crack when conduit is bent.
3. **Interior surface:** Protected by zinc, enamel, or engineering approved equivalent corrosion-resistant coating.
4. **Manufacturer:** Republic Steel "Galvite", Triangle PWC, Allied Tube and Conduit Corporation "GRC", or engineering approved equivalent.
5. **Applicable Standards:** ANSI C80.1, NEMA FB1, UL6, Federal Specification WW-C-58LD and ANSI C80.

3E.4.2 **Below Grade Conduit.** The Contractor shall field route conduit according to the general routing indicated on the Drawings and shall coordinate conduit locations with other work and existing equipment above and below grade. Conduit shall be accurately positioned and securely anchored before backfilling. Conduit which will be visible above the finished grade shall be straight and plumb. Conduit which is stubbed shall be plugged prior to backfilling and shall remain plugged until the conduit is extended later. Underground conduits shall be galvanized rigid steel GRC or PVC types.

a. **Bends** shall be made from straight conduit lengths or shall be factory fabricated. Bend Radii shall be in accordance with the NEC. The conduit length for field bending shall be heated to approximately 275 F by radiant heat, hot air, or hot liquid immersion. Open flame heating will not be permitted. Special mandrels or forms shall be used to provide a smooth bend without reduction of the conduit diameter. Conduit discolored by prolonged heating will not be acceptable.

b. **Where plastic conduit is required to be buried directly in the earth as indicated on the Drawings,** a minimum of 4 inches of washed, screened sand shall be placed under, beside, around, and on top of all conduit. Backfill above the washed, screened sand layer shall be screened sand, medium mesh, and shall be approximately 18 inches deep. Backfill shall not contain stones greater than one inch in any dimension, and shall not contain ashes, cinders, shell, or frozen material.

c. **Intermediate and base spacers** for 1-1/2" separation between ducts and 3 inches beneath ducts shall be installed for conduit runs containing more than two (2) conduits. Intermediate spacers shall be used as caps on the top tier. Spacers shall not exceed 5 foot intervals and shall be placed at each coupling. The trench bottom shall be solid, undisturbed earth. Pockets of unsuitable soil shall be replaced with compacted sand. A minimum of 4 inches of washed, screened sand shall be placed beside the duct layout. A minimum of 3 inches of washed, screened sand shall be placed on top of the duct layout measured from the top of the top-most conduit. An 18 inch layer of backfill shall be placed upon the washed, screened sand.
3E.4.3 Plastic Conduit Fittings for Underground Use

a. Uses and limitations: Below finished floor

b. Conduit shall be Carlon PVC, Type 40, 90°C UL rated or engineering approved equivalent. Conduit shall be composed of polyvinyl chloride and shall conform to NEMA standards. It shall be UL listed in conformity with Article 347 of the NEC.

c. Fittings: For use with Schedule 40 PVC by same manufacturer.

d. Material: Polyvinyl chloride (PVC) plastic compound.

e. Fittings shall withstand temperatures of power cables operating at 90°C installed within.

f. Threadless type: connect to conduit by solvent cement process.

g. Adapter fittings:
   1. For connection of plastic conduit to rigid steel conduit.
   2. Threadless connection to plastic, threaded connection to rigid steel, female-type.
   3. Expansion coupling.

h. Couple lengths of conduit together using solvent cement connections.

i. Manufacturer: Carlon Plus 40 Rigid Non-metallic Conduit, Part No. 49011-20, (Schedule 40), or buyer approved equal.


3E.4.4 Electrical Metallic Tubing (EMT):

a. Uses permitted: Building interior

b. EMT: FSWW-C-563 galvanized tubing

c. Fittings and Conduit Bodies: ANSI/NEMA FB1; steel or malleable iron, compression type.

3E.4.5 Liquid-tight Flexible Conduit:

a. Heavy galvanized steel core, Type OR-H.

b. Oil resistant thermoplastic cover, grey color.

c. Integral ground wire, sizes 1” inch to 2” inches or per NEC Code.
d. For high/low temperature applications use Type H.C.

e. Use steel, gasketed, insulated throat, compression type, Liquid-tight fittings.
   1. Bushings for metal conduit terminations shall be the nylon insulated type throat, with grounding type locknut ahead of bushing.
   2. Die cast zinc-alloy and pressure cast and indenter type fittings shall not be approved. Provide steel or malleable iron only.
   3. Expansion fittings shall be weatherproof type with bonding jumper or internal bond.
   4. Use nylon insulated throat type bushings for all terminations.
   5. Provide galvanized steel locknuts, each termination.
   6. Provide grounding bushings with insulated throat and ground lug.
   7. All fittings, UL listed, steel or malleable iron.
   8. Use sealing locknuts for all wet/damp areas.
   9. Use grounding type locknuts for rigid or IMC terminations not equipped with grounding bushing.
  10. Fittings for liquid tight flexible conduits shall be screw-in type manufactured by Thomas and Betts Company or Pittsburgh Standard Conduit Company.
  11. Flexible couplings shall be Crouse-Hinds Company, Type EG or equal by Appleton.

f. Usage length can not exceed more than 4 feet without approval from the Construction Supervisor; unless otherwise shown on the drawings or specified in the work summary.

### 3E.4.6 Installation Details:

a. Conduits and fittings shall be assembled and installed in the specified configuration following the detailed design drawings. The conduits shall be installed in a straight line except where bends are necessary. Conduits shall be cut and installed as required to form bends as well as straight sections.

b. Entrance conduits including terminations and bends, shall be suitably restrained by backfill with sand with no sharp objects to maintain its design position under stress of installation procedures, cable pulling operations and other conditions such as settling and frost uplift.

c. All conduits shall, where practicable, slope toward vertical riser and be installed to avoid pockets from which condensation or water seepage could occur where possible.

d. Excess sloping (5 percent or over) shall be avoided due to the possibility of cable creepage which must receive careful consideration. Under excess sloping, cable anchors may be required.
e. Conduit shall be joined in a manner sufficient to prevent solid matter from entering the conduit run. Joints shall form a sufficiently continuous smooth interior surface between joining conduit sections so that cable will not be damaged when pulled past the joint.

f. Ends of conduits shall be plugged or capped to prevent foreign material from entering. PVC - a threaded plastic end cap. Galvanized steel - A threaded end fitting.

g. Galvanized steel conduit bends and PVC conduit connections shall be made using threaded fittings in such a manner as to provide watertight connections. Rigid steel conduit with a galvanized finish is the only form of steel conduit approved for general underground use, including outdoor riser conduits and below grade bends.

1. When necessary to cut conduit, use a metal pipe cutter or hacksaw. A square cut shall be made. The freshly cut section shall be threaded using appropriate tools and cutting dies. The burrs, dust, metal shavings shall be removed using a wire brush and rough edges reamed smooth.

2. In joining conduit and/or fittings, the mating parts shall be dry and wiped clean of foreign matter (i.e., dirt and grease).

3. The mating parts shall be joined and drawn up tightly using a pipe wrench or similar tool. The internal finish of the conduit and joint shall be free of sharp edges or burrs which could damage the cable.

4. Care shall be exercised in handling to prevent twisting or excessive bending, when one of the conduits being joined cannot be turned to complete the joint, such as a conduit having a bend, standard bolt type split couplings shall be used. However, this situation shall be avoided, if possible.

5. Each conduit shall be identified at each end, by permanent marker, with a unique conduit number in accordance with the design drawings.

h. PVC conduit assemblies shall be made using PVC fittings and PVC solvent cement.

1. When necessary to cut conduit, use a fine tooth carpenter's crosscut wood saw or fine tooth hacksaw or plastic pipe cutter. A square cut shall be made. (A miter box or similar saw guide may be used to keep the material steady and assure a square cut. The end of the conduit shall not be distorted when cutting.) The burrs, dust, plastic shavings and rough edges shall be removed from the freshly cut and using a file. The inside surface MUST be reamed smooth.

2. In joining conduit and/or fittings, the mating parts shall be dry and wiped clean or foreign matter (i.e., dirt or grease).
3. Apply a uniform wet coat of PVC solvent cement to both mating parts, including the full length of the bell socket depth on the conduit or the fitting socket depth, whichever is applicable, and the area that will be inserted in the socket. Use the applicator brush furnished with cement or use a natural bristle brush; do not use a plastic bristle brush. Use small cans, i.e., pint cans, of PVC solvent cement since it dries rapidly. Keep can covered when not in use and keep away from excessive heat or open flame. Excess cement on the fitting shall be avoided as it may be wiped into the conduit when making the joint. Immediately after applying cement (work fast), slip conduit straight and firmly into the fitting with a slight twist (optional) 15 seconds (up to 1 minute in extremely cold weather) to allow initial set strength to develop and to prevent socket disengagement. Do not twist after insertion is completed. Wipe off any excess cement that is left on the mating parts after completing joint with a clean dry cloth.

4. The joint members shall be allowed to remain undisturbed for approximately 10 minutes to allow higher strength to develop before the conduit is handled or subjected to any bending action. After this curing period, care shall be exercised in handling to prevent twisting, excessive bending, or pulling on the joint. In cold or damp weather, the curing time should be increased. The internal finish of the conduit and joint shall be free of sharp edges or burrs which could damage the cable.

5. Another fitting or conduit section can be added to the opposite end within approximately 5 minutes if care is exercised in handling so that distortion or stress is not placed on the previously assembled joint.

6. Any joint shall not be under stress for the curing period. If, however, the potential situation exists due to misalignment or other factors, staking or other means shall be used to relieve the stress on the joint until the conduit is cured and backfilled.

i. Generally conduit fill shall be no more than 40% unless otherwise directed by the applicable NEC code, the drawings, or approved by the Owner’s Engineering Department.

j. After all cables have been installed in the conduits or ducts, the ends of all of the conduits or ducts shall be sealed with duct sealant-type putty or foam.

3E.5 ELECTRICAL CABLE TRAY SYSTEM

The Contractor shall furnish all materials, unless directed otherwise and shall install an electrical cable tray system in accordance with the Drawings and this Specification. Cable trays in this section refer to overhead or wall mounted cable trays and other structures used to support cables excluding conduit. They carry power, control, instrumentation, and relaying cables. Cable tray sections shall be identified and labeled.
3E.5.1 General Installation. The Contractor shall install the cable tray systems, supports, and enclosures in accordance with the cable tray manufacturer's instructions and the following sections.

a. Tray Surfaces. The Contractor shall cut the tray to length as required. The tray shall be cut with a saw and all surfaces over which the conductors and cables will be laid shall be ground or filed to remove any sharp edges which could cause damage to the cable jacket or insulation either during installation or in normal service.

b. Application and Location of Supports. The cable tray shall be bracket supported from the control house or switchgear enclosures outdoor wall at an interval not to exceed 8 feet measured along the tray center line between supports. All fittings shall be supported in accordance with NEMA VE 1. Clamps shall be used to secure support to structural metal.

c. Tray Enclosure. The outdoor enclosure shall be sealed and weatherproofed to prevent entry of blowing rain.

d. Cable Tray to Cable Trench Transition. A formed aluminum sheet shall be used to transition from the cable riser to the cable trench system. The Contractor shall install the formed aluminum sheet in accordance with the Drawings. The formed aluminum sheet shall be sealed and weatherproofed to prevent entry of blowing rain and rodents.

e. Cable Tray Types. Aluminum cable trays are generally acceptable. Refer to the Bill of Materials List for specific manufacturers required.

f. Anchoring. When drilled-in expansion type concrete anchors are used for cable tray supports, they shall be installed in accordance with the design drawings, specifications, and manufacturer’s recommendations.

g. Codes & Standards. The cable tray system shall be installed in accordance with all local and state codes and regulations having jurisdiction.

h. Materials. The Contractor shall obtain and verify that the cable tray materials are the correct materials including type, grade, and size as detailed in the Bill of Materials and listed on the drawings. Any questions shall be referred to the Owner’s Construction Supervisor for disposition.
i. Cable Tray Supports. The Contractor shall install the cable tray supports at the locations and heights shown on the drawings. Supports shall be located such that when the tray is installed, the tray location (horizontally) is within 6" of the location indicated on the drawings. No additional attachments shall be made to the new cable tray supports or raceways unless approved by the Owner’s Engineering Department. When the cable tray removal is extensive, make sketches of the existing support system prior to removal. Drawings for the specific supports may be used. Then, proceed in removing the supports.

j. Installation Details

1. Install and verify that the tray location is with 6" of the location on the drawing.

2. Install the tray lengths specified as indicated on the drawings on the supports. Connect adjoining trays using splice plates. All splice plate hardware shall be installed and tightened. Where interferences prevent installation of splice plates, insure each section of tray is grounded by jumper sections of tray or jumping the tray to ground. The tray shall be fastened down at each support location and rigid.

3. Where hanger rods are used, they shall be continuous from top to bottom of a vertical row of trays, and may be considered continuous if standard coupler nuts are used between sections of rod. Rod ends shall be threaded into coupler nuts to butt near the center of the coupler. To facilitate visual inspection and to verify if loosening is occurring, mark one half the depth of the coupler nut on each portion of the rod ends to be inserted with an indelible mark such as a punch or paint mark.

4. Install any separation barriers inside the tray, if specified.

5. Protrusions of pipe, HVAC, etc., or associated supports into the area of the minimum of 12" above the upper plane of the tray and the side rails of the tray are not acceptable.

6. Install a ground connection between the tray and the ground grid. Cable tray shall be mechanically grounded at each end and at intervals not exceeding 100 ft. unless specified otherwise. For cable trays for medium voltage or higher power cables, a ground cable is required to be installed the length of the cable tray. In these cases and as shown on the drawings the Contractor shall run a #4/0 bare copper ground cable along the entire length of the tray, and bond each tray section to the cable.

7. Verify that the cable tray is grounded.

8. Cable tray grounding shall use a ground conductor not less than No. 4/0 AWG, copper, unless otherwise indicated on the drawings.
9. Install sleeves, if required, at locations where cable trays approach walls. Cable trays shall not be run through walls or floors unless otherwise specified on the drawings.

10. Where outdoor vertical cable tray risers penetrate indoors into buildings and or enclosures, the opening shall be properly sealed to insure a weather and rodent proof installation.

11. Label the cable trays with a minimum letter/numeric height of 1-1/2", in accordance with the cable tray identifications specified on the drawings.

12. Tray alphanumeric identification marking shall be applied on the outside of tray side rails in such locations as to be readily visible from the floor.

13. Indelible markers or stenciling shall be provided at each end of each tray section, except that a tray section 8 ft. or less in length may have the marker at the midpoint of the section.

k. Replacement of Cable Tray

1. Check the existing cable trays for the following: Cable Tray Manufacturer, Type, and Size.

2. If sections or parts removed are complex or the removal time is extensive, make sketches of the existing cable tray layout prior to removal.

3. Remove cable tray section or part of a cable tray section or cable tray components.

4. Provide temporary means of supporting the cables as necessary. Also provide a means of protecting the cables from damage as necessary. If necessary to remove cables, follow instructions in related sections of this specification.
3E.6 BOXES AND CABINETS

The Contractor shall install all boxes and cabinets required throughout the electrical raceway system in accordance with the Drawings and this Specification.

3E.6.1 Installation. Boxes and cabinets shall be rigidly mounted. Mounting on concrete shall be secured by self-drilling anchors. Mounting on metal shall be by drilled and tapped screw holes, or by special support channels welded to the metal, or by both. Cabinets shall be leveled and fastened to the mounting surface with not less than ¼ inch air space between the enclosure and mounting surface. All mounting holes in the enclosure shall be used. Except as prevented by the location of other work, all junction boxes and outlet boxes shall be centered on structures. Conduit openings in boxes shall be made with a hole saw or shall be punched. All outdoor junction boxes and enclosures, shall have heaters and thermostats installed to prevent freezing in the winter. The self regulating type heater (PTC) from Waukesha is the preferred option.

Section 3F (260513) (260519) (260523) - CONDUCTORS

3F.1 GENERAL

The Contractor shall install insulated cable, conductors, and conductor accessories in accordance with the requirements of the Drawings and this Specification. This section applies to Medium voltage, Low voltage, and Control voltage cables and related conductor types.

3F.1.1 The Contractor shall furnish all insulated cable and conductors and conductor accessories, EXCEPT as specified in the Material Lists as being furnished by the Owner, in quantities sufficient for a complete installation as indicated in the Conduit & Cable Schedule, on the Drawings, and in this Specification.

3F.1.2 Installation shall include placement, splicing, terminating conductors, coiling and taping of spare conductors, identification, testing, and verification of each circuit, cable, and conductor.

3F.1.3 Terminating a conductor shall include installing cable termination kits for shielded cable, attaching the conductor at its designated location and insulating the entire connection where specified or required by the application.

3F.1.4 The Contractor shall store and handle cable reels in a manner which will prevent physical damage to the cable. Cable reels shall be stored on a hard surface to prevent contact between cable insulation and earth due to sinking of the reel. Impact damage between reels shall be prevented by aligning reels flange to flange or by using guards across flanges.

3F.2 CONDUCTOR ACCESSORIES

The Contractor shall furnish and install all conductor accessories including connectors, terminations, insulating materials, support grips, markers, and cable ties.
3F.2.1 Terminal Connectors

a. Supplier's installation instructions shall be obtained for cable accessories. These instructions shall be in the possession of the craftsmen while installing the accessories and shall be available to the Owner for reference.

b. Terminal Connectors for Conductors. Terminal connectors for conductors shall be pressure or bolted clamp type. Acceptable connectors included with Owner-furnished equipment may also be used. Pre-insulated ring type terminal connectors shall be used for all terminations and connections. The use of non insulated terminal connectors is prohibited unless approved by the Owner’s Engineering Department.

c. Terminations to terminal blocks and equipment shall be made with the following ring type connectors or engineering approved equivalents. The Contractor shall supply all terminations to terminal blocks and equipment.
### Table 3F-1
Terminal, ring tongue, for #12-10 AWG copper cable to #10 stud, tin plated copper body with yellow nylon insulation.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burndy</td>
<td>YAEV10</td>
</tr>
<tr>
<td>Tyco</td>
<td>36161</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RC10-10</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN10-10R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY1210R</td>
</tr>
</tbody>
</table>

### Table 3F-2
Terminal, ring tongue, for #12-10 AWG cable to #8 stud, tin plated copper body with .230 in. yellow nylon insulation.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burndy</td>
<td>YAEV10-T11</td>
</tr>
<tr>
<td>Tyco</td>
<td>320568</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RC10-8</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN10-8R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY1208R</td>
</tr>
</tbody>
</table>

### Table 3F-3
Terminal, ring tongue, for #12-10 AWG cable to #6 stud, tin plated copper body with yellow nylon insulation for switchboard wiring.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burndy</td>
<td>YAEV10-T11</td>
</tr>
<tr>
<td>Tyco</td>
<td>320567</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RC10-6</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN10-6R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY1206R</td>
</tr>
</tbody>
</table>
Table 3F-4
Terminal, ring tongue, for #16-14 AWG cable to #10 stud, tin plated copper body with blue nylon insulation.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burndy</td>
<td>YAEV14</td>
</tr>
<tr>
<td>Tyco</td>
<td>36160</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RB14-10</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN14-10R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY1610R</td>
</tr>
</tbody>
</table>

Table 3F-5
Terminal, ring tongue, for #16-14 AWG cable to #8 stud, tin plated copper body with blue nylon insulation for switchboard wiring.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burndy</td>
<td>YAEV14</td>
</tr>
<tr>
<td>Tyco</td>
<td>360627</td>
</tr>
<tr>
<td>Tyco</td>
<td>8-320627-2</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RB14-8</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN14-8R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY1608R</td>
</tr>
</tbody>
</table>

Table 3F-6
Terminal, ring tongue, for #16-14 AWG cable to #6 stud, tin plated copper body with blue nylon insulation for switchboard wiring.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyco</td>
<td>360631</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RB14-6</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN14-6R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY1606R</td>
</tr>
</tbody>
</table>
Table 3F-7
Terminal, ring tongue, for #22-18 AWG cable to #10 stud, tin plated copper body with red nylon insulation for switchboard wiring

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burndy</td>
<td>YAEV18</td>
</tr>
<tr>
<td>Tyco</td>
<td>36154</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RA18-10</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN18-10R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY2210R</td>
</tr>
</tbody>
</table>

Table 3F-8
Terminal, ring tongue, for #22-18 AWG cable to #8 stud, tin plated copper body with red nylon insulation for switchboard wiring

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burndy</td>
<td>YAEV18</td>
</tr>
<tr>
<td>Tyco</td>
<td>320551</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RA18-8</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN18-8R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY2208R</td>
</tr>
</tbody>
</table>

Table 3F-9
Terminal, ring tongue, for #22-18 AWG cable to #6 stud, tin plated copper body with red nylon insulation for switchboard wiring

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Catalog no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyco</td>
<td>326878</td>
</tr>
<tr>
<td>Thomas &amp; Betts</td>
<td>RA18-6</td>
</tr>
<tr>
<td>Panduit</td>
<td>PN18-6R</td>
</tr>
<tr>
<td>Tyton</td>
<td>NY2206R</td>
</tr>
</tbody>
</table>

3F.2.2 Reserved for future use
3F.2.3 **Crimping Tools.** Crimping tools used to secure conductors in compression type connectors or terminal lugs shall be those made for that purpose and for the conductor sizes involved. The crimping tools shall accurately crimp the connector barrel and shall accurately crimp the conductor insulation support sleeve where provided. Crimping tools shall be provided with guides to position connectors in the tool, shall be provided with stops to prevent over-crimping, and shall be of a type which prevents the tools from opening until the crimp action is completed. Crimping tools shall be a product of the connector manufacturer or shall be as recommended by the connector manufacturer and acceptable to the Owner for use with the connectors. The Contractor shall establish and maintain a tool certification program to ensure that crimping tools are kept in accurate operating condition.

3F.2.4 **Insulating Materials.** Insulating materials for 600 volt cable terminal connectors or bolted type splicing connectors shall consist of varnished cambric tape, rubber tape, and vinyl tape. Taping materials shall be as listed below or acceptable equal.

   a. Varnished Cambric Tape - 3M Company Irvington 2520  
   b. Rubber Tape - 3M Company Scotch 130C  
   c. Vinyl Tape - 3M Company Scotch 33+

3F.2.5 **Support Grips.** Cable support grips shall be either split or closed woven wire type as manufactured by Hubbell Incorporated (Wiring Device–Kellems Division), Milford CT.

3F.2.6 **Wire & Conductor Markers.** All terminals on terminal blocks provided for termination of external circuits shall be identified by typed black circuit designations acceptable to the Owner on the terminal block strips. All other wiring terminations shall be identified by typing on conductor identification sleeves. A conductor identification sleeve shall be provided on each end of each conductor. Each sleeve shall be marked with the opposite end destination. Conductor identification sleeves shall be not less than 1/2 inch long and shall be as manufactured by the Dura Mark Company, Port Washington, New York or acceptable equal. After inscription of the conductor identification, the marking sleeve shall be covered with a clear plastic or acrylic coating or cover. Conductor identification shall be permanent, unaffected by heat, solvents, or steam, and not easily dislodged. The preferred method is to use Brady heat-stamp sleeves or similar Owner approved equivalent.

3F.2.7 **Cable Ties.** Lacing materials for field installed cable shall be non-releasing, weather resistant black nylon ties manufactured by Thomas & Betts Company, Elizabeth, New Jersey; Panduit Corp., Tinley Park, Illinois; 3M Company; or acceptable equal.

3F.2.8 **Arco proofing Material.** Material for arc proofing cable shall be an unsupported intumescent self extinguishing elastomer tape, 3M Company Scotch Brand No.77 or acceptable equal, and a pressure sensitive silicone adhesive backed glass cloth holding tape, 3M Company Scotch Brand No.69, or acceptable equal.
3F.3 INSTALLATION

Conductor installation shall be in accordance with the cable manufacturer's recommendations and as specified herein.

