CONDENSATION IN SWITCHGEAR AND ANTI-CONDENSATION HEATERS

September 13, 2017 (This document replaces PTB #91)

Condensation, or dew, occurs when the temperature of still air falls to the point the air can no longer hold the water vapor suspended in it as a gas. When this occurs in switchgear, the resulting liquid condensate may combine with dust or other contaminants present on bus bar and support insulation. There are very few surfaces where the result is not detrimental. When deposited on the surface of an insulator, the combination of moisture and solid contaminates, which may themselves be non-conductive, can create a semi-conductive pocket on the insulator surface that effectively results in “shorting out” of a portion of the creep path. This reduction of insulator impedance allows an increase in leakage current and this can create carbon tracking.

In addition to the problems caused by the semi-conductive material on the insulator surface, the moisture can also be absorbed by many types of insulator material. While improvements in insulating materials and finishing techniques have greatly reduces the incidence of this type of insulation failure, it is still considered a best practice to seal all raw edges of insulators with an anti-track sealer to minimize moisture absorption.

The condensation occurs when warm moist still air comes in contact with a cold surface. The cold surface chills the air to a temperature below the dew point and condensation is the result. A common technique to control the occurrence of condensate in switchgear is to maintain an elevated temperature relative to the ambient inside the enclosure. Typically, condensation is only considered a problem if the relative humidity inside the switchgear is 65% or greater. Experience has found that raising the switchgear internal temperature by an additional 10°C eliminates the opportunity for condensation. The 10°C temperature increase results in air movement and helps prevents the switchgear internal air from approaching the dew point.

Outdoor equipment that is not thermally insulated is very susceptible to condensation. When the outside panel of the equipment is exposed to colder air, the temperature is thermally conducted by the metal enclosure and acts on the internal air neat the panel. The chilled panels may cause the water vapor to condense on the interior surfaces. Several design considerations are relevant to minimizing this condensation possibility.

- To control the entrance of moist air, ventilation should only be used when necessary to keep the temperature rise below the acceptable design limits.

- Space heaters are used to raise the temperature in the enclosure by supplementing the heating naturally present in energized equipment.

- The heating created by load currents will be adequate as long as there is a significant current flowing. A 500 amp load current flowing through a vertical section of 1200 amp rated equipment will result in an internal temperature rise of 11°C. But, a current flow of only 200 amps results in a temperature rise of less than 2°C and space heaters must be used to maintain dew point control.

Powell Industries, Inc.
PO Box 12818
Houston, TX • 77217

Tel: 713.944.6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com

CONDENSATION IN SWITCHGEAR AND ANTI-CONDENSATION HEATERS

- Special care also must be used in cable compartments with outdoor ventilation, vapor barriers in bus duct, and for outdoor switchgear. In all of these cases, the internal temperature close to the sheet metal is greatly influenced by changes in external temperature.

For further reading, I extracted the following information from the web to provide a better understanding of the definition of dew point and relative humidity.

What is “Dew Point and Relative Humidity”?

“The warmer the air, the more water vapor it can hold.” Dew point is a measure of how much water vapor is actually in the air. Relative humidity is a measure of the amount of water in the air compared with the amount of water the air could hold at the measurement temperature. To see how this works, let’s use the chart below which is adapted from *Meteorology Today* by C. Donald Ahrens, published by West Publishing.

Air Temperature in °C	Water Vapor Air Can Hold at This Temperature
30°	30 grams per cubic meter of air
20°	17 grams per cubic meter of air
10°	9 grams per cubic meter of air

These numbers, which apply to air at sea level pressure, are based on measurements over the years. They are basic physical facts.

Now, let’s see how dew point and relative humidity work. Imagine that at 3:00 pm you measure the air temperature at 30°C and you measure its humidity at 9 grams per cubic meter of air. What would happen if this air cooled to 10°C with no water vapor being added or taken away? As it cools to 10°C, the air becomes saturated; that is, it cannot hold any more water vapor than 9 grams per cubic meter. Cool the air even a tiny bit more and its water vapor will begin condensing to form dew. Back at 3:00 pm, when the measurements were taken, we could say that the air’s dew point was 10°C. That is, if this particular air was cooled to 10°C at ground level, its humidity would begin condensing to form dew.

How about relative humidity? At 3:00 pm the air has 9 grams of water vapor per cubic meter of air. We divide 9 by 30 and multiply by 100 to get a relative humidity of 30%. The air actually has 30% of the water vapor it could hold at its current temperature. Cool the air to 20°C. Now we divide the 9 grams of water vapor, the vapor actually in the air, by 17, the amount of vapor it could hold at its new temperature, and multiply by 100 to get a relative humidity of approximately 53%. Finally, when the air cools to 10°C, we divide 9 by 9 and multiply by 100 to get a relative humidity of 100%. The air now has as much vapor as it can hold at its new temperature.

What does all this mean to Powell switchgear designs?

Powell Industries, Inc.
PO Box 12818
Houston, TX • 77217

Tel: 713.944.6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com

CONDENSATION IN SWITCHGEAR AND ANTI-CONDENSATION HEATERS

At Powell we recommend these guidelines for minimizing the possibility of condensation:

- 500W/240V ac space heaters running at 120V ac to produce 125 watts per heater.
    - It is preferred to install the heaters with no thermostat.
    - If a thermostatic control is required, it should be non-adjustable:
        - set to turn off at approximately 45°C +/- 5°C.
        - set to turn on at approximately 40°C +/- 5°C.

- We recommend installation of space heaters in each of the cable and the circuit breaker compartments for all switchgear 5kV through 38kV.
    - A single space heater is required in the cable and circuit breaker compartments for 5kV and 15kV switchgear.
    - Two space heaters are required in the cable and circuit breaker compartments for 27kV and 37kV switchgear.

- Space heaters should be placed under the primary disconnect bushings; as close as possible without violating the required dielectric clearances for the equipment rating.

- A second set of space heaters is recommended for applications operating for extended periods in climates below 0°C. This set is in addition to the number of heaters recommended for typical operating conditions.

- Additional space heaters should be installed within 2 feet of the outdoor side of any bus duct vapor barrier to prevent condensation when the bus duct is not energized.

- Space heaters are required in arc resistant switchgear exhaust ducts when the gear is installed in cold climates. Space heaters should be placed within 10” of the exterior cover of all plenum exhaust ducts to minimize ice build-up.

- Epoxy or porcelain standoff insulators are recommended for outdoor equipment. The low water absorption of these materials is beneficial in the event of condensing moisture.

- It is recommended that an ammeter be placed in each space heater circuit to monitor circuit health.

- The use of enclosures designed to minimize the chance of condensation forming on to current carrying parts is recommended.

Michael Wactor, P.E.
Technical Director – R&D

Powell Industries, Inc.
PO Box 12818
Houston, TX • 77217

Powered by Safety®

Tel: 713.944.6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com