Thermal Imaging Best Practices:
The Measuring Object

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Introduction

In times of rising energy prices and costly downtimes, non-contact temperature measurement is establishing itself as a cost effective means for assessing building efficiency and industrial maintenance. Although, thermography is a relatively easy concept to understand, practicing thermography requires following a few basic ground rules in non-contact temperature measurement.

Two basic but vital considerations are understanding the environment in which you are operating and the characteristics of the object or objects being measured. Each can effect your thermal imagers accuracy and reliability.

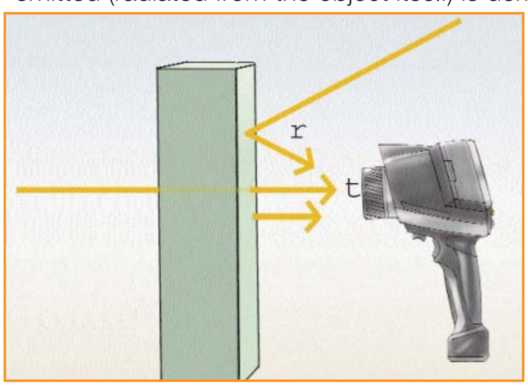
Thermography in Practice

The Target Object

1. Material and emissivity

The surface of each material has a specific emissivity from which the amount of the infrared radiation emitted from the material that is

- reflected and
- emitted (radiated from the object itself) is derived.



Emission, reflection, and transmission

2. Color

The color of a material has no noticeable effect on the long-wave infrared radiation emitted by the object to be measured when measuring the temperature with a thermal imager. Dark surfaces absorb more short-wave infrared radiation than light surfaces and therefore heat up more quickly. However, the emitted infrared radiation depends on the temperature and not on the color of the surface of the target object. A heater painted black, for example, emits exactly the same amount of long-wave infrared radiation as a heater painted white at the same temperature.

3. Surface of the target object

The properties of the surface of the target object play a crucial role in the measurement of temperature with a thermal imager. For the emissivity of the surface varies according to the structure of the surface, soiling or coating.

- Structure of the surface

Smooth, shiny, reflective and/or polished surfaces generally have a slightly lower emissivity than matt, structured, rough, weathered and/or scratched surfaces of the same material. There are often specular reflections with extremely smooth surfaces.

- Wetness, snow and frost on the surface

Water, snow and frost have relatively high emissivities (approx. $0.85 < \varepsilon < 0.96$), so measurement of these substances is generally unproblematic. However, you must bear in mind that the temperature of the target object can be distorted by natural coatings of this kind. Wetness cools the surface of target object as it evaporates and snow has good insulating properties… however frost usually does not form a sealed surface, so the emissivity of the hoarfrost as well as that of the surface underneath it must be taken into account when measuring.

- Soiling and foreign bodies on the surface

Soiling on the surface of the target object such as dust, soot or lubricating oil generally increases the emissivity of the surface. For this reason, measuring dirty objects is generally unproblematic. However, your thermal imager always measures the temperature of the surface, i.e. the dirt, and not the exact temperature of the surface of the target object underneath.

Thermography in Practice

The Measuring Environment

1. Ambient temperature

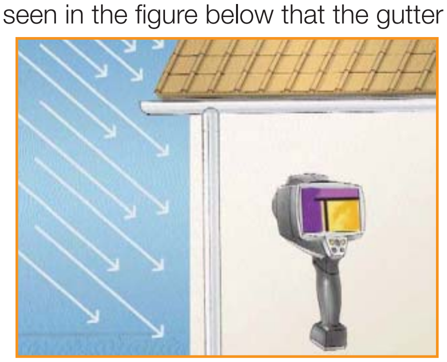
You should also factor in the setting of the reflected temperature (RTC) as well as the emissivity setting (ε) so that your thermal imager can calculate the temperature of the surface of the target object correctly. In many measurement applications, the reflected temperature corresponds to the ambient temperature. You can measure this with an air temperature thermometer, e.g. a testo 810. An accurate setting of the emissivity is particularly important where there is a large difference in temperature between the target object and the measuring environment.

The emissivity of a material depends primarily on the structure of the surface of the material. Note the correct emissivity setting according to the covering on the surface of the target object. Avoid measuring on wet surfaces or surfaces covered with snow or frost. Avoid measuring on loose-lying soiling (distortion of temperature by air pockets).
When measuring smooth surfaces in particular, be aware of any possible sources of radiation in the vicinity (e.g. sun, heaters etc.).

2. Radiation
Every object with a temperature above absolute zero (0 Kelvin = -459.7 °F) emits infrared radiation. In particular, objects with a large difference in temperature from the target object can distort the infrared measurement as a result of their own radiation. You should avoid or eliminate sources of interference of this kind wherever possible. By blocking the sources of interference (e.g. with canvas or a cardboard box), you will reduce this unwanted effect on the measurement. If the effect of the source of interference cannot be removed, the reflected temperature does not correspond to the ambient temperature. A globe thermometer or Lambert radiator, for example, is recommended for measuring the reflected radiation in conjunction with your thermal imager.

