

## Introduction to Thermal Imaging

While spot infrared thermometers present only a single temperature at a single spot, Thermal Imaging Cameras give you the whole picture. Thermal imaging is the most effective method for finding problems or potential problems in a variety of applications across many fields.

Thermal imagers allow users to measure temperature in applications where conventional sensors cannot be employed. Specifically, in cases dealing with moving objects (i.e., rollers, moving machinery, or a conveyor belt), or where non-contact measurements are required because of contamination or hazardous reasons (such as high voltage), where distances are too great, or where the temperatures to be measured are too high for thermocouples or other contact sensors. The thermal imagers provide an image, which shows the temperature difference of the object being measured. Hot spots can be seen immediately versus traditional infrared guns, which average the area being measured. Typical applications include:

- Solving Electrical Problems
- Detecting Flow of Heat
- Checking Thermal Insulation
- Lubrication and HVAC
- Building Insulation Inspection

There are generally two ways of using a thermal imager:

1. Either you can read the exact readings of various parts displayed in the display and see what the temperature of various parts is displayed on the screen is, or;
2. You can do a comparative study of the displayed picture with another picture of a similar load under similar load conditions.

## Introduction to Thermal Imaging

All objects will radiate infrared energy. The actual surface temperature and emissivity of the target directly affect the quantity of energy radiated. Emissivity is defined as the ratio of the energy radiated by an object at a given temperature to the energy emitted by a perfect radiator, or blackbody, at the same temperature.

The Imager measures the infrared energy from the surface of the target and uses this data to calculate an estimated temperature. Many common materials such as wood, water, skin, cloth, and painted surfaces - including metal - radiate energy well and therefore have a high emissivity factor of  $\geq 90\%$  (or 0.90). The Imager measures temperatures more accurately on targets with a high emissivity.

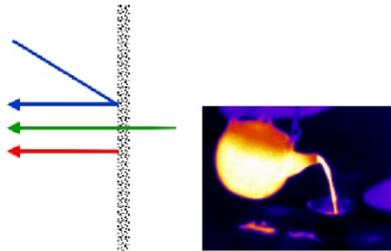
Surfaces with an emissivity of  $< 0.60$  make it far more difficult to determine reliable and consistent actual temperatures. The lower the emissivity is the greater the potential of error is when the Imager calculates the temperature because more of the energy reaching the camera is specified as background temperature. This is also true even when adjustments to the emissivity and reflected background adjustments are performed properly.

A Thermal camera only sees the surface of a target and calculates the temperature from three sources for the total heat energy:

1. Reflected Energy
2. Transmitted Energy
3. Emitted Energy

## Introduction to Thermal Imaging

This thermal image of a hot water pot is derived from infrared radiation detected exclusively from the surface. The camera does not see anything deeper than the surface of the pot. The inside is “seen” only to the extent of a heat footprint created on the surface.



The temperature information is given in the emitted radiation, but the imager also “sees” the reflected and transmitted components. Most materials are opaque to infrared, so we can usually ignore the transmitted energy. However, many materials (with low emissivity) reflect infrared radiation. Therefore, with these materials we must make a “reflected temperature compensation” (RTC)

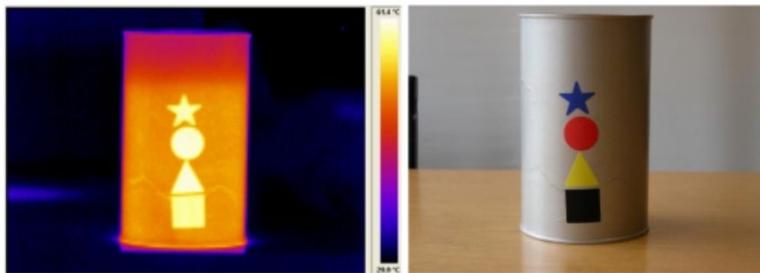
Consider the two objects below. The tire on the racing car is black, opaque, and non-reflective. The emissivity of rubber is known and we can therefore accurately measure the thermal profile. The objects on the right include highly reflective metallic traffic lights and we must be concerned about reflections of infrared radiation, which would, if not properly compensated, result in apparent thermal readings that are significantly inaccurate.



