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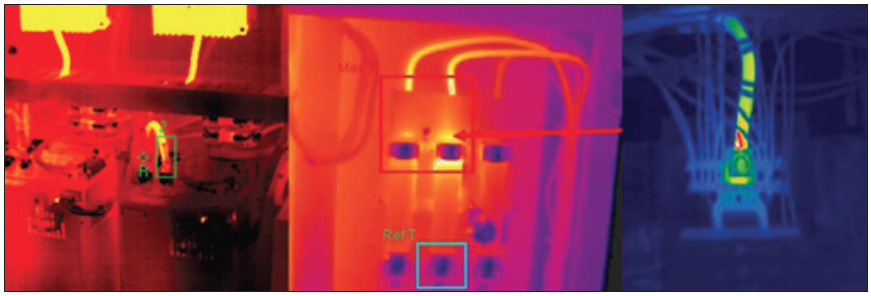
Do **Sweat the Small Stuff** – *The Benefit of Inspecting "Small" Equipment with Infrared Thermography*

Today's cameras are smaller, less expensive and have increased portability as compared to what we lugged around in the "old days".

Figure 1



The benefits of utilizing Infrared Thermography as a predictive maintenance (PdM) tool for electrical applications are well known. Most PdM programs in industrial facilities have routes and frequencies for inspecting their critical electrical assets. Substation equipment, service main switchgear and MCC's are commonly inspected with frequencies as high as monthly in some instances. Yet for every large distribution apparatus scanned with regularity, any number of 208Y/120 panels, control panels and other "small" devices are overlooked.

This paper will explore the benefit of including previously uninspected "small" electrical system components to routes that have previously been occupied by switchgear and MCC's. Many large scale processes are either controlled or monitored by Human Machine Interface (HMI) devices or control systems are powered by 120VAC and lower supplies. Small panels in offices or control rooms often power servers or desktop computers that annunciate processes or monitor critical data within a process. The amperage rating of a device or enclosure no longer correlates to criticality, so it is time we, as PdM professionals, started sweating the "small stuff".

The field of Infrared Thermography (IR) has seen quite a few changes over the years. Camera innovation would be chief among those. Thermography was once upon a time a much more tedious and cumbersome endeavor than it is today.

As an instructor of IR, I often have students in level one courses who complain about the size and weight of their cameras. That all ceases after I show photos of older equipment, Figure 1 (left), such as this Inframetrics 740 rig from back in the early 1980's. Believe it or not, this was once considered "man-portable".

Well thank goodness for technology. Today's cameras are smaller, less expensive and have increased portability as compared to what we lugged around in the "old days". Most every camera on the market today has onboard memory, which is a far cry from

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Figure 3

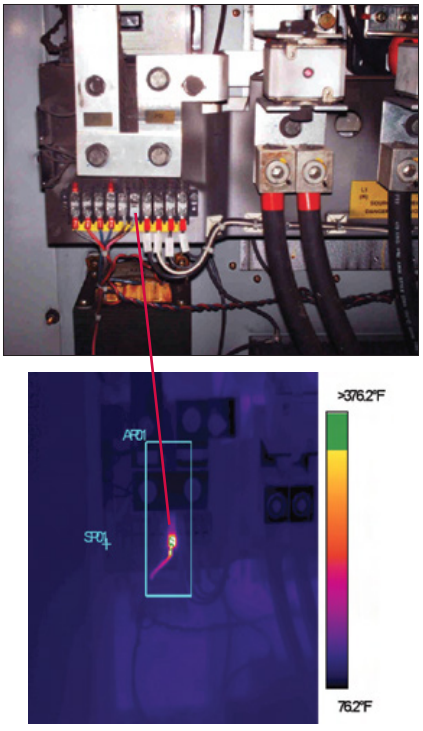


Figure 4

the Polaroid camera attachment days and even a huge improvement over carrying a video recorder attached to your imager. These technological advancements mean we can get more done in less time and at a reduced cost. But are we taking full advantage of these improvements? As a service provider, my personal experience has been that as inspection costs decrease, the savings are not passed on to increase the number of assets within the scope or the frequency of inspection. The opposite is often true with the scope of an inspection *decreasing*, leaving "small" equipment out in the cold while switchgear equipment and large distribution devices remain on inspection lists.

