CONTRACT DOCUMENTS

AND

SPECIFICATIONS

FOR

PROJECT NO. ES 2020-05
NORTHSIDE WWTP 13.2 KV SWITCHGEAR IMPROVEMENTS

ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY

PREPARED BY:
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CITY OF Tulsa
A New Kind of Energy

ERIC LEE, DIRECTOR
WATER & SEWER DEPARTMENT
TULSA MUNICIPAL UTILITY AUTHORITY

Account Numbers: 193320003Z.SewerTreat.75003122-541101

Water & Sewer Department
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TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS
FOR
NORTHSIDE WWTP 13.2 KV SWITCHGEAR IMPROVEMENTS
PROJECT NO. ES 2020-05

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Tulsa, OK

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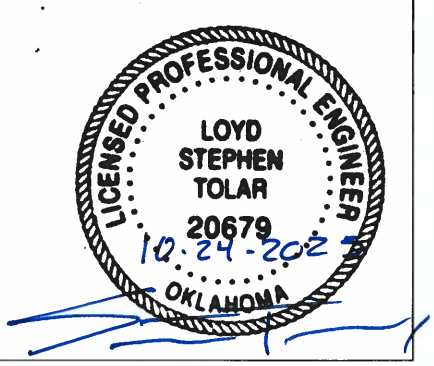

Stephen Tolar, P.E., S.E.
OK 20679

Holloway, Updike and Bellen, Inc.
C.A. No. 219
Expires June 30, 2025

Tulsa Metropolitan Utility Authority
Tulsa, OK

Northside WWTP 13.2 KV Switchgear Improvements
Project No. ES 2020-05

Specification Certification Sheet

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Bruce Brown, P.E.
OK 20995

Brown Engineers of Arkansas, LLC.
C.A. No. 4933
Expires June 30, 2024

1.1 PROJECT TITLE:

Northside WWTP 13.2 KV Switchgear Improvements

1.2 PROJECT IDENTIFICATION:

Project No. ES 2020-05

1.3 OWNER:

Tulsa Metropolitan Utility Authority

1.4 PLANS AND SPECIFICATIONS PREPARED BY:

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1.5 MEASUREMENT AND PAYMENT:

It is the intent of the Proposal and these Special Conditions that the total bid, as submitted, shall cover all work shown on the contract drawings and required by the Specifications and other Contract Documents. All costs in connection with the work, including furnishing of all materials, equipment, supplies and appurtenances; providing all construction equipment and tools, and performing all necessary labor to fully complete the work, shall be included in the unit and lump sum prices named in the Proposal. No item of work that is required by the Contract Documents for the proper and successful completion of that contract will be paid for outside of or in addition to the prices submitted in the Proposal. All work not specially set forth in the Proposal as a pay item shall be considered a subsidiary obligation of the Contractor and all costs in connection therewith shall be included in the Lump Sum Prices named in the Proposal.

Payment cannot exceed 90% on any schedule of value item until items 1.13 Operation and Maintenance Manuals, item 1.15 Manufacture's Startup/certification/Training Requirements and item 1.16 Miscellaneous Project Documentation with completed project's equipment warrantee log have been completed and provided to the City as applicable. These last components as described in these sections of the contract's work

constitutes the last 10% of the cost of each item of the schedule of values as applicable.

1.6 ALLOWANCE:

An allowance has been provided in the contract for various mechanical, electrical, and plumbing (MEP) work.

A. The allowance shall be used for the cost of materials, labor, installation, and overhead and profit, in accordance with GC-26, for additional MEP work that is not identified in the Construction Documents / Plans, and not included in the base bid lump sum.

B. The allowance shall be used only at the discretion of the Authority.

C. The Contractor shall provide, to the Authority Representative, a written request for the use of the allowance, with a schedule of values, and associated backup information.

D. Contractor shall proceed with work included in the allowance only after receiving a written order, from the Authority Representative, authorizing such work. Proceeding with work in the allowance without a written order from the Authority Representative will be at the Contractor's cost.

1.7 SCHEDULE OF VALUES:

The Contractor shall prepare a Schedule of Values for the work covered by the Agreement.

A. Generally, the Schedule of Values should reflect the format of the Proposal and include specified allowances, alternates and any alternate equipment selected by the Owner as applicable.

B. For Lump Sum items in the Schedule of Values should include breakdowns for major portions of the work including the following breakdown or as additionally required by the Engineer to facilitate the pay application process.

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

D. Summation of the Complete Schedule of Values representing all Work shall equal the Contract Price.

E. The Schedule of Values shall be submitted to Engineer for approval prior to pay application processes and should be submitted during the week of the pre-construction meeting.

1.8 TRADE NAMES AND MATERIALS:

Where materials or equipment are specified by a trade or brand name, it is not the intention of the Owner to discriminate against an equal product of another manufacturer, but rather to set a definite standard of quality of performance, and to establish equal basis for the evaluation of bids. Where the words "Equivalent", "proper", or "equal to" are used, they shall be understood to mean that the thing referred to shall be proper, the equivalent of, or equal to some other thing, in the opinion or judgment of the Engineer. Unless otherwise specified, all materials shall be the best of their respective kinds and shall be in all cases fully equal to approved samples. Not withstanding that the words "or equal to" or other such expressions may be used in the Specification in connection with a material, manufactured article or process, the material, article or process, specifically designated shall be used, unless a substitute shall have been approved in writing by the Engineer and the Engineer shall have the right to require the use of such specifically designed material, article or process.

No material which has been used by the Contractor for any temporary purpose whatsoever is to be incorporated in the permanent structure without written consent of the Engineer.

1.9 COORDINATION:

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

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

C. Conduct Work outside regular working hours only with prior written consent of Owner.

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

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

F. Any tanks or pipelines requiring drainage prior to construction will be drained by the Owner’s staff to the maximum extent possible utilizing existing piping and

drains where they exist. Contractor shall provide temporary pumping and effort to complete drainage of tank or pipeline as required. Provide minimum 7 days notice to Engineer and Owner of need to drain a facility, unless otherwise specified.

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

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

1.10 STANDARD SPECIFICATIONS:

The City of Tulsa Public Works Department Standard Specifications and Standard Details March 2022 are hereby adopted as part of these Specifications where reference is made. Said Specifications will be referred to as the "Standard Specifications".

The Oklahoma State Highway Commission "Standard Specifications for Highway Construction" latest edition are hereby adopted as part of these Specifications where reference is made. However, no portion of the Standard Specifications referring to Basis of Payment will be adopted as part of these Specifications.

1.11 CONTRACTOR'S FIELD OFFICE:

Not required.

1.12 ENGINEER'S FIELD OFFICE:

Not required.

1.13 OPERATIONS AND MAINTENANCE MANUALS:

Three (3) hard copies and One (1) digital copy, unless otherwise stated, of manuals containing specifications, drawings and descriptions of each individual item of the equipment, equipment summary sheet, installation instructions, operating and maintenance instructions, inspection startup reports, initial set points if applicable, certifications and parts lists shall be provided. The manual shall be a single manual covering complete operating installation, separate sheets or brochures for the equipment not manufactured by the major supplier shall all be included. A cover pages and index shall also be included. These manuals shall be in addition to any instructions packed with the equipment and shall be submitted not later than the date of shipment of the equipment.

Preliminary O&Ms shall be submitted for review by the City and Engineer prior to equipment installation.

Final O&Ms shall be provided in 3-ring binder(s), 3" maximum, with clear view cover and spine, clearly identifying the project name/number and include index tabs if applicable, start up reports, certification, initial set points if applicable, City of Tulsa equipment summary sheet and Manufacture's equipment O&M included. No spiral bound volumes permitted; spine must be suitable for affixing a self-adhesive label. All material content shall be clearly legible; material obscured or rendered partially illegible resolution as a result of photo-electronic reproduction will be considered unacceptable.

Digital copy shall be provided on CD or USB Drive of the complete final O&M. All files shall be formatted in current searchable Adobe PDF format.

O&Ms shall include a completed equipment summary data sheet (attached) for each equipment item that has been named/tagged/numbered on the drawings.

Final O&Ms shall include a "screen shot" PDF of each HMI screen updated and/or added by this contract into related equipment's Final O&M. Contractor shall also transmit a complete package of PDF screen shots of each HMI screen updated and/or added by this contract as a summer booklet of HMI information and part of contract close out documentation.

Key project O&Ms shall be provided for:

a. Switchgear
b. ATS
c. Any other major electrical equipment.

Other appropriate equipment part of the project or requested by the Engineer. See other specification sections for additional requirements.

1.14 PROGRESS MEETINGS:

Monthly progress meetings shall be scheduled on a weekday mutually agreeable to the Authority, Engineer and the Contractor. A reoccurring date shall be agenda item in the pre-construction meeting (pre-work). The Contractor shall run the Monthly Meetings for the duration of the project and provide a meeting agenda including work completed, work planned, project updates, submittal/RFI logs, monthly updated project schedule, monthly updated warrantee log and other pertinent project status information.

The contractor shall submit a work progress and planned completion schedule for each bid item at the monthly progress meeting. The pre-construction (pre-work) conference will constitute the first monthly progress meeting, however the City will run the meeting. The Contractor, at the contractor's option may include Subcontractor's in the Monthly Progress Meeting as appropriate and helpful for coordination during construction.

1.15 MANUFACTURER'S START-UP, CERTIFICATIONS & TRAINING REQUIREMENTS:

Manufacture's certification that the equipment is suitable and will perform within specification and manufacturer's design operating parameters for the locations and conditions herein specified. Manufacture's services shall also include site visits by the Manufacture's *Technical Representative's* prior to construction, during installation and for start-up, as necessary for an inspection, detailed start up report and Manufacture's certification of proper installation. Submit the Manufactures start-up report(s) and certification(s) of proper installation when they become available to the Engineer and during the week the equipment is being put into service. Included final copies of the Manufacture's Start-up Certificates in the final O&Ms. Start-up report/Manufacture's Certification should include pertinent start up details, equipment description, location, project information, complete initial set points, initial operational readings, equipment numbers and date and other pertinent system information for future operations and maintenance.

Training shall also be provided for the equipment and systems installed. Submit a draft training agenda, draft handouts, power point/video and a Manufacture's Technical Representative's resume for acceptance prior to scheduling the start-up and training. Provide two separate training days, as coordinated with the Plant to accommodate both day and night shifts. The Contractor may be required to provide additional training beyond specific equipment training where the equipment is part of a system. Multiple training events may be required for both the equipment components, control/integration and for the "system". The duration of the training should be a minimum of 4 hours per training day of classroom and field training or more, if recommended by the Manufacturer. A professional video services shall also be provided to cover both complete classroom and field training sessions. Deliverables are to include the full training video on DVD with the final O&Ms to the City. Provide additional standard Manufacturer's videos if available on the same DVD in the final O&M.

1.16 MISCELLANEOUS PROJECT DOCUMENTATION:

Warrantee Equipment Log: Submit within 90 calendar days from the issuing of the Notice to Proceed, a draft Warrantee Equipment Log spreadsheet complete with project equipment information and equipment numbers for review. From that point on, the log will be updated each month by the Contractor and be a handout in the Monthly Meetings. A live spread sheet version shall be provided by the Contractor upon request by the Authority. Upon project completion, the spread sheet shall be completed with all required information from the Contractor such as equipment numbers, start up dates, training dates, O&M dates and other relevant information and transmitted to the Owner for their future use in maintaining the equipment. A sample spread sheet is available upon request from the Engineer. *The warrantee log will be used as the project tool to establish and agree on equipment warrantee period start date(s). Equipment start up, City staff training completed and submission of draft O&Ms are the minimum requirements for a warrantee start date.*

1.17 EXPLOSIVES:

The use of explosives will not be allowed.

1.18 INSPECTION:

The Contractor will provide access to the work site and facilities for representatives of the Environmental Protection Agency and Oklahoma Department of Environmental Quality and other agencies, as well as Owner and Engineer, as required whenever the work is in progress.

1.19 SATURDAY, SUNDAY, HOLIDAY AND NIGHT WORK:

No work shall be done between the hours of 7:00 p.m. and 7:00 a.m., nor on Saturday, Sunday or legal holidays without the written approval or permission of the Owner, in each case, except such work as may be necessary for the proper care, maintenance and protection of work already done, or of equipment, or in the case of an emergency.

1.20 PROTECTION OF PROPERTY:

A. The protection of Local, State, and Government monuments, street signs and other Owner's property is of prime importance, and if the same be damaged, destroyed or removed, they shall be repaired, replaced or paid for by the Contractor. Disturbance to this property must first be approved by the agency which controls it.

B. No valves or other control on any utility main or building service line shall be operated for any purpose by the Contractor. Coordinate with Plant Operations for valve and other control on any utility main or building service line.

C. At places where the Contractor's operations are adjacent to the plant of railway, telegraph, telephone, electric and gas companies, or water, sanitary sewers and storm sewers, damage to which might result in expense, loss or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been completed.

D. The contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner and that services rendered by those parties will not be unnecessarily interrupted. The revision and crossings of the various types of lines shall be made as follows:

(1) Storm sewers and culverts may be removed at the time of crossing or may be adequately braced and held in position while the pipe is placed beneath them. If the storm sewer or culvert is removed, it shall be replaced with pipe of the same type and size as that removed and it shall be re-joined to

the undisturbed line with a joint satisfactory to the Engineer. Backfill over the main up to and around the storm sewer shall be thoroughly compacted in order that no settlement will occur. The revision and crossing of said lines shall be at the expense of the Contractor.

(2) All overhead and buried telephone and electrical conduits, to be revised or crossed by the construction of this project shall be protected in accordance with the directions of the utility company owning the conduits and/or mains. The Contractor shall notify the companies and obtain their permission before making any crossing or revisions. The revision and crossing of said lines shall be at the expense of the Contractor. Any overhead cables or buried cables or conduits damaged by the Contractor shall be repaired at his expense to the satisfaction of the Engineer and of the Owner.

(3) The Contractor shall not remove any water or sanitary sewer lines except as directed by the Owner or as required by the Drawings and Specifications, and shall adequately brace and protect them from any damage during construction. Any existing water main or sewer main damage caused by the Contractor's operations will be repaired by the Contractor. The repairs will be made at the Contractor's expense.

E. The location of utility service lines serving individual properties are generally not shown on the Drawings, but the CONTRACTOR shall assume that such service lines exist whether or not they are shown on the Drawings, and it shall be the responsibility of the CONTRACTOR to contact the necessary utilities and have all utilities located. It shall be the responsibility of the CONTRACTOR to make any necessary changes in the line and/or grade of such services or to secure the necessary changes therein to be made by the particular utility company involved or other owner thereof, or by an agent or individual CONTRACTOR approved by such utility company or other owner. CONTRACTOR shall pay the cost of all such revisions whether performed by CONTRACTOR, the utility company or other owner, or an approved CONTRACTOR. In the event of interruption of a utility service as a result of accidental breakage, CONTRACTOR shall promptly notify the ENGINEER and the owner of the utility, and shall repair or cause the same to be repaired, in the same manner as necessary changes above are provided for, the CONTRACTOR shall do all things necessary to see that the restoration of services are done as promptly as may be reasonably done.

F. In the event the Contractor in any way fails to comply with the requirements of protecting, repairing and restoring of any utility or utility service, the Owner may, upon forty-eight (48) hours written notice proceed to protect, repair, rebuild or otherwise restore such utility service as may be deemed necessary, and the cost thereof will be deducted from any money due or which may become due the Contractor pursuant to the terms of his contract.

1.21 ASSISTANCE BY ENGINEER:

It is understood and agreed that such assistance as the Engineer may render to the Contractor in connection with the interpretation of drawings and Specifications shall not relieve the Contractor from any responsibility for the work. Any work which proves faulty shall be corrected by the Contractor without delay. The failure of the Engineer, or Resident Project Representative to call the Contractor's attention to faulty work or work performed which is not in accordance with Drawings and Specifications shall not imply acceptance or exempt the Contractor for correcting the improper work.

1.22 INCIDENTAL WORK:

Work called for on the Drawings and/or Specifications and are not set forth in the Bid Schedule as pay items, shall be considered as incidental work and will not be paid for directly, but shall be included in the price bid for the various pay items.

1.23 SUBSTANTIAL AND FINAL COMPLETION:

When the work is substantially complete, Contractor shall notify the Owner and Engineer in writing that the entire work is substantially complete (operational or beneficial occupancy) and request that Engineer issues a certificate of substantial completion. Work which may remain uncompleted at substantial completion shall include only minor surface work relative to right-of-way restoration, sodding, seeding, pavement replacement, etc.

Upon written notice from Contractor to the Engineer and Owner that the entire work is complete within the time called out on the Bid the Engineer will make a final inspection with Owner and Contractor and will notify Contractor in writing all particulars of the project which are incomplete or defective. The Contractor shall immediately take such measures as are necessary to complete such work prior to final payment.

1.24 EXCAVATION:

No additional payment shall be made for encountering materials such as limestone, groundwater, or other natural formations.

Prior to any excavation work, Contractor shall contact OKIE (1-800-CALL-OKIE) as well as all utility Owners within the work site.

1.25 SCHEDULES:

The Contractor shall provide the following relative to project schedules.

A. PROJECT SCHEDULE:

The Contractor shall furnish the Engineer with a tentative baseline schedule, in a

format approved by the Engineer, setting forth in detail the procedure he proposes to follow, and giving the dates on which, he expects to start and to complete separate portions of the work. The tentative baseline schedule shall be submitted prior to the Contractor's first pay application. The schedule shall be updated and submitted to the Engineer on a monthly basis corresponding with the date of the monthly progress meetings. If at any time, in the opinion of the Engineer, proper progress is not being maintained, such changes shall be made in the schedule of operations which will satisfy the Engineer that the work will be completed within the period stated in the proposal, or extension thereof made as herein provided.

B. WEEKLY SCHEDULE OF WORK:

The CONTRACTOR shall submit to the Resident Project Representative a schedule of work to be done each week. The listing shall include the work to be done each day of the week and the locations. The schedule shall be submitted by the close of business on the Friday before the week covered by the schedule.

C. PROJECT MILESTONES:

The Contractor shall complete the work in accordance with the following Project Milestones:

Project Milestones:	Calendar Days from Notice to Proceed
Submit approvable equipment submittals for all major electrical equipment.	60
Substantial Completion	840
Final Completion of al work	900

1.26 DETERMINATION AND EXTENSION OF CONTRACT TIME:

The contract time consists of the number of calendar days stated in the Contract for the completion of the work beginning on the effective date of the work order or the date the CONTRACTOR begins work, whichever is earlier, including all Sundays, holidays and non-work days. All calendar days elapsing between effective dates of any orders of the Engineer to suspend work and to resume work for suspensions, not the fault of the CONTRACTOR shall be excluded.

The occurrence of unusually severe weather during the life of the contract will be considered a basis for extending contract time when work is not already suspended for other reasons. Unusually severe weather shall mean weather which at the time of year it occurs is unusual for the place in which it occurs.

Extension of time for unusually severe weather will be determined on a monthly basis and will include only those actual adverse weather days in excess of the normal adverse weather days included in the contract time. Normal adverse weather shall mean adverse weather which, regardless of its severity, is to be reasonably expected for that particular place at that particular time of year. The normal adverse weather days included in the contract time as shown in Table A are based on historical records of temperature and precipitation.

Actual adverse weather days are those days meeting one or more of the criteria in "a", "b", "c" and "d" below. Time extensions for days meeting more than one criterion will take into consideration only that criterion having the greatest impact. Those actual adverse weather days covered by criterion "a", "b", or "c" that are in excess of the days in Table A will be allowed without regard to when they occur (except prior to mobilization or during suspension for other reasons) or their impact on contract completion. However, those days covered by criterion "d" will be subject to the limitations as noted:

"a" Days with Maximum temperature of 32º F or less - one full day allowed.

"b" Days with Minimum temperature of 32º F or less, but whose Maximum temperature is over 32º F - one-half day allowed.

"c" Days when 1/2" or more precipitation (rain or snow equivalent) occurs - one full day allowed.

"d" Days when weather related conditions exist which prohibit proper performance of work as specified - one full day allowed. Allowance of such days will be subject to the work which is being delayed, being critical to timely contract completion and the CONTRACTOR making every reasonable effort to minimize the adverse impact of the conditions.

TABLE A
NORMAL ADVERSE WEATHER DAYS
(BY MONTH)

MONTH	NORMAL ADVERSE WEATHER DAYS
January	9
February	7
March	6
April	3
May	3
June	3
July	2
August	2
September	3
October	3
November	5
December	7

END OF SECTION

1.1 SCOPE. This section covers delivery, storage, and handling of materials and equipment.

1.2 DELIVERY. Contractor shall bear the responsibility for delivery of equipment, spare parts, special tools, and materials to the site and shall comply with the requirements specified herein and shall provide required information concerning the shipment and delivery of the materials specified in this Contract. These requirements also apply to any sub-contractor suppliers making direct shipments to the Site.

Contractor shall, either directly or through contractual arrangements with others, accept responsibility for the safe handling and protection of the equipment and materials furnished under this Contract before and after receipt at the port of entry. Acceptance of the equipment shall be made after it is installed, tested, placed in operation and found to comply with all the specified requirements.

All items shall be checked against packing lists immediately on delivery to the site for damage and for shortages. Damage and shortages shall be remedied with the minimum of delay.

Delivery of portions of the equipment in several individual shipments shall be subject to review of Engineer before shipment. When permitted, all such partial shipments shall be plainly marked to identify, to permit easy accumulation, and to facilitate eventual installation.

1.3 STORAGE. Upon delivery, all equipment and materials shall immediately be stored and protected until installed in the Work.

Stacked items shall be suitably protected from damage by spacers or load distributing supports that are safely arranged. No metalwork (miscellaneous steel shapes and reinforcing steel) shall be stored directly on the ground. Masonry products shall be handled and stored in a manner to hold breakage, chipping, cracking, and spalling to a minimum. Cement, lime, and similar products shall be stored off the ground on pallets and shall be covered and kept completely dry at all times. Pipe, fittings, and valves may be stored out of doors, but must be placed on wooden blocking. PVC pipe, geomembranes, plastic liner, and other plastic materials shall be stored off the ground on pallets and protected from direct sunlight.

Pumps, motors, electrical equipment, and all equipment with antifriction or sleeve bearings shall be stored in weathertight structures maintained at a temperature above 60°F. Electrical equipment, controls, and insulation shall be protected against moisture and water damage. All space heaters furnished in equipment shall be connected and operated continuously.

Equipment having moving parts, such as gears, bearings, and seals, shall be stored fully lubricated with oil, grease, etc., unless otherwise instructed by the manufacturer. Manufacturer's storage instructions shall be carefully followed by Contractor.

When required by the equipment manufacturer, moving parts shall be rotated a minimum of twice a month to ensure proper lubrication and to avoid metal to metal "welding". Upon installation of the equipment, Contractor shall, at the discretion of Engineer, start the equipment at one-half load for an adequate period of time to ensure that the equipment does not deteriorate from lack of use.

When required by the equipment manufacturer, lubricants shall be changed upon completion of installation and as frequently as required thereafter during the period between installation and acceptance. New lubricants shall be put into the equipment by Contractor at the time of acceptance.

Equipment and materials shall not show any pitting, rust, decay, or other deleterious effects of storage when installed in the Work.

In addition to the protection specified for prolonged storage, the packaging of spare units and spare parts shall be for export packing and shall be suitable for long-term storage in a damp location. Each spare item shall be packed separately and shall be completely identified on the outside of the container.

1.4 HANDLING. Stored items shall be laid out to facilitate their retrieval for use in the Work. Care shall be taken when removing the equipment for use to ensure the precise piece of equipment is removed and that it is handled in a manner that does not damage the equipment.

END OF SECTION

PART 1 – GENERAL

1.1 SCOPE. This section covers the furnishing and installation of nameplates and tags for identification of equipment, valves, gates, panels, and instruments.

1.2 GENERAL. Except as otherwise specified in equipment, valve, and instrumentation sections, nameplates and tags shall be as specified herein. Nameplates or tags shall be provided for all equipment, valves, operator interfaces, control and electrical panels, cabinets, instruments, and instrument racks that have been named and/or tagged on the Drawings.

1.3 SUBMITTALS. Drawings and data shall be submitted in accordance with the requirements of the Submittals Procedures section for each type of tag provided including materials, colors, sizes, letter sizes, and installation instructions.

PART 2 - PRODUCTS

2.1 EQUIPMENT NUMBER PLATES. All Equipment tagged on the drawings, except for submerged equipment shall be provided with number plates bearing the equipment tag number and general description of item identified on the Drawings. The number plate and the description plate shall be two plates with number mounted one above the other as coordinated with the Engineer. Number plates shall be bevelled, 1/8th inch thick laminated blue phenolic plastic engraving stock with white core. Lettering on number plates shall be capitalized block letters ¾ inch high. Number plate height shall be twice the letter height. Number plate length shall be as needed, with suitable margins all around. Lettering shall be placed in one row where practicable; however, where necessary due to excessive length, lettering shall be placed on more than one row and centered.

Number plates shall be attached with stainless steel panhead screws, stainless steel rivets, or stainless steel drive screws.

When a number plate cannot be installed due to the physical size, space, other limitations or mounting surface geometry of the equipment, the Contractor shall provide a 12 gauge stainless steel tag with engraved or imprinted equipment tag number. Lettering on tags shall be ¼ inch high. Tags shall be rectangular with smooth edges, and shall be fastened to the equipment with stainless steel mechanical fasteners or with a stainless steel chain.

Additional tags showing the primary Equipment Number (ID number) and a secondary equipment description tag shall be provided for ancillary equipment that does not have an individual Equipment Number assigned. Ancillary equipment includes electrical control panels, power panels, transformers, disconnects, seal water stations, valves and other miscellaneous equipment as determined by the Owner.

2.2 VALVE AND GATE TAGS.

A. Temporary Tags. Each valve and gate with an identifying number indicated on the Drawings or listed in the valve or gate schedule, shall be tagged or marked in the factory with the identifying number.

B. Permanent Tags. All valves and gates, except buried or submerged valves, that have been assigned an equipment number on the Drawings or in the valve or gate schedule, shall be provided with a permanent number plate. Equipment Number Plates shall be round 1.5" and 1/16" thick laminated blue phenolic plastic engraving stock that is U/V stable. Lettering shall be in 3 sections, centered, and white capitalized block letters 3/16" high and engraved to a depth of 0.08mm.

Example: 1st line XXXX -
2nd line XXXX -
3rd line XXXX -

Equipment Number Plates must follow the equipment numbering scheme.

Equipment Number Plates shall be attached with permanent ties.

All buried valves shall be tagged with a 304 stainless steel 1/32" plate with embed anchoring cast into a concrete collar pad at grade around valve box (See plans for detail). The numbers and service description shall be engraved in the plate with lettering and numerals at least 1 inch [25 mm] high.

Valve and gate tags shall at a minimum contain the following information:
"Descriptive System or Equipment Name", as applicable
"Equipment Number"
"Plan ID (if different from Equipment Number)"

2.3 EQUIPMENT, PANELS, INSTRUMENTS.

A. Temporary Tags. Each equipment, panel or instrument with an identifying number indicated on the Drawings or listed in plan sheet schedule as applicable, shall be tagged or marked in the factory, by the factory with the identifying number and description tag.

B. Permanent Tags. All equipment tagged on the drawings, except for buried submerged equipment shall be provided with an Equipment Number Plate bearing the equipment tag number identified on the drawings. Equipment Number Plates shall be rectangular 3.5"x .75" and 1/16" thick laminated blue phenolic plastic engraving stock that is U/V stable. Lettering shall be

1 line of text, centered, and white capitalized block letters .25” high and engraved to a depth of 0.08mm.

Example: 1st line XXXX -
2nd line XXXX -
3rd line XXXX -

Equipment Number Plates must follow the equipment numbering scheme.

Equipment Number Plates shall be attached with permanent adhesive.

Tags shall at a minimum contain the following information:
“Descriptive System or Equipment Name”, as applicable
“Equipment Number”
“Plan ID (if different from Equipment Number)”

PART 3 – EXECUTION

Not used. See City of Tulsa standards and other specification sections as applicable.

