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WHITE PAPER:

MEASUREMENT CONSIDERATIONS

of Metallic Sources of Heat Using Non-Contact Infrared Sensors

How to best use laser pyrometer to measure the temperatures of a diverse variety of materials commonly found in many commercial facilities

BY DAVE KADONOFF

When working in the real world, we encounter a variety of materials operating at a variety of temperatures. Understanding how they may be accurately read for temperature is critical to making informed decisions about preventative maintenance. The single most common device used for non-contact temperature inspection worldwide is the "laser pyrometer," also known as a temperature gun, or spot radiometer. They are inexpensive, very portable, and are very accurate if used within their defined limits.

The term laser pyrometer, however, is a bit of a misnomer for this instrument. A very common misunderstanding is that they are indicating the temperature of the exact laser spot no matter how far you are from the target, and this simply is not the case. By and large, laser pyrometers employ the same basic sensing technologies that many sophisticated IR cameras use, namely uncooled microbolometers.

Because of this, they are limited in accuracy to the same principles of operation that even the most sophisticated IR cameras available are. These principles are emissivity, reflected temperature, and measurement field of view (MFOV) that equates to the minimum resolution or object that you can measure the temperature of and resolve.

Spot radiometers are generally a single element sensor with a fixed lens with its focus set to infinity. The spot size ratio of the IDEAL 61-686, is 12:1 which simply means that it is looking at a one-inch diameter circle and averaging the temperature within that circle when it is held 12 inches away from the target.

The laser spot denotes the center of the circle of measurement. I have watched users aim at high bay lighting, place the laser on the ballast, take a reading and pronounce that all is well. I estimated that they were 30 feet away, and therefore they were measuring a 30-inch circle trying to read a 12-14 inch enclosure. You can see for yourself the limitations of the accuracy of such a scenario.

More advanced models, such as the IDEAL 61-686 allow for the adjustment of emissivity and have a secondary input for a thermocouple allowing the comparison of contact and non-contact values. IR Cameras which record images and display color palettes of the target item, typically have 2000, 6400, 20,000 or more individual heat sensing pixels which allow for higher image resolution, clearer images, and the ability to resolve smaller targets at greater distances. Each has its own applications and suitability for specific purposes, but they all work in very much the same way when detecting surface temperatures of devices.

I have often noticed users confuse emissivity with reflected temperature. Shiny surfaces and, to be sure, surfaces that appear non-reflective to the eye, can easily be highly reflective in the IR spectrum. A great example of this is galvanized steel. Often used in electrical panels, it is very common to image hot spots coming off the back of the panel.

I have listened to numerous users proclaim that there must be a heat source on the far side of the panel or wall. Of course, it is much more likely that you are looking at your own body's heat reflecting off of the galvanized steel or some other heat source behind you. Simply moving slightly and watching if the heat moves

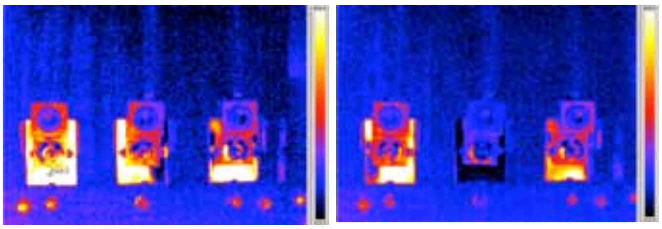
Students in the IDEAL Industries Level I thermography classes often give the following answers to the question, where should you best target the beam for the most accurate heat reading?

- The very top as heat rises
- The middle, to average the temperature
- The black electrical tape because black absorbs more heat
- The yellow, the blue, don't image the tape as it acts like an insulator

How full is the bottle? Look at the readings in the photo and answer the question. Hint: the answer is in the blue box on the last page of this article.

with you will quickly determine if it is reflected or not. And it is just as possible to image a cool reflection as a hot one! Ways to mitigate this are covered in detail at the Level I and II thermography seminars that IDEAL Industries offers. Look at the two images below.

