

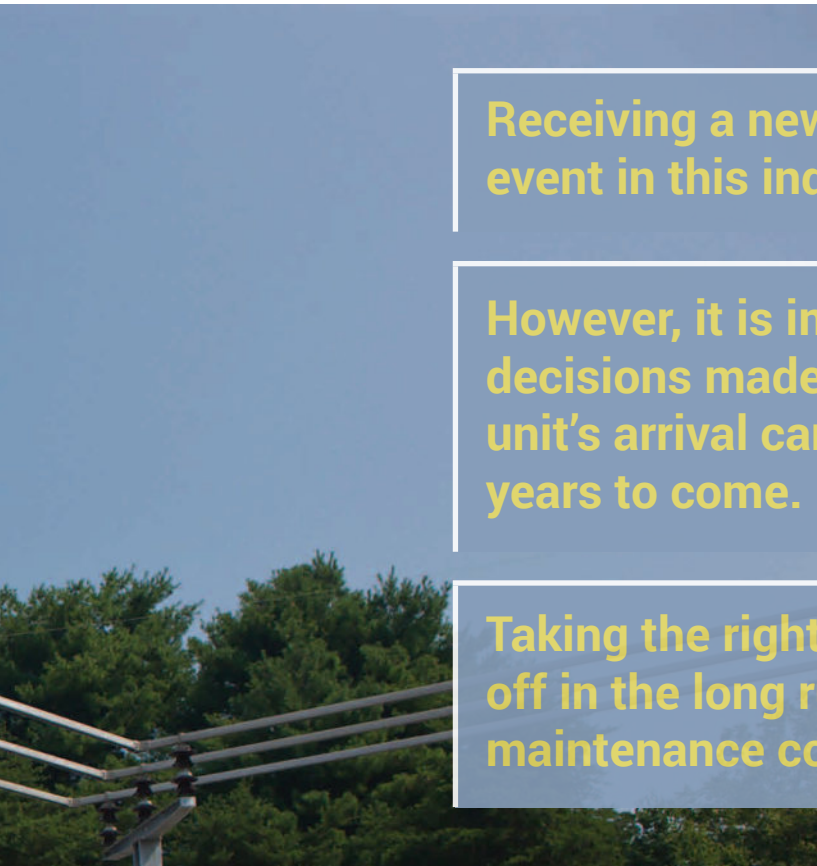
Right from the Start:

Best Practices for Transformer Testing & Inspection Upon Arrival

by **Shane Smith**
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Shane Smith received his BSEE from Virginia Tech and started his career with Delta Star in 1997. He has worked in the electrical industry for over 20 years with expertise in transformer testing and controls while simultaneously playing a critical role in the development of technical relationships. He is currently employed as the Director of Quality for Delta Star, is a certified Six Sigma Black Belt and a member of IEEE.



Receiving a new transformer is a familiar event in this industry.

However, it is important to remember that decisions made immediately upon a new unit's arrival can affect costs and labor for years to come.

Taking the right steps initially can pay off in the long run through reductions in maintenance costs and downtime.



Here are some best practices to observe as soon as the new transformer arrives.

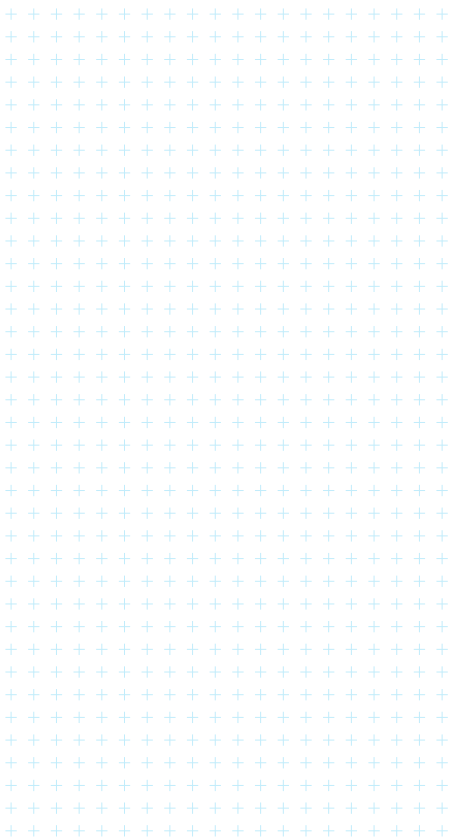


A Thorough “Once-Over”

First, did the transformer truly arrive safely? If the unit shipped with an impact recorder, check to ensure that it had a smooth trip. Impacts *on any axis of 4 Gs or greater* may indicate rough handling that could potentially have caused damage to the transformer.