END OF SECTION

EQUIPMENT NAMEPLATE AND SUMMARY DATA

Equipment Number: _____

Description (Include size): _____

Project #: _____

Spec. #: _____

Vendor: _____

Manufacturer: _____

Model #: _____

***Item or Drawing #** _____

***Serial #**: _____

Purchase Price: $_____

Date Placed in Service (for 1-yr Warranty): _____

Manufacturer's Warranty Period and End Date: _____

Parts / Associated Details: _____

_____

_____

_____

Maintenance Schedule

(May be an attached sheet from O&M Manual; do not use "See O&M Manual")

- ✓ Initial: _____
- ✓ Weekly: _____
- ✓ Monthly:_____
- ✓ Semi-Annual:_____
- ✓ Annual: _____

Applicable Motor Information: N.A. (Circle if not applicable)

Vendor: _____

Manufacturer: _____

Model #: _____

Item #: _____

Serial #: _____

Frame: _____ Insul. Class: _____

Volts/Hz/Amps:_____

HP / RPM / SF: _____

Manufacturer's Warranty Period and End Date: _____

*__Item or Drawing #__ may not be unique. For example, it may be the same for a group of same size valves or gates, each one having this same number that is unique to the group. The __Serial #__ should be listed only when unique to this individual piece of equipment, otherwise it is N.A.

1. SHOP DRAWINGS, SAMPLES AND PRODUCT DATA

1.1 GENERAL - Submittals on component parts forming a system, or that are interrelated, shall be submitted at one time as a single submittal in order to demonstrate that the items have been properly coordinated and will function as a unit.

1.2 Shop Drawings - Identify details by reference to sheet and detail numbers shown on Contract Drawings. Use same symbols wherever practicable. Reproductions of Contract Drawings are acceptable as shop drawings only when specifically authorized in writing by the Engineer.

1.3 Samples - Includes all required physical examples to illustrate materials, equipment or workmanship, which establish standards by which completed work is urged. Must be of sufficient size and clarity, and in sufficient quantity to clearly Illustrate functional characteristics and full range of colors, patterns, textures or other properties which will be actually produced.

1.4 Product Data - Includes manufacturer's schematic drawings, catalog sheets, brochures, diagrams, schedules, performance charts, illustrations, test reports, certificates of compliance, and other descriptive data not included on shop drawings. Modify standard descriptive data to delete information which is not applicable, and clearly identify pertinent data.

1.5 SUBMISSION REQUIREMENTS - Submittals shall be made with a letter of transmittal to the Engineer by the Contractor, and not by sub-contractors, suppliers or manufacturers.

1.6 Submit samples in number specified, or if not so specified, in triplicate.

1.7 Submit Project Data in sufficient quantity for required distribution and record, allowing two copies to be retained by Engineer.

1.8 Identify all submittals with the following information, as applicable:

Project title and Engineer's project number.
Name of Contractor, Engineer, originating sub-contractor or supplier.
Submittal date, and all revision dates.
Identify each product or material submittal by reference to Specification section and page no., drawing no., or any other contract document reference applicable thereto.

Applicable conformance standards.

Include certification of Contractor review and conformity to contract requirements per General Conditions, Paragraph 6.25. Identify any deviations from Contract Documents. Provide 3" x 3" minimum space for Engineer's review stamp.

2. PROJECT RECORD DOCUMENTS

2.1 MAINTENANCE OF DOCUMENTS - Maintain at jobsite one record copy of Contract Drawings, Specifications, Addenda, approved Shop Drawings, Change Orders, other modifications to the Contract, field test records and other approved documents submitted by Contractor in compliance with Specification requirements.

2.2 Maintain documents at the project apart from documents used for construction. Do not use record documents for construction purposes. Maintain documents in clean, legible condition. Make documents available at all times for inspection of the Engineer and Owner.

2.3 RECORDING - Label each document "PROJECT RECORD COPY" in 2" high printed letters. Keep record documents current. Do not permanently conceal any work until required information has been recorded.

2.4 CONTRACT DRAWINGS - Legible mark most appropriate drawing to record, where applicable:

- Depths of various elements of foundation in relation to first floor level.
- Horizontal and vertical location of underground utilities and appurtenances referenced to permanent surface improvements.
- Location of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of structure.
- Field changes of dimension and detail made during construction process.
- Changes made by Change Order or Field Order.
- Details not on original Contract Drawings.
- Any change in location of facilities. Use City Survey Control System.

2.5 SPECIFICATIONS AND ADDENDA - Legibly mark up each Section to record:

- Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.
- Changes made by Change Order or Field Order.
- Other matters not originally specified.

2.6 SHOP DRAWINGS - Maintain as record drawings. Legibly annotate shop drawings to record changes made after review. Use red felt tip marking pen for all recording.

2.7 SUBMITTALS- At completion of project, deliver record documents to the Engineer. Accompany submittal with transmittal letter, in duplicate, containing:

- Date, project title and number.
- Contractor's name and address.
- Title and number of each record document.
- Certification that each document as submitted is complete and accurate.
- Signature of Contractor or his authorized representative.

3. PROJECT SUBMITTAL LOG

3.1 Contractor shall provide draft submittal log prior to the first monthly meeting identifying and listing by specification number, description and other submittal information for use on the project. Contractor will incorporate comments provided by the Owners Representative. Log shall separately list the preliminary O&Ms also. Contractor shall maintain and provide a copy of the submittal log at each Monthly Progress Meeting.

END OF SECTION

PART 1- GENERAL

1.1 CLEARING AND GRUBBING

A. This item shall consist of the clearing and/or grubbing, including the disposal of materials for all areas within the construction limits of work reflected on the plans and any other areas designated on the plans.

B. Clearing shall consist of the removal of all trees, brush, stumps, logs, or other objects in the designated area(s).

C. Grubbing shall consist of the removal of all stumps, roots, buried logs, brush, grass, and other unsatisfactory materials to a depth of at least 18 inches unless the object if left would be detrimental to the purpose of the site in which case the object shall be totally removed to at least a depth which would not be detrimental to the purpose of the site.

D. Depressions left from the clearing and grubbing operations shall be filled using suitable fill material. The fill operation shall be done in six-inch (compacted thickness) lifts and compacted to 90% of maximum in future grass areas as determined by the Standard Proctor Test (ASTM D698) and to 95% of maximum in future pavement or structure areas as determined by the Standard Proctor Test (ASTM D698).

1.2 EXCAVATION AND EMBANKMENT

A. This item shall consist of the excavation, placement, compaction, and disposal of earth materials within the project area to the lines and grades shown on the plans. The contractor shall remove and dispose of excess excavation off site or provide borrow material from off site, both at his expense.

B. All excavation and embankment shall be unclassified with respect to pay purposes and shall be included in the lump sum contract price including any rock excavation.

C. Before beginning excavation, grading and embankment operations in any area, the area shall be completely cleared and/or grubbed.

D. The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All unsuitable material shall be suitably disposed of by the Contractor. Waste areas shall be graded to allow positive drainage of the area and adjacent areas.

E. If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor

shall notify the Engineer, who shall arrange for their removal if necessary. The Contractor shall, at his/her own expense, satisfactorily repair or pay the cost of all damage to such facilities or structures which my result from any of the Contractor's operations during the period of the contract.

F. The contractor shall provide drains, pumps, well points or other equipment as necessary to dewater the site as required to perform the sitework.

G. All fill or embankment shall be placed in six-inch (compacted thickness) lifts and compacted, using suitable equipment to 95% of maximum as determined by the Standard Proctor Test (ASTM D698). Compliance with this requirement shall be evidenced by independent laboratory tests performed by and paid for by the Owner.

H. Rock in size or quantities such that a well compacted embankment cannot be assured will not be permitted in the fill material.

Stones or rocks in excess of four inches in their greatest dimension shall not be permitted in the top 24 inches of fill unless specifically required on the Construction Drawings. No rocks or debris larger than 6 inches in their greatest dimension shall be used as backfill.

I. Blasting will not be permitted

J. When an embankment is to be constructed on existing grade, all sod and vegetation shall first be removed and the cleared surface scarified to a depth of six inches and compacted to the same density as the fill to be placed.

K. The Contractor shall provide all necessary water and equipment to meet compaction requirements of fill material.

1.3 TOPSOIL

A. This item shall consist of the furnishing and placement of topsoil on embankments, excavations or areas directly or indirectly disturbed by the project work. If sufficient topsoil is not available on site the contractor shall obtain topsoil from offsite at no additional cost to the owner.

B. Topsoil shall be the surface layer of soil not less than 4” or if greater what is observed onsite with no admixture of refuse or material toxic or inhibitive to plant growth and shall be reasonably free of sub-soil, brush, roots, rocks, clay lumps, or similar objects.

The topsoil used from on site or otherwise furnished shall have a pH range of 5.5 to 7.6 when tested in accordance with the "Methods of Testing" of the Association of Official Agricultural Chemists. The organic content shall be not less than 3% nor more than 20% as determined by the Wet Combustion Method (chronic acid

reduction). There shall be not less than 20% nor more than 80% of the material passing the 200 mesh sieve as determined by the Wash Test in accordance with AASHTO T11.

C. Immediately prior to dumping and spreading topsoil, the surface shall be loosened by disc to a minimum depth of two inches. Prior to placing topsoil, the area shall be cleared of rocks in excess of 1½ inches in one dimension and any other debris or trash.

D. Topsoil shall be spread evenly on the prepared areas to a uniform depth of three inches after compaction.

Spreading shall not be done when ground conditions are too wet or otherwise in a condition detrimental to the work.

After spreading clods shall be broken up and rocks in excess of two inches, and any debris shall be removed.

After spreading and debris removal is complete, the topsoil shall be compacted by rolling with a multi-packer.

1.4 SODDING

A. General:

This item shall consist of sodding preparation, furnishing and placing sod in those areas top soiled per section 1.3 these specifications and areas disturbed during construction activities. The use of seeding or vegetative mulch are not part of this project unless for the Contractors own temporary use(s).

B. Materials and Construction Methods:

1. Sod shall be place in accordance with City of Tulsa Standard Specifications and Details, October 2013.
2. Contractor shall coordinate and schedule final site fine grading and placement to promote grass growth. Full “carpet” grass growth of more than three inches shall be established during growing seasons.
3. Spray for weeds and undesirables after grass is established.
4. Sodding activity shall be shown on the Contractor project schedule.
5. Fertilizer - Fertilizer shall be applied in liquid form at a concentration to provide the equivalent of a 10-20-10 commercial fertilizer applied at the rate of two hundred (200) pounds per acre, unless recommended otherwise by the Sod Supplier.

END OF SECTION

PART 1 - GENERAL

1.1 SCOPE

This section covers the demolition of existing piping, equipment and sitework and the salvage of existing material and equipment as indicated on the drawings.

1.2 GENERAL - Contractor shall be responsible for all work under this section.

All structures and facilities of the existing lift station which are not to be removed must remain in continuous operation during the proposed work. Demolition and salvage work shall create minimum interference with Owner's operations and minimum inconvenience to Owner.

Blasting will not be permitted.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 DEMOLITION

A. Project Demolition

1. Refer to Construction Drawings for site demolition. Contractor is to protect the existing onsite structures, electrical, water and other services during demolition and the construction work. Refer to the Demolition Plan for demolition notes.

2. All miscellaneous metals shall be removed from structures and disposed of off site by the Contractor. This includes, grating, pipe supports, handrail, ladders, doors, door frames, window frames and other related items.

3. All surface and buried items associated the proposed structure and service shall be removed. This also includes sequenced demolition during construction and coordination for the removal of the gravity sanitary sewer piping at the new screening structure. Refer to the Demolition Plan and the Proposed Structural Plans for additional information.

B. Piping and Equipment Demolition – The following piping and equipment shall be removed and shall become the property of Contractor. All such items shall be promptly removed from the jobsite.

1. Existing valves and pump equipment not salvaged by the City and other related process and electrical equipment as shown on the Construction Drawings.

2. Excluding items identified in Demolition section 3.2 Salvage or shown on the Construction Drawings, demolition shall include pumps, piping, wire-conduits to extent possible, electrical cabinets, valves, equipment, related process items, electrical equipment and appurtenances being demolished.

3. Other underground piping as required to accomplish the proposed grading and proposed screening facilities as shown in the Construction Drawings.

C. Sitework Demolition shall include the following as indicated on the drawings:

1. Removal of concrete sidewalks, electrical duct, curbs, fencing, cable guards, trees-shrubs and other miscellaneous structures within the limits of the proposed grading as shown on the Construction Drawings.

3.2 SALVAGE

A. Items To Be Salvaged by Owner – Contractor shall coordinate with the Owners Representative to identify any Owner salvage items, if any. Contractor will be remove, packaged and delivered to Plant Maintenance Department. Larger items, like valves, fittings should be palletized and delivered to Plant Maintenance Department.

Items identified to be salvaged include at Owner option during construction:
a. Pumps and appurtenances
b. Valves and/or valve components
c. Jib crane

B. Items To Be Salvaged by Contractor - Removed and salvaged equipment or facilities shall include removal and salvage of all accessories, piping, wiring, supports, associated electrical starters and devices, baseplates and frames, and all other appurtenances, unless otherwise directed.

1. Existing Materials and equipment removed, and not reused as a part of the work, shall become Contractor's property unless otherwise specified, and shall be removed from the jobsite.

2. Contractor may, at his option, furnish and install new items instead of those specified or indicated to be salvaged and reused, in which case such removed items will become Contractor's property.

END OF SECTION

A DESCRIPTION OF WORK

This Section includes the following:

Preparation of subgrade for building slabs, foundations and structures.

Grading, excavation and fill for the site and structures shall be performed by the contractor to the grades indicated on drawings. The site plan shows approximate existing and proposed finish grades and elevations.

Undercut areas of subgrade that are spongy and yielding as designated by the engineer.

B DEFINITIONS

1. Excavation consists of removal of material encountered to subgrade elevations indicated and subsequent disposal of materials removed.

2. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer shall be at Contractor's expense.

3. Additional Excavation: When excavation has reached required subgrade elevations, notify Engineer, who will make an inspection of conditions. If Engineer determines that bearing materials at required subgrade elevations are unsuitable, continue excavation until suitable bearing materials are encountered and replace excavated material as directed by Engineer.

4. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular subbase, granular base, or topsoil materials.

5. Structure: Buildings, foundations, slabs, tanks, curbs, or other man-made stationary features occurring above or below ground surface.

C SUBMITTALS

1. Product data for the following:

   Each type of plastic warning tape.

   Vapor barrier.

2. Samples of the following:

   Coordinate, provide access to and provide equipment for selected samples(s) and/or deliver samples to City's Independent Testing lab as required for new work. Submit Reports for products intended for backfill use.

3. Test reports: In addition to test reports required under field quality control, submit the following:

   Laboratory analysis of each soil and base course material proposed for fill and backfill from on-site and borrow sources.

   One optimum moisture-maximum density curve for each soil material.

   Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.

D QUALITY ASSURANCE

1. Codes and Standards: Perform excavation work in compliance with applicable requirements of authorities having jurisdiction.

2. Retesting of work: When initial testing indicates unacceptable work or materials, retesting will be paid for by the Contractor until acceptable results are achieved.

3. Codes and Regulations: All operations shall conform to applicable local and state codes and regulations including OSHA requirements.

E PROJECT CONDITIONS

1. Site Information: No geotechnical investigation has been performed.

2. Existing Utilities: It is the Contractor's responsibility to locate existing underground utilities in areas of excavation work prior to beginning the excavation. If utilities are indicated to remain in place, provide adequate means of support and protection during earthwork operations. The Contractor shall notify the appropriate utility for field location of all utilities.

3. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

4. Do not interrupt existing utilities serving facilities occupied by Owner or others, during occupied hours, except when permitted in writing by Engineer and then only after acceptable temporary utility services have been provided.

5. Provide minimum of 48-hour notice to Engineer, and receive written notice to proceed before interrupting any utility.

6. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shutoff of services if lines are active.

8. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.

9. Operate warning lights as recommended by authorities having jurisdiction. Construction within street right-of-way may require an approved barricade and maintenance of traffic plan.

10. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

11. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.

F SOIL MATERIALS

1. It is acceptable to utilize the on-site soil materials for subgrade construction not indicated to be “backfill or fill” if the material can be successfully proof-rolled with a 20,000 pound pneumatic tired roller or loaded dump truck without excessive rutting or "pumping".

2. Granular Base Course: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100% passing a 3/4" sieve and not more than 5% passing a No. 4 sieve. Acceptable material will include coarse aggregate for concrete. Washed Concrete sand may also be used.

3. Backfill and Fill Materials: Soil materials having a liquid limit less than 45, a Plasticity Index (PI) between 8 and 20, free of rock or gravel larger than 2 inches in any dimension, debris, waste, frozen materials, vegetation, organics and other deleterious matter is designated “satisfactory” as determined by the Engineer and may be used for backfill and fill material.

4. Subbase Material: Soil material designated "satisfactory".

5. Vapor Barrier: Vapor Barrier required under all interior concrete slabs on grade and where noted in Drawings shall be polyethylene sheet, 6 mil thickness conforming to ASTM E-154.

G EXCAVATION

1. Excavation is unclassified and includes excavation to subgrade elevations indicated, regardless of character of materials and obstructions encountered.

2. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Engineer.

3. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by Engineer. If unsuitable bearing materials are encountered at required elevations, carry excavation deeper and replace excavated material as directed by Engineer.

4. Additional Excavation: When excavation has reached required subgrade elevations, notify Engineer who will make an inspection of conditions.

5. Stability of Excavations:

   a. Slope sides of excavations to comply with local codes, ordinances, and requirements of agencies having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

   b. Shoring and Bracing: Establish requirements for trench shoring and bracing to conform with local codes and authorities having jurisdiction. Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses.

6. Trench and Excavation Safety Systems

   a. Description: This section covers trench and excavation safety system required for constructing improvements that necessitate open excavations on the project. All work under this item shall be in accordance with the

current edition of the "Occupational Safety and Health Administration Standard for Excavation and Trenches Safety System", 29 CFR 1926, Subpart P.

b. Notifications Required: The Contractor, prior to beginning any excavation, shall notify the State Department of Labor (Safety Division) that work is commencing on a project with excavations greater than five feet.

c. The Contractor shall notify all Utility Companies and Owners in accordance with OSHA Administration 29 CFR 1926.651(b) (2) for the purpose of locating utilities and underground installations.

d. Existing Structures and Utilities: Where the trench or excavation endangers the stability of a building, wall, street, highway, utilities or other installation, the Contractor shall provide support systems such as shoring, bracing, or underpinning to ensure the stability of such structure or utility. The Contractor may elect to remove and replace or relocate such structures or utilities with the written approval of the Owner of the structure of utility and the Project Owner.

H DEWATERING

1. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area. No fill shall be placed in water or upon saturated soils.

2. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

3. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or runoff areas. Do not use trench excavations as temporary drainage ditches.

4. The Contractor is responsible for all surface runoff, ground water, rain or snow and system piping dewatering as necessary of the contract work.

I STORAGE OF EXCAVATED MATERIALS

1. Stockpile excavated materials satisfactory for backfill and fill where directed. Place, grade, and shape stockpiles for proper drainage.

2. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.

3. Dispose of excess excavated soil material and materials not satisfactory for use as backfill or fill.

J EXCAVATION FOR STRUCTURES

1. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, and other construction and for inspection.

2. Excavations for footings and foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive other work.

K TRENCH EXCAVATION FOR PIPES AND CONDUIT

1. Excavate trenches to uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches of clearance on both sides of pipe or conduit.

2. Excavate trenches and conduit to depth indicated or required to establish indicated slope and invert elevations and to support bottom of pipe or conduit on undisturbed soil. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

3. Where rock is encountered, carry excavation 6 inches below required elevation and backfill with a 6-inch layer of crushed stone or gravel prior to installation of pipe.

4. For pipes or conduit less than 6 inches in nominal size, and for flat-bottomed, multiple-duct conduit units, do not excavate beyond indicated depths. Hand-excavate bottom cut to accurate elevations and support pipe or conduit on undisturbed soil.

5. For pipes and equipment 6 inches or larger in nominal size, shape bottom of trench to fit bottom of pipe for 90 degrees (bottom 1/4 of the circumference). Fill depressions with tamped sand backfill. At each pipe joint, dig bell holes to relieve pipe bell of loads ensure continuous bearing of pipe barrel on bearing surface.

L BACKFILL AND FILL

1. General: Place satisfactory soil material in layers to required subgrade elevations, for each area classification listed below, using materials specified herein.

2. Under building slabs, Provide satisfactory soils over an acceptable subbase material and provide a granular base immediately under slabs.

3. Under piping and conduit and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation. Shape excavation bottom to fit bottom 90 degrees of cylinder.

4. Backfill trenches with concrete where trench excavations pass within 18 inches of column or wall footings and that are carried below bottom of such footings or that pass under wall footings. Place concrete to level of bottom of adjacent footing.

5. Backfill trenches for utility and piping as required for the area adjacent to the trench.

6. Do not backfill trenches until tests and inspections have been made and accepted. Use care in backfilling to avoid damage or displacement of pipe systems.

7. Backfill excavations as promptly as work permits, but not until completion of the following:

   a. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.

   b. Inspection, testing, approval, and recording locations of underground utilities have been performed and recorded.

   c. Removal of concrete formwork.

   d. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.

   e. Removal of trash and debris from excavation.

   f. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

M PLACEMENT AND COMPACTION

1. Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to

placement of fills. Plow strip, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with existing surface.

2. Proof roll all existing soil areas under pavements, buildings and other structural site improvements with a 20,000 pound pneumatic tired roller or loaded dump truck. Areas which can be successfully proof rolled without excessive rutting or "pumping" are acceptable. Where proof rolling cannot be successfully accomplished, scarify and compact to stable condition. If stable condition cannot be achieved, notify Engineer.

3. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

4. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

5. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

6. Control soil and fill compaction, providing minimum percentage of density specified for each area classification indicated below. Correct improperly compacted areas or lifts as directed by Engineer if soil density tests indicate inadequate compaction.

    a. Under pavements, and exterior slabs, compact the upper portion of the natural subgrade soils and fill material to not less than 95 % of maximum Standard Proctor dry density (ASTM D-698). Compact select fill layer to not less than 95% of maximum modified Proctor dry density (ASTM D-1557).

    b. Under structures and building areas, compact upper 8” of natural subgrade soils; fill and backfill materials (each layer) to 98 percent of maximum modified Proctor dry density (ASTM D-1557).

7. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer of soil material. Apply water in minimum quantity as necessary to prevent free water from appearing on surface during or subsequent to compaction operations.

8. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

N GRADING

1. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated or between such points and existing grades.

2. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding.

3. Surface of fill under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grade within a tolerance of 1/2 inch when tested with a 10-foot straightedge.

4. Any excavation or grading under a building, structure or piping shall be backfilled with ODOT type A aggregate base rock and compacted to 98% standard proctor unless required contractually otherwise and is more stringent required. Rock backfill shall be extend at least two feet beyond structure “drip line” minimum.

O BUILDING SLAB BASE

1. General: Building slab base consists of placement of vapor barrier and granular base in layers of indicated thickness, over subgrade surface to support concrete building slabs.

2. Placing: Place granular base material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Compaction shall be by powered or hand tampers to 98% maximum density and then install vapor barrier.

P FIELD QUALITY CONTROL

1. Quality Control Testing During Construction: Allow testing service to inspect and approve each subgrade and fill layer before further backfill or construction work is performed.

2. If, in opinion of Engineer, based on testing service reports and inspection, subgrade or fills that have been placed are below specified density, additional compaction and testing shall be performed at the Contractor's expense until specified density is obtained.

Q EROSION CONTROL AND STORM WATER CONTROL

Provide erosion control and storm water runoff control methods in accordance with requirements of local and state authorities having jurisdiction.

R MAINTENANCE

1. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

2. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

3. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.

4. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn, or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

S DISPOSAL OF EXCESS AND WASTE MATERIALS

Remove trash, debris, and waste materials and dispose of it off Owner's property.

END OF SECTION

PART 1 - GENERAL

1.1 STANDARDS

A. Concrete work shall conform to all requirements of ACI 301-89 "Specifications for Structural Concrete for Buildings", ACI 350 “Code Requirements for Environmental Engineering Concrete Structures”, ACI 318-89 "Building Code Requirements for Reinforced Concrete" except as modified herein.

B. All referenced standards shall be the latest editions.

1.2 SCOPE

A. Work consists of furnishing all plant, labor, materials, equipment and appliances, and performing all operations in connection with installation of the concrete work, complete, in strict accordance with the Specifications and Drawings.

1.3 INSPECTION

A. Embedded items must be inspected and tests for concrete and other materials shall have been completed and approved by the Engineer before concrete is placed.

1.4 SLAB ON EARTH

A. Before proceeding to construct concrete slabs on earth, all pipes under concrete floor on earth shall have received the required tests. All backfill and fill material under slabs on grade shall be compacted in 6" layers to 95% maximum density as measured by AASHTO T99 test method. Unsuitable material encountered in subgrade shall be removed and replaced with material approved by the Engineer. Subgrade shall be brought to true, even plane and compacted to solid bearing. Gravel drainage fill shall be placed and compacted where shown on Drawings.

PART 2 - MATERIALS

2.1 All concrete materials shall conform to the latest revised ASTM Designations listed below and shall be subject to the approval of the Engineer:

A. Coarse Aggregate shall be crushed stone conforming to ASTM C-33 with a maximum size of 1".

B. Fine Aggregate shall conform to ASTM C-33 and shall be washed river sand composed of clean, uncoated grains of strong materials.

C. Cement shall be Portland cement conforming to ASTM Specification C-150, Type V. Only one brand of cement shall be used for exposed concrete.

D. Water: Clean, fresh and free from oil, acids, alkali, vegetable, sewage, organic or other deleterious matter.

E. Air-Entraining Admixtures shall conform to ASTM C-260.

G. Premolded Expansion Joint Filler Strips shall be non-extruding type conforming to the current AASHTO Designation M213.

H. Non-Shrink Grout shall be Pre-mixed "Embeco" as manufactured by Master Builder's, "Ferrolith G" as manufactured by Sonneborn-Contech, or approved equal. Type as recommended by the manufacturer for the particular applications.

I. Liquid Curing Compound/Sealer shall be "MC 429" as manufactured by Master Builder's, "Kure-N-Seal" as manufactured by Sonneborn-Contech, "Thompson's Water Seal" as manufactured by E. A. Thompson, Inc. or approved equal.

J. Granular Drainage Fill: Required under all interior building concrete slabs on grade and where noted on the drawings. It shall be either:

1. Clean, washed gravel with particle sizes grading from maximum of 1" down to not more than 5% passing a No. 4 sieve.

2. Clean, washed coarse sand with particular sizes ranging from pea gravel down to largest grains permitted in concrete sand.

K. Joint Waterproofing for existing structures or as required on the plans shall be Ironite (Metallic) Waterproofing as manufactured by the Ironite Company of Chicago, Illinois or approved equal.

L. Vapor Barrier required under all interior concrete slabs on grade and where noted in drawings shall be polyethylene sheet, 6 mil thickness conforming to ASTM E-154.

M. Liquid Chemical Hardener shall be the magnesium fluosilicate and zinc fluosilicate type "Lapidolith" as manufactured by Sonneborn-Contech, Inc., "Symons Quad Cure" as manufactured by Symons Corp., "Hornolith" as manufactured by W. R. Grace & Co., or approved equal.

N. Cementitious Waterproofing and Finish Compound shall be "Thoroseal Plaster Mix" with "Acryl 60" as manufactured by Standard Dry Wall Products or equal.

