

POWER TRANSFORMERS -GENERAL REQUIREMENTS

PART 1 -GENERAL

1.01 WORK INCLUDED

- A. The work consists of furnishing a Power Transformer(s) as herein specified, delivering transformer to the designated site, and installing the new transformer on the existing concrete foundation (8' X 14').

This section outlines equipment standards, and requirements for the transformer tank, weatherproofing and painting, oil preservation equipment, insulating oil, progress photographs, submittal requirements, and shipping, delivery, installation and field testing.

1.02 RELATED SECTIONS

- A. Division 0 of these specifications is a part of this section as if incorporated herein.
- B. Other related sections are as listed below.

1. Section 16-003, Power Transformers - Category III.

1.03 REFERENCES

The transformer, accessories and equipment shall be of a design accepted as standard except as otherwise specifically stated herein. The work shall, as a minimum, conform to applicable provisions of the latest edition or revision of the following standards, except as modified herein.

- A. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE):
- C57.12.00 General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.
 - C57.12.10 Requirements for Transformers 230 kV and Below 833/958 through 8333/10417 kVA, Single-Phase a 750/862 through 60,000/80,000/100,000 kVA, Three-Phase (Includes Supplement ANSI C57.12.10a)
 - C57.12.90 T e s t Code for Liquid-Immersed Distribution, Power and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers.
 - C57.13 Requirements for Instrument Transformers.
 - C57.19.00 General Requirements and Test Procedures for Outdoor Power Apparatus Bushings.
 - C57.19.01 P e r f o r m a n c e Characteristics and Dimensions for Outdoor Apparatus Bushings.
 - C57.92 Guide for Loading Mineral-Oil-Immersed Power Transformers up to and Including 100 MVA with 55°C or 65°C Winding Rise.
 - C57.98 Guide for Transformer Impulse Tests.
 - C57.109 Guide for Liquid-Immersed Transformer Through-Fault-Current Duration

C57.113 Guide for Partial Discharge Measurement in Liquid-Filled-Power Transformers and Shunt Reactors.

C57.131 Standard Requirements for Load Tap Changers.

B. American Society for Testing and Materials (ASTM):

A 343 Test Method for Alternating Current Magnetic Properties of Materials at Power Frequencies Using Watt Meter-Ammeter-Voltmeter Method and 25 cm Epstein Test Frame.

A 712 Test Method for Electrical Resistivity of Soft Magnetic Alloys.

A 725 Specification for Flat-Rolled, Grain-Oriented Silicon Iron Electrical Steel.

D 88 Test Method for Saybolt Viscosity.

D 92 Test Method for Flash and Fire Points by Cleveland Open Cut.

D 97 Test Methods for Pour Point of Petroleum Oils.

D 664 Test Method for Neutralization Number by Potentiometric Titration.

D 878 Test Method for Inorganic Chlorides and Sulfates in Insulating Oils.

D 971 Test Method for Interfacial Tension of Oil Against Water by Ring Method.

D 974 Test Method for Neutralization Number by Color Indicator Titration.

D 1275 Test Method for Corrosive Sulphur in Electrical Insulating Oils.

D 1533 Test Method for Water in Insulating Liquids.

D 1816 Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.

D 1933 Nitrogen Gas as an Electrical Insulating Material.

D 2029 Water Vapor Content of Electrical Insulating Gases by Measurement of Dew Point.

D 4059 Analysis of Polychlorinated Biphenyls in Mineral Insulating Oils by Gas Chromatography.

C. National Electrical Manufacturers Association (NEMA)

TR1 Transformers, Regulators and Reactors

1.04 DESIGN AND PERFORMANCE REQUIREMENTS

- A. The workmanship, design and materials shall be of the highest quality and be the most suitable for the application. The material shall be new, of proven manufacture, and free of defects. The design shall provide maximum mechanical and dielectric strength of the insulation, uniform flux density an distribution, minimum dielectric losses, minimum interference with oil circulation, and the elimination of potential discharge (corona) at test and operating voltages.

- B. All standard fittings and accessories shall be included and located in accordance with latest ANSI Standards.

