

## TRANSFORMER and OIL-FILLED REACTOR INSTALLATION PROCEDURE

### SP-TRF-INST

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## TRANSFORMER INSTALLATION PROCEDURE

### 1 Scope

The scope of this procedure is to provide general guidelines for receiving; installation; and baseline testing prior to initial energizing of all relocated and new substation class transformers, shunt reactors, large voltage regulators and other similar oil filled devices. Throughout this procedure, the term transformer is used in the generic sense and is meant to include all the equipment types listed above. For most of these devices, the installation activities are essentially similar to that of an oil filled transformer. Exceptions to this are for example: specific testing requirements and items that may not apply to a particular device, such as the testing of a load tap changer, which is not present on some transformers or on any reactors.

This procedure may not cover all types of transformers and/or accessories. Most transformer manufacturers require specific tests for validation of warranty. The manufacturer's guidelines may include additional tests or procedures that exceed this guideline. Obtain the manufacturer's installation guidelines before work is begun. When there is a conflict between the owner procedures and the manufacturer procedures, the owner procedures shall prevail unless specifically otherwise agreed to by owner's substation technical services.

### 2 Purpose

The purpose of this procedure is to ensure that PacifiCorp-owned transformers are properly installed and tested prior to placing them in service.

Specific instructions for transformers that are to be stored as spares, or for those for which the final installation is deferred temporarily, are listed in section 8 of this document.

Completion of owner forms will be required as part of the transformer receiving, installation and energizing work scope. These forms are listed in this document in section 4. Form SF-TRF-INST is required to be filled out per this transformer receiving, installation, and testing procedure.

### 3 References

- 3.1 Equipment manufacturer instruction manuals;
- 3.2 Confined space entry procedure;
- 3.3 PacifiCorp procedure SP-INSRES Insulation Resistance Testing;
- 3.4 PacifiCorp procedure SP-OIL-QUAL Oil Quality Analysis Sampling;
- 3.5 PacifiCorp procedure SP-TTR Transformer Turns Ratio (TTR) Test;
- 3.6 PacifiCorp contractor procedure SPC-TRF-OILPROC Transformer Vacuum Processing;
- 3.7 PacifiCorp procedure SP-OIL-DGA Dissolved Gas Analysis (DGA) Sampling;
- 3.8 PacifiCorp procedure PCP-CT-INST Current Transformer Installation;
- 3.9 PacifiCorp procedure PCP-RLY-INST-Q509 Qualitrol 509-100 Installation;
- 3.10 PacifiCorp procedure PCP-MTR-INST-INCON Incon 1250 Installation;

- 3.11 PacifiCorp procedure PCP-RLY-INST-M2001C Beckwith M-2001B/C Installation;
- 3.12 Exhibit A, section 16 – substation testing and commissioning specifications for contractors and / or Exhibit X – SLA substation testing and commissioning specifications; and
- 3.13 Equipment manufacturer’s installation / maintenance manual and procedures.

#### **4 Required documentation**

The forms and electronic test results listed below shall be completed and submitted to the owner for review before the transformer installation work can be accepted by the owner. Refer to section 10 for submittal instructions.

- 4.1 PacifiCorp form SF-TRF-INST Transformer Installation, Version 12;
- 4.2 PacifiCorp form SF-OIL-DGA Dissolved Gas Analysis (DGA) Sampling;
- 4.3 Laboratory generated DGA and oil quality data;
- 4.4 PacifiCorp form SF-TTR Transformer Turns Ratio Test;
- 4.5 PacifiCorp form SF-INSRES-XXX Insulation Resistance Test, where XXX is substituted with the letters corresponding to the specific form for the specified winding configuration.
- 4.6 PacifiCorp form SFC-TRF-OILPROC Vacuum Processing Log;
- 4.7 PacifiCorp form PCF-CT-INST Current Transformer Installation;
- 4.8 PacifiCorp form PCF-RLY-INST-Q509 Qualitrol 509-100 Installation;
- 4.9 PacifiCorp form PCF-MTR-INST-INCON Incon 1250 Installation;
- 4.10 PacifiCorp form PCF-RLY-INST-M2001C Beckwith M2001B/C Installation;
- 4.11 Field Sweep Frequency Response test reports generated from the test set, in both PDF and electronic raw data file format;
- 4.12 Power factor and excitation test results in both PDF and in electronic raw data files from Doble M4000 software; and
- 4.13 Impact recorder print-out or electronic recorded data file, if applicable.