2.2 QUALITY AND CONTROL

A. Design

Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate and water. All concrete shall be designed by an independent testing laboratory, approved by the Engineer, in accordance with the A.C.I. Standard "Recommended Practice for Selecting Proportions for Concrete" (ACI 211) to produce the strength for each class of concrete specified, and with slumps and maximum sizes of coarse aggregate in accordance with the requirements outlined below. The concrete shall be so designed that the concrete materials will not segregate and excessive bleeding will not occur. Submit laboratory trial mix designs and test results for each class of concrete to be used to the Engineer for approval before any concrete is placed. Any costs of the testing laboratory for designing concrete mixes shall be borne by the Contractor. Concrete strengths shall be as follows:

Class A Concrete - 4000 psi minimum @ 28 days (Air entrained) - six (6) sacks cement minimum

Class B Concrete - 3000 psi @ 28 days - five (5) sacks cement minimum

Class C Concrete - 2000 psi @ 28 days

Class D Concrete - 3000 psi @ 28 days (3/8" Max. Aggregate Size "Pea Gravel")

MAXIMUM SLUMPS FOR VARIOUS
TYPES OF CONSTRUCTION

Types of Construction	Hand Placed Maximum	High Frequency Vibrator Used - Maximum
Reinforced Foundation, Footings and Base Slabs of Tanks	5"	3"
Slabs, Beams and Reinforced Walls	6"	5"
Building Columns	6"	5"
Pavements, curb and sidewalks	3"	3"

The slump shall not exceed the maximum specified above for the type of construction for which it is to be used. The 28 day compressive strength determined in accordance with current ASTM Specifications C-39 and C-31 and with specimens cured in accordance with C-31 shall not be less than that shown above for the specified class of concrete. No water will be added after the amount specified by the mix design.

B. Production of Concrete

All ready-mix concrete shall be batched, mixed and transported in accordance with "Specifications for Ready-Mixed Concrete (ASTM C-94)". Plant equipment and facilities shall conform to the "Check List for Certification of Ready-Mixed Concrete Production Facilities" of the National Ready-Mixed Concrete Association. Site mixed concrete shall conform to the requirements of "Specifications for Structural Concrete" (ACI 301). The Contractor may elect to use either ready-mixed or site mixed concrete for this project provided he informs the Engineer of his choice.

C. Laboratory Testing

The Owner shall engage an independent testing laboratory to conduct concrete tests. Contractor will be responsible for sampling concrete for test cylinders, recording, and delivering them to the laboratory, providing all materials required, and for making all slump tests in the field directed by the Engineer. All costs in connection with work performed by the laboratory will be paid by the Owner. The Contractor shall be responsible for the costs of work performed by the laboratory required for redesign of concrete proportions and additional testing of in place concrete when cylinders indicate low strength concrete has occurred.

At least one test shall be made on fresh concrete for each one hundred (100) cu. yds. of each class of concrete (or fraction thereof) placed on any one day and in any event, not less than one test for each class of concrete each day it is used. Testing shall be done in accordance with the following ASTM Specifications, latest edition:

C172- Standard Method of Sampling Fresh Concrete

C31 - Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field

C39 - Standard Method of Test of Compressive Strength of Molded Concrete Cylinders

C143- Standard Method of Slump Test for Consistency of Portland Cement Concrete

Before any concrete is poured, the Contractor shall construct a storage box in accordance with ASTM Specification C31. Each set of tests shall consist of one slump test and four compression test cylinders. All cylinders shall be kept in the storage box for the first 24 hours. The four cylinders shall be laboratory cured and tested for adequacy of the design for strength of the concrete in accordance with ASTM Specification C31. One cylinder shall be tested at 7 days and two at 28 days.

The fourth cylinder will be retained for subsequent testing if required by the Engineer.

D. Failure of Concrete to Meet Strength Requirements: The concrete shall be considered acceptable if, for any one class of concrete, the average of all tests of any five consecutive sets is equal to or greater than the specified strength, provided that no more than one test in ten falls between 90% and 100% of the specified strength. The only cylinders to be used for determination of concrete acceptability will be those laboratory cured and tested at 28 days. When it appears the tests of laboratory-cured cylinders will fail to meet these requirements, the Engineer may require changes in the proportions of concrete for the remainder of the work in order to meet the strength requirements. In addition, the Engineer may also require additional curing on portions of the concrete already poured.

The Engineer may also require tests in accordance with Methods of Securing, Preparing and Testing Specimen from Hardened Concrete for Compressive and Flexural Strengths (ASTM Specifications C42) when the concrete cylinder tests fail to meet strength requirements. In the event there still is question as to the quality of the concrete in the structure, the Engineer may require load tests for that portion where the questionable concrete has been placed. Such load tests will be made as outlined in American Concrete Institute Building Code, (ACI 318), and shall be at the expense of the Contractor. In-place testing shall be at the expense of the Contractor.

E. Removal of Under Strength Concrete: If the above tests indicate that a particular batch of previously placed concrete is under strength, the Engineer may direct that the under strength batch be removed and replaced. The removal of the under strength concrete shall also include the removal of concrete that has obtained the required strength if the Engineer deems this necessary to obtain structural or visible continuity when the concrete is replaced.

The removal, and replacement of any under strength concrete, shall be made at no additional cost to the Owner. This shall include any new formwork required or any reinforcing steel that may be required. The Owner shall not be charged any additional costs for any extra work that is required because of the failure of any concrete to meet the minimum test requirements.

F. Concrete Strengths: The various strengths of concrete shall be installed as follows:

1. Class A, 4000 psi, Air-Entrained shall be used for all liquid containing and non-liquid containing structures, (footings, driveways, slabs, walls, columns and roofs.)

2. Class B, 3000 psi shall be used for sidewalks, curbs and thrust blocking.

3. Class C, 2000 psi shall be used for all non-structural fill concrete, mud slabs, over excavation concrete and other selective backfill conditions as approved by the Engineer.

4. Class D, 3000 psi pea gravel concrete (maximum aggregate size of 3/8") shall be used for all masonry fill, masonry columns cells, and masonry bond beams.

PART 3 - INSTALLATION

3.1 PREPARATION BEFORE PLACING

A. Water shall be removed from excavations before concrete is deposited. Hardened concrete, wood chips, shavings, and other debris shall be removed from interior of forms and inner surfaces of mixing and conveying equipment. Wood forms shall be oiled or, except in freezing weather, wetted with water in advance of pouring. Reinforcement shall be secured in position, inspected and approved by the Engineer before starting pouring of concrete.

3.2 CONVEYING

A. Concrete shall be conveyed from mixer to forms as rapidly as practicable and by methods, which will prevent segregation or loss of ingredients. It shall be deposited as nearly as practicable in its final position. Chutes used shall be such that concrete slides in them and does not flow. Chutes, if permitted, shall have a slope of less than 1 on 2. Where a vertical drop greater than five (5) feet is necessary, placement shall be through elephant trunks or similar devices to prevent segregation. Ready-mixed concrete shall be delivered with a load ticket showing mix proportions and the time mixing began for each load. The load ticket shall be furnished to the Engineer.

3.3 PLACING

A. Concrete shall be placed before initial set has occurred and in no event after it has contained its water content for more than 30 minutes for site mixed concrete or 1 hour for ready-mixed concrete. Unless otherwise specified, all concrete shall be placed upon clean, damp surfaces free from running water, or upon properly

consolidated fills, but never upon soft mud or dry, porous earth. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section.

B. If a section cannot be placed continuously, provide construction joints as herein specified. The concrete shall be compacted and worked in an approved manner into all corners and angles of the forms and around reinforcement and embedded fixtures as to prevent segregation of the coarse aggregate. Construction of forms for the lifts of vertical walls shall be such as to make all parts of the walls easily accessible for the placement, spading, and consolidation of the concrete as specified herein.

C. No "finished water" shall be surface applied during finishing efforts.

D. Curing methods shall be submitted to the Engineer and applied per manufacture's recommendations.

3.4 VIBRATION

A. All concrete shall be placed with the aid of mechanical vibration equipment as approved by the Engineer. Vibration shall be transmitted directly to the concrete; in no case shall it be transmitted through forms. The duration of vibration at any location in the forms shall be held to the minimum necessary to produce thorough compaction. Vibrations shall be supplemented by forking or spading by hand, and adjacent to the forms on exposed faces in order to secure smooth, dense and even surfaces, with particular care being taken to prevent coarse aggregate from becoming set too near any surfaces that are to receive rubbed finish.

3.5 CONSTRUCTION JOINTS

A. Construction joints shall be formed as indicated on the drawings or as approved or directed by the Engineer. Contractor shall submit a joint location plan for each structure to the Engineer for approval 28 days prior to commencing concrete operations on that structure. Where indicated or required, dowel rods shall be used. All concrete at the joints shall have been in place not less than 12 hours, and longer if so directed by the Engineer, before concrete resting thereon is placed. Before placing is resumed, or commenced, excess water and laitance shall be removed, and concrete shall be cut away, where necessary, to insure a strong dense concrete at the joint. In order to secure adequate bond, the surface of concrete already in place shall be cleaned, roughened, and then spread with a one-half (½) inch layer of mortar of the same cement-sand ratio as is used in the concrete, immediately before the new concrete is deposited. The unit of operation is not to exceed 40 feet in any horizontal direction, unless otherwise required by the Drawings. Construction joints, if required, shall be located near the mid-point spans for slabs, beams or girders. Joints in columns or piers shall be made at the

underside of the deepest beam or girder at least five (5) hours before any overhead work is placed thereon. Joints not shown or specified shall be so located as to least impair strength and appearance of work. Vertical joints in wall footings shall be reduced to a minimum. Placement of concrete shall be at such a rate that surfaces of concrete not carried to joint levels will not have attained initial set before additional concrete is placed thereon.

B. Girders, beams and slabs shall be placed in one operation. To insure a level straight joint in exposed vertical surfaces, a strip of dressed lumber may be tacked to the inside of the forms at the construction joint. The concrete shall be poured to a point one (1) inch above the underside of the strip. The strip shall be removed one (1) hour after concrete has been placed and any irregularities in the joint line leveled off with a wood float and all laitance removed. Waterstops shall be installed in all construction joints below grade or in liquid containing structures as noted on the Plans. Install as per SECTION 3.3, CONSTRUCTION JOINTS, EXPANSION JOINTS, & WATERSTOPS.

3.6 PATCHING

A. Any concrete which is not formed as shown on the Plans, or for any reason is out of alignment or level or shows a defective surface shall be considered as not conforming with the intent of these Specifications and shall be removed from job by Contractor at his expense, unless the Engineer grants permission to patch defective area, which shall be done in accordance with the following procedure. Permission to patch any such area shall not be considered a waiver of the Engineer's right to require complete removal of defective work if patching does not, in his opinion, satisfactorily restore quality and appearance of surface. Suitable non-shrink, latex or epoxy mortar shall be used for patching and repairing defective surface if permitted by the Engineer.

B. After removing forms, all concrete surfaces shall be inspected and any poor joints, voids, stone pockets, all tie holes, or other defective areas shall be patched, if permitted by the Engineer. Where necessary, defective areas shall be chipped away to a depth of not less than one (1) inch with edges perpendicular to the surface. Area to be patched and a space at least six (6) inches wide entirely surrounding it shall be wetted to prevent absorption of water from the patching mortar. A grout of equal parts Portland cement and sand, with sufficient water to produce a brushing consistency, shall then be well brushed into the surface followed immediately by the patching mortar. The patch shall be made of the same material and of approximately the same proportions and shall not be richer than 1 part cement to 3 parts sand. White Portland cement shall be substituted for a part of the gray Portland cement to match color of the surrounding concrete. The proportion of white and gray cements shall be determined by making a trail patch. The amount of mixing water shall be as little as consistent with the requirements of handling and placing. The mortar shall be retempered without the addition of water by allowing it to stand for a period of one (1) hour during

which time it shall be mixed occasionally with a trowel to prevent setting.

C. The mortar shall be thoroughly compacted into place and screened off so as to leave patch slightly higher than surrounding surface. It shall then be left undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished. The patch shall be finished in such a manner as to match the adjoining surface. On surfaces where unlined forms have been used, the final finish shall be obtained by striking off the surface with a straightedge spanning the patch and held parallel to the direction of the form marks.

D. Tie holes left by withdrawal of rods or the holes left by removal of ends of ties shall be filled solid with non-shrink grout after first being thoroughly wetted within 7 days of placement and prior to any area backfill.

3.7 SLAB FINISHES

A. Exterior Concrete Walks:

After thoroughly consolidating the concrete the top surface shall be struck off with a straight edge and tamped or vibrated sufficiently to bring mortar to the surface. Finish with a wood float to a smooth, even surface and lightly broomed to provide "slip resistant" surface. Edges shall be rounded with a 1/4" radius.

B. Interior slabs to receive grout fill or mortar setting bed shall be finished by tamping concrete with special tools to force coarse aggregate below the surface, and screened with straightedges to bring surface to finish plane with a tolerance not exceeding 1/8" in 2 feet. Surface shall be left roughened sufficiently to produce good bond with topping material. Use stiff brushes, brooms or rakes as necessary to provide 1/8 inch deep grooves at maximum of ½ inch on center.

C. Top and bottom slabs of all structures and water carrying conduits except as noted otherwise on the Plans shall be finished as follows: The top of the slab shall be screened to grade and cross section; lightly tamped as required to bring up a good bed of mortar for finishing and re-screened as necessary. The surface shall then be finished with a wood float and leveling darby. No further finish will be required on top slabs of structures or conduits, which are to be buried. In the case of all exposed top slabs of structures and conduits, they shall be given a final wood float and a lightly broomed, slip resistant finish to a uniform surface, which conforms with accuracy to required shape, slope and grade. Slabs shall be edged as appropriate. No liquid hardener is to be applied to these surfaces.

D. Interior floor slabs that are not to receive any finish floor covering shall be "slip resistant finish" as follows: The top surface shall be steel troweled and have a final finish applied by brushing lightly with a soft bristle brush to form a slightly roughened surface.

E. Liquid Hardener shall be applied to the floors where scheduled to be exposed concrete. Concrete surfaces to be treated must be thoroughly set and dry, clean and free of dust. Three applications of the liquid hardener are required, using one gallon per 100 square feet for the complete treatment. Apply hardener strictly according to the manufacturer's printed instructions. Liquid floor hardener is not required when a minimum of two (2) coats of Thompson's Waterseal or equal has been used as a curing and/or separating compound. Submit material and method to be used for Engineer's approval.

3.8 FINISH OTHER THAN SLABS

A. All top surfaces, other than slabs, not covered by forms, and which are not to be covered by additional concrete or fill shall receive a wood float finish without additional mortar. Care shall be taken that no excess water is present when the finish is made. Other surfaces shall be brought to finished elevations and left true and regular. All exposed top surface interior concrete shall be grouted smooth and given a cement wash of one part light colored Portland cement and two parts fine aggregate mixed with water to consistency of thick paint. Grout shall be cork or wood floated to fill all pits, air bubbles, and surface holes. Excess grout shall be scraped off with a trowel and rubbed with burlap to remove any visible grout film. Surface shall be kept damp during setting period. The finish for any area shall be completed in the same day and the limits of a finished area shall be made at natural breaks in finished surface. Painting of exposed-to-view concrete surfaces is specified under SECTION 9.1 - PAINTING of these Specifications.

B. Rubbed Finish:

Unless otherwise indicated, all faces (except top surfaces of slabs) exposed to view, such as walls, grade beams, columns, beams, walls of water carrying conduits to a point 1'-0" below normal water level, canopy soffits and fascias, etc. shall be finished as follows:

Forms shall be removed, as specified in SECTION - CONCRETE FORMWORK, and all fins removed, off-sets leveled, damaged places and depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in the proportion which has been employed for the particular class of concrete treated. The surface film of all such pointed places shall be carefully removed before setting occurs. After the point has set sufficiently to permit it, all exposed surfaces shall be dampened and rubbed with a No. 16 Carborundum stone, to a smooth even plane. Final rubbing shall be done with a No. 30 Carborundum stone, or an abrasive of equal quality, to obtain an entire surface of a smooth texture and uniformity in color. Mortar or grout worked up during rubbing shall be promptly removed by sacking with burlap or other suitable means so that no visible grout film or paste will remain. A cement wash or plaster coat shall not be used. All surfaces shall be finished uniformly smooth and washed clean. The rubbed finish for any area shall be completed in

the same day and the limits of a finished area shall be made at natural breaks in the finished surface. If the Contractor does not provide suitable surface finish using Carborundum stones specified above, the Engineer, without additional cost to the Owner, may require the use of a power operated grinding machine or other methods to produce the desired finish.

C. Cementitious Waterproofing and Finish:

As an option to the rubbed finish, as specified herein, all faces (except top surfaces of slab) exposed to view, such as walls, grade beams, columns, beams, canopy soffits and facias, etc., shall be finished using "Thoroseal" coating or approved equal as described in the following paragraphs.

1. General

Forms shall be removed, as specified in SECTION 3.4 - CONCRETE FORMWORK, and all fins removed, off-sets leveled, damaged places and depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in proportion which has been employed for the particular class of concrete treated. The surface film of all such pointed places shall be carefully removed before setting occurs. After the point has set sufficiently to permit it, all exposed surfaces shall receive the following treatment.

2. Mixing

Thoroseal plaster mix shall be prepared using a solution composed of not less than one part Acryl 60 (approximately two quarts Acryl 60 per bag) and three parts of clean, potable water (for ceilings, use 1 part Acryl 60 to 2-1/2 parts of the water). This solution shall then be added to the Thoroseal plaster mix slowly in sufficient quantity so that the mixture is the consistency of a heavy batter suitable for application by method specified. Color to be selected by the Owner.

3. Application

At Contractor's option, one of the following methods of application shall be selected:

a. Sprayed-on finish should be applied with plaster-type spray gun, not high pressure paint type. Spray on evenly distributed coat of Thoroseal plaster mix. To spot-fill deep holes, float or brush first coat before starting second spray application.

Thoroseal plaster mix shall be applied on average surfaces in two coats at the rate of 5 to 6 lbs. per square yard for concrete walls, 6

to 9 lbs. per square yard for masonry walls; but sufficient material shall be applied to fill all holes and voids.

b. Trowel and float finish - Apply light trowel coat of Thoroseal plaster mix over entire surface to be treated. The workman shall make sure the material is firmly pressed into all voids and leveled. Allow this coat to cure thoroughly before applying the regular trowel application. When surface is set so it will not roll or lift, float uniformly using a sponge float.

Thoroseal plaster mix shall be applied on average surfaces at the rate of 4 to 6 lbs. per square yard for concrete walls, 6 to 9 lbs. for masonry walls. If concrete is rough or untrue, 6 to 9 lbs. per square yard may be required, but sufficient material shall be applied to fill and seal all pores and voids. This application will be approximately 1/8" thick. Leveling uneven surfaces will require more material per square yard.

To prevent shadowing of struck or deep masonry joints, or areas of unequal absorption (like some form marks), after key coat has cured for 5 days, apply a light trowel coat of Thoroseal plaster mix with Acryl 60 in the mixing water over the entire surface to be treated. Allow this coat to set thoroughly before applying the regular trowel application as outlined above.

Do not apply when temperatures are 40ºF or due to fall below 40ºF within 24 hours or to frozen or frost-filled surfaces.

3.9 CURING

A. General - Immediately following placing, all Class A and Class B concrete shall be protected from premature drying, hot and cold temperatures, rain, flowing water and mechanical injury. Maintain above 50ºF and in moist condition for at least seven (7) days after placing for normal concrete and three (3) days for high early strength concrete. Comply with "Recommended Practice for Curing Concrete" ACI 308, unless otherwise indicated. Curing compound of satisfactory composition and characteristics may be used except on surfaces to which new concrete is to be bonded or surfaces scheduled to be painted or to receive other coating and provided such compound does not stain or discolor any surface which will be exposed. Cure formed concrete surfaces, including undersides of beams, supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.

B. Cold Weather Procedures - Protect concrete work from physical damage or reduced strength, which could be caused by frost, freezing actions, or low temperatures, in compliance with ACI 306, "Cold Weather Concreting", and as herein specified.

1. When air temperature has fallen to or is expected to fall below 40ºF, uniformly heat water and aggregates before mixing as required to obtain a concrete mixture temperature of not less than 55ºF, and not more than 80ºF at point of placement.

2. Do not use frozen materials or materials containing ice, frost or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt and other materials containing antifreeze agents or chemical accelerators, unless otherwise accepted in mix designs.

4. Contractor shall obtain and keep on the Project site a copy of the current edition of ACI 306, "Recommended Practice for Cold Weather Concreting", for reference during all concrete operations in cold weather.

C. Hot Weather Procedures:

When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305, "Hot Weather Concreting", and as herein specified.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90ºF. Mixing water may be chilled, or chopped ice may be used to control the concrete temperature provided the water equivalent of the ice is calculated to the total amount of mixing.

2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.

3. Wet forms thoroughly before placing concrete.

4. Do not use retarding admixtures unless otherwise accepted in mix designs.

5. Contractor shall obtain and keep on the project site a copy of ACI 305R, "Hot Weather Concreting" for reference during all concreting operations in hot weather.

D. Protection from the Sun:

All concrete shall be adequately protected from injurious action of sun in a manner satisfactory to the Engineer.

E. Temperature Control:

During and at the conclusion of the specified curing period, means shall be provided to insure that the temperature of the air immediately adjacent to the concrete does not fall more than 3ºF in any 1 hour nor more than 30ºF in any 24 hours.

3.10 NON-SHRINKING GROUT

A. Where non-shrinking grout is called for on the Plan, it shall be mixed in strict accordance with the manufacturer's directions. It shall be of a type as recommended by the manufacturer for the particular application.

END OF SECTION

PART 1 – GENERAL

1.1 SCOPE

A. The extent of concrete reinforcement is shown on the drawings and in schedules.

B. The work includes fabrication and placement of reinforcement for cast-in-place concrete, including bars, welded wire fabric, ties and supports.

1.2 QUALITY ASSURANCE

A. Codes and Standards:

Comply with requirements of the latest edition of the following codes and standards, except as herein modified:

American Welding Society (AWS), AWS D1.4 "Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction".

Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice". (Current Ed.)

American Concrete Institute (ACI), ACI 318 "Building Code Requirements for Reinforced Concrete".

American Concrete Institute (ACI), ACI 350 “Code Requirements for Environmental Engineering Concrete Structures

B. Submittals:

Mill Certificates; Concrete Reinforcement: Submit steel producer's certificates of mill analysis, tensile and bend tests for reinforcing steel.

Shop Drawings: Reinforcing number, sizes, spacing dimensions, configurations, locations, mark numbers, lap splice lengths, concrete cover and reinforcing supports. Sufficient reinforcing details to permit installation of reinforcing without reference to contract drawings.

1.3 DELIVERY, HANDLING AND STORAGE

A. Deliver reinforcement to the project site bundled, tagged and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings shown on placement diagrams.

B. Store concrete reinforcement materials at the site to prevent damage and accumulation of dirt or excessive rust.

1.4 MATERIALS

A. Steel reinforcement shall conform to the "Specification for Deformed Billet Steel Bars for Concrete Reinforcement," ASTM A615, Grade 60.

B. Wire fabric reinforcement shall conform to the current "Specifications for Welded Steel Wire Fabric for Concrete Reinforcement," ASTM A-185, or "Specifications for Welded Deformed Steel Wire Fabric for Concrete Reinforcement," ASTM A-497.

C. Supports for Reinforcement shall be bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcement in place. Use only wire bar type supports complying with CRSI recommendations, unless otherwise indicated. Do not use wood, brick, and other unacceptable materials.

1.5 SPLICES

A. No splices of bars, except when shown on the Plans, will be permitted without the approval of the Engineer. Minimum lap splice shall be 48 bar diameters unless specifically detailed or noted otherwise on drawings. Splices in adjacent bars shall be staggered a minimum distance equal to the lap splice length. Bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer. Welding may not be used except with the specific approval of the Engineer. Welding, when approved, shall conform to the AWS D1.4. Welded wire fabric shall be lap spliced a minimum of 2 inches plus the wire spacing at edge laps and end laps.

1.6 DETAILING & FABRICATION

A. Furnish Shop Detail and Field Placing Drawings for all reinforcing steel for approval of the Engineer. Shop Drawings shall include reinforcing, placing plans and details indicating size, location, arrangement, splice locations, bending diagrams, placing sequence, etc. Placing Drawings shall be in sufficient detail to allow field personnel to accurately place reinforcing. Shop and Placing Drawings shall be prepared in accordance with "Manual of Standard Practice for Detailing Reinforced Concrete Structures" ACI 315, current edition. Photographic copies of engineering drawings shall not be used as placing drawings.

B. Reinforcement bars shall be bent cold to the shapes indicated on the Plans. Fabrication tolerances, fabrication, and detailing of steel reinforcement shall conform to the "Manual of Standard Practice for Detailing Reinforced Concrete Structures" (ACI-315).

C. Steel reinforcement shall be of the type and size, cut to lengths and bent to shapes as indicated on the Plans. Unless otherwise indicated, hooks, lap splices, embedment lengths, and other details of reinforcement shall be provided as set

forth in the ACI Building Code (ACI 318) to develop the full tensile strength of the bar.

1.7 PLACING REINFORCEMENT

A. All reinforcement at the time concrete is placed shall be free from mud, oil, paint, excessive rust and excessive mill scale or any other coating that would destroy or reduce its bond with the concrete.

B. All reinforcement shall be secured in place true to lines and grades indicated by use of metal or concrete supports, spacers, or ties as approved by the Engineer. The bars and mesh shall be tightly secured against displacement by ties of annealed wire, or suitable clips at intersections. Wall reinforcement shall be supported and held securely against displacement in its proper position clear of the forms as indicated on the Plans. Placing tolerance shall conform to ACI 318.

C. Nails shall not be driven into the wall forms to support reinforcement nor shall any other device used for this purpose come in contact with the form on the liquid side of any liquid containing structure. Metal devices used to provide the required clear distances from reinforcing steel to liquid side of concrete surfaces shall be galvanized, or shall be as approved by the Engineer.

D. The main reinforcement of slabs in contact with the ground shall be supported in its proper position, as indicated on the Plans, by means of precast cement mortar blocks, of approved dimensions, resting on the slabs' subbase. Such precast blocks shall be made of mortar composed of 1 part cement to 2 parts sand and shall have a loop of No. 16 black annealed wire cast into each block. The length of the wire loop shall be sufficient to allow the block to be tied to the reinforcement. Blocks shall be spaced at the intervals required to maintain the reinforcement in its required position in the slab during the placing of the concrete. The slab reinforcement shall not be used to support planking or runways used in placing concrete.

E. Bending of bars embedded in hardened concrete will not be permitted except when specifically approved by the Engineer for the field condition encountered. Field cutting of bars will only be permitted when specifically approved by the Engineer.

F. In the case of exposed finish surfaces of floor slabs, galleries, deck slabs, and beams, metal chairs, spacers and other metal accessories necessary to provide the required clear distances and proper alignment and spacing between bars shall be galvanized or shall have plastic protective covering over portions in contact with forms.

1.8 CONCRETE PROTECTION FOR REINFORCEMENT

A. Steel reinforcement shall be placed and held in position so that the concrete cover, as measured from the surface of the bar shall be the following, except as otherwise shown, on the drawings:

1. Slabs:

   1½ inches, in general, top and bottom.
   1½ inches at surfaces troweled as floor finish, walkway, or driveway.
   2 inches on bottom for slabs over water and where exposed to the weather.

2. Footings:

   2 inches at top of footings.
   3 inches at bottom, sides, and end of footings.

3. Walls:

   2 inches on surfaces against earth.
   1½ inches on interior surfaces.
   2 inches on interior surfaces contacting water.

4. Beams and Girders in Contact with Water:

   2 inch minimum to stirrup steel.
   2½ inch minimum to main longitudinal steel.

5. Columns:

   2 inches, in general, to main vertical reinforcement.
   2½ inches, to main reinforcement on surfaces in contact with water.

6. Beams and Girders: General:

   1½ inch minimum to stirrup steel.
   2 inches minimum to longitudinal steel.

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1.9. ADDITIONAL REINFORCEMENT

A. The Contractor shall provide on the job site additional reinforcement to be used at locations as directed by the Engineer at no additional cost to the Owner. The contract price shall include all labor and material charges for handling, field cutting and bending, bar supports, and placing of said reinforcement. Additional reinforcement shall be ASTM A615, Grade 60 and is beyond reinforcement indicated on the contract drawings. Field bending will be limited to right angle bends and standard 90 degree hooks on No. 3 & No. 4 Bar sizes. Additional steel shall be as follows:

No. 3 bars - 20 pieces 20'-0" long
No. 4 bars - 30 pieces 20'-0" long
No. 5 bars - 30 pieces 20'-0" long
No. 6 bars - 20 pieces 20'-0" long

END OF SECTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Construction joints, expansion joints, and the placing of waterstops where such are indicated on the plans.