3F.3.1 Cable Routing. The Contractor shall route all conductors in accordance with the Owner’s conduit and cable schedule and/or drawings and as described herein.

a. Pull all conductors into a raceway at the same time. Use UL listed pulling lubrications for pulling all cables and larger wires. Petroleum based grease is not acceptable.

b. Install wire in raceway after all mechanical work likely to injure conductors has been completed.

c. The Contractor shall inspect all conduit sections before pulling cable to insure that they are free of foreign materials. The Contractor shall test each conduit by pulling a mandrel through the conduit. The mandrel shall be flexible, about ¼ inch less in diameter than the inside diameter of the conduit and shall be pulled through the conduit followed by a wire brush. If the mandrel encounters opposition, the cause of opposition or scoring must be removed and the conduit re-tested until acceptable to the Owner. A small diameter plastic pulling line, Cartage Group Radiant Poly Line Model 1 ply-110-2 mil or as approved by the Owner, shall be installed during the final test and left in the conduit.

d. Cable shall not be handled when the cable temperature is below the minimum temperature recommended by the manufacturer. If cable heating is required prior to placement, the cable shall be stored in a heated building in accordance with the manufacturer's recommendations for at least 24 hours. The cable shall not be removed from heated storage until it is ready to be installed that same day.

e. If at any time during the progress of the work the Contractor finds raceways which appear inadequate to accommodate the assigned cable, the Owner shall be notified at once and the Contractor shall discontinue any further work on the questionable raceway until advised by the Owner as to how to proceed.

f. Immediately prior to the placement of each cable or cable group, the raceway route to be followed shall be inspected and ascertained to be complete in installation and free of all materials detrimental to the cable or its placement. All cable assigned to a particular duct or conduit shall be grouped and pulled in simultaneously using cable grips and acceptable lubricants.

g. All cable shall be carefully checked both as to size and length before being pulled into conduits or ducts. Cable pulled into the wrong conduit or duct or cut too short to rack, train, and splice as specified herein shall be removed and replaced by and at the expense of the Contractor. Cable removed from one conduit or duct shall not be pulled into another conduit or duct.
h. **Cable in Trays.** All cable shall be carefully laid in or pulled through the tray system so that neither the cable nor the trays are damaged. Cable may be laid along the side of the tray system during placement provided it is protected from dirt, water, oil, or other detrimental materials and from mechanical injury. Cable shall be cut sufficiently long to conform to the contour of the trays, with particular attention paid to vertical inside bends. All excessive slack shall be removed from the cable so that it lies parallel to the sides of the trays. Multiple single conductor cable which constitutes a single power circuit shall be grouped together to minimize magnetic influence on other cable in the area. The cable shall be tied to the trays with nylon ties at 10 foot intervals to hold it in place. Cable clamps designed for holding the cable inside the trays shall be installed at all vertical bends.

i. **Cable Pulling.** Fishing and pulling shall be done with flexible round metal tape, CO₂ propelled polyethylene cord, nylon rope, or manila rope. Unless specified otherwise or acceptable to the Owner, cable shall not be pulled in a single pull through two sections of raceway connected by a pull box. Cable shall be pulled out at each pull box to the length required for termination. Prior to re-pulling of the pulled out cable, the cable shall be thoroughly inspected, cleaned, and re-lubricated. Damaged cable shall be removed and replaced by and at the expense of the Contractor. Cable may be pulled in a single pull through two sections of raceway connected by a pull box only if it can be determined by calculation to the satisfaction of the Owner, that the pulling tension will not exceed the maximum tension allowed by the cable manufacturer.

j. **Cable Grips.** Factory installed pulling eyes shall be used for pulling cable where they are available. Woven wire cable grips shall be used to pull all single conductor cable 2/0 AWG and larger, where pulling eyes are not available, and all multiconductor cable. Pulling loops shall be used to pull single conductor cable smaller than 2/0 AWG. All sharp points and edges on the hardware attaching the pulling rope to the cable shall be taped to prevent snagging or damaging the raceway. When a cable grip or pulling eye is used for pulling, the area of the cable covered by the grip or seal plus 6 inches shall be cut off and discarded when the pull is completed. When pulling loops are used, the entire loop shall be cut off and discarded when the pull is completed. As soon as the cable is pulled into place, the pulling eyes, cable grips, or pulling loops shall be removed and any cable which was sealed shall be resealed.

k. **Swivels.** A reliable nonfreezing type of swivel, or swivel connection, shall be inserted between the pulling rope and the cable pulling eye, grip, or loop to prevent twisting under strain.
l. Feeding Tubes. A 4 inch or larger flexible feeding tube, with a removable nozzle sized to fit the ducts, shall be used in pulling all underground cable. The feeding tube shall be long enough to extend from the duct entrance to the outside of the manhole and shall be so arranged that it will be impossible for the cable to drag across the edge of the manhole ring or any other damaging surface. The bending radius of the tube shall not be less than the minimum bending radius of the cable specified in this section under the article titled Cable Bends.

m. Pulling Lubricants. Only lubricants recommended by the cable manufacturer and acceptable to the Owner shall be used. Lubricants shall be applied liberally and continuously during the pull.

n. Inspection. The Contractor shall carefully inspect the outside of each cable reel and shall remove all protruding nails, fastenings, or other objects which might damage the cable. A thorough visual inspection for flaws, breaks, or abrasions in the cable sheath shall be made as the cable leaves the reel, and the pulling speed shall be slow enough to permit this inspection. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be replaced by and at the expense of the Contractor.

o. Pulling Tension. The pulling tension of any cable shall not exceed the maximum tension recommended by the cable manufacturer. Pulling mechanisms of both the manual and power types used by the Contractor shall have the rated capacity in tons clearly marked on the mechanism. Whenever the capacity of the pulling mechanism exceeds the recommended pulling tension of the cable as given by the cable manufacturer, a dynamometer shall be used to show the tension on the cable and the indicator shall be constantly watched. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected.

p. Sidewall Pressure. To avoid insulation damage from excessive sidewall pressure at bends, the pulling tension in pounds at a bend shall not exceed 300 times the radius of the bend in feet.

q. Cable Bends. Tape shielded, flat tape armored, and wire armored cable shall not be bent to a radius of less than 12 times the overall cable diameter. All other cables shall not be bent to a radius of less than eight times the cable diameter.
r. **Supports.** All cable supports and securing devices shall have bearing surfaces located parallel to the surfaces of the cable sheath and shall be installed to provide adequate support without deformation of the cable jackets or insulation. Adequate cable end lengths shall be provided and properly placed in junction boxes to avoid longitudinal strains and distorting pressures on the cable at conduit bushings and duct end bells. Final inspection shall be made after all cable is in place and, where supports or raceway fittings deform the cable jacket, additional supports shall be provided as directed by the Owner. Additional cable protection such as a wrapping of light rubber belting, friction tape, or similar material shall be provided where required.

s. **Spare Conductors.** All spare conductors of a multiconductor cable shall be left at their maximum lengths for possible replacement of any other conductors in the cable. Each spare conductor shall be neatly coiled and then taped to the conductors being used. If the drawings show that the spare conductors are to be terminated, the Contractor shall terminate these conductors.

t. **Lacing.** Nylon ties shall be used to neatly lace together conductors entering switchboards and similar locations after the conductors have emerged from their supporting raceway and before they are attached to terminals.

u. **Cable Identification.** The Contractor shall identify the ends of all cables listed in the Conduit & Cable Schedule. Each marker shall bear the number of the cable according to the Conduit & Cable Schedule and the Drawings. At terminations, the Contractor shall identify each conductor of power circuits, each multiconductor cable, and each conductor of circuits consisting of multiple single conductors where the conductors are not otherwise identified. Markers shall be attached where the first individual conductor is routed away from the assembly. Each phase of multi-phase power circuits shall be individually identified.

v. **Cable Color Coding.** All cables shall be wired to the color coding shown in the Standard Cable Color Coding Spec. CABLCOLR. Single conductor DC power cable shall be wired as white being positive and as black being negative.

3F.3.2 **Splices.** No splices shall be made in conductors for instrument circuits or control circuits except where required at connections to accessory devices equipped with factory installed pigtails. Protective relay wires from CTs and PTs shall not be spliced. Shields may be spliced where necessary to permit connection to the station ground. Any other proposed splicing must be approved by the Owner’s Engineering Department.

a. Power cable circuits shall not be spliced.

b. Splices shall not be made to utilize short lengths of cable nor shall they be made to provide correct lengths on cable initially cut too short for a particular circuit, unless otherwise approved by the Owner’s Engineering Department.
c. Splices, joints, and connections shall be made only in pull boxes or junction boxes as indicated on the Drawings. Use solder less pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. Use split bolt connectors for copper wire tap, 6 AWG and larger. Tape un-insulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.

3F.3.3 Terminations. The Contractor shall install cable terminations per the drawings and as specified herein.

a. Make taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

b. Thoroughly clean wires before installing large lugs and connectors.

c. The Contractor shall carefully train cable in place avoiding sharp bends and cut squarely to required length. At points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike, and approved manner by a qualified person specialized in this class of work with particular attention being given to higher voltage terminations and shielded conductor terminations. Spare cables shall be trimmed, taped and bundled neatly within the cabinet so their presence will not interfere with connected terminations. They shall be trimmed to a length such that they can be made up and connected to the farthest terminal block within the cabinet.

d. The Contractor shall carefully remove the necessary amount of cable jacket and insulation without damage to the conductor, with a qualified stripping instrument.

e. The Contractor shall install terminals or terminal connectors as required, ensuring a firm metal-to-metal contact. Appropriately sized wire ring terminals shall be used.

f. Control cable terminations shall be made in accordance with the Owner’s connection and interconnection diagrams. All control circuits shall be labeled with individual wire numbers as described in the labeling section of this document.

g. It is the intent that the Contractor shall terminate all of the cables which he installs, except as otherwise specified by the Owner. Spare cables shall also be labeled as such.

h. Mechanical ground wires shall be green throughout the system. Insulated ground wires may be used provided the ends are properly identified.

i. Where additional protection and support of trimmed conductors is required at terminations, etc.; Raychem heat shrink tubing or equivalent shall be used to cover exposed conductors.
j. Insulation of 600 Volt Cable Connections.

Each connection of cable to an insulated conductor (whether cable, bus, or equipment bushing) shall be insulated. The insulation shall cover all exposed surfaces of the conductors; the insulation voltage level of the completed termination shall be not less than the insulation voltage level of the connected conductors. Where connections of cable rated 600 volts or less require insulation, all exposed conductor and connector surfaces shall be covered and taped with:

- One half-lapped layer of varnished cambric tape
- A minimum of three half-lapped layers of rubber tape, elongated not more than 20 percent; applied over the varnished cambric tape
- A minimum of three half-lapped layers of vinyl tape applied over the rubber tape. (The vinyl tape shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the insulation of the conductor to which the cable is connected.)

3F.3.4 Conductor Tests.

All insulated conductors shall be electrically tested after placement. All circuits, including lighting circuits, shall be tested with the circuit complete except for connections to equipment. All splices, stress cones on shielded cable, and terminal connector attachments shall be complete prior to testing. In addition to the tests performed after cable placement is complete, continuity tests and insulation tests shall be performed on all supervisory and communication cable before and after each splice is made. Any circuit failing to test satisfactorily shall be replaced or repaired and then retested.

Before any power cable terminal connections are made, conductors shall be rung out. Connections shall be made according to wiring diagrams. Polarity or phasing shall be checked before final connections are made, and corrections of polarity, phasing or rotation shall be made without additional cost to the Owner.

a. Continuity Tests. All insulated conductors shall be tested for continuity. Continuity tests shall include all tests necessary to confirm that each conductor is continuous throughout its entire length.

b. Identification Tests. All insulated conductors shall be tested for conductor identification. Identification tests shall include all tests necessary to confirm that the conductor being investigated originates and terminates at the locations designated in the Conduit & Cable Schedule or indicated on the Drawings.
c. **Cable Rated Below 5000 Volts.** All insulated conductors, except supervisory and communication cable, rated less than 5000 volts shall be tested for resistance from ground provided by the insulation with a 1000 volt megger or an equivalent testing device, in accordance with the manufacturer’s test requirements. These tests shall be done prior to making final connections. Insulation resistance measurements shall be made between each conductor and ground and between each conductor and all other conductors of the same cable. Minimum acceptable resistance values shall be approximately 500 megohms. This includes all CT Cable Conductors.

d. **Cable Rated Above 5000 Volts.**
   For cables installed above 5000 volts, the tester shall megger check the conductors in accordance with the Owner’s Distribution Underground Standards, EOPUG004, latest revision.

e. **Supervisory and Communication Cable.** All insulated conductors of supervisory and communication cable shall be tested for resistance with a 500 volt megger or an equivalent testing device. Insulation resistance measurements shall be made between each conductor and the cable shielding tape and between the two conductors in each pair. Minimum acceptable resistance values shall be 500 megohms divided by the actual cable length in miles.

f. **CT Cable Conductors.** Contractor shall test all the CT cable conductors with a Megger insulation testing instrument prior to making final connections to the equipment. In the event the insulation value is unacceptable, corrective measures shall be taken and the test shall be repeated. Test shall be performed, as applicable, in accordance with Clause 11 of IEEE 525 in conjunction with the cable manufacturer’s recommendations.

**3F.3.5 Codes and Standards.** The Contractor shall conform to the following minimum applicable codes and standards for Section 3F.

a. **NEMA WC 3 – Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.**

b. **NEMA WC 5 – Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.**

c. **Cable Pulling and Testing Requirements.** IEEE Std. 525 Clauses 10 &11.

d. **Electric Station Standards Section 10.0 Conductors and the Substation Field Issue Materials List**

e. **NFPA-70, "2005 National Electrical Code" or latest.**
3F.3.6 CABLE TYPES. All cable materials supplied by the Contractor shall meet or exceed the minimum requirements listed in the applicable cable specifications included in the Substation Field Issue. Any exceptions to these minimum requirements shall be approved by the Owner’s Engineering Department in advance, so that the overall installation schedule will not be impacted. The Contractor should be aware that these cables may be considered special order cables and should plan in advance for long lead times.

Section 3G (265100) (265600) - INTERIOR/EXTERIOR LIGHTING

3G.1 GENERAL

The Contractor shall install all lighting materials and equipment as indicated on the Drawings and specified herein. The Contractor shall furnish all lighting materials, except as specified in the Material Lists as being furnished by the Owner, in quantities sufficient for a complete installation.

3G.2 INSTALLATION

Lighting equipment, material, and wiring devices shall be installed according to the Drawings and as specified herein.

3G.2.1 Fixtures. Each complete fixture shall be secured to its support assembly. This work includes but is not limited to all special drilling, assembling, disassembling, reassembling, and wiring. Fixture maintenance shall be continuous until the date of commercial operation. All fixtures shall be cleaned immediately prior to the Contractor leaving the job site.

a. Location. Fixture locations indicated on the Drawings are approximate and shall be coordinated with other work in the same area to prevent interference between lighting fixtures and other equipment. Any fixture shall be relocated if, after installation, it is found to interfere with other equipment or is so located to prevent its practical and intended use. No fixture shall be located such that it prevents the full use of any access way beneath a removable grating or slab.

b. Alignment. Fixtures installed in rows shall be carefully aligned vertically and horizontally.

3G.2.2 Wiring Device Mounting Heights. Unless otherwise indicated on the Drawings, receptacles shall be mounted 36 inches above finished grade (or finished floor) and switches shall be mounted 48 inches above finished grade (or finished floor).

3G.2.3 Lighting Conductors. The installation of lighting conductors shall conform to the applicable installation procedures specified elsewhere herein for power and control conductors.

a. At least 6 inches of free lighting conductor shall be left at each outlet except where the conductor loops through an outlet without splice or connection.
b. General purpose cable shall be used to connect all incandescent lighting fixtures. The general purpose cable shall be installed in the circuit between the lighting circuit outlet box and the fixture terminal.

c. Wires to be spliced shall use solderless pressure connectors with insulating covers.

3G.2.4 Exterior Area Lighting Installation. Outdoor area and outdoor equipment lighting shall be installed on structures as indicated on the Drawings and as specified herein.

a. For outdoor area lighting, the structures shall be installed before lighting fixtures are mounted on the structure. Cable connections for outdoor pole mounted fixtures shall be completed in the handhole located near the base of the light support structure.

b. For outdoor equipment, uplighting lighting fixtures shall be mounted after the structures have been fully erected. Cable connections shall be completed in the junction boxes located on the structures.

c. Conductors. Underground conductors of the outdoor area lighting and equipment uplighting systems shall be comprised of jacketed aluminum sheathed multiple conductor cable, unless otherwise noted on the drawings. Above ground conductors of the outdoor area lighting system will be single conductor cable. Above ground conductors of the outdoor equipment uplighting system will be comprised of aluminum sheathed multiple conductor cable. Conductors shall be routed as indicated on the Drawings.

d. Grounding. All outdoor lighting equipment shall be grounded in accordance with the Drawings and as specified elsewhere in this Specification.

Section 3H (260700) - POWER CIRCUIT BREAKERS

3H.1 INSTALLATION

3H.1.1 This section is applicable for all outdoor free standing circuit breaker installations. This section may be modified or omitted depending on the summary of work descriptions in the Substation Field Issue.

3H.1.2 The Contractor shall provide all labor, materials, tools, equipment, accessories, and services necessary to unload and install each circuit breaker assembly in its permanent location, as shown on the contract drawings and described in these specifications.

3H.1.3 The Contractor shall provide placement and anchoring (if necessary) of each circuit breaker on its foundation.

3H.1.4 The Contractor shall remove all shipping members and protective coverings.
3H.1.5 The Contractor shall make the primary conductor terminations to the bushings per the cable manufacturer’s and Owner’s instructions.

3H.1.6 The Contractor shall ensure connecting circuit breaker to the station grounding system.

3H.2 MATERIALS DELIVERY, STORAGE AND RIGGING

3H.2.1 The Contractor shall store materials properly to prevent theft, damage, deterioration and inclusion of foreign matter. Packaged materials delivered must be kept in the original shipping cartons to avoid loss of parts.

3H.2.2 The Contractor shall handle the circuit breaker by rolling or lifting using appropriate rigging as required.

3H.2.3 For SF6 gas circuit breakers, the Contractor shall properly fill the circuit breakers with SF6 gas in accordance with the manufacturer’s instructions.

3H.2.4 The Contractor is responsible for the full installation and setup of the circuit breaker including full compliance with the manufacturer’s recommendations. The Owner will do the functional testing and commissioning, unless otherwise called out in the Substation Field Issue.

3H.3 CODES AND STANDARDS

The Contractor shall comply with the provisions of the National Electric Code (NEC) for the breakers auxiliary wiring except where more stringent requirements are shown or specified.

3H.4 PRODUCTS GENERAL

The Owner will supply the circuit breaker(s) to install. The Contractor shall furnish all miscellaneous material not previously installed by prior work and not provided by the Owner as indicated on Bill of Materials List to complete the circuit breaker installation.

3H.5 INSTALLATION GENERAL

3H.5.1 The Contractor shall install the circuit breaker using the appropriate rigging as per the manufacturer’s recommendations for the locations shown on the Owner’s drawings. The Contractor shall provide all rigging required. The circuit breaker dimensions and weight are shown on the Owner’s provided drawings.

3H.5.2 Each circuit breaker shall be placed on it’s foundation in accordance with the manufacturer’s recommendations.

3H.5.3 The Contractor shall complete all power cable terminations with the correct phasing arrangements to the high and low side bushings.
3H.5.4 The Contractor shall perform any degassing of SF6 circuit breakers, gas top-ups for circuit breakers, and gas startup measures; in addition to what is called out in the work summary.

3H.6 CIRCUIT BREAKER REMOVALS

Where indicated in the Substation Field Issue, the Contractor shall remove all existing circuit breakers and accessories from their foundations and dispose of them as directed by the work summary. Any oil handling requirements shall be carried out as indicated in the work summary and shall be in strict compliance with all environmental rules and regulations that apply.

Section 3I (261200) - POWER TRANSFORMERS

3I.1 INSTALLATION

3I.1.1 This section is applicable to power transformers. This section may be modified and/or omitted depending on the summary of work descriptions. In some cases the transformer supplier will perform the installation of the transformer. In these cases this section may not apply.

3I.1.2 The Contractor shall provide all labor, materials, tools, equipment, accessories, and services necessary to unload and install the power transformer(s) assemblies in their permanent locations as shown on the contract drawings and described in these specifications.

3I.1.3 The Contractor shall remove of all shipping members and protective coverings.

3I.1.4 The Contractor shall provide placement and anchoring of the power transformer(s) on the foundation(s).

3I.1.5 The Contractor shall make all power cable connections per the cable manufacturer’s and the Owner’s instructions. The Contractor shall ensure the phasing arrangements are correct.

3I.1.6 The Contractor shall connect the power transformer(s) to the station grounding system, as applicable.

3I.2 MATERIALS DELIVERY, STORAGE AND RIGGING:

3I.2.1 The Contractor shall be responsible for transporting the transformer(s) from their storage locations to the jobsite. The Contractor shall coordinate arrival at this storage facility for pickup with the Owner’s personnel ahead of time by communicating this through the Construction Supervisor. The Contractor should inspect the major electrical equipment at the storage facility for any damage prior to moving it to the jobsite and should inform the Owner of any defects found prior to starting the moving procedure.
3I.2.2 The Contractor shall store all materials properly to prevent theft, damage, deterioration and inclusion of foreign matter. Packaged materials delivered must be kept in the original shipping cartons to avoid loss of parts.

3I.2.3 The Contractor shall handle the power transformer(s) by rolling or lifting using appropriate rigging as required.

3I.2.4 The Contractor shall refer to the summary of work to determine if transformer oil filling is necessary.

3I.2.5 The Contractor is responsible for fully dressing out the transformer(s). The Owner will perform the functional testing and commissioning of the transformer(s).

3I.3 CODES AND STANDARDS

The Contractor shall comply with the provisions of the National Electric Code (NEC), as a minimum, for all auxiliary wiring to the transformer, except where more stringent requirements are shown or specified.

3I.4 INSTALLATION MATERIALS

The Owner will supply and provide the transformer(s) to install, unless the contract calls out for something different. The Contractor shall furnish all other miscellaneous material not previously installed by prior work and not provided by the Owner as indicated on the Bill of Materials List.

3I.5 INSTALLATION OF TRANSFORMER PADS

If applicable in the summary of work, the Contractor shall furnish and install a concrete pad in accordance with the Owner’s structural drawings and the Owner’s structural requirements specified within.

3I.6 INSTALLATION OF TRANSFORMERS

3I.6.1 The Contractor shall install the transformer(s) using the appropriate rigging required in the locations shown on the Owner’s drawings. The Contractor shall provide all rigging required. The transformer dimensions and weight are shown on the Owner’s provided drawings.

3I.6.2 Each power transformer shall be placed on it’s foundation in accordance with the manufacturer’s recommendations.

3I.6.3 All power cable terminations shall be completed with the correct phasing connections to the high and low side bushings.
3I.1.6 Transformer Testing:

a. The Contractor shall do a point to point wire check of the auxiliary control and relay wiring per the drawings and shall verify by continuity or otherwise that all connections are correct, prior to completing the installation of the transformer(s). The Owner will functionally test and commission the transformer(s).

3I.7 TRANSFORMER REMOVALS

Where indicated, the Contractor shall remove all existing transformers and accessories from their foundations and dispose of them as directed by the work summary. Any oil handling requirements shall be carried out as indicated in the work summary and shall be in strict compliance with all environmental rules and regulations that apply.

Section 3J (260525) - MEDIUM VOLTAGE SWITCHGEAR

3J INSTALLATION

3J.1.1 This section is applicable for indoor and outdoor medium voltage switchgear installations, only. This section may be modified or omitted depending on the summary of work descriptions.

3J.1.2 The Contractor shall provide all labor, materials, tools, equipment, accessories, and services necessary to unload and install the switchgear assemblies in their permanent locations as shown on the contract drawings and described in these specifications.

3J.1.3 The Contractor shall remove all shipping members and protective coverings.

3J.1.4 The Contractor is responsible for the placement and anchoring of the switchgear on its foundation.

3J.1.5 The Contractor shall make all bus connections between the shipping sections per the manufacturer’s instructions.

3J.1.6 The Contractor shall reconnect all the control wires and ground connections between shipping sections per manufacturer’s instructions, if the sections were shipped separated.