Special features of outdoor thermography

The infrared radiation emitted from the clear sky is referred to informally as “cold diffuse celestial radiation”. If the sky is clear, “cold diffuse celestial radiation” (~ -58 °F to -76 °F) and hot sunlight (~ 5500 °C) are reflected during the day. In terms of area, the sky outstrips the sun, which means that the reflected temperature in outdoor thermography is usually below 32 °F, even on a sunny day. Objects heat up in the sun as a result of absorbing sunlight. This affects the surface temperature considerably – in some cases for hours after exposure to sunlight.
It can be seen in the figure below that the gutter is shown



Reflection for measurements outdoors.

colder than the house wall on the thermal image. However, both are roughly the same temperature. The image must therefore be interpreted.

Let us assume that the surface of the gutter is galvanized and has extremely low emissivity (ε = 0.1). Only 10% of the long-wave infrared radiation emitted by the gutter is therefore emitted inherent radiation, 90% is reflected ambient radiation. If the sky is clear, “cold diffuse celestial radiation” (~ -58 °F to -76 °F) is reflected on the gutter. The thermal imager is set to ε = 0.95 and RTC = -131 °F to ensure correct measurement of the house wall. Due to the extremely low emissivity and the extremely high reflectance, the gutter is shown too cold on the thermal image. To show the temperatures of both materials correctly on the thermal image, you can change the emissivity of certain areas retrospectively using analyzing.

3. Weather
- Clouds
A thickly clouded sky offers the ideal conditions for infrared measurements outdoors, as it screens the target object from sunlight and “cold diffuse celestial radiation.

- Precipitation
Heavy precipitation (rain, snow) can distort the measurement result. Water, ice and snow have high emissivity and are impervious to infrared radiation. In addition, the measurement of wet objects can result in measuring errors, as the surface of the target Please always be aware of the effect of your own personal infrared radiation. Change your position during the measurement in order to identify any reflections. Reflections move, thermal features of the target object remain in the same place, even if the slant changes.

Avoid measurements close to very hot or cold objects, or screen these. Avoid direct sunlight, including for a few hours before the measurement. Take measurements in the early morning. Wherever possible, perform outdoor measurements when it is cloudy.

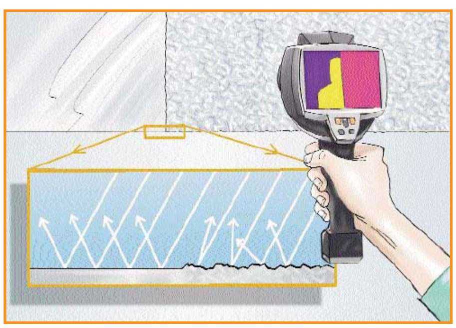
4. Air
- Air humidity
The relative air humidity in the measuring environment should be low enough so that there is no condensation in the air (mist), on the target object, on the protection glass or the lens of the thermal imager. If the lens (or protection glass) has misted over, some of the infrared radiation hitting

the thermal imager will not be received, as the radiation fails to penetrate fully through the water onto the lens.

Extremely dense mist can affect the measurement, as the water droplets in the transmission path let less infrared radiation through. Ideally, perform measurements with heavy clouds. Also make note of the clouds a few hours before the measurement. Avoid heavy precipitation during the measurement.

- Air flows

Wind or a draft in the room can affect the temperature measurement with the thermal imager. As a result of the heat exchange (convection), the air close to the surface is the same temperature as the target object. If it is windy or there is a draft, this layer of air is “blown away” and replaced by a new layer of air that has not yet adapted to the temperature of the target object. As a result of convection, heat is taken away from the warm target object or absorbed by the cold target object until the temperature of the air and the surface of the target object have adjusted to each other. This effect of the heat exchange increases greater temperature difference between the surface of the target object and the ambient temperature.



Specular and diffuse reflection.

- Air pollution

Some suspended matter such as dust, soot and smoke, for example, as well as some vapors have high emissivity and are barely transmissive. This means that they can impair the measurement, as they emit their own infrared radiation that is received by the thermal imager. In addition, not all of the infrared radiation of the target object can penetrate through to the thermal imager, as it is scattered and absorbed by the suspended matter.

5. Light

Light or illumination do not have a significant impact on measurement with a thermal imager. You can also take measurements in the dark, as the thermal imager measures long-wave infrared radiation. However, some light sources emit infrared heat radiation themselves and can thus affect the temperature of objects in their vicinity. You should therefore not measure in direct sunlight or near a hot light bulb, for example. Cold light sources such as LEDs or neon lights are not critical, as they convert the majority of the energy used into visible light and not infrared radiation.

Summary

Using thermal imagers as a preventive maintenance tool can save valuable time and money. It’s most effective when you follow some simple best practices.

When conducting a thermal imaging survey consider the object being measured and the environment in which you are performing your measurement. Variables, such as, light, wind, pollution, and weather can influence your measurement. In addition, the characteristics of the object, such as color, composition and emissivity can also impact the accuracy of your thermal measurement.

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TESTO, INC. is a world leader in the design, development and manufacture of portable instrumentation. Backed by nearly 50 years of measuring engineering experience our mission is to provide the best quality, service and value in the industry. In addition, Testo is also recognized as the leading worldwide manufacturer of portable combustion efficiency analyzers and air emission analyzers.

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