B. Construction joints shall be of the type indicated on the drawings and shall be located as shown on the plans unless otherwise approved by the Engineer. Contractor shall submit a joint location plan as specified in SECTION 3.1 - CAST-IN-PLACE CONCRETE.

1.2 WATERSTOPS

A. Waterstops shall be installed in construction joints as required by the Plans. All waterstops shall be continuous throughout their length.

B. The waterstops shall be heavy duty polyvinyl waterstop conforming to Corps of Engineers Specification CRD-C-572, latest edition, as manufactured by Serviced Products Division of W.R. Grace and Company: Vinylstops by Sonneborn-Contech; Sealtight Duo-PVC Waterstops by W. R. Meadows, Inc.; Vinylex Corporation; "labyrinth" waterstop, Type B-2 as manufactured by Water Seals, Inc.; or an approved equal of the same type and material and approximately equal in dimensions and weight but not necessarily of exactly the same shape. Waterstops shall be of the size and type designated on the Plans.

C. "Rib Type" waterstops shall be of ribbed construction with a center bulb, 5" wide, capable of resisting a maximum pressure load of 65 feet of water.

D. All waterstops shall be installed so that one-half its width will be embedded on one side of the joint and one-half on the other. The Contractor shall employ a method of holding the waterstop in position for the first pour that is satisfactory to the Engineer. The method selected must insure that the waterstop will be held securely in true vertical or horizontal position and in straight alignment in the joint.

E. Care shall be exercised to ensure that the waterstop is completely encompassed in good mortar.

F. Preformed Plastic Waterstops:

Preformed Plastic Waterstop, when approved by the Engineer, shall meet or exceed all requirements of Federal Specifications SS-S-00210, "Sealing Compound, Preformed Plastic for Expansion Joints", Type I or Type II. Such plastic waterstop shall be equal to SYNKO-FLEX as manufactured by Synko-Flex Products Company, Houston, Texas, or "CenSeal GS-231" by Concrete Sealants, Inc., New Carlisle, Ohio and shall meet the following requirements:

The plastic waterstop shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler, and shall contain no solvents, irritating fumes or obnoxious odors. The plastic waterstop shall not depend on oxidizing, evaporating or chemical action for its adhesive or cohesive strength. It shall be supplied in extruded form of suitable cross-section and of a size to seal the joint areas of concrete sections. The plastic waterstop shall be protected by a suitable removable two-piece wrapper. The two-piece wrapper shall be so designed that one-half may be removed longitudinally without disturbing the other half, to facilitate application of the sealing compound.

1.3 JOINTS IN WATERSTOPS

A. All waterstops shall be continuous and so joined at all points of contact in the same plane, or at intersections with waterstops in different planes, as to form a complete barrier to the passage of water through any construction or contraction joint.

B. Joints in the waterstops, whether made for the purpose of continuity in a straight strip or for the purpose of securing a watertight junction between strips in different planes, shall be made by heat welding as hereinafter specified.

C. Joints in PVC waterstops shall be made by heating the two surfaces to be jointed until the material has softened to the point where it is just short of being fluid and then bringing the two softened surfaces together with a slight rubbing motion followed by firmly pressing them together so that a solid and tight bond is made.

D. The joints in strips of waterstop made in the above manner shall be such that the entire cross section of the joint shall be dense, homogeneous and free of all porosity. All finished joints shall have a tensile strength of not less than 75 percent of the material of the strip as extruded.

E. The heating of the surfaces to be joined shall be done by means of an electric splicing iron designed for the specified purpose and controlled by means of a voltage regulator.

F. In use, the heat of the hot plate shall be so regulated as to prevent too rapid melting and accompanying charring of the waterstop material.

G. The use of makeshift hot plates will not be permitted nor will other means of heating the strips to be joined be allowed except in a case of emergency, as determined by the Engineer.

H. The Contractor shall provide such jigs as will assist in making the joints in a proper and workmanlike manner and in holding the strips so that the alignment of jointed strips is correct and angles are true to those required.

I. Prior to embedment all joints in the waterstop strips will be inspected by the Engineer and any found defective shall be remedied without delay.

1.4 PROTECTION OF WATERSTOP BETWEEN POURS

A. The Contractor shall take such steps as are necessary to protect exposed waterstops in the interim period between concrete pours. This would include damage from construction equipment, tools and concrete "slobbers". In the event the waterstop receives small amounts of construction debris and/or concrete "slobbers" while concrete is "green", the Contractor shall fully clean waterstop directly following the stripping of formwork and prior to the placement of future reinforcement.

1.5 EXPANSION JOINTS

A. Expansion joints of the size and type shown on the plans, or specified herein, shall be placed in concrete pavement or structure as shown on the plans.

1. Materials:

a. Preformed Asphalt Fiber Joint Material

Asphalt fiber sheet filler shall consist of preformed strips of inert material impregnated with asphalt. It shall be of the thickness shown on the Plans or indicated in these Specifications.

The sheet filler shall conform to the requirements of AASHTO Specification M-213 with the following additional provisions.

The sheet filler shall be of such character that it will not be deformed by ordinary handling during hot weather nor become hard and brittle in cold weather. It shall be of a tough, resilient, durable material not affected by weathering.

b. Hot Poured Rubberized Tar Joint Sealer

Hot poured rubberized mastic joint sealer shall consist of a mixture of durable, elastic rubber, coal tar pitch and other materials which will form a resilient and adhesive compound capable of effectively sealing concrete joint surfaces against repeated expansion and contraction. The material shall be installed in accordance with the manufacturer's directions. Hot poured tar sealer shall be used for pavement and sidewalk expansion joints.

B. Joint Surface Preparation:

1. Clean joint surfaces immediately before installation of sealant or caulking compound. Remove dirt, insecure coatings, moisture and other substances which would interfere with bond of sealant or caulking compound.

2. For all sealants, do not proceed with installation of sealant over joint surfaces which have been painted, lacquered, waterproofed or treated with water repellent or other treatment or coating unless a laboratory test for durability (adhesion), in compliance with Paragraph 4.3.9 of FS TT-S-00227, has successfully demonstrated that sealant bond is not impaired by coating or treatment. If laboratory test has not been performed, or shows bond interference, remove coating or treatment from joint surfaces before installing sealant.

3. Etch concrete and masonry joint surfaces to remove excess alkalinity, unless sealant manufacturer's printed instructions indicate that alkalinity does not interfere with sealant bond and performance. Etch with 5% solution of muriatic acid; neutralize with diluted ammonia solution, rinse thoroughly with water and allow to dry before sealant installation.

C. Installation:

1. Comply with sealant manufacturer's printed instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

2. Prime or seal joint surfaces where shown or recommended by sealant manufacturer. Do not allow primer/sealer to spill or migrate onto adjoining surfaces.

3. Employ only proven installation techniques, which will insure that sealants will be deposited in uniform, continuous ribbons without gaps or air pockets, with complete "wetting" of joint bond surfaces equally on opposite sides. Except as otherwise indicated, fill sealant rabbet to a slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, fill joint to form a slight cove, so that joint will not trap moisture and dirt.

4. Install sealants to depths as shown or, if not shown, as recommended by sealant manufacturer but within the following general limitations, measured at center (thin) section of bead.

5. For sidewalks, pavements and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to a depth equal to 75% of joint width, and neither more than 5/8" deep nor less than 3/8" deep.

6. For normal moving joints sealed with elastomeric sealants, but not subject to traffic, fill joints to a depth equal to 50% of joint width, but neither more than ½" deep nor less than 1/4" deep.

7. Do not allow sealants or compounds to overflow or spill onto adjoining surfaces, or to migrate into voids of adjoining surfaces. Use masking tape or other precautionary devices to prevent staining of adjoining surfaces, by either primer/sealer or the sealant.

8. Remove excess and spillage of compounds promptly as the work progresses. Clean adjoining surfaces by whatever means may be necessary to eliminate evidence of spillage, without damage to adjoining surfaces or finishes.

9. Placement of expansion joint material shall fully cover joint area(s) between concrete placements. No gaps or joint material opens which permit fresh concrete to flow to existing concrete surface will be allowed.

D. Cure and Protection

1. Cure sealants in compliance with manufacturer's instructions and recommendations, to obtain high early bond strength, internal cohesive strength and surface durability. Do not cure in a manner which would significantly alter material's modules of elasticity or other characteristics.

2. Installer shall advise Contractor of procedures required for curing and protection of sealants during construction period, so that they will be without deterioration or damage (other than normal wear and weathering) at time of Owner's acceptance.

END OF SECTION

PART 1 - GENERAL

1.1 SCOPE

A. Work in this section includes all labor, plant and material necessary to furnish and install all concrete formwork required by the project. Concrete formwork shall conform to all requirements of current editions of ACI 301 "Specifications for Structural Concrete for Buildings" and ACI 318 "Building Code Requirements for Reinforced Concrete" and ACI 347 "Recommended Practice for Concrete Formwork" and ACI 350 "Code Requirements for Environmental Engineering Structures" except as modified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Forms shall be of wood, metal, highly water resistant plywood, or other material approved by the Engineer. Forms for sections greater than 18" thick shall be of wood. Form surfaces shall be smooth and free from irregularities, dents, sags, or holes when used for permanently exposed surfaces. Bolts and rods used for internal ties shall be so arranged that, when the forms are removed, all metal will not be less than two (2) inches from any concrete surface. Wire ties will not be permitted where concrete surface will be exposed to weathering, and discoloration would be objectionable. Exposed concrete shall have approved form liners of Masonite or plywood, or shall be constructed of smooth surfaced plywood.

B. Corner forms forming 3/4 inch chamfers or as otherwise specified on plans, shall be used on all outside corners that are to be exposed in the finished structure. Chamfer forms shall be of molded plastic or polyvinyl chloride chamfer strips. Use one style of form throughout the project. The type to be used shall be submitted to the Engineer for approval.

C. Rustication and Score Line Strips shall be a non-absorbent material such as extruded polyvinyl chloride, plastic, fiberglass or metal or they may be milled from a good quality lumber and well sealed to prevent moisture absorption, wood strips may not have protruding splinters which may become embedded in the concrete. Sealing wood shall be accomplished by emersion or brushing on two coats of form coating.

D. Form Ties for concrete shall have an approved waterstop barrier to prevent seepage of moisture along the ties. The ends of the metal after breaking off shall be minimum of 2 inches from the finished wall face. Submit samples to the Engineer for review. All temporary tie components of tie system shall be removed from placement once placement is completed and prior to backfilling. Non-shrink grout shall be placed at all voids created by ties.

E. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing compounds.

F. Cylindrical Columns and Supports: Form round-section members with paper or fiber tubes, constructed of laminated plies using water-resistant type adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation.

G. Inserts: Provide metal inserts, anchor bolts and other embedded items for anchorage of materials or equipment to concrete construction, not supplied by other trades and as required for the work.

H. Provide sheet metal reglets formed of the same type and gauge as the flashing metal to be built into the reglets, unless otherwise indicated. Where resilient or elastomeric sheet flashing or bituminous membranes are terminated in reglets, provide reglets of not less than 26 gauge galvanized sheet steel. Fill reglet or cover face opening to prevent intrusion of concrete or debris.

I. Side forms of footings may be omitted and concrete placed directly against excavation only when requested by Contractor and accepted by Engineer. When forms are omitted, provide additional concrete required beyond the minimum design profiles and dimensions of the footings as indicated to provide minimum concrete coverage for reinforcement. Contractor shall maintain the earth form to proper alignment with no sloughing of material into the minimum design profile shown on the drawings.

J. Dovetail Anchor Slots at surfaces to receive masonry veneer to be Heckman #100 or equal.

K. Formwork used for exposed finished concrete surface placements shall be in like new condition and designed to provide flat and true surfaces.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design and engineering of formwork, shoring and reshoring as well as its construction is the responsibility of the contractor. Design formwork for loads, lateral pressures and allowable stresses outlined in ACI 347R and for design considerations, wind loads, allowable stresses and other applicable requirements of the controlling local Building Code. Where conflicts occur between these two standards, the more stringent requirements shall govern.

B. Forms shall be built true to line and grade, and be mortartight and sufficiently

rigid to prevent displacement or sagging between supports. All formwork and shoring shall be designed for the construction loads to be placed on them, and the design and construction of said forms shall be in accordance with ACI Standard "Recommended Practice for Concrete Formwork" (ACI 347). The structural adequacy of the formwork shall rest with the Contractor. All forms shall be so constructed that they can be removed without hammering or prying against the concrete.

C. Before concrete placement check the lines and levels of erected formwork. Make corrections and adjustments to ensure proper size and location of concrete members and stability of forming systems.

D. During concrete placement check formwork and related supports to ensure that forms are not displaced and that completed work will be within specified tolerances.

E. Provide temporary openings in wall forms, columns forms and at other locations necessary to permit inspection and clean-out.

3.2 EMBEDDED ITEMS

A. Before placing concrete, care shall be taken to determine that any embedded metal or wood parts are firmly and securely fastened in their correct location as indicated. Use setting drawings, diagrams, instruction and directions provided by suppliers of items attached thereto. They shall be thoroughly clean and free from coating, rust, scale, oil, or any foreign matter. Embedding of wood in concrete shall be avoided whenever possible, metal being used instead. If wood is allowed, it shall be thoroughly wetted before concrete is placed.

B. All aluminum embedded items shall be coated with epoxy paint where in contact with concrete.

3.3 FORM REMOVAL

A. Forms shall not be removed without approval of the Engineer. Forms shall not be removed before the minimum times given below, or longer if job control tests indicate the concrete has not attained strength specified below, except when specifically authorized by the Engineer.

Beams and Slabs	14 days or proof of strength requirements met.
Walls up to 12" Thick and Vertical Surfaces	1 day if minimum daily temperature is above 50°F, 3 days otherwise
Columns	5 days or proof of strength requirements met.
Walls greater than 12" Thick	3 days if minimum daily temperature is

above 50°F with proof of strength requirements met, 7 days otherwise.

B. In general, forms or shores for supported slabs and beams shall not be removed until the concrete, so supported, has acquired 70% of its design strength; except where loads other than the dead weight of the concrete are added, the shores shall not be removed until 24 hours after the concrete has obtained 90% of its design strength. Forms shall be removed immediately after expiration of the lapsed times specified above or sooner, if required by the Engineer, where concrete is to receive a rubbed finish.

END OF SECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. General requirements applicable to all Electrical Work.

2. General requirements for electrical submittals.

3. Interfaces to equipment, instruments, and other components:

4. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.

5. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:

    a. Make all changes necessary to meet the manufacturer’s wiring requirements.

    b. Submit all such changes and additions to the Engineer for acceptance.

6. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:

    a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.

B. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:

1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.

2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.

3. Owner is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

C. Contract Documents:

1. General:

a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.

2. Specifications:

a. The General and Supplementary Conditions of the Contract Documents govern the Work.

b. These requirements are in addition to all General Requirements.

3. Contract Drawings:

a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.

b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:

c. The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.

d. The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer’s equipment fits in the allotted space. It is the Contractor’s responsibility to ensure that the equipment being furnished fits within the defined space.

e. Installation details:

1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.

2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.

1.2 REFERENCES

A. Code compliance:

1. As specified in Section 01410 - Regulatory Requirements.
The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.

2. The standards listed are hereby incorporated into this Section.

a. American National Standards Institute (ANSI).

b. American Society of Civil Engineers (ASCE):

c. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.

d. ASTM International (ASTM).

e. Illuminating Engineering Society (IES).

f. Institute of Electrical and Electronics Engineers (IEEE).

g. Insulated Cable Engineers Association (ICEA).

h. International Code Council (ICC):

i. International Code Council Evaluation Service (ICC-ES).

j. AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).

k. International Society of Automation (ISA).

l. National Electrical Manufacturers Association (NEMA):

m. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

n. National Fire Protection Association (NFPA):

o. 70 - National Electrical Code (NEC).

p. National Institute of Standards and Technology (NIST).

q. Underwriters' Laboratories, Inc. (UL).

r. Compliance with laws and regulations: As specified in Document 00700 - General Conditions.

1.3 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:

1. IEEE.

2. NETA.

3. IES.

4. ISA.
5. NEC.
6. NEMA.
7. NFPA.
8. NIST.
9. Specific definitions:
10. FAT: Factory acceptance test.
11. LCS: Local Control Station
12. ICSC: Instrumentation and controls subcontractor.
13. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
14. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
15. PCIS: Process control and instrumentation system.
16. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
17. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
18. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
19. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
20. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.4 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:

a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.

2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.

3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.

4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.

5. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:

a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.

b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.

c. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:

1) As specified in the Contract Documents.

B. Operating facility:

1. The Facility is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:

a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.

b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.

c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.

d. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.

e. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.5 SUBMITTALS

A. General:

1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.

2. Furnish the submittals required by each section in the Electrical Specifications.

3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:

4. Uniquely number each wire.

5. Wire numbers must appear on all Equipment Drawings.

6. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

B. Submittal organization:

1. First page:

a. Specification section reference.

b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.

c. Name and telephone number of individual who is primarily responsible for the development of the submittal.

d. Place for Contractor’s review stamp and comments.

2. Next pages:

a. Provide confirmation of specification compliance:

1) Specification section: Include with each submittal a copy of the relevant specification section.

2) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (√) or deviation with a consecutive number (1, 2, 3).

3) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.

b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:

1) In the order that the comments or questions were presented throughout the submittal.

2) Referenced by index section and page number on which the comment appeared.

c. Acceptable responses to Engineer's comments are either:

1) Engineer's comment or change is accepted and appropriate changes are made.

2) Explain why comment is not accepted or requested change is not made.

3) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.

d. Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.

e. No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining pages:

a. Actual submittal data:

1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.

2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

C. Submittal requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.

2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.

4. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
5. Submit copies of shop drawings, and product data:
    a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
    a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
7. Exceptions to Specifications and Drawings:
    a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
    c. Acceptance of any exception is at the sole discretion of the Engineer.
    d. Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
    e. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
8. Specific submittal requirements:
    a. Shop drawings:
        1) Required for materials and equipment listed in this and other sections.
        2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
        3) Shop drawings requirements:
            a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
            b) Locations of conduit entrances and access plates.
            c) Component layout and identification.

d) Schematic and wiring diagrams with wire numbers and terminal identification.

e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.

f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.

g) Weight.

h) Finish.

b. Nameplates:

1) As specified in Section 16075 - Identification for Electrical Systems.

2) Temperature limitations, as applicable.

c. Product data:

1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.

2) Include:

a) Catalog cuts.

b) Bulletins.

c) Brochures.

d) Quality photocopies of applicable pages from these documents.

e) Identify on the data sheets the Project name, applicable specification section, and paragraph.

f) Identify model number and options for the actual equipment being furnished.

g) Neatly cross out options that do not apply or equipment not intended to be supplied.

h) Detailed sequence of operation for all equipment or systems.

D. Operation and maintenance manuals:

1. As specified in Section 01782 - Operation and Maintenance Data.

2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.

E. Material and equipment schedules:

1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:

2. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

F. Schedule of values:

1. In addition to completing all items referred to in the schedule of values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

G. Record Documents:

1. Provide Record Documents of all Electrical Drawings.
2. Record Drawing requirements:
    a. Update Record Drawings weekly.
    b. Record Drawings must be fully updated as a condition of the monthly progress payments.
    c. Submit Record Drawings upon completion of the Work for final review.
    d. Clearly and neatly show all changes including the following:
        1) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
3. Shop drawings:
    a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
    b. Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch paper.
    c. Size all drawings to be readable and legible on 11-17-inch media.
    d. Provide electronic copies of these documents on CD-ROM or DVD disks in PDF format.
4. Review and corrections:
    a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
    b. Promptly correct and re-submit record documents returned for correction.

H. Test reports:

1. Include the following:
    a. A description of the test.
    b. List of equipment used.
    c. Name of the person conducting the test.

d. Date and time the test was conducted.

e. All raw data collected.

f. Calculated results.

2. Each report signed by the person responsible for the test.

3. Additional requirements for field acceptance test reports are specified in Section 16950 - Field Electrical Acceptance Tests.

I. Calculations:

1. Where required by specific Electrical Specifications:

a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.6 QUALITY ASSURANCE

A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

B. Shipping precautions:

1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.

2. Place dehumidifiers, when required, inside the polyethylene coverings.

3. Skid-mount the equipment for final transport.

4. Provide lifting rings for moving without removing protective covering.

5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

C. Delivery and inspection:

1. Deliver products in undamaged condition, in manufacturer’s original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

D. Special instructions:

1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.8 PROJECT OR SITE CONDITIONS

A. Site conditions:

1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.

2. Outdoor installations:

a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.

b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:

c. Provide all wiring necessary to power these devices.

d. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:

1) NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.

2) NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.

3) NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.

4) NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.

5) NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052 - Hazardous Classified Area Construction.

3. Plant area Electrical Work requirements:

a. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Outdoor	NEMA 3R	Galvanized rigid steel	W	Stainless steel

Modify exposed conduit runs as specified in Section 16130 - Conduits.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:

1. Testing requirements are specified in Section 16950 - Field Electrical Acceptance Tests and other sections.

B. Pre-submittal conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.

2. Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.

C. Factory acceptance testing (FAT):

1. Where FAT is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:

2. Indicate the desired dates for inspection and testing.

3. Schedule the FAT after approval of the FAT procedures submittal:

a. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.

b. Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

A. Warrant the Electrical Work as specified in General Conditions:

B. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:

B. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.

B. Allowable manufacturers are specified in individual Electrical Specifications.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in General Conditions.

C. Stainless steel:

1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.

2. Provide exposed screws of the same alloys.

3. Provide finished material free of any burrs or sharp edges.

4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.

5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.

6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES (NOT USED)

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The electrical subcontractor is encouraged to visit the site to examine the premises completely before bidding.

B. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

C. Comply with pre-bid conference requirements as specified in Instructions to Bidders.

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:

B. Verify all dimensions indicated on the Drawings:

1. Actual field conditions govern all final installed locations, distances, and levels.

C. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.

D. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.

E. Provide a complete electrical system:

1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.
2. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

F. Cutting and patching:

1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
2. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
3. Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
    a. Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
    b. Use tone-locate system or X-ray to ensure that area is clear of obstructions.
    c. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
4. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
    a. 3M: CP 25WB+: Caulk.
    b. 3M: Fire Barrier: Putty.
5. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
    a. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
    b. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
    c. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
    d. Adjust equipment locations as necessary to avoid any obstruction or interferences.
    e. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.

f. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

G. Earthwork and concrete:

1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:

a. Requirements as specified in the Contract Documents.

H. Terminations:

1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

I. Miscellaneous installation requirements:

1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in General Conditions.

2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.

3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.

4. Circuits of different service voltage:

a. Voltage and service levels:

b. Medium voltage: greater than 1.0 kV.

c. Low voltage: 120 V to 480 V.

d. Instrumentation: Less than 50 VDC.

e. Install different service voltage circuits in separate raceways, and junction boxes.

5. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.

6. Labeling:

J. Equipment tie-downs:

1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 FIELD QUALITY CONTROL

A. Inspection:

1. Provide any assistance necessary to support inspection activities.
2. Engineer inspections may include, but are not limited to, the following:
3. Inspect equipment and materials for physical damage.
4. Inspect installation for compliance with the Drawings and Specifications.
5. Inspect installation for obstructions and adequate clearances around equipment.
6. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
7. Inspect equipment nameplate data to verify compliance with design requirements.
8. Inspect raceway installation for quality workmanship and adequate support.
9. Inspect cable terminations.
10. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.

B. Field acceptance testing (Functional Testing):

1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
2. Perform the field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.
3. Record results of the required tests along with the date of test:
4. Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:

1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
2. Neatly coil and label spare wiring lengths.
3. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.8 ADJUSTING (NOT USED)

3.9 CLEANING

A. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.

B. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:

C. Use of compressors or air blowers for cleaning is not acceptable.

D. As specified in other sections of the Contract Documents.

3.10 PROTECTION

A. Protect all Work from damage or degradation until Substantial Completion.

END OF SECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Grounding materials and requirements.

1.2 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.3 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.4 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cut sheets.

1.5 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All grounding components and materials shall be UL listed and labeled.

1.6 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.7 PROJECT/SITE CONDITIONS (NOT USED)

1.8 SEQUENCING (NOT USED)

1.9 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Exothermic connectors: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Burndy.
   4. Thomas & Betts.

B. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Nehring.
   4. Thomas & Betts.

C. Ground cable: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Nehring.
   4. Southwire.

D. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.2 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.
   3. Ground connections.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950 - Field Electrical Acceptance Tests, shall be:
   1. 5 ohms or less for industrial systems.

2.3 EXISTING PRODUCTS (NOT USED)

2.4 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10 feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. The copper-to-steel bond shall be corrosion resistant.
   3. In accordance with UL 467.
   4. Sectional type joined by threaded copper alloy couplings.
   5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:
   1. Requirements:
      a. Soft drawn (annealed).
      b. Concentric lay, coarse stranded in accordance with ASTM B8.
   2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Exothermic welds:
   1. Current carrying capacity equal to that of the conductor.
   2. Permanent molecular bond that cannot loosen or corrode over time.
   3. Will not deteriorate with age.
   4. Use low emission welds for indoor installations.

D. Equipment grounding conductors:
   1. Conductors shall be the same type and insulation as the load circuit conductors:

a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.

2. Minimum size in accordance with the NEC.

E. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.

F. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

2.5 MANUFACTURED UNITS (NOT USED)

2.6 EQUIPMENT (NOT USED)

2.7 COMPONENTS (NOT USED)

2.8 ACCESSORIES

A. Precast ground well boxes:
1. Minimum 10-inch interior diameter.
2. Traffic-rated cast iron cover.
3. Permanent “GROUND” marking on cover.

2.9 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

D. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

E. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

F. Ground connections:
   1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using exothermic welds as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.

G. Grounding electrode system:
   1. Ground ring:
      a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
      b. Ground ring conductor shall be in direct contact with the earth.
      c. Minimum burial depth 36 inches or as indicated on the Drawings.
      d. Re-compact disturbed soils to original density in 6-inch lifts.
   2. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
   3. Metal frame of building or structure:
      a. Bond metal frame of building or structure to grounding electrode system.
   4. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
   5. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.
   6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

H. Where indicated on the Drawings, install ground rods in precast ground wells.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING (NOT USED)

3.8 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.9 ADJUSTING

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
   1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Medium voltage cables rated 5,000 through 35,000 volts.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Association of Edison Illuminating Companies (AEIC):
   1. CS8 - Specification for Extruded Dielectric, Shielded Power Cables Rated 5 through 46 kV.

C. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   3. B496 - Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.

D. Insulated Cable Engineers Association (ICEA):
   1. S-93-639 - 5-46 kV Shielded Power Cable for Use in the Distribution of Electrical Energy.
   2. S-94-649 - Standard for Concentric Neutral Cables Rated 5 Through 46 kV.
   3. S-97-682 - Standard for Utility Shielded Power Cables Rated 5 Through 46 kV.

E. Underwriter’s Laboratories (UL):
   1. 1072 - Standard for Safety for Medium-Voltage Power Cables.

F. InterNational Electrical Testing Association (NETA):
   1. ANSI/NETA ATS-2021 Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Definitions of terms and other electrical considerations as set forth by:
   1. ICEA.
   2. ASTM.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete medium voltage cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer.
   2. Voltage class.
   3. Conductor:
      a. Size.
      b. Material.
      c. Stranding.
   4. Insulation:
      a. Type.
      b. Level.
   5. Shielding.
   6. Temperature rating.
   7. Jacket material.

C. Shop drawings:
   1. Show splice locations.
   2. Provide details on the pull plan:
      a. Show splice locations, if applicable.
      b. Cable layout locations, if applicable.
      c. Actions for protecting cables at each phase of the installation.