- C. The transformer shall be constructed in accordance with ANSI/IEE C57.12.10 and shall include all items necessary for complete assembly. The material and workmanship shall be of high quality and the unit shall be modern in appearance and design.
- D. The transformer shall be designed and constructed to be completely self-protected by its ability to withstand, without mechanical damage, the effects of external short circuits, as specified in ANSI/IEEE C57.12.00, Section 7, ANSI/IEEE C57.12.90, Section 12 and ANSI/IEEE C57.109.

1.05 SUBMITTALS

The Equipment Contractor shall provide a complete schedule of data submittals within ten days of the receipt of Purchase Order.

- A. Submit Transformer Outline Drawing (including bushing, stud size and details of terminals), Transformer Base Details, Nameplate Drawings, and Auxiliary Schematic Diagrams, Physical Drawings for remote mounted equipment and performance data for review within one-fifth (20%) of the quoted delivery time. Submittal shall include the following data:
 - 1. Weight of core and coils.
 - 2. Weight of tank and fittings.
 - 3. Weight and quantity of oil.
 - 4. Total weight.
 - 5. Shipping weight.
 - 6. Height overall.
 - 7. Height over case.
 - 8. Floor space (footprint).
 - 9. Center of gravity.
 - 10. Details of bushings terminals

11. Location and detailed list of all accessories.
 12. Number, size and type of fan and/or pump motors.
- B. Bushing Drawings, Lightning Arrester Drawings, Radiator Details, Wiring Diagrams, and Current Transformer Curves shall be submitted for review within one-half (50%) of the quoted delivery time.
- C. Submit detailed specifications on painting and protective finishes.
- D. Submit proof of short circuit design considerations by short circuit calculations. The calculations shall include electrical and mechanical forces.
1. Short circuit force values shall include, but not be limited to, short circuit amperes, repulsion force in pounds and vertical force in pounds.
 2. Indicate mechanical safety factors used in design of: hoop strength of the outer winding, buckling strength of the inner winding, core clamp strength, vertical bar strength, clamping ring strength and jackscrew strength.
- E. Instruction Manuals shall be submitted for review four weeks before shipment. Instruction Manuals shall contain information on receiving, storing and assembly of the transformer; they shall provide complete description, including manufacturer's catalog or part numbers for all components, including, without limitation, relays, switches, bushings, arresters, gauges, LTC, radiators, valves and all other parts which might require maintenance or replacement in the course of normal operation. Copies of final approved drawings shall also be included.
- F. Submit impact recorder information with the shipping instructions, including manufacturer, type and model number of the impact recorders to be used. The Equipment Contractor shall also state the maximum limit the recorders can register both vertical and horizontal before the manufacturer considers

the transformers may have been damaged during shipment. The Equipment Contractor shall furnish the necessary information for releasing and returning the impact recorders at no additional cost to the Owner.

- G. Factory Tests: Certified test reports for tests performed by the manufacturer shall be submitted for review prior to shipment.
- H. Installation Tests
 - 1. A complete outline of the transformer installation testing procedures to be conducted by the Equipment Contractor shall be submitted to the Owner for review, and comments shall be incorporated before installation testing by the Equipment Contractor or his Subcontractor commences at the site.
 - 2. Submit final field test results, including the technician's field copied test sheets, before the equipment is delivered as ready to be put into service.
- I. Final record drawings shall be furnished via email in a format compatible with Autodesk AutoCAD Release 2018 (two copies). Drawings to be emailed to Lisa Crouthamel lcrouthamel@ocalafl.gov, Robert Whitehead Rwhitehead@ocalafl.gov, Matt O'Cull mocull@ocalafl.gov.

1.06 PHOTOGRAPHS

- A. The Equipment Contractor shall furnish photographs that shall be taken just prior to placing the completed core and coil assembly into the tank.
- B. Photographs are to be emailed to Robert Whitehead & Matt O'Cull. A total of five different views are required as follows (Segments as defined in ANSI C57.12.10):
 - 1. Top view.

2. Front view.
3. Left side view, Segment 2.
4. Rear view, Segment 3.
5. Right side view, Segment 4.

1.07 DELIVERY, STORAGE AND HANDLING

Deliver the transformer with all manufacturers' tags and labels intact. Deliver packaged material and equipment in manufacturer's original unopened containers bearing manufacturer's name. Handle and store the transformer and packaged materials in such a manner so as to avoid damage to the units.