Otherwise, inspect closely for any signs of damage that may have occurred during transit. Scuffs, dents, and scrapes in the paint are obvious clues, but take a careful look at all of the following:

- Tie rods or chains used to secure unit to trailer or rail car
- Tank pressure level – [See Slidebar 1](#)
- Signs of leaks on the main tank (for units shipped with oil) and bushings
- Attached fittings, conduits, cabinets, boxes, terminals, gauges, valves and switches
- Condition of all accessories, such as radiators, fans, bushings, etc. (Loose condenser bushings can also undergo power factor testing upon receipt outside the transformer, provided they are properly configured with test taps, and are upright and stabilized.) – [See Slidebar 2](#)



Exercising due diligence in the initial inspection and testing process can pinpoint issues that could lead to unplanned outages down the road.



Photo: Delta Star

Sidebar 1

Perform Pressure Check

In order to maximize the life of the transformer, we must keep moisture out of the insulation system. Tank pressure is a critical factor to observe because it serves as an indicator of potential moisture ingress into the winding insulation.

Check the gas pressure in the transformer as soon as possible after arrival. The transformer will have been pressurized at the factory (commonly to approximately 5 psig, but this can vary according to manufacturer)—so if gas in the tank is at atmospheric pressure, there could be a leak in the tank.

When a unit ships empty, the pressure that was initially applied at the factory will vary based on thermal changes, but normally a unit should not arrive at zero pressure or in a vacuum state.

When a unit ships oil filled, there is a much smaller gas space, and the pressure changes relative to the factory benchmark can be more substantial as the oil level varies with temperature changes. The pressure may transition to a vacuum state (if the temperature drops) or increase to the point where the pressure relief device actuates (if the temperature increases).

If there has been no pressure change since the unit left the factory, then there has been no opportunity for moisture to enter the unit, and you can rely on the manufacture’s original dew point, which was captured under stable, controlled conditions.

Sidebar 2

Perform Power Factor Test

For units that arrive fully assembled and oil filled, Power Factor testing should be a priority. Performing capacitance and dissipation tests on the bushing insulation can be an extremely valuable precaution.

Capacitance readings from the bushings can show whether moisture acquired during shipment has compromised the performance of the capacitive layers. (A rise in capacitance of more than 10% points to a potentially hazardous condition.)

Looking Deeper

Once the external condition has been assessed, it’s time to examine key internal and functional details— all of which further confirm that the transformer is properly fit for service. (Note: Do *not* attempt electrical testing on units in a vacuum state.)

Confirm Core to Ground Insulation Resistance

Using an insulation resistance meter (usually at 1000 Vdc), check the resistance from the core ground bushing or grounding strap. A reading below 100 Meg Ohms should be reported to the manufacturer.

It is also important to identify whether the unit is gas filled or oil filled so the results can be properly compared to the manufacturer’s original readings in the same condition.

Verify Moisture Levels

For units shipped without oil and filled with dry air or nitrogen, there is little chance the insulation system has picked up any moisture if positive pressure is present upon arrival. To be certain, check the dew point of dry gas in the transformer and compare it to the factory results.

The factory dew point readings are often taken indoors and therefore in a stable thermal environment. Thermal stability can be difficult to replicate in the field due to constantly changing ambient conditions, but early morning is generally the best time.

For units shipped in oil, it is advisable to take an oil sample in a syringe and have an oil lab measure its moisture content.



Sweep Frequency Response Analysis (SFRA)

For units that arrive with bushings installed (temporary shipping bushings work as well), SFRA testing is another preliminary test that can help determine if there has been any mechanical change or damage during transportation. Sweep Frequency Testing can be performed prior to removal from the truck or railcar and compared to factory results.

If external damage or impacts greater than 4Gs are noted, an internal inspection may be justified to look for signs of movement or shifting. Contact the manufacturer to discuss the findings that led to inspection, and to identify the specific features to inspect.

Before undertaking any internal investigation, remove pressure slowly. Purge the unit with dry air to minimize moisture ingress and verify the air quality inside the unit per OSHA and safety requirements, as some will ship filled with nitrogen.