D. Calculations:
   1. Submit cable pulling calculations to the Engineer for review and comment showing that the maximum cable tension and sidewall pressure will not exceed Manufacturer recommended values:
      a. Provide a table showing the manufacturer’s recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
   2. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

E. Qualifications:
   1. Submit qualifications for the individual(s) that will be performing medium voltage cable splices and terminations at least 30 calendar days before splicing or terminating.
   2. Documentation that the individual has received training by splice/termination Manufacturer or an independent testing laboratory.
   3. A statement of the number of years in which the individual has been splicing and terminating medium voltage cable.

F. Test reports:
   1. Submit AC withstand partial discharge (corona) test x-y plots after manufacture and prior to shipment.
   2. Submit field test reports as specified in Section 16950 - Field Electrical Acceptance Tests.

G. Record documents:
   1. Submit record documents with any field modification.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Manufacturer qualifications: Minimum of 10 years of experience in manufacturing medium voltage power cables.

C. Medium voltage cables shall be UL listed and labeled.

1.07 DELIVERY STORAGE AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal: Engineer knows of no equal.
   1. Okonite Co.
   2. General Cable.
   3. Southwire Co.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Conductors:
   1. Annealed uncoated copper in accordance with ASTM B3.
   2. Compact stranded in accordance with ASTM B496.

B. Insulation:
   1. Ethylene propylene rubber, (EPR).

C. Jacket:
   1. **Polyvinyl chloride (PVC).**

2.04 MANUFACTURED UNITS

A. General:
   1. Permanently mark each cable with the following at 24-inch intervals:
      a. American Wire Gauge (AWG) size or circular mill area.
      b. Voltage rating.
      c. Grade of insulation.
      d. UL symbol.
      e. Manufacturer’s name.

B. Medium voltage cable:
   1. Provide cables manufactured in the last 12 months.
   2. Voltage ratings as indicated on the Drawings or on the conduit schedule.
   3. Type MV-105:
      a. Rated for 105 degrees Celsius.
   4. Single-conductor:
      a. Stranding:
         1) In accordance with ASTM B3 and B8 Class B.
   5. Conductor screen:
      a. Extruded semiconducting thermosetting compound.
      b. Applied directly over the conductor.
      c. In accordance with:
         1) AEIC CS8.
         2) UL 1072.
   6. Insulation level:
      a. 133 percent.
      b. Insulation screen:
         1) Extruded semiconducting thermosetting compound.
         2) Applied directly over the insulation.
         3) In accordance with:
            a) ICEA S-93-639 and ICEA S-97-682.
            b) Free-striping.

4) Provide color differentiation between semi-conducting layers and insulation.

7. Shield:
   a. 5-mil annealed copper tape with an overlap of 25 percent.
8. Applications:
   a. Suitable for use in wet and dry locations in conduit and underground duct systems.
   b. Cables larger than AWG 1/0 suitable for CT use in cable tray.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Manufacturer cable in accordance with the latest standards of the ASTM and ICEA and test full cable length by these standards:
   1. AC withstand partial discharge (corona) test per AEIC CS8 and ICEA S-94-649.
      a. Results not to exceed 5 picocoulombs.

B. Provide cable reels with both ends of cables available for high-potential testing before installation.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install and terminate cable per manufacturer recommendations:
   1. Use proper stripping and terminating tools to ensure integrity of insulation.
   2. Ground shield at all terminations and splices.
   3. Maintain manufacturer’s or NEC’s minimum bending radius, whichever is larger.

4. Do not bend, kink or nick cable jacket or insulation.
5. Properly coat wires and cables with pulling compound recommended by cable manufacturer before pulling into conduits and prevent mechanical damage to conductors during installation:
    a. Other lubricants substituted must be accompanied by a statement from cable manufacturer as to its acceptable use with cables being installed.
6. Do not exceed the pulling tension and sidewall pressures recommended by cable manufacturer. Install additional pull boxes as required to meet cable manufacturer's recommendations.
7. Electrical identification: As specified in Section 16075 - Identification for Electrical Systems.
8. Use only tools that are recommended by the termination or splice manufacturer.
9. Use a dynamometer during cable pulling operations to monitor cable pulling tensions.

C. Do not install cables until the Engineer reviews the Contractor prepared cable-pulling calculations:
    1. Cable pulling crew shall have “in hand” all cable pulling calculations and cable pulling limitations.

D. Cable pulling requirements:
    1. Pull cable directly from reels into the ducts.
    2. Cable may not be laid on the ground or otherwise handled for cutting or sorting without protection from debris or physical damage.
    3. Follow cable manufacture installation instructions for proper handling.
    4. Do not pull cables through more than one intermediate manhole on one pull.
    5. Seal all cable ends against moisture after pulling.
    6. Use non-metallic pull ropes to prevent cutting of duct materials.
    7. Pull cables from conductor, do not use cable pulling socks that attach to the insulation.

E. Installation of cables in manholes and handholes:
    1. Install cables not utilizing the shortest route, but routed along those walls providing the longest route and the maximum spare cable lengths.
    2. Run all cables closely parallel to the walls, not interfering with duct entrances.
    3. Support cables on brackets and cable insulators spaced at a maximum of four feet.
    4. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required for a neat and workmanlike installation with all cables properly arranged and supported.

F. Splices:
    1. Provide continuous circuits from origin to termination:
        a. Provide where necessary when cable pulling tension or sidewall pressure exceeds manufacturer recommendation for the cable.

2. Make splices in manholes or pull boxes only:
   a. Leave sufficient slack to make proper connections.
   b. Do not pull splices into conduit.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

B. After cable installation, test in accordance with ANSI/NETA ATS, including voltage tests and VLF hi-potential tests, before energizing the circuits.
   1. Verify that no equipment is connected to the cables during tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
1. Metallic conduits.
2. Nonmetallic conduits.
3. Conduit bodies.
4. Conduit fittings and accessories.
5. Conduit installation.

1.2 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI):
1. C80.1 - Electrical Rigid Steel Conduit.
2. C80.3 - Steel Electrical Metallic Tubing.
3. C80.5 - Electrical Rigid Aluminum Conduit.
4. C80.6 - Electrical Intermediate Metal Conduit.

C. National Electrical Manufacturer's Association (NEMA):
1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
5. TC13 - Electrical Nonmetallic Tubing.
6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

D. Underwriters Laboratories (UL):
1. 1 - Standard for Flexible Metal Conduit.
2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
4. 360 - Standard for Liquidtight Flexible Steel Conduit.
5. 651 - Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
6. 651B - Standard for Continuous Length HDPE Conduit.
7. 797 - Standard for Electrical Metallic Tubing - Steel.
8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
9. 1653 - Standard for Electrical Nonmetallic Tubing.
10. 1660 - Standard for Liquidtight Flexible Nonmetallic Conduit.

11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.3 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
   2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
   3. GRC: Galvanized rigid steel conduit.
   4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
   5. EMT: Electrical metallic tubing.
   6. PVC: Polyvinyl chloride rigid nonmetallic conduit.
   7. SLT: Sealtight-liquidtight flexible conduit.
   8. EFLX: Explosion proof flexible conduit.
   9. RAC: Rigid aluminum conduit.
   10. NPT: National pipe thread.

1.4 SUBMITTALS

A. Furnish submittals as specified in Sections and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Furnish complete manufacturer’s catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer’s recommended special tools to be used for installation if required.

C. Certifications:
   1. Furnish PVC-coated conduit manufacturer’s certification for each installer.

D. Record Documents:
   1. Incorporate all changes in conduit routing on electrical plan drawings.
   2. Dimension underground and concealed conduits from building lines.
   3. Furnish hard copy drawings.

1.5 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit.

1.6 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Do not expose non-metallic conduit to direct sunlight.

C. Do not store conduit in direct contact with the ground.

D. Do not store aluminum conduit in contact with concrete.

1.7 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.8 SEQUENCING

A. Before installing any conduit or locating any device box:
   1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
   2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.9 SCHEDULING (NOT USED)

1.10 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Western Tube and Conduit.
      b. Allied Tube and Conduit.

c. Wheatland Tube Co.

B. PVC-coated rigid steel conduit:
1. One of the following or equal:
a. Robroy Ind.
b. Ocal, Inc.
c. Calbond.
d. Allied.
e. NEC, Inc. BlackGuard.

C. Rigid nonmetallic PVC conduit:
1. One of the following or equal:
a. Carlon.
b. Cantex.
c. Triangle Conduit and Cable.

D. Joint compound:
1. The following or equal:
a. Thomas and Betts.

2.2 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

2.3 EXISTING PRODUCTS (NOT USED)

2.4 MATERIALS (NOT USED)

2.5 MANUFACTURED UNITS (NOT USED)

2.6 EQUIPMENT (NOT USED)

2.7 COMPONENTS

A. GRC:
1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
a. Running conduit threads are not acceptable.
2. Hot-dip galvanized inside and out:
a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
b. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
a. UL-6.
b. ANSI C80.1.

B. PCS:
   1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for Type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory-bonded PVC jacket:
      a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
      c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
      d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
         1) Confirm bond with certified test results.
   4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
      a. Nominal thickness of 0.002 inch.
      b. Conduits having areas with thin or no coating are not acceptable.
      c. All threads shall be coated with urethane.
   5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
   6. PCS conduit bodies and fittings:
      a. Malleable iron.
      b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
      c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
      d. 0.002-inch interior urethane coating.
      e. Utilize the PVC coating as an integral part of the gasket design.
      f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
      g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
         1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
         2) The sleeve shall provide a vapor- and moisture resistant seal at every connection.

C. PVC:
   1. Extruded from virgin PVC compound:
      a. Schedule 40 unless otherwise specified.

b. Schedule 80 extra-heavy wall where specified.
2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

2.8 ACCESSORIES

A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. PVC fittings:
1. Materials:
a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
b. All metal hardware shall be stainless steel.

2.9 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
1. Conduit routing:
a. The electrical drawings are diagrammatic in nature:
1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
b) Make changes in conduit routing due to the relocation of equipment.

3) The electrical drawings do not indicate all required junction boxes and pull boxes:
   a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
      (1) To meet cable manufacturer's pulling tension requirements.
      (2) To limit total conduit bends between pull locations.
   b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
   1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
   2) Perform any changes resulting in additional conduits, or extra work from such deviations.
   3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
   a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
   b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
   c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
   d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
   a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
   b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:

a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.

9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
11. Install conduits through wall and floor seals where indicated on the Drawings.
12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    a. Remove and replace conduits through which mandrel will not pass.
13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
14. Install complete conduit systems before conductors are installed.
15. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
16. Underground conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
        1) As specified in Section 16133 - Duct Banks.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    d. Seal around conduit penetrations of below grade walls with a mechanical seal.

C. Conduit usage:

1. Concrete-encased and embedded conduits:
    a. Straight runs and bends less than 45 degrees:
        1) Type PVC Schedule 40.
    b. Bends with total deflection greater than 45 degrees;
        1) PCS,
    c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
        1) PCS.
    d. Minimum size:
        1) 2-inch in duct banks.

2) 1-inch for in-slab conduits.
3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.

2. PVC-coated rigid metallic conduit:
   a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
3. GRC:
   a. Conduit shall be cut square and reamed before threading.

D. Conduit joints and bends:
1. General:
   a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
   b. Keep bends and offsets in conduit runs to an absolute minimum.
   c. All bends shall be symmetrical.
   d. The following conduit systems shall use large-radius sweep elbows:
      1) Underground conduits.
      2) Conduits containing fiber optic cables.
   e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
   f. Make field bends with a radius of not less than the requirements found in the NEC:
      1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
      2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
         a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
         b) For the serving utilities, make bends to meet their requirements.
   g. Replace all deformed, flattened, or kinked conduit.
2. Threaded conduit:
   a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
   b. Thoroughly ream conduit after threads have been cut to remove burrs.
   c. Use bushings or conduit fittings at conduit terminations.
   d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar™," or CRC "Zinc It."
   e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
      1) Apply to the male threads and tighten joints securely.
      2) Clean excess sealant from exposed threads after assembly.

f. Securely tighten all threaded connections.
g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. PVC:
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
   b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
      1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

E. Empty conduits:
   1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
   2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
      a. Keep ends sealed until immediately before pulling conductors.

3.4 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING (NOT USED)

3.8 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct bank installation requirements.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Shop drawings:
   1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.
   2. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
      a. Submit shop drawings detailing the new building footer crossing locations and plan drawings labeling all equipment to be installed on top of the new routing for approval by the project Structural Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Conduit spacers:
   1. One of the following or equal:
      a. Carlon Snap-Loc.
      b. Cantex.
      c. Osburn Associates, Inc.

B. Detectable underground marking tape:
   1. One of the following or equal:
      a. Blackburn Manufacturing Co.
      b. Pro-Line Safety Products.
      c. Panduit.

C. Pull line:
   1. One of the following or equal:
      a. Arnco.
      b. Greenlee.
      c. Osburn Associates, Inc.

D. Duct seal:
   1. The following or equal:
      a. OZ Gedney type DUX.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Provide conduit as specified in Section 16130 – Conduits:
   1. Use duct suitable for use with 194 degree Fahrenheit rated conductors.

B. Provide reinforcing steel:
   1. Provide minimum Number 4 reinforcing steel.

2.04 MANUFACTURED UNITS

A. Conduit spacers:
   1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
   2. Saddle type.
   3. Non-metallic, non-corrosive, non-conductive.
   4. Interlocking type:
      a. Vertical interlocking.
      b. Horizontal interlocking.
   5. Suitable for concrete encasement.
   6. Molded-in rebar holder.
   7. Accommodates 2-inch through 6-inch conduit sizes.
   8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
   1. Minimum 1/4-inch wide, flat design.
   2. Polyester.
   3. Minimum pulling strength 1,200 pounds.

C. Detectable marking tape:
   1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
   2. Aluminum core laminated between polyethylene film.
   3. 6-inch wide red tape imprinted with black lettering stating "CAUTION - BURIED ELECTRIC LINE BELOW" or equivalent.

D. Duct seal:
   1. Non-hardening sealing compound.
   2. Flexible, can be applied by hand.
   3. UL Listed for use with installed conductors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES

A. Provide a red-oxide conduit encasement coloring agent.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Duct banks:
1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
2. Damage minimization:
   a. Conduit should not be left exposed in an open trench longer than is necessary.
   b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank.
5. Install underground ducts to be self-draining:
   a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
   b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
   c. Slope a minimum of 1/4 inch per 10 feet.
6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.

7. Install pull line in spare conduits:
    a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
    b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Trenching:
1. Trench must be uniformly graded with the bottom, rock free and covered with select material.
2. Whenever possible, use the walls of the trench as forms for concrete encasement:
    a. Forms are required where the soil is not self-supporting.
3. Avoid damaging existing ducts, conduits, cables, and other utilities.

D. Duct spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings:
    a. Separate medium voltage ducts a minimum of 7.5 inches on center.
2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
    a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
        1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
            a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers shall not be located at the center of a bend:
    a. Locate spacer in the tangent, free of the coupling on fabricated bends.
    b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

E. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
4. Install duct seal in all conduits including spare conduits, at entrance to manholes/handholes, and building/equipment stub-ups. Form by hand to conduit and around cables to develop moisture barrier.
5. New manhole or handhole applications, provide a single opening or “window” per duct bank, sized to accommodate the duct bank envelope.

F. Concrete:
   1. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
      a. Tie wire shall not act as a substitute for spacers.
   2. Install minimum 3-inch cover around conduit and rebar.
   3. Consolidation of encasement concrete around duct banks shall be by hand puddling, with no mechanical vibration.
   4. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking tape:
   1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING (NOT USED)

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

END OF SECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Terminations.
   2. Splices.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 48 - IEEE Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 KV.
   2. 386 - Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5kV through 35kV.
   3. 404 - IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV.

C. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of cables connectors, terminators, fittings, etc. for a complete cabling system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cut sheets.
   2. Installation instructions.
   3. Medium voltage systems:
      a. Documentation demonstrating compliance with the required tests.
      b. Characteristics and installation procedures for all splices, terminators, and junction modules.

C. Shop drawings:
   1. Drawings showing the installation of junction modules, splices, and terminators.

D. Operation and maintenance manuals:
   1. Drawings and data for medium voltage cable connectors, splices, and junction modules.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Tape:
   1. Fire and electric arc proofing tape:
      a. Minimum 30-mil, flexible, elastomer tape that expands in fire to form an insulating firewall between flame and cable.
      b. Bind in place with glass cloth electrical tape.
      c. Manufacturers: The following or equal:
         1) 3M, Scotch Number 77.
   2. Glass cloth electrical tape:
      a. Thermosetting, 7.4-mil silicone adhesive that performs at Class H temperatures 180 degrees Celsius (356 degrees Fahrenheit).
      b. Use for the following applications:
         1) To secure non-PSA insulations such as glass in high-temperature areas.
         2) Splice wire rated at 150 degrees Celsius, 180 degrees Celsius, and 200 degrees Celsius.
         3) For binding fire and electric arc proofing tape.
      c. Meeting and complying with:
         1) UL recognized component listing for 200 degrees Celsius (Guide OANZ2, File E17385).
      d. Manufacturers: The following or equal:
         1) 3M, Scotch Number 69.
   3. Self-fusing silicone rubber tape:
      a. High-temperature, 12-mil, track resistant, insulating tape.
      b. Composed of fully cured inorganic silicone rubber.
      c. Use as a protective overwrap for terminating medium voltage cables.
      d. Manufacturers: The following or equal:
         1) 3M, Scotch Number 70.

B. Cable splices and terminations:
   1. Splices:
      a. Permanent in-line splice.
      b. Suitable for submersible, direct burial applications.
      c. Electrical requirements:
         1) Continuous current rating equal to cable.
         2) 5 to 8 kilovolts (kV) voltage class:
            a) Maximum voltage phase-ground.
            b) Minimum partial discharge voltage (less than 3 pC) 7 kV.
            c) AC withstand, 1 minute: 23 kV.
            d) AC withstand, 1 hour: 35 kV.
            e) AC withstand, 5 hour: 23 kV.
            f) DC withstand, 15 minutes: 45 kV.
            g) Impulse withstand, 1.2 by 50 microsecond 95 kV (crest).
         3) 15 kV voltage class:

a) Minimum partial discharge voltage (less than 3 pC): 13 kV.
b) AC withstand, 1 minute: 35 KV.
c) AC withstand, 1 hour: 53 kV.
d) AC withstand, 5 hour: 35 kV.
e) DC withstand, 15 minutes: 70 kV.
f) Impulse withstand, 1.2 by 50 microsecond 110 kV (crest).

d. Power cable splices for shielded solid dielectric plastic-insulated cables shall utilize factory engineered kits containing all necessary components to maintain primary cable insulation level and metallic shielding/grounding systems.
e. Splice insulation shall be of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductive layer for shielding. The splice shall be covered with a heavy-wall heat-shrinkable sleeve overlapping the cable insulation, with a waterproof mastic seal on both ends.
f. The splice shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. When assembled on cables the splice shall be capable of passing the electrical test in accordance with:
1) IEEE 48.
2) IEEE 404.
g. Manufacturers: The following or equal:
1) Raychem.
2) 3M.

2. Live front terminators:
a. Terminators for shielded solid dielectric plastic-insulated cables shall utilize factory engineered kits containing all necessary components to terminate the primary cables and shield systems.
b. All locations exterior of buildings shall be considered outdoors and appropriate heat-shrinkable skirts of a non-tracking material shall be installed.
c. Terminators shall be of a material that will relieve the voltage stresses at the point of termination.
d. Non-tracking.
e. Ultraviolet, ozone, sulfur dioxide resistant.
f. Terminator insulation shall be of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system.
g. Electrical requirements:
1) Continuous current rating equal to cable.
2) 5 to 8 kV voltage class:
a) Minimum partial discharge voltage (less than 3 pC) 9 kV.
b) AC withstand, 1 minute: 35 kV.
c) DC withstand, 15 minutes: 65 kV.
d) Impulse withstand, 1.2 by 50 microsecond (outdoor) 95 kV (crest).

e) Impulse withstand, 1.2 by 50 microsecond (indoor) 80 kV (crest).
f) Wet withstand, 10 seconds: 30 kV RMS.
g) Dry withstand, 6 hours: 25 kV RMS.

3) 15 KV voltage class:
a) Minimum partial discharge voltage (less than 3 pC) 13 kV.
b) AC withstand, 1 minute: 50 kV.
c) DC withstand, 15 minutes: 75 kV.
d) Impulse withstand, 1.2 by 50 microsecond (outdoor) 110 kV (crest).
e) Impulse withstand, 1.2 by 50 microsecond (indoor) 95 kV (crest).
f) Wet withstand, 10 seconds: 45 kV RMS.
g) Dry withstand, 6 hours: 35 kV RMS.

h. The terminator kit shall accommodate a range of cable sizes and be completely independent of cable manufacturer’s tolerances. When assembled on cables the terminator shall be capable of passing the electrical test in accordance with:
1) IEEE 48.

i. Manufacturers: The following or equal:
1) Raychem.
2) 3M.

3. Dead front terminators (600 Amperes):
a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory engineered kits containing all necessary components to terminate the primary cables and shield systems.
b. Modular, pre-molded, fully shielded dead front system.
c. Submersible.
d. Capable of mating with any manufacturer’s interface in accordance with IEEE 386.
e. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
f. To be used as an elbow or a "T".
g. Cable stress relief adapters to connect the cable insulation to the dead front terminator.
h. Heat shrink seal over the junction between the cable insulation and the terminator body.
i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
j. Terminator shall be bolted to the bushing or connector plug, with an insulating plug to cover the connection.
k. Conductive cap covering the insulating plug.
l. Conductive shield to provide reliable continuity between jacket of cable and connector.
m. Conductive insert around connector to prevent corona.

n. With a capacitive test point on the insulating plug to allow circuit testing without disturbing the connection.
o. Electrical requirements:
1) Voltage class: 15 kV:
a) Maximum voltage:
(1) Phase to Ground: 8.3 KV RMS.
(2) Phase to Phase: 14.4 KV RMS.
b) Withstand voltage:
(1) Impulse (1.2 by 50 microseconds) 95 KV Crest.
(2) AC 1 minute: 34 KV.
(3) DC 15 minutes: 53 KV.
c) Minimum corona extinction level:
(1) 11 kV RMS.
d) Continuous current rating:
(1) 600 amps RMS.
e) Momentary rating:
(1) 25,000 amps RMS at .17 seconds.
(2) 10,000 amps RMS at 3.0 seconds.
p. Manufacturers: One of the following or equal:
1) Elastimold.
2) 3M.
3) Cooper.

4. Dead front terminators (200 Amperes):
a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory engineered kits containing all necessary components to terminate the primary cables and shield systems.
b. Modular, pre-molded, fully shielded dead front system.
c. Loadbreak type.
d. Submersible.
e. Capable of mating with any manufacturer’s interface in accordance with ANSI 386.
f. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
g. To be used as an elbow or a "T".
h. Heat shrink seal over the junction between the cable insulation and the terminator body.
i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
j. Conductive shield to provide reliable continuity between jacket of cable and connector.
k. Conductive insert around connector to prevent corona.
l. With a capacitive test point with protective cover to allow circuit testing without disturbing the connection.
m. With hold-down bail to hold connector to terminal or junction bushing.
n. Electrical requirements:
1) Voltage class 15 kV.

2) Withstand voltage:
   a) Impulse (1.2 by 50 microsecond) 95 kV Crest.
   b) AC 1 minute: 34 kV.
   c) DC 15 minutes: 53 kV.
3) Minimum corona extinction level:
   a) Eleven kV RMS.
4) Continuous current rating:
   a) 200 A RMS.
5) Momentary rating:
   a) 10,000 A RMS, symmetrical at 0.17 seconds.
   b) 3,500 A RMS, symmetrical at 3.0 seconds.

o. Manufacturers: One of the following or equal:
   1) Elastimold.
   2) 3M.
   3) Cooper.

5. Cap all unused taps with an insulating cap approved for the application:
   a. Manufacturers: One of the following or equal:
      1) Elastimold.
      2) 3M.
      3) Cooper.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Medium voltage systems:
   1. Ground shield at all terminators and splices.
   2. Install cable terminators and splices in conformance with the manufacturer's specifications.

3. Fireproof all exposed portions of cables.
    a. Half-lapped layer of fire and electric arc proofing tape, secured with double-wrapped band of glass cloth electrical tape at each end.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

1.0 GENERAL

1.1 The metal-enclosed switchgear shall conform to the following specification.

1.2 Drawings

(a) The metal-enclosed switchgear assembly shall be in accordance with the plans and drawings.

(b) The manufacturer shall furnish, with each metal-enclosed switchgear assembly, a set of drawings complete with a bill of material. The drawings shall include typical front and open side views for each module as well as typical components, their positions, and available space for cable termination; an anchor bolt plan with dimensions; a single-line diagram; and appropriate wiring diagrams.

(c) The manufacturer shall furnish a comprehensive instruction manual covering installation of the switchgear assembly and operation of the various components.

1.3 The metal-enclosed switchgear assembly shall consist of one or more outdoor self-supporting bays containing interrupter switches along with power fuses and /or electronic fuses, with the necessary accessory components, all completely factory-assembled and operationally checked.

1.4 Ratings

(a) The distribution system shall be grounded with 2000 amperes ground-fault current, or delta.

(b) The ratings for the integrated switchgear assembly shall be as designated below

Nominal Voltage, kV - 13.8

Maximum Voltage, kV – 17.0

BIL Voltage, kV - 95

Main Bus Continuous Current, Amperes - 600

Short-Circuit Amperes, RMS, Symmetrical - 25000

MVA, Three-Phase Symmetrical, at Rated Nominal Voltage - 600

Two-Time Duty-Cycle Fault-Closing, Amperes, RMS, Asymmetrical - 40,000

1.5 Certification of Ratings

(a) The manufacturer of the metal-enclosed switchgear shall be completely and solely responsible for the performance of the basic switch and fuse components as well as the complete integrated assembly as rated.

(b) The manufacturer shall furnish, upon request, certification of ratings of the basic switch and fuse components and /or the integrated metal-enclosed switchgear assembly con sitting of the switch and fuse components in combination with the enclosure(s).

(c) The integrated switchgear assembly shall have a BIL rating established by test on switchgear of the type and kind to be furnished under this

specification. Certified test abstracts establishing such ratings shall be furnished upon request.

1.6 Compliance with Standards and Codes

The metal-enclosed switchgear shall conform to or exceed the applicable requirements of the following standards and codes:

(a) IEEE C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear

(b) The applicable portions of:

(1) Article 490 in the National Electric Code, including Article 490-21(e), which specifies that the interrupter switches in combination with power fuses shall safely withstand the effects of closing, carrying, and interrupting all possible currents up to the assigned maximum short-circuit rating

(c) For standard 4.16-kV and 13.8-kV bays with 600-ampere or 1200-ampere main bus and Mini-Rupter® Switches or 1200-ampere Alduti-Rupter® Switches only: The switchgear manufacturer shall furnish equipment that is listed by Underwriters Laboratories Inc.

2.0 CONSTRUCTION

2.1 To ensure a completely coordinated design, the metal-enclosed switchgear shall be

constructed in accordance with the minimum construction specifications of the fuse and/ or switch manufacturer to provide adequate electrical clearances and adequate space for fuse handling.

2.2 Enclosure Construction

(a) In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors, such as controlled access; tamper-resistance; corrosion resistance; protection from ingress of rodents, insects, and weeds; and the possibility of arcing faults within the enclosure.

(b) The enclosure of each bay shall be of unitized monocoque construction to maximize strength, minimize weight, and inhibit corrosion.

(c) The material for all external sides of the enclosure and the roof shall be 11-gauge hot-rolled and pickled and oiled steel sheet.

(d) Each bay containing high-voltage components shall be a complete unit in itself, with full side sheets, resulting in double-wall construction between bays. To guard against unauthorized or inadvertent entry, side and rear sheets and the top shall not be externally bolted.

(e) The base shall be a continuous steel channel of a thicker gauge material than used for the enclosure and shall extend completely around all four sides of each bay.

(f) Access to the interior of the enclosure shall be from the front only, allowing placement of the metal-enclosed switchgear assembly tightly against a wall or back-to-back, to minimize floor-space requirements.