1.08 WARRANTY

- A. The transformer manufacturer's warranty period shall extend five years from date of on-site acceptance test and incorporation of any comments made during the review of the test.
- B. The transformer manufacturer's extended warranty shall include all parts of the transformer regardless of manufacturer.

PART 2-PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. All material and equipment shall be new, approved and labeled, where required, by UL. Only products by manufacturers regularly engaged in production of specified units will be acceptable
- B. Where two or more units of the same class of equipment or materials are required, provide all units from a single manufacturer.

- C. Provide materials and equipment of suitable material to perform satisfactorily when exposed to conditions of project site.
 - 1. Provide breather and drain fittings in all raceways and enclosures where necessary to prevent condensation or trapping of moisture.
 - 2. Provide heaters in all control panels to prevent condensation.

2.02 TANK AND BASE

- A. The transformer tank shall be rectangular or equivalent oval and shall be of welded steel plate construction. Welding shall comply with applicable requirements of the latest codes of the American Welding Society. All tanks shall be suitable for vacuum filling in the field. Tanks, covers and appurtenances (i.e., valves, etc.) shall be designed to withstand full vacuum with 800 pounds on the cover, and shall include the required number of manholes in the cover necessary for inspection and installation (two minimum) with handholes as necessary. Minimum inside diameter of manholes shall be 20 inches.
- B. The tank cover shall be provided with lifting eyes for lifting cover or hood assembly only. The main tank shall be provided with lugs for lifting the entire unit with oil. Two copper-faced ground pads shall be welded at diagonal corners of the bottom of the tank for grounding purposes. Ground pads shall be drilled and tapped on 1.75-inch centers for 0.5-13 bolts. A stainless-steel name and diagram plate describing the unit, its taps and ratings, with schematic diagrams, shall be furnished and attached to the tank at not more than five feet above top of concrete pad. Screws, if used to attach name and diagram plate, shall be stainless steel.
- C. The base shall be furnished with pulling eyes and skid noses suitable for skidding on rails on rollers in directions parallel and perpendicular to a line through the high voltage bushings. Provision for jacking shall be furnished

per ANSI Standards. The transformer shall be provided with channel base rather than flat base, (the channel base shall not have a continuous plate on the bottom side) and shall allow free circulation of air to bottom of tank.

- D. The tank shall be furnished with a combination oil drain, sampling, and lower filter press valve and upper filter press valve. A vacuum filling connection shall be furnished on the cover. Gas purging connections shall be furnished on the side wall to allow purging from ground level.
- E. The transformer shall be furnished with two 1-inch valves located approximately 6 inches down from the cover. One valve is to be located at the end away from the vacuum connection on the low voltage side and one valve is to be located above the main drain valve. Three horizontal +++ marks shall be stamped on the tank directly above the main drain valve at the oil level required to cover the core, coils and all critical high voltage insulation.
- F. The transformer shall be furnished with detachable radiators with provisions to drain each individual radiator unit and with shut-off valves located between each radiator and main tank or header at both top and bottom connections. Valves shall be repairable without requiring a person to enter the transformer tank. Radiator flanges shall be supplied and arranged such that radiators may be mounted or removed for repair with 3500-pound handling facilities.
- G. All valves shall be designed and manufactured to operate at full vacuum.
- H. Hinged doors shall be provided in all outer tank walls for easy access to, and exposing, complete load tap changer compartment, inspection doors, drain and shut off valves, filling and vacuum plugs, vent and exhaust devices. Any hinged door exceeding 5 feet in height shall be split into two doors of equal vertical height.
- I. The transformer shall be equipped with one automatic reset pressure relief device per each 10,000 gallons of oil or fraction thereof in the main

transformer tank. The device(s) shall be located on the tank cover, complete with visual indicator and alarm contacts, shall be of self-resealing type and shall minimize discharge of oil and exclude the weather after operation. The device shall be located as close to the HV and LV bushings as practical for maximum protection of tank in the event of bushing failure.

- J. The transformer shall be equipped with 8510816 DBI Sala Advanced Portable Fall Arrest Post bases for attaching our fall arrest device when performing maintenance.