3J.1.7 The Contractor shall make all power cable connections per the switchgear manufacturer’s and owner’s instructions.

3J.1.8 The Contractor shall reconnect the ground bus between the shipping sections and connect the switchgear to the station grounding system.
3J.2 MATERIALS DELIVERY, STORAGE AND RIGGING

3J.2.1 The Contractor shall store materials properly to prevent damage, deterioration and inclusion of foreign matter. Packaged materials delivered must be kept in the original shipping cartons to avoid loss of parts.

3J.2.2 The Contractor shall handle the switchgear by rolling or lifting in accordance to the manufacturer’s recommendations.

3J.3 CODES AND STANDARDS

3J.3.1 The Contractor shall comply with the provisions of the following codes, specifications and standards listed within, except where more stringent requirements are shown or specified.

- National Electric Code latest edition, NFPA 70
- Owner’s power cable description (22-UC16), and power cable installation cabinet (7-501-7-506).

3J.4 INSTALLATION GENERAL

3J.4.1 The handling of the switchgear assemblies should be done either by rolling or lifting, using a spreader bar in accordance with the manufacturer’s and C37.20.1 recommendations. All rigging shall be supplied by the Contractor.

3J.4.2 The switchgear shall be assembled on it’s foundation in accordance with the manufacturer’s and IEEE C37.20.1 recommendations. The switchgear dimensions and weight are shown on the drawings.

3J.4.3 Switchgear sections shall be attached to the floor as specified on the drawings, leveled and aligned, and mechanical connections between panel shipping sections shall be completed, as applicable.

3J.4.4 The Owner will do the final functional testing and commissioning of the switchgear after final protective relay testing is complete.

3J.4.5 The Contractor shall ensure that all breakers and relays shall be installed and made ready for the pre-operation check.

3J.4.6 The Contractor shall ensure that all power cables terminations are completed with the correct phasing arrangement.

3J.4.7 The Contractor shall ensure that the grounding terminations are consistent with the Owner’s grounding practices throughout the station for power equipment in this voltage classification.
3J.4.8 The Contractor shall ensure that after installation, any remaining shipping protection shall be removed and the switchgear shall be checked to ensure that they are in good condition and to discover any hidden damage to finish, instruments, or equipment. All protective relays, instruments, meters and other devices shall be checked for physical damage.

3J.4.9 Particular care shall be used in the installation of switchgear to ensure that support, bracing, and hold down details are properly installed, with bolts and fasteners tightened to the specified vendor’s torque values.

Section 3K (260000) - BATTERY AND BATTERY CHARGERS

3K.1 GENERAL

Battery cells are not to be stored for more than the time period recommended by the manufacturer without applying a charge to the battery. In all cases, a period of 3 months storage of the battery is allowable between charges if the cells are stored in a clean, dry, cool location without exposure to extremely low ambient temperatures or localized sources of heat.

No battery installation shall be initiated until appropriate permanently installed or portable eyewash stations are available and operational.

After the eyewash station is installed and operational, the Contractor shall then immediately install and connect the battery and battery charger and prepare them for operation. A temporary power supply shall be connected to the battery charger and shall be maintained in service until permanent power supplies are installed and ready for continuous service. The source for the temporary power supply shall be as selected by the Owner as being the most reliable. The Contractor shall check with the Owner should a temporary portable battery trailer be required to facilitate the installation/replacement of the existing batteries and charger.

3K.1.1 Assembly. The assembly of the battery and battery rack shall be in accordance with the manufacturer’s recommendations and assembly instructions.

a. The individual cells shall be lifted onto the rack using the lifting equipment recommended by the battery manufacturer. Cells shall be lifted by the bottom of the case and not by the cell posts. Cells shall be placed on the designated racks and checked for positive to negative connections throughout the battery prior to the installation of inter-cell connectors.
b. Prior to installing inter-cell connectors, the Contractor shall inspect all terminal posts and connecting hardware. Any area showing evidence of corrosion, dirt, or acid shall be cleaned by rubbing gently with a brass suede brush or fine emery paper, exercising care to prevent removal of lead plating. A thin film of corrosion inhibiting grease shall be applied to all contact surfaces. Inter-cell connections shall be completed with connectors and associated hardware supplied by the battery manufacturer. Where more than one inter-cell connector per cell post is required, the connectors shall be mounted on opposite sides of the post for maximum surface contact. Both ends of the connection bolts shall be tightened to the manufacturers recommended torque values.

c. All cell covers and containers shall be cleaned. A water moistened clean wiper shall be used for the removal of dust and dirt. A bicarbonate of soda and water moistened wiper shall be used for cleanup of electrolyte spillage. All wipers used shall be free of oil distillates. Explosion resistant vent plugs shall be installed where provided. Individual cell numbers in sequence with No. 1 at the positive (+) end of the battery shall be applied for permanent identification.

d. The Contractor shall measure the voltage of the battery to ensure that individual cells are connected correctly. If the measured voltage is less than approximately the number of cells multiplied by the measured voltage of one cell, the individual cell polarities shall be rechecked.

e. The Contractor shall measure and record inter-cell connection resistance. Any connection with a resistance measurement exceeding 10 per cent above the average shall be remade and re-measured.

f. Final connections from the battery to the charger and dc system shall be installed after assembly of the battery has been completed.

g. After the battery assembly is complete to the stage of inter-cell connections, the Contractor shall protect the battery from construction dirt and debris.

3K.1.2 Maintenance Inspections and Testing. All applicable Substation Maintenance Procedures (SMP) for acceptance testing of chargers and batteries installed shall be followed.

Refer to the following SMP for inspection and acceptance procedures.
- SMP406.03.2 Battery Charger Procedure
- SMP406.01.2 Lead Acid Battery Procedure
- SMP406.02.2 Nickel-Cadmium Battery Procedure
3K.1.3 Records and Documentation. All applicable Battery and Charger Inspection Cards shall be completely filled out to document acceptance testing performed and provided to the Owner.

- SMP406.03.3 Battery Charger Inspection Card
- SMP406.01.3 Lead Acid Battery Inspection Card
- SMP406.02.3 Nickel-Cadmium Battery Inspection Card

Section 3L (260000) – DISCONNECT SWITCHES

3L.1 General Description

3L.1.1 Provide all labor, materials, tools, equipment, accessories, and services necessary to unload and install the specified disconnect switches in their permanent location per the contract drawings and as described in this specification.

3L.1.2 The work of this section includes but is not limited to the following principal items:

a. Removal of all shipping members and protective covering.

b. Mounting of disconnect switches on the structures as indicated on the Owner’s drawings and per the manufacturer’s installation instructions.

c. Terminating the line and load end of the cable and cable connections per Owner’s instructions. Ensuring the phase connections are correct.

d. If the disconnect switch contains a motor operator, the Contractor shall be responsible for installing the motor operator, the motor operator boxes, all linkages, and all accessories required for the complete electrical operation of the disconnect switch.

e. The Contractor shall install, test, and or commission the disconnect switches in accordance with the requirements in the applicable disconnect switch SMS and SMP standards and procedures listed in the Substation Field Issue.

3L.2 Materials Delivery, Storage, and Rigging

3L.2.1 Store materials properly to prevent theft, damage, deterioration and inclusion of foreign matter. Packaged materials delivered must be kept in the original shipping cartons to avoid loss of parts.

3L.2.2 Handle the disconnect switches using the proper handling equipment for the job in accordance with the manufacturer’s recommendations.
3L.3 Quality Assurance

3L.3.1 Codes and Standards

a. Comply with the provisions of all applicable IEEE standards and ANSI codes, unless otherwise specified within.

3L.4 Procurement

3L.4.1 Generally, the Owner will procure and supply the disconnect switches. However, this will generally be called out on the Bill of Materials for the job. The Contractor shall furnish all miscellaneous material that may not be included on the Bill of Materials to complete the disconnect switch installation.

3L.5 Transportation Requirements

3L.5.1 Unless otherwise specified, The Contractor shall be responsible for transporting the disconnect switches their storage facility to the jobsite. The Contractor shall coordinate arrival at this storage facility for pickup with Owner’s personnel ahead of time by communicating this through the Construction Supervisor. The Contractor should inspect the disconnects at the storage facility for any damage prior to moving it to the jobsite and shall inform the Owner of any defects found prior to starting the moving procedure.

3L.6 Installation

3L.6.1 The Contractor shall install the disconnect switches in accordance with the approved Owner’s drawings, this specification, and the manufacturer’s installation instructions. Any rigging required shall be supplied by the Contractor.

3L.7 Testing

3L.7.1 The Contractor shall supply testing and commissioning support if requested by the Owner. Refer to the scope of work in Substation Field Issue.
Section 3M (265000) - TESTING AND COMMISSIONING

3M.1 GENERAL

Generally, the Owner will perform all final functional tests and commissioning, unless otherwise directed in the summary of work section. The Contractor shall provide all Owner requested support and assistance so that the Owner may fully complete this testing and commissioning. All installation deficiencies detected by the Owner prior to, during, or after the final testing shall be corrected by the Contractor at the Contractor’s expense. The individuals performing the final testing and commissioning, whether employed by the Owner, or by the Contractor, shall follow the “Substation Commissioning and Energization” procedure SMP480.01.2. This procedure will contain all references to the required SMS and SMP standards & procedures, including the cards required to be filled out for the testing and energization phase of the project. All questions regarding the applicability of these standards and procedures, and how they are to be used, shall be directed to the Construction Supervisor for the project.
DIVISION 4 - UNDERGROUND CONSTRUCTION

Section 4A (260000) - CONTRACTOR FURNISHED MATERIALS

4A.1 GENERAL

The Contractor shall furnish all equipment and materials, except those specified herein to be furnished by the Owner or other contractors, as necessary to make a complete operational installation as shown on the Drawings and this Specification. Contractor shall be responsible for determining the quantities of material required. The content of this Specification does not necessarily cover all design details and features. The right is reserved to require modifications of construction details or operational features which may not have been discussed in this Specification and which, in the estimation of the Owner, are substandard or undesirable.

4A.1.1 ENGINEERING DATA. The Contractor shall submit drawings to the Owner for acceptance on all major items of material it is required to furnish by this Specification. The Contractor shall submit drawings which adequately indicate the general arrangement of major items of material, principles of operation, sizes, general appearance, and materials of construction.

4A.1.2 CORRECTION OF MANUFACTURING ERRORS. The materials shall be complete in all respects within the limits herein outlined as determined by the Owner. All manufacturing errors or omissions required to be corrected in the field shall be done by the Contractor at his expense, or if done by the Owner, the cost of the same shall be deducted from the contract price.

4A.1.3 MATERIAL LISTS. The Contractor shall furnish all the items labeled or noted as “By Field” on the drawings and Material Lists contained in the Substation Field Issue.

4A.2 INSTALLATION

The Contractor shall install all materials in a neat and workmanlike manner. All work shall be in accordance with the best practices of the electrical construction industry. The completed installation shall provide a minimum of hazard to personnel and shall not interfere with the use, as intended, of the area in which they are installed.

Section 4B (260000) - OWNER FURNISHED MATERIALS

4B.1 GENERAL

Owner-furnished equipment and materials are identified in the Substation Field Issue. Delivery dates and estimated weights for major pieces of Owner-furnished electrical equipment and materials are also included in the Substation Field Issue. All other material and equipment not supplied by the Owner shall be supplied by the Contractor.
REVISION HISTORY

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Description of Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>07/01/08</td>
<td>First version of new document based on existing NE and NY documents.</td>
</tr>
</tbody>
</table>
APPENDIX A

INDUSTRY CODES AND STANDARDS

All work performed by Contractor for this project shall comply with the latest applicable federal, state, local, and municipal codes and standards and applicable industry standards including but not limited to the following:

AISC - American Institute of Steel Construction
AISC Code - Code of Practice
AISC Manual - Manual of Steel Construction
AISC Q.C. - Quality Criteria and Inspection Standards
AWS - American Welding Society
AWS A2.4 - Symbols for Welding and Nondestructive Testing
AWS A3.0 - Welding Terms and Definitions
AWS A5.1 to A5.23 - Specifications for Welding Electrodes
AWS A6.1 - Recommended Safe Practice for Gas-Shielded Arc Welding
AWS D1.1 - Structural Welding Code - Steel
AWS D1.3 - Structural Welding Code - Sheet Steel
OSHA - Occupational Safety and Health Act
NEC - National Electric Code
NEMA - National Electrical Manufacturers Association
NESC - National Electric Safety Code
IEEE - Institute of Electrical and Electronic Engineers
ANSI - American National Standards Institute
ASME - American Society of Mechanical Engineers
UL - Underwriters Laboratories
SSPC - Steel Structures Painting Council
SSPC-PA1 - Shop, Field and Maintenance Painting
SSPC Vis 1 - Guide to Vis 1 - Pictorial Surface Preparation Standards for Painted Steel Surfaces
APPENDIX A

SSPC-SP - Surface Preparation Specifications
SSPC-SP2 - Hand Tool Cleaning
SSPC-SP3 - Power Tool Cleaning
SSPC-SP6 - Commercial Blast Cleaning
IEEE 980-1994 “Guide for Containment and Control of Oil Spills in Substations”
NECA/NEMA 105-2002, “Recommended Practice for Installing Metal Cable Trays (ANSI)”
IEEE C57.93 “Guide for Installation of Liquid-Immersed Power Transformers-Revision of ASA C57.93-1958”

Standards, specifications, manuals, codes and other publications of nationally recognized organizations and associations are incorporated by reference as if fully set forth herein. References to these documents are to the latest issue date of each document, unless otherwise indicated, together with the latest additions, addenda, amendments, supplements, etc., thereto, in effect as of the date of Contract for the work.

References throughout the Specification to specific articles or paragraphs of the foregoing Standards are convenience only and shall not relieve the contractor from all obligations of the applicable requirements of the standards.

In the event of conflict between the foregoing standards and the Specification or the Drawings in the Substation Field Issue, the Specification and the Drawings shall govern.
INTRODUCTION

This procedure shall be followed to ensure that National Grid substation projects are commissioned into service in a consistent manner and without risk to personnel safety, substation equipment, or system stability.

PURPOSE

The purpose of this procedure is to:

Define the electrical testing and testing documentation requirements for the project.

Define the procedures for approval and energization for new substations or substation additions.

ACCOUNTABILITY

Project Managers, Distribution Operations, O&M, and Construction & Services organizations involved in Substation Project Commissioning shall ensure that all appropriate sections within this procedure are complied with.

APPLICABILITY

Project Managers shall ensure that Commissioning and Energization roles and responsibilities are defined and assigned to specific individuals at the time of the initial project meeting as required based on the scope and complexity of the project. Specific maintenance and relay procedures that shall be followed for the testing and documentation requirements for the project shall be identified at that time.

REFERENCES

National Grid Substation Maintenance Standards – SMS
National Grid Substation Maintenance Procedures – SMP
National Grid System Protection – Relay Procedures PR’s
Engineering Document PR.09.03.000 - Project Execution
Investment Recovery Document Substation Decommissioning Procedure IRP 313.2

DEFINITIONS

Energization Plan - A step-by-step switching and testing document used to perform the initial energization of electrical apparatus and protection systems

Transmission Outage Application (TOA) - A process used to request and schedule system outages and clearances for transmission and distribution substation and circuits

OFF-LOAD Testing - Testing that is performed prior to energization (out of service tests) documented through the use of the ACCEPTANCE CERTIFICATE (Appendix E) by each respective team member assigned to perform the specified tests

ON-LOAD TESTING - Testing that is performed after initial energization (in service tests) documented through the use of the ACCEPTANCE CERTIFICATE (Appendix F) by each respective team member assigned to perform the specified tests.
**TRAINING**

The Owner will define any required training based on type of apparatus being installed and/or changes in operating procedures.

The Installer shall conduct any necessary training on new equipment for the Owner’s personnel. This training is limited to on-site discussions and demonstrations during the initial tests and/or during the commissioning energization process.
## DOCUMENT CONTENTS

Table of Contents

1.0 DEFINITION OF ROLES AND RESPONSIBILITIES .................................................. 5
2.0 GENERAL ............................................................................................................. 6
3.0 OWNER RESPONSIBILITIES .............................................................................. 6
4.0 CONSTRUCTOR RESPONSIBILITIES ................................................................. 6
5.0 CONSTRUCTION SUPERVISOR RESPONSIBILITIES ..................................... 7
6.0 TESTER RESPONSIBILITIES ............................................................................. 8
7.0 ENERGIZATION COORDINATOR RESPONSIBILITIES ................................. 9
8.0 WORK PLANS, SCHEDULES, AND NOTIFICATIONS ................................... 10
9.0 GENERAL TESTING REQUIREMENTS ............................................................ 11
10.0 TEST EQUIPMENT REQUIREMENTS ............................................................ 11
11.0 CONTROL BUILDING AND YARD TEST REQUIREMENTS ........................... 12
12.0 ELECTRICAL APPARATUS TEST REQUIREMENTS ..................................... 15
13.0 CONTROL CABLE AND WIRING TESTING ............................................... 18
14.0 TESTER SUPPORT OF CONSTRUCTION PERFORMING WIRING ............... 19
15.0 PRE-COMMISSIONING RELAY AND CONTROL CIRCUIT TESTING .......... 19
16.0 RELAY AND CONTROL CIRCUIT TEST REQUIREMENTS .......................... 20
17.0 REMOTE TERMINAL UNIT (RTU) COMMISSIONING .................................. 24
18.0 PANEL METER COMMISSIONING ................................................................. 25
19.0 REVENUE METER COMMISSIONING ........................................................... 26
20.0 TRAINING ......................................................................................................... 26
21.0 DOCUMENTATION AND REPORTING REQUIREMENTS .......................... 27
22.0 RELAY AND WIRING TESTING DOCUMENTATION .................................... 30
23.0 EQUIPMENT/RELAY MMS DATA FORMS .......................................................... 31
24.0 POWER EQUIPMENT DECOMMISSIONING WORKSHEET .......................... 31
25.0 ENERGIZATION PROCESS ........................................................................... 32
26.0 APPENDIX A - ENERGIZATION COORDINATOR (EC) CHECKLIST .............. 38
27.0 APPENDIX B – CONSTRUCTION SUPERVISOR (CS) CHECKLIST .................. 40
28.0 APPENDIX C – TESTER (T) CHECKLIST ...................................................... 42
29.0 APPENDIX D – COMMISSIONING & ENERGIZATION TEAM MEMBER LIST .... 44
30.0 APPENDIX E – ACCEPTANCE CERTIFICATE – PART 1 ............................... 47
31.0 APPENDIX F – ACCEPTANCE CERTIFICATE – PART @ ............................... 48
32.0 APPENDIX G – AC POTENTIAL CIRCUIT INJECTION FORM ...................... 49
33.0 APPENDIX H – AC POTENTIAL CIRCUIT SECONDARY INJECTION FORM .... 50
34.0 APPENDIX I – CT 1 PH SECONDARY INJECTION FORM ............................. 51
35.0 APPENDIX J – 3 PH SECONDARY INJECTION FORM ................................. 52
36.0 APPENDIX K – CT EXCITATION FORM ....................................................... 53
37.0 APPENDIX L – FUNCTIONAL TRIP TEST FORM ........................................ 54
38.0 APPENDIX M – IN SERVICE /LOAD CHECK FORM ..................................... 60
39.0 APPENDIX N – OPEN LINK / LIFTED LEAD / JUMPER REMOVED LOG SHEET .... 61
40.0 APPENDIX O – RELAY OPERATING TEST FORM ....................................... 62
41.0 APPENDIX P – RELAY TEST LEAD FORM ............................................... 63
42.0 APPENDIX Q – WAVE TRAP / LINE TUNER ............................................. 64
43.0 APPENDIX R – SCHEME TEST SAMPLE FORMS ....................................... 66
44.0 APPENDIX S – EQUIPMENT DATA FORMS - RELAYS .............................. 68
45.0 REVISION HISTORY .................................................................................... 69
1.0 DEFINITION of ROLES and RESPONSIBILITIES

Note: Individuals are selected during the Commissioning and Energization meeting to perform the requirements of this procedure and may be management or representative individuals.

1.1 Constructor

National Grid employees or contractor responsible for the project physical installation and connection of structural components, electrical apparatus, and/or associated control, protection, and metering systems.

1.2 Construction Supervisor

A National Grid management employee (System Delivery Supervisor, PTO Supervisor, Substation Supervisor, etc.) assigned to coordinate and oversee all construction activities of internal resources or external contractors. The CONSTRUCTION SUPERVISOR will ensure the project is constructed according to established specifications and be a liaison with the Energization Coordinator.

1.3 Energization Coordinator

A National Grid management employee designated by O&M Services responsible to ensure all tests have been performed and results received are complete and acceptable for the operation and energization of the system. In addition, ensures Transmission Outage Applications (TOA) are in affect or submitted for the energization of installed electrical apparatus or systems.

The position is supported internally by National Grid Test personnel from Relay, Telecom, Meter, and Station O&M as required to ensure the collection of required data and reports necessary to certify the substation and apparatus are ready for service.

The ENERGIZATION COORDINATOR may request from the appropriate department management the individuals for the respective area of responsibilities to be assigned.

1.4 Owner

National Grid or designated representative responsible for the project.

1.5 Project Manager

A National Grid or designated representative responsible for all aspects of the project as outlined in the Project Management Playbook.

1.6 Tester

National Grid Testers from Relay, Telecom, Meter, Stations O&M or TEST CONTRACTOR employees that verify the proper installation of electrical apparatus and components as well as performing all required startup testing and documentation as required by National Grid. Testing includes, but is not limited to, electrical apparatus and equipment acceptance testing, electrical testing, and the testing of associated control, protection, and metering systems.
2.0 GENERAL

All substation apparatus and components must be installed, tested, and commissioned in accordance with National Grid Procedures. When these procedures do not specifically address specific tests, the manufacturer’s recommendations or standard industry practices shall be followed.

Specific approvals must be obtained for any procedural deviation or alternate tests requested by contacting the appropriate National Grid Procedures Administrators.

Final on site commissioning and energization shall be performed or witnessed by National Grid Personnel.

3.0 OWNER RESPONSIBILITIES

3.1 The Owner shall:

3.1.1 Advise of any project related installation or testing that will not be part of the work scope.

3.1.2 Notify of work site locations and connections to Interconnected Utilities related to the project.

3.1.3 Advise of any approved suppliers, manufacturers, or other vendors for installation and/or testing of electrical apparatus that will be performed as part of the project under the CONSTRUCTOR’s/TESTER’s direction.

3.1.4 Provide all protective relay settings.

3.1.5 Supply revenue meters for the project.

3.1.6 Arrange for the required telephone circuits.

4.0 CONSTRUCTOR RESPONSIBILITIES

4.1 The Constructor shall:

4.1.1 Be responsible to ensure all precautions have been taken to guarantee personnel safety and prevent equipment damage.

4.1.2 Notify the OWNER when any secondary work involving the interconnection to in-service systems is planned. Notification format and documentation forms shall be discussed and agreed to during the initial project team meeting.

a. The CONSTRUCTOR shall be responsible to ensure connection safeguards are installed and removed as necessary.

b. The CONSTRUCTOR shall maintain a report describing the safeguards used, reasons for use, and where applied.
4.1.3 Ensure that all safety aspects of the project are addressed during construction. This shall include but is not limited to:

a. Clearance and Control requirements
b. Work area identification
c. Eyewash stations, portable or permanent
d. Fire fighting equipment
e. Personal Protective Equipment
f. Safe Work Practices

4.1.4 Request any outages required to perform construction, including the date, time, and duration, from the CONSTRUCTION SUPERVISOR.

4.1.5 Immediately inform the OWNER, and provide written documentation, of any equipment related problems, issues, (i.e. foundation, structural or apparatus damage) or discrepancies.

4.1.6 Inspect and verify controls or secondary systems for equipment being removed from service and remaining in place are disconnected and isolated and made safe from inadvertent energization or operation.

4.1.7 Document new, removed, or decommissioned electrical apparatus using the appropriate documentation requirements, report formats, and forms as described in this procedure.

4.1.8 Identify other maintenance or testing requirements during the course of the project and inform the ENERGIZATION COORDINATOR for direction.