#### **5 Equipment used**

- 5.1 Handheld digital multimeter;
- 5.2 TTR tester;
- 5.3 Sweep Frequency Response analyzer;
- 5.4 Insulation resistance tester;
- 5.5 Current transformer tester;
- 5.6 Oil quality sample containers;
- 5.7 DGA sample syringes;

- 5.8 Oil processing equipment, including cold trap unit;
- 5.9 Power factor testing equipment; and
- 5.10 Other equipment specific testers as may be needed.

## 6 Precautions

- 6.1 Follow all applicable PacifiCorp safety procedures.
- 6.2 Follow all testing precautions in referenced manuals, standards and procedures.
- 6.3 Follow all requirements from the confined space entry procedure.

## 7 Assembly and acceptance testing

### 7.1 Owner-installed transformers:

The activities listed in section 7.3 – 7.6 shall be performed and the results approved by the owner before the transformer is removed from the rail car or truck.

### 7.2 Vendor-installed transformers:

The activities listed in section 7.3 - 7.6 shall be performed as shortly as possible after the transformer has been placed on the pad or defined storage location.

### 7.3 Visual inspection – outside of transformer

**7.3.1** Verify that the transformer main tank has a positive pressure. If pressure is not positive, contact the owner immediately.

**7.3.2** Verify that there are no oil leaks.

**7.3.3** Inspect for signs of impact or any other damage such as broken tie downs, movement, etc.

**7.3.4** Inventory and inspect the auxiliary components (bushings, radiators, radiator fans, surge arrestors, device supports and braces, grounding materials, etc.). Refer to the manufacturer's parts list to inventory parts shipped separately from the transformer.

### 7.4 Impact recorder

**7.4.1** For contractor-installed transformers, it is preferable for a PacifiCorp representative to witness the impact recorder inspection if mechanical chart-type impact recorders were used. Contact the project manager to make arrangements for a PacifiCorp representative to witness the impact recorder inspection. For electronic impact recorders for which the data can be interrogated remotely, copies of the data recording shall be submitted to owner for review before dress-out of the transformer may begin.

**7.4.2** Obtain and review the impact recorder data. Paper recorders must be operational and recording. Data from electronic recorders must be downloaded and reviewed. If the equipment did not record or is not operational, contact the owner.

- 7.4.3** Record if any impacts were greater than three gravities (G). If impacts greater than three G's are discovered on the impact recorder, then the owner may require more acceptance testing. Contact substation technical services for determination of additional acceptance tests.
  - 7.4.4** Stop work and contact the owner immediately if impacts of greater than five G's are noted. If the transformer is still on the rail car or truck, do not unload until a complete internal inspection is performed unless express permission from the owner has been received to proceed with offloading.
  - 7.4.5** Impact recorder data (tapes, recordings or electronic data) must be included with the installation and testing documentation. The transformer serial number and equipment identification number shall be noted on the records.
- 7.5** Core ground test
- 7.5.1** If ship, rail car and/or trailer are used for transportation, a core ground test of each individual core ground connection shall be performed on the transformer before it is unloaded from all modes of transportation.
  - 7.5.2** Perform the test per the "Core Ground Test" section located in procedure SP-INSRES. Record values on form SF-TRF-INST.
  - 7.5.3** Contact owner's substation technical services representative immediately if the reading is below 1,000 megohms for new equipment or below 100 megohms for existing equipment. The test voltage shall be 1,000 VDC, unless the transformer manufacturer specifies a different test voltage.
- 7.6** Internal inspection
- An internal inspection shall be performed on all transformers shipped without oil unless waived by the owner. Contact owner's substation technical services at least five business days before performing an internal inspection to verify whether a PacifiCorp representative will witness the internal inspection.
- 7.6.1** Precautions
    - 7.6.1.1** Refer to the confined space entry procedure for requirements regarding breathing atmosphere monitoring and fall protection and retrieval equipment.
    - 7.6.1.2** Keep all loose items (bolts, nuts, tools, etc.) on top of the transformer tank away from any open manhole lid.
    - 7.6.1.3** Always apply a constant dry air purge when working internally to prevent atmospheric air from entering the transformer tank.
    - 7.6.1.4** Never allow rain or snow to enter the transformer.
  - 7.6.2** Visually inspect the inside of the transformer for any foreign materials such as metal filings, dirt or other abnormal conditions.
  - 7.6.3** Visually inspect all accessible internal components for damage incurred during loading and shipping of the transformer.

