Non-contact temperature measurements using IR thermometers

Application Note

Infrared technology makes safe measurements possible in a variety of dangerous or hard-to-reach situations.

Infrared (IR) thermometers allow non-contact measurement of surface temperatures by analyzing the invisible, infrared spectrum emitted from an object.

IR devices, like the Fluke 61 and 65, make it safe to take surface temperature measurements of items like rotating, hard-to-reach, electrically live or dangerously hot targets. For preventative maintenance tasks, they cut measurement time to almost zero with the ability to take a surface temperature reading in less than one second.

IR thermometers can be used to conduct thousands of different types of measurements, including:

- **Electrical:** IR thermometers can be used to troubleshoot problems in electrical connections and verify uninterruptible power supplies by locating hot spots in the output filters or dc battery connections. They can also be used to check components in battery bank, power panel terminations, ballasts, switch gears, and fuse connections that could be draining energy due to the heat created by loose connections or corrosion buildup.
- **Preventive maintenance:** Using IR thermometers for preventive maintenance measurements of hard-to-reach equipment such as HVAC supply diffusers or dangerous equipment like motors, generators, and bearings helps identify potential problems.
- **HVAC/R:** It's estimated up to 30 percent of air conditioning leaks are due to faulty ducting, which can be quickly and easily detected with an IR thermometer.
- **Steam:** IR thermometers are particularly useful in taking surface temperature measurements of uninsulated steam lines, steam valves and fittings, receiver tanks and condensate return lines which pose a large safety hazard due to the potential presence of live steam.
- **Fast test of multiple targets:** IR thermometers are excellent for checking multiple points easily from one location, saving time and money.

Proper use of IR technology

Although IR temperature measurement will never be as accurate as a calibrated contact temperature device, a typical reading will be within 2 °F of the absolute temperature when the instrument is properly applied.

Putting IR technology to use is easy but there are two critical parameters that must be understood to ensure proper and consistent temperature measurements with infrared type devices:

- Optical resolution, and
- Emissivity

Optical resolution

Optical resolution refers to the sample area the IR meter is measuring at a given distance (see Figure 1). Optical resolution is also referred to as the "distance-to-spot-size ratio" or "field-of-view."

Know your application! A device with a 4:1 optical resolution cannot effectively be used to measure an item's temperature 15 feet away – even if the laser beam sight can go that far. On the other hand, the 4:1 ratio gives a smaller minimum spot size than the 10:1 (i.e., the 4:1 can sample a smaller spot than the 10:1).

Try to determine how you are going to apply the IR thermometer before purchasing, and then buy the one that provides the appropriate optical resolution for the application. Many erroneous readings are taken because the technician unknowingly samples a larger area than the object he is trying to measure.

Emissivity

Emissivity indicates the ability of an object to emit infrared energy. Emissivity is based upon the material from which the object is constructed and the surface finish. Values can range from less than 0.1 for a highly reflective body to 1.0 for an ideal black body (see Figure 2).

Items such as soft-drawn copper are very smooth and shiny even under a microscope, while other objects such as lacquer paint appear quite porous under the microscope. The porous object will have a relatively high emissivity (typically 0.7 to 0.98), while new soft-drawn copper (shiny, not oxidized) will have a low emissivity (typically below 0.2). Shiny objects have a tendency to reflect IR energy from objects surrounding them, which dilutes the IR energy from the measured object. A porous body tends to absorb surrounding IR energy, thus emitting its IR energy without dilution (like a black body).

Low-cost IR measurement instruments (under $400) are typically fixed at 0.95 emissivity (the Fluke 61 and 65 have a 0.95 emissivity). To get an effective absolute temperature reading, the surface being measured must have an emissivity close to 0.95. This can be accomplished by measuring a surface that is not too reflective. A shiny surface can be coated with black paint, electrical tape, felt pen or anything else that will be less reflective.

Optical resolution
Ratio of the distance from the measured object vs. the sampling spot size.

Examples:
- 4:1 optical resolution: 4" away from measured object → 1" diameter sampling size.
- 10:1 optical resolution: 20" away from measured object → 2" diameter sampling size.