4.1.9 Arrange for the required telephone circuits. As the construction activities progress, (apparatus placement, cabling, terminations, wiring) the CONSTRUCTOR will inform and coordinate with the TESTER the required acceptance and electrical testing in accordance with the work schedule. Acceptance and testing should not be deferred until the end of the project unless agreed to by the OWNER.

4.1.10 Appropriate outages or coordination shall be conducted in order to schedule and complete testing requirements.

5.0 CONSTRUCTION SUPERVISOR RESPONSIBILITIES

5.1 The Construction Supervisor shall:

5.1.1 Manage all aspects of field construction including the activities of the CONSTRUCTOR and TESTER. Specific activities are included in the text of this procedure and checklists in the appendices section.

5.1.2 When connections to existing circuits (live or dead) are scheduled, investigate the construction plan and methodology to ensure other equipment within the substation, energized transmission lines, and the power grid have neither their reliability nor integrity compromised.
6.0 TESTER RESPONSIBILITIES

6.1 The Tester shall:

6.1.1 The TESTER has responsibility for the testing and commissioning work including supplying the required trained personnel, test equipment, hardware, vehicles, manlifts, ladders, harnesses, power supplies or other apparatus or materials to complete the equipment tests and comply with the applicable safety regulations.

6.1.2 Perform acceptance, calibration, and performance tests of all new electrical apparatus, systems and circuits required for commissioning and energization.

   a. This includes all the electrical tests associated with new installations and the associated tests required to integrate new installations into existing energized facilities following existing testing procedure documents.

   b. This includes any tests that may be required or recommended by the equipment manufacturers and shall be stated at the Commissioning and Energization Project Team Meeting. Follow equipment manufacturers test requirements if there are no existing test procedures.

   c. These tests establish the equipment initial condition and provide a baseline for future maintenance work.

   d. Testing shall verify that all components perform satisfactorily both electrically and mechanically at their specified rating. The majority of the testing is normally performed at the substation location under construction. However, testing work may also be required at locations other than the Owner's facilities. Exceptions to on-site testing are to be discussed in advance with the CONSTRUCTION SUPERVISOR.

   e. Verify all equipment alarm and status points are connected and function properly. This includes connections to the input points of Remote Terminal Units (RTU) and Event Recorders.

   f. As the construction activities progress (apparatus placement, cabling, terminations, wiring) the TESTER shall perform the required acceptance and electrical testing in accordance with the work schedule. Acceptance and testing should not be deferred until the end of the project unless agreed to by the OWNER.

   g. Coordination with interconnecting utilities (end-to-end) tests may be required.

6.1.3 The TESTER shall meet with the Owner’s PTO, O&M Services, Substation Supervisor, or System Delivery Supervisor to review project requirements specific for the work to be performed.

6.1.4 The OWNER will supply an example of a typical Test Plan for the TESTER’s use. The Test Plan will include all the standard steps and procedures to test and commission an equivalent facility (i.e. specific macros used for relay or device testing).
6.1.5 It is the TESTER’s responsibility to ensure the OWNER’s standard procedures and documentation are used, using the OWNER approved version of software for Doble test equipment or other manufacturer’s device specific protocols or software.

6.1.6 The TESTER is responsible to ensure testing to be performed has been communicated, and permission to proceed has been received, from the CONSTRUCTION SUPERVISOR.

6.1.7 The TESTER shall test all secondary devices as described in this document.

6.1.8 Protective relays shall be tested by using a programmable current and voltage sources, personal computer and ProTest (Doble Engineering) software and test programs specified by the Owner.

6.1.9 The applicable sections of National Grid Procedures and Standards shall be followed for installation and testing of electrical apparatus and relays being installed.

6.1.10 National Grid will supply the CONSTRUCTOR/TESTER with electronic or paper copies of Procedures and Standards required by the project.

6.1.11 All applicable Substation Maintenance Procedures are listed in SMS 400.00.1 – List of Substation Maintenance Documents and Protection Systems Relay Maintenance Documents.

6.1.12 The TESTER shall submit the following documentation and qualifications:

   a. A reference list with contact personnel names, addresses and emails.
   b. Resumes for all personnel involved with the work.
   c. Employee training and certification such as ANSI Standard ANSI/NETA ETT-2000 (Standard for Certification of Electrical Testing Technicians) or equivalent
   d. Summary of the Installer’s company experience over the past five years
   e. Sample test reports using ProTest Software for relay testing over the past five years.

7.0 ENERGIZATION COORDINATOR RESPONSIBILITIES

7.1 The Energization Coordinator shall:

    7.1.1 Manage the energization of the facility and coordinate activities of the CONSTRUCTION SUPERVISOR and TESTER as outlined but not limited to in this procedure. Specific activities are included in the text of this procedure and checklists in the appendices section.
8.0 WORK PLANS, SCHEDULES, and NOTIFICATIONS

8.1 Work Schedules

8.1.1 Tester shall prepare and submit to the OWNER a schedule for all acceptance tests.

8.1.2 Tester shall designate a principal or on-site contact person who shall be present, as required, during construction and testing.

8.2 Work Sequence Schedule

8.2.1 Tester shall prepare schedule which shows:

- Date of mobilization on the site
- A specific outage plan as required
- Approximate date for each piece of equipment to be tested or alternatively how the testing will be coordinated with the construction activities
- Starting and ending time duration for each test. These times shall incorporate levelized manpower so there will be sufficient people to complete these tests as required by the commissioning schedule. The TESTER shall work with OWNER to ensure all apparatus, components, and hardware are safe, ready for service and properly calibrated and tested.
- Any discrepancies or irregularities observed by the TESTER shall be identified in writing and communicated immediately to the CONSTRUCTION SUPERVISOR of the specific test conducted. The CONSTRUCTION SUPERVISOR and TESTER shall meet to resolve the issue. Others will be invited to attend as required by the Owner.

8.3 Test Plan Outline

8.3.1 Tester shall prepare and submit to the OWNER a plan outlining:

- Scope of work
- List of Reference documents
- Identify in a table format all hardware, apparatus, components, relays, or other devices to be tested.
- List of tests to be executed or witnessed and the specific test procedure or specification reference, which describes the test.

8.4 Initial Test Results

8.4.1 Upon completion of a specific test, the TESTER shall provide results to the OWNER per the timeframe agreed to at the project initiation.

8.5 Test Notification

8.5.1 The OWNER shall be notified by the TESTER a minimum of five days in advance of all tests.

8.6 Project Meeting Attendance
8.6.1 The TESTER shall be available to meet with the OWNER on-site or at the project office location specified at a minimum of once every two weeks to review the progress of the work completed. During the outage period the meeting frequency shall be increased as necessary but at the minimum of once every week. Additional meetings may be required periodically with the OWNER, manufacturers, etc. These meetings will be held at a site determined by the OWNER and all participants shall be informed of the meeting details. The TESTER shall attend all scheduled meetings.

8.7 Progress Reports
8.7.1 In a format approved by the OWNER, the TESTER shall submit weekly progress reports, or on a timeframe agreed to, that includes the equipment or systems tested, personnel on-site, schedule compliance, percent completed and percent of tests remaining, discrepancies identified and any other relevant information regarding the facility testing or commissioning.

8.8 Work Documentation
8.8.1 On certain projects it will be necessary to have corrections updated on construction drawings and new drawings reissued for National Grid personnel to complete final commissioning work. The OWNER will determine when this is required.

9.0 GENERAL TESTING REQUIREMENTS

9.1 The Owner reserves the right to witness all test activities.

9.2 Technical Inquires / Variances / Approvals
9.2.1 As technical questions arise the TESTER shall contact the CONSTRUCTION SUPERVISOR. The CONSTRUCTION SUPERVISOR may delegate this requirement on a case-by-case basis to a member of the project team. The CONSTRUCTION SUPERVISOR shall maintain the list of inquiries and problems along with resolutions as part of the project documentation requirements.

9.3 Relay Settings Modifications
9.3.1 There shall be no changes to any relay settings without the explicit approval of the OWNER’s Protection Engineer. Any recommended changes by the TESTER shall be submitted in writing with a detailed explanation for the modification prior to making any modifications to installed components.

10.0 TEST EQUIPMENT REQUIREMENTS

10.1 Calibration Documentation
10.1.1 If equipment or instruments being used on the project require periodic calibration by the manufacturer, the TESTER shall provide to the OWNER Certificates of Instrumentation Calibration, traceable to the National Bureau of
### 10.1.2 Refer to National Grid [SMS 400.90.1 Approved Test Equipment](#) for calibration requirements.

### 10.2 Required Test Equipment

10.2.1 Tester shall complete all appropriate electrical apparatus tests utilizing the Doble M4000 Insulation Power Factor Test set with DTAF V5.5 software, Doble M4110 Leakage Reactance module, Doble M5x00 Sweep Frequency Response Analyzer with SFRA V5.1 software, Doble TDR-9000 or TDR-900 Circuit Breaker Analyzer with latest version of T-Doble software.

10.2.2 Other test equipment to be used shall be listed in the [SMS 400.90.1 Approved Test Equipment](#) or as approved by the OWNER.

10.2.3 Tester shall perform protective relay testing using the Doble ProTest software and equipment using the OWNER approved version of software.

### 10.3 Test Results Forms and Formats

10.3.1 Only the National Grid approved documentation forms or electronic formats will be used.

### 10.4 Test Deviation Requests and Approval

10.4.1 If deviation from the specified testing is requested, the TESTER shall obtain approval from the OWNER or his designated representative.

10.4.2 Tester shall maintain the list of requests and approvals received as part of the project documentation requirements.

## 11.0 CONTROL BUILDING and YARD TEST REQUIREMENTS

### 11.1 Ground Grid and Grounding

11.1.1 Ground Grid Resistance test – Perform a ground grid resistance test using a Biddle-Megger Ground Earth Resistance Model DET test set or its equivalent.

11.1.2 Ground Grid continuity to equipment – Verify each piece of equipment in the yard, such as transformers, breakers, regulators, etc. has two grounds connected and measure the resistance to ground using a low resistance ohmmeter.

11.1.3 Ground Grid continuity to structures - Verify that each structure such as columns and stands has one ground lead connected and measure the resistance to ground using a low resistance ohmmeter.

11.1.4 Ground Grid continuity to Control Building - Verify that the grounding system in the control building is connected to the station ground grid and equipment such as control panels, cabinets, raceways, battery racks, etc. inside the building are grounded.
11.1.5 Ground Grid continuity to fence - Verify that the fence is properly grounded per National Grid grounding specification and swinging gates, barbed wire, metal fabric, etc. are properly grounded.

11.2 AC Station Service Checks
   11.2.1 Overcurrent Protection – Verify Fusing and circuit breaker settings.
   11.2.2 Voltage – Measure voltage and record if it is within plus 2.5% minus 2.5% range. On a 120 volts base, this is plus 2.5% (123 volts) minus 2.5% (117 volts).
   11.2.3 Phase Rotation – Verify phase rotation and phase placement on switchboards.
   11.2.4 Transfer Switch – Verify settings, proper operation, and phasing of transfer switch for dual service installations, see Emergency Generator section for requirements for emergency generators.

11.3 Emergency Generator
   11.3.1 Test per manufacturer’s requirements and latest version of SMP and record results on Inspection Card.
      a. SMP 405.01.2 Emergency Generator Procedure
      b. SMP 405.01.3 Emergency Generator Inspection Card

11.4 DC Station Service
   11.4.1 Battery Eyewash – Check that the battery eyewash station is within 25 feet of the battery installation, filled and ready for use. Make sure area immediately beneath eye wash station is clear of obstructions and designated with floor tape markings.
   11.4.2 Battery and Charger and alarms– This testing is performed under section 12.2.
   11.4.3 DC Panel Board – Check that the panel is labeled with voltage and all circuits are identified. Verify overcurrent protection fuse and breaker sizes.
   11.4.4 Ground Test – Test for and clear station battery grounds. Battery grounds must be monitored throughout the construction and commissioning process. The battery shall be tested for grounds at the beginning of each work day and whenever a new DC circuit is energized.
   11.4.5 For dual battery installations, verify that there are no cross connections between batteries. The battery shall be tested for cross connects at the beginning to each work day and when a new DC circuit is energized.

11.5 Control Building Power and Lighting
   11.5.1 Check that the power panels are all labeled with voltage and circuit information.
   11.5.2 Check all receptacles for correct grounding and polarity; check GFI operation.
   11.5.3 Check that all building lighting is functioning.
   11.5.4 Check that all building emergency lighting is functioning.
11.5.5 Check that any special building power receptacles are properly wired with correct grounding and polarity.

11.6 Yard Power and Lighting
11.6.1 Check that the power panels are all labeled with voltage and circuit information
11.6.2 Check all receptacles for proper grounding and polarity; check GFI operation.
11.6.3 Check that all yard lighting and photo, time clock are functioning and can be operated locally and if EMS, controlled remotely.
11.6.4 Check that yard lighting has proper light distribution at night.
11.6.5 Check that all emergency lighting is functioning
11.6.6 Check that all cabinet heaters are functioning.
11.6.7 Check that any special power receptacles are properly wired with correct grounding and polarity.

11.7 Control Building HVAC
11.7.1 Check that building ventilation fans and controls are functioning, control settings made, and any fire or smoke detector shutdown circuits function.
11.7.2 Check that building heaters and controls are functioning, control settings made, and any fire or smoke detector shutdown circuits function.
11.7.3 Check that air conditioning is commissioned per manufacturer’s requirements controls are functioning, control settings made, and any fire or smoke detector shutdown circuits function.

11.8 Control Building Fire Equipment, Fire Alarms, Smoke Alarms
11.8.1 Fire and Smoke alarms - Check that the fire and smoke alarms function and alarm to the RTU if so equipped.
11.8.2 Fire Extinguishers – Check that fire extinguishers are installed and properly labeled.

11.9 Control Building Intrusion Alarms and Security System
11.9.1 Check that the door switches and alarms function and activate the security system
11.9.2 Check the motion sensors function and activate the security system.
11.9.3 Check the station card reader

11.10 Station Signage
11.10.1 Check that all required signage is installed per SMS 400.84.1 Substation Signs and Placards

11.11 Wildlife Control Measures
11.11.1 Check that all wildlife control measures have been installed per drawings and specifications.
11.11.2 Check that the wildlife electric fence is functioning per the manufacturer’s instructions.

11.12 Locking Provisions

11.12.1 Ensure the proper level of locking provisions have been installed for perimeter, control buildings, and electrical apparatus.

12.0 **ELECTRICAL APPARATUS TEST REQUIREMENTS**

12.1 The Owner shall:

12.1.1 Provide the required National Grid Substation Maintenance Procedures (SMP) for the electrical apparatus or systems that are being installed. The TESTER shall refer to the Acceptance Test section of the SMP for the required inspections and testing to be performed. The corresponding Inspection Card(s) and Equipment Data Forms shall be filled out by the TESTER and submitted to the ENERGIZATION COORDINATOR.

12.2 Approval by Energization Coordinator

12.2.1 Any deviation from Procedures shall be approved by the ENERGIZATION COORDINATOR in writing prior to performing any acceptance or electrical testing.

12.3 Requirements by Energization Coordinator

12.3.1 Substation Maintenance Procedures and Inspection Cards may also be provided to the TESTER as required by the ENERGIZATION COORDINATOR.

12.4 SMS 400.00.1 List of Substation Maintenance Documents

Refer to SMS 400.00.1 for a complete list of documents. The relevant list of documents is listed below.

12.4.1 Circuit Breakers, Line Reclosers, Vacuum Switches, Sectionalizers and other circuit interrupting devices –

a. The mechanism for all circuit interrupting devices shall be inspected per:
   - SMP 401.20.2 Circuit Breaker Mechanism Procedure
   - SMP 401.20.3 Circuit Breaker Mechanism Inspection Card

b. Vacuum Circuit Breakers will be tested per:
   - SMP 401.03.2 Vacuum Circuit Breaker Procedure
   - SMP 401.03.3 Vacuum Circuit Breaker Inspection Card

c. Gas Puffer Circuit Breakers will be tested per:
   - SMP 401.06.2 Gas Puffer Circuit Breaker Procedure
   - SMP 401.06.3 Gas Puffer Circuit Breaker Inspection Card
d. For other types of circuit interrupting devices, refer to SMS 400.00.1 to find the correct procedure and inspection card.

12.4.2 Power Transformers – Refer to the specific version of SMP 402.xx.x for the type of Transformer being tested.

a. Transformers shall be received per:
   SMP 402.11.2 Power Transformer Installation and Acceptance Procedure
   SMP 402.13.2 Power Transformer Delivery Inspection Procedure
   SMP 402.13.3 Power Transformer Delivery Inspection Card

b. Transformers 15 MVA and above shall be tested per:
   SMP 402.01.2 Transformer 15 MVA and Above Procedure
   SMP 402.01.3 Transformer 15 MVA and Above Inspection Card

c. Transformers 2.5 to 14.9 MVA and other smaller transformers shall be tested per:
   SMP 402.02.2 Transformer 2.5 to 14.9 MVA Procedure
   SMP 402.02.3 Transformer 2.5 to 14.9 MVA Inspection Card

12.4.3 Instrument Transformer
   SMP 403.01.2 Instrument Transformer Procedure
   SMP 403.01.3 Instrument Transformer Inspection Card

12.4.4 Voltage Regulating Equipment – Test per the following SMP. If the station has a paralleling scheme test, ensure that the scheme maintains a difference of no more than two(2) step positions. The OWNER will supply all settings for the voltage regulating device.
   SMP 404.01.2 Step Voltage Regulator Procedure
   SMP 404.01.3 Step Voltage Regulator Inspection Card
   SMP 412.01.2 Load Tap Changer (LTC) Procedure
   SMP 412.01.3 Load Tap Changer (LTC) Inspection Card

12.4.5 Battery and Charger System – Test per the following SMP. Check that all Battery alarms operate to the station annunciator and RTU. Check for and clear battery grounds.
   SMP 406.01.2 Lead/Acid Battery Procedure
   SMP 406.01.3 Lead/Acid Battery Inspection Card
   SMP 406.02.2 Nickel-Cadmium Battery Procedure
   SMP 406.02.3 Nickel-Cadmium Battery Inspection Card
   SMP 406.03.2 Battery Charger Procedure
   SMP 406.03.3 Battery Charger Inspection Card
<table>
<thead>
<tr>
<th>Specification No. 103014-Above Grade Version 1.2 - 01/25/10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUBSTATION MAINTENANCE</strong></td>
</tr>
<tr>
<td><strong>Procedure</strong></td>
</tr>
<tr>
<td><strong>Substation Commissioning and Energization</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>12.4.6 Bushing Potential Device – Test per below SMP. Adjust output voltage per manufacturer's instructions to obtain correct output voltage.</td>
</tr>
<tr>
<td>SMP 407.01.2 Bushing Potential Device Procedure</td>
</tr>
<tr>
<td>SMP 407.01.3 Bushing Potential Device Inspection Card</td>
</tr>
<tr>
<td>12.4.7 CCVT – Test per below SMP. Adjust output voltage per manufacturer's instructions to obtain correct output voltage.</td>
</tr>
<tr>
<td>SMP 407.02.2 Coupling Capacitors and CCVT Procedure</td>
</tr>
<tr>
<td>SMP 403.02.3 Coupling Capacitors and CCVT Inspection Card</td>
</tr>
<tr>
<td>12.4.8 Wave Trap – Test per:</td>
</tr>
<tr>
<td>SMP 407.03.2 Wave Trap Procedure</td>
</tr>
<tr>
<td>SMP 407.03.3 Wave Trap inspection Card</td>
</tr>
<tr>
<td>12.4.9 Capacitor Banks – Test per:</td>
</tr>
<tr>
<td>SMP 408.01.2 Station Capacitor Bank Procedure</td>
</tr>
<tr>
<td>SMP 408.01.3 Capacitor Inspection Card</td>
</tr>
<tr>
<td>12.4.10 Disconnect Switches – Test per:</td>
</tr>
<tr>
<td>SMP 409.01.2 Disconnect Switch Procedure</td>
</tr>
<tr>
<td>SMP 409.01.3 Disconnect Switch Inspection Card</td>
</tr>
<tr>
<td>12.4.11 Circuit Switcher – Test per below SMP</td>
</tr>
<tr>
<td>SMP 409.02.2 Circuit Switch Procedure</td>
</tr>
<tr>
<td>SMP 409.02.3 Circuit Switch Inspection Card</td>
</tr>
<tr>
<td>12.4.12 Metal Clad Bus, Switchgear – Test per below SMP</td>
</tr>
<tr>
<td>SMP 417.02.2 Metal Clad Bus, Switchgear and Station Procedure</td>
</tr>
<tr>
<td>SMP 417.02.3 Metal Clad Bus, Switchgear and Station Inspection Card</td>
</tr>
<tr>
<td>12.4.13 Surge Arrester – Test per below SMP</td>
</tr>
<tr>
<td>SMP 419.01.2 Surge Arrester Procedure</td>
</tr>
<tr>
<td>SMP 419.01.3 Surge Arrester Inspection Card</td>
</tr>
<tr>
<td>12.4.14 High Voltage Bus – Test per below SMP</td>
</tr>
<tr>
<td>SMP 417.03.2 Open Air Substation Bus Procedure</td>
</tr>
<tr>
<td>12.4.15 Approval by Energization Coordinator</td>
</tr>
<tr>
<td>a. Any deviation from these procedures shall be approved by the OWNER in writing prior to performing any acceptance or electrical testing.</td>
</tr>
<tr>
<td>12.4.16 Requirements by Energization Coordinator</td>
</tr>
<tr>
<td>a. Substation Maintenance Procedures and Inspection Cards shall be provided to the TESTER as required by the OWNER.</td>
</tr>
</tbody>
</table>
13.0 CONTROL CABLE and WIRED TESTING

13.1 Control Cable Verification – Insulation and Continuity Checks

13.1.1 After installation of cables, wires, and cable terminations installed by the CONSTRUCTOR are complete and considered finished, the CONSTRUCTOR shall perform the following steps to confirm cable conductor continuity and insulation integrity. Using a person at either end of the cable or wire with communication, lift the wire, verify continuity and perform the following tasks. This needs to be performed one wire at a time on all wires including spares.

a. Confirm each electrician has the end of the same wire being checked.

b. Verify the cable tag is in place and is correctly numbered at each end.

c. Verify the wire tag is in place, correctly numbered and the color is the same at each end.

d. Inspect the termination, verify the wire insulation is properly stripped, the termination connector/lug is correctly sized and its insulation is correct and proper.

e. Verify the end of the wire is terminated at the correct device terminal. (Check with drawings)

f. Before the wire is re-terminated a 1,000-volt insulation resistance test shall be performed on each conductor, between the conductor and ground by the CONSTRUCTOR. **Note: multiple conductor checks** are not permitted, conductors shall be insulation tested one at a time. The CONSTRUCTOR shall review the insulation resistance tests and report any irregularities to the OWNER.

  g. Re-terminate the wire and physically pull/tug in the wire to confirm that it has seated firmly.

13.1.2 AC and DC Station Service Cables - All interconnecting DC and AC station service cables from the control building to the switchyard shall be checked to be free of shorts or grounds, by 1000volt DC insulation resistance tests

13.1.3 Wiring Drawing Verification – The testing shall be documented on the wiring drawings. **Yellow** pencil or highlighter shall be used to verify circuits that have been checked, **Red** pencil or highlighter shall be used to show conductor changes that need to be added, and **Green** pencil or highlighter shall be used to identify conductor changes that need to be removed

13.1.4 Marked-Up Drawings - Two sets of marked-up drawings shall be made at the jobsite. One set shall be designated a “working copy” and show all modifications made during tests, commissioning etc. The second set shall be the “as-built” drawings and documentation. The OWNER shall have access to both sets at any time.
13.1.5 Lifted Lead and Jumper Log - One commissioned, any wire that is disconnected or if jumpers are installed for testing purpose, this shall be recorded in the Lifted Lead and Jumper Log. Refer to Documentation and Forms Appendix N.