(g) To guard against unauthorized or inadvertent entry, there shall be no access to high voltage through side or rear sheets of the metal-enclosed switchgear assembly and no access to high voltage by means of externally removable panels.

(h) To guard against corrosion, all hardware (including door fittings, fasteners, etc.), all operating-mechanism parts, and other parts subject to abrasive action from mechanical motion shall be of either nonferrous materials or galvanized or zinc-nickel-plated materials. Cadmium-plated ferrous parts shall not be used.

(i) Externally accessible hardware shall not be used for support of high-voltage components or switch-operating mechanisms within the switchgear.

2.3 Door Construction

(a) Doors shall be constructed of 11-gauge hot-rolled and pickled and oiled steel sheet.

(b) Doors shall have 90-degree flanges and shall overlap with the door openings. For strength and rigidity and to minimize exposure, the door flanges shall be welded at the corners and shall be formed (at the top and both sides as a minimum) with a double bend so the sheared-edge flanges at the top and both sides fold back parallel to the inside of the door. The double bend shall not be required on arc-resistant switchgear.

(c) Doors more than 40 inches (1016 mm) in height shall have a minimum of three concealed galvanized steel or non-ferrous hinges with stainless steel hinge pins. Doors 40 inches in height or less shall have a minimum of two such hinges.

(d) Each door shall be equipped with a door handle. The door handle shall be padlock-able and, on outdoor gear, shall incorporate a hood to protect the padlock shackle from tampering.

(e) In consideration of controlled access, tamper-resistance, and arcing faults, each door more than 40 inches (1016 mm) in height shall have a minimum of three concealed, interlocking, high strength latches. Doors 40 inches in height or less shall have a minimum of two such latches.

(f) Doors providing access to interrupter switches or interrupter switches with power fuses shall be provided with a wide-view window constructed of an impact-resistant material to facilitate checking of switch position without opening the door.

(g) Doors providing access to solid-material power fuses or fused voltage transformers shall have provisions to store spare fuse units or refill units. Doors providing access to electronic power fuses shall have provisions to store spare interrupting modules, if possible.

(h) All doors providing access to high-volt age components shall be provided with a sturdy, self-latching door holder, which shall be zinc-nickel plated and chromate dipped.

2.4 Access Control

Access control shall be provided as follows:

(a) Doors providing access to interrupter switches with fuses shall be mechanically or key interlocked to guard against both:

(1) Opening the door if the interrupter switch on the source side of the fuse is closed

(2) Closing the interrupter switch if the door is open

(b) Doors providing access to interrupter switches only that are operated by stored-energy type switch operators shall be mechanically or key interlocked to guard against operating the interrupter switch if the door is open.

(c) Doors and hinged-bolted panels providing access to high-voltage components shall be provided with flush-mounted key-operated snaplocks and shall have provisions for padlocking.

2.5 Internal Protective Screens

(a) In addition to the enclosure door, each bay or compartment containing high-volt-age components shall be provided with an internal bolted-closed protective screen to guard against inadvertent entry to these components when the enclosure door is open.

(b) Each bay containing a control-power transformer capable of 5 kVA or greater output shall be provided with an internal bolted-closed protective screen to guard against inadvertent contact with the primary fuse when the enclosure door is open. In such cases, the screen shall also be interlocked to ensure the secondary load has been disconnected prior to removal of these fuses.

2.6 Insulators

The interrupter-switch and fuse-mounting insulators, main-bus support insulators, insulated operating shafts, and (if applicable) push rods shall be of a cycloaliphatic epoxy resin system with characteristics and restrictions as follows:

(a) Operating experience of at least 25 years under similar conditions

(b) Adequate leakage distance established by test per IEC Publication 507, “Artificial Pollution Test on High Voltage Insulators to be Used on AC Systems,” First Edition, 1975

(c) Adequate strength for short-circuit stress established by test

(d) Conformance with applicable ANSI or Canadian standards

(e) Homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs (Ablation caused by high temperatures from power arcs shall continuously expose more material of the same composition and properties so no change in mechanical or electrical characteristics takes place because of arc-induced ablation. Furthermore, any surface damage to insulators during installation or maintenance of switchgear shall expose material of the same composition

and properties so that insulators with minor surface damage need not be replaced.)

2.7 Bus

High-Voltage Main Bus

(a) Bus supports, bus, and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the switch gear.

(b) Before installation of the bus, all electrical contact surfaces shall first be prepared by machine-abrading to remove any aluminum-oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.

(c) The bus to which cable will be terminated shall be equipped with grounding provisions. Grounding provisions shall also be provided on the ground bus in such bays.

(d) Bus rated 1200 amperes and to which cable will be terminated shall be equipped with provisions for two cables per phase.

(e) Bus and interconnections shall consist of tin-plated copper bar CA110, square edge, hard temper per ASTM B187. Bolted copper-to-copper connections shall have silvered interfaces and shall be made with $^{1}/_{2}$-13 stainless-steel bolts, with two brass flat washers per bolt, one under the bolt head and one under the nut, and with a stainless-steel split lockwasher between the flatwasher and the nut. These bolts shall be tightened to 35 foot-pounds torque

2.7.1 Ground Bus

(a) Ground bus with a short-circuit rating equal to that of the integrated assembly (or a ground connection, in the case of single-bay switchgear) shall be provided, maintaining electrical continuity throughout the metal-enclosed switchgear.

(b) In each bay, the ground bus (or connector) shall be bolted to a nickel-plated steel bracket, which shall be welded in place.

(c) Nickel-plated steel brackets (at least one per bay) shall have a short-time current-carrying capability consistent with the short-circuit rating of the metal-enclosed switchgear.

(d) Bolted connections shall be as specified for the main bus, except only one Belleville spring washer shall be required per bolt for attachment of ground bus to the nickel-plated steel bracket.

(e) For multi-bay metal-enclosed switchgear assemblies, two ground cable connectors accommodating No. 2 through 500 kc mil conductors shall be provided for connection of ground bus to station ground.

(f) The ground bus shall consist of tin-plated copper bar CA110, square edge, hard temper per ASTM B187. Bolted copper-to-copper connections shall have silvered interfaces and shall be made with $^{1}/_{2}$–13 stainless steel bolts, with two brass flat washers per bolt, one under the bolt head and

one under the nut, and with a stainless-steel split lockwasher between the flat washer and the nut.

2.8 Low-Voltage Components

(a) All low-voltage components, switch operators (except those integrally mounted in the switchgear stile), source-transfer controls, meters, instruments, and relays shall be located in grounded, metal-enclosed compartments separate from high voltage to provide isolation and shall be arranged to allow complete accessibility for operation without exposure to high voltage.

(b) Space heaters, where used, shall have a grounded, perforated, galvanized steel guard.

(c) To provide isolation from high voltage, low-volt age wiring, except for short lengths such as at terminal blocks or at secondaries of sensing devices, shall be in grounded conduit, cable trays, or raceways.

2.9 Cable-Termination Space

To facilitate cable pulling and installation of cable terminators, provisions shall be made for:

(a) Full front access for positioning and removal of cable-pulling sheaves

(b) Free access without interference from nonremovable structural members or from mechanical linkages between the interrupter-switch blades and operating mechanism

3.0 FINISH AND FEATURES

3.2 Outdoor Switchgear

3.2.1 Outdoor Finish

(a) The enclosure finish shall conform to or exceed the applicable requirements of ANSI C57.12.28-2014.

(b) During fabrication, the areas of structural parts that may later become inaccessible, such as folded edges and overlapping members, shall be given an iron-oxide zinc-chromate anticorrosion primer to ensure all surfaces are protected.

(c) Full coverage at joints and blind areas shall be achieved by processing enclosures independently of components such as doors and roofs before assembly into the unitized structures.

(d) To remove oils and dirt, to form a chemically and anodically neutral conversion coating to improve the finish-to-metal bond, and to retard underfilm propagation of corrosion, all surfaces shall undergo a thorough pretreatment process comprised of a fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied. By utilizing an automated pretreatment process, the enclosure shall receive a highly consistent thorough treatment, eliminating fluctuations in contact time, temperature, pressure/flow and chemical concentrations.

(e) After pretreatment, protective coatings shall be applied to help resist corrosion and protect the steel enclosure. To establish the capability to

resist corrosion and protect the enclosure, representative test specimens coated by the enclosure manufacturer's finishing system shall satisfactorily pass the following tests:

(1) Crosshatch-adhesion testing per ASTM D 3359 Method B, with no loss of paint

(2) Humidity test: 1000 hours of humidity testing per ASTM D 4585, with no blistering as evaluated per ASTM D 714 and softening as evaluated per ASTM D3363

(3) Impact test: 80-inch-pound impact, followed by adhesion testing per ASTM D 2794, no red rust visible in the impact area of the panel after the panel exposed to 24 hours of salt spray per ASTM B117

(4) Ultraviolet accelerated-weathering test (QUV): 500 hours of ultraviolet-accelerated weathering testing per ASTM D4587, utilizing the FS 40 bulb, 4 hr. UV at 60°C (140°F) and 4 hr. condensation at 50°C (122°F) (Loss of gloss shall not exceed 50% per ASTM D523. No cracking as evaluated per ASTM D 661 or checking per ASTM D660 under unaided visual inspection.)

(5) Simulated corrosive atmospheric breakdown (SCAB) test: follow IEEE test procedure and evaluate per ASTM 1654 Table 1 (Maximum average of 3 mm (1/8 in.) loss adhesion from scribe after 15 cycles. No blisters per ASTM D 714.)

(6) Abrasion Resistance test: 3000 cycles of abrasion testing per ASTM 4060 (Abraded panel must exhibit no rust after salt spray exposure for 24 hours.)

(7) Gravelometer test: the coating panel to be test as per ASTM D 3170 and expose the test panel 24 hours in salt spray per ASTM B117. A minimum rating of 4 B per SAE J400

(8) 4000 hours of salt-spray testing per internal testing requirements for harsh-climate durability.

Certified test abstracts substantiating the above capabilities shall be furnished upon request.

(f) A heavy coat of insulating "no-drip" compound shall be applied to the inside surface of the roof structure to prevent condensation of moisture.

(g) After the enclosures are completely assembled and the components (switches, fuses, bus, etc.) are installed, the finish shall be inspected for scuffs and scratches. Blemishes shall be touched up to restore the protective integrity of the finish.

(h) Touch-up materials—with complete instructions—shall be included with each shipment of metal-enclosed switchgear for touch-up in the field.

(i) The finish shall be ANSI 70 gray. Additional colors can be made available upon request.

3.2.2 Outdoor Features

(a) Enclosure Ventilation

(1) Ventilation openings shall be provided at the top and bottom on the front and rear of each bay. Ventilation openings on the front of arc-resistant switchgear shall be provided at the top only.

(2) Vents shall be rain-resistant and corrosion-resistant.

(3) Each vent shall have an inside screen and baffle to exclude insects and to protect against insertion of foreign objects.

(4) Infrared windows for imaging of terminal pads and terminations. Window placement shall be as described in the drawings.

(b) Lifting eyes shall be removable. Sockets for lifting eyes shall be blind-tapped.

(c) Gasketing and Sealing

(1) Door openings and openings for hinged bolted panels (and bolted panels providing access to low-volt age components) shall have resilient compression gasketing to prevent water from entering the enclosure.

(2) Gasket seals shall be provided at the top and side edges of adjoining bays to prevent water entry between the double walls.

(3) The top and both sides of bus openings between bays shall be covered with channel gaskets as an additional protection against entrance of water, or external labyrinthine metal rain shields shall be provided over enclosure roof flanges between adjacent bays.

(4) Roofs shall be weather-sealed in place with a suitable sealant.

(d) Space Heaters

(1) Space heaters with sheaths of high-temperature chrome steel shall be provided to maintain air circulation inside the enclosure.

(2) There shall be a space heater in each bay.

(3) Space heaters shall be wired.

(4) A low-voltage circuit breaker shall be provided in the strip heater circuit.

(5) Infrared windows for imaging of terminal pads and terminations.

4.0 BASIC COMPONENTS

4.1 Interrupter Switches

(a) Interrupter switches shall have a one-time or two-time duty-cycle fault-closing rating equal to or exceeding the short-circuit rating of the switchgear. These ratings define the ability to close the interrupter switch either alone (unfused) or in combination with the appropriate fuse, once or twice (as applicable) against a three-phase fault with asymmetrical current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Tests substantiating these ratings shall be performed at

maximum voltage. Certified test abstracts establishing such ratings shall be furnished upon request.

(b) Interrupter switches intended for manual operation shall be operated by means of an externally operable, nonremovable handle. The handle shall have provisions for pad locking in both the Open and Closed positions. Interrupter switches intended for power operation shall be operated by means of a switch operator expressly designed to be compatible with the interrupter switch.

(c) Interrupter switches shall use a quick-make quick-break mechanism installed by the switch manufacturer. The mechanism shall swiftly and positively open and close the interrupter switch independent of the switch-handle or switch-operator-operating speed.

(1) For manually operated interrupter switches and for interrupter switches operated by direct-motor-drive switch operators, the quick-make quick-break mechanism shall be integrally mounted to the switch frame.

(2) For interrupter switches operated by stored-energy switch operators, the quick-make quick-break mechanism shall be an integral part of the switch operator.

(d) Interrupter switches shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame. The frame shall be of welded steel construction so the frame intercepts the leakage path that parallels the open gap of the interrupter switch to positively isolate the load circuit when the interrupter switch is in the Open position.

(e) Interrupter switches shall be provided with a single blade per phase for circuit closing, including fault closing, continuous current carrying, and circuit interrupting. Spring-loaded auxiliary blades shall not be permitted.

(f) Circuit interruption shall be accomplished by use of an interrupter, which is positively and inherently sequenced with the blade position. Circuit interruption shall take place completely within the interrupter, with no external arc or flame. Any exhaust shall be vented in a controlled manner through a labyrinthine muffler or a deionizing vent.

(g) Interrupter switches shall have a readily visible open gap when in the Open position to allow positive verification of switch position.

(h) Terminals on interrupter switches to which cable will be terminated shall be equipped with grounding provisions. Grounding provisions shall also be provided on the ground bus in such bays.

(i) Terminals on interrupter switches rated 1200 amperes and, for entrance-bay applications only, terminals on interrupter switches used in conjunction with fuses rated 600 amperes or greater, shall be equipped with provisions for two cables per phase.

4.2 Grounding Switch

4.2.1 Grounding switches shall meet the requirements of:

(1) IEEE C37.20.4

4.2.2 Grounding switches shall have a peak current withstand rating equal to or exceeding the peak current withstand rating of the switchgear.

4.2.3 In feeder (outgoing) bays, grounding switches shall be interlocked so the associated interrupter switch must be open before the grounding switch can be closed.

4.2.4 In entrance bays, the grounding switch may be interlocked so an upstream device must be open before the grounding switch can be closed if required by the utility or owner.

4.3 Fuses

4.3.1 Solid-Material Power Fuses

(a) Solid-material power fuses shall utilize refill-unit-and-holder or fuse-unit-and-end-fitting construction. The refill unit or fuse unit shall be readily replaceable.

(b) For switchgear rated up through 270 MVA at 4.16 kV, 600 MVA at 13.8 kV, 860 MVA at 25 kV, and 1000 MVA at 34.5 kV, mountings for solid-material power fuses shall be disconnect style. Non-disconnect style mountings for power fuses shall be used only where higher ratings are required.

(c) Fusible elements shall be nonaging and nondamageable, so it is unnecessary to replace unblown companion fuses following a fuse operation.

(d) Fusible elements for refill units or fuse units, rated 10 amperes or larger, shall be helically coiled to avoid mechanical damage caused by stresses from current surges.

(e) Fusible elements that carry continuous current shall be supported in air to help prevent damage from current surges.

(f) Refill units and fuse units shall have a single fusible element to eliminate the possibility of unequal current sharing in parallel current paths.

(g) Solid-material power fuses shall have melting time-current characteristics (TCCs) that are permanently accurate with a maximum total tolerance of 10% in terms of current. TCC curves shall be available that permit coordination with protective relays, automatic circuit reclosers, and other fuses.

(h) Solid-material power fuses shall be capable of detecting and interrupting all faults, whether large, medium, or small (down to minimum melting current); under all realistic conditions of circuitry; and with line-to-line or line-to-ground volt age across the power fuses. And they shall be capable of handling the full range of transient recovery voltage severity associated with these faults.

(i) All arcing accompanying solid-material power fuse operation shall be contained within the fuse, and any arc products and gases evolved during fuse operation shall be vented through exhaust control devices that shall effectively control fuse exhaust.

(j) Solid-material power fuses shall be equipped with a BLOWN FUSE indicator that shall provide visible evidence of fuse operation while installed in the fuse mounting.

(k) Solid-material power fuses in feeder bays shall be equipped with grounding pro-visions on the load side of each fuse and on the enclosure ground bus.

4.3.2 Electronic Power Fuses

(a) Electronic power fuses shall use an expendable interrupting module and a reusable control module.

(1) The interrupting module shall consist of a main-current section and a fault-interrupting section. These sections shall be arranged coaxially and contained within the same housing.

(2) The main-current section shall carry current under normal operating conditions.

(3) The fault-interrupting section shall operate only under fault conditions. It shall not carry enough current continuously to determine the TCC minimum operating curve shape.

(4) The fusible-element section shall not be subject to damage caused by current surges.

(5) All arcing accompanying operation of the electronic power fuse shall be contained within the interrupting module and fuse operation shall be silent, without any exhaust.

(6) The control module shall continuously monitor the line current through an electronic sensing circuit.

(7) The electronic components shall be located within a cylindrical cast aluminum housing that shall serve as a path for continuous current and as a shield to protect the electronic components against interference from external electric fields.

(8) To prevent damage to the control-module circuits by surges (such as because of lightning or inrush currents), the control module shall be free of external control wiring and connections to ground, and shall incorporate a device that acts as a buffer to isolate the electronic components at a level of current well below their surge-withstand capability.

(9) The control module shall be factory-sealed to ensure a dry, contaminant-free environment for the electronic components.

(10) The control module shall be self-powered with the capability to supply power for operating the sensing logic circuits and to actuate the inter rupting module when a fault occurs.

(11) The control module shall include one or more integrally mounted current transformers to provide both the sensing signal and the control power.

(12) The current transformer used to provide control power shall be designed to act as a buffer against surges in the line by saturating at a level of current well below the surge-withstand capability of the electronic components.

(13) No leads (including coaxial leads) between the current transformers and the electronic components shall be exposed.

(b) To make the integrity of the electrical connection between the interrupting and control modules independent of the mechanical force with which the modules are joined, the connection shall be through a louvered ring-type sliding contact.

(c) Electronic power fuses in feeder bays shall be equipped with grounding provisions on the load side of each fuse and on the enclosure ground bus.

(d) Electronic power fuses shall be equipped with a BLOWN FUSE indicator that shall provide visible evidence of fuse operation while installed in the fuse mounting. Fuse mountings shall be disconnect style.

(e) It shall not be necessary to replace unblown companion interrupting modules following operation of an electronic power fuse.

(f) Electronic power fuses shall have TCCs that are permanently accurate. TCC curves shall be available that permit coordination with a variety of source-side and load-side protective devices (e.g., protective relays, automatic circuit reclosers, other power fuses, etc.).

4.3.3 Current-limiting power fuses

(a) Provide current-limiting power fuses in accordance with IEEE C37.40, IEEE C37.41, IEEE C37.46, and IEEE C37.47.

4.5 Switch Operators

4.5.1 The following requirements apply to switch operators that incorporate an integral quick-make quick-break mechanism for solenoid trip-open and solenoid trip-closed operation with motor recharge—for use with interrupter switches rated 4.16 kV and 13.8 kV nominal, 600 amperes load interrupting and 25 kV nominal, 400 amperes load interrupting (600 amperes continuous):

(a) Switch operators shall be of the stored-energy type. They shall be equipped with an integral quick-make quick-break mechanism installed by the switch operator manufacturer. The mechanism shall store sufficient mechanical energy to either open or close the interrupter switch. The mechanism shall swiftly and positively open and close the associated interrupter switch independent of the speed of the charging motor or manual handle.

(b) Switch operators shall be equipped with a tripping solenoid to release the stored energy to open or close the associated interrupter switch in response to a control signal. Total operating time for opening or closing shall not exceed 4 cycles from the time the solenoid is energized.

(c) Switch operators shall be equipped with a charging motor that shall charge the quick-make quick-break mechanism within 1½ seconds after each switch operation.

(d) Switch operators shall be equipped with a torque limiter to absorb deceleration forces when travel limits are reached during charging to allow the motor to positively and completely charge the quick-make quick-break mechanism without transmitting excessive torque to the mechanism.

(e) Pushbuttons shall be provided to permit local electrical trip-open and trip-closed operation. Local electrical operation shall be prevented when the source-transfer control is in the automatic mode.

(f) Switch operators shall be provided with a manual charging access port and a removable manual-charging handle to allow manual charging of the quick-make quick-break mechanism in the absence of control power. While the manual charging access port is open, the motor-charging circuit shall be disconnected to prevent inadvertent electrical charging of the quick-make quick-break mechanism.

(g) Switch operators shall be equipped to permit local mechanical trip-open and trip-closed operation in the event control power is lost.

(h) Switch operators shall be located within a grounded, metal-enclosed low-volt age compartment in the switchgear stile and shall be mounted on a drawout carriage. The metal-enclosed compartment shall provide isolation from high voltage to help protect operating personnel. The drawout carriage shall permit decoupling of the switch operator from the associated interrupter switch for testing and exercising of the switch operator without opening or closing the interrupter switch and without exposure to high voltage. When the switch operator is decoupled, the associated interrupter switch shall be locked open or closed, depending upon switch position at the time of decoupling. It shall not be possible to recouple the switch operator to the interrupter switch unless the switch operator is in the same position (Open or Closed) as the interrupter switch.

(i) Switch operators shall be equipped with targets to show whether the quick-make quick-break mechanism is charged or discharged; whether the switch operator is in the Switch Open or Switch Closed position; whether the associated interrupter switch is in the Open or Closed position; and whether the switch operator is in the Coupled or Decoupled position.

(j) Switch operators shall be equipped with an operation counter.

(k) Switch operators shall be provided with a hinged padlockable steel cover or door to protect the switch operators and to guard against tampering. The cover or door shall be equipped with windows (unless Category A enclosures are required) to allow observation of the switch operator targets. Gasketing shall be installed between the cover or door and the mounting surfaces.

(l) Switch operators shall be equipped with an extra 4-PDT auxiliary switch coupled to the switch operator.

4.6 Source-Transfer Controls

4.6.1 Operating Description

4.6.1.1 Common-Bus Primary-Selective System

(a) Transfer on Loss and Return of Source Voltage

(1) The source-transfer control shall use the common-bus primary-selective system. The normal condition shall be with one source interrupter switch
(For the preferred source, as field-programmed) closed to energize the high-voltage bus, and with the other source interrupter switch (for the alternate source) open with its associated circuit available as a standby.

(2) The control shall monitor the conditions of both power sources and in initiate automatic switching when the preferred-source voltage has been lost (or reduced to a predetermined level) for a period of time sufficient to confirm that the loss is not transient. The automatic switching shall open the preferred-source interrupter switch and then close the alternate-source interrupter switch to restore power to the high-volt age bus.

(3) When normal voltage returns to the preferred source for a preset time, the control shall initiate retransfer to the preferred source if in the Automatic Return mode, or await manual retransfer if in the Hold Return mode. In the Hold Return mode, if the alternate source fails and if the preferred source has been restored, the control shall initiate automatic retransfer to the preferred source.

(4) In the Automatic Return mode, the control shall provide either open transition (nonparalleling) or closed transition (paralleling) on retransfer as field-programmed.

(b) Transfer on Unbalance Condition

(1) A field-programmable Unbalance Detection feature shall initiate automatic switching on detection of source-side open-phase conditions at the same voltage level as the metal-enclosed switchgear, whether caused by utility-line burndown, broken conductors, single-phase switching, equipment malfunctions, or single-phasing resulting from blown source-side fuses. The control shall continuously develop and monitor the negative-sequence voltage to detect any unbalance present as a result of an Open Phase condition. Automatic switching shall occur when the system unbalance exceeds a predetermined unbalance-detect voltage for a period of time sufficient to confirm that the condition is not transient.

(2) When normal phase voltages return to the preferred source, the control shall initiate retransfer to the preferred source as described in 4.6.1.1(a) (03) and (04).

4.6.2 Control Features

(a) The operating characteristics of the source-transfer control and its voltage-, current-, and time-related operating parameters shall be field-programmable and entered into the control by means of a keypad. To simplify entry of this in formation, a menu arrangement shall be used including keys dedicated to the operating characteristics and to each of the operating parameters. Entry of an access code shall be necessary before any operating characteristic or operating parameter can be changed.

(b) All operating characteristics and operating parameters shall be available for review on a liquid-crystal display with backlighting.

(c) Light-emitting diode lamps shall be furnished for indicating the presence of acceptable voltage on each high-volt age source.

(d) A light-emitting diode lamp shall be furnished for indicating that all switch operators are coupled to their respective interrupter switches and in the
correct positions, the control is in Automatic mode, all doors providing access to interrupter switches powered by stored-energy switch operators are closed and latched, and all control circuitry is properly connected for automatic trans fer. The display specified in 4.6.2 (b), when not being used to show menu information, shall show messages explaining why this lamp is not lighted.

(e) A selector switch shall be furnished for choosing Manual or Automatic operating mode. In Manual mode, local electrical trip-open and trip-closed operation by means of pushbuttons shall be enabled while automatic switching shall be inhibited.

(f) Test keys shall be furnished for simulating loss of voltage on each of the two sources as well as for checking the functioning of the lamps, display, and keypad.

(g) The control shall automatically record system status and source-transfer control status every time a control operation occurs for use in analyzing system events. All such operations shall be indicated by the illumination of a light-emitting diode lamp and shall be available for display by means of a dedicated event key.

(h) The present source voltage and current inputs and the present status of discrete inputs to and outputs from the control shall be available for display by means of a dedicated examine key.

(i) The control shall have the capability to automatically calibrate to a known volt age on each source. This capability shall be keypad-selectable.

(j) An Overcurrent Lockout feature shall be provided to prevent an automatic transfer operation that would close a source interrupter switch into a fault. The feature shall include a light-emitting diode lamp for indicating when a Lockout condition has occurred, a reset key for manually resetting the Lockout condition, and three current sensors for each source. Provisions shall be furnished for manually resetting

the Overcurrent Lockout feature from a remote location. Test keys shall be provided for simulating an Overcurrent condition on each source.

(k) Remote-indication provisions shall be provided to permit remote monitoring of the presence or absence of preferred- and alternate-source voltage; the operating mode of the source-transfer control (i.e., Automatic or Manual); and the status of the indicating lamp furnished in 4.6.2 (d), the indicating lamp furnished in 4.6.2(g), and (where applicable) over current lockout.

(l) A test panel shall be provided to permit the use of an external, adjustable three-phase source to verify, through independent measurement, the response of the control to Loss of Source, Phase Unbalance, and (where applicable) Overcurrent-Lockout conditions.

(m) A communications card shall be provided to permit local loading to a user-furnished personal computer of system events recorded by the source-transfer control; operating characteristics and voltage-, current-, and time-related operating parameters programmed in the control; discrete inputs and outputs from the control; and messages explaining why the indicating lamp furnished in 4.6.2(d) is not lighted. The communications card shall also permit local downloading of the user's standard operating parameters from the personal computer to the control.

4.6.3 Construction Features

(a) The source-transfer control shall use an advanced microprocessor and other solid-state electronic components to provide the superior reliability and service ability required for use in power equipment. All components shall be soldered on printed-circuit boards to minimize the number of interconnections for increased reliability.

(b) All interconnecting-cable connector pins and receptacle contacts shall be gold-over-nickel plated to minimize contact pressure.