- 7.6.4** If a PacifiCorp representative is not present for the inspection, notify the project manager and owner's substation technical services immediately if any abnormal conditions are found in the transformer.
- 7.6.5** If the transformer will be left overnight or for any period longer than 12 hours without oil inside, care should be taken to prevent moisture from entering the transformer. Fill the transformer with dry air or nitrogen to a minimum of two to three psig of pressure.
- 7.7** Sweep Frequency Response Analysis (SFRA) – Before removing the transformer from the rail car or trailer.

**Note: This is only required if the transformer was shipped equipped with special test bushings for this purpose.**

For large or critical transformers the owner may require the manufacturer to install special test bushings to elect to have a secondary set of SFRA tests performed on critical units. This set of tests shall typically be performed with the transformer still on the rail car or trailer, and the transformer will have special dummy test bushings installed for this purpose.

- 7.7.1** For transformers with dummy test bushings, a SFRA test must be performed in accordance with Doble Engineering's guide titled "Power Transformer – Test Specification Transformer Sweep Frequency Response Analysis Test" (version 5.2 dated October 2006).
- 7.7.2** The tests shall be performed using exactly the same test configurations and tap positions as those performed at the factory. The field test configuration and setup will be logged in the notes section in the SFRA setup. The following items shall be recorded in the test configuration, if applicable:
- 7.7.2.1** DETC position;
  - 7.7.2.2** Neutral point grounded or ungrounded;
  - 7.7.2.3** Tertiary windings open or closed or closed delta, grounded or ungrounded; and
  - 7.7.2.4** LTC position.
- 7.7.3** Test results shall be compared to the equivalent tests performed by the manufacturer before the transformer was shipped from the factory. If any discrepancies are found, contact owner's substation technical services representative immediately.
- 7.7.4** Test results shall be labeled and identified for their purpose, date of test and location of test. The results shall be included with the final field test report and submitted to PacifiCorp documentation department on a CD-ROM in raw electronic data format (e.g. file.sfra) in addition to any other paper or scanned test reports.

**7.8 Oil test - bulk oil**

**7.8.1** Draw an oil quality sample for laboratory analysis on bulk oil prior to filling the transformer, per owner's procedures SP-OIL-QUAL and SP-OIL-DGA.

**7.8.2** Use form SF-OIL-DGA for logging the samples and submit the samples and form to a PacifiCorp-approved laboratory for analysis. A copy of the completed sample form shall be included with the documentation to be submitted to owner.

**7.9 Assembly**

**7.9.1** Follow the manufacturer's assembly instructions with particular emphasis on the steps outline below.

**7.9.2** Inspect the load tap changer for shipping damage, and follow manufacturer guidelines to complete any model specific installation tasks.

**7.9.3** Verify that the bushings are not damaged or leaking and have correct oil levels.

**7.9.4** Clean the top and bottom insulator surfaces and draw-lead tubes on all bushings prior to testing or installing in the transformer.

**7.9.5** Perform power factor tests on all bushings prior to their installation. Measure C1 and C2 capacitances and power factor on bushings where test or voltage taps are available. Compare results to nameplate details and factory test report and contact owner's substation technical services for any anomalies.

**7.9.6** Submit test equipment-generated report for bushing power-factor tests with installation forms. The original electronic data file generated by the test set shall be included on a CD-ROM in the "file.xml" format, in addition to any other scanned or paper documents. Label the test files to clearly indicate the purpose of the tests, date of tests and location of bushings.

**7.9.7** Install components (bushings, radiators, radiator fans, surge arresters, oil pumps, device supports and braces, grounding materials, temperature and monitoring devices, etc.) in accordance with manufacturer instructions and layout diagrams.

**7.9.8** If applicable, note the draw lead condition and length. Draw lead slack should not be greater than two inches.

**7.9.9** Surge arresters that are made up of stacked units shall be checked to ensure the correct serial numbers are used in each phase stack and that they are properly assembled with each unit in the correct location relative to other units in the stack.

**7.9.9.1** Verify that proper grounding connections are applied to all surge arresters.

**7.9.9.2** Verify that surge arrester expulsion vents face away from bushings.





**7.13 Transformer turns ratio (TTR) test**

**7.13.1** Testing of transformers without Load Tap Changers (LTC) shall include measuring the ratios on all five de-energized tap changer (DETC) positions.