14.0 Tester Support of Construction Performing Wiring

14.1 The Tester shall:
Support the CONSTRUCTOR for projects that involve connections to existing relay and control facilities by:

14.1.1 Review of construction drawings – The construction drawings shall be reviewed for accuracy and required corrections brought to the attention of the OWNER and CONSTRUCTOR. In particular, the AC current and potential wiring drawings should be reviewed for continuity and shorts.

14.1.2 Hold a pre-construction meeting with CONSTRUCTOR performing wiring to review the sequence of construction and agreed upon testing schedule.

14.1.3 Isolate and identify DC and AC inputs to the schemes.

14.1.4 Provide assistance as required to CONSTRUCTOR performing wiring.

14.1.5 The precautions to be taken shall be agreed to and documented and as determined at the project meeting.

15.0 Pre-commissioning Relay and Control Circuit Testing

15.1 Relay and Control Circuit Testing

15.1.1 Prior to starting Relay and Control Circuit Testing, the TESTER shall verify the wiring is correct per schematics, power up the control panels and test the inputs and outputs function as designed.

15.2 Insulation Tests shall:

15.2.1 Only be performed on isolated control cables with no connected devices, cabinets or other components. The CONSTRUCTOR is responsible for continuity and 1,000 volt insulation resistance tests for the control cables and conductors from the control house to the switchyard equipment for all cables the CONSTRUCTOR has pulled and terminated.

15.3 All wiring shall:

15.3.1 Be verified to be connected as per the station’s AC elementary for the AC wiring; or the DC elementary for DC controls.

15.4 Two sets of working prints shall:

15.4.1 Be kept to accurately reflect the exact “point to point” and functional areas of verification. Panel wiring and circuits shall be documented by yellow highlighting the drawings. Corrections shall be noted using green for removals, and red for...
15.5 Device Instruction Books shall:
15.5.1 Be consulted as required to ensure that the equipment is being utilized and wired as specified by the manufacturer.

15.6 DC relaying, control and alarm wiring:
15.6.1 In verifying series and parallel contacts, the TESTER shall operate each contact or combination of contacts to verify they perform their intended function.

15.7 AC relaying and metering wiring (AC secondary):
15.7.1 In verifying potential circuits, an AC secondary voltage should be injected to the circuit and that voltage should be measured at all appropriate points as per the elementary drawings. The TESTER shall ensure that it does not back energize the high voltage sources. Measure and record the burden of the potential circuit. Check that each potential circuit has only one ground connection.

15.7.2 In verifying CT circuits, an AC secondary current should be injected to the circuit. Polarity of the current circuit shall be tested and verified for proper connections as indicated on the drawings. Measure and record the burden of the current circuit. Check that each CT circuit has only one ground connection.

16.0 RELAY and CONTROL CIRCUIT TEST REQUIREMENTS

The TESTER shall test relay and control circuits per this section. This section establishes the minimum tests to be performed for testing of protective relays and related equipment for new installations and does not contain step-by-step procedures for performing the tests.

16.1 Current Transformer
16.1.1 Polarity
16.1.2 Ratios
16.1.3 Excitation
16.1.4 Insulation
16.1.5 Confirm CT location for proper over-lapping of protective zones

16.2 Current Circuits
16.2.1 Location of grounds, insulation test
16.2.2 Secondary signal injection
   a. A test current should be applied as close to the CT terminals as practical. The test should be made from each set of current transformers and include all phase-to-phase-to-neutral combinations. A check should be made at all devices for the presence or absence and polarity of current for each test condition.
16.2.3 All circuits will be marked as tested on elementary drawings (yellow highlighter)
16.2.4 All changes will be marked on elementary and wiring diagrams (green for remove / red for add)
16.2.5 Volt-Ampere Burden
   a. The test should be made at a point as close to the CT terminal as practical. A suggested applied current is 3 amperes. The test should include all phase-to-phase-to-neutral connected burden.

16.3 Potential Transformer
   16.3.1 Polarity
   16.3.2 Ratios
   16.3.3 Insulation
   16.3.4 Confirm VT location for proper voltage sensing of protective zones

16.4 Potential Circuits
   16.4.1 Location of grounds, insulation test
   16.4.2 Secondary signal injection
   16.4.3 All circuits will be marked as tested on elementary drawings (yellow highlighter)
   16.4.4 All changes will be marked on elementary and wiring diagrams (green for remove / red for add)

16.5 Ground Relay Polarizing Circuits
   16.5.1 Current polarizing sources, low voltage / high current test
   16.5.2 Potential polarizing sources, in-service test
   16.5.3 All circuits will be marked as tested on elementary drawings (yellow highlighter)
   16.5.4 All changes will be marked on elementary and wiring diagrams (green for remove / red for add)

16.6 Other Transformer Protection
   The following must be confirmed by field test:
   16.6.1 Fault Pressure
   16.6.2 Low Oil
   16.6.3 Hot Spot CT properly wired
   16.6.4 Over Temperature
   16.6.5 Water Flow
   16.6.6 Other as designed

16.7 Circuit Breakers and Other Interrupting or Insulation Devices
   The following are performed in conjunction with the Substations Department
16.7.1 Trip and trip-free, close and anti-pump
16.7.2 Auxiliary switched – Adjuster to proper operating position
16.7.3 Timing

16.8 Dual Trip Coils on Circuit Boards
16.8.1 Individual test of trip coils
16.8.2 Simultaneous tests of trip coils

16.9 Relays
16.9.1 All testing to be executed in Doble Protest
16.9.2 Sample test plans and data structure will be provided by the local relay office
16.9.3 Electronic test files will be returned to the local relay office

16.10 Relay and Control Circuits (Wiring)
16.10.1 Confirm all wiring circuit checking / ringing / tracing has been completed
16.10.2 Grounds (if any) location and insulation test has been completed

16.11 Relay and Control Circuits (Functional)
16.11.1 Contact logic, functional test of all contact combinations
16.11.2 All DC contact logic chains will be marked (yellow highlighter) as tested on schematic drawings
16.11.3 All changes will be marked on elementary and wiring drawings (green for remove / red for add)
16.11.4 Pilot channels
16.11.5 Transfer Trip
16.11.6 Reclosing
16.11.7 Lockout devices
16.11.8 Breaker failure functional test
16.11.9 Verify all protection (relay or auxiliary device) alarms to EMS
16.11.10 Verify that communication circuit will continue to operate with loss of AC power

16.12 Power Line Carrier
16.12.1 Wave trap – frequency
16.12.2 Wave trap – ground behind trap
16.12.3 Line tuning equipment – alignment to specified frequency – VSWR – re-verify when the line is energized and carrying load.
16.12.4 Transceivers - frequency

16.13 Transfer Trip
16.13.1 Transceivers – frequency
16.13.2 Communication circuits – frequency response
16.13.3 Verify that communication circuit will continue to operate with loss of AC power

16.14 Transient Fault Records
16.14.1 Analog inputs
16.14.2 Digital inputs
16.14.3 Time clock
16.14.4 Remote communications

16.15 End-to-End Tests
16.15.1 The TESTER shall provide the required personnel, equipment, hardware etc. to perform end-to-end tests. In the case of the OWNER’s remote substation protection systems, in a similar manner the TESTER shall supply all the personnel, equipment or support required to complete end-to-end tests.

16.15.2 If interconnecting utilities are involved at remote sites, it will be the OWNER’s responsibility to schedule the required end-to-end tests. The TESTER shall coordinate with the other utilities personnel to complete the necessary tests.

16.16 Load Check (Energized Circuit)
16.16.1 Currents
16.16.2 Voltage
16.16.3 Phase Angles
16.16.4 Manufacturer recommended in-service tests

16.17 Monitor DC Station Service
16.17.1 Ground Test – Test for and clear station battery grounds. Battery grounds must be monitored throughout the construction and commissioning process. The battery shall be tested for grounds at the beginning of each work day and whenever a new DC circuit is energized.

16.17.2 For dual battery installations, verify that there are no cross connections between batteries. The battery shall be tested for cross connects at the beginning to each work day and when a new DC circuit is energized.

16.18 Documentation
16.18.1 Print verification and connections – 3 sets
16.18.2 Relay setting requests and records
16.18.3 Electronic relay test data including ProTest database
16.18.4 Documentation of other tests
16.18.5 All test documentation will be completed and returned to the local relay office for review
16.19 Open Link – Lifted Lead – Jumper Log

16.19.1 After a new panel or cabinet has been determined ready for service by the technicians, a log sheet will be kept at each panel / cabinet so that if any further work needs to be done requiring open links, lifted wires or jumpers to be changed can be tracked. Any changes will be logged on the form with the designation, date, person’s name and reason why. When the work is completed, the responsible person will then date and sign when the links, wires or jumpers are returned to the original state.

16.19.2 During any commissioning phase which requires open links, lifted wires or jumpers to be changed from original positions on existing panels or cabinets a log sheet for that location will be implemented immediately. The responsible person will log on the form the designation, date, person’s name and reason. When the work is completed, the responsible person will then date and sign when the links, wires or jumpers are returned to the original state. This procedure includes any momentary changes necessary to perform the tasks at hand.

16.19.3 At the end of the project, the log sheets from each panel / cabinet will be gathered and saved in the work folder or filed per the local field offices practice.

17.0 REMOTE TERMINAL UNIT (RTU) COMMISSIONING

17.1 Commissioning Document

17.1.1 Verifies the operation of the Energy Management System (EMS) from the equipment monitored or controlled to the system operator display

17.2 Commissioning of the RTU

17.2.1 Must be scheduled with the EMS center by submitting a request to the outage coordinator for all work on RTU equipment.

17.3 RTU Start-Up and Configuration

Specific information on the tests is in the “Remote Terminal Unit Commissioning Test Procedure”.

17.3.1 The RTU equipment must be verified against the drawings to insure the correct equipment has been received.

17.3.2 The RTU Firmware and Configuration Software versions shall be recorded and checked against the design documents.

17.3.3 The RTU configuration, drawings, and points list shall be checked to see if they agree.

17.3.4 The software, dip switch settings, and board jumpers must be verified. The battery supplying the memory card must be checked on the board.

17.3.5 The field installation shall be checked to see that the RTU is installed according to the drawings and that the status and control point wiring is checked from point to point.
17.3.6 Before any testing begins, all station test switches shall be opened to isolate the RTU from station equipment.

17.3.7 The RTU will be powered up and the AC and DC input supply voltages measured and recorded. The DC power supply output voltages on the RTU must be measured and recorded.

17.3.8 Download the RTU configuration and verify it downloaded without error.

17.3.9 Test each Status, Control and Analog point locally via laptop connection.

17.3.10 The communication circuit between the RTU and the EMS center must be checked against the network print and verified for correct operation. This test must be coordinated with the EMS center technicians, and includes confirmation that the circuit complies with NERC/CIP security requirements and as defined by the OWNER. Verify that communication circuits will continue to operate with loss of AC power.

17.3.11 For telephone circuits, power should be removed from the Positron set to insure that communications continue with loss of power.

17.4 RTU Input/Output Testing

17.4.1 Each input and output from the RTU will be tested. Specific information on the tests is in the “Remote Terminal Unit Commissioning Test Procedure”

17.4.2 The results of the testing will be kept by the EMS group. Points which have tested correctly shall be recorded as in service on the database listing along with any other information that would be helpful for future reference. A point discrepancy form shall be completed for points that have problems and database listing shall be marked to indicate problem.

17.4.3 Follow-up items shall be recorded on a punch list maintained by the EMS group for corrective actions.

17.4.4 All field changes shall be recorded on engineering drawings and documents with a copy to be returned to engineering for correction.

18.0 PANEL METER COMMISSIONING

18.1 Panel Indication Meters

18.1.1 Meters shall be tested by comparing its’ displayed and output values in magnitude and direction against a known standard or by calculating the value based on the inputs. If the device supplies the RTU, the value must be compared to the value recorded in the RTU, the EMS database and the value displayed on the operator’s screen.
19.0 REVENUE METER COMMISSIONING

19.1 Revenue Metering

Revenue metering will be commissioned per the latest revision of the “Meter Commissioning and Site Verification Guideline”.

19.1.1 This procedure verifies the operation of the revenue meter from the device to the desired recipient of the metering data to the Energy Management System (EMS), and/or the Meter Data Services MV 90 information system.

19.1.2 The commissioning of the revenue meter must be coordinated with the receiver of the data: EMS center or Meter Data Services for the MV 90 system.

20.0 TRAINING

20.1 The Owner

Will identify and communicate the training requirements necessary to personnel who shall operate and maintain the equipment based on type of apparatus being installed and changes in operating requirements. The training requirements will be discussed and agreed to at the beginning of the project. The manufacturer’s representative(s) shall be fluent in oral and written English to train the OWNER's operating personnel.

20.1.1 The CONSTRUCTION SUPERVISOR and/or PROJECT MANAGER shall provide coordination of manufacturer's representative(s) to train OWNER's operating personnel in the use and application of equipment and apparatus supplied for the project.

20.1.2 The TESTER and/or PROJECT MANAGER shall provide coordination of manufacturer's representative(s) to train the OWNER's operating personnel in the use and application of protective relays, Remote Terminal Units, Digital Fault Recorder, metering equipment or other associated controls and hardware for the project.

20.1.3 The training shall consist of two seminars with both classroom theory (first session) and practical "hands-on" training (second session). The classroom theory training shall be conducted prior to delivery of any apparatus.

20.1.4 Once the project is near completion, the second seminar will be held, and shall include "hands-on" oriented maintenance and equipment tests. A portion of classroom time shall be included in the second session to review project drawings and other site specific documentation.

20.1.5 The outline of the training course and any audio visual equipment requirements shall be submitted in writing to the OWNER. Specific training topics required by the OWNER will be discussed and agreed to at the beginning of the project.

20.1.6 Each two part seminar shall be limited to 8 individuals in multiple training groups. Each session shall be identical in content. The party providing the training shall supply a copy of all drawings, texts, slides or other instructional materials for each individual. The OWNER shall supply the classroom facilities.
20.1.7 Training Documentation - One complete presentation of the training shall be recorded in DVD format for the OWNER’s future use.

20.1.8 Twelve (12) copies of the DVD training CDs shall be supplied and the OWNER permitted to make additional copies for internal use only with no additional costs incurred.

21.0 DOCUMENTATION and REPORTING REQUIREMENTS

For all tests including Doble Engineering equipment, paper and electronic test results shall be provided to OWNER. The TESTER shall document all test results for each test requirement outlined in this specification. The test readings shall become benchmarks for all future evaluations.

21.1 Report Formats

21.1.1 The OWNER will specify at the initial meetings the acceptance and electrical tests documentation and reporting requirements for paper and/or electronic test results.

21.1.2 The CONSTRUCTOR shall complete all electrical apparatus and equipment installation forms as outlined and specified by the OWNER.

21.1.3 The TESTER shall complete all electrical apparatus an equipment test results forms for each test requirement outlined and specified by the OWNER.

21.2 Nameplate Data

21.2.1 As specified by the OWNER, the online Change and Addition (C&A) application available on the Substation Engineering Services website shall be used to document the equipment being installed or removed from service.

21.2.2 Copies of the Equipment Data Form - Relays may be requested to collect the necessary information for each new primary device, electrical apparatus, secondary devices, or protection relays installed and the entered in the system using the online Change and Addition process. Only the online C&A process or relay forms provided shall be used by the CONSTRUCTOR to complete this requirement.

21.3 Test Results

21.3.1 Each test result shall include:

a. The date of the test

b. Name and contact information of the individual making the test

c. A description of the test performed

d. The system or device tested

e. Test equipment used with the hardware identification number and certification date

f. The results with any discrepancies or irregularities identified
g. The initial technical test data shall be provided to the OWNER on bond paper for distribution

21.4 Relay Settings

21.4.1 The TESTER shall apply all approved protective relay settings and return to the OWNER the setting sheet or electronic setting data as a certified document/record.

a. The TESTER shall log protective relay setting and logic setting requests upon receipt. Revisions shall be tracked. Upon completion, the TESTER shall sign the cover sheet and return to the OWNER the completed forms and the “as left” relay settings file downloaded from the protective relays.

b. OWNER will specify the format of the “as left” setting file to be saved. The saved file will normally be the same filename as the setting file followed by _r which designates that this is a downloaded file. Example Andover 3_87T3 TD/OC_01_01_2009_r.mdb

21.5 As-Builts Test Records

21.5.1 At the conclusion of the project, the TESTER shall provide four (4) certified copies of all test records for work performed. This includes conductor insulation tests, ground resistance, circuit continuity, primary or secondary equipment tests etc. The test data records shall be supplied in a bound indexed binder format.

21.5.2 In addition to the required hard copies, all the records and documents including test results shall be in an electronic DVD or CD format. Four (4) copies of the electronic disks (DVD or CD) shall be provided.

21.5.3 A copy of the Protest Database that was used for protective relay testing will be turned over to the owner when requested for periodic review during the project and at the completion of the project.

21.5.4 OWNER has the right to request and the TESTER will provide test results or database during the course of the project.

21.6 As-Builts Drawings

21.6.1 As-Builts are defined as specified changes noted on construction drawings that identify changes per field modifications or observations.

21.6.2 The TESTER shall provide three (3) complete sets of as-builts drawings and Mark-up as described below. These drawings shall be full size, hard copies.

21.6.3 Mark-Up Requirement

a. As-Builts need to be submitted to the Station Engineering & Design Manager or Engineering Design Firm

b. As-Builts must be legible

c. As-Builts must be made with red and green colors only. Additions should be noted in red. Deletions should be noted in green.
d. Do not use white out to cover areas of the drawing. This makes it difficult to determine what is changing.

e. Do not use highlighters to color photocopies

f. Original hand as-builts should be submitted

g. Use “stamped” sets for the returned as-builts

h. One copy of every drawing issued shall be returned, even if no field changes are made on the drawing.

i. As-builts from both Relay & Control and Stations should be on the same set of drawings (or at a minimum submitted at the same time).

j. The individual responsible for the work should sign and date as-builts. That way, if questions arise we know whom to contact.

k. As-Builts must be complete and thorough

1. Make sure that changes reflected on one drawing are also shown on associated drawings. (Single Line, AC/DC, Wiring, Panel Fronts, Physicals, etc.)

2. Show conduits with accurate dimensions to reference points such as structures or equipment centerlines.

3. As-Builts should be inclusive of all disciplines.

4. As-Builts should improve the quality of drawings by correcting ANY/ALL incorrect information shown on the prints affected, even if the information does not pertain to that specific project.

l. All affected drawings and diagrams will be marked up as "Field Checks" and returned to Functional Engineering department within 30 days from acceptance date with notification to the Project Manager.

21.7 Commissioning and Decommissioning Documentation

21.7.1 The CONSTRUCTION SUPERVISOR shall ensure the required Equipment Data Forms, Change and Addition and Decommissioning Forms are completed. The OWNER will provide any necessary specific instructions and the required forms for the project.

21.8 Manuals and Instruction Books

21.8.1 All manuals, instruction books, or other manufacturer provided documentation used by the TESTER / CONSTRUCTOR shall be provided to the OWNER for distribution to local Substation Management and Substation O&M Services as required.

21.9 The Tester shall

21.9.1 Document all test results for each test requirement outlined in this specification. The test readings shall become benchmarks for all future evaluations.

21.10 Nameplate Data – Equipment and Relays
21.10.1 As determined by the OWNER, equipment data sheets/C&A shall be completed for each new primary device or component (circuit breaker, disconnect, current or potential transformers, etc) and any new secondary devices.

21.11 Test Results – Each Test shall

21.11.1 Be accompanied by an initial test report including the date, name and contact information of the individual making the test, a description of the test e.g. the system or device and test equipment used with the hardware identification number and certification date, the test results, and any discrepancies or irregularities identified. The initial technical test data shall be provided to the OWNER on bond paper for distribution.

21.12 Relay Settings – The Tester shall

21.12.1 Apply all approved protective relay settings and return to the OWNER a setting sheet or electronic setting data as a certified document/record.

21.13 As-Built Test Records – Project Conclusion

21.13.1 At the conclusion of the project, four (4) certified copies of all test records for work conducted by the TESTER shall be provided. This includes conductor insulation tests, ground resistance, circuit continuity, primary or secondary equipment tests etc. The test data records shall be supplied in a bound indexed binder format.

21.14 All Records and Documents

21.14.1 In addition to the required hard copies, all the records and documents supplied by the TESTER, including test results, shall be in an electronic DVD or CD format. Four (4) copies of the electronic disks (DVD or CD) shall be provided.

22.0 RELAY and WIRING TESTING DOCUMENTATION

For all tests including Doble Engineering equipment, paper and electronic test results shall be provided to OWNER. The TESTER shall document all test results for each test requirement outlined in this specification. The test readings shall become benchmarks for all future evaluations.

22.1 Current Transformer Forms
22.2 Current Circuit Forms
22.3 Potential Transformers Forms
22.4 Potential Circuit Forms
22.5 Operation/Functional/Scheme Test Form
22.6 In-Service Forms
22.7 Wave-Trap / Line Tuner Forms
22.8 Open Link / Lifted Lead Log
23.0  EQUIPMENT/RELAY CHANGE & ADDITION PROCESS AND DATA FORMS

23.1  System Changes to National Grid substations

23.1.1  Must be provided to Substation O&M Services (equipment) or Protection Services & Support (relay) for updating the Maintenance Management System (MMS) database.

23.2  Equipment/Relay Nameplate Information

   Shall be submitted using the online Change & Addition application by the TESTER / CONSTRUCTOR for each individual piece of apparatus installed. Hard copy Equipment Data Forms may also be used to collect the necessary equipment information for later entry to the online application.

23.2.1  OWNER will supply the blank MMS Data forms if required for the project to collect the necessary information for information entry into the Change and Addition online process.

23.2.2  TESTER / CONSTRUCTOR shall complete the required MMS Data Forms upon completion of the installation of the apparatus in an operating position and submit the data.

23.2.3  All completed MMS Data Forms shall be submitted to the CONSTRUCTION SUPERVISOR.

23.2.4  CONSTRUCTION SUPERVISOR shall ensure information was submitted online using the Change and Addition process and if used submit collected MMS Data Forms to Substation O&M Services (equipment forms) or Protection Standards & Support (relay forms) for updating the MMS database.

24.0  POWER EQUIPMENT DECOMMISSIONING WORKSHEET

24.1  Requirement

24.1.1  Power Equipment Decommissioning worksheets are required for all apparatus to be removed from service and disposed of.

24.2  The Owner shall

24.2.1  Supply the blank Power Equipment Decommissioning worksheets.

24.3  Filling Out Form

24.3.1  A Power Equipment Decommissioning form shall be filled out by the CONSTRUCTION SUPERVISOR for each individual piece of apparatus removed for disposal.

24.4  The Construction Supervisor shall

24.4.1  Notify Investment Recovery and Substation O&M Services to coordinate arrangements for apparatus disposal.
24.5 Reference
24.5.1 Refer to Investment Recovery & Recycling Services IRP 313.2.1 - Substation Equipment Decommissioning Procedure and IRP 313.3.1- Substation Equipment Decommissioning Check-List

25.0 ENERGIZATION PROCESS

25.1 Energization Process
25.1.1 The ENERGIZATION COORDINATOR shall be selected and named at the Project Team kick-off Meeting.
25.1.2 The ENERGIZATION COORDINATOR shall obtain the names of those individuals that will be responsible to complete the specific sections of the Energization Plan.
25.1.3 The ENERGIZATION COORDINATOR shall ensure that the individuals named to complete the specific sections of the Energization Plan are informed if they were not directly involved in the initial meeting and a copy of the list is provided to the individuals listed on the form.
25.1.4 The ENERGIZATION COORDINATOR shall inform the personnel designated to assist in the energization plan at least one (1) month in advance of the upcoming energization date and tentative rain date.
25.1.5 The ENERGIZATION COORDINATOR shall contact the appropriate Control Center to ensure that the EMS screens are updated to reflect the new installation.

25.2 Energization Plan
25.2.1 An Energization Plan shall be prepared by the ENERGIZATION COORDINATOR.
25.2.2 The Energization Plan shall include such items as but not limited to:
   a. Steps for the removal of grounds and releasing of corresponding Clearances
   b. A sequence of switching to energize or de-energize apparatus
   c. Required phasing and synchronization tests
   d. Load and operational tests required to place the apparatus or systems on line without risk to the electrical infrastructure
25.2.3 The Energization Plan shall be submitted to the SYSTEM OPERATOR for approval.