2.03 PAINT AND WEATHERPROOFING

- A. Exterior of transformer tank and base (and the outside shell of a double wall where required to maintain low noise level) shall be given two primer coats of one mil each and three finish coats of one mil each to a minimum thickness of 3 mils.
- B. The interior surfaces of the transformer tank, control compartment and tap changer compartment shall be primed and painted.
- C. Paint shall be the manufacturer's best quality specifically selected for the application and shall not be affected by insulating oil. Exterior finish shall be ANSI 70 Gray. Interior finish shall be white.
- D. Prior to painting, all surfaces shall be properly cleaned by sand blasting, shot blasting or be solvent-, steam-, or pressure-washed to remove all dirt, grease, rust or mill scale. After cleaning, all surfaces shall be degreased using an appropriate commercially available degreasing solution and rinsed with clean water, dried, primed and painted as outlined above. All galvanized surfaces shall be properly primed before painting.
- E. The transformer will be installed outdoors in a locality subject to high ambient temperatures, tropical hurricane winds and torrential rains. The Equipment Contractor shall be responsible for adequate weatherproof design to protect

against these conditions.

- F. External Fasteners (bolts, nuts, washers, lock washers, machine screws) for bolt thread diameters less than 5/16 inch shall be stainless steel or bronze. External fasteners for bolt thread diameters 5/16 inch or larger shall be hot dipped galvanized, stainless steel, or bronze.
- G. The transformer tank base and internal surfaces "boxed-in" by the support channels shall be undercoated with bitumastic at the factory.

2.04 OIL PRESERVATION EQUIPMENT

The transformer shall be provided with an approved type of automatic, positive pressure, gas seal system to protect the insulating oil against oxidation. The equipment provided shall be a complete unit with compressed gas cylinder, pressure regulator, necessary gauges, alarm contacts, valves and piping, all contained in a weatherproof cabinet on the side of the transformer tank. All gasket joints shall be located below the minimum oil level so transformer leaks will be detected.

2.05 INSULATING OIL

- A. Insulating oil shall be new fractionally distilled pure oxidation-inhibited mineral oil especially refined for transformers, free from moisture, acid, alkali and injurious Sulphur compounds and shall not form a deposit under maximum anticipated operating temperatures.
- C. Physical properties of insulating oil shall be as follows:
 - 1. Dielectric Breakdown Voltage - 35,000 volts min. (curved electrodes), ASTM D 1816.
 - 2. Viscosity - Not over 62 Saybolt at 37.8°C, ASTM D 88.
 - 3. Pour Point - Not higher than minimum -40°C, ASTM D97.
 - 4. Flash Point - Not under 146°C, ASTM D92.

5. Fire Point - Not Under 160°C, ASTM D 92.
6. Neutralization Number - 0.03 maximum, ASTM D 664 and D 974.
7. Interfacial Tension - 40 dynes per square centimeter minimum, ASTM D 971.
8. Water Content at 25°C -25 ppm maximum, ASTM D 1533 (Karl Fisher Method).
9. Corrosive Sulphur - None, ASTM D 1275.
10. Inorganic Chlorides and Sulphates - None, ASTM D 878.

PART 3-EXECUTION

1.01 SHIPMENT

- A. Assembly: The transformer core and coil shall be shipped completely assembled in the tank, in oil, or in a dry inert gas atmosphere having a maximum dew point of -50°F. The dew point of the gas in the tank shall be determined just prior to shipment. If shipped in dry inert gas atmosphere, the assembly shall be pressurized to 5 psig sufficiently in advance of shipment to permit verification that a seal is obtained. The transformer shall be shipped upright and as complete as possible consistent with shipment limitations and protection of the equipment. At the option of the Equipment Contractor, the oil, bushings, frames, minor accessories, and radiators may be shipped separately.
- B. Packing: The method of packing shall be such as to adequately protect the case, radiators, core and coils, bushings and all other auxiliary devices or accessories against corrosion, dampness, breakage, or vibration injury that might reasonably be encountered in transportation and handling. Packing crate shall be such that prolonged outdoor storage will not result in

deterioration of crates or damage to contents. A complete set of spare gaskets shall be shipped with the transformer.

