Fine Tune Your Infrared Thermography Skills

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What is it that separates the rookies from the superstars, the novices from the experts, and the amateurs from the professionals? It is training and experience. This applies to many endeavors, not only thermography. While training and experience may not guarantee success, lack of these will certainly increase the odds of impending failure. We have had the fortunate opportunity to see many thermographers advance in their careers. This article explores some of the areas considered vital to their success.

Safety

On the back of our ASNT Membership cards is the phrase "**. . . creating a safer world**." With that in mind, it is fitting that we begin by including a few words about safety.

Electric power appears harmless. It is not snarling, roaring, or displaying claws or canines, all prehistoric danger signals we humans have learned to recognize and avoid for our survival. Electricity is just there, not obviously dangerous. It may crackle, hiss, buzz, or hum, but it does not appear to pose an obvious threat. Therefore, we must learn through training how to stay alive in this seemingly benign but potentially deadly environment. High voltage is unforgiving. You do not get second chances.

For electrical work, never enter an unknown or dangerous environment without being accompanied by qualified personnel. Always have a tailgate meeting before starting your IR survey. Learn and follow the client's rules and guidelines with respect to safety equipment, clothing, restrictions, lockouts, etc.

Focus on Focus

The focus of a thermogram, or thermal image, can be critical for two reasons. First, it is a poor reflection on the thermographer to provide a blurry image to the client. Secondly, the temperature measurements and temperature difference measurements will be incorrect for an improperly focused image, especially when trying to measure small hot spots, and you cannot refocus after you freeze and save the image!

Take a look at the images below. The unfocused image shows a lower temperature and a lower temperature difference than the correctly focused image. *Always focus carefully!*

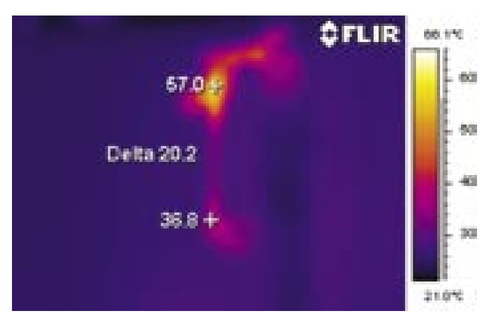

Figure 1 — Out-of-focus thermograms lead to incorrect measurements. Simulated hot spot problem from the Infrared Training Center IR camera laboratory.

Figure 2 — Correct focus produces good measurements and looks professional. Simulated hot spot problem from the Infrared Training Center IR camera laboratory.

Temperature Range

While many infrared cameras claim to be able to detect and measure objects somewhere from 4°F to 2732°F (–20°C to 1500°C), they cannot do it within the temperature span of a single image. Most modern infrared cameras break up the total temperature measurement specification into a number of defined temperature ranges.

Let us say that you are operating an infrared camera on Range 1 (-40°F to 248°F or -40°C to 120°C) and you capture a thermogram where the temperatures of the objects vary between 68°F and 392°F (20°C and 200°C). The hot objects above 248°F (120°C) will show up as white, but you can not tell *how* hot they are because the data was captured on too low a range.

When analyzing thermograms, changing the emissivity or the reflected apparent temperature (Background, Tamb, or Trefl – terminology used depends on your camera) can push the reading out of range. Not all software can correct for this. If you are unsure about the emissivity of the target, save at least one image on a range where the lowest emissivity value does not cause an out-of-range condition. If the temperature difference cannot be reconciled on one thermogram within a given range, take two thermograms that will allow calculating the temperature difference later. If you are not familiar with the terms *emissivity* and *reflected apparent temperature*, do not expect to get temperature measurements with an infrared camera with any confidence. Get trained!

Finally, there can be occasions where the IR image details are important but are lost due to the range setting required to capture a hot spot. In these cases take two thermograms, one that will give IR details and one that will give proper temperature measurement of the hot spot. It is much easier to take too many thermograms than not enough.

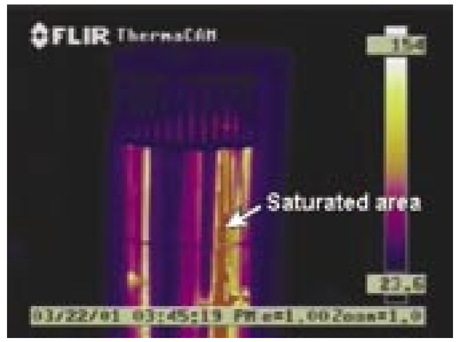

Figure 3 — This image of a quartz heater has been captured in an incorrect range. The highlighted area in red cannot be analyzed.

