

Introduction to Infrared Pyrometers

Why should I use an infrared pyrometer to measure temperature in my application?

Infrared pyrometers 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 conveyer 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.

What should I consider about my application when selecting an infrared pyrometer?

The critical considerations for any infrared pyrometer include field of view (target size and distance), type of surface being measured (emissivity considerations), spectral response (for atmospheric effects or transmission through surfaces), temperature range and mounting (handheld portable or fixed mount). Other considerations include response time, environment, mounting limitations, viewing port or window applications, and desired signal processing.

FIELD OF VIEW

What is meant by Field of View, and why is it important?

The field of view is the angle of vision at which the instrument operates, and is determined by the optics of the unit. To obtain an accurate temperature reading, the target being measured should completely fill the field of view of the instrument. Since the infrared device determines the average temperature of all surfaces within the field of view, if the background temperature is different from the object temperature, a measurement error can occur (figure 1).

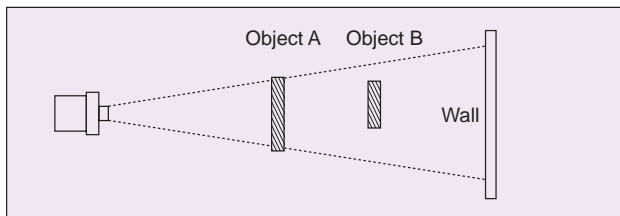


Figure 1: Field of view

Most general purpose indicators have a focal distance between 20 and 60". The focal distance is the point at which the minimum measurement spot occurs. For example, a unit with a distance-to-spot size ratio of 120:1, and a focal length of 60" will have a minimum spot size of 0.5" at 60" distance. Close-focus instruments have a typical 0.1 to 12" focal length, while long-range units can use focal distances on the order of 50". Many instruments used for long distances or small spot sizes also include sighting scopes for improved focusing. Field of view diagrams are available for most instruments to help estimate spot size at specific distances.

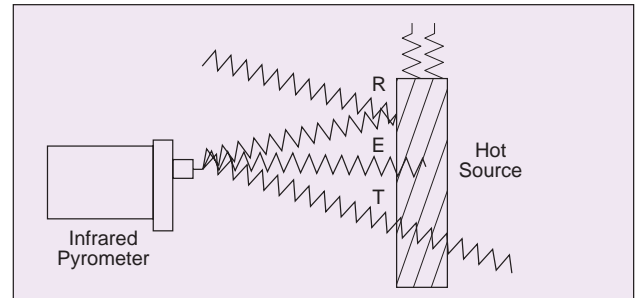
EMISSION

What is emissivity, and how is it related to infrared temperature measurements?

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 emissivity of a blackbody is 1.0. All values of emissivity fall between 0.0 and 1.0.

Emissivity (ϵ), a major but not uncontrollable factor in IR temperature measurement, cannot be ignored. Related to emissivity are reflectivity (R), a measure of an object's ability to reflect infrared energy, and transmissivity (T), a measure of an object's ability to pass or transmit IR energy. All radiation energy must be either emitted (E) due to the temperature of the body, transmitted (T) or reflected (R). The total energy, the sum of emissivity, transmissivity and reflectivity is equal to 1:

$$E + T + R = 1.0$$



Total infrared radiation reaching pyrometers

The ideal surface for infrared measurements is a perfect radiator, or a blackbody with an emissivity of 1.0. Most objects, however, are not perfect radiators, but will reflect and/or transmit a portion of the energy. Most instruments have the ability to compensate for different emissivity values, for different materials. In general, the higher the emissivity of an object, the easier it is to obtain an accurate temperature measurement using infrared. Objects with very low emissivities (below 0.2) can be difficult applications. Some polished, shiny metallic surfaces, such as aluminum, are so reflective in the infrared that accurate temperature measurements are not always possible.



Reflectivity is usually a more important consideration than transmission except in a few special applications, such as thin film plastics. The emissivity of most organic substances (wood, cloth, plastics, etc.) is approximately 0.95. Most rough or painted surfaces also have fairly high emissivity values.

FIVE WAYS TO DETERMINE EMISSIVITY

There are five ways to determine the emissivity of the material, to ensure accurate temperature measurements:

1. Heat a sample of the material to a known temperature, using a precise sensor, and measure the temperature using the IR instrument. Then adjust the emissivity value to force the indicator to display the correct temperature.
2. For relatively low temperatures (up to 500°F), a piece of masking tape, with an emissivity of 0.95, can be measured. Then adjust the emissivity value to force the indicator to display the correct temperature of the material.
3. For high temperature measurements, a hole (depth of which is at least 6 times the diameter) can be drilled into the object. This hole acts as a blackbody with emissivity of 1.0. Measure the temperature in the hole, then adjust the emissivity to force the indicator to display the correct temperature of the material.
4. If the material, or a portion of it, can be coated, a dull black paint will have an emissivity of approx. 1.0. Measure the temperature of the paint, then adjust the emissivity to force the indicator to display the correct temperature.
5. Standardized emissivity values for most materials are available (see pages 114