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Application of the Transformer Advantage LTC

The mission of the Advantage LTC Monitor is to measure the true temperature differential between the main and LTC tank fluids, reject transient temperature differences and alarm when the true temperature differential exceeds a pre-set magnitude.

The main tank contains the working windings of the transformer, which produce large I^2R and eddy current heating when the transformer is energized. Because a "healthy" LTC switch generates essentially no heat when it is not switching, the temperature of the LTC tank is typically lower than the main tank. There is some effect due to transformer cooling, but the Advantage recognizes this condition. When the main windings and LTC are operating normally, the long term temperature differential between the two tanks is roughly constant.

As the LTC switch contacts age or wear, their resistance increases. Heat generated from this increased resistance raises the LTC fluid temperature. At some point the heat becomes too great for the surrounding fluid to dissipate. Rapid contact degradation and LTC failure eventually occur. Before this point, the Advantage LTC can provide a warning of the increase in LTC temperature, allowing preventative measures to be taken.

Probe Selection & Location

The Advantage uses stable, precise platinum RTDs to measure fluid temperature. Since the measurement of concern is the temperature difference, both the main and LTC probes must be of identical type and construction. The most accurate temperature reading is obtained from a probe mounted in a thermowell. Many LTCs do not have a thermowell, so magnetic temperature probes are also offered. These are more susceptible to environmental influences such as sun, rain, wind or ice. Proper placement and digital filtering in the Advantage reduce these effects.

For best results, both magnetic probes should be positioned on the same side of the unit. The northern side is preferred. Select locations where they will be exposed to equal but minimal sun, wind and water conditions. For good heat transfer, use thermally conductive grease at the center of the magnetic ring. Place each probe in the desired position, with the cable pointed down. Attach the weather cover and seal the perimeter against the tank with silicone caulk. Connect the Main Tank probe to the RTD1 terminals inside the Transformer Advantage. Connect the LTC probe to the RTD2 terminals.

Measurements

The Advantage LTC measures main tank and LTC tank temperatures, applies appropriate digital filters, and calculates the difference and deviation values.

For each tank temperature, a measurement is taken and processed through a digital filter to reject electrical noise and transients. An RTD OFFSET may be applied to correct for a known fixed error in the measurement on each channel (e.g. skin 10 degrees cooler than the oil). The reading is then stored for use in the differential calculations (and available for display or SCADA output).

The DIFFERENTIAL temperature (Main - LTC) is calculated and processed through a second digital filter, to eliminate erroneous short term changes (because a signal which is changing too fast probably does not reflect a

valid LTC change). This is critical since the threshold for an alarm may be a change of only a few degrees. Two parameters control this digital filter: sample period (DELAY) and change magnitude (STEP). These parameters are set by the user, based on the thermal profile of the equipment and installation. The delay period has a range of 0 to 99999 seconds, in 1 second increments. The allowed step magnitude is 0 to -20 degrees, in 0.01 degree increments. Values of 0 delay and -20 step provide the quickest response to large changes.

The PEAK DIFFERENTIAL is the lowest (least positive to most negative) differential value. This value does not require any additional filtering and is retrievable as a walk up function by pressing the up button when the display shows "DIFF".

DEVIATION is the lowest (least positive to most negative) result of subtracting the initial differential value (IDIFF) from the PEAK DIFFERENTIAL value. It represents the change in differential temperature over time. IDIFF is entered during setup. The DEVIATION value is retrievable as a walk up function by pressing the DOWN button when the display shows "DIFF". Since 2 levels of filters have been applied to the source measurements for this calculation, no additional filters are required.

Example

Once the digital filters have been applied, the DIFFERENTIAL temperature is obtained. The difference may be decreasing or increasing, depending on the absolute temperatures of the main and LTC tanks . For example: If the Main tank measures 60^{O}C and the LTC tank measures 55^{O}C initially, the differential temperature would be 60-55 = 5^{O}C. As the LTC contacts degrade, the LTC tank temperature rises with respect to the main tank and the differential temperature actually decreases. Let us assume with the passage of time (years) the main tank temperature still measures 60^{O}C and the LTC tank measures 63^{O}C. Now the differential temperature is 60 - 63 = -3^{O}C. Although the present differential is only -3^{O}C, the deviation from the initial differential is -8^{O}C. Both values are important. The present differential temperature indicates impending danger. Most LTC manufacturers state that potential trouble is indicated when the LTC tank temperature exceeds the main tank temperature. An immediate response may be required when the temperature differential exceeds –5^{O}C. The deviation value is important because it establishes a basis for time and magnitude-to-failure trending.

Set Points and Alarms

The Advantage LTC can be ordered with up to seven set point relays. Each relay may be linked to Main tank temperature, LTC tank temperature, DIFFERENTIAL temperature or DEVIATION temperature. Each relay can be set to trip on a value from -40 to 200^{O}C in 0.1 degree increments. Relays 1 through 5 have form B contacts which are closed when an alarm is activated, a sensor failure is detected or power to the Advantage is lost. Relay 6 and the AUX relay have both normally open and normally closed contacts (form C). The non-alarm state for each form C relay can be programmed from the setup menu.

The set points for the tank temperatures can be positive or negative (above or below 0^{O}C). Normally these are used to indicate when a high temperature threshold is reached (when the measured quantity is greater than or equal to the set point value). However a tank set point can also be used to flag a below normal temperature condition.

Set points assigned to the differential temperatures may also be positive or negative. This reflects the mathematical result of subtracting the LTC tank temperature from a main tank temperature, as shown in the example above.

The deviation set point should always be negative. The set point is exceeded when the calculated deviation is less than or equal to the set point value. The deviation set point is unique in that it responds to the maximum calculated historical difference between the main and LTC tanks. The indication of a failing LTC contact is a temperature differential which is moving in the negative direction over a period of time.

A third digital filter checks the trend of the main tank temperature prior to issuance of an alarm. If the main tank temperature is decreasing, an alarm based on differential is temporarily suppressed (since LTC failures are signaled by rising LTC tank temperatures, not falling main tank temperatures).

IDIFF

This variable allows the user to define an initial temperature difference between the main & LTC tanks. IDIFF is a user entered parameter to provide flexibility in setting alarms based on long term temperature changes. Typically the value entered is the temperature difference between the two tanks when the unit was put into service, or when maintenance was last performed. This parameter also allows the user to adjust the Deviation calculation (and any associated alarm set points) for offsets applied to main or LTC tank temperatures. The IDIFF value and all other setup variables are stored in non-volatile memory.

STEP

This variable sets the maximum allowed change per delay time. If the signal changes more than the step value, the change is rejected until the next sample period. Because there are no mean values for this parameter, the user must determine an appropriate setting based on experience with the equipment at that site.

DELAY

This parameter sets the timed sample period for evaluation of the step magnitude. This distinguishes long term from short term events. As with the STEP parameter, the user must determine an appropriate setting based on experience with the equipment at that site.

Temperature Calculation Summary

Main = RTD1 + Offset1, with a fixed window filter for noise rejection.
LTC = RTD2 + Offset2, with a fixed window filter for noise rejection.

Differential = Main - LTC, with a programmable step & delay low pass filter.
Peak Differential = Least positive or most negative Differential value.

Deviation = Peak Differential - IDIFF.