At first glance, they appear to show three hot spots possibly requiring attention. On closer inspection, we can see that in the second image, taken just seconds later, there are only two hot spots. With further analysis we find that these 'hot spots' are below our body temperature but higher than the background temperature on a



Images of lugs and reflective background metal appearing to be hot. *Photos courtesy of IDEAL Industries*

working panel. Load was very low, thus creating little heat, and even the lugs are clearly showing reflected heat from the thermographer.

This difference appears to be great with the camera set in auto mode. The actual span is just 12 degrees. By adjusting the level and span, you can effectively change the contrast of the image to make analysis far easier, accurate and meaningful.

Reflected temperature (notice how I didn't use the word *heat*) is one consideration when striving for maximum accuracy in thermal imaging. The other major factor is known as emissivity. I define emissivity as the efficiency with which a surface emits IR radiation, in the wavelengths that the camera is designed to detect. In the case of the IDEAL HeatSeeker Model 61-846, this is from 8 to 14 microns wavelength which is fairly typical for this class of camera. To be sure, there are other IR wavelengths emitted from any heat source, and certain cameras are tuned to detect other wavelength patterns for specialty applications, such as gas detection.

Many materials are very efficient at emitting in the wavelengths that IR cameras are designed to detect while many other very common materials are not. This almost always results in a temperature reading lower, or even far lower than the actual temperature of the target. Look at the image shown above. First, ask yourself where the best place would be to make an accurate reading of temperature. Then look further and read the values indicated by the laser pyrometer. Most people expect to see a different reading on various colors of tape and the most accurate on the aluminum, but then there is the effect of emissivity.

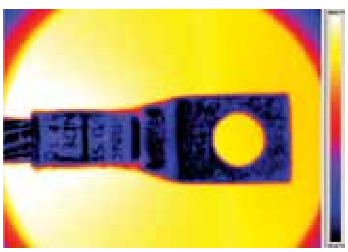
Metals in general, are inefficient emitters and must be treated with due consideration when reading their temperature. The application of tape and paint, or reading the temperature of nearby electrical insulation can improve the reading accuracy immensely if it is possible to employ these techniques. The classic demonstration of this is imaging a human hand with a gold ring on one finger. Human skin is a very efficient emitter and thus can be read much more accurately than metal. Although the ring has likely been in place for many years and one can assume that it is the same temperature as your hand, it appears to be far cooler.

In the case of emissivity, the crucial factor is the surface material. The surface material is what is emitting the IR detected by the imager. If you have a 4-inch-thick piece of steel, set the E value for steel. If it has been painted, then set E for paint. Place a piece of tape on it, set it for tape. Interestingly, raw machined aluminum will have one value, polished another value, black anodized another, and clear anodized another.

Here is one last picture for your consideration. This is an image the author took of a compression lug, and copper conductor being heated on a coffee warmer. I intentionally left the lug on the heated pad of the warmer to create a great deal of contrast. The heating surface is black, the lug is tin plated copper, and the conductor is copper. There is printing that is legible on the lug.

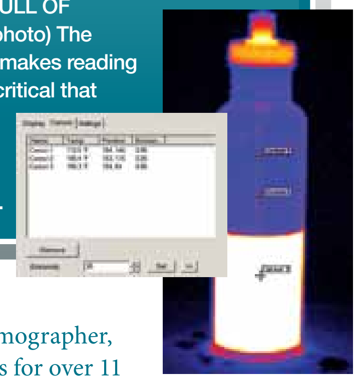
Question: Why are you able to read the print?

Answer: The difference in emissivity between the tin and the printing ink. You can learn about emissivity and much more when you attend IDEAL Industries three day Level I thermographers class. The experience you gain in these classes can be applied in real-life situations at facilities where understanding how to read temperatures accurately is critical to ensure your facility is running at its optimal potential. FEJ



Now as you can see, the color of the tape makes very little if any difference to the temperature that the IR cameras 'sees'. To the camera, all it senses is temperature. If the emitting source's surface is efficient at producing wavelengths that the camera can detect, then you will easily and accurately detect them. If the surface is ineffecient at emitting these wavelengths, accuracy falls dramatically.

THE BOTTLE IS TOTALLY FULL OF HOT WATER. (see right hand photo) The inefficient nature of aluminum makes reading temperature challenging. It is critical that you understand exactly what you are looking at to ensure that you can trust the temperatures you are reading.



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