SECTION 261213 - LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section Includes:

Liquid-filled, medium-voltage substation transformers, with primary and secondary bushings within or without air-terminal enclosures.

Control network.

Warning labels and signs.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. BIL: Basic Impulse Insulation Level.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each type of product.

Include rated capacities, operating characteristics, and furnished specialties and accessories.

* + - * 1. Shop Drawings: For liquid-filled, medium-voltage transformers.

Include plans and elevations showing major components and features.

Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace, and locations of penetrations for grounding and conduits.

Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Include single-line diagram.

Include list of materials.

Include nameplate legends.

* + - * 1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.

Retain "Coordination Drawings for Outdoor Installations" and "Coordination Drawings for Indoor Installations" paragraphs below to coordinate installation of products and materials by separate installers. Coordinate paragraphs with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations.

* + - * 1. Coordination Drawings for Outdoor Installations:

Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

* + - * 1. Coordination Drawings for Indoor Installations:

Location plan, showing heavy equipment or truck access paths for maintenance and replacement.

Dimensioned concrete base, outline of transformer, conduit entries, and grounding equipment locations.

Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, cabletrays[**, busways,**] [**and seismic anchors**].

Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

* + - * 1. Qualification Data: For testing agency.

Retain "Seismic Qualification Certificates" paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 260548.16 "Seismic Controls for Electrical Systems." See ASCE/SEI 7 for certification requirements for equipment and components.

* + - * 1. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

* + - * 1. Product Certificates: For transformers, signed by product manufacturer.
				2. Source quality-control reports.

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.
			2. QUALITY ASSURANCE

Retain "Testing Agency Qualifications" paragraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article.

* + - * 1. Testing Agency Qualifications: Member company of NETA or an NRTL.

Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

* + - * 1. Equipment Qualifications For Products Other Than Those Specified:

At the time of submission provide written notice to the Director of the intent to propose an “or equal” for products other than those specified. Make the “or equal” submission in a timely manner to allow the Director sufficient time to review the proposed product, perform inspections and witness test demonstrations.

If products other than those specified are proposed for use furnish the name, address, and telephone numbers of at least 5 comparable installations that can prove the proposed products have performed satisfactorily for 3 years. Certify in writing that the Director’s Representative of the 5 comparable installations will allow inspection of their installation by the Director's Representative and the Company Field Advisor.

Make arrangements with the Director’s Representative of 2 installations (selected by the Director) for inspection of the installations by the Director's Representative. Also obtain the services of the Company Field Advisor for the proposed products to be present. Notify the Director a minimum of 3 weeks prior to the availability of the installations for the inspection, and provide at least one alternative date for each inspection.

Only references from the actual Director’s Representative or Director’s Representative (Security Supervisor, Maintenance Supervisor, etc.) will be accepted. References from dealers, system installers or others, who are not the actual Director’s Representative of the proposed products, are not acceptable.

Verify the accuracy of all references submitted prior to submission and certify in writing that the accuracy of the information has been confirmed.

The product manufacturer shall have test facilities available that can demonstrate that the proposed products meet the contract requirements.

Make arrangements with the test facility for the Director's Representative to witness test demonstrations. Also obtain the services of the Company Field Advisor for the proposed product to be present at the test facility. Notify the Director a minimum of 3 weeks prior to the availability of the test facility, and provide at least one alternative date for the testing.

Provide written certification from the manufacturer that the proposed products are compatible for use with all other equipment proposed for use for this system and meet all contract requirements.

1. PRODUCTS

See Editing Instruction No. 1 in the Evaluations for cautions about named manufacturers and products.

* + - 1. MANUFACTURERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=9945) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Cooper Industries, Inc](http://www.specagent.com/Lookup?uid=123457159546).

[GE Power; General Electric Company](http://www.specagent.com/Lookup?uid=123457175482).

[Square D; Schneider Electric USA](http://www.specagent.com/Lookup?uid=123457159549).

Or equal.

* + - 1. SYSTEM DESCRIPTION

Retain NFPA 70 compliance required in "Electrical Components, Devices, and Accessories" paragraph below when the transformer is installed pursuant to conditions listed in NFPA 70 for liquid-filled, medium-voltage transformers.