25.3 Energization plan Coordination and Responsibilities
25.3.1 At least one (1) month before the anticipated initial energization date, the CONSTRUCTOR, TESTER, CONSTRUCTION SUPERVISOR, and ENERGIZATION COORDINATOR will meet to review the Energization Plan.
25.3.2 If deemed necessary by the ENERGIZATION COORDINATOR, an on-site meeting will be held prior to the energization date to review details of the initial energization.

25.4 Responsibilities prior to and during the Energization process

The following lists are not intended to be in sequential order.

25.4.1 The TESTER/CONSTRUCTION shall:

a. Make final preparations (e.g. remove/add test leads or jumpers, close slide links) required for initial energization.

b. Complete work required for initial energization. Note: No work is to proceed on primary voltage existing facilities until authorization for Clearances have been given or obtained by the appropriate ENERGIZATION COORDINATOR for the specific work at hand.

c. Coordinate with the ENERGIZATION COORDINATOR to obtain the required clearances.

d. Verify all necessary test blocks are in place.

e. Verify all secondary fuses are installed in their respective AC and DC circuits.

f. Verify all required AC and DC supplies are in service and have satisfactory voltage.

g. Verify no battery grounds exist.

h. Verify all necessary trouble alarms are working and in service.

i. Verify all necessary communications for relaying are in service.

j. Verify all required oscillographs and other recorders have been installed and are ready to operate.

k. Verify grounding switches on coupling-capacitor type voltage transformers (CCVT) are open.

l. Verify all required metering is in service.

m. Verify that turning on all pumps simultaneously on the transformer, if so equipped, will not operate the fault pressure relaying.

n. Inform ENERGIZATION COORDINATOR that all protective relays, temporary protective relays, back-up relaying, or other devices designated in the energization plan are in service or ready for service.

o. Perform necessary corrective work required during initial energization if so required.

p. Perform all tests required during initial energization.

q. Coordinate with manufacturer’s field representative when such representative’s presence is required for initial energization.
r. Provide personnel during initial energization as required for a 24-hour-a-day, seven-day-a-week basis or on an as agreed to basis.

25.4.2 The ENERGIZATION COORDINATOR shall:

   a. Develop the energization plan and checklist.
   b. Coordinate with the TESTER /CONSTRUCTOR the necessary construction and testing for initial energization
   c. Ensure that all required tests have been completed, reviewed, and found acceptable before the energization of the new facilities/equipment.
   d. Be present during the energization process
   e. Determine and inform all parties the method of voice communication to be used during the commissioning / energization process.
   f. Ensure appropriate personnel are scheduled to perform the removal of personal grounds, releasing of corresponding EOP G014 Clearances, and to perform the required switching to energize or de-energize apparatus
   g. Verify test grounds removed from the facilities/equipment to be energized.
   h. Verify all grounding switches, if applicable, have been opened checked opened, and locked in the open position.
   i. Verify all circuit breaker air, SF6, or hydraulic pressures are normal.
   j. Verify operations counters on all apparatus used for energization have been recorded.
   k. Verify automatic reclosing has been disabled from circuit breakers used for energizing apparatus or circuits
   l. Ensure initial energization of equipment is performed in accordance with Energization sequence.
   m. Note: If problems are encountered upon initial energization or other conditions are detected, the facilities shall be immediately de-energized.
   n. Witness initial energization or operation of equipment.
   o. Obtain and hold clearances on existing facilities to allow final permanent connections to be made.
   p. The OWNER, or his representative, may stop energization from proceeding if such work, in their estimation, will or may cause OWNER’S system to operate unsatisfactorily or jeopardize service to its electric customers or if ISONE or NYISO so requires.
   q. Verify load and power flows after initial energization.
   r. Ensure three phase current readings were performed to check for three phase continuity.
   s. Verify voltage regulation and parallel schemes are operational.
t. Verify DGA sample is taken before energizing.

u. All transformers shall be allowed to remain energized after initial energization before applying load to the transformer. Transformers rated below 115kV – 15 minutes. Transformers rated 115kV and above – 12 hours. Deviations from these times must be discussed with Substation O&M Services prior to energization and development of the energization plan.

v. Ensure additional DGA samples are taken within 1 week of initial energization and monthly thereafter for the first three months.

w. Upon successful completion of the energization process, release the new facility to the Control Center.

x. The initial energization procedure may be amended, if required, with the consent of ENERGIZATION COORDINATOR and SYSTEM CONTROL CENTER.

25.5 Outage Coordination and Applications

25.5.1 The ENERGIZATION COORDINATOR has the ultimate responsibility to ensure the required Clearances are issued or released for the energization of electrical apparatus or protection schemes. The ENERGIZATION COORDINATOR is responsible to act as the Authorized Person to hold the required Clearance(s).

25.5.2 Where new interconnections with adjacent foreign utilities are made, appropriate steps shall be followed to establish the proper inter-company guarantees through the utilization of the Clearance and Control Procedures.

25.5.3 The ENERGIZATION COORDINATOR and CONTROL CENTER shall inform the ISONE or NYISO of the energization plan as necessary.

25.6 Approvals for Energization

25.6.1 Prior to the energization of new facilities, the ENERGIZATION COORDINATOR shall ensure that the required testing and certifications have been completed and the results have been reviewed and found acceptable.

25.7 Steps Prior to Initial Energization

25.7.1 The ENERGIZATION COORDINATOR shall ensure that appropriate fixed taps and load tap changing information is provided to the TESTER. The tap positions and the LTC voltage level, band width, and compensation settings shall be provided, installed, and verified before the initial energization of the transformer.

25.7.2 Prior to energization, all deluge or fire protection systems, where installed, shall be fully operational.

25.8 Phasing and Synchronization Steps

25.8.1 Phasing and synchronization tests shall be made by the TESTER on all circuits that can be energized from two or more sources.

a. The phasing and synchronization is to be identified in the energization plan.
b. A visual walk down inspection, where possible, shall be made prior to energization to check for proper phase installations.

c. When interconnecting with adjacent utilities using other than the phase 1, 2, 3 notation, proper correlation of phasing shall be made during the design stage.

d. Following energization, phase identification and rotation shall be verified before interconnection with the system or picking up load.

e. Phasing tests should verify transformer nameplate phase relationships.

25.8.2 Test operation of synchroscopes on control boards by comparing two potentials energized from the same source.

25.8.3 After synchroscopes have been tested, test synchronizing connections and synchronism check relays for individual lines

25.9 Load and Operation Tests

25.9.1 For each step of the bus or equipment energization plan, the TESTER shall measure and record:

a. Voltage checks on all applicable relays, meters, etc

b. Phase angle checks on all applicable relays, meters, etc

25.9.2 Once load is applied, the TESTER shall complete a final set of load tests and checks to include, but not be limited to, the following:

a. Current checks on all applicable relays, meters, etc

b. Voltage checks on all applicable relays, meters, etc

c. Phase angle checks on all applicable relays, meters, etc

d. The measurements may also be made by obtaining the protective relay records.

25.9.3 The TESTER shall also record all circuit breaker operation counter readings, and circuit breaker gas pressure readings, where applicable.

25.9.4 The TESTER shall perform a test on the new revenue meters to verify the meter wiring and final accuracy, when there is sufficient load.

25.10 Operating Requirements

25.10.1 The ENERGIZATION COORDINATOR shall coordinate with the CONTROL CENTER the development of the required substation operating procedures for new or modified National Grid substations.
25.10.2 The ENERGIZATION COORDINATOR shall ensure that all necessary paperwork required for updating the substation one line diagrams are submitted to Substation Engineering.

25.11 Trouble / Emergency Switching

25.11.1 If either the SYSTEM OPERATOR or the Switch Person determines that there is a safety or operational concern they must stop all switching and communicate these concerns to the System Operator and the Energization Lead.

   a. The ENERGIZATION COORDINATOR will review the concern and modify the Energization Plan if necessary before proceeding.

25.11.2 Under emergency conditions that endanger life or property, a qualified person working for National Grid can perform switching to open apparatus without first contacting the System Operator.

   a. The person performing the emergency switching assumes full responsibility for the switching and must inform the System Operator and ENERGIZATION COORDINATOR as soon as possible.

   b. If a device is opened for any reason, it shall not be closed without receiving permission from the System Operator.
26.0 APPENDIX A - ENERGIZATION COORDINATOR (EC) CHECKLIST

<table>
<thead>
<tr>
<th>ENERGIZATION COORDINATOR Checklist</th>
</tr>
</thead>
</table>
| **Project Title:** ____________________  **Project Funding No.:** ____________________  
| **Name:** ____________________  **Dept.:** ____________________  **Date:** ____________________  |

The following checklist is not intended to be in sequential order

✓ a checked box indicates item Completed  --- a strikethrough box indicates item Not Applicable

The **ENERGIZATION COORDINATOR** shall ensure that all of the following steps have been completed for the energization phase of the project.

- [ ] EC1- Develop the energization plan.
- [ ] EC2- Ensure the Commissioning & Energization Team Member list is completed.
- [ ] EC3- Coordinate with the CONSTRUCTION SUPERVISOR, TESTERS, and CONTROL CENTERS the necessary construction, testing, and operating requirements for initial energization.
- [ ] EC4- Ensure that ACCEPTANCE CERTIFICATES are received indicating that all required OFF-LOAD tests have been completed and found acceptable prior to the beginning of the energization process.
- [ ] EC5- Determine and inform all concerned parties the method of voice communication to be used during the commissioning / energization process.
- [ ] EC6- Ensure appropriate personnel are scheduled to perform the removal of personal protective grounds, releasing of corresponding EOP G014 Clearances, and to perform the required switching to energize or de-energize apparatus.
- [ ] EC7- Verify all personal grounds are removed and grounding switches, if applicable, have been opened checked opened, and locked in the open position.
- [ ] EC8- Verify all circuit breaker air, SF6, or hydraulic pressures are normal.
- [ ] EC9- Verify operations counters on all apparatus used for energization have been recorded.
- [ ] EC10- Verify automatic reclosing has been disabled from circuit breakers used for energizing apparatus or circuits
- [ ] EC11- Coordinate the initial energization of equipment.
- [ ] EC12- Witness initial energization or operation of equipment.
- [ ] EC13- Ensure load and power flows after initial energization are performed.
- [ ] EC14- Verify voltage regulation and parallel schemes are operational.
- [ ] EC15- Verify DGA sample is taken before energizing.
- [ ] EC16- All transformers shall be allowed to remain energized after initial energization before applying load to the transformer. Transformers rated below 115kV – 15 minutes. Transformers rated 115kV and above – 12 hours. Deviations from these times must be discussed with Substation O&M Services prior to energization and development of the energization sequence.
- [ ] EC17- Ensure additional DGA samples are taken within 1 week of initial energization and monthly thereafter for the first three months
- [ ] EC18- Upon successful completion of the energization process, release the new facility to the Control Center
- [ ] EC19- The initial energization procedure may be amended, if required, with the consent of ENERGIZATION COORDINATOR and CONTROL CENTER.
## ENERGIZATION COORDINATOR Checklist

<table>
<thead>
<tr>
<th>Project Title:</th>
<th>Project Funding No:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td>Dept:</td>
</tr>
</tbody>
</table>

The following checklist is not intended to be in sequential order

- ✓ a checked box indicates item Completed  
- --- a strikethrough box indicates item Not Applicable

- [ ] EC20- Ensure all training required is completed for new apparatus
- [ ] EC21- Ensure all reports are submitted by TESTER in paper and electronic format
- [ ] EC22- Ensure a setting sheet or electronic setting data is submitted by TESTER
- [ ] EC23- Ensure As-Built Test Records are completed and submitted
- [ ] EC24- Ensure As-Built Drawings are completed and submitted
- [ ] EC25- Ensure new Equipment Data Forms are completed and submitted
- [ ] EC26- Ensure Change and Addition forms are completed and submitted.
- [ ] EC27- Ensure Power Equipment Decommissioning Worksheets are completed and submitted.
- [ ] EC30- Ensure Punch List (including site walk through) is completed and submitted with corrective actions completed.
- [ ] EC31- If applicable, ensure station one-line diagram has been completed or updated as necessary.
- [ ] EC32- Turnover facilities to Local Operations which includes all completed acceptance and inspection/maintenance forms.
- [ ] EC33- Ensure all necessary Relay, DETC, LTC settings are available for installation.

### Special Precautions:

Note: The Control Center and Customer Operations designees shall de-energize the facilities immediately if problems are encountered, or other unusual conditions are detected following initial energization.

The OWNER, or his Representative, may stop energization from proceeding if such work, in their estimation, will or may cause OWNER’S system to operate unsatisfactorily or jeopardize service to its electric customers or if ISONE or NYISO so requires.

### Notes:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
27.0 APPENDIX B – CONSTRUCTION SUPERVISOR (CS) CHECKLIST

CONSTRUCTION SUPERVISOR Checklist

Project Title: ___________________________ Project Funding No: ___________________________
Name: _________________________________ Dept: ______________________ Date: ____________

The following checklist is not intended to be in sequential order
✓ a checked box indicates item Completed   --- a strikethrough box indicates item Not Applicable

The CONSTRUCTION SUPERVISOR shall ensure that all of the following steps have been completed for the commissioning phase of the project.

☐ CS1- Coordinate the physical installation and acceptance testing as required for the commissioning phase of the project.
☐ CS2- Ensure all aspects for job safety are followed for the project, (i.e. Work Area Identification, PPE, personal protective grounding, Eye Wash Station, Fire Extinguishers, etc.).
☐ CS3- Ensure the TOA process is followed to obtain appropriate clearances to provide adequate work zone of protection.
☐ CS4- Coordinate with the CONTROL CENTER and ENERGIZATION COORDINATOR the appropriate zone of protection required and obtain the necessary Clearances.
☐ CS5- Complete work required for initial energization. Note: No work is to proceed on primary voltage existing facilities until authorization for Clearances have been given or obtained.
☐ CS6- Verify all secondary fuses are installed in their respective AC and DC circuits.
☐ CS7- Attend project meetings as required.
☐ CS8- Ensure technical inquiries, variances, and approvals are documented and submitted by the TESTER. Notify appropriate departments or issues and resolutions.
☐ CS9- Ensure all Change and Addition forms are completed and submitted.
☐ CS10- Ensure new Equipment Data Forms are completed and submitted.
☐ CS11- Ensure all Electrical Apparatus Inspection Cards are completed and submitted.
☐ CS12- Ensure all training required is completed for new apparatus
☐ CS13- Ensure Power Equipment Decommissioning Worksheets are completed and submitted.
☐ CS14- Ensure As-Built Drawings are completed and submitted
☐ CS15- In conjunction with the TESTER and ENERGIZATION COORDINATOR, perform necessary corrective work required during initial energization if so required.
☐ CS16- Ensure all required tests are completed prior to initial energization.
☐ CS17- Coordinate with manufacturer’s field representative when such representative’s presence is required for initial energization.
☐ CS18- Provide personnel during initial energization as required.
☐ CS19 - Assist in the development of the Energization Plan and complete all steps assigned
☐ CS20- Complete appropriate sections of the Acceptance Certificate – Part 1 OFF-LOAD Inspection and Acceptance Testing Form is completed and submitted.
☐ CS21- Complete appropriate sections of the Acceptance Certificate – Part 2 – ON-LOAD Inspection and Acceptance Testing is completed and submitted.
CONSTRUCTION SUPERVISOR Checklist

Project Title: ___________________________ Project Funding No: _______________________
Name: _______________________________ Dept: ___________________ Date: ____________

The following checklist is not intended to be in sequential order
✓ a checked box indicates item Completed  --- a strikethrough box indicates item Not Applicable

☐ CS22- Coordinate an onsite walk through that includes PM, Engineering, Operations, Maintenance, and Safety personnel. Assist the PM in the preparation of a Punch List. The Punch List will identify items that require corrective measures or follow-up prior to energization.
☐ CS23- Coordinate the completion of the Punch List items and inform the ENERGIZATION COORDINATOR when the facilities installed are ready for initial energization.
☐ CS24- Turnover to Local Operations all completed acceptance and inspection/maintenance forms.
☐ CS25- Ensure CONSTRUCTOR / TESTER site demobilization is completed.
☐ CS26- Ensure all electrical equipment, perimeter gates, and control buildings have padlocks installed as required.
☐ CS27- Obtain and hold work clearances on existing facilities to allow final permanent connections to be made as required for construction.

Notes:
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
28.0 APPENDIX C – TESTER (T) CHECKLIST

<table>
<thead>
<tr>
<th>TESTER Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Title:</strong> ________________________________  <strong>Project Funding No:</strong> ________________________________</td>
</tr>
<tr>
<td><strong>Name:</strong> ________________________________  <strong>Dept:</strong> ________________________________  <strong>Date:</strong> ________________________________</td>
</tr>
</tbody>
</table>

The following checklist is not intended to be in sequential order

✓ a checked box indicates item Completed  --- a strikethrough box indicates item Not Applicable

The **TESTER** shall ensure that all of the following steps have been completed for the commissioning phase of the project.

- T1- Participate in the initial Project Team Meeting, accept, and/or assign responsibilities as required.
- T2- Attend project meetings as required to review issues and work completed.
- T3- Coordinate the testing with the physical installation of the equipment and construction schedule as required.
- T4- Ensure all aspects for job safety are followed for the work being performed.
- T5- Ensure TESTERS are working under appropriate Clearances that provide adequate work zone protection for the work being performed.
- T6- Coordinate with the **ENERGIZATION COORDINATOR or CONSTRUCTION SUPERVISOR** to obtain the required clearances.
- T7- Ensure technical inquiries, variances, and approvals are documented and submitted to the **CONSTRUCTION SUPERVISOR**. Notify appropriate departments or issues and resolutions.
- T8- Verify the correct size and that all secondary fuses are installed in their respective AC and DC circuits.
- T9- Ensure all Change and Addition forms are completed and submitted.
- T10- Ensure new Relay Data Forms are completed and submitted.
- T11- Ensure all training required is completed for new systems and equipment.
- T12- Ensure As-Built Drawings are completed and submitted.
- T13- In conjunction with the **CONSTRUCTOR** and CONSTRUCTION SUPERVISOR, perform necessary corrective work required during initial energization.
- T14- Perform all tests required during initial energization.
- T15- Obtain and install all necessary Relay, DETC, LTC settings.
- T16- Coordinate with manufacturer’s field representative when such representative’s presence is required for initial energization.
- T17- Provide personnel during initial energization as required.
- T18- Ensure all tests are performed and documented on the appropriate forms and electronic files are completed and submitted to the **OWNER**. The electronic format will be agreed to at the project meeting.
- T19- Ensure the protection setting sheets or electronic settings file is submitted to the **PROTECTION ENGINEER**.
- T20- Ensure As-Built Test Records are completed and submitted.
- T21- Ensure As-Built Drawings are completed and submitted.
### TESTER Checklist

<table>
<thead>
<tr>
<th>Project Title:</th>
<th>Project Funding No:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td>Dept:</td>
</tr>
<tr>
<td>Date:</td>
<td></td>
</tr>
</tbody>
</table>

The following checklist is not intended to be in sequential order

- ✓ a checked box indicates item Completed
- --- a strikethrough box indicates item Not Applicable

- □ T22- Assist in the development of the Energization Plan and complete all steps assigned.
- □ T23- Inform ENERGIZATION COORDINATOR that all protective relays, temporary protective relays, back-up relaying, or other devices designated in the energization plan are in service or ready for service.
- □ T24- Complete appropriate sections of the Acceptance Certificate – Part 1 OFF-LOAD Inspection and Acceptance Testing Form is completed and submitted.
- □ T26- Ensure Punch List (including site walk through) is completed and submitted with corrective actions completed.
- □ T27- Turn over all manuals to Local Operations.
- □ T28- Initiate, monitor, and ensure TESTER site demobilization.
- □ T29- Take three phase current readings to insure three phase continuity.

Notes:

---

---

---

---

---
### 29.0 APPENDIX D – COMMISSIONING & ENERGIZATION TEAM MEMBER LIST

<table>
<thead>
<tr>
<th>Function</th>
<th>Name</th>
<th>National Grid Department Cont. company</th>
<th>Office Phone</th>
<th>Cell Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Team</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROJECT MANAGER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBSTATION ENGINEER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBSTATION DESIGNER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROTECTION ENGINEER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBSTATION O&amp;M SERVICES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBSTATION SUPERVISOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYSTEM SECURITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction Team</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTION SUPERVISOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTION SUPERVISOR (Alternate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td>Name</td>
<td>National Grid Department Cont. company</td>
<td>Office Phone</td>
<td>Cell Phone</td>
<td>Email</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------</td>
<td>----------------------------------------</td>
<td>--------------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>Testing &amp; Energization Team</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGIZATION COORDINATOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGIZATION COORDINATOR (Alternate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER – CONTROL BUILDING &amp; YARD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER - APPARATUS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER – CONTROL CABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER - SUPPORT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER – PRE-COMM – RELAY &amp; CONTROL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER – RELAY &amp; CONTROL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER – RTU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER – PANEL METERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TESTER – REVENUE METERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRANSMISSION CONTROL CENTER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td>Name</td>
<td>National Grid Department Cont. company</td>
<td>Office Phone</td>
<td>Cell Phone</td>
<td>Email</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------</td>
<td>----------------------------------------</td>
<td>--------------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>Testing &amp; Energization Team</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISPATCH / REGIONAL CONTROL CENTER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISPATCH / CONTROL CENTER RTU/EMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUTAGE PLANNER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 30.0 APPENDIX E – ACCEPTANCE CERTIFICATE – PART 1

#### ACCEPTANCE CERTIFICATE – PART 1 COMPLETION: OFF-LOAD INSPECTION and ACCEPTANCE TESTING

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Project Funding No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Apparatus and/or Relays identified below have been satisfactorily OFF-LOAD tested per the required sections of Substation Maintenance Procedure SMP 400.80.2 Commissioning and Energization Procedure and conditions specified in the contract. The Apparatus and/or Relays may now be energized and tested in accordance with PART 2 of the Commissioning Plan. All appropriate forms, Inspection Cards, and Tests Results have been provided to the ENERGIZATION COORDINATOR.

#### DESCRIPTION OF APPARATUS and/or RELAYS TESTED | DESCRIBE WORK PERFORMED

1.  
2.  
3.  
4.  
5.  
6.  
7.  
8.  
9.  
10.  
11.  
12.  
13.  
14.  

#### EXCEPTIONS: OUTSTANDING WORK (List items that remain outstanding, remediation plan and responsible party).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I Issued by:  

Acknowledged by:  

Date:
### 31.0 APPENDIX F – ACCEPTANCE CERTIFICATE – PART 2

| ACCEPTANCE CERTIFICATE – PART 2 COMPLETION: ON-LOAD INSPECTION and ACCEPTANCE TESTING |
|----------------------------------|----------------------------------|

<table>
<thead>
<tr>
<th>Project Title:</th>
<th>Project Funding No:</th>
</tr>
</thead>
</table>

The Apparatus and/or Relays identified in PART 1 of the ACCEPTANCE CERTIFICATE, and as listed below, have been satisfactorily ON-LOAD tested per the required sections of Substation Maintenance Procedure SMP 400.80.2 Commissioning and Energization Procedure and conditions specified in the contract and are available for operational service with any Exceptions or Limitations noted below. The drawings and requirements for operational service of the Apparatus and/or Relays have been provided to the ENERGIZATION COORDINATOR.

<table>
<thead>
<tr>
<th>DESCRIPTION OF APPARATUS and/or RELAYS TESTED</th>
<th>DESCRIBE WORK PERFORMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
</tr>
</tbody>
</table>

EXCEPTIONS: OUTSTANDING WORK (List items that remain outstanding, remediation plan and responsible party).

