Case Study: Medium Voltage Space Heaters

Abstract:
Strip or space heaters are specified to provide effective heating of the interior spaces of electric motors and other machines. One primary reason they are present is to provide some measure of defense against the deleterious effects of water contamination/penetration on the electric coils and elements of motor/electric insulation system. When they work properly, operators are rewarded with the performance they expect out of their motors. Installed deep inside the motor… out of sight means out of mind, their hidden utility may be forgotten, or not understood.

When heaters are forgotten or ignored, and/or not energized at the proper times, condensing moisture can lead to sometimes irreversible damage to hidden interior components of motors. Very costly, unanticipated problems can result.

Therefore, a need exists for a simple, minimally invasive, effective and easy to understand "early warning" method for alerting staff about proper operation of their electric motor space heaters.

Background:
Large electric motors are important and expensive power plant or company assets. Obtaining maximum service life is important for the companies that employ them. For example, in power generation, they provide motive force for various cooling pumps, compressors, fans, conveyors, etcetera to support the output of the electric generator. 1000-5000HP motors are used for these purposes. A generating station will use multiple types of these motors to provide the support functions for their several hundred megawatt generator, providing power to the electrical grid. When and if these supporting motors go offline unexpectedly – or *when they do not come online, after a scheduled maintenance outage* the plant operator may be forced to reduce output, or may not be able to raise steam altogether, until the problem is identified and repaired. This is very costly, delays generation and loss of profit is a result.

Where does the water come from?
In many areas of the world, there are high, to extremely high ambient humidity conditions for some (or all) of a typical calendar year. In the USA, this would include areas such as states along the Gulf of Mexico, the Pacific Northwest or Eastern/Northeastern high precipitation areas. In addition to this, the effects of torrential rain, tropical storms and weather are able to grossly aggravate this condition. This environmental condition can result in the deposit of condensing water droplets on exterior and interior surfaces of motors. Why can this happen?

A natural phenomenon named the Dew Point Temperature is also in play. In the presence of very high humidity, the ability of air to carry water vapor is generally enhanced. This water will remain in vapor state, and not precipitate or condense upon surfaces – as long as there are no objects in proximity to the air *that are at a temperature below dew point*.

For example; a freshly poured glass of iced tea, placed on a table top in central Florida rapidly sweats water droplets (condensing out of the air, from vapor) these eventually begin running down the sides of the glass, (by their own weight) and a puddle forms. Eventually a sodden napkin will result. This example of water running down, causing a sodden napkin becomes important to remember.

How do space heaters help mitigate the problem?

Motor space heaters dissipate electrical power, typically by passing a current through a resistive element. This results in controlled heat. Large motors may have two or more heating elements, located inside the stator frame, typically in proximity to the end windings, or under the stator. There are different form factors (resistance wire, cartridges, flexible silicone coated strips, etc) but the fundamental idea is that by somewhat elevating the temperature inside the motor, the physical process of water penetration, or dew point related condensation on the interior spaces can be interrupted. Providing a bit of heat is a practical method to prevent condensation. Simply elevating the interior temperature above the dew point temperature (at all times) is required.

The environment generally provides the deposition of dew in the morning hours. Think of your car windshield? When does it usually have a coating of dew? Usually in the mornings… Think of your lawn, when does it have a coating of dew? Usually in the mornings… This phenomenon is related to why and when motor interiors attract water.

In general when an operating motor is turned off, or 'shut down' the motor will begin to cool *down* toward ambient temperature. This is because most motors have internal losses, both from resistive heating in the electric coils, as well as other losses in the iron core, etc. These losses are most apparent as heat, which elevates the motor enclosure and its interior elements above ambient temperature. Volumes have been written on the subject. Suffice it to say, the motor interior spaces may have been in excess of 100 degrees C, keeping water from having any chance at all of condensing inside its enclosure.

Consider the example motor, which has just been shut off for an extended plant maintenance outage. The motor will tend to cool towards the ambient temperature. It may take a day or two for the motor to cool, depending on the size, and the difference between its interior and ambient (exterior) temperatures.

Because it has a relatively large amount of mass, motor interior spaces will tend to "follow behind" the ambient temperature. In other words, if the average ambient temperature during the weeks of shutdown was 90 degrees F for the high temperature, and 60 degrees F for the low temperature, the motor interior will not drop below, or exceed these external temperatures.

Therein lies the "kicker"… in a very humid ambient condition, the interior spaces temperatures will *lag behind* the ambient temperature, and during these times, the motor interior spaces will sometimes become vulnerable to condensing moisture.

Motor Space Heaters can prevent motor failures.

Recall our earlier example; the glass of iced tea? The cool surfaces inside the motor now act in a similar fashion to the cold surface of the glass. Moisture may form droplets of water on the various components inside the motor. If, as in our example of the glass of tea, these droplets start running down the surfaces, and pooling, degradation of the insulation system may begin to occur. What happens is that any contaminates (rust, salt, dust, particles of iron, ash, coal, etc) may run down (with these drops of water) into the electric coils. These types of contaminates are nicely conductive. Since they are conductive, they form easy pathways (sometimes very long) for electrical leakage to occur. This can be via any penetrating defect, pinhole or crack in the surface of the motor electrical insulation. A clean, dry motor will not have these pathways coated over. If the motor is re-started in this type of highly contaminated situation, it is possible that the motor can be damaged. Why?

Because the leakage pathways let electricity flow where it's not supposed to flow! If enough electricity flows where it's not supposed to, it may burn permanent holes through or across the surfaces of insulation systems in the motor.