Technical Information Data Bulletin

How to Determine Emissivity Values

TEMPERATURE & PROCESS INSTRUMENTS INC

Infrared energy

Each body, at temperatures above the absolute zero (-273°C or 0K), emits energy in the form of electromagnetic radiation. As the temperature of the body rises, the intensity of this infrared energy increases. The temperature of the body can therefore be determined by measuring the intensity of this infrared energy. An equipment used to measure the temperature with this method is called "infrared thermometer" or a "non-contact thermometer" since the thermometer is not required to be in contact with the body in order to measure its temperature.

OPTCTLT15 - CT LT15 Compact Infrared Thermometer

Applications

The temperature measurement of liquids or gases is well accomplished using a thermoelectric sensor thanks to the good thermal exchange between the sensor and the fluid. When solid objects are to be measured it is difficult to obtain a good thermal exchange and the possibility of making an additional error should be kept into consideration. Temperature measurements with direct contact are often mpossible to be carried out when the target is moving or is connected to dangerous electrical sources or when, for any other reason, it is impossible or difficult to touch it.

CS Series Fixed Mounted Infrared Therermometer

Emissivity

The infrared energy emitted by a body differs according to the composition of the body and to the physical condition of the surface. Non-contact thermometers are calibrated using a Blackbody source (made with material that absorbs energy at all wavelengths) as a reference standard. However, to obtain the reading of the true temperature, it is necessary to compensate the thermometer for the actual emissivity of the object to be measured.

$$\text{Emissivity} = \frac{\text{Surface Radiation}}{\text{Blackbody Radiation}}$$

The emissivity values relevant to different materials and surface conditions are detailed below "How to Determine an Object Emissivity". The values from the above tables are reference values only: emissivity can in fact be slightly higher with a higher oxidation of the material .

Reflected energy compensation

The radiation perceived from the thermometer is the one emitted by the target plus the radiation reflected by the surface of the object itself. To obtain more accurate readings, particularly for measurements of low emissivity temperature objects, the energy reflected from the target should be considered; that energy changes according to the temperature of the surrounding environment.

How to Determine an Object Emissivity

Emissivity is the measure of an object ability to absorb, transmit, and emit infrared energy. It can have a value from 0 (shiny mirror) to 1.0 (blackbody). If a value of emissivity higher than the actual one is set, the output will read low, provided that the target temperature is above the ambient one. For example, if 0.95 is set in and the actual emissivity is 0.9, the reading will be lower than the true temperature when the target temperature is above the ambient one.

The emissivity can be determined by one of the following methods, in order of preference:

1. Determine the actual temperature of the material using a sensor such as a RTD, thermocouple or another suitable method. Next, measure the object temperature and adjust the emissivity setting until the correct value is reached. This is the correct emissivity for the measured material.

CS Series Fixed Mounted Infrared Therermometer

2. For relatively low temperature objects (up to 260°C or 500°F, place a piece of tape, such as a masking, on the object. Make sure the tape is large enough to cover the field of view. Next, measure the tape temperature using an emissivity setting of 0.95. Finally, measure an adjacent area on the object and adjust the emissivity setting until the same temperature is reached. This is the correct emissivity for the measured material.

3. If a portion of the surface of the object can be coated, use a flat black paint, which will have an emissivity of about 0.98. Next, measure the painted area using an emissivity setting of 0.98. Finally, measure an adjacent area on the object and adjust the emissivity setting until the same temperature is reached. This is the correct emissivity for the measured material.

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Metals - Typical Emissivity Values

