TELEDYNE INSTRUMENTS
Hastings Instruments
A Teledyne Technologies Company

APPLICATION NOTE

HASTINGS

Transformer Oil Purification

Why degas transformer oil?

Maybe the first question should be, "why is it important to have purified oil in a transformer?" Dissolved gasses in transformer oil can cause arcing, corona discharges, and overheating--reducing the electrical efficiency and lifetime of the transformer. Likewise, water contamination at levels as low as 30 ppm (parts per million) can adversely affect the insulating strength of the oil. With ever-increasing standards for energy efficiency of power distribution transformers, the need to effectively degas will become even more important in the future. Dissolved gas is different from gas bubbles; it's distributed in the oil as individual molecules or as clusters of molecules which are invisible to the naked eye. The way to get the gas out is to reduce the pressure. It's similar to carbonation in soda which is invisible until the cap is removed. Once the bottle is opened, the pressure is lowered and some of the carbon dioxide gas comes out as bubbles. Likewise to remove the dissolved gas in transformer oil, you must lower the pressure enough so that the molecules collect into bubbles; the bubbles expand due to the natural tendency of gasses to increase their volume as pressure is reduced; and finally, the bubbles rise to the surface or are forced through a coalescer where the gas can be pumped away. To ensure that degassing is happening effectively and to know when the oil has been sufficiently degassed, a process based on pressure measurement is much more reliable than one based simply on time. When filling a transformer, moisture in the winding insulation and other components will quickly degrade the oil quality. With the proper instrumentation in place, monitoring pressure during the pre-fill pump-out indicates when the water or other contamination by-products have been removed. It is much easier to remove traces of moisture from the transformer before oil filling than after.

Objectives

- ✓ Improve degassing effectiveness using pressure measurement
- ✓ Ensure removal of contamination by monitoring transformer pump-out
- ✓ Select proper instrumentation for oil degas and transformer pump-out

Method for Degassing Transformer Oil

The oil degassing process begins with a pumpdown from atmosphere and continues until a pre-specified vacuum level indicates that complete degassing has been achieved. Depending on the dissolved gas requirements, the temperature of the oil, and the method for evolving the gas; the level is typically set between 0.1 and 5 Torr. This requires a vacuum gauge that can accurately measure pressures in the sub-Torr range. Another important requirement for the gauge is that it be rugged and tolerant of the oil environment. Dial gauges are not accurate enough for the task. Also, the visual-only output of a dial gauge is inadequate for the current and future needs of this application. Functional features like electronic interfacing and settable trip-points provide integration with process controllers, reduce operator error, and enable data logging and documentation.

Method for Transformer Pump-out

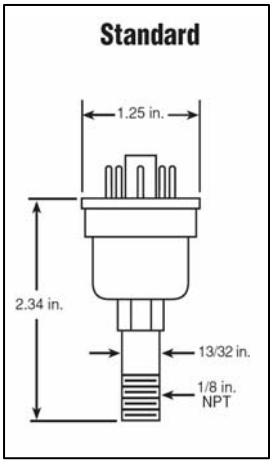
Evacuating a transformer prior to filling removes trace liquid and gas impurities which, if allowed to remain would quickly deteriorate the purity of the fill oil. Moisture absorbed by the coil insulation and other internal structures after exposure to a humid environment can easily contaminate the fill oil to levels exceeding 100 ppm. Residual solvents and cleaning fluids left behind can also severely degrade the dielectric (or insulating) properties of the oil. A mild bake while pumping is most effective for driving off

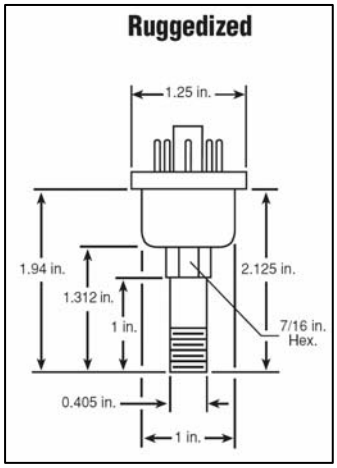
these contaminants. Depending on the specific transformer and requirements, typical vacuum levels of 0.1 to 0.5 Torr indicate successful pump-out. This approach is superior to a timed pumping method since it ensures sufficient removal of contamination and reduces cycle time to the minimum for a particular process. Ideally, the system should monitor the pressure throughout the pumpdown, including pressure versus time data as this information provides a quality indicator to flag an overly contaminated part. This function can also be accomplished as a go-no-go qualifier using a "time-to-trip-point" approach. So in a common implementation, one trip point is set at 10 Torr and must be actuated before a predetermined time-out period, while another trip point is set at 0.1 Torr to indicate the end of the pump-out cycle.

Instrument Selection

Even though the oil degassing and transformer pump-out processes are quite different, the vacuum gauge requirements are very similar. Both applications require a gauge with rugged construction and a measurement range extending to below 0.1 Torr. Depending on the need for electrical interface and automation additional features such as electrical output, settable trip points, and digital communication may be desired as well.

Ideally suiting the measurement requirements is the Hastings DV-4. The DV-4 is a thermocouple vacuum gauge tube providing high reliability and sensitivity in the 0.1 to 10 Torr range. With a standard stainless steel housing, a ruggedized version, and offering a variety of standard fittings including 1/8" NTP, it is the recommend sensor for standard transformer pump-out and oil degassing applications. When coupled with the Digital VT, the pressure reading is reported on an easy-to-read bright LED display. If an analog meter display is preferred, the VT-4 is an economical alternative. For electrical interface capability, the CVT-4 is recommended. It can be ordered with a selection of interface configurations including 0-1 Volt output and up to two settable trip point relays.





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