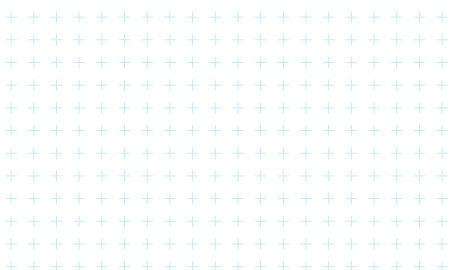
All of these precautions should be taken before the unit is removed from the truck or railcar, and any concerns should be documented in photos and reported to both the manufacturer and the carrier.

Keep all materials in the shipment together; if components are damaged and must be replaced, be sure to reunite those replacements with the original shipment.

Preparing for the Future

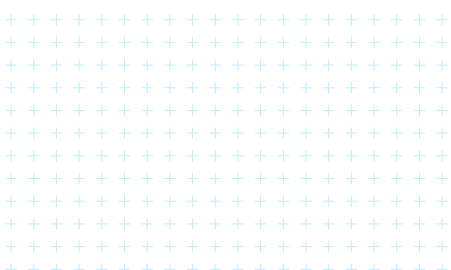
The next steps of the receiving process are determined by the transformer’s assignment status. Specifically, is it headed into storage, or immediately into service?

Ideally, the transformer would be completely assembled and filled with oil immediately upon arrival, but if the unit is destined for storage, this may not be practical. In those cases, the methods to employ will be based on the expected duration of storage and will largely revolve around guarding against condensation and rust.



Short-Term Storage

For units that will be stored for one to three months, pressurize the tank with dry gas at approximately 5 psi. Record the initial pressure, then check and log pressure levels at least monthly—with weekly measurements being preferable. Supply power to the control cabinet and energize the heater to prevent condensation – See [Slidebar 3](#).



Long-Term Storage

For storage periods greater than four months, the transformer should be completely assembled (including radiators), vacuum processed, and filled with oil above the 77°F/25°C level, leaving at least 6 inches for oil expansion. Pressurize the tank to approximately 5 psi. Pressure should be checked and logged at least monthly to ensure that this pressure is maintained. (All readings should indicate either positive or negative pressure.) Supply power to the control cabinet and energize the heater.



Leaving transformers empty for an extended period of time is a major risk, due to the threat of moisture damage to the insulation.

Sidebar 3

General Storage Tips:

- Units stored outside should have their bushings and tank properly grounded to help prevent damage during electrical storms.
- Fill radiators with oil or pressurize with dry gas to prevent rust.
- Remove protective covers from fans and gauges; store accessories in a dry location.



Assemble and Oil Fill as Soon as Possible

Leaving transformers empty for an extended period of time is a major risk, due to the threat of moisture damage to the insulation.

Oil filling and assembling the units promptly not only protects and preserves the solid insulation, it also enables prompt testing such as:

- Baseline DGA
- Oil Quality Testing
- Turns Ratio
- 10 kV Excitation
- Power Factor & Capacitance
- Bushing Power Factor & Capacitance
- Insulation Resistance of Windings
- Insulation Resistance of Core
- Winding Resistance
- Control Functions
- Current Transformer Ratio and Polarity

Keep those points in mind when evaluating storage plans. For many utilities, maintaining a spare transformer fleet has become a top priority. Given the fact that those spares may not be fully assembled, filled and dressed out, careful and consistent testing and evaluation

throughout the storage period becomes essential to keep the spares ready for prompt deployment.

Coming out of Storage

When the transformer is removed from short-term storage, measure the empty unit's dew point and compare to the figures obtained upon arrival. If the moisture exceeds the manufacturer's allowable range, follow the manufacturer's dry-out procedures.

Another critical post-storage consideration is tank pressure. Take a final reading prior to installation and compare to the readings compiled over the storage period. All readings should show either positive or negative pressure (or both) but should not have dropped to zero and remained there. A sustained zero pressure level likely indicates a leak, which will have to be repaired before installation.

Careful Installation

Installation and commissioning can now be accomplished following the manufacturer's instructions.

Repeating the Basics

Exercising due diligence in the initial inspection and testing process can pinpoint issues that could lead to unplanned outages down the road. And when units have to be removed from service unexpectedly, it can trigger a domino effect that impacts secondary assets and systems. Addressing those issues right from the start can help reduce downtime and extend transformer lifespans. The precautions presented here may not be revolutionary, but even the most experienced industry veteran can sometimes benefit from a review of the basics. Getting the unit inspected, assembled, processed and filled with oil as quickly as possible sets the stage for prompt, thorough testing.

The goal of the entire process is to help ensure that whenever the transformer is needed, it will truly be ready.