<table>
<thead>
<tr>
<th>ISUESD BY:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGED BY:</td>
<td>Date:</td>
</tr>
</tbody>
</table>
32.0  APPENDIX G – AC POTENTIAL CIRCUIT INJECTION FORM

<table>
<thead>
<tr>
<th>STATION:</th>
<th>DATE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCUIT:</td>
<td>CABLE#</td>
</tr>
<tr>
<td>BUMPING FROM:</td>
<td></td>
</tr>
</tbody>
</table>

\[ VA = \quad VB = \quad VC = \]

<table>
<thead>
<tr>
<th>CIRCUIT</th>
<th>PHASE</th>
<th>STUD</th>
<th>PHASE TO PG</th>
<th>PHASE</th>
<th>STUD</th>
<th>PHASE TO PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PRINTED COPIES ARE NOT DOCUMENT CONTROLLED.
FOR THE LATEST AUTHORIZED VERSION PLEASE REFER TO THE APPROPRIATE DEPARTMENT WEBSITE OR DOCUMENTUM.

File: SMP 400.80.2 Substation Commissioning and Energization

Originating Department: Substation O&M Services

Sponsor: Donald T. Angell
### APPENDIX H – AC POTENTIAL CIRCUIT SECONDARY INJECTION FORM

<table>
<thead>
<tr>
<th>STATION:</th>
<th>DATE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCUIT:</td>
<td>CABLE#</td>
</tr>
<tr>
<td>BUMPING FROM:</td>
<td></td>
</tr>
<tr>
<td>VA =</td>
<td>VB =</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CIRCUIT</th>
<th>PHASE</th>
<th>STUD</th>
<th>PHASE TO PG</th>
<th>PHASE</th>
<th>STUD</th>
<th>PHASE TO PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
34.0  APPENDIX I – CT 1 PH SECONDARY INJECTION FORM
35.0 APPENDIX J – 3 PH SECONDARY INJECTION FORM

<table>
<thead>
<tr>
<th>Device</th>
<th>Stud No.</th>
<th>D-G</th>
<th>E-G</th>
<th>F-G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bumping Quantities</th>
<th>TEST SET</th>
<th>PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = 1 amp @ 0'</td>
<td>1</td>
<td>BUSHING</td>
</tr>
<tr>
<td>B = 2 amp @ 120'</td>
<td>2</td>
<td>BLOCK</td>
</tr>
<tr>
<td>C = 3 amp @ 240'</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>D = 1.73 amp @ 210'</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CIR</th>
<th>PRI</th>
<th>STA</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0</td>
<td>P0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CT LOC &amp; ID</th>
<th>AØ</th>
<th>BØ</th>
<th>CØ</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CT RATIO &amp; TAPS</th>
<th>2:1</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CIR MEGGER</th>
<th></th>
</tr>
</thead>
</table>

| BUMP FROM TAPS | |

<table>
<thead>
<tr>
<th>LOAD</th>
<th>BUMP @ 3 AMPS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BURDEN @ 3 AMPS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BURDEN @ 3 AMPS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GRD ($) LOC</th>
<th>CABLE #</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>STA</th>
<th>PRI</th>
<th>CIR</th>
<th>DATE</th>
</tr>
</thead>
</table>
### 36.0 APPENDIX K – CT EXCITATION FORM

**CT EXCITATION SHEET**

<table>
<thead>
<tr>
<th>Station</th>
<th>Circuit</th>
<th>Date</th>
<th>Test By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trans / BKR / Device Serial No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polarity</td>
<td>MEGGAR</td>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Phase</td>
<td>Bushing</td>
<td>CT Block</td>
<td>Taps</td>
</tr>
<tr>
<td>Amps</td>
<td>Volts</td>
<td>Volts</td>
<td>Volts</td>
</tr>
<tr>
<td>Type</td>
<td>Code</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turns</td>
<td>Excited Taps</td>
<td>In Service Taps</td>
<td>In Service Ratio</td>
</tr>
<tr>
<td>Revsions</td>
<td>Date</td>
<td>By</td>
<td></td>
</tr>
</tbody>
</table>

[Diagram of CT Excitation Sheet]

---

PRINTED COPIES ARE NOT DOCUMENT CONTROLLED. FOR THE LATEST AUTHORIZED VERSION PLEASE REFER TO THE APPROPRIATE DEPARTMENT WEBSITE OR DOCUMENTUM.
37.0 APPENDIX L – FUNCTIONAL TRIP TEST FORM

[Image of the functional trip test form with fields to fill in information like Office, Station Name, Voltage kV, and File name.]

[Excerpt from the form showing the fields filled: Office: National Grid, Station Name: Somewhere, Voltage: 345 kV, File name: Somewhere 345 Trip Test.xls, and the date: February 20, 2009.]
### Relay Operations Group

**National Grid**

Type 1 Test Trip Report

- **Station:** Somewhere
- **Test Date:** __/__/____
- **kV:** 345
- **File:** Somewhere 345 Trip Test.xls

<table>
<thead>
<tr>
<th>Circuit</th>
<th>System</th>
<th>O-L</th>
<th>Date</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**February 20, 2009**
<table>
<thead>
<tr>
<th>Circuit</th>
<th>System</th>
<th>O-T</th>
<th>Date</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit</td>
<td>System</td>
<td>O-T.</td>
<td>Date</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>-----</td>
<td>------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit</td>
<td>AFI Source</td>
<td>Yes/No</td>
<td>Trip Relay</td>
<td>Location</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>--------</td>
<td>------------</td>
<td>----------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock</td>
<td>BFI Source</td>
<td>Yes</td>
<td>No</td>
<td>Trip Fader</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>-----</td>
<td>----</td>
<td>------------</td>
</tr>
</tbody>
</table>

February 20, 2010

Tech: __________

BFI Functional Test
Station: Somewhere
Test Date: __/__/____

File: Somewhere 345 Trip Test.xlsx
38.0  APPENDIX M – IN SERVICE /LOAD CHECK FORM

<table>
<thead>
<tr>
<th>CIRCUIT</th>
<th>PH</th>
<th>STUD</th>
<th>CT RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE:

---

 specification No. 103014-Above Grade

SUBSTATION MAINTENANCE
Procedure
Substation Commissioning and Energization

Doc. # SMP 400.80.2
Page 60 of 70

Version 1.0 – 07/30/09

PRINTED COPIES ARE NOT DOCUMENT CONTROLLED.
FOR THE LATEST AUTHORIZED VERSION PLEASE REFER TO THE APPROPRIATE DEPARTMENT WEBSITE OR DOCUMENTUM.
39.0 APPENDIX N – OPEN LINK / LIFTED LEAD / JUMPER REMOVED LOG SHEET

<table>
<thead>
<tr>
<th>Designation</th>
<th>Date Link Opened, Wire Lifted, Jumper removed</th>
<th>Responsible Person</th>
<th>Reason</th>
<th>Date Link Closed, Wire Insulated, Jumper replaced</th>
<th>Responsible Person</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 40.0 APPENDIX O – RELAY OPERATING TEST FORM

### RELAY OPERATING TEST

<table>
<thead>
<tr>
<th>STATION:</th>
<th>BREAKER:</th>
<th>DATE:</th>
<th>TESTERS:</th>
</tr>
</thead>
</table>

### TIMING FIRST SHOT

<table>
<thead>
<tr>
<th>Profile #:</th>
<th>Close Test #:</th>
<th>MCon:</th>
<th>Start:</th>
<th>No timing, breaker open before test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip 1 Test #:</td>
<td>MCon:</td>
<td># of Trips:</td>
<td>End:</td>
<td></td>
</tr>
<tr>
<td>DC on Close</td>
<td>Adj:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TRIPS

#### TRIP COIL #1

<table>
<thead>
<tr>
<th>Device</th>
<th>Contacts</th>
<th>Test Device / Stud:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### TRIP COIL #2

<table>
<thead>
<tr>
<th>Device</th>
<th>Contacts</th>
<th>Test Device / Stud:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TIMER RECLOSE

<table>
<thead>
<tr>
<th>1st Reclose</th>
<th>2nd Reclose</th>
<th>RS Contact</th>
<th>Lockout</th>
<th>Reset</th>
<th>Manual Close</th>
</tr>
</thead>
</table>

### BLOCKS

<table>
<thead>
<tr>
<th>Device</th>
<th>Contacts</th>
<th>1st</th>
<th>2nd</th>
<th>Auto</th>
<th>Man:</th>
</tr>
</thead>
</table>

### EMS/RE01

<table>
<thead>
<tr>
<th>Open</th>
<th>Close</th>
<th>Status</th>
</tr>
</thead>
</table>

### ALARMS

<table>
<thead>
<tr>
<th>Local</th>
<th>OK</th>
</tr>
</thead>
</table>

### ANTI-PUMP

<table>
<thead>
<tr>
<th>In manual blocks</th>
<th>In auto (auto-man) blocks</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>In off blocks</th>
<th>In test blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>In HN blocks</td>
<td></td>
</tr>
</tbody>
</table>

### REMARKS:

---

---
41.0 APPENDIX P – RELAY TEST LEAD FORM

## RELAY TEST LIST

<table>
<thead>
<tr>
<th>STATION No.</th>
<th>DESCRIPTION: Panel Identification</th>
<th>Protected Element: Transmission Line, Bus, Transformer</th>
<th>ITEM</th>
<th>RELAY/type</th>
<th>NMPC DESIGNATED FUNCTION</th>
<th>RELAYS (CKT/FDR/TB)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: 1</td>
<td>SEL587</td>
<td>87</td>
<td></td>
<td></td>
<td>TB1</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

### RELAY TOTALS

Performed by: __________________ Company: ___________ Date: ________

Approved by: __________________ Company: ___________ Date: ________

Reviewed by: __________________ Company: ___________ Date: ________

---

PRINTED COPIES ARE NOT DOCUMENT CONTROLLED.
FOR THE LATEST AUTHORIZED VERSION PLEASE REFER TO THE APPROPRIATE DEPARTMENT WEBSITE OR DOCUMENTUM.

File: SMP 400.80.2 Substation Commissioning and Energization

Originating Department: Substation O&M Services

Sponsor: Donald T. Angell
42.0 APPENDIX Q – WAVE TRAP / LINE TUNER

<table>
<thead>
<tr>
<th>Freq [KHz]</th>
<th>Impedance (K Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.1</td>
<td>0.22</td>
</tr>
<tr>
<td>30.2</td>
<td>0.24</td>
</tr>
<tr>
<td>31.1</td>
<td>0.27</td>
</tr>
<tr>
<td>31.6</td>
<td>0.21</td>
</tr>
<tr>
<td>32.1</td>
<td>0.35</td>
</tr>
<tr>
<td>32.6</td>
<td>0.44</td>
</tr>
<tr>
<td>32.7</td>
<td>0.45</td>
</tr>
<tr>
<td>32.8</td>
<td>0.48</td>
</tr>
<tr>
<td>32.9</td>
<td>0.5</td>
</tr>
<tr>
<td>33.0</td>
<td>0.525</td>
</tr>
<tr>
<td>33.1</td>
<td>0.65</td>
</tr>
<tr>
<td>33.2</td>
<td>0.6</td>
</tr>
<tr>
<td>33.3</td>
<td>0.65</td>
</tr>
<tr>
<td>33.4</td>
<td>0.7</td>
</tr>
<tr>
<td>33.5</td>
<td>0.75</td>
</tr>
<tr>
<td>33.6</td>
<td>0.85</td>
</tr>
<tr>
<td>33.7</td>
<td>1.05</td>
</tr>
<tr>
<td>33.8</td>
<td>1.015</td>
</tr>
<tr>
<td>33.9</td>
<td>1.025</td>
</tr>
<tr>
<td>34.0</td>
<td>1.5</td>
</tr>
<tr>
<td>34.1</td>
<td>1.75</td>
</tr>
<tr>
<td>34.2</td>
<td>2</td>
</tr>
<tr>
<td>34.3</td>
<td>2.5</td>
</tr>
<tr>
<td>34.4</td>
<td>3</td>
</tr>
<tr>
<td>34.5</td>
<td>3</td>
</tr>
<tr>
<td>34.6</td>
<td>3</td>
</tr>
<tr>
<td>34.7</td>
<td>2.5</td>
</tr>
<tr>
<td>34.8</td>
<td>2</td>
</tr>
<tr>
<td>34.9</td>
<td>1.75</td>
</tr>
<tr>
<td>35.0</td>
<td>1.3</td>
</tr>
<tr>
<td>35.1</td>
<td>1.2</td>
</tr>
<tr>
<td>35.2</td>
<td>0.95</td>
</tr>
<tr>
<td>35.3</td>
<td>0.85</td>
</tr>
<tr>
<td>35.4</td>
<td>0.65</td>
</tr>
<tr>
<td>35.5</td>
<td>0.3</td>
</tr>
<tr>
<td>35.6</td>
<td>0.7</td>
</tr>
<tr>
<td>35.7</td>
<td>0.65</td>
</tr>
<tr>
<td>35.8</td>
<td>0.5</td>
</tr>
<tr>
<td>35.9</td>
<td>0.25</td>
</tr>
<tr>
<td>36.0</td>
<td>0.55</td>
</tr>
<tr>
<td>36.1</td>
<td>0.5</td>
</tr>
<tr>
<td>36.2</td>
<td>0.4</td>
</tr>
<tr>
<td>36.7</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Wave Trap Make:
- **TRENCH**
- **L200XXZ063-8322PA1**
- **0050385-1**
- **0**
- **1, 2, 3 & 4**

Line Amps:
- **30 - 90 KHz**
- **H**
## SUBSTATION MAINTENANCE

### Procedure

**Substation Commissioning and Energization**

---

| SUBSTATION: __________________________ | DATE: __________ |
| LINE: ______________________________ | SYSTEM: __________ |

---

### LINE TUNER TEST PERFORMANCE

#### CARRIER

**CARRIER TRAP UNIT (PARALLEL L & C)**
Trap to block DTT frequencies,
CARRIER side of tuner cabinet.

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>DTT FREQ. @ CARR SIDE</th>
<th>DTT FREQ. @ DTT SIDE</th>
<th>ISOLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>kHz</td>
<td>dB's</td>
<td>dB's</td>
<td>dB's</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### DTT

**DTT TRAP UNIT (PARALLEL L & C)**
Trap to block CARRIER frequencies,
DTT side of tuner cabinet.

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>CARRIER FREQ. @ CARR SIDE</th>
<th>CARRIER FREQ. @ DTT SIDE</th>
<th>ISOLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>kHz</td>
<td>dB's</td>
<td>dB's</td>
<td>dB's</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### CARRIER TUNING UNIT (SERIES L&C)

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>REFLECTED POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### DTT TUNING UNIT (SERIES L&C)

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>REFLECTED POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### IMPEDANCE MATCHING TRANSFORMER (IMT)

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>REFLECTED POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**PRINTED COPIES ARE NOT DOCUMENT CONTROLLED.**

FOR THE LATEST AUTHORIZED VERSION PLEASE REFER TO THE APPROPRIATE DEPARTMENT WEBSITE OR DOCUMENTUM.

File: SMP 400.80.2 Substation Commissioning and Energization

Originating Department: Substation O&M Services

Sponsor: Donald T. Angell
43.0  APPENDIX R – SCHEME TEST SAMPLE FORMS
<table>
<thead>
<tr>
<th>SUBSTATION MAINTENANCE Procedure</th>
<th>Doc. # SMP 400.80.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substation Commissioning and Energization</td>
<td>Page 67 of 70</td>
</tr>
<tr>
<td></td>
<td>Version 1.0 – 07/30/09</td>
</tr>
</tbody>
</table>
44.0 APPENDIX S – EQUIPMENT DATA FORMS - RELAYS

Equipment Data Form – Relays

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equip No.</td>
<td>33</td>
</tr>
<tr>
<td>Substation:</td>
<td></td>
</tr>
<tr>
<td>OP Position:</td>
<td></td>
</tr>
<tr>
<td>Package: (A, B)</td>
<td></td>
</tr>
<tr>
<td>Nominal kV:</td>
<td></td>
</tr>
<tr>
<td>Equipment:</td>
<td></td>
</tr>
<tr>
<td>Manufacturer:</td>
<td></td>
</tr>
<tr>
<td>Item:</td>
<td></td>
</tr>
<tr>
<td>Vendor:</td>
<td></td>
</tr>
<tr>
<td>Serial No:</td>
<td></td>
</tr>
<tr>
<td>Relay Design Type: (EM, SS, uP)</td>
<td></td>
</tr>
<tr>
<td>Firmware Version:</td>
<td></td>
</tr>
<tr>
<td>Basic Relay Range:</td>
<td></td>
</tr>
<tr>
<td>Warranty Date:</td>
<td></td>
</tr>
<tr>
<td>Installation Date:</td>
<td></td>
</tr>
<tr>
<td>Remarks:</td>
<td></td>
</tr>
</tbody>
</table>

2/28/06 Name: ___________________________ Date Completed: ___________________________
45.0 REVISION HISTORY

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Description of Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>07/30/09</td>
<td>Initial version of document.</td>
</tr>
<tr>
<td>SUBSTATION MAINTENANCE Procedure</td>
<td>Doc. # SMP 400.80.2</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------------</td>
<td></td>
</tr>
<tr>
<td>Substation Commissioning and Energization</td>
<td>Page 70 of 70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Version 1.0 – 07/30/09</td>
<td></td>
</tr>
</tbody>
</table>

[PAGE INTENTIONALLY LEFT BLANK]
This standard provides the required information to Engineering and Design for the application and location of all necessary safety signs applicable to substations.

**TABLE OF CONTENTS**

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 SCOPE</td>
<td>2</td>
</tr>
<tr>
<td>2.0 CODES AND STANDARDS</td>
<td>2</td>
</tr>
<tr>
<td>3.0 REQUIRED SAFETY SIGNS</td>
<td>3</td>
</tr>
<tr>
<td>3.1 Safety Sign Requirements for New Substations</td>
<td>3</td>
</tr>
<tr>
<td>3.2 Safety Sign Requirements for Existing Substations</td>
<td>4</td>
</tr>
<tr>
<td>3.3 Safety Signs for Special Situations</td>
<td>4</td>
</tr>
<tr>
<td>3.4 Obsolete and Non-Conforming Safety Signs</td>
<td>4</td>
</tr>
<tr>
<td>4.0 SAFETY SIGN DESIGN</td>
<td>4</td>
</tr>
<tr>
<td>4.1 Content, Layout and Dimensions</td>
<td>4</td>
</tr>
<tr>
<td>4.2 Material and Finish</td>
<td>6</td>
</tr>
<tr>
<td>4.3 Mounting Provisions</td>
<td>6</td>
</tr>
<tr>
<td>4.4 911 Station Name and Address Signs</td>
<td>7</td>
</tr>
<tr>
<td>4.5 Danger Signs and Decals</td>
<td>7</td>
</tr>
<tr>
<td>5.0 SIGN LOCATION</td>
<td>7</td>
</tr>
<tr>
<td>5.1 Substation Perimeter, Fence and Gates</td>
<td>7</td>
</tr>
<tr>
<td>5.2 Substation Yard, Structures and Outdoor Equipment</td>
<td>8</td>
</tr>
<tr>
<td>5.3 Control Building and Indoor Equipment</td>
<td>8</td>
</tr>
<tr>
<td>6.0 FIGURES, TABLES AND CHARTS</td>
<td>9</td>
</tr>
<tr>
<td>Figure 1a</td>
<td>911 Station Name (Long Address)</td>
</tr>
<tr>
<td>Figure 1b</td>
<td>911 Station Name (Short Address)</td>
</tr>
<tr>
<td>Figure 2</td>
<td>No Trespassing</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Danger Keep Out</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Sign Placement on Perimeter Gates and Fence</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Sign Placement on Fence</td>
</tr>
<tr>
<td>Table-1</td>
<td>Specifications of the Safety Colors for CIE Illuminant C and the CIE 1931 - 2° Standard Observer</td>
</tr>
<tr>
<td>Table-2</td>
<td>Examples of Word Message Letter Heights and Minimum Safe Viewing Distances</td>
</tr>
<tr>
<td>Chart-1</td>
<td>Index of Class I and Class II Safety Signs</td>
</tr>
<tr>
<td>Chart-2</td>
<td>Index of Class I, II, and III Non-Safety Signs</td>
</tr>
<tr>
<td>7.0 REFERENCES</td>
<td>21</td>
</tr>
<tr>
<td>8.0 REVISION HISTORY</td>
<td>22</td>
</tr>
</tbody>
</table>
1.0 **SCOPE**

The purpose for the standard shall cover requirements for environmental and facility hazards, and convey safety alert messages in a way that is clearly and rapidly understood, regardless of the viewer’s backgrounds in language, or general or technical knowledge. Safety signs shall conform to safety standards, primarily ANSI Z535, and insure that proper warnings of dangerous areas for substation personnel and the general public are given.

The scope of this standard shall provide guidance for safety signage to be used in National Grid substations. The standard shall apply to fixed signage used to alert persons to potential injury, property damage or other hazards inherent in the environment of the substation. Temporary signage for these purposes is addressed in Substation Maintenance Procedure SMP 499.10.2.

This standard requires that the signs include easily recognizable safety symbols if the actions required for avoiding the hazard, or the consequences of not avoiding the hazard are not obvious. Use of standard formats, sizes, colors and shapes, and possible viewer training for understanding of the level of severity of the hazard are vital for avoiding accidents and injuries.

This standard specifies that all new substation design and construction shall comply with these standards, and existing facilities meet the new standard when next upgraded.

See ANSI Z535.4 for the requirements for product safety signs and labels which are signs, labels, or decals affixed to a product that provides hazard information about that product.

The standard provides the criteria for:

1. A uniform visual system of potential hazard identification in the design and construction of new substations and upgrades to existing facilities.
2. The selection, application and use of signs employing this system.
3. Minimizing the number of sign layouts and designs employed, but still providing flexibility to meet unique and specific situations.
4. Recognizing, but not necessarily replacing, existing signs uniquely applicable to specific substations or uses.
5. Eliminating non-standard signage.
6. Avoiding conflict with federal, state or municipal regulations.

2.0 **CODES AND STANDARDS**

This standard addresses ANSI Z535.2 – Environmental and Facility Safety Signs – summarizing present status and making recommendations to be included in future revisions. There have been several iterations of standards used in the United States for defining the format for safety signs and labels. The original ANSI committees on Safety Sign Colors (Z53) were combined in 1979 to form the ANSI Z535
2.0 CODES AND STANDARDS (continued)

committee on Safety Signs and Colors, with new publications of the standards beginning in 1991. The latest revision consists of:

2.2 ANSI Z535.2 – Environmental and Facility Safety Signs (2007)
2.4 ANSI Z535.4 – Product Safety Signs and Labels - Incorporates Errata August 23, 2007
2.5 ANSI Z535.5 – Safety Tags and Barricade Tapes (for Temporary Hazards)


- The Z535.4 format is friendlier to symbols, which are increasing in importance as the world of communications moves toward symbols.
- Word messages on the Warning and Caution signs are more legible without a colored background.
- The safety alert symbol (a triangle enclosing an exclamation mark) is now a permanent element on all U.S. personal injury-related safety signs and labels.
- The 2002 standards (and any upgrades or revisions of them) set a goal of establishing a national uniform system for hazard recognition.

Compliance with the standards in the ANSI Z535 series automatically ensures compliance with OSHA standards. The current ANSI Z535 series were derived from the OSHA regulations written in the 1970s, which in turn were based upon the ANSI standards then in use. Although compliance with ANSI Z535 standards is voluntary, ANSI Z535 standards are held up as “state-of-the-art” in U.S. courts, and the legal “duty to warn” for facilities and manufacturers is to meet or exceed these standards.

2.6 ADA Accessibility Guidelines for Buildings and Facilities (2002) was also used in developing this standard.

3.0 REQUIRED SAFETY SIGNS

3.1 Safety Sign Requirements for New Substations:

3.1.1 National Grid new substations shall post the following signs:

- 911 – Station Name and Address Signs (Reference Figures 1a and 1b)
3.0 **REQUIRED SAFETY SIGNS** (continued)

- **DANGER** signs including where applicable:
  1. **No Trespassing** (Reference Figure 2)
  2. **Keep Out** (Reference Figure 3)

3.1.2 Safety Sign requirements for pad mounted transformers are found in section 4.1.7 of this document. The requirements of that section will be referenced when pad mounted transformers are used for station service in substations.