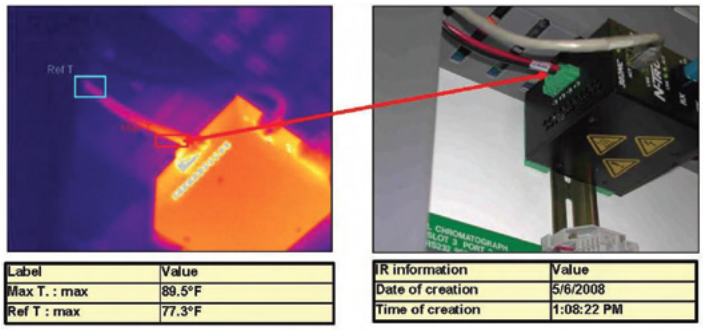


Figure 2

Of course facility switchgear equipment is quite critical as it is the heart of the electrical distribution system. Obviously industrial equipment requires its operating voltage in order to perform, hence the inspection of distribution devices that feed process equipment. But why leave off the circuits feeding the process control or HMI devices like touch screens and control panels? If the switchboard feeder breaker for your conveyor line never goes down, but the Programmable Logic Controller (PLC, seen above in Figure 2) controlling it fails catastrophically due to a heat related failure in its distribution path, what has been saved?

Most anyone with knowledge of thermography as applicable to electrical apparatus inspections understands how we find anomalies. Increased contact resistance in an electrical connection causes heating that increases as the square of the applied current. For this reason, NFPA-70B *(Recommended Practice for Electrical Equipment Maintenance)* suggests a minimum of 40% load on a circuit at the time of inspection with IR for optimum results. One common misconception is that the resistance within the connection point has to be very high in order to cause heating. This is untrue. In Figure 3 (top left), the electrical resistance between the failed component and the new replacement component was 2.2 *micro*-ohms. Not exactly what we would normally consider "high", but significant nonetheless.

Another common misconception is that lower power devices do not carry enough current to be susceptible to heat related failure. This is also untrue. While abnormal heating is a product of current *squared* times the resistance (I2R), and electrical devices are rated according to their ability to accommodate the flow of current, lower current rated devices can also experience heat related failure. Notice the following example in Figure 4 (bottom left).

The voltage level of the device has no bearing on the potential for a heat related failure – these images are from a 24 volt power supply.

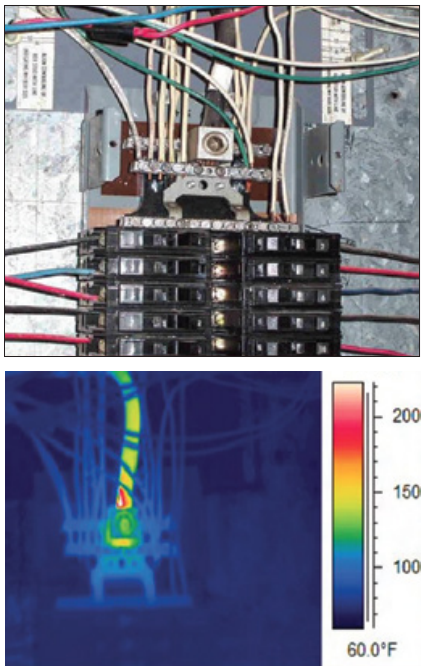


Figure 5

We are looking at what appears to be 14AWG control wire, which is rated for between 25 and 35 amps depending upon which particular wire type is used. In the thermal image above you will notice that the conductor is only showing abnormal heat at the connection point, not on the entire conductor. This would appear to indicate that the conductor itself is not over loaded and that the heat present is due only to the current flowing through the high resistance connection point. Note the apparent temperature of the anomaly by comparing the color to the temperature scale. An apparent load of significantly less than 30 amps is producing over 300°F (149°C). Also important to note is that the control circuit was for an industrial boiler and if it had failed the boiler would shut down, halting the process of this facility. Another example appears left in Figure 5 (left).

For the electrically uninitiated, the white tape on the large conductor in the center of the visual image indicates that this is a neutral. We expect that a neutral conductor in a panel should carry some amount of current. If operating correctly though, this amount of current should be a fraction of what is being carried by the phase conductors. Notice the temperature scale on the thermal image. The point of saturation is on the wire insulation (which has a high emissivity therefore giving a relatively accurate reading) and indicates an apparent temperature of greater than 200°F (93°C). THHN wire is rated at 194°F (90°C) so we are looking at the potential for thermal damage here.