		1.0 micron	1.6 micron	5.1 micron	8-14 microns
Aluminum					
	Non-Oxidized	0.1-0.2	0.02-0.2	0.02-0.2	0.02-0.1
	Oxidized	0.4	0.4	0.2-0.4	0.2-0.4
Alloy A 3003					
	Oxidized	NA	0.4	0.4	0.3
	Roughened	0.2-0.8	0.2-0.6	0.1-0.4	0.1-0.3
	Polished	0.1-0.2	0.02-0.1	0.02-0.1	0.02-0.1
Brass					
	Polished	0.8-0.95	0.01-0.05	0.01-0.05	0.01-0.05
	Burnished	NA	NA	0.3	0.3
	Oxidized	0.6	0.6	0.5	0.5
Carbon					
	Non-oxidized	0.8-0.95	0.8-0.9	0.8-0.9	0.8-0.9
	Graphite	0.8-0.9	0.8-0.9	0.7-0.9	0.7-0.8
Chromium		0.4	0.4	0.03-0.3	0.02-0.2
Copper					
	Polished	0.05	0.03	0.03	0-03
	Roughened	0.05-0.2	0.05-0.2	0.05-0.15	0.05-0.1
	Oxidized	0.2-0.8	0.2-0.9	0.5-0.8	0.4-0.8
Gold		0.3	0.01-0.1	0.01-0.1	0.01-0.1
Haynes Alloy		NA	0.5-0.9	0.3-0.8	0.3-0.8
Inconel					
	Oxidized	0.4-0.9	0.6-0.9	0.6-0.9	0.7-0.95
	Sandblasted	0.3-0.4	0.3-0.6	0.3-0.6	0.3-0.6
	Electro-polished	0.2-0.5	0.25	0.15	0.15
Iron					
	Oxidized	0.4-0.8	0.5-0.9	0.6-0.9	0.5-0.9
	Non-oxidized	0.35	0.1-0.3	0.05-0.25	0.05-0.2
	Rusted	NA	0.6-0.9	0.5-0.8	0.5-0.7
	Molten	0.35	0.4-0.6	NA	NA
Iron Cast					
	Oxidized	0.7-0.9	0.7-0.9	0.65-0.95	0.6-0.95
	Non-oxidized	0.35	0.3	0.25	0.2
	Molten	0.35	0.3-0.4	0.2-0.3	0.2-0.3
Iron Wrought Dull		0.9	0.9	0.9	0.9
Lead					
	Polished	0.35	0.05-0.2	0.05-0.2	0.05-0.1
	Rough	0.65	0.6	0.4	0-4
	Oxidized	NA	0.3-0.7	0.2-0.6	0.2-0.6
Magnesium		0.3-0.8	0.05-0.3	0.03-0.15	0.02-0.1
Mercury		NA	0.05-0.15	0.05-0.15	0.05-0.15
Molybdenum					
	Oxidized	0.5-0.9	0.4-0.9	0.3-0.7	0.2-0.6
	Non-oxidized	0.25-0.35	0.1-0.3	0.1-0.15	0.1
Monel (Ni-Cu)		0.3	0.2-0.6	0.1-0.5	0.1-0.14
Nickel					
	Oxidized	0.8-0.9	0.4-0.7	0.3-0.6	0.2-0.5
	Electrolytíc	0.2-0.4	0.1-0.3	0.1-0.15	0.05-0.15
Platinum					
	Black -	NA	0.95	0.9	0.9
Silver		0.04	0.02	0.02	0.02
Steel					
	Cold-Rolled	0.8-0.9	0.8-0.9	0.8-0.9	0.7-0.9
	Ground Sheet	NA	NA	0.5-0.7	0.4-0.6
	Polished Sheet	0.35	0.25	0.15	0.1
	Molten	0.35	0.25-0.4	0.1-0.2	NA
	Oxidized	0.8-0.9	0.8-0.9	0.7-0.9	0.7-0.9
	Stainless	0.35	0.2-0.9	0.15-0.8	0.1-0.8
Tin (Non-oxidized)		0.25	0.1-0.3	0.05	0.05
Titanium					
	Polished	0.5-0.75	0.3-0.5	0.1-0.3	0.05-0.2
	Oxidized	NA-	0.6-0.8	0.5-0.7	0.5-0.6
Tungsten		NA	0.1-0.6	0.05-0.5	0.03
	Polished	0.35-0.4	0.1-0.3	0.05-0.25	0.03-0.1
Zinc					
	Oxidized	0.6	0.15	0.1	0.1
	Polished	0.5	0.05	0.03	0.02

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Non-metals - Typical Emissivity Values

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	1.0 micron	1.6 micron	5.1 micron	8-14 microns
Asbestos	0.9	0.9	0.95	0.95
Asphalt	NA	0.95	0.95	0.95
Basalt	NA	0.7	0.7	0.7
Carborundum	NA	0.9	0.9	0.9
Ceramic	0.4	0.8-0.95	0.95	0.95
Clay	NA	0.8-0.95	0.95	0.95
Concrete	0.65	0.9	0.95	0.95
Cloth	NA	0.95	0.95	0.95
Glass				
Plate	NA	0.98	0.85	0.85
"Gob"	NA	0.9	NA	NA
Gravel	NA	0.95	0.95	0.95
Gypsum	NA	0.4-0.97	0.8-0.95	0.8-0.95
Ice	NA	NA	0.98	0.98
Limestone	NA	0.4-0.98	0.98	0.98
Paint -	NA	NA	0.9-0.95	0.9-0.95
Paper(any color)	NA	0.95	0.95	0.95
Plastic (opaque				
Over 20 mils)	NA	0.95	0.95	0.95
Rubber	NA	0.9	0.9	0.95
Sand	NA	0.9	0.9	0.9
Snow	NA	0.9	0.9	0.9
Soil	NA	NA	0.9-0.98	0.9-0.98
Water	NA	NA	0.93	0.93
Wood, Natural	NA	0.9-0.95	0.9-0.95	0.9-0.95

To optimize surface temperature measurements consider the following guidelines:

1. Determine the object emissivity using the suitable instrument for measurement.
2. Avoid reflections by shielding the object from surrounding high temperature sources.
3. For higher temperature objects use shorter wavelength instruments, whenever any overlap occurs.
4. For semi-transparent materials such as plastic films and glasses, assure that the background is uniform and lower in temperature than the object.
5. Mount the sensor perpendicularly to the surface whenever the emissivity is less than 0.9. In any case, do not exceed angles more than 30 degrees from incidence.

OPTCTLT15 - CT LT15 Compact Infrared Thermometer Sensor with LCD Display

OPTCTLT15 - CT LT15 Compact Infrared Thermometer Sensor with LCD Display

- **Temperature Range -58°F to 1112°F (-50°C to 600°C) scalable via programming keys or optional USB, RS232, interface and software**
- **High Optic Resolution of 15:1**
- **Spectral response 8 to 14µm**
- **Compact Size M12x1, 1.1 in. (28mm) long, stainless steel sensor housing**
- **Ambient temperature sensor head rugged and usable up to 356°F (180°C) ambient temperature without cooling**
- **Separate electronics housing with easy accessible programming keys and LCD backlit display**
- **IP 65 (NEMA-4) Sensing Head and Electronic Housing**
- **Emissivity 0.100 to 1.000 adjustable via programming keys and LCD backlit display**
- **Signal processing: Peak Hold, Valley Hold, Average; Extended hold function with Threshold and Hysteresis**
- **Scalable analog output: 0/4 to 20mA, 0 to 5V, 0 to 10 V, or Thermocouple Type K or J**

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