* + - * 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
				2. Comply with IEEE C2.
				3. Comply with IEEE C57.12.00.
			1. PERFORMANCE REQUIREMENTS

Retain "Seismic Performance" paragraph below with "Seismic Qualification Certificates" paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Coordinate requirements with structural engineer.

* + - * 1. Seismic Performance: The transformers shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified[**and the transformer will be fully operational after the seismic event**]."

For life-safety components required to function after an earthquake, the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5. If Project requires transformers with different Component Importance Factor, delete "Component Importance Factor" subparagraph below and add to schedule on the Drawings or to "Capacities and Characteristics" paragraph below.

Component Importance Factor: [**1.5**] [**1.0**].

See ASCE/SEI 7 Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table for requirements to be inserted in "Component Amplification Factor" and "Component Response Modification Factor" subparagraphs below. See Editing Instruction No. 2 in the Evaluations for guidance.

Component Amplification Factor: [**2.5**] <**Insert number**>.

Component Response Modification Factor: [**6.0**] <**Insert number**>.

* + - * 1. Windings Material: [**Aluminum**] [**Copper**].

See Editing Instruction No. 4 in the Evaluations for guidance on retaining "Surge Arresters" paragraph below.

* + - * 1. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.
				2. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.
				3. Four or five-legged core/coil construction.
				4. Live front construction.

Retain "Efficiency" paragraph below unless efficiencies higher than the minimum are required. If Project requires transformers with different efficiencies, delete "Efficiency" subparagraph below and add to schedule on the Drawings or to "Capacities and Characteristics" paragraph below. See the Evaluations for discussion of transformer efficiency and life-cycle cost consideration.

* + - * 1. Efficiency: Comply with 10 CFR 431, Subpart K.
				2. Insulation:

Retain one of or both subparagraphs below. When retaining both, indicate the temperature rise along with the kVA rating.

Transformer kVA Rating[**, when Indicated at 65 deg C Rise,**] Shall Be as Follows: The average winding temperature rise above ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.

Transformer kVA Rating[**, when Indicated at 55/65 deg C Rise,**] Shall Be as Follows: The average winding temperature rise above ambient temperature shall not exceed 55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life. The rating shall conform to the requirements of IEEE C57.12.90.

* + - * 1. Bushings shall comply with IEEE C57.19.01 requirements for impulse and low-frequency insulation levels.
				2. Tap Changer: External, for de-energized operation.

Retain option in "Tank" paragraph below if more than the minimum tank strength is a Project requirement. See Editing Instruction No. 7 in the Evaluations for additional data.

* + - * 1. Tank: Sealed, with welded-on cover.[**Designed to withstand internal pressure of not less than 7 psi without permanent distortion and 15 psig without rupture. Comply with IEEE C57.12.36.**]
				2. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.

Retain either "Mineral Oil" or "Less-Flammable Liquids" subparagraph in "Insulating Liquid" paragraph below. If "Less-Flammable Liquids" subparagraph is retained, delete "Mineral Oil" subparagraph below and retain "Edible-Seed-Oil-Based Dielectric," "Biodegradable and Nontoxic Dielectric," or "Silicone-Based Dielectric" subparagraph below; verify availability with selected transformer manufacturers. Transformer primary voltage must be 35 kV or less for less-flammable liquids. See Editing Instruction No. 5 in the Evaluations for discussion of transformer-insulating liquids.

* + - * 1. Insulating Liquids:

Mineral Oil: ASTM D3487, Type II, and tested for compliance with ASTM D117.

Less-Flammable Liquids:

Edible-Seed-Oil-Based Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall be biodegradable and nontoxic, having passed the Organization for Economic Co-operation and Development G.L.203 with zero mortality, and shall be certified by the U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.

Biodegradable and Nontoxic Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92.

Silicone-Based Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall have low toxicity and be nonhazardous.

* + - * 1. Sound level shall comply with NEMA TR 1 requirements.

If Project has more than one type or configuration of liquid-filled, medium-voltage transformers, delete "Capacities and Characteristics" paragraph below and schedule transformers on Drawings.

* + - * 1. Capacities and Characteristics:

Location: [**Indoors**] [**Outdoors**].

The "Additional" in title of first subparagraph below refers to requirements that are complementary to, and are in addition to, those in IEEE C57.12.00.

See "Standards" Article in the Evaluations for assistance in selecting and retaining applicable IEEE standard(s) to suit Project.