Also notice the wire colors on the breakers. This is a 208VAC panel, which are often overlooked in the inspection process. You might notice that the panel components are completely exposed. Surface scanning is an excellent pre-inspection process, but is not a substitute for fully exposing a panel. If this panel had not been completely opened, this anomaly would not have been revealed until catastrophic failure occurred. Assume for a moment that this panel feeds an office space in a manufacturing facility and within this office is the computer that monitors a critical process. What happens in the event of a failure in this panel? Assigning criticality of an asset based on nothing more than its voltage or current rating might have led to the panel in this example having *never* been inspected.

What about voltage levels? Among the common criteria used to determine criticality of electrical apparatus for inspection is the voltage class or rating of the device. Again, abnormal heating in an electrical connection is a product of *current*, not voltage. The voltage level of the device has no bearing on the potential for a heat related failure. Take a look at Figure 6 (below).

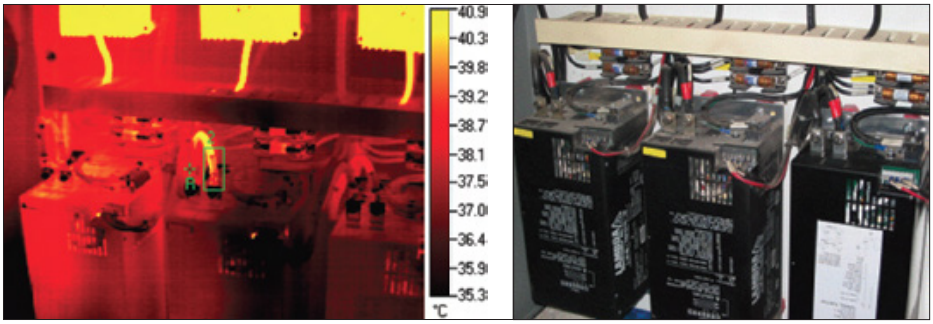


Figure 6

Control panels offer an excellent opportunity to maximize the benefit of thermography as a predictive technology, but sadly they are often overlooked.

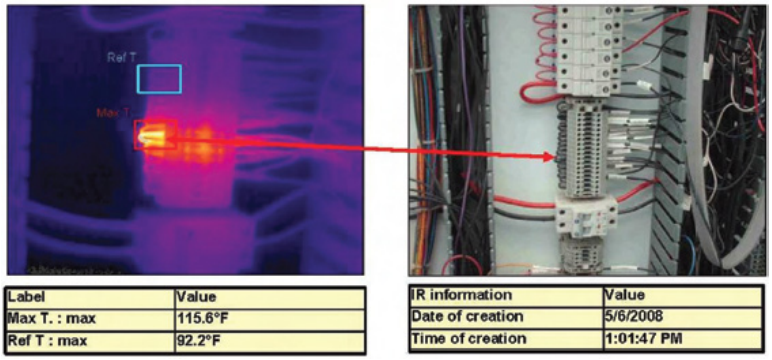


Figure 7

These images are from a 24 volt power supply. The temperature scale beside the thermal image indicates an apparent temperature of approximately 40.5°C (105°F) compared to an apparent 37°C (98°F) on an adjacent connection point. Had this particular device not been deemed critical due to other factors, and its importance gauged solely on the voltage level, this anomaly might not have been found until it failed.

Control panels offer an excellent opportunity to maximize the benefit of thermography as a predictive technology, but sadly they are often overlooked. Contained within a typical control panel are transformers, fuse blocks, circuit breakers and a host of other electrical devices that are inspected in their larger forms inside of bigger devices. The control transformer inside a control panel operates exactly the same as the larger ones we inspect as part of the utility equipment. Just because they are smaller versions of what we normally would consider critical devices does not mean they should be inspected at a reduced frequency. In Figure 7 (above) you will note that even "small" components like those mounted on DIN rail can have sufficient I^2R in their connection points to experience heat related failures.

