

## Technical Bits . . . *of knowledge*

### Receiving Large Power Transformers – TB003

The most costly investment in an AC high-voltage substation is typically the power transformer (excluding static VAR compensators, AC-DC conversion stations, large generators, etc). Not only is the power transformer typically the most expensive piece of major apparatus, but many times it also has the longest lead time. Additionally, unlike the other major apparatus, it takes a very coordinated effort to ship a large power transformer in or out of a high-voltage substation. In the event that a major defect is identified, the damaged unit must typically be returned to the factory for repair and re-testing.

For the reasons outlined above, it is advisable to achieve a level of comfort that when a large power transformer arrives on site, it is in good condition. The transformer is fully tested at the factory before shipment. However, prior to shipment the transformer is disassembled (i.e. radiators, external devices, and bushings are typically removed and packed). Also, depending on the size of the transformer and depending on the route of delivery the oil may also have to be drained from the transformer (i.e. transformer is shipped with dry air). Next, the transformer is loaded on a truck or rail car where it leaves for the final destination. As you can imagine, many things can occur between factory testing and arrival on site which may make the transformer inoperable. Some of these include:

- Dropped debris/materials in the main tank, which undetected can lead to insulation failure or flashover
- Improper sealing of the main tank, which leads to wet a core and windings
- Humping of rail cars, which can lead to core and winding movement/distortion
- Traffic accidents and/or road incidents, which can lead to core and winding movement/distortion
- Vandalism

Prior to releasing a transformer for shipment (from the manufacturer's test floor), the following recommendations are provided:

- Ensure that all tests were properly performed with the actual components that will be shipped to the site (i.e. radiators, bushings, etc). It is not advisable to allow testing to be performed using factory test components (i.e. radiators, bushings, etc). Using the actual components that will be assembled on site provides you with a comfort level that the components will properly be fit when assembled on site, and test results using the actual components will provide you with a better benchmark to compare with field-test results (specifically when it comes to component sensitive tests such as the sweep frequency response analysis (SFRA)).
- Review all factory acceptance test (FAT) results
- Ensure that at least two (2) impact recorders (with 3-axis measurements) are installed **and operational** on the main tank upon completion of the testing and before the transformer is removed from the test floor. Modern impact recorders include satellite global positioning capabilities such that the client can track the location of the transport and/or monitor the recorded data.

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- Ensure that the tank is sealed and pressurized. This step is very important to ensure that the core and windings remain dry.

Upon arrival on site and once the transformer is set on the foundation (final destination), an inspection and testing should be performed as soon as possible to ensure proper shipment:

- Visual inspection to identify signs of vandalism and/or problems which may have been encountered during shipment
- Verify that the impact recorders are still enabled and operational
- Download or removal of impact recorder readings to check of accelerations which may have exceeded the manufacturer's acceptable criteria
- Verify and record positive tank pressure
- Check dryness of transformer internals
  - If the unit was shipped without oil, perform a dew-point measurement
  - If the unit was shipped with oil, perform an oil screen to determine the quality of the oil and compare with results from FAT.
- Test the core ground. It is advisable that the transformer specification is written such that the core ground bushing is accessible without opening the tank. Typically, a 1 kVDC Megger is used for this test, however, the test voltage and duration of the test should be confirmed with the manufacturer.
- For large units that are shipped from overseas, the client may request that the transformer is shipped with "temporary bushings" which can be quickly field-installed when the unit arrives such that a SFRA test can be performed before the transformer is filled with oil or dressed out. If this is to be done, then it is very important that the transformer is also SFRA tested with the "temporary bushings" at the factory before shipment. This will provide a baseline for comparison with field-tests.

In some cases, the manufacturer or client may opt to perform some or all of these tests at various points of the transportation. For example, if a unit is shipped from overseas by ship, then by rail, and then by truck, the manufacturer or client may request that some of the tests are performed when the ship arrives in the port or when the transformer is received on the rail car. In the event that the tests show that the transformer was damaged during that segment of transport, the ability to identify the responsible party will be much easier. Also, turning the transformer around to the factory for repair at that point will greatly reduce the delays when compared to discovering the defect once the transformer arrives on site.

These tests/inspections are not guaranteed to detect all of the defects. The final acceptance electrical field- tests after the transformer has been fully assembled serves this function; however, early detection can make a difference in whether the project is completed on-time and under-budget or not.