Additional IEEE Standards: Comply with [**IEEE C57.12.10**] [**IEEE C57.12.36**].

Retain first subparagraph below if required by authorities having jurisdiction; the listing is generally available as an option from transformer manufacturers. This listing does not include the evaluation of the transformer in applications where NFPA 70 special provisions for different types of transformers are required. Verify availability with manufacturers.

Comply with UL 1062 listing requirements.

Retain one of first two subparagraphs below. Both approvals certify that transformer complies with NFPA 70 special provisions that apply to installations of less-flammable transformers.

Comply with FM Global Class No. 3990.

Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.

Service Conditions: Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00, except for the following:

Retain and revise subparagraphs below, and specify features required to provide satisfactory service. See the Evaluations for discussion of service conditions.

Altitudes above 3300 feet.

Cooling air or water temperature exceeds limits.

Excessive load current harmonic factor.

Operation above rated voltage or below rated frequency.

Exposure to explosive environments.

Exposure to fumes, vapors, or dust.

Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.

Exposure to seismic shock or to abnormal vibration, shock, or tilting.

Applying to first subparagraph below: Usual temperatures are down to minus 20 deg C and up to 40 deg C with average ambient-air temperature in any 24-hour period not more than 30 deg C.

Exposure to excessively high or low temperatures.

Unusual transportation or storage conditions.

Unusual grounding-resistance conditions.

Unusual space limitations.

Retain "Connections" subparagraph below for transformers that are not provided for open-wire connections to cover- or sidewall-mounted bushings.

Connections:

Primary connections in "Primary" subparagraph below are available at 200 kV BIL and less. Retain subparagraph if connections are not shown on Drawings.

Primary: [**Air-filled terminal cabinet for cable connection**] [**Throat for busway connection**] [**Terminals for close connection to a primary switch**] [**Open wire**].

Secondary: [**Air-filled terminal cabinet for cable connection**] [**Throat for busway connection**] [**Open wire**].

Transformer Ratings. Comply with IEEE C57.12.00 for cooling class.

Retain one of "Self-Cooled Rating, Class (Insert letters)," "Future Forced-Air-Cooled Rating, Class (Insert letters)," or "Forced-Air-Cooled Rating, Class (Insert letters)" subparagraphs below. Typically, forced-air cooling increases the kVA rating of transformers 300 kVA to 2000 kVA by 15 percent, and increases the kVA rating of transformers 2500 kVA and larger by 25 percent. See the Evaluations for explanation of letters that indicate cooling system class.

Self-Cooled Rating, Class <**Insert letters**>: <**Insert number**> kVA.

Future forced-air cooling is typically available for transformers 750 kVA and larger.

Future Forced-Air-Cooled Rating, Class <**Insert letters**>:

Self-Cooled: <**Insert number**> kVA.

Forced-Air Cooled: <**Insert number**> kVA.

Make provision for future addition of forced-air-cooling equipment. The transformer bushings, leads, and related components shall be sized for the future equipment. Provide fan mounts, conduit supports, and terminal boxes.

Forced-Air-Cooled Rating, Class <**Insert letters**>:

Self-Cooled: <**Insert number**> kVA.

Forced-Air Cooled: <**Insert number**> kVA.

Equip with forced-air-cooling equipment, including fans, conduit, wiring, motor controllers, and top liquid thermometer for fan control.

See the Evaluations for discussion on the selection of impedance.

Impedance: Not less than [**5.75**] <**Insert number**> percent.

Temperature Rise: [**65 deg C**] [**55/65 deg C**].

Coils Connection:

High-Voltage Winding: [**Delta**] <**Insert connection**>.

Low-Voltage Winding: [**Wye**] <**Insert connection**>.

BIL ratings in "Voltage and BIL Ratings" subparagraph below are minimums according to IEEE C57.12.00. Alternate BIL for 13 800-V nominal is 110 kV. Alternate BILs for 34 500 V nominal are 150 kV and 200 kV. IEEE C57.12.36 requires 150 kV BIL for wye and 200 kV BIL for delta-connected transformers. See Editing Instruction No. 3 in the Evaluations for guidance.

Voltage and BIL Ratings:

Nominal primary phase-to-phase voltage and BIL: [**4160 V, 60 kV**] [**13 800 V, 95 kV**] [**34 500 V, 125 kV**] <**Insert requirements**>.