- C. Weatherproof: All auxiliary equipment shall be shipped in weatherproof packages. Packing material shall be such that it will provide weatherproof protection for a period of one year in outdoor storage areas. Accessories shall not be shipped separately without the prior knowledge and consent of the Owner.
- D. Moisture Control: All conduits and auxiliary equipment mounting positions shall be sealed and/or covered to prevent water damage during storage.
- E. Positive Pressure: All valves, shipping covers, etc. shall be sealed and effectively crated to prevent tampering or removal while in transit, and a means shall be provided for allowing gas pressure to be measured without requiring release of the gas.
- F. Recorder Installation: The Equipment Contractor shall furnish a minimum of two each two-way (horizontal and vertical) impact recorders for the transformer shipped. Recorders shall be attached to the transformer and to the carrier on which the transformer is shipped. At least one recorder must operate satisfactorily throughout the time the transformer is in transit.
- G. Complete Shipment: Shipment of the transformer shall be made so that the transformer, complete with all accessories, can be made to an individual destination simultaneously. Fans shall be packed so they can be removed readily from the transporting unit for storage.
- H. FOB Site: Shipment shall be made FOB Foundation Pad at site (8' X 14'). Freight and handling shall be prepaid for delivery to designated site.

3.02 INSPECTION

- A. The transformer shall be inspected upon receipt. In the event residual pressure (allowing for differences in temperature) is not sufficient to ensure that positive pressure was maintained throughout the temperatures encountered during shipment, the transformer shall be considered as possibly contaminated by moisture, and special precautions acceptable to the Owner shall be taken by the Equipment Contractor prior to placing the transformer in service.

- B. Upon arrival and before unloading the transformer, the impact recorder tape will be removed and inspected by the Owner, the Equipment Contractor and the Carrier's Agent. It shall be the Equipment Contractor's responsibility to see that the transformer is supplied with a recorder that is still operating when the transformer is received. If in the opinion of the Owner, the Equipment Contractor or the Carrier's Agent the impact recorder tape or other considerations indicates rough handling during shipment, the Equipment Contractor shall take immediate action to determine if any damage has occurred and shall report in writing to the Owner defining the conditions that exist and recommending corrective action. It will be the Owners discretion of whether or not to proceed with repairs or reject unit based on the severity of damage. The recorder tape will be retained by the Owner for study and will be returned to the Equipment Contractor when studies are completed.

3.03 DELIVERY AND INSTALLATION

The transformer furnished hereunder shall be delivered to the Owner complete and ready to be placed in service, including satisfactorily completing all required field acceptance tests. The Equipment Contractor shall make all necessary provisions required for the transportation, receipt, handling and unloading of the transformer and provide delivery and placement as described herein. This shall include but not be limited to loading and unloading, rigging, transporting, handling, placing, assembling, filling with insulating oil, testing, checking of current transformers, relays and other accessories and/or auxiliaries and satisfactorily placing the transformer in service as work of this Contract. All work involved in assembling and testing the

transformer shall be performed under the supervision of a fully qualified factory trained service engineer and the Equipment Contractor shall provide all necessary supervision, labor, equipment, materials, tools and devices necessary for complete and satisfactory assembly and testing. The foundation will be provided by others. Connections to the high voltage, low voltage, neutral, and ground terminals, and connections of low voltage power, CT, and control circuits to incoming terminals will also be provided by others. The Equipment Contractor shall advise the Owner not less than ten days in advance of the date of arrival of the transformer.

3.04 FIELD INSTALLATION TESTS

All tests recommended or required by the transformer manufacturer shall be conducted; and, in addition thereto, a nitrogen dew point test, an oil analysis, Power Factor Tests, TTR tests, Insulation Resistance tests, current transformer tests, Leakage Reactance and an operational test of the sudden pressure relay. The hot oil and hot spot dial indicators shall be calibrated with the thermocouple in hot oil and a current input, where applicable.

- A. Insulating oil for the transformer shall be treated, heated, filtered and processed, with a vacuum in the tank, in strict accordance with the requirements of these specifications or in strict accordance with the published recommendations of the equipment manufacturer, whichever shall require the most complete treatment or processing. See Appendix 1. An oil analysis shall mean, as a minimum, the following tests: Dielectric test, acidity test, color test, power factor test and interfacial tension test. Where acidity, interfacial tension or other tests indicate the presence of acidic, colloidal or other contaminants, a re-refining process, the Fuller's Earth pressure percolation method, shall be used to remove these contaminants.
 - 1. The delivered transformer oil and oil used at the factory shall be non-PCB oil. The Manufacturer shall certify, by statement on the transformer test report, that all oil used in processing and testing the

transformer contained less than 2 PPM polychlorinated biphenyls as determined by test method ASTM D4059 or equivalent.

