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Transformer Monitoring Accessories

Modern transformers are highly efficient and dependable. Depending on application however, they may be susceptible to repeated inrush currents and heavy harmonic loading. Such conditions can lead to overheating and accelerated aging of the insulation system. Although traditional accessories such as thermometers, oil level gauges, and pressure relief devices have become "standard" over the years, they merely provide for visual readings. Properly employed, additional equipment may be used to monitor and protect the transformer against premature aging and failure.

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The transformer pictured above is a good example of one well equipped to monitor operating temperatures, oil level, and operating pressure/vacuum. These devices have also been equipped so as to de-energize the transformer under defined conditions, energize cooling fans, and/or activate alarms. This paper will provide an introduction as to how these devices are employed.

We'll begin with thermometers. Although most transformers include a top oil thermometer as a standard accessory, by including user adjustable contacts, it may be used to activate cooling fans, set off an alarm, trip a breaker, or send a signal to a remote monitoring device. Multiple contacts per thermometer are available. The temperature levels at which the contacts are set can be seen in the picture to the right. A cable connection at the bottom of the thermo-meter routes the wiring from the contacts to a junction box in which relays are located. The closing of a set of contacts energizes the applicable relay to operate the external device.

A thermometer well (above) is threaded though a weld flange on the transformer tank wall that is located near the top of the insulating fluid volume. The thermometer is inserted in the well and measures the "top oil temperature" resulting from of the heat generated by the energized transformer. This measurement is referred to as the "average temperatures rise above ambient". There is a thermal lag in the top oil temperature since it can take considerable time for the oil volume to react to load changes. As such, it does not provide an accurate measurement of the winding temperature nor transformer "hot spot" at a specific time or while under a specific load.

For most distribution loads, top oil temperature monitoring is adequate. Transformers subject to high duty cycles and variable loads however, may require closer monitoring to guard against accelerated deterioration of the winding insulation. Changes in top oil temperature vary slowly since it is comprised of the average temperature rise within the transformer over time. To scrutinize and manage sudden temperature increases within the coils, the addition of a winding temperature thermometer may be appropriate.

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The winding temperature thermometer pictured on the right is mechanically equivalent to the liquid temperature thermometer with the only difference being the labeling and temperature range.

Originally, the winding temperature was measured by way of a capillary probe extending from the thermometer to a point inside one of the coils. This practice proved to be a problem since doing so introduced a ground point within the coil and the potential for a coil failure.

The thermometer probe has since been replaced by a heater coil installed around the thermometer well. So, how is this possible?

When a transformer is tested at the factory, the winding temperature at rated kVA is determined by resistance measurements during the required ANSI heat run test. This temperature measurement corresponds to a current level flowing through the coils. With this value known, the manufacturer installs a current transformer which receives an input directly from the transformer winding, steps it down to a lower level which is then fed to the heater coil mounted on the thermometer well by way of an adjustable resistance which enables the manufacturer to calibrate the output temperature to that of the winding. This results in the recognition of a winding temperature change significantly in advance to that of a top oil thermometer reading. Armed with this info, the winding temperature contact settings may energize cooling fans, set off /send an alarm, or de-energize the transformer in a more timely manner.

Another standard accessory on a transformer is the liquid level gauge. It provides a visual indication as to the fluid level at its present temperature.

This gauge is also available with contacts. Although a contact for a high fluid level is provided, the more important is that of a low level alarm contact since a low level can result in exposed energized components that rely on the dielectric properties of the insulating fluid. A fluid level that is too low can result in internal tank flashovers and transformer failures.

There are two primary causes of low liquid levels in transformers. The first is obvious…. leaking. This could be a result of a bad gasket surface or perhaps an overstressed weld seam. The other possibility is that the transformer is lightly loaded but is installed in an extremely cold location. This is possible since insulating fluid not only expands with heat but also contracts proportionally in cold environments.

A liquid level gauge with alarm contacts provides a means of identifying liquid level problems in time to take corrective action.

Pressure vacuum gauge

After the tank is filled with liquid insulating fluid to the 25 degree centigrade level, the fluid is blanketed with a positive nitrogen gas pressure. This provides a moisture barrier and room for the insulating fluid to expand. Normal equipment operation and changes in the environmental temperature cause changes in the fluid and gas volume. The insulating fluid and gas expand when heated and contract when cooled. The expansion causes an increase in the gas pressure and the contraction causes a decrease in the gas pressure. Pressure vacuum gauges measure and indicate the gas space pressure or vacuum while also validating the integrity of the sealed tank construction. The pressure vacuum gauge can be equipped with contacts for external monitoring.


Rapid pressure rise relay

Arcing within the transformer tank generates gas and deterioration of the insulation properties of the fluid and insulating paper. Depending on the severity, the generated gas can result in a sudden pressure increase within the tank. A rapid pressure rise relay is a mechanical device for the detection of such sudden pressure events. Mounted on the transformer tank wall above the fluid level, the relay actuates not on the level of pressure, but on the rate of rise of the transformer tank pressure in a given time period. It is calibrated to quickly alarm and trip during dangerous, sudden pressure changes. A breaker trip deenergizes the transformer thereby halting arcing and minimizing the potential of transformer tank damage. It will *not* however, operate under normal pressure variations caused by changes in temperature and transformer loading.

To provide a means of releasing the gradual build up of internal operating pressure, a mechanical pressure relief device (PRD) may be mounted to the transformer tank cover. The cover mounted PRD consists of a spring loaded diaphragm which lifts upward when the internal tank pressure exceeds that for which the device has been set. This quickly releases the internal pressure to the atmosphere. When the pressure has returned to normal, the diaphragm resets itself to reseal the tank. Upon operation an indicator pin projects upwards to provide a indication of operation. An optional semaphore (yellow object in picture to the right) may be provided for better visibility. The indicator pin and semaphore must be manually reset for subsequent operations. As with all of the previous accessories discussed, the PRD may be provided with alarm contacts.

Cover mounted pressure relief device

These accessories reveal information on the current status of the liquid filled transformer to provide the opportunity to take action to protect it against accelerated aging and failure. Electrical contacts can be set to activate cooling fans, breaker protection equipment and/or alarms. An activated alarm provides the opportunity for one to address and correct the issue to minimize or alleviate downtime. When the transformer is employed in supplying power to equipment for a process that is locally manned, visual monitoring is the norm. In the event that multiple transformers are installed throughout an industrial site, a more logical approach may be to equip the transformers with monitoring accessories that can be managed in a central location.

Monitoring multiple transformers from a central location has been made possible by setting up a SCADA system (supervisory control and data acquisition) in which analog outputs from the transformer monitoring accessories are fed to remote terminal units (RTUs). The RTUs are used to convert the electrical data into digital signals for remote monitoring and control.

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