Nominal secondary voltage and BIL: [**208Y/120 V, 45 kV**] [**480Y/277 V, 45 kV**] <**Insert requirements**>.

See the Evaluations for a discussion of K-factor.

K-Factor: <**Insert number**>, complying with UL 1561.

Retain one of "Outdoor Transformer Enclosure Finish," "Indoor Transformer Enclosure Finish," and "Special Corrosion-Resistant Enclosure Finish" subparagraphs below, depending on corrosion-resistance requirements. Retain third subparagraph for higher corrosion resistance for locations, such as waste-water treatment plants and environments that are subjected to salt spray.

Outdoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard color, corrosion resistance complying with IEEE C57.12.28.

Enclosure Integrity: ANSI C57.12.29 1999 Pad-Mounted Equipment-Enclosure Integrity for Coastal Environments.

Indoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

Enclosure Accessories:

Door handle and three-point latching mechanism for low-voltage compartment door. Equip door handle with locking device that includes provision for securing door handle with padlock. Padlock: Yale/Scovill 7300 Series with hardened steel triple plated shackle, 8 inch brass chain, two No. 47 keys with each padlock.

One or more captive and recessed pentahead bolts for additional security of the low-voltage compartment door.

Key interlock between transformer low-voltage compartment door and pad mounted high voltage switch and fuse assembly so that transformer door cannot be opened unless the high voltage switch is in the open position (both switches if dual radial primary feeder). Match key interlock supplied with high voltage switch. Flush mount key interlock. Padlock type key interlocks are not acceptable.

Internal locking device for high-voltage compartment door, which is accessible only after low-voltage compartment door is opened.

Special Corrosion-Resistant Enclosure Finish: Factory-applied, corrosion-resistant finish in manufacturer's standard color that withstands [**120**] [**480**] hours of exposure to salt-spray test specified in ASTM B117 without loss of paint or release of adhesion of paint primer coat to metal surface in excess of 1/16 inch from test mark. Scribed test mark and test evaluation shall be according to ASTM D1654 with a rating of not less than 7 according to Table 1 (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel, or mill-galvanized sheet steel shall be coated with a manufacturer's standard zinc-rich paint.

Retain "Taps" subparagraph below if a de-energized tap changer is required. See Editing Instruction No. 6 in the Evaluations for tap configurations that are available to comply with other voltage-adjustment requirements.

Taps: Two 2-1/2-percent, full-capacity taps above, and two 2-1/2-percent, full-capacity taps below rated voltage. Comply with IEEE C57.12.36 requirements.

Transformer Accessories:

Drain and filter connection.

Filling and top filter press connections.

Pressure-vacuum gauge.

Dial-type analog thermometer with alarm contacts.

Magnetic liquid level indicator with high and low alarm contacts.

Pressure-relief device set to operate at 10 psig, plus or minus 2 psig, and then automatically reseal when pressure drops to 6 psig minimum. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.

At least four stainless-steel ground connection pads.

Provisions for jacking, lifting, and towing.

Machine-engraved nameplate made of anodized aluminum or stainless steel.

Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide [**with**] [**without**] seal-in delay.

* + - 1. CONTROL NETWORK

See Editing Instruction No. 8 in the Evaluations for guidance on control network communications options.

* + - * 1. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.
			1. WARNING LABELS AND SIGNS
				1. Warning signs shall be made of baked enamel.
				2. Equipment Identification Labels: [Engraved, laminated-acrylic or -melamine label] [Stenciled legend **4 inches** high].
			2. SOURCE QUALITY CONTROL
				1. Provide manufacturer's certificate verifying the transformer design tests comply with IEEE C57.12.90.
				2. Perform the following factory-certified routine tests on each transformer for this Project:

Tests in first nine subparagraphs below are required for each transformer to comply with IEEE C57.12.00.

Resistance.

Turns ratio, polarity, and phase relation.

Transformer no-load losses and excitation current at 100 percent of ratings.

Transformer impedance voltage and load loss.

Operation of all devices.

Control (auxiliary) and consumption losses.

Lightning impulse.

Low frequency.

Leak.

Tests in subparagraphs below are optional according to IEEE C57.12.00.

Transformer no-load losses and excitation current at 110 percent of ratings.

