Non-Contact Temperature Measurement

Engineer's Notebook

Infrared (IR) thermometers have become standard tools for maintenance personnel, with applications throughout any manufacturing plant. They enable quick and easy temperature measurements of objects that would otherwise be difficult to measure. Moving conveyers and webs, live electrical contacts, rotating electrical equiment, and overhead steam lines or traps are just a few of the common applications. IR Thermometers are available in a wide range of prices and features; understanding the basics will help you choose an appropriate tool.

Infrared thermometers: How they work

Any object radiates infrared energy if its temperature is above absolute zero. This energy travels like light, at the speed of light, in all directions. An infrared thermometer is pointed at a target of interest, and its lens collects and focuses the IR energy onto a sensor. The sensor produces a small voltage output, proportional to the target temperature, which is processed and displayed.

Field of view

The farther an IR thermometer is from its target, the larger the target area will be. This relationship between distance and target size is normally expressed as the distance to spot, or D:S ratio. As an example, a D:S ratio of 20:1 would indicate that at a distance of 20 feet, the target "spot" would be 1 foot in diameter. At 20", the spot would be 1". In all cases, the thermometer will display the average temperature across the target area.

If you attempt to measure a small target (say 2") in a large target area, your measurement will not reflect the true temperature of your target.

Generally speaking, a narrower field of view requires better optics, and a higher cost. Low cost general purpose units may have D/S ratios of 4:1 or less, while premium models can be as high as 180:1. If you are measuring the temperature of overhead connections in a power substation, the investment probably makes sense. Be sure to consider working distance and target size when selecting a thermometer.

Sighting on a target

The simplest thermometers have no sighting mechanism, being intended for close-in targets. As you move farther from the target, you need a sighting guide.

Options are:

1. "Gun-sight" notch.
While purely mechanical, these are inexpensive, and for short to intermediate distances they may be adequate.

2. Laser sighting.
These red sighting lasers have come down in cost over the last few years, and are now available on even lower cost units. They may emit a single beam which accurately indicates the center of the target area, or they may effectively draw a "circle" around the target, removing any doubt about your measurement area. In bright or outdoor light, or over long working distances, the laser may not be visible, so keep this in mind.

3. Through-the-lens sighting.
Similar to a camera, these thermometers let you look through the actual lens to view the target spot. They are effective in any light, and generally more expensive than comparable laser equipped models.

Emissivity

Some items reflect infrared radiation as well as emit it. For example, a shiny or polished metal surface will reflect energy; a flat or dull material tends to reflect very little. An emissivity factor is used to account for reflected versus emitted radiation. An item with no reflective property would be said to have an emissivity of 1. Reflective items have lower emissivity levels. The least sophisticated thermometers have fixed (not adjustable) emissivity, usually at 0.95. As you move up in price and features, emissivity is adjustable.

To measure temperature on a reflective material, masking tape or a flat paint spot will give you a non reflective target with high emissivity. If you want to adjust emissivity on a thermometer, you can use figures from a reference table supplied with most thermometers. Better yet, apply tape to a target spot, measure the spot and an adjacent area, and adjust the emissivity until the two readings agree.

Spectral response

The wavelength of infrared energy used for temperature measurement ranges from 0.65 to14 µm. General purpose thermometers respond to a wide band, typically the entire spectrum from 8 to 14 µm. However there are specific narrow wavelengths which are better suited for certain applications.

For example:

1. A spectral response of 1.0 to 1.06 µm is preferred for high temperature measurements of metals, and will read through glass (instead of reading the glass itself).
2. A spectral response of 4.8 to 5.2 µm is preferred for measuring glass and ceramic surfaces.
3. There are two-color versions which compare two adjacent wavelengths near 0.9 µm. Measurements made with these two color instruments are independent of emissivity. They are suited for high temperature measurements, usually above 1400°C.

Such specialized thermometers are relatively expensive, but in many cases they are the only accurate way to measure temperature.

Calibration

Do you need to calibrate your IR thermometer? If you use it just as a diagnostic or troubleshooting tool, probably not. On the other hand, if you are using a fixed sensor for process control, or making critical measurements, you probably should calibrate your thermometer. IR thermometers are calibrated using a black body calibration source. A black body calibrator is a calibrated precision temperature source with perfect emissivity. Calibration is performed by pointing the thermometer at the calibrator target, and comparing or adjusting the output or display.

Black body sources can cost from a few hundred to more than $20,000 depending on the temperature range. You'll find a selection of general purpose black bodies in the following pages of this catalog.

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