2. Failure of any of the above tests shall be grounds for refusal of the oil shipment, and a new shipment required immediately.
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- B. A complete Doble or Biddle power factor test shall be performed on the transformer. Power factor tests shall be performed in accordance with the standards and procedures established by the test equipment manufacturer for the type of equipment and voltage class applicable and shall include windings, bushing tests and surge arresters. Three copies of a complete written report shall be submitted to the Owner for each piece of equipment, identifying test equipment, the test procedures followed, and the "as-found" and "as left" condition of equipment tested.
 - C. Ratio Tests shall be made (1) at all connection positions of the manual tap changer for de-energized operation with the automatic load-tap-changer on the rated voltage position, and (2) at all automatic load-tap-changer with the manual tap changer for de-energized operation on the rated voltage position.
 - D. The insulation resistance test, by resistance bridge or an approved electronic voltmeter, shall be performed to produce results that can be directly compared to the technique used and the results obtained by the original equipment manufacturer for establishing the base resistance values. Resistance readings shall be recorded for all windings on the full winding tap position.
 - E. All current transformers shall be checked for ratio, saturation excitation, burden and polarization. The correct location and polarity as per identification marking shall be verified.

3.05 FACTORY SERVICE ENGINEER

The services of a fully qualified factory trained service engineer shall be made available during assembly, filling with oil and testing after assembly. The service engineer shall be made available for one eight-hour day to instruct Owner's personnel in the proper operation, adjustment, test, and maintenance of the transformer. Such instructions shall be in addition to work specified above.

- A. The work of the service engineer to be performed under the scope of this contract shall be coordinate with the work to be performed by the Owner.
- B. When the presence of a service engineer is required at the time equipment is placed in service, the service engineer shall perform all operations required to establish that the unit is ready to be placed in service, to advise the Owner when the unit is ready to be energized and upon approval by the Owner, to place the unit in service. As part of this operation, the service engineer shall afford opportunity to Owner's personnel to observe and learn the correct practices to be followed prior to energizing equipment.
- C. A fully qualified service engineer must be available upon 24 hours' notice and qualified shop facilities must be available within a radius of 400 miles of the Owner.

SECTION 16-000
APPENDIX 1 - OIL TREATMENT

A. GENERAL:

The purpose of this appendix is to set certain minimums for oil filling, which may be superseded by more stringent requirements of a particular equipment manufacturer. This appendix shall not be construed as establishing the details as to how the equipment is to be received, tested, erected, and made ready for installation and connection to the energized circuit; nor is it to establish the details as to how the oil that will be used in such equipment is to be received, treated and placed in such equipment. The details are to be established by the recommendations of the manufacturer of the equipment to be installed or by a good standard practice. Acceptable procedures, depending upon which establishes the most stringent requirements for the procedures required to erect or install the equipment or to process and treat the oil to be placed therein, are as follows:

- A. Those set forth in this appendix.
 - B. The published recommendations or requirements for procedures prepared by the equipment manufacturer.
 - C. Special recommendations or requirements issued by the equipment manufacturer for this application.
2. All appropriate receiving inspections and tests shall be made of and on the equipment to be installed. All operations required for the proper erection and installation of such equipment, including necessary detailed testing, shall be scheduled as shall the operations that are inherent in the testing and placement of oil. All necessary grounds shall be positively established including, without limitation, those

grounds required to control the development of static electricity and to disperse and eliminate any static electricity that develops.

3. All appropriate receiving tests shall be performed on the insulating oil. Tests shall be individually made and shall be complete for each compartment of each carrier. Certified copies of tests made at the depot where oil is placed in transport shall be compared with requirements of equipment manufacturer. Shipping and receiving tests shall demonstrate that the oil proposed for delivery meets the equipment manufacturer's requirements. Necessary arrangements shall be made for the delivery, placement and setup of oil processing equipment, necessary safety precautions shall be taken and provisions for required testing shall be satisfactorily completed.
4. Oil-processing equipment shall be of adequate capacity for the size of equipment to be installed and for the services required. Adequate vacuum levels must be maintained. The necessary corrective action shall be taken to eliminate leaks which would be a contributing factor to the inability to maintain and hold vacuum.
5. Important considerations are the elimination of moisture and oxygen, both in free air space or entrapped or entrained in windings or oil. Acceptable level of oxygen is 0%. Acceptable levels of moisture shall be stated in the published recommendation of the equipment manufacturer and shall be established by proper dew point tests.
6. Vacuum levels and periods of time for holding such levels shall be not less than those stated herein and shall be increased as necessary to maintain the levels recommended by standard test procedures or the specific recommendations of the equipment manufacturer.