Insulation power factor.

Applied potential.

Induced potential.

Resistance measurements of all windings on rated voltage connection and at tap extreme connections.

Ratios on rated voltage connection and at tap extreme connections.

Polarity and phase relation on the rated voltage connection.

No-load loss at rated voltage on the rated voltage connection.

Exciting current at rated voltage on the rated voltage connection.

Impedance.

Retain paragraph below if Owner wants tests to be witnessed.

* + - * 1. Director’s Representative will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
1. EXECUTION
	* + 1. EXAMINATION
				1. Examine liquid-filled, medium-voltage transformers upon delivery.

Upon delivery of transformers and prior to unloading, inspect equipment for any damage that may have occurred during shipment or storage.

Verify that tie rods and chains are undamaged and tight, and that all blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.

Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.

Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on high- or low-voltage bushing parts, and at transformer base.

Transformers are factory sealed under vacuum and pressurized to prevent contamination of insulating liquid by contact with moisture or ambient air.

Verify that there is positive pressure or vacuum on the tank. Check the pressure gauge; it is required to read other than zero.

Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.

Verify presence of polychlorinated biphenyl content labeling.

Unload transformers carefully, observing all packing label warnings and handling instructions.

Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

* + - * 1. Handling:

Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.

Protect transformer termination compartments against entrance of dust, rain, and snow.

Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in the windings. Do not tilt or tip transformers.

Verify that transformer weights are within rated capacity of handling equipment.

Use only manufacturer-recommended points for lifting, jacking, and pulling. Use all lifting lugs when lifting transformers.

Use jacks only at corners of tank base plate.

Use nylon straps of same length to balance and distribute weight when handling transformers with a crane.

Use spreaders or a lifting beam to obtain a vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.

Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

* + - * 1. Storage:

Store transformers in accordance with manufacturer's recommendations.

Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.

Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.

Store transformers with compartment doors closed.

Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions. Verify that an effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

* + - * 1. Examine areas and space conditions for compliance with requirements for liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.
				2. Examine roughing-in of conduits and grounding systems to verify the following:

Wiring entries comply with layout requirements.

Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

* + - * 1. Examine walls, floors, roofs, and concrete bases for suitable conditions for transformer installation.
				2. Pre-Installation Checks:

Verify removal of any shipping bracing after placement.

Remove a sample of insulating liquid according to ASTM D923. Insulating-liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:

Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.

Acid Neutralization Number: ASTM D974.

Retain "Specific Gravity" subparagraph below if Project conditions require. This is normally considered an optional field test.

Specific Gravity: ASTM D1298.

Interfacial Tension: ASTM D971.

Color: ASTM D1500.

Visual Condition: ASTM D1524.

Retain water-in-insulating-liquid test in "Water in Insulating Liquids" subparagraph below for transformers 25 kV and higher, and for all silicone-based liquids. For others, this is normally considered an optional field test.

Water in Insulating Liquids: ASTM D1533.

Retain power-factor or dissipation-factor test in "Power Factor or Dissipation Factor" subparagraph below if Project conditions require. This is normally considered an optional field test.

Power Factor or Dissipation Factor: ASTM D924.

Revise 5-ohm value in first paragraph below to suit Project conditions.

* + - * 1. Proceed with installation only after unsatisfactory conditions have been corrected.
			1. INSTALLATION

Retain first paragraph below to require equipment to be installed on cast-in-place concrete equipment bases.

* + - * 1. Install transformers on cast-in-place concrete equipment base(s).
				2. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.

Retain first paragraph below for interior installations. Indicate vibration isolation and seismic control device type and minimum deflection in supported equipment schedule on Drawings.

* + - * 1. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
			1. CONNECTIONS
				1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable, with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
				2. At Exterior Locations:

For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep lead lengths as short as practicable, with no kinks or sharp bends.

Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 feet Bond each gate section to fence post using 1/8 by 1 inch [**tinned**]flexible braided copper strap and clamps.

Make joints in grounding conductors and loops by exothermic weld or compression connector.