**7.13.2** For transformers with LTCs, measurements of the ratios on LTC positions 16 Lower through 16 Raise shall be completed with the DETC in the position that it will be in during normal operation of the transformer. Contact the project manager to determine the final operational position of the DETC before performing the tests.

**7.13.3** Testing results shall be recorded on form SF-TTR. If an electronic TTR test set is used, the test set generated data file together with a printout of the electronic test results (in PDF format) shall be attached to form SF-TTR. Filling out of the calculated and measured results on form SF-TTR is not required if electronic test results are attached.

**7.13.4** Any test values that are not within the acceptable criteria outlined in section 9 of this document or as specified in the procedure SP-TTR shall be brought to the attention of owner's substation technical services representative immediately.

**7.14 Power factor/exciting current test****7.14.1 Power factor tests**

**7.14.1.1** Power factor testing shall be done in accordance with the test equipment manufacturer's published data.

**7.14.1.2** Perform a overall power factor test on all windings and the oil.

**7.14.1.3** Repeat C1 and C2 power factor tests on all bushings that have potential taps after bushing installation.

**7.14.1.4** Any test results that deviate from acceptable industry standards or the manufacturer's published acceptable values shall be brought to the attention of owner's substation technical services representative.

**7.14.1.5** In addition to a printed or PDF report, the original electronic test file in original Doble software raw data format (file.xml) will be included on a CD-ROM or in the email message together with the rest of the documentation package for owner review.

**7.14.2 Excitation tests**

**7.14.2.1** Exciting current testing shall be done in accordance with the test equipment manufacturer's published data.

**7.14.2.2** Perform exciting current tests on all de-energized tap positions with the LTC on neutral.

**7.14.2.3** Perform exciting current tests on all LTC positions from 16L-16R with the de-energized tap changer on the final de-energized tap position per protection and control relay settings sheet.

**7.14.2.4** Any test results that deviate from the manufacturer's published acceptable values shall be brought to the attention of owner's substation technical services representative.

**7.14.2.5** In addition to any printed reports, the original electronic test file in original Doble software raw data format (file.xml) will be included on a CD-ROM together with the rest of the documentation package for owner review.

## **7.15** Sweep Frequency Response Analysis (SFRA)

**7.15.1** A sweep frequency test is required once the transformer is installed in its final position.

**7.15.2** Perform Sweep Frequency Analysis Test in accordance with Doble Engineering's guide titled "Power Transformer - Test Specification Transformer Sweep Frequency Response Analysis Test" (version 5.2, dated October 2006).

**7.15.3** This guide is available from Doble Engineering, or a copy can be obtained from owner's substation technical services.

**7.15.4** The tests shall be performed using exactly the same test configurations and tap positions as those performed at the factory. The field test configuration and setup will be logged in the notes section in the SFRA setup. The following items shall be recorded in the test configuration, if applicable:

**7.15.4.1** DETC position;

**7.15.4.2** Neutral point grounded or ungrounded;

**7.15.4.3** Tertiary windings: open; closed delta; buried; accessible; grounded or ungrounded; and

**7.15.4.4** LTC position.

**7.15.5** These test results shall be compared to the equivalent tests performed by the manufacturer prior to shipping the transformer. If any discrepancies are found, contact owner's substation technical services representative immediately.

**7.15.6** If the standard configuration tests for the specific winding layout are different from the tests performed at the factory, repeat a full set of tests in the recommended test positions as described in the Doble Engineering test specification listed in 7.15.2 to obtain a set of standardized baseline tests for future reference.

**7.15.7** All test results shall be submitted to the PacifiCorp documentation department on a CD-ROM in original electronic Doble software raw data format (file.sfra), in addition to any other paper or scanned test reports. If more than one set of tests were performed, each shall be clearly identified for the exact purpose both in the software comments and in the documentation submittals.

**7.16** Insulation resistance test

**Caution:** Any DC test may magnetize the core.

**7.16.1** Perform an insulation resistance test as per procedure SP-INSRES.

**7.16.2** Use form SF-INSRES-XXX Insulation Resistance (where XXX represents the letters used for the specific configuration of transformer) to record the test results.