7. All vacuum gauges shall be properly operable and shall have current calibrations.
8. Check rotation of pump and motor to confirm that the wheel of the pump is turning in the direction established by markings on the housing.
9. Establish with certainty that the valves to radiators, coolers, or other compartments (except conservator tank) connected to the main tank are open before drawing a vacuum on the equipment tank. Further attention shall be given to ensure that all interconnecting valves are operable and are in the proper position as are any connections or openings between the bushings, structural chambers, the bushing mounting and the main equipment tank and to ensure that the connections and valves to the conservator tank are in the proper position.
10. Disable the transformer load tap changer to ensure that the equipment cannot be operated while the main tank is under a vacuum.
11. Take the necessary steps, including but not limited to, grounding of terminals to ensure that no voltage is applied to the equipment while under vacuum. This includes the elimination of any test or other procedure which could cause any voltage in the equipment.
12. Equipment must be under the observation and control of qualified personnel while vacuum tests are in progress. This includes the periods of waiting while the vacuum is being held for stated periods of time.

13. In the event vacuum or oil processing equipment should fail during the accomplishment of tests or processing, it shall be necessary to restart the tests or processing procedure. This requirement for restarting procedures will not be justification for extension of contract time or changes in contract price, therefore it may be appropriate to have backup equipment available.
14. All necessary installation operations that are required shall be performed in a timely manner so that once vacuum procedures are established and the equipment has been dried, the oil may be introduced with minimum requirements for opening or otherwise reducing the quality of treatment of the environment in which the insulating oil is placed or of the oil itself.
15. All necessary precautions must be taken as regards the equipment to be installed, the test equipment, the oil, the oil handling and transfer equipment.
16. The Service Engineer, as required elsewhere in these specifications, shall be present at the time the equipment and oil is received, receiving tests are conducted and during all other procedures and tests for processing and placement of oil.

B. VACUUM AND RELATED PROCEDURES:

1. Dew point tests (ASTM D 2029) shall be conducted as part of the receiving test. In the event these dew point tests indicate moisture content above that acceptable to the equipment manufacturer, the carrier and the equipment manufacturer shall be notified, and operations suspended until instructions (to be confirmed in writing,

with copies to the Owner) are received from the equipment manufacturer.

2. A careful log shall be maintained of the time that the equipment is open. Operations shall be suspended, and equipment shall be closed if temperature, humidity, or other weather conditions are such that the operations requiring the equipment to be opened would jeopardize the condition of the equipment. The time that operations are suspended shall be counted as "open" time in determining how long equipment is to be held under a vacuum unless the equipment is sealed and secured under dry nitrogen (ASTM D 1933) at a minimum pressure of 3.0 psig.
3. If the dew point test conducted as part of the receiving test for the equipment demonstrates moisture content acceptable to the equipment manufacturer, and subject to acceptable temperature, humidity and other weather conditions, the necessary steps in the assembly and erection of the equipment shall be completed.
4. Information as to the local temperature, humidity and other weather conditions and the time required for the equipment to be opened for assembly and erection shall be coordinated with the Service Engineer. A record of such local weather conditions shall be maintained in the log.
5. The equipment to be installed shall be closed. Prior to closing, dew point tests shall be taken, following which the equipment shall be pressurized with dry nitrogen. The dew point of the dry nitrogen used to charge the equipment shall be taken and the equipment shall be allowed to sit a minimum of 24 hours, after which time a dew point test shall again be taken and, depending upon the moisture content evidenced by a dew point, the equipment processing shall proceed or shall be suspended, pending advice from the equipment manufacturer.