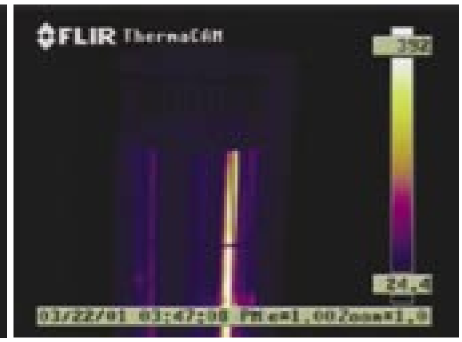

Figure 4 — Switching to a higher range allows the entire scene to be analyzed

Distance and Spot-Size Ratio

Thermal image data is dependent on distance due to spatial resolution and atmospheric interference of the infrared energy from an object. The effects of optical resolution far outweigh the atmospheric effects for most condition monitoring thermography.

Can you read a newspaper from across a room? Of course not. You need to get closer to the paper or view it through a good set of binoculars. Infrared cameras are no different! Just because you see a "hot spot" in the image does not necessarily mean that you will be able to read a good temperature. Knowledge of your camera's optical resolution is imperative in determining the correct distance to object relationship before you save a thermogram.

The figure below illustrates this. Two thermograms of the same problem show two very different readings. One is taken with normal optics, the other just minutes later with a 3X telescope. For the set of severity criteria used by the thermographer, the temperature rise went from a minor problem without a telescope to a critical problem with the telescope. The thermographer knew the spot size ratio was much too small to get a good reading without the telescope. Had he not known this, he would have made an incorrect evaluation of the severity of the problem.

Knowledge of the "Spot Size Ratio" is necessary to properly assess the maximum distance you can be from your target and still get a good reading. Some camera manufacturers make it easy by designing a cursor that allows you to find the correct distance easily. All you have to do is move close enough (or use a telephoto lens) so that your hot spot fills the interior of the cross hairs and your measurement will be correct.

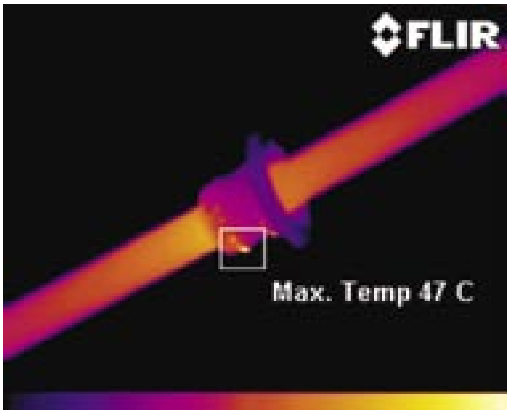

Figure 5 — Thermogram of a connector using a standard lens at 25 feet distance. Note the maximum temperature is 117° F (47 °C).

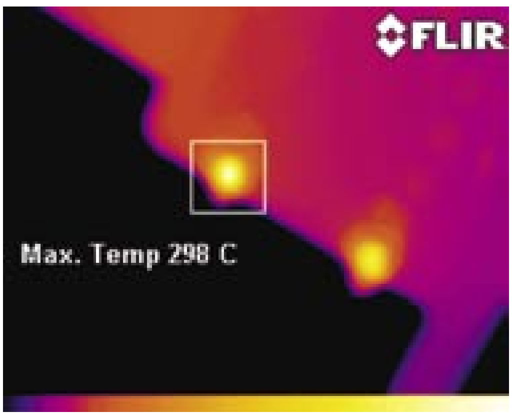

Figure 6 — A 3X telescope was placed on the camera at the same distance and now the maximum temperature has jumped to almost 572° F (300° C)!

If your target is too small to properly resolve, then your temperature reading will be lower (assuming a hot target with cooler surroundings) than the actual temperature. Don't be fooled into thinking that if you are only performing temperature difference measurements that you are okay. Unfortunately the same thing is true for differentials. If you are too far away, the delta T's are too low!

Thermal Tuning

We have often seen thermographers with their infrared cameras pointed at components surrounded by a clear sky—not unusual for substations or power distribution. Usually they press the auto-adjust key. This will set the level and span to some typical values from minus 40° F to plus 120° F (-40° C to 49° C), in many cases close to the entire dynamic range of many IR cameras. This greatly reduces the contrast and washes out the components so much, they can not find any problems, where problems indeed existed.

You do not want to have the sky as part of the dynamic range. You need to have the level and span adjusted to give the best view of the components. If you are going to use auto-adjust, aim the camera away from the sky, so only ambient targets are viewed. This is such an issue that some newer cameras actually have a low offset the user can set so the auto-adjust does not go below a preset value. You want your span across the temperature range of the good and bad targets.

The goal is to have the minimum span set so you can see the targets in their ambient environment, and the problem targets are readily apparent. Figures 7 and 8 give an idea of what we are talking about. On a sunny day in the field, it is much more difficult to find problems with the level and span settings shown in Figure 7. The thermographer probably would have missed this critical problem completely.

Further adjustment and analysis can be made in the field and also on the report. Here, we are just trying to spot the problems.