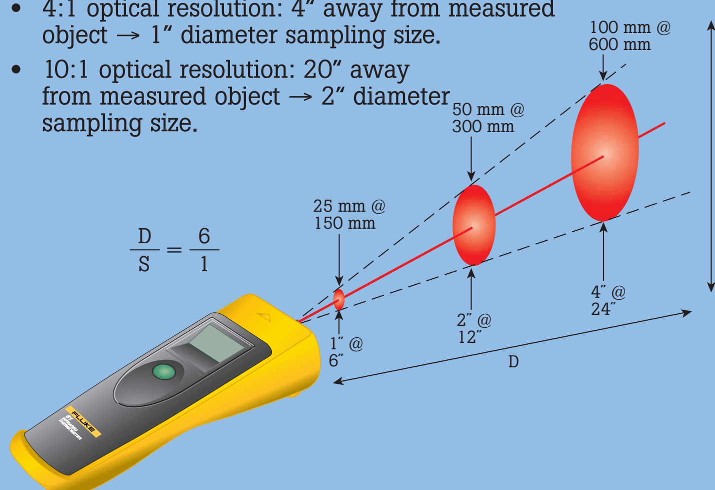

Figure 1.

Emissivity
A numerical value between 0 and 1 that indicates the ability of an object to emit infrared energy. To ensure the optimal measurement accuracy, the target being measured should have an emissivity in the vicinity of 0.95. Emissivity is determined primarily by the material from which an object is constructed and its surface finish.

Examples:
- Polished Brass: 0.03
- Oxidized Brass: 0.61
- Roughly Polished Copper: 0.07
- Black Oxidized Copper: 0.78
- Black Lacquer Paint: 0.96
- Commercial Sheet Aluminum: 0.09
- Oxidized Lead: 0.43
- Rusted Iron: 0.78
- Oxidized Iron: 0.84

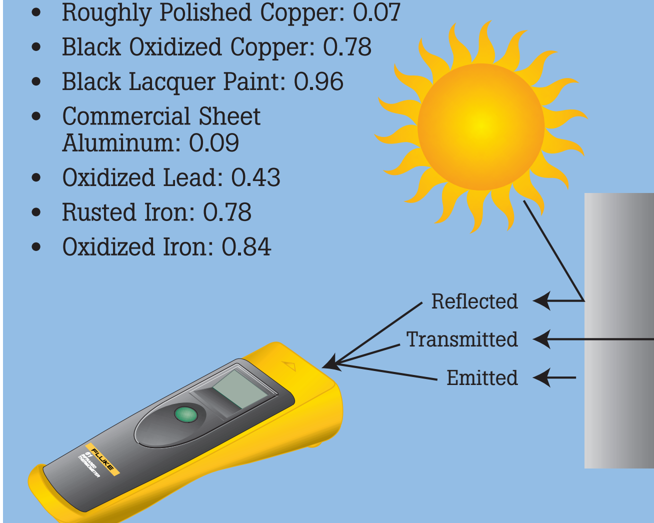

Figure 2.

If a 0.95 fixed emissivity IR instrument is used to measure an object that is not close to 0.95, the reading will be incorrect as follows:

- If the measured object is warmer than ambient temperature, the reading will be erroneously lower than the actual temperature;
- If the measured object is colder than ambient temperature, then the reading will be erroneously higher than the actual temperature.

The effect of incorrect application

Understanding the optical resolution and emissivity ratings of your IR thermometer and the target you plan to measure will help you avoid inaccurate measurements. The example below illustrates how an incorrect application can lead to inaccurate results.

The task
A technician needs to take a temperature measurement on an air conditioner's new chill water line to calculate the efficiency of the system's heat exchanger. The technician has just purchased his first IR thermometer and is anxious to put it to use. He decides to compare it against his digital contact thermometer. Here are the facts:

- IR thermometer: Fixed at 0.95; Optical resolution of 4:1
- Target size: 2˝ diameter copper pipe

  (Hint: This pipe will provide a 2˝ diameter sample area from the side.)
- Ambient temperature: 74 °F
- 55 degree chill water line

Attempt # 1:
The technician already knows the proper line temperature of the chill water line is around 55 °F. He holds the IR thermometer 12 inches away from the line and reads a temperature of 72 °F. He moves the thermometer to within three inches of the target and the measurement on the IR thermometer lowers to 68 °F. A slight improvement, but still not close to the expected value.

In this first attempt, the technician has adjusted his distance from the target to fall within the instrument's optical resolution, but has not accounted for emissivity differences between the instrument rating and the material.

Attempt # 2:
Ten minutes later, the technician returns to the air conditioning unit with his IR instruction sheet and some black electrical tape in hand. He applies a few pieces of the electrical tape to cover the supply and discharge of the shiny copper chill water line. Upon re-measuring at a distance of three inches with the IR thermometer targeted at the electrical tape, the thermometer registers 56 °F, which is within the accuracy specifications for the instrument.

He then measures the discharge at the heat exchanger, which is 72 degrees. With the two temperature readings, he can now calculate the heat removal rate on the heat exchanger, which is the measure of the system's efficiency.

The technician leaves the jobsite with a better understanding of IR technology and the constraints of optical resolution and fixed emissivity.