(c) The surge withstand capability of the control shall be verified by subjecting the device to both the ANSI/IEEE Surge Withstand Capability Test (ANSI Standard C37.90.1) and to:

(1) ANSI Standard C62.41 Category B Power Line Surge

(d) To identify and eliminate components that might be prone to early failure, the control shall be subjected to a dielectric test, a functional check, and a 48-hour screening test followed by a second functional check. For the screening test, the control shall be energized at rated control voltage while subjected to 48 hours of temperature cycling repeatedly between -40°C (-40°F) and 65°C (149°F).

(e) The control shall be located in a grounded, metal-enclosed low-volt age compartment in the switchgear stile and shall be mounted on a drawout carriage. The metal-enclosed compartment shall provide isolation from high voltage.

(f) For source-transfer control connections not soldered directly to the printed-circuit board, all interconnecting-cable connector pins and receptacle contacts shall be gold-over-nickel plated to minimize contact resistance.

(g) Source-transfer controls shall be provided with a hinged padlockable steel cover or door to protect the control and to guard against tampering. The cover or door shall be equipped with a window (unless Category A enclosures are required) to allow observation of the status indicator on the control. Gasketing shall be installed between the cover or door and the mounting surfaces.

4.8 Voltage-Sensing Devices

(a) Voltage-sensing devices for use with open-phase detectors shall be capacitively coupled voltage sensors on three phases. Volt age-sensing devices for use with source-transfer controls shall be capacitively coupled voltage sensors on two phases and a voltage transformer for sensing and control power on the third phase.

(b) To maximize usable cable-training space within the switchgear assembly, the voltage sensors shall directly replace apparatus insulators at the hinge end of fuses or the lower terminal of interrupter switches. Separate mounting shall be permitted for special applications.

(c) Voltage sensors shall be constant-current-output devices that do not require primary fuses.

(d) The output voltage of the voltage sensors shall be directly proportional to line-to-ground voltage and shall have relay accuracy over an ambient temperature range of -40°C (-40°F) and 71°C (160°F).

(e) The output of the voltage sensors shall be connected to a secondary burden that does not require adjustment to compensate for a difference between system line-to-ground voltage and the sensor’s rated nominal line-to-ground voltage.

(f) Test jacks and adjustment screws shall be provided, allowing measurement and adjustment of the voltage-sensor signal inputs.

(g) Each voltage sensor shall be equipped with a secondary-side protective device to prevent damage to the voltage sensor in the event that the secondary circuit is inadvertently opened or the burden is removed.

5.0 METERING BAY

5.1 Utility metering bay

(a) Provide 3 voltage transformers connected phase-to-ground in accordance with utility requirements.

(b) Provide 3 current transformers in accordance with utility requirements.

(c) Provide meter(s) in accordance with utility requirements.

(d) Provide design of the metering bay in accordance with utility specifications.

5.2 Owner metering bay

(a) Provide 3 voltage transformers connected phase-to-ground.

(b) Provide 3 current transformers sized at the ratings of the gear.

(c) Provide meter(s) as shown on drawings.

6.0 LABELING

6.1 Hazard-Alerting Signs

(a) All external doors and hinged bolted panels providing access to high voltage shall be provided with "Caution—High Voltage—Keep Out" signs.

(b) All internal protective screens providing access to high voltage shall be provided with "Danger—High Voltage—Keep Out—Qualified Persons Only" signs.

(c) All internal protective screens providing access to interrupter switches shall be provided with warning signs indicating that "Switch Blades May Be Energized in Any Position."

(d) All internal protective screens providing access to fuses shall be provided with warning signs indicating that "Fuses May Be Energized in Any Position."

6.2 Ratings Nameplates and Labeling

(a) The integrated switchgear assembly shall be provided with an external nameplate indicating the manufacturer's drawing number and the following: voltage ratings (kV, nominal; kV, maximum; kV, BIL); main bus continuous current rating (amperes); short-circuit ratings (amperes, RMS, symmetrical and MVA, three-phase symmetrical, at rated nominal volt age); and the momentary and fault-closing ratings (amperes, RMS, asymmetrical). If the assembly is UL listed, the external nameplate shall include the UL classification markings, comprised of "UL" in a circle; the word "Listed;" the assigned control number; and the product identity. If the assembly is CSA listed, the external nameplate shall include the CSA certification markings consisting of a stylized "C" with the letters "SA" inside.

(b) Each individual bay shall bear a nameplate indicating the ratings of the interrupter switch (amperes, continuous and interrupting); the maximum rating of the fuse (amperes); and the catalog number of the fuse units, refill units, or interrupting modules and control modules. If the individual bay is UL listed, this nameplate shall include the UL classification markings, comprised of "UL" in a circle; the word "Listed;" the assigned control number; and the product identity. In addition, the enclosure category shall be specified. If the assembly is CSA listed, the external nameplate shall include the CSA certification markings consisting of a stylized "C" with the letters "SA" inside.

(c) A weather-resistant one-line representation of the contents of each bay or "mimic bus" shall be applied to the exterior of the bay doors.

7.0 TRAINING

7.1 Equipment manufacturer shall provide, on site installation inspection, operational & programming training for each unit installed – minimum of 8 hours for each of the (3) pieces of equipment (total of 24 hours across 3 separate non-consecutive training days).

7.2 All travel expenses for training shall be included as part of this contract.

7.3 Additional training from the local manufacturers representative shall be available at no additional cost.

8.0 ACCESSORIES

8.1 Fuse units, refill units, voltage-transformer fuses, interrupting modules, and control
modules shall be provided, as required, for original installation and for spares.

8.2 A fuse handling tool and universal pole as recommended by the fuse manufacturer shall be provided.

8.3 A total of 1 set of three grounding jumpers [8 feet (244 cm) or 10 feet (305 cm)] in length shall be provided, complete with a storage bag for each set.

8.4 A voltage tester with audio-visual signal capability shall be provided, complete with batteries, shotgun clamp-stick adapter, and storage case.

8.5 A shotgun clamp stick *[6 feet-51-inches (197 cm) or 8 feet-51-inches (258 cm)]* in length shall be provided, complete with canvas storage bag.

8.6 A portable remote-control station with 50-foot (1524-cm) cord shall be provided for power-operated switchgear, to permit Open/Close operations of power-operated switches from an adjacent location.

End of Section

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
1. Coordination with the utility companies to provide service.
2. Contractor's responsibilities for connecting to utilities and providing utility service to the facilities.
3. Descriptions of utility services required.

1.2 REFERENCES

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

1.3 DEFINITIONS

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

1.4 SYSTEM DESCRIPTION

A. Electrical service:
1. Provide all Work and materials and bear all costs for providing temporary construction power and the permanent electrical service, including but not limited to:
a. All Work and materials not provided by the electric utility.
b. All permits and fees required by the electric utility.
2. Provide electrical ducts, raceways, conductors and connections indicated on the Drawings, and all other Work and materials required for a complete electrical service, including but not limited to the following:
a. Electrical service conduits and conductors from the point of electric utility connection to the service entrance equipment.
b. Metering conduits from the instrument transformers to the meter.

B. General:
1. Coordinate and obtain inspections and final installation approval from the serving utilities and other authorities having jurisdiction.

1.5 SUBMITTALS

A. Furnish submittals as specified in Sections 16.1 - 16050 - Common Work Results for Electrical.

B. Certification:
1. Submit certification that the intended installation has been coordinated with the utility companies.

2. Include a narrative description of the utility's requirements and points of connection, names and telephone numbers for contacts at the utilities.

1.6 QUALITY ASSURANCE

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

B. Materials and equipment used in performance of Electrical Work shall be listed or labeled by UL, or other equivalent recognized independent testing laboratory, for the class of service intended.

1.7 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.8 PROJECT OR SITE CONDITIONS

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Electrical systems:
1. Before bidding, the electrical contractor shall contact the utilities to determine the Work and materials that will be required from the Contractor, and all fees and permits that will be required, so that all utility systems furnished by the Contractor will be included in the bid.
2. Coordinate Work with Engineer to minimize downtime of existing operating equipment and electrical distribution systems and to preclude unsafe operation:
a. Notify Owner 10 days before power interruptions.
b. Coordinate downtime with Owner and local electric utility.
3. Before commencing Work, coordinate electric service entrance requirements with local electric utility to ensure that the installation will be complete as specified in these Contract Documents:

B. Before commencing Site Work, coordinate underground conduit installations with other Work to eliminate conflicts and avoid interferences with other underground systems.

1.11 WARRANTY

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS (NOT USED)

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

A. Furnish materials in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

A. Furnish equipment in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES (NOT USED)

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.8 FIELD QUALITY CONTROL

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16.1 - 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
1. Medium voltage, outdoor, liquid-filled pad mounted transformers.

1.2 REFERENCES

A. General:
1. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI).

C. Institute of Electrical and Electronic Engineers (IEEE):
1. C57.12.00 - IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.
2. C57.12.10 - IEEE Standard Requirements for Liquid-Immersed Power Transformers.
3. C57.12.26 - IEEE Standard for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers.
4. C57.12.28 - IEEE Standard for Pad-Mounted Equipment-Enclosure Integrity.
5. C57.12.70 - IEEE Standard Terminal Markings and Connections for Distribution and Power Transformers.
6. C57.12.80 - IEEE Terminology for Power and Distribution Transformers.
7. C57.12.90 - IEEE Standard Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers.
8. C57.91 - IEEE Guide for Loading Mineral-Oil-Immersed Power Transformers up to and including 100 MVA with 65 degrees or 55 degrees Average Winding Rise.
9. C57.93 - IEEE Guide for Installation of Liquid-immersed Power Transformers.
10. C57.98 - IEEE Guide for Transformer Impulse Tests.
11. C57.106 - IEEE Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment.
12. C57.147 - IEEE Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers.

D. National Electrical Manufacturers Association (NEMA):
1. TR-1 - Transformers, Regulators, and Reactors.

E. U.S. Department of Energy (DOE):
1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.3 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. As listed in IEEE C57.12.80.

1.4 SYSTEM DESCRIPTION

A. Outdoor oil-filled, pad mounted transformers for operation on a 60 hertz system with voltage and kilovolt-ampere ratings as indicated on the Drawings:
   1. Suitable for continuous operation at full load at the Project location and elevation after applying any derating factors.
   2. Pad mounted transformers shall be compartmental type, designed for outdoor installation on a concrete pad.

1.5 SUBMITTALS

A. Furnish submittals as specified in Sections 16050 - Common Work Results for Electrical.

B. Product data:
   1. Complete installation instructions.
   2. Complete storage and handling instructions.
   3. Kilovolt-ampere rating, including derating calculations.
   4. Primary/secondary connections.
   5. Primary voltage and available taps.
   6. Secondary voltage.
   7. BIL rating.
   8. Temperature rise.
   9. Lightning arrester data.
   10. %Z, %X, %R, X/R.
   11. Efficiency.
   12. Gross weight.
   13. Torque values for all bolted connections for secondary cable connections.
   14. Manufacturer’s suggested hi-potential test procedures and test levels for field-testing:
      a. Initial field test.
      b. Subsequent maintenance tests.
   15. Certification from the manufacturer stating the transformer design complies with IEEE C57,12,00.
   16. Type of oil.
   17. Gallons of oil.
   18. Weight of oil.
   19. Complete MSDS sheets. There is no C57 standard for ANSI or IEEE.

20. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.

C. Shop drawings:
1. Complete detailed, dimensioned drawings showing the equipment being furnished, with all pertinent information, including the following:
    a. Dimensions and locations of conduit entrance windows.
2. Complete nameplate schedule, except impedance.

D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
    a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
    b. Submit anchoring drawings with supporting calculations.
    c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:
1. Complete as-built dimensioned and scaled drawings for transformer
2. Recommended periodic maintenance requirements.
3. Maintenance instructions including schedules, parts identification, troubleshooting, assembly instructions, parts list, and predicted life of parts subject to wear and deterioration.
4. Recommended field test levels and procedures before installation and for maintenance purposes after being placed in service.
5. Periodic and preventative maintenance torque values for all bolts.
6. List of recommended preventative maintenance tests, test frequencies, test procedures, acceptable test result ranges and disposal recommendations for utilized mineral oil in accordance with IEEE C57.106 or natural ester fluids in accordance with IEEE C57.147.
7. Copies of factory test reports.

F. Test reports:

1. Certified copies of test reports from factory tests.

G. Record documents.

1.6 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Manufacturer qualifications:
1. Manufacturer shall be in the business of regularly manufacturing the specified transformers for minimum 10 years with satisfactory performance record.

1.7 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Furnish temporary equipment heaters within the transformer to prevent condensation from forming.

1.8 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.9 SEQUENCING

A. Make all necessary field measurements to verify the equipment will fit in the allocated space in full compliance with the minimum clearances required by the NEC and local codes.

B. Conduct factory acceptance test and submit certified test results for Engineer’s review.

C. Ship equipment to Project Site after successful completion of factory acceptance test.

D. Assemble equipment in the field.

E. Conduct field acceptance test and submit certified test results for Engineer’s review.

F. Verify installation is in accordance with IEEE C57.93.

G. Submit manufacturer’s certification that equipment has been properly installed and is fully functional for Engineer’s review.

H. Set taps.

I. Commissioning as specified in Section 01756 - Commissioning.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide the services of a manufacturer's authorized representative:
   1. Inspect installation before start-up.
   2. Witness energization.

C. Energize transformer according to manufacturer’s recommended procedure and in accordance with IEEE C57.91.

1.13 OWNER’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. One of the following or equal:
   1. Asea Brown Boveri (ABB).
   2. General Electric (GE).
   3. Cooper Power Systems.
   4. Schneider Electric.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

A. Windings:
   1. Primary and secondary windings shall be high conductivity copper.

B. Insulating fluid:
   1. Mineral oil.
   2. Insulating fluid shall meet or exceed the requirements of the appropriate IEEE and ASTM fluid standards.

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

A. The transformer and associated terminal compartments designed and constructed to be tamper-resistant:
   1. No externally removable screws, bolts, or other devices.

B. Ratings:
   1. 3-phase, 60 hertz.
   2. Self-cooled.
   3. 65-degree Celsius rise.
   4. Primary voltage as indicated on the Drawings.
   5. Primary connection as indicated on the Drawings.
   6. Secondary voltage as indicated on the Drawings.
   7. Secondary connection as indicated on the Drawings.
   8. Kilovolt-ampere rating as indicated on the Drawings.
   9. Basic impulse insulation level (BIL) in accordance with IEEE C57.98:
      a. 1.2 kV Class: 30 kV.
      b. 2.5 kV Class: 45 kV.
      c. 5.0 kV Class: 75 kV.
      d. 8.7 kV Class: 75 kV.
      e. 15 kV Class: 95 kV.
   10. Sound levels:
      a. In accordance with NEMA TR1.
      b. Measurement procedure in accordance with IEEE C57.12.90.
   11. Efficiency:
      a. Transformers 2,500 kVA and less shall have an efficiency rating in accordance with DOE 10 CFR Part 431.
   12. Short-circuit capacity:
      a. Mechanical short-circuit capability in accordance with IEEE C57.12.90.
   13. Thermal short-circuit capability in accordance with IEEE C57.12.00.

2.6 COMPONENTS

A. Core and coil:
   1. Manufactured from burr-free, grain-oriented silicon steel laminations and stacked to eliminate gaps in the corner joints.
   2. Insulated with B-stage, epoxy coated, diamond pattern, insulating paper, thermally cured under pressure to ensure proper bonding of conductor and paper.
   3. Clamped and braced to resist distortion caused by short-circuit stresses within ratings or by shipping and handling and to prevent the shifting of core laminations.
   4. Vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system:

a. Energize the windings under vacuum to heat the coils and drive out moisture.
b. While under a vacuum and the coils are heated, fill the tank with preheated, filtered and degassed insulating fluid.

B. Tank:
1. Conforming to the enclosure integrity requirements in accordance with IEEE C57.12.28.
2. Equipped with extra-heavy duty, welded-in-place lifting lugs and jacking pads.
   a. Provide adequate cross-bracing of the base to allow skidding or rolling in any direction.
3. Capable of withstanding a pressure of 7 pounds per square inch gauge without permanent distortion, and 15 pounds per square inch gauge without rupturing.
4. Provide a pressure relief valve as a means to relieve pressure in excess of pressure resulting from normal operation:
   a. Cracking pressure: 10 pounds per square inch gauge within 2 psig.
   b. Resealing pressure: 6 pounds per square inch gauge minimum.
   c. Zero leakage from reseal pressure to 8 pounds per square inch gauge.
   d. Flow at 15 pounds per square inch gauge: 35 scfm minimum.

C. Terminal compartments:
1. Conforming to the enclosure integrity requirements in accordance with IEEE C57.12.28.
2. Full-height, air filled primary and secondary terminal compartments with hinged doors shall be located side-by-side separated by a steel barrier, with the primary compartment on the left, complete with tamper resistant hardware.
3. Hinges and pins to be passivated Type 304 stainless steel or equivalent corrosion-resistant metal.
4. Doors and compartment hood shall be removable:
   a. Removable doorsill on compartments shall be provided to permit rolling or skidding of unit into place over conduit stubs in foundations.
5. The doors in both the high voltage section and the low voltage section shall be able to be latched in the open position.
6. The entire terminal compartment for the transformer shall be bolted to the transformer so that the terminal compartment may be unbolted from the transformer and the transformer removed without disturbing conduits that enter the compartment from the side or top.
7. Minimum of 30 inches deep.
8. Secondary compartment:
   a. The secondary compartment shall enclose the low voltage bushings and provide for incoming cable from below the compartment.
   b. This compartment shall also house:
      1) Liquid level indicator.
      2) Drain valve with sampling device.
      3) Dial type thermometer.

4) Pressure relief valve.
5) Vacuum pressure gauge.

c. Door to low voltage section shall have a 3-point latching mechanism with pad-locking provision.

9. Primary compartment:
   a. The primary line compartment shall enclose the high voltage bushings and provide for incoming cables from below the compartment.
      1) Coordinate primary bushing size with incoming cables size as determined by field investigation, and approved by Engineer.
   b. This compartment shall also house:
      1) Dead front lightning arresters.
      2) No-load tap changer.
      3) Parking stands for 6 elbows.
   c. The primary compartment shall be accessible only after the door for the secondary compartment has been opened. The door shall be held closed by a captive bolt; access to this bolt shall be provided only when the door to the low voltage section is opened.
10. Primary terminals:
   a. Dead front construction, in accordance with IEEE C57.12.26, utilizing high voltage elbows for connections to primary cable and lightning arresters.
   b. Terminal arrangement with 3-bushing wells:
      1) 3 for terminating primary power cables and for connecting lightning arresters.
   c. Supporting structure within cabinet to support cables and eliminate mechanical stress on insulators.
11. Secondary terminals:
   a. 4 low voltage spade bushings with 2 holes for each cable, in accordance with IEEE C57.12.26.
   b. Extend low voltage bushings as necessary to accommodate the cable arrangement as determined by field investigation and approved by Engineer.
      1) Extension via a fully rated, tin-plated, copper bus system braced to withstand the available fault current.
   c. Neutral brought out through an insulated bushing and externally grounded to the tank with a removable ground strap.
   d. Supporting structure within cabinet to support cables and eliminate mechanical stress on insulators.

D. De-energized tap changer:
   1. Furnish with full capacity high-voltage taps:
      a. Two 2-1/2 percent taps above and below rated voltage.
   2. Labeled to indicate that the transformer must be de-energized before operating the tap changer as required by IEEE C57.12.10.

3. Externally operated no-load tap changer switch with snap action switch and lever handle.
4. Padlocking provision in each tap position.
5. Position indication.

2.7 ACCESSORIES

A. Lightning arresters:
   1. High voltage dead front design for elbow connection.
   2. Metal oxide varistor arresters.
   3. Distribution class arresters.
   4. Rating consistent with the distribution voltage.

B. Tank ground pads:
   1. 2 stainless steel pads, welded to the tank wall, with unpainted surfaces:
      a. 1 pad in primary compartment.
      b. 1 pad in secondary compartment:
         1) If additional load ground connections are required, a tin-plated, copper equipment ground bus shall be bolted to the pad.

C. Dial-type thermometer:
   1. Direct stem mounted in a closed well so that the thermometer can be removed without breaking the tank seal:
      a. The well shall be threaded into a fitting that is welded to the transformer tank wall.
   2. The thermometer shall have a slave hand which is moved by the indicating hand to indicate maximum oil temperature. The slave hand shall be externally resettable.

D. Sampling device:
   1. Allow for sampling of the transformer insulating fluid.
   2. Threaded into a fitting that is welded to the transformer tank wall.

E. Liquid level gauge:
   1. Dial-type liquid level gauge.

F. Vacuum pressure gauge:
   1. 10 pounds per square inch gauge vacuum to plus 10 pounds per square inch gauge scale:

G. Pressure relief device:
   1. Located in the air space in the transformer tank to provide a method of relieving internal tank pressure.
   2. Self-relieving.
   3. Indicating.
   4. Operating pressure: 10 within 2 pounds per square inch gauge.

H. Nameplates:
   1. Provide nameplate as specified in Section 16075 - Identification for Electrical Systems and the following:
      a. Provide complete nameplates identifying equipment, caution, voltage, etc.
      b. Provide complete nameplates for both inside and outside of the transformer terminal compartments.
      c. Provide diagrammatic nameplate.

I. Bolted 8-inch (minimum) diameter round handhold on cover.

J. Lifting lugs at each corner of tank for lifting complete transformer.

K. Jacking facilities at each corner of base for jacking the complete transformer.

L. Base designed for rolling or skidding in any direction.

M. Load break oil rotary switch:
   1. Gang-operated.
   2. Either radial or loop feed switching as indicated on the Drawings.
   3. Spring-loaded cam-operated kicker to provide quick make and break action.
   4. Continuous and interrupting current: per full load primary amperage.

N. Bayonet-type fuse:
   1. Oil immersed expulsion type fuse with an interrupting rating of 3,800 amperes at 8.3 kilovolts; 2,000 amperes at 15.5 kilovolts.
   2. Hook stick-operable.
   3. Drawout.
   4. Load break design.
   5. 2 types of fuse links:
      a. Overload sensing; or
      b. Fault sensing.

O. Current limiting fuses:
   1. Submersible rated for oil immersion and series rated for use in series with the manufacturer’s selected bayonet fuse and to limit transformer primary short circuit current.

2.8 MIXES (NOT USED)

2.9 FABRICATION

A. Tanks:
   1. Construction: Sealed tank construction with welded cover. Permanently locate an inorganic gasket between the cover and the tank flange during the welding of the transformer cover to prevent the entrance of weld spatter into the tank.
   2. Large handhole with bolted cover and protected with a weather cover.

3. 4 lifting hooks.
4. Jacking pads.
5. Fluid sample valve.
6. Designed for 7 pounds per square inch gauge without permanent distortion; 12 pounds per square inch gauge when silicone oil insulating fluid is specified.

2.10 FINISHES

A. In accordance with IEEE C57.12.28 including the following performance requirements:
   1. Salt spray test.
   2. Crosshatch adhesion test.
   3. Humidity test.
   4. Impact test.
   5. Oil resistance test.
   6. Ultraviolet accelerated weathering test.
   7. Abrasion resistance: Taber® Abraser.

B. Procedure:
   1. Clean with an alkaline cleaning agent to remove grease and oil.
   2. Chemically bond iron phosphate coating to metal surface to ensure coating adhesion and retard corrosion.
   3. Prime metal surface with an electrodeposited powder epoxy to provide a barrier against moisture, salt, and corrosives.
   4. Coat with an electrostatically applied, oven-cured polyester powder coat to enhance abrasion and impact resistance.
   5. Topcoat: Liquid polyurethane coating to seal and add ultraviolet protection.
      a. Color: Munsell Green 7GY.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:

1. Furnish concrete pad and all lugs, bolts, anchors, sealants, and other accessories needed to complete the installation of the transformer.
2. Assemble and install the transformer in the location and layout indicated on the Drawings.
3. Perform Work in accordance with manufacturer's instructions and shop drawings.
4. Raise the tank above the pad to protect the bottom finish during installation and to minimize corrosion due to moisture accumulation.
5. Furnish components and equipment as required to complete the installation.
6. Replace any hardware lost or damaged during installation or handling.
7. Position the transformer so all required working space and clearance requirements of the National Electrical Code and the local building authorities are met.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Perform the following factory tests as required by IEEE C57.12.00 and in accordance with IEEE C57.12.90:
   1. No-load (85 degrees Celsius) losses at rated current. (Maximum allowable no load losses: 10 percent).
   2. Total (85 degrees Celsius) losses at rated current. (Maximum allowable total losses: 6 percent).
   3. Percent impedance (85 degrees Celsius) at rated current.
   4. Excitation current (100 percent voltage) test.
   5. Winding resistance measurement tests.
   6. Turns ratio tests using all tap settings.
   7. Polarity and phase relation tests.
   8. Temperature test.

C. Verification of performance:
   1. Submit manufacturer's certified test results before shipping the transformer.

3.8 FIELD QUALITY CONTROL

A. As specified in Section 16950 - Field Electrical Acceptance Tests.

B. Provide the services of a qualified manufacturer's representative to:
   1. Install all transformer equipment shipped separately from the transformer.

2. Fill the transformer with insulating fluid.
3. Install the nitrogen blanket.

C. Any and all other Work required to make the transformer ready for testing and energization.

3.9 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Medium voltage fuses.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Institute of Electrical and Electronic Engineers (IEEE):
   1. C37.40 - Standard Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.
   2. C37.46 - American National Standard for High-Voltage Expulsion and Current-Limiting Power Class Fuses and Fuse Disconnecting Switches.
   3. C37.48 - Guide for Application, Operation and Maintenance of High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

C. International Organization for Standardization (ISO):
   1. 9001 - Quality Management Systems - Requirements.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Definition of terms in accordance with IEEE C37.40.

1.04 SYSTEM DESCRIPTION

A. Provide complete fuse assemblies that are accurate and of the correct capacity for:
   1. Rated voltages as **indicated on the Drawings**.
   2. Proper interrupting rating to quickly and safely interrupt maximum available fault currents and prevent extensive damage to associated equipment.
   3. Rated continuous current.
   4. Proper overcurrent protection.
   5. Protection against thermal damage.
   6. Ambient temperatures and altitudes as specified in Section 16050 - Common Work Results for Electrical.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cut sheets.
   2. Complete fuse schedule:
      a. Indicate manufacturer, rating, and location where each fuse is to be installed.
   3. Catalog cut sheets for applicable accessories included, but not limited to:
      a. Mountings.
      b. Fittings.
      c. Disconnecting switches and blades.
      d. Refill units.
      e. Insulating assemblies, holders, and connectors.
   4. Melting and clearing time-current characteristics for each fuse current rating and type:
      a. Fuse characteristics shall match curves within a maximum total tolerance of 10 percent in terms of current.
      b. Minimum melting curves.
      c. Maximum clearing type curves.
   5. Preloading adjustment factors.
   6. Ambient temperature adjustment factors.
   7. Documentation that fuses are sufficient for available fault conditions at installed locations per fault coordination study as specified in Section 16305 - Electrical System Studies.
   8. Current-limiting fuses:
      a. Peak let-through curves for each fuse current rating and type:
         1) Fuse characteristics shall match curves within a maximum total tolerance of 10 percent in terms of current.
      b. Peak arc voltage data.
   9. Installation requirements.
   10. Verification that supplied fuses are consistent for feasible coordination with corresponding fuses, breakers, and other protection devices.
   11. Manufacturer’s certifications:
      a. Provide test results that show the medium voltage fuse design that has been tested in accordance with ANSI and NEMA standards.

C. Shop drawings:
   1. Include drawings of spare fuse cabinet(s).

D. Operation and maintenance manuals:
   1. Complete assembly, installation, and testing manuals for each major component.

2. Include product data information, as well as spare fuse cabinet information.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. The manufacturer shall be ISO 9001 certified.
   1. Provide documentation certifying an approved test method (such as a helium mass spectrometer leak test) that demonstrates compliance with this requirement.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16305 - Electrical System Studies and submit results for Engineer’s review.