**7.17** Test and calibrate all auxiliary devices.

Perform operational and calibration checks on all applicable auxiliary devices listed below. This list may not include all transformer auxiliary devices installed on the transformer. Additional devices not listed in this document may also need testing.

**7.17.1** Fans

Each fan shall be checked for proper operation. Test shall include a check for correct fan rotation.

**7.17.2** Pumps, if applicable

Each pump shall be bump tested for proper operation. Check each oil pump flow indicator to ensure proper operation and pump rotation.

**7.17.3** Temperature gauges, if applicable

**7.17.3.1** Each temperature gauge and its micro-switch contacts (for fans, alarming and tripping) shall be checked for proper operation.

**7.17.3.2** Contact temperature set points shall be set per PacifiCorp's transformer specification.

**7.17.3.3** The alarm and trip logic shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

**7.17.3.4** Record the transformer oil temperature as indicated on each gauge on form SF-TRF-INST.

**7.17.4** Liquid level gauges

**7.17.4.1** Each liquid level gauge and its micro-switch contacts (alarming and tripping) shall be checked for proper operation.

**7.17.4.2** The alarm and trip logic shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

**7.17.4.3** Record the liquid level as indicated on each gauge on form SF-TRF-INST.

**7.17.5** Pressure relief device

**7.17.5.1** Inspect the pressure relief device(s) and assemble the yellow operate flag.

**7.17.5.2** Each pressure relief device shall be inspected and its alarm contacts shall be checked for proper operation.



output terminal blocks.

**7.17.11.4** Record the pressure indicated on gauge on form SF-TRF-INST.

**7.17.12** Cooling loss of power

**7.17.12.1** Each under-voltage alarm relay shall be tested for proper operation.

**7.17.12.2** Relay contacts will be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

**7.17.13** LTC failure, if applicable

**7.17.13.1** The LTC failure indication alarm shall be tested for proper operation in accordance with the manufacturer's specifications.

**7.17.13.2** The alarm contact shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

**7.17.14** LTC vacuum interrupter protection circuit

**7.17.14.1** Verify correct operation of the LTC vacuum interrupter protection circuit in accordance with manufacturer instructions.

**7.17.15** LTC filter, if applicable

**7.17.15.1** The LTC filter indication alarm shall be tested for proper operation in accordance with the manufacturer's specifications.

**7.17.15.2** The alarm contact shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

**7.17.16** Desiccant/dehydrating breathers, if applicable

**7.17.16.1** Verify that desiccant breathers for both the main tank and LTC compartment are assembled in accordance with the manufacturer's instructions.

**7.17.16.2** Verify that the breathing cups are properly filled with oil, and that the desiccant containers are properly filled with new desiccant.

## **8 Spare transformers or transformers installed in a temporary location**

Transformers that are designated to be stored as spares or that will be installed in temporary location shall be handled in the same manner as transformers that are to be installed ready to be energized, with the following additional requirements:

- 8.1** On a case by case basis, and only with specific prior approval from owner's substation technical services: Transformers that are already earmarked for installation in a substation and that will be in temporary storage for less than three months may be exempted from oil filling, dress out and testing until they are moved to their final destination. Contact owner's substation technical services for approval and specific

instructions before work is started.

**8.2** Unless specific other instructions are provided by PacifiCorp, transformers shall be installed on suitable treated timbers. Timbers shall be of quality and size that they will withstand the weight of the transformer and they shall be treated to withstand years of outdoor exposure.

**8.3** Unless specific other instructions were provided by PacifiCorp, radiators and radiator fans will not be installed.

**8.3.1** Radiators shall be filled with nitrogen to keep moisture from coming in contact with the radiator internal walls.

**8.4** Transformers that are filled with oil but without the radiators installed shall be overfilled to compensate for the oil that would normally be contained by the radiators. The purpose of this is to minimize or avoid the need for make-up oil once the radiators are installed at a later date.

**Warning: Verify that sufficient expansion space remains in the overfilled transformer to prevent damage due to expansion of oil as a result of ambient temperature changes.**

**8.5** If make-up oil has to be added to a transformer it shall be added by following all the requirements of owner procedure SPC-TRF-OILPROC. Oil that is added shall be processed by degassing and heating first. A vacuum shall not be pulled on an oil-filled transformer before adding oil. Contact owner's substation technical services for specific arrangements.

**8.6** All equipment and accessories shall be installed and tested as described in this document, with the exception of the radiators, cooling fans and surge arresters.