* + - * 1. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate number of conductors for termination.
				2. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.
				3. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
				4. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.
			1. KEY INTERLOCK PROCEDURE
				1. Remove padlock securing low-voltage compartment door handle.
				2. Release pentahead bolts.
				3. Obtain key from key interlock provided on the pad mounted high voltage switch and fuse assembly serving the transformer. (High voltage switch must be in the open position before the key can be removed).
				4. Insert key into key interlock on transformer low-voltage compartment door and release key interlock.
				5. Operate door handle to unlatch and open low-voltage compartment door.
				6. Release internal locking device that allows high-voltage compartment door to be opened.
			2. SIGNS AND LABELS
				1. Install warning signs as required to comply with 29 CFR 1910.269.
			3. FIELD QUALITY CONTROL

Retain "Testing Agency," "Manufacturer's Field Service," and "Perform the following tests and inspections" paragraphs below to identify who shall perform tests and inspections. If retaining second option in "Testing Agency" paragraph, or if retaining "Manufacturer's Field Service" or "Perform the following tests and inspections" paragraph, retain "Field quality-control reports" paragraph in "Informational Submittals" Article.

* + - * 1. Testing Agency: [**Director’s Representative will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

Retain "Manufacturer's Field Service" paragraph below to require a factory-authorized service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a Company Service Advisor to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform the following tests and inspections" paragraph below to require Contractor to perform tests and inspections.

* + - * 1. Perform the following tests and inspections[**with the assistance of a** **Company Service Advisor**]:

General Field-Testing Requirements:

NFPA 70B reference in first subparagraph below contains requirements for qualifications of test operators and test equipment.

Comply with provisions of NFPA 70B, Ch. "Testing and Test Methods."

Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

After installing transformer but before primary is energized, verify that grounding system at substation is tested at specified value or less.

After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.

Visual and Mechanical Inspection:

Verify equipment nameplate data complies with Contract Documents.

Inspect bolted electrical connections for high resistance using one of the following two methods:

Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.

Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

Remove and replace malfunctioning units and retest.

Prepare test and inspection reports. Record as-left set points of all adjustable devices.

Medium-Voltage Surge Arrester Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage, alignment, grounding, and clearances.

Verify arresters are clean.

Verify that ground lead on each device is individually attached to a ground bus or ground electrode.

Verify that stroke counter is correctly mounted and electrically connected if applicable. Record stroke counter reading.

Electrical Test:

Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.

Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

Liquid-Filled Transformer Field Tests:

Visual and Mechanical Inspection:

Test dew point of tank gases if applicable.

Inspect anchorage, alignment, and grounding.

Verify bushings are clean.

Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.

Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.

Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.

Perform specific inspections and mechanical tests recommended by manufacturer.

Verify presence of transformer surge arresters and that their ratings are as specified.

Verify that as-left tap connections are as specified.

Verify presence of surge arresters and that their ratings are as specified.

Electrical Tests:

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.

Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.

Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.

Retain power-factor test in first subparagraph below if the importance of the load served by the transformer warrants. This is normally considered an optional test.

Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.

Retain one or more of first four subparagraphs below if those tests are not included in "Source Quality Control" Article in Part 2. Turns-ratio, excitation-current, winding-resistance, and applied-voltage tests are normally considered optional field tests.

Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.

Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows a different pattern.

Measure resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in Operations and Maintenance Manual.

Perform an applied-voltage test on high- and low-voltage windings-to-ground.

Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

Remove a sample of insulating liquid according to ASTM D923, and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D3612.

* + - 1. FOLLOW-UP SERVICE
				1. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Director’s Representative, but not more than six months after Final Acceptance, perform the following voltage monitoring:

During a period of normal load cycles as evaluated by Director’s Representative, perform seven days of three-phase voltage recording at the outgoing section of each transformer. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during test period, is unacceptable.

Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

Adjust transformer taps.

Prepare written request for voltage adjustment by electric utility.

Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.

Report:

Prepare a written report covering monitoring performed and corrective action taken.

* + - * 1. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.

After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.

Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C.

Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists results as follows:

Description of equipment to be tested.

Discrepancies.

Temperature difference between area of concern and reference area.

Probable cause of temperature difference.

Areas inspected. Identify inaccessible and unobservable areas and equipment.

Identify load conditions at time of inspection.

Provide photographs and thermograms of deficient area.

Act on inspection results according to recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Director’s Representative's operations permit. Retest until deficiencies are corrected.

* + - 1. DEMONSTRATION
				1. [**Engage a Company Service Advisor** **to train**] [**Train**] Director’s Representative's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261213