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Myths and Truths About Wind and Load Correction Factors

How do we know the windspeed we are measuring on the ground is the same as the wind speed at the object?

There are a number of formulas and computer programs for 'correcting' or predicting what will happen to the temperature (or temperature rise) of an electrical fault when the load or wind changes. While these formulas are somewhat useful to indicate that significant changes in temperature may take place when the load or wind changes, they are subject to much abuse and misuse and may be downright misleading when it comes to prioritizing repairs.

We like to ask thermographers who regularly use these formulas why they use them. Invariably their answers include: to better predict the priority; to 'normalize' one fault against another; to correct a trend in a graph when monitoring a fault condition; or to predict when failure may occur.

Indeed our Level I, II and Electrical Specialty classes are witness to excellent experiments which illustrate the effects of convection and/or load in order to understand why and how the fault temperatures should generally change with increasing load and wind. But when it comes to predicting, normalizing, or correcting a temperature, or temperature difference, there is a significant danger of severely under-estimating or over-estimating the 'true' fault temperature and the consequent severity and priority.

Wind Correction

The misuse of wind correction mainly comes into play when thermographers use infrared under conditions of high convection to 'permit them to continue' and estimate the temperature when the wind will be lower. There are however many other variables, other than wind speed, which affect the convective heat transfer co-efficient including wind direction (orientation), shape of the object, surface roughness and whether the flow is laminar, turbulent, or has separated from the surface.

The change in the convective heat transfer co-efficient can increase significantly when wind increases from 0 to 15 mph and may, for a horizontal downward heated surface increase more than five times (1.08 to 6 BTU/hr-ft2-F), yet for an upward facing surface increases only 3.7 times (1.63 to 6 BTU/hr-ft2-F)

The ASHRAE Handbook of Fundamentals shows that at 15mph the convective heat transfer co-efficient changes by 50% by moving from a smooth surface to very rough surface. (6 to 9 BTU/hr-ft2-ºF) Either of these two factors could easily represent more than a 50% error in temperature calculation if an incorrect assumption about orientation or roughness is made in the correction factor.

While we could argue this complexity and even try to correct for it using a more sophisticated model, the fact remains that we can be a significant distance from the energized

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surface. How do we know the windspeed we are measuring on the ground is the same as the wind speed at the object, which can be many feet in the air, and away from any surface effect? Add to this that the wind is constantly changing in velocity and direction and we find ourselves in a very uncertain place.

Load Correction

Fault heat generation varies with the square of the current. There is no doubt that if load increases the component temperature will rise. But by how much? Load increase algorithms over-simplify the real-world. The question you should always ask is whether the surface temperature being observed is the actual fault temperature or simply an indicator of the fault temperature.

In all likelihood the surface temperature we measure will not be the fault temperature. If the fault is beneath, or behind the surface being detected with infrared, the 2nd Law of Thermodynamics states that the heat will flow from the point of highest temperature (the fault) to the area of lowest temperature (likely the surrounding air). Heat, like electricity, however takes the path of least (thermal) resistance to achieve this flow. The surface temperature we are observing may or may not be along this path of least resistance.

In reality, whether it is a cabinet attached to a wall, a conduit leading away from a box, or the bus bar/conductors leading out of the vicinity of the fault, unknown parallel paths of heat flow will exist. The pathway creating the resistance between the fault and the surface we are observing results in a thermal gradient which may or may not have a very large value – i.e.: the surface temperature may be quite different than the fault temperature and any load correction formula made to the ‘surface temperature’ may not produce a correction factor even close to reality!

Thermal Run-Away

Another very important part of prioritization involves the issue of thermal run-away. Many types of failures occur when a change to the system happens (load increases, motor starts, wind decreases, ambient temperature increases) and the thermal output of the fault increases.

At this point many variables come into play to dissipate the additional heat generation including specific heat, mass, surface area and paths of thermal conductivity. If this additional heat generation at the fault cannot be dissipated as fast as it is generated, the temperature of the fault increases accordingly.

The electrical resistance of many types of faults increases with temperature, which in turn generates more heat and a rapid failure cycle starts. This is called thermal run-away. There are so many variables unknown to the thermographer that predicting thermal run-away simply becomes guesswork.

If predicting failure is guessswork then prioritization based on such assumptions can only be described as irresponsible. One thing we do know is thermal run-away most often occurs at the worst possible time: at startup; during switching; at peak loads; or at extreme ambient conditions, see Figure 1 (left).

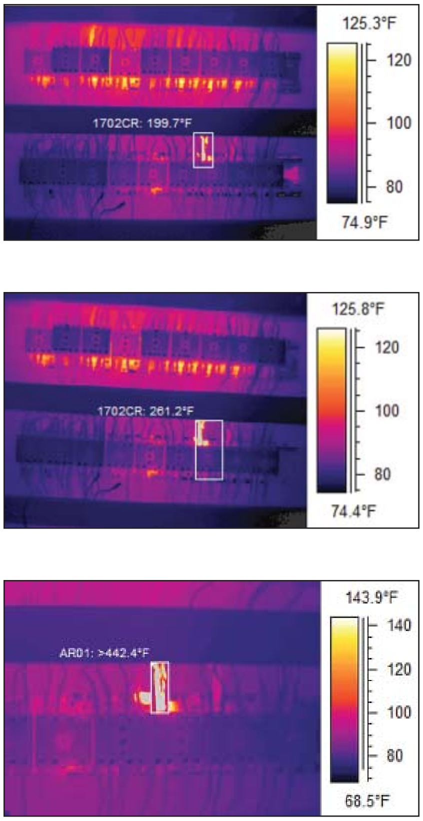

Figure 1. Example of Thermal Run-Away. Images taken over a 45 minute period during an inspection on May 22, 2003. The strands were arcing in the third image at 1:29 p.m. *Images courtesy of Doug Gerhold.*

Alternative Strategies

One thing that is true about correction formulas is that they are dangerously convenient. Everyone's job would be far easier if we could just plug in a number and find a solution. Unfortunately, the only real answer to prioritization is to say 'We have a identified a potential problem" and the more we do not know or understand about it, the clearer we have to be that we simply do not know how bad it is or could get. So what is an alternative?

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1. Ask yourself whether you really need to quantify theroblem at all. Based upon all factors such as criticality, safety, spare parts, quality, reliability, etc., if you do find a problem (no matter what the temperature or temperature rise is) the best course of action in most cases is simply get it fixed!

2. Identify whether there are other methodologies better suited to diagnose this particular type of problem. Motor circuit testing, impedance testing, megaohm testing and oil testing are sometimes viable fault validation tools.

3. Always take into consideration the possibility of thermal run-away and the factors which may cause it. If you are not sure run-away could happen, or when it might happen, say so. An underestimated fault which fails has cost the credibility of more than a few thermographers' programs.

4. Go back and re-shoot the component under different, more favorable conditions (lower wind, higher load).

5. Start trending the problem – the less you understand about the nature of the problem (and the severity) the greater the initial inspection frequency should be for this particular component.

6. Gather other information that will allow you to prioritize without using temperature as the only dete mining factor. Consider all relevant factors contributing to the thermal situation such as present load, future load, duty cycling, ambient temperature, wind, and past history of the component to estimate the probability of failure. Combine this estimate with the criticality of the component with respect to safety, environmental consequences, effect on operations and the cost of failure and you have a very good method for prioritizing each fault.

Finally, always remember that while correction formulas for wind and load may provide thermographers with convenient thermal performance indicators, unfortunately, they are not very reliable for prioritizing repairs. It is our recommendation that you give strong consideration to these alternative strategies when conducting inspections.