6. The degree of pressure to be applied shall be as established by the equipment manufacturer and shall be held for a period of 24 hours. Leaks, if any, shall be detected and corrected. The equipment shall be repressurized and held for a period of 24 hours and the process repeated until such time as satisfactory conditions are established. If satisfactory moisture conditions cannot be established after two pressure/vacuum/pressure cycles are completed, a complete dry-out procedure recommended by the manufacturer and approved by the Owner shall be satisfactorily accomplished.
7. The oil processing equipment shall be assembled. At an appropriate time, the vacuum equipment shall be connected from the vacuum pump to the equipment to be installed, making the connection at the approved vacuum connector location. Any vacuum/pressure detection or relief devices shall be left in an operating condition. Connection shall be made with a pipe of adequate size, but not less than 2-1/2 inches I.D. This pipe shall be used to connect the vacuum hose with the cutoff valve and a vacuum gauge. The vacuum millimeter sending unit shall be placed on the equipment to be installed in the most logical location.
8. Proper connection and testing of pumps shall be accomplished. The vacuum pump shall be run with the vacuum booster cut off at a 30- inch vacuum to establish that the pump is operating satisfactorily. The vacuum booster valve shall be open to dry the vacuum hose (by establishing a minimum reading of 0.2 millimeters under blanked-off conditions measured on the vacuum gauge connected to the vacuum pump).
9. Before opening the valve to extend the vacuum to the equipment to be installed, the initial moisture level shall be established by the dew point test.

10. After the dew point reading of the equipment to be installed is established, the valve at the top of the equipment shall be opened to extend the vacuum into the equipment and the exact time for opening the valve and initiating the vacuum shall be noted and recorded.
11. The vacuum shall be pulled to a level of 1.0 millimeter, or less.
12. The specified vacuum shall be maintained for a minimum of 24 hours, or 12 hours plus 2 hours for each hour that the equipment has been "open" or exposed to the atmosphere during installation and erection, whichever time shall be greater. If satisfactory moisture levels have been established prior to pulling down the vacuum test, proceed to Paragraph 21. If satisfactory moisture conditions have not been established by dew point tests, proceed as described in the following paragraphs.
13. Break the vacuum with extra-dry nitrogen. The condition of nitrogen used for this purpose shall be verified by a dew point test at the site.
14. Re-pressurize the equipment with extra-dry nitrogen in accordance with the recommendation of the equipment manufacturer.
15. Equipment shall be left under pressure for a minimum of 24 hours.
16. Conduct all required dew point tests of the equipment and verify that readings satisfy the requirements or recommendations of the equipment manufacturer.
17. If the dew point tests do not produce satisfactory results, the pressure/vacuum/pressure cycle shall be repeated. See Paragraph 6. If satisfactory results are obtained proceed as described in the following paragraphs.

18. Restart the vacuum pump in preparation of drawing the vacuum for oil filling. Start the pump, with the main valve on the equipment being installed closed, to pull pump and hose down to 0.2 millimeters under blanked-off conditions to ensure that pump and hose are working properly. Maintain vacuum for a minimum of one hour; leave the booster in manual mode, with booster valve closed, if booster is in service.
19. Open the main vacuum valve at the top of the equipment to be installed. Put the booster in the automatic mode and open the booster valve.
20. Pull the vacuum down to 1.0 millimeter or less (not more than 1.0 millimeter) and hold for a minimum of 12 hours.
21. Conduct necessary receiving tests on oil after vacuum conditions have been satisfied and oil satisfies the test requirements as specified by the equipment manufacturer. Start oil flow into the main tank.
22. Maintain a vacuum of not more than 3 millimeters while oil is filling.
23. Adjust flow rate of oil so that specified vacuum is maintained.
24. Bring the oil to the level stated by the manufacturer above core and coils. Once the oil has reached the established level, shut down the oil flow, maintain the vacuum pump in operation at not more than 1 millimeter of vacuum, for a minimum of four hours.

25. Break the vacuum with extra-dry nitrogen, with the condition of the nitrogen verified by on-site dew point test.
26. Pressurize the tank to the level specified by the equipment manufacturer. Following the recommended procedure stated by the equipment manufacturer, and fill other compartments as required.
27. Ensure that oil is filled to the level specified by the equipment manufacturer.
28. Be sure that all oil valves are left in proper position. Record all readings, have readings verified by the Service Engineer and deliver the original to the Owner's representative. Follow all necessary safety procedures. The responsibility for the equipment to be installed shall remain with the equipment manufacturer until the Service Engineer certified the equipment as ready to be energized and the equipment is accepted as being in this condition by the Owner's representative.