B. After successful review of the initial fault current study, submit complete equipment submittal.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Spare fuses:
   1. Minimum 3 of each type and size installed under any section of these Specifications.
   2. For fuse units with replaceable fuse units, provide 1 spare fuse holder assembly and 3 spare replaceable elements for each type and size installed under any section of these Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Expulsion fuses:
      a. S&C Electric Co.
      b. Eaton.
   2. Current-limiting fuses:
      a. Eaton.
      b. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Provide durable, readily visible label inside each fuse enclosure, clearly indicating the correct type, size, and rating for replacement fuses.
   2. Label all fuse units, refill units, or fuse links in accordance with IEEE C37.46.
   3. Explosion-proof.
   4. Include all necessary accessories and mounting:
      a. Disconnect-type fuse mountings shall not be used as load-breaking devices.
   5. Permanently accurate to match time-current characteristic curves.
   6. Non-aging and non-damageable fuse element construction:
      a. It shall be unnecessary to replace un-blown companion fuses following a fuse operation.
   7. Equipped with a blown-fuse indicator to provide visible evidence of fuse operation while installed in the fuse mounting.
   8. To ensure selective coordination of protective devices:
      a. Provide fuses for new facilities by the same manufacturer.
      b. Provide fuses for renovations of the same manufacturer as existing fuses.
      c. Verify that supplied fuses are consistent for feasible coordination with corresponding fuses, breakers, and other protection devices:
         1) Submit coordination data to Engineer.
   9. Ratings:
      a. The interrupting rating shall equal or exceed the maximum available short circuit current at the installed location indicated on the Drawings.
      b. Frequency: 60 hertz.
      c. Voltage: Equal to or greater than the nominal voltage **indicated on the Drawings**.

B. Expulsion-type fuses:

1. Construction:
    a. Solid-material type utilizing refill-unit-and-holder or fuse-unit-and-end-fitting construction with readily replaceable refill unit or fuse unit.
    b. Fiber-lined expulsion fuses are not allowed.
    c. Glass-epoxy fuse casing.
    d. Hermetically seal fuse refill to prevent water ingress.
    e. Capable of detecting and interrupting down to minimum rating.
    f. Capable of handing the full range of transient recovery voltage severity associated with a fault condition at the installed location.
    g. Contain all arcing accompanying fuse operation within the fuse.
    h. Vent all arc products and gases evolved during fuse operation through exhaust control devices that can effectively control fuse exhaust.
    i. Utilize silencer for quiet fuse operation.
2. Current ratings:
    a. The continuous current rating of the expulsion-type fuse shall equal or exceed the maximum continuous load current that can pass through it.

C. Current-limiting fuses:
1. Self-protecting type with visible fuse condition indicators.
2. Incorporate special time/current characteristics for motor service allowing proper coordination with the contactor and overload relay for maximum motor protection:
    a. Coordinate such that under a low-fault condition the interrupting rating and drop-out time of the contactor properly coordinated with all possible fuse sizes to eliminate contactor racing.
3. Vertically mount power fuses to permit easy inspection and replacement without starter disassembly.
4. Provide a fuse puller.
5. Implemented with another interrupting device capable of interrupting currents below the backup fuse’s minimum interrupting current.
6. Construction:
    a. Pure silver fuse elements (0.999 fine), high-purity silica sand filler, and a glass resin outer casing.
    b. Provide a single fusible element for each refill unit or fuse unit. Contain all arcing accompanying operation of the current-limiting power fuse within the fuse:
        1) Operation shall be silent and shall not expel any exhaust.
    c. Provide fusible elements that operate in such a manner as to substantially limit the peak let-though current by interrupting the fault before the first current peak is attained.
7. Current ratings:
    a. Sustain rated full load current continuously with no adverse effect on fuse performance:
        1) Without exceeding temperature rise in accordance with IEEE C37.40.

2) Derate current ratings for ambient temperatures in excess of 25 degrees Celsius in accordance with IEEE C37.48.

b. Current-limiting fuses are not to be applied as overload devices.

c. The peak value of the voltage that can exist across a current-limiting fuse during its arcing interval shall be in accordance with IEEE C37.46 requirements.

D. Fuses:

1. Fuses for potential transformers, control power transformers, power transformers, and feeder circuits:
   a. Manufacturers: One of the following or equal:
      1) General Electric Co., Type EJ-1.
      2) Eaton, Type CLE.
   b. Ratings:
      1) In accordance with manufacturer's recommendations or as **indicated on the Drawings**.
   c. Supports:
      1) Non-disconnect type unless otherwise **indicated on the Drawings**.
2. Fuses for power transformer protection:
   a. Hermetically seal oil-submersible fuses against the ingress of oil.
      1) Adjust oil-submersible fuse ratings according to the ambient temperature of the transformer oil in accordance with IEEE C37 Standards.
   b. Shall not operate or be damaged by the transformer's magnetizing inrush current.
   c. Implement the lowest fusing ratio that corresponds to a point beneath the ANSI point for the transformer's short-time characteristic curve for transformer primary fuses unless otherwise specified.
   d. Current rating less than the transformer anticipated maximum load current.
   e. Match backup current-limiting fuses with expulsion fuses according to manufacturer's recommendations to ensure proper integrated protection and operation.
3. Fuses for motor starter duty:
   a. Manufacturers: One of the following or equal:
      1) General Electric Co., Type EJ-2.
      2) Eaton, Type CLS.
   b. Characteristics:
      1) Ensuring positive interruption of faults to limit the magnitude of short circuit currents and electro-mechanical stresses to values within allowable design of component apparatus of motor control assembly.
      2) Control surge voltage, produced during limited short circuits, to maximum twice-nominal voltage rating.
      3) Protect power transformers, control transformers, potential transformers, feeder circuits, and motor starter equipment.

4) Withstand frequent severe heating and cooling cycles without fatigue failure.
5) Characteristic curves used for coordination adjusted to allow for the effects of starting inrush current, loading, and manufacturing tolerances.
6) Blown fuse, easily identified by positive action indicator.
7) Prevent flame or gas discharge when operated without discharge filters, fireboxes, special vents, or reinforcing.
8) Mounted on draw out assemblies.

4. Fuses for services, switchboards, switchgear mains, feeders, and branch circuits:
   a. Fuses shall match the distribution equipment in which they are to be installed and as **indicated on the Drawings**.
5. Fuses for power factor correction capacitors:
   a. Ratings:
      1) In accordance with manufacturer's recommendations or as **indicated on the Drawings**.
   b. Adequately protect systems from failed capacitor units.
   c. Prevent damage to adjacent capacitors and associated equipment.
6. Fuses for motor branch circuits:
   a. Type "R" unless alternate type is approved by Engineer.
   b. Ampere ratings shall not exceed manufacturer's recommended values.
   c. Ratings shall be determined by actual full-load and starting current characteristics.
   d. A motor having starting duty or other special characteristics requiring larger fuses than specified above, may have branch circuit fuse ratings increased as necessary to meet motor's requirements, but no larger than maximum permitted by the NEC.
      1) Increased requirements for an individual motor shall not be cause for increasing size of all fuses.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to verify that Project conditions are within "usual service conditions," in accordance with IEEE C37.40.
   1. Notify the Engineer of any installation conditions that may be shown at variance with these conditions and the manufacturer's recommendations.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install all equipment in accordance with the manufacturer's recommendations.

B. Evenly torque mounting bolts and nuts in accordance with ASTM recommendations for type and diameter of mounting bolts or studs provided.
   1. Affix a label to the inside of fuse access doors indicating recommended torque for fuse mounting bolts or studs.

C. Check all fuses for correct resistance values before start-up.

D. Securely lock, latch, or hold fast in the closed position all fuses as recommended by manufacturer.

E. Provide all necessary hardware to secure complete assembly in place.

F. Completely install, connect, and test for insulation integrity all equipment that requires fuses before installation of fuses.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
1. Responsibilities for testing the electrical installation.
2. Adjusting and calibration.
3. Acceptance tests.

B. Copyright information:
1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI).

C. ASTM International (ASTM):
1. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
2. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
3. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
4. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
5. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
6. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
7. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
8. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
9. D1533 - Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
10. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
11. D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
12. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

D. Institute of Electrical and Electronics Engineers (IEEE):

1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
4. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
5. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
6. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
7. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
8. C57.13 - IEEE Standard Requirements for Instrument Transformers.
9. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
10. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
11. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

E. Insulated Cable Engineer’s Association (ICEA).

F. InterNational Electrical Testing Association (NETA).
   1. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

G. International Electrotechnical Commission (IEC).

H. Manufacturer’s testing recommendations and instruction manuals.

I. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).
   2. 110 - Standard for Emergency and Standby Power Systems.

J. National Institute of Standards and Technology (NIST).

K. Specification sections for the electrical equipment being tested.

L. Shop drawings.

1.03 DEFINITIONS

A. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.

B. Conduct all tests in the presence of the Engineer or the Engineer's representative:
   1. Engineer will witness all visual, mechanical, and electrical tests, and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

D. Responsibilities:
   1. Contractor responsibilities:
      a. Ensure that all resources are made available for testing, and that all testing requirements are met.
   2. Electrical subcontractor responsibilities:
      a. Perform routine tests during installation.
      b. Demonstrate operation of electrical equipment.
      c. Commission the electrical installation.
      d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
         1) Providing electrical power as required.
         2) Operating of electrical equipment in conjunction with testing of other equipment.
         3) Activating and shutting down electrical circuits.
         4) Making and recording electrical measurements.
         5) Replacing blown fuses.
         6) Installing temporary jumpers.
   3. Testing laboratory responsibilities:
      a. Perform all acceptance tests specified in this Section.
      b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

B. Test report:
   1. Include the following:
      a. Summary of Project.
      b. Description of equipment tested.

c. Description of tests performed.
d. Test results.
e. Conclusions and recommendations.
f. Completed test forms.
g. List of test equipment used and calibration dates.

C. Test data records:
1. Include the following:
a. Identification of the testing organization.
b. Equipment identification.
c. Nameplate data.
d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
e. Dates of inspections, tests, maintenance and or calibrations.
f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
g. Expected results when calibrations are to be performed.
h. Indication of as-found and as-left results as applicable.
i. Indication of all test results outside specified tolerances.

D. Testing laboratory qualifications:
1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
1) Corporate history and references.
2) Resume of individual performing test.
3) Equipment list and test calibration data.

E. Division of responsibilities:
1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Testing laboratory qualifications:
1. The testing laboratory may be qualified testing personnel from the electrical subcontractor’s staff or an independent testing company.
2. NETA certification required.
3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:
   1. Perform routine tests as the equipment is installed including:
      a. Insulation-resistance tests.
      b. Continuity tests.
      c. Rotational tests.
   2. Adjusting and preliminary calibration.
   3. Acceptance tests.
   4. Demonstration.
   5. Commissioning and plant start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Test instrument calibration:
   1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
      a. The calibrating standard shall be of better accuracy than that of the equipment tested.

2. The accuracy shall be traceable to the NIST in an unbroken chain.
3. Calibrate instruments in accordance with the following frequency schedule:
   a. Field instruments: 6 months maximum.
   b. Laboratory instruments: 12 months maximum.
   c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
4. Dated calibration labels shall be visible on all test equipment.
5. Maintain an up-to-date instrument calibration record for each test instrument:
   a. The records shall show the date and results of each calibration or test.
6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Do not begin testing until the following conditions have been met:
1. All instruments required are available and in proper operating condition.
2. All required dispensable materials such as solvents, rags, and brushes are available.
3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
5. Data sheets to record all test results are available.

3.03 INSTALLATION

A. Test decal:
1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
   a. White: electrically and mechanically acceptable.
   b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
3. The decal shall include the following information at a minimum:
   a. Testing organization.
   b. Project identifier.
   c. Test date.
   d. Technician identifier.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. Testing and Training Phase: Installation Testing:
   1. Also called "Field Acceptance Testing".
   2. Switchgear and switchboard:
      a. Visual and mechanical inspection:
         1) Compare equipment nameplate data with the Contract Documents.
         2) Inspect physical and mechanical condition.
         3) Inspect anchorage, alignment, grounding and required area clearances.
         4) Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
         5) Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study as well as to the circuit breakers address for microprocessor-communication packages.
         6) Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
         7) Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
         8) Inspect bolted electrical connections for high resistance using one of the following methods:
            a) Use of low-resistance ohmmeter.
            b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
               (1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
         9) Verify operation and sequencing of interlocking systems:
            a) Attempt closure on locked-open devices.
            b) Attempt to open locked-closed devices.
            c) Make/attempt key-exchanges in all positions.
         10) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
         11) Inspect insulators for evidence of physical damage or contaminated surfaces.
         12) Verify correct barrier and shutter installation and operation.
         13) Exercise all active components.
         14) Inspect mechanical indicating devices for correct operation.
         15) Verify that filters are in place and/or vents are clear.
         16) Perform visual and mechanical inspection of instrument transformers as specified in this Section.
         17) Perform visual and mechanical inspection of surge arresters as specified in this Section.
         18) Inspect control power transformers:
            a) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.

b) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
c) Verify correct functioning of drawout disconnecting contacts grounding contacts, and interlocks.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute.
a) Perform test in accordance with NETA ATS tables.
3) Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data:
TRefer to NETA ATS tables in the absence of manufacturer's published data.
a) The test voltage shall be applied for 1 minute.
4) Perform ground-resistance tests:
a) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
5) Test metering devices as specified in this Section.
6) Control power transformers:
a) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground:
(1) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
(2) Perform a turns-ratio test on all tap positions.
b) Perform secondary wiring integrity test:
(1) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
(a) Verify correct potential at all devices.
c) Verify correct secondary voltage by energizing primary winding with system voltage:
(1) Measure secondary voltage with the secondary wiring disconnected.
7) Perform current injection tests on the entire current circuit of each switchgear or switchboard:
a) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:
(1) Verify the correct magnitude of current at each device in the circuit.
8) Perform system function tests.
9) Verify operation of space heaters.
10) Perform electrical tests of surge arresters as specified in this Section.

c. Test values:

1) Compare bolted connection resistance values to values of similar connections:
    a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data:
    a) Refer to NETA ATS tables in the absence of manufacturer's published data.
    b) Investigate insulation values less than the allowable minimum.
    c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
4) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
5) Instrument transformer test values shall be as specified in this Section.
6) Meter test values shall be as specified in this Section.
7) Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
8) Control power transformers:
    a) Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data:
        (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
        (2) Investigate insulation values less than the allowable minimum.
    b) Turns-ratio test results shall not deviate by more than 1/2 percent from either the adjacent coils or the calculated ratio.
        (1) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
    c) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
    d) Secondary voltage shall be as indicated on the Drawings.
9) Current-injection tests shall prove current wiring is as indicated on the Drawings and specified in the Specifications.
10) Results of system function tests shall match the drawings and Specifications.
11) Heaters shall be operational.
12) Phasing checks shall prove the switchgear or switchboard phasing is correct and in accordance with the system design.
13) Results of electrical tests on surge arresters shall be as specified in this Section.

3. Liquid-filled transformers:
    a. Visual and mechanical inspection:
        1) Compare equipment nameplate data with the Contract Documents.
        2) Inspect physical and mechanical condition.
        3) Inspect impact recorder before unloading.
        4) Test dew point of tank gases if applicable.
        5) Inspect anchorage, alignment, grounding and required clearances.
        6) Verify the presence of PCB content labeling.
        7) Verify removal of any shipping bracing after placement.
        8) Verify the bushings are clean.
        9) Verify that alarm, control and trip settings on temperature and level indicators are as specified.
        10) Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, gas accumulator, and fault pressure relay, if applicable.
        11) Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.
        12) Inspect bolted electrical connections for high resistance using one of the following methods:
            a) Use of low-resistance ohmmeter.
            b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
                (1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
        13) Verify correct liquid level in tanks and bushings.
        14) Verify valves are in the correct operating position.
        15) Verify that positive pressure is maintained on gas-blanketed transformers.
        16) Perform inspections and mechanical tests as recommended by the manufacturer.
        17) Test load tap-changer in accordance with NETA ATS requirements.
        18) Verify presence of transformer surge arresters.
        19) Verify de-energized tap-changer position is left as specified.
    b. Electrical tests:
        1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
        2) Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
            a) Apply voltage in accordance with manufacturer’s published data:
                (1) Refer to NETA ATS tables in the absence of manufacturer’s published data.
            b) Calculate polarization index.
        3) Perform turns ratio tests at all tap positions.
        4) Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer’s published data.

5) Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap:
   a) In the absence of a power-factor/capacitance tap perform hot-collar tests.
   b) Perform tests in accordance with test equipment manufacturer's published data.
6) Perform excitation-current tests in accordance with test equipment manufacturer's published data.
7) Perform sweep frequency response analysis tests.
8) Measure the resistance of each primary winding in each no-load tap changer position. Measure the resistance of each secondary winding in each no-load tap changer position.
9) Remove a sample of insulating liquid in accordance with ASTM D923 and test per the following standards:
   a) Dielectric breakdown voltage: ASTM D877 or ASTM D1816.
   b) Acid neutralization number: ASTM D974.
   c) **Specific gravity: ASTM D1298.**
   d) Interfacial tension: ASTM D971.
   e) Color: ASTM D1500.
   f) Visual condition: ASTM D1524.
   g) Water in insulating fluids: ASTM D1533.
   h) **Power-factor or dissipation-factor: ASTM D924.**
10) Remove a sample of insulating liquid in accordance with ASTM D924. Sample shall be tested for the following:
   a) Dissolved-gas analysis: IEEE C57.104 or ASTM D3612.
11) Test instrument transformers as specified in this Section:
12) Test surge arresters as specified in this Section if applicable.
13) Test transformer neutral grounding impedance device if applicable.
14) Verify operation of cubicle or air terminal compartment space heaters.

c. Test values:
   1) Alarm control, and trip circuits from temperature and level indicators as well as pressure relief device and fault pressure relay shall operate within manufacturer's recommendations for their specified settings.
   2) Cooling fans and pumps shall operate.
   3) Compare bolted connection resistance values to values of similar connections:
      a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   4) Bolt-torque levels shall be in accordance with manufacturer's published data:
      a) Refer to NETA ATS tables in the absence of manufacturer's published data.
   5) Liquid levels in the transformer tanks and bushings shall be within indicated tolerances.

6) Positive pressure shall be indicated on pressure gauge for gas-blanketed transformers.
7) Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
   b) Investigate insulation values less than the allowable minimum.
8) The polarization index shall be greater than 1.0:
   a) Compare to any previous values.
9) Turns-ratio test result shall not deviate by more than 1/2-percent from either the adjacent coils or the calculated ratio.
10) Maximum winding insulation power-factor/dissipation-factor values shall be in accordance with the manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
11) Investigate bushing power-factor values that vary from nameplate values by more than 150 percent. Investigate bushing capacitance values that vary from nameplate values by more than 5 percent. Investigate bushing hot-collar test values that exceed 0.1 Watts.
12) Typical excitation-current test data pattern for a 3-legged core transformer is 2 similar current readings and 1 lower current reading.
13) Sweep frequency response analysis test results shall be comparable to previously obtained results.
14) Consult the manufacturer if winding-resistance test values vary by more than 2 percent from factory test values or between adjacent phases.
15) Investigate leakage reactance per phase test results that deviate from the average of the 3 readings by more than 3 percent. The 3 phase equivalent test results serve as a benchmark for future tests.
16) Core insulation values shall be comparable to previously obtained results but not be less than 1.0 megohm at 500 VDC.
17) Investigate the presence of oxygen in the nitrogen gas blanket.
18) Insulating liquid values shall be in accordance with NETA ATS tables.
19) Evaluate results of dissolved-gas analysis in accordance with IEEE C57.104.
20) Results of electrical tests on instrument transformers shall be as specified in this Section.
21) Results of surge arrester tests shall be as specified in this Section.
22) Compare grounding impedance device results to the manufacturer's published data.
23) Heaters shall be operational.

4. Medium voltage cables (NEW CABLES ONLY):
   a. Visual and mechanical inspection:
      1) Compare cable data with the Contract Documents.
      2) Inspect exposed sections of cables for physical damage.

3) Inspect bolted electrical connections for high resistance using one of the following methods:
    a) Use of low-resistance ohmmeter.
    b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
4) Inspect compression-applied connectors for correct cable match and indentation.
5) Inspect shield grounding, cable support, and terminations.
6) Verify the visible bends meet or exceed ICEA and manufacturer's published minimum allowable bending radius.
7) If cables are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
8) Inspect for correct identification and arrangements.
9) Inspect jacket insulation and condition.

b. Electrical tests:
    1) Perform resistance measurements through bolted connections with low-resistance ohmmeter.
    2) Perform an insulation-resistance test individually on each conductor with all other conductors and shields grounded:
        a) Apply voltage in accordance with manufacturer's published data:
            (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    3) Perform shield-continuity test on each power cable.
    4) Perform cable and time domain reflectometer (TDR) measurements on each conductor.
    5) In accordance with ICEA, IEC, IEEE, and other power cable consensus standards, testing can be performed by means of direct current, power frequency alternating current, very low frequency alternating current, or damped alternating current. These sources may be used to perform insulation-resistance tests, and baseline diagnostic tests such as partial discharge analysis, and power factor or power dissipation factor. The selection shall be made after an evaluation of the available test methods and a review of the installed cable system. Some of available test methods are as follows:
        a) Dielectric withstand:
            (1) Direct current dielectric withstand voltage.
            (2) Very low frequency dielectric withstand voltage.
            (3) Power frequency dielectric withstand voltage.
            (4) Damped alternating current voltage.
        b) Baseline diagnostic tests:
            (1) Power factor/dissipation factor (tan delta):
                (a) Power frequency.

(b) Very low frequency.
(2) Direct current insulation-resistance.
(3) Partial discharge:
(a) Online (50/60 hertz).
(b) Offline:
(c) Power frequency.
(d) Very low frequency.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) The minimum bend radius to which insulated cables may be bent for permanent training shall be in accordance with NETA ATS tables.
4) Insulation-resistance values shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
b) Investigate values of insulation-resistance less than the allowable minimum.
5) Shielding shall exhibit continuity:
a) Investigate resistance values in excess of 10 ohms per 1,000 feet of cable.
6) If no evidence of distress of insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
7) Based on the test methodology chosen, refer to the applicable standards or manufacturer's literature for acceptable values.

5. Instrument transformers - current transformers:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.
2) Inspect physical and mechanical condition.
3) Verify correct connection of transformers with system requirements.
4) Verify that adequate clearances exist between primary and secondary circuit wiring.
5) Verify the unit is clean.
6) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter.
b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

7) Verify that all required grounding and shorting connections provide contact.
8) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
a) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
3) Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
4) Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
5) Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
6) Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
7) When applicable perform insulation-resistance tests on the primary winding with the secondary grounded:
a) Test voltages shall be in accordance with NETA ATS tables.
8) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
9) Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
a) That grounding point should be located as specified by the Engineer in the Contract Documents.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
4) Polarity results shall agree with transformer markings.
5) Ratio errors shall be in accordance with IEEE C57.13.

6) Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
7) Measured burdens shall be compared to instrument transformer ratings.
8) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
9) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
   a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.
10) Test results shall indicate that the circuits have only 1 grounding point.

6. Instrument transformers - voltage transformers:
   a. Visual and mechanical inspection:
      1) Compare equipment nameplate data with the Contract Documents.
      2) Inspect physical and mechanical condition.
      3) Verify correct connection of transformers with system requirements.
      4) Verify that adequate clearances exist between primary and secondary circuit wiring.
      5) Verify the unit is clean.
      6) Inspect bolted electrical connections for high resistance using one of the following methods:
         a) Use of low-resistance ohmmeter.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      7) Verify that all required grounding and connections provide contact.
      8) Verify correct primary and secondary fuse sizes for voltage transformers.
      9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
      10) Perform as-left tests.
   b. Electrical tests - voltage transformers:
      1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      2) Perform insulation-resistance tests winding-to-winding and winding-to-ground:
         a) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
         b) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
      3) Perform a polarity test on each voltage transformer to verify the polarity marks on H_1- X_1 relationship as applicable.

4) Perform a turns ratio test on all tap positions.
5) Measure voltage circuit burdens at transformer terminals.
6) Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
   a) The dielectric voltage shall be in accordance with NETA ATS tables.
   b) Apply the test voltage for 1 minute.
7) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.
8) Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
   a) That grounding point should be located as specified by the Engineer in the Contract Documents.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
   a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
   a) Refer to NETA ATS tables in the absence of manufacturer's published data.
4) Polarity results shall agree with transformer markings.
5) Ratio errors shall be in accordance with IEEE C57.13.
6) Measured burdens shall be compared to instrument transformer ratings.
7) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
8) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
   a) In the absence manufacturer's published data, use the test equipment manufacturer's published data.
9) Test results shall indicate that the circuits have only 1 grounding point.

7. Metering devices, microprocessor based:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.
2) Inspect meters and cases for physical damage.
3) Clean front panel.
4) Verify tightness of electrical connections.
5) Record the following:

a) Model number.
b) Serial number.
c) Firmware revision.
d) Software revision.
e) Rated control voltage.

6) Verify operation of display and indicating devices.
7) Record passwords.
8) Verify the unit is grounded in accordance with the manufacturer's instructions.
9) Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.

b. Electrical tests:
1) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
2) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital and analog.
3) After initial system energization, confirm measurements and indications are consistent with loads present.

c. Test values:
1) Nameplate data shall match the Contract Documents.
2) Tightness of electrical connections shall ensure a low resistance connection.
3) Display and indicating devices shall operate per manufacturer's published data.
4) Measurement and indication of applied voltages and currents shall be within the manufacturer's published tolerances for accuracy.
5) All auxiliary input/output features shall operate per settings and manufacturer's published data.
6) Measure and indications shall be consistent with energized system loads.

8. Grounding systems:
a. Visual and mechanical inspection:
1) Inspect ground system for compliance with the Contract Documents, and the NEC.
2) Inspect physical and mechanical condition.
3) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter.
b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
(1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
4) Inspect anchorage.

b. Electrical tests:

1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2) Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
3) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.

c. Test values:
1) Grounding system electrical and mechanical connections shall be free of corrosion.
2) Compare bolted connection resistance values to values of similar connections:
a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
3) Bolt-torque levels shall be in accordance with manufacturer's published data:
a) Refer to NETA ATS tables in the absence of manufacturer's published data.
4) The resistance between the main grounding electrode and ground shall be as specified in Section 16060 - Grounding and Bonding.
5) Investigate point-to-point resistance values that exceed 0.5 ohm.

9. Surge arresters, medium and high voltage:
a. Visual and mechanical inspection:
1) Compare equipment nameplate data with the Contract Documents.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, grounding, and clearances.
4) Verify the arresters are clean.
5) Inspect bolted electrical connections for high resistance using one of the following methods:
a) Use of low-resistance ohmmeter.
b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
(1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
7) Verify that stroke counter is correctly mounted and electrically connected, if applicable.
8) Record stroke counter reading.
b. Electrical tests:
1) Perform resistance measurements through bolted connections with a low resistance ohmmeter.
2) Perform an insulation-resistance test on each arrester, phase terminal-to-ground:
a) Apply voltage in accordance with manufacturers published data.

b) Refer to NETA ATS tables in the absence of manufacturer's published data.

3) Test grounding connection as specified in this Section.

c. Test values:

1) Compare bolted connection resistance values to values of similar connections:

a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels shall be in accordance with manufacturer's published data:

a) Refer to NETA ATS tables in the absence of manufacturer's published data.

3) Insulation-resistance values shall be in accordance with manufacturer's published data:

a) Refer to NETA ATS tables in the absence of manufacturer's published data.

b) Investigate insulation values less than the allowable minimum.

4) Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

10. Fiber-optic cables:

a. Visual and mechanical inspection:

1) Compare cable, connector, and splice data with the Contract Documents.

2) Inspect cable and connections for physical and mechanical damage.

3) Verify that all connectors and splices are correctly installed.

b. Optical tests:

1) Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):

a) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.

b) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.

2) Perform connector and splice integrity test using an optical time domain reflectometer.

3) Perform cable attenuation loss measurement with an optical power loss test set:

a) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.

b) Test multimode fibers at 850 nanometer and 1,300 nanometer.

c) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.

4) Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:

a) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for

multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.

5) Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
   a) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.
   b) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.

c. Test values:
   1) Cable and connections shall not have been subjected to physical or mechanical damage.
   2) Connectors and splices shall be installed in accordance with industry standards.
   3) The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
   4) Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
   5) Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION


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