**Note: If electrical power is not readily available for testing purposes, the installer shall make the necessary arrangements to provide power through the use of a portable generator.**

**8.7** After all testing has been completed, short all bushings together with suitable copper wire. The shorted bushings shall then be connected to the tank wall and ground, if possible.

**8.8** If site AC power is available, connect the power source to the transformer to power the control cabinet heaters during storage.

**8.9** Any miscellaneous parts associated with the transformer that are not installed on the transformer shall be clearly marked using a weather-resistant method and stored near the transformer.

**8.9.1** This would include items such as radiators, fans, cooling pumps, surge arresters, arrester brackets, bushing cover plates, etc.

**8.9.2** All such accessories shall be stored on pallets and covered with tarpaulins in a manner that will ensure they will not be damaged if stored for any length of time. The pallets shall be located to allow easy access so they can be ready for shipment in a short period of time.

## 9 Minimum acceptance criteria

In order for the owner to accept the transformer as being ready for service, the following acceptance criteria apply for new transformers. If the transformer fails to pass any of the tests below, corrective action will have to be negotiated with the owner before the transformer can be accepted.

### 9.1 TTR test

The TTR test shall test for correct ratio on all five DETC positions. For transformers with LTC the TTR test shall test for correct ratio on steps 16L through 16R.

**9.1.1** No deviation greater than 0.5 percent from the manufacturer factory acceptance test results is accepted. Each tap position (16L through 16R) must be tested with the de-energized tap changer in the nominal position.

### 9.2 Power factor test

**9.2.1** Overall power factor and bushing tests should have no more than 0.5 percent deviation from nameplate or factory tests, with a maximum absolute power factor value of 0.5 percent. Perform C1 and C2 bushing power factor tests. All tests should have a pass rating assigned by the internal software analysis feature, if applicable.

### 9.3 Excitation test

**9.3.1** No mismatch greater than 0.5 percent from the factory test results is accepted.

**9.3.2** The core shall not be magnetized. If any test results indicate the core may be magnetized, the core shall be demagnetized and the excitation and SFRA tests shall be repeated.

**9.3.3** Tests shall be performed with the de-energized tap changer in the final in-service tap position, and all load tap changer positions from 16L – 16R.

### 9.4 Insulation resistance tests (core ground and windings)

**9.4.1** Minimum of 1,000 megohms for new transformers, and minimum 100 megohms for used transformers is required.

### 9.5 Accessories

**9.5.1** All mechanical and electrical accessories must be installed and functioning as designed.

### 9.6 Documentation

**9.6.1** All receiving and installation checks and tests must be documented and submitted as described in section 10.

## 10 Post-installation activities and documentation submittals

**10.1** Once all installation activities have been completed, all pallets, scrap materials and other shipping or assembly materials that are no longer needed or used shall be properly disposed of. The work area around the transformer shall be left in similar condition as when the work started.

- 10.2** Failure to submit proper test reports as described below may lead to a delay of acceptance of the transformer by the owner. Equipment shall not be energized under any circumstances if all installation and test reports have not been reviewed and accepted by the owner. In addition, delays in submitting test reports may result in a delay of payment to the manufacturer or contractor. Field copies of installation tests and reports shall be submitted to owner for review during and no less than two days after completion of installation work. After all installation and testing is completed, a final field installation test report shall be submitted that shall include the following information:
- 10.2.1** A cover page listing the transformer test location, transformer serial number, transformer purchase order (PO) number, transformer equipment number (SAP number), date of tests, name of test company and their test personnel contact numbers.
  - 10.2.2** An index page listing all test results included in the report.
  - 10.2.3** Doble power factor and excitation electronic data test files (in "file.xml" format) and Doble SFRA electronic data test files (in "file.sfra" format) shall be included with the electronic test report as attachments in addition to any other printed results for those tests.
  - 10.2.4** Final copies of all field installation forms used for recording accessory inspections, testing or verification and electrical test results such as transformer turns ratio, insulation resistance (e.g. Megger) and vacuum processing log sheets shall be included as attachments with the test report.
  - 10.2.5** Copies of lab test results for oil samples (DGA and oil quality, corrosive sulfur, etc.) shall be included with the test report.
- 10.3** All test reports shall be signed and dated by the test personnel who performed the work. Contact details for test personnel shall be provided.