## Introduction to Thermal Imaging

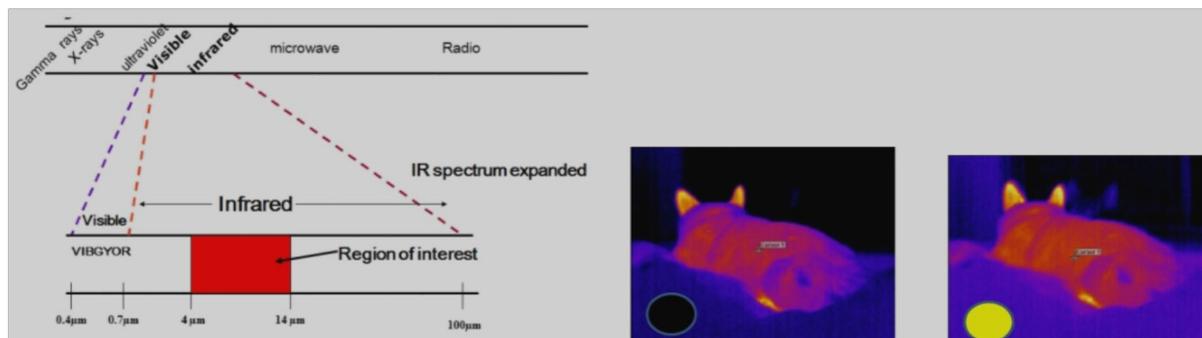
Things that are transparent in the visible light world are not necessarily transparent in the IR world and vice versa. For example, window glazing is transparent in visible light, but nearly opaque in IR light -- so, if you take an IR image "through" a window, what you are really getting is the surface temperature of the window glazing, not the temperatures of the stuff on the other side of the window. Some things that are opaque to visible light are transparent to IR -- black poly film for instance.

Emissivity is not related to colour? The coloured labels below are all at the same temperature



Infrared thermal imaging cameras do not detect visible light (see below left, response region marked in red).

Below right are two thermal images of a dog, taken under night and day illumination levels. Both images are virtually the same as the camera only responds to its long wave infrared signature.

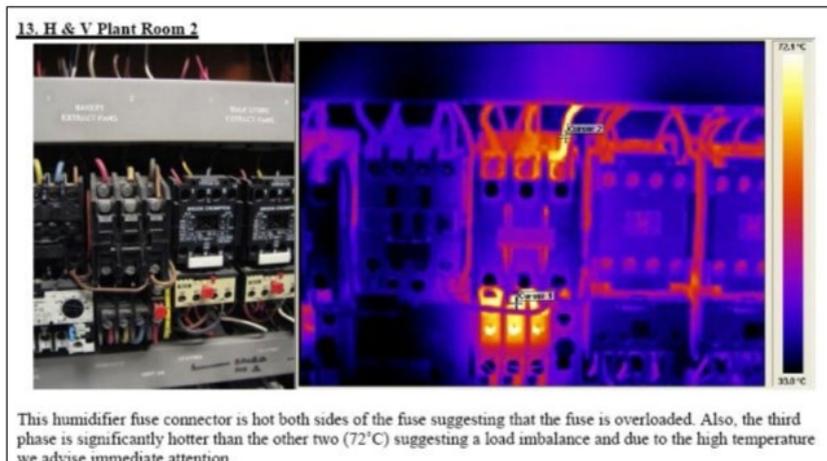


## Introduction to Thermal Imaging

Sensitivity expresses the ability of an infrared camera to display a very good image even if the thermal contrast in a scene is low. Put another way, a camera with good sensitivity can distinguish objects in a scene that have very little temperature difference between them.. For most inspection and engineering applications, thermal sensitivity of .1C is more than sufficient.

Sensitivity is most often measured by a parameter called Noise Equivalent Temperature Difference or NETD, for example, NETD @ 30 C : 80mK. A Kelvin degree is the SI base unit of thermodynamic temperature equal in magnitude to a degree Celsius, so mK means thousandths of a degree (80mK = 0.080 K).

Infrared-image fusion takes a visible light picture and overlays - or fuses - the infrared image over this. It aids in identifying exact areas or items when making a measurement.



## Introduction to Thermal Imaging

Typical Emissivity Values			
Substance	Emissivity	Substance	Emissivity
Asphalt	0.90 - 0.98	Aluminium Foil	0.04
Concrete	0.94	Aluminium (oxidized)	0.01 - 0.40
Cement	0.96	Brass (oxidized)	0.50 - 0.65
Sand	0.90	Chromium oxides	0.81
Earth	0.92 - 0.96	Copper oxides	0.78
Water	0.92 - 0.96	Copper (oxidized)	0.20 - 0.88
Ice	0.96 - 0.98	Steel (oxidized)	0.79 - 0.80
Snow	0.83	Zinc (oxidized)	0.10 - 0.11
Glass	0.90 - 0.95	Iron (oxidized)	0.50 - 0.90
Ceramic	0.90 - 0.94	Iron (rust)	0.65 - 0.96
Marble	0.94	Wood	0.80 - 0.90
Plaster	0.80 - 0.90	Graphite	0.70 - 0.80
Plasterboard	0.91	PVC	0.91 - 0.93
Mortar	0.89 - 0.91	Coal	0.80
Brick	0.93 - 0.96	Cardboard	0.81
Rubber (black)	0.94	Cloth (black)	0.98
Plastic	0.85 - 0.95	Human Skin	0.97 - 0.99
Textiles	0.90	Charcoal (powder)	0.96
Paper	0.70 - 0.94	Electrical Terminal Blocks	0.60