The 20 amp circuit breakers inside a control panel have the same potential for failure as the 400 amp ones in a distribution switchboard. Does the 20 amp circuit breaker cost less to replace? Sure it does, but what impact on the overall process of the facility does it have? Can we reasonably expect that a circuit breaker could not experience the same

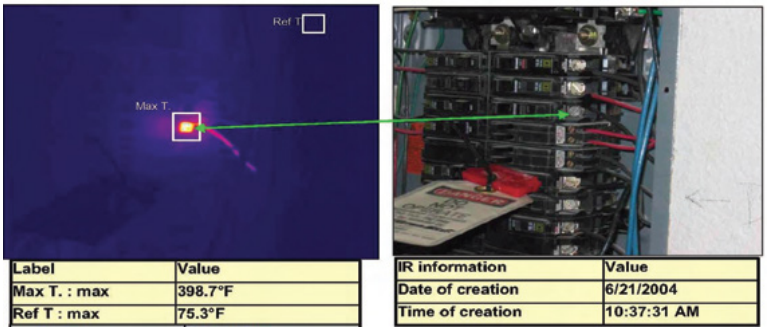


Figure 8

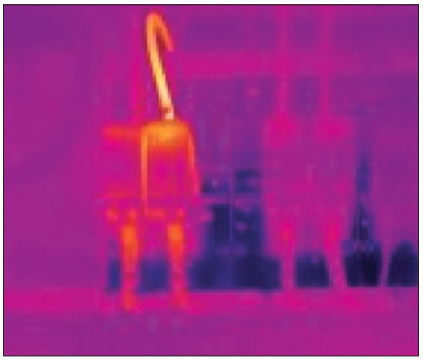
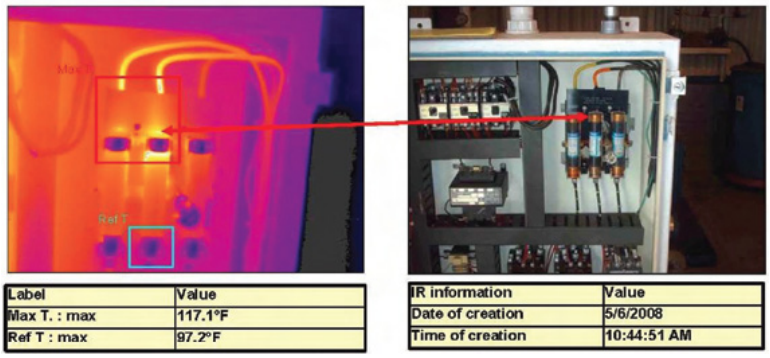


Figure 10



Label	Value
Max T. : max	117.1°F
Ref T : max	97.2°F

IR information	Value
Date of creation	5/6/2008
Time of creation	10:44:51 AM

Figure 9

degree of abnormal heating because it is in a 120VAC panel as opposed to a 480VAC distribution board? Check out Figure 8 (previous page). We have what appears to be a 20 amp circuit breaker in a 208Y/120VAC panel. Notice the apparent temperature of the anomaly. Now what if this circuit breaker is the one feeding the production computer terminal in an office space? Are *you* sweating the small stuff yet?

Service main switches are routinely inspected, but what about the 20 amp service disconnect for the control panel? See Figure 9 (above right). Downtime is downtime, no matter the cause. We need to be inspecting these devices inside of control panels.

The anomaly seen in Figure 10 (above left) was found inside a control panel at a textile facility in Alabama. As my escort walked me past this control panel on our way to another device, I asked if we were going to inspect it. The answer I received was "if we have time after the important stuff". Upon the discovery of this item, my escort decided to take time to look at the other 19 identical control panels to this one, each one of which was responsible for the operation of finishing machines at the end of their process. Had this control panel failed, one half of the finishing process would have ground to a halt. Subsequent inspection of the remaining control panels in this production area yielded two additional discoveries. They are sweating the small stuff now!

As reliability professionals within a facility, your input to the routes and frequencies of asset inspections is crucial in bringing about a change. The assessment of criticality for any asset within a particular route needs to consider the impact of failure of devices previously believed to be unimportant due to its voltage class or current rating.

As a service provider for client companies, your task is to educate your customers on the importance of including these "small" devices in their routes. Often a service provider only sees their customers once or twice a year and they are almost always pushed to get as much out of their annual visit as they can and to cut time out of the inspection process to stay competitive in their pricing. It is often an uphill battle to make changes, we know that from the history of IR Thermography itself. But it can happen and you can make it happen if *you* start sweating the small stuff.

For additional information about thermography, building inspections, and infrared training, visit www.thesnellgroup.com or contact The Snell Group at 1-800-636-9820.