3.2 Safety Sign Requirements for Existing Substations

3.2.1 National Grid existing substations when upgraded shall post the following signs:

- See paragraph 3.1.1 above.

3.3 Safety Signs for Special Situations

3.3.1 These signs have been developed for special uses and have been separated from the other categories of hazard alerting devices by special layout. Signs in this category shall have specific message panel descriptions.

3.3.2 When no federal, state, or local government code, regulation, standard, or guideline specifically requires the use of a particular hazard alerting signal word (signal words are the word or words that designate a degree or level of safety alerting), it shall be up to those responsible to select the appropriate hazard classification. Each situation requiring the use of a hazard alerting device should be reviewed with regard to the definitions given in section 3.0 inclusive and 4.0 inclusive.

3.4 Obsolete and Non-Conforming Safety Signs

3.4.1 Previous formats for safety signs shall not be used for new sign procurement. Existing signs in the older formats, either currently in use or already manufactured and in stock with vendors, may be used. Preferably the latest revision of ANSI Z535.2 should be used.

4.0 **SAFETY SIGN DESIGN**

4.1 Content, Layout and Dimensions

4.1.1 A safety sign is a visual alerting device in the form of a sign, label, decal, placard, or other format that advises the observer of a potential hazard(s) which can cause an accident, and the level of the hazard’s seriousness. The sign may also provide directions to avoid,
4.0 SAFETY SIGN DESIGN (continued)

eliminate or reduce the hazard, or advise of probable consequences of not avoiding, eliminating or reducing the hazard.

4.1.2 The safety sign consists of one or more panels. These panels have a distinctive background color different from adjacent areas of the sign. They shall be clearly delineated by a line, border or margin. There are three types of panels that a safety sign shall use:

- The **signal word panel** contains the signal word or words that designate a degree of alerting and the signal word panel shall be a distinctive panel in the uppermost portion of the sign. It may also contain a safety symbol.

- The **message panel** contains words related to identification of the hazard, how to avoid the hazard and probable consequence(s) of not avoiding the hazard.

- The **safety symbol panel** contains the safety symbol, which is a graphic representation conveying a message of a hazard, precaution or consequence.

4.1.3 One type of safety sign for Substation use:

- **DANGER** – This sign, with its signal word DANGER, is limited to the most extreme situations. It indicates immensely hazardous situations which may lead to serious injury or death. It is used for property damage hazards only if personal injury risk may be involved.

4.1.4 Signs shall conform to color and message as detailed in this standard.

4.1.5 All exterior signs shall contain, clearly and permanently, the name of the vendor and the month-and-year date of manufacture.

4.1.6 Signs, both interior and exterior, shall be rigid, flexible or self-adhering, depending on location and use as detailed in the standard.

4.1.7 The National Grid Underground Construction Standard, Section 31 pages 31-11 to 31-20, shall be followed for selection of and design of “No Trespassing” signs and include “Warning and Danger” decals for pad-mounted transformers.

4.1.8 Sizing for signs identifying substations:

- Size: 24” x 36” (Reference Figures 1a and 1b)

4.1.9 **DANGER**:

- **High Voltage Within – Keep Out** – 8” x 18” (Reference figure 3)
4.0 SAFETY SIGN DESIGN (continued)

4.1.10 NO TRESPASSING signs – 8” x 18” (Reference figure 2)

4.2 Material and Finish

4.2.1 The sign panels shall be specified as aluminum, Fiberglass Reinforced Plastic (FRP), Polyvinyl Chloride (PVC), High Density Polyethylene (HDP) or self-adhering sheeting consisting of a retroreflective lens system.

4.2.2 Both exterior and interior signs shall be rigid, flexible or self-adhering, depending upon where they are to be mounted. Flexible and self-adhering signs are used on curved or poly-sided surfaces.

4.2.3 The sign finish used shall be determined by whether or not the sign is to be exposed to weather conditions, chemicals, or other factors that may cause fading, cracking or blistering. The manufacturer of the sign should be consulted when the signs operating environment is unusual.

4.2.4 Careful records should be kept of the dates of purchase, the suppliers, and any warranty or guarantees to the purchaser. Reference SP.03.06.001 section 4.2 for details.

4.2.5 Details and specifications of sign colors and word message letter heights are contained in the latest revision of ANSI Z535.1 and ANSI Z535.2. (Reference Table 1 and Table 2)

4.3 Mounting Provisions

4.3.1 Signs shall be placed where they are legible, non-distracting and not hazardous in themselves. They should not be placed where they are likely to be dislodged, or removed or damaged by the hazardous device or condition for which they serve as a warning. They shall not be blocked by movable entities such as doors, windows, racks, gates, etc.

4.3.2 If necessary, supplemental illumination or retroreflectorization shall be furnished so that the signs are easily noticeable and readable. Emergency lighting should also be available for use when necessary.

4.3.3 Signs shall be displayed with due consideration abnormal situations such as emergencies, problems of visibility, power failure, etc.

4.3.4 No Trespassing signs shall be placed on the station fence and gates, and mounted with stainless steel ties. The sign shall be mounted so as to be clearly visible to anyone approaching the facility. There shall be a minimum of one sign on each side of the substation. (Reference Figure 2 for details and Figure 4 for placement)
4.0 **SAFETY SIGN DESIGN** (continued)

4.3.5 The placement of signs should be coordinated with existing public lighting and the design of the substation exterior lighting. Sign specific illumination is generally not required.

4.4 **911 Station Name and Address Signs**

4.4.1 **911 Station Name and Address** signs shall be placed on 4” x 4” pressure treated posts at the end of the station driveway near the public road access if substation is not clearly visible from road or is more than 100 yards off the public road; at the right or left side of the access gates/doors; and if applicable on the right end of the building side that is facing the street.

4.4.2 Guidance for selecting the “Long Address” Figure 1a or the “Short Address” Figure 1b sign depends on what the 911 Emergency Response System has on file.

4.5 **Danger Signs and Decals**

4.5.1 **DANGER** signs shall be placed on the station fence, and mounted with stainless steel ties. The sign shall be mounted so as to be clearly visible to anyone approaching the facility. There shall be a maximum spacing of 50’ between signs and a minimum of one sign on each side of the substation (Reference Figure 3 for details and Figure 4 for placement).

4.5.2 If equipment does not have factory installed **DANGER** decals, the appropriate ones shall be installed at the time of the equipment’s onsite inspection. Switchgear or enclosures with doors front and back shall have decals both front and back.

4.5.3 **DANGER** decals shall be mounted on the insides of equipment, with a decal in each compartment of multi-compartment equipment.

5.0 **SIGN LOCATION**

5.1 **Substation Perimeter, Fence and Gates**

5.1.1 Refer to figure 4 and 5 for posting of substation chain link fences.

5.1.2 Mounting height shall be 60in (1525mm) above grade to the centerline of the sign.

5.1.3 Sign all gates with the sign centered and mounted at a height of 60in (1525mm) above grade to the centerline of the sign.

5.1.4 Maximum distance between signs along fence perimeter not to exceed 50 feet.

5.1.5 Sign unhinged side of single gates at a height of 60in (1525mm) above grade to the centerline of the sign and one foot from gate post.

5.1.6 Remove old signs and return to stores for disposal.
5.0  **SIGN LOCATION** (continued)

5.1.7  On stations where customer owns fence and property and the Company owns equipment inside the fence – do not install Company name decal to sign.

5.2  Substation Yard, Structures and Outdoor Equipment

5.2.1  Safety signs shall be so placed to alert and inform the viewer in sufficient time to take appropriate evasive actions to avoid the potential harm from the hazard. Equipment identification signs shall be attached to outdoor structures supporting electrical equipment and other equipment within the substation yard protected area.

5.3  Control Building and Indoor Equipment

5.3.1  Control buildings and indoor spaces that house various cabinets, racks, panels and switchgear. All this equipment shall be labeled with the proper identification and warning signs.
6.0 FIGURES, TABLES AND CHARTS

Figure 1a: 911 Station Name (Long Address)

Exhibit B1: National Grid New England Station Sign Layout (long address)

Moore Station Access Rd.
at Route 18, Lebanon, NH
Craft Hill #11 Substation
In case of emergency call
1-800-322-3223

January 3, 2006
6.0 FIGURES, TABLES AND CHARTS (continued)

Figure 1b: 911 Station Name (Short Address)

Exhibit B2: National Grid New England Station Sign Layout (short address)

1 Bunker Road
Nantucket, MA

Bunker Road #102 Substation

In case of emergency call
1-800-322-3223

January 3, 2006
6.0 FIGURES, TABLES AND CHARTS (continued)

Our supplier for the 911 Station signs is:

W.S. Sign Design Corporation
Ron Whitaker, president
1434 Memorial Ave
West Springfield, MA 01089
Phone: 413.241.6916
Toll free: 800.927.3977
Fax: 413.241.6918
Ron's Cell: 413.244.6209
ronw@wsssign-design.com
Purchase Order (National Grid, PeopleSoft): 33411

To order a 911 Station sign, send an email to Ron Whitaker (address above) and include the following:

1. Subject line should read: National Grid Order - (station/facility name) Sign Order.
2. The complete street address, town and state (no abbreviations). Make sure the address is 911-system compliant.
3. The complete unique station/facility name exactly as it should appear on the sign.
4. The emergency phone number exactly as it should appear on the sign.
5. The number of signs needed.
6. The complete name, address, phone number and email address of the person placing the order. This should be the person whose PeopleSoft work list should get the invoice.
7. The complete name, address, phone number and email address of the person to whom the sign(s) should be shipped.
8. Date signs are needed (if critical; normal turnaround is two weeks).

The Vendor shall prepare a PDF proof and send it to the person placing the order for approval prior to production. That person should reply as soon as possible clearly indicating their approval, or the changes that need to be made.

Once the Vendor receives final approval they should produce and ship the order. The person who receives the signs should inspect them and report any problems (including seeking replacements) to the person who placed the order and the Vendor.

6.0 FIGURES, TABLES AND CHARTS (continued)
The Vendor shall prepare an invoice that should be marked ordered by (person's name)" and shall reference the station/facility name and address. The invoice should be mailed to:

Accounts Payable, C-1
National Grid
300 Erie Boulevard West
Syracuse, NY 13202
6.0 FIGURES, TABLES AND CHARTS (continued)

Figure 2: No Trespassing

Figure 3: Danger Keep Out
6.0 FIGURES AND TABLES (continued)

Figure 4: Sign Placement on Perimeter Gates and Fence

Notes:
1. Sign chain-link fences using DANGER sign “Chart-1 Item 1”.
2. Sign chain-link fences using NO TRESPASSING sign “Chart-2 Item 3”.
3. Sign 4”x 4” posts at access road and chain-link fences using station “911” sign “Chart-2 Item 1 & 2”.
4. All signs shall be mounted as close to a height of 60in (1525mm) above grade to the centerline of the sign as possible. Attach signs as level as possible.
5. Sign all gates at a height of 60in (1525mm) above grade to centerline of sign with sign at gate center.
6. Fence sides that contain no gates should have symmetrical sign placement as much as is possible.
7. Maximum distance between signs along fence perimeter not to exceed 50 feet.
8. Refer to Figure 4 and 5 for placement detail.
9. Sign unhinged side of single gates at a height of 60in (1525mm) above grade to centerline of sign one foot from gate post.
10. Remove old signs and return to stores for disposal.
11. On stations where customer owns fence and property and the Company owns equipment inside the fence – do not install Company name decal to sign.
6.0 FIGURES AND TABLES (continued)

Figure 5: Sign Placement on Fence

Substation Sign Placement Details

1 Bunker Road
Nantucket, MA
Bunker Road 100 Substation
1-800-322-3223

Notes:

1. All signs shall be mounted as close to a height of 60in (1525mm) above grade to the centerline of the sign as possible. Attach signs as level as possible.
### Table 1

<table>
<thead>
<tr>
<th>Color Names</th>
<th>Standard and Tolerances</th>
<th>Munsell Notation Specifications</th>
<th>Equivalent CIE Data Specifications</th>
<th>Boundary Equations on the CIE 1931 Chromaticity Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Red</td>
<td>Standard</td>
<td>7.5 R 4.0/14</td>
<td>0.5959 0.3269 12.00</td>
<td>Purple y = 0.4181 – 0.1700x</td>
</tr>
<tr>
<td></td>
<td>Hue +</td>
<td>8.5R 4.0/14</td>
<td>0.6037 0.3389 12.00</td>
<td>White y = 1.1084x – 0.2892</td>
</tr>
<tr>
<td></td>
<td>Hue –</td>
<td>6.5R 4.0/14</td>
<td>0.5869 0.3184 12.00</td>
<td>Orange y = 0.4054-0.1099x</td>
</tr>
<tr>
<td></td>
<td>Value +</td>
<td>7.5R 4.5/14</td>
<td>0.5775 0.3320 15.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value –</td>
<td>7.5R 3.5/14</td>
<td>0.6226 0.3141 9.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma +</td>
<td>7.5R 4.0/16</td>
<td>0.6260 0.3192 12.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma -</td>
<td>7.5R 4.0/12</td>
<td>0.5603 0.3321 12.00</td>
<td></td>
</tr>
<tr>
<td>Safety Orange</td>
<td>Standard</td>
<td>5.0YR 6.0/15</td>
<td>0.5510 0.4214 30.05</td>
<td>Red y = 0.2678 + 0.2545x</td>
</tr>
<tr>
<td></td>
<td>Hue +</td>
<td>6.25YR 6.0/15</td>
<td>0.5452 0.4329 30.05</td>
<td>White y = 0.5331</td>
</tr>
<tr>
<td></td>
<td>Hue –</td>
<td>3.75YR 6.0/15</td>
<td>0.5551 0.4091 30.05</td>
<td>Yellow y = 0.3722x + 0.2301</td>
</tr>
<tr>
<td></td>
<td>Value +</td>
<td>5.0YR 6.0/15</td>
<td>0.5427 0.4206 36.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value –</td>
<td>5.0YR 6.5/15</td>
<td>0.5606 0.4218 24.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma +</td>
<td>5.0YR 5.5/15</td>
<td>0.5597 0.4239 30.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma</td>
<td>5.0YR 6.0/13</td>
<td>0.5311 0.4154 30.05</td>
<td></td>
</tr>
<tr>
<td>Safety Yellow</td>
<td>Standard</td>
<td>5.0Y 8.0/12</td>
<td>0.4562 0.4788 59.10</td>
<td>Orange y = 0.9837x + 0.0112</td>
</tr>
<tr>
<td></td>
<td>Hue +</td>
<td>6.5Y 8.0/12</td>
<td>0.4498 0.4865 59.10</td>
<td>White y = 1.1007 - 104631x</td>
</tr>
<tr>
<td></td>
<td>Hue –</td>
<td>3.5Y 8.0/12</td>
<td>0.4632 0.4669 59.10</td>
<td>Green y = 1.2183x - 0.0615</td>
</tr>
<tr>
<td></td>
<td>Value +</td>
<td>5.0Y 8.5/12</td>
<td>0.4508 0.4754 68.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value –</td>
<td>5.0Y 7.5/12</td>
<td>0.4620 0.4823 50.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma +</td>
<td>5.0Y 8.0/14</td>
<td>0.4699 0.4920 59.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma</td>
<td>5.0Y 8.0/10</td>
<td>0.4376 0.4601 59.10</td>
<td></td>
</tr>
<tr>
<td>Safety Green</td>
<td>Standard</td>
<td>7.5G 4.0/9</td>
<td>0.2111 0.4121 12.00</td>
<td>Yellow y = 0.7598 – 1.4306x</td>
</tr>
<tr>
<td></td>
<td>Hue +</td>
<td>0.5BG 4.0/9</td>
<td>0.1974 0.3809 12.00</td>
<td>White y = 1.8471x – 0.0417</td>
</tr>
<tr>
<td></td>
<td>Hue –</td>
<td>5.0G 4.0/9</td>
<td>0.2237 0.4399 12.00</td>
<td>Blue y = 0.4935 – 0.5714</td>
</tr>
<tr>
<td></td>
<td>Value +</td>
<td>7.5G 4.5/9</td>
<td>0.2204 0.4060 15.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value –</td>
<td>7.5G 3.5/9</td>
<td>0.2027 0.4163 9.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma +</td>
<td>7.5G 4.0/11</td>
<td>0.1848 0.4319 12.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma –</td>
<td>7.5G 4.0/7</td>
<td>0.2350 0.3922 12.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma --††</td>
<td>7.5G 4.0/6</td>
<td>0.2467 0.3822 12.00</td>
<td></td>
</tr>
</tbody>
</table>
### 6.0 FIGURES AND TABLES (continued)

#### Table 1 (continued)

<table>
<thead>
<tr>
<th>Color Names</th>
<th>Standard and Tolerances</th>
<th>Munsell Notation Specifications</th>
<th>Equivalent CIE Data Specifications</th>
<th>Boundary Equations on the CIE 1931 Chromaticity Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hue Value/Chroma</td>
<td>x y y%</td>
<td></td>
</tr>
<tr>
<td>Safety Blue</td>
<td>Standard</td>
<td>2.5PB 3.5/10</td>
<td>0.1691 0.1744 9.00</td>
<td>Green y = 0.8725x + 0.0457</td>
</tr>
<tr>
<td></td>
<td>Hue +</td>
<td>4.5PB 3.5/10</td>
<td>0.1796 0.1711 9.00</td>
<td>White y = 0.2852 − 0.4696x</td>
</tr>
<tr>
<td></td>
<td>Hue −</td>
<td>10.0B 3.5/10</td>
<td>0.1557 0.1815 9.00</td>
<td>Purple y = 1.1134x − 0.0290</td>
</tr>
<tr>
<td></td>
<td>Value +</td>
<td>2.5PB 4.0/10</td>
<td>0.1805 0.1888 12.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value −</td>
<td>2.5PB 3.0/10</td>
<td>0.1575 0.1600 6.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma +</td>
<td>2.5PB 3.5/12</td>
<td>0.1516 0.1547 9.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma</td>
<td>2.5PB 3.5/8</td>
<td>0.1888 0.1964 9.00</td>
<td></td>
</tr>
<tr>
<td>Safety White</td>
<td>Standard</td>
<td>N9.0/</td>
<td>0.3101 0.3163 78.00</td>
<td>See Figure 2</td>
</tr>
<tr>
<td></td>
<td>Hue +</td>
<td>N9.5/</td>
<td>- - 90.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hue −</td>
<td>N8.75/</td>
<td>- - 73.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value +</td>
<td>/1.0(5R-5Y)</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value −</td>
<td>/0.5(5G-5P)</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma +</td>
<td>/0.0</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma</td>
<td>/0.0</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td>Safety Black</td>
<td>Standard</td>
<td>N1.5/</td>
<td>0.3101 0.3163 2.02</td>
<td>See Figure 2</td>
</tr>
<tr>
<td></td>
<td>Hue +</td>
<td>N2.5/**</td>
<td>- - 4.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hue −</td>
<td>N2.0/</td>
<td>- - 3.13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value +</td>
<td>N0.5/</td>
<td>- - 0.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value −</td>
<td>/0.5</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma +</td>
<td>/0.0</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chroma</td>
<td>/0.0</td>
<td>- -</td>
<td></td>
</tr>
</tbody>
</table>

(Reference ANSI Z535.1 – 2006)
6.0 FIGURES AND TABLES (continued)

Table 2

<table>
<thead>
<tr>
<th>Minimum Safe Viewing Distance</th>
<th>Minimum Height for FAVORABLE Reading Conditions</th>
<th>Recommended letter Height for UNFAVORABLE Reading Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ft.)</td>
<td>[Viewing distance (ft)/25] [Viewing distance (m)/3]</td>
<td>[Viewing distance (ft)/12] [Viewing distance (m)/1.43]</td>
</tr>
<tr>
<td>≤4</td>
<td>0.04* [2] 0.16* [2.5]</td>
<td>0.33 [2.5] 0.8 [2.5]</td>
</tr>
<tr>
<td>6</td>
<td>0.32 [2.5] 0.6 [2.5]</td>
<td>0.6 [2.5] 1.3 [2.5]</td>
</tr>
<tr>
<td>8</td>
<td>0.4 [2.5] 0.8 [2.5]</td>
<td>0.83 [2.5] 2.1 [2.5]</td>
</tr>
<tr>
<td>10</td>
<td>0.6 [2.5] 1.0 [2.5]</td>
<td>1.27 [2.5] 3.2 [2.5]</td>
</tr>
<tr>
<td>15</td>
<td>0.8 [2.5] 1.5 [2.5]</td>
<td>1.68 [2.5] 4.3 [2.5]</td>
</tr>
<tr>
<td>20</td>
<td>1.0 [2.5] 2.0 [2.5]</td>
<td>2.51 [2.5] 6.4 [2.5]</td>
</tr>
<tr>
<td>30</td>
<td>1.2 [2.5] 3.0 [2.5]</td>
<td>3.36 [2.5] 8.5 [2.5]</td>
</tr>
<tr>
<td>40</td>
<td>1.6 [2.5] 4.1 [2.5]</td>
<td>5.04 [2.5] 12.8 [2.5]</td>
</tr>
<tr>
<td>125</td>
<td>5.0 [2.5] 12.7 [2.5]</td>
<td>12.58 [2.5] 32.0 [2.5]</td>
</tr>
<tr>
<td>150</td>
<td>6.0 [2.5] 15.2 [2.5]</td>
<td>16.79 [2.5] 42.7 [2.5]</td>
</tr>
<tr>
<td>200</td>
<td>8.0 [2.5] 20.3 [2.5]</td>
<td></td>
</tr>
</tbody>
</table>

*0.16 inch (0.4 cm) type is suggested minimum type size for use on environmental/facility safety signs. (Reference ANSI Z535.2 – 2007)
### Chart 1 - Index of Class I and Class II Safety Signs

<table>
<thead>
<tr>
<th>Type Sign</th>
<th>Material</th>
<th>Size H x W</th>
<th>Safety Alert Panel</th>
<th>Signal Word Panel</th>
<th>Message Panel</th>
<th>Safety Symbol Panel</th>
<th>Layout</th>
<th>Item ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I (Rigid)</td>
<td>1</td>
<td>x</td>
<td>8” x 18”</td>
<td>DANGER</td>
<td>KEEP OUT HAZARDOUS VOLTAGE WITHIN WILL SHOCK, BURN OR CAUSE DEATH</td>
<td></td>
<td></td>
<td>0810029</td>
</tr>
<tr>
<td>Class II Flexible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class II Flex. RBL</td>
<td></td>
<td>x</td>
<td>8” x 18”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5483454</td>
</tr>
</tbody>
</table>

IT = Item #  FRP = Fiberglass Reinforced Plastic  PVC = Polyvinyl Chloride  HDP = High Density Polyethylene  AL = Aluminum
6.0 FIGURES, TABLES AND CHARTS (continued)

Chart 2 - Index of Class I, II, and III Non-Safety Signs

<table>
<thead>
<tr>
<th>Type Sign</th>
<th>Material</th>
<th>Size H x W</th>
<th>Alert Symbol</th>
<th>Category</th>
<th>Message Panel</th>
<th>Symbol Panel</th>
<th>layout</th>
<th>Item ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>1</td>
<td>x</td>
<td>x</td>
<td>24” x 36”</td>
<td>N/A</td>
<td>Street Address Station Name Phone Number (Long Address)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Class II</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td>24” x 36”</td>
<td>N/A</td>
<td>Street Address Station Name Phone Number (Short Address)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Class III</td>
<td>3</td>
<td>x</td>
<td>x</td>
<td>8” x 18”</td>
<td>N/A</td>
<td>NO TRESPASSING NATIONAL GRID</td>
<td>N/A</td>
<td>5483190 5483390</td>
</tr>
</tbody>
</table>

IT =Item #  FRP= Fiberglass Reinforced Plastic PVC= Polyvinyl Chloride HDP= High Density Polyethylene AL= Aluminum
7.0 REFERENCES

7.1 National Grid Underground Construction Standard (Section 31)
7.2 SMP 499.10.2 (Substation Work Area Identification Temporary Signs)
7.3 SP.03.06.001 Substation Sign Specification
## 8.0 REVISION HISTORY

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Description of Revision</th>
</tr>
</thead>
</table>