Figure 7— Poorly thermally tuned for finding problems.

Figure 8 — Properly thermally tuned for finding problems.

Solar Loading Effects

The figure below gives an example of how solar loading masks a thermal anomaly. Returning in the early morning when solar loading is minimal, one sees the problem clearly.

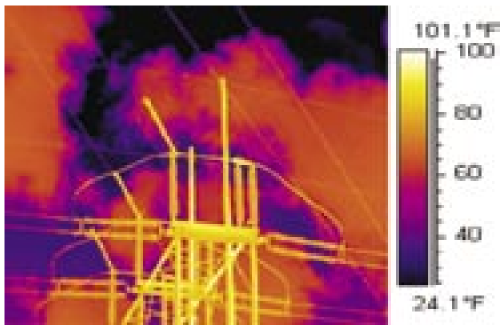

Figure 9 — Solar loading warms up the tower lines and switchgear, masking a thermal anomaly.

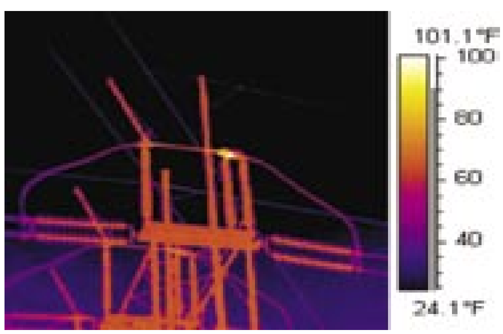

Figure 10 — Thermogram shows problem distinctly in early morning prior to solar loading.

Wind Correction

Speaking of wind, how do we correct for it? We do not. The figure below shows results of a lab experiment on effect of wind on a hot spot. The important result to note is that it does not take much wind to dramatically reduce the temperature rise. For example, at a power input of 27 watts (top curve), the temperature rise at 0 mph wind speed is about 130°F (72°C). At 5 mph the temperature rise has dropped to 60°F (33°C), less than half! The other important item to note is there are different curves for every power setting. This means a different correction factor for every different power, so, you cannot really correct for wind unless you know the power being dissipated in the hot spot. If you know that, however, you already have your result! The bottom line is that wind correction is difficult at best, problematic at worst. You should still measure wind speed and note it in your IR reports. Wind cools things off, even if we cannot correct for it.

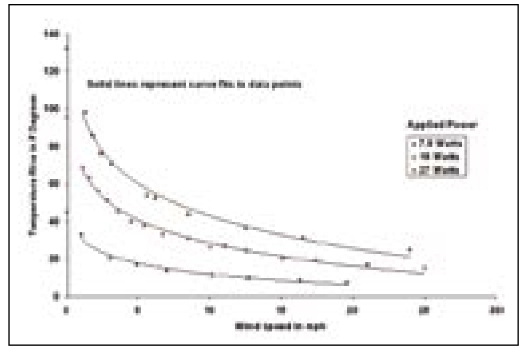

Figure 11 — Temperature rise versus wind speed for various power settings.

Some closing remarks

Compare, compare, compare. If there was ever a diagnostic technology that succeeds by comparison, IR thermography is it. This is especially true for electrical systems, as you normally have three phases at which to look .

Collectively, we have over 50 years experience in infrared thermography. One thing we have learned is that it is essential to keep active and informed. We strongly recommend that serious thermographers attend and participate in conferences, take advantage of free newsletters and internet posts, and sharpen their skills through training, seminars, and continuous experience. When asked to give advice to new thermographers, Dana Curtis, a skilled and experienced thermographer, without hesitation said, "Never let your infrared camera collect dust."

Mr. Lyon holds a BSc degree in secondary education, Earth Sciences major. With nearly twenty years experience in the infrared industry, he has been teaching and consulting in IR Thermography since 1986, both in-house and at customer sites. in the U.S. and internationally. He had conducted ten courses in Brussels, addressing the needs of the European training demands, prior to the construction of the Infrared Training Center in Sweden. On occasion he has been a guest speaker for General Motors, Delaware Valley Power Quality Group and other organizations. Additionally, he has over five years experience in servicing, calibrating, customizing, and operating infrared imaging systems. He is an active member of ASNT, serving on two committees and has also conducted a short course on thermography for the organization.

Dr. Madding is a graduate of the University of Missouri with a BS in Physics, and a Masters and Ph. in Physics from the University of Wisconsin-Madison. He began the first infrared thermography seminar at the University of Wisconsin Extension in 1978. He co-founded the Thermosense Conference in 1978 with two other colleagues from the UW. In 2000 he founded the InfraMation Conference, the largest annual IR conference for thermographers. He has published numerous technical papers on infrared thermography applications, as well as contributing chapters to textbooks such as Applied Thermal Design and the Encyclopedia of Optical Engineering. Bob has over 30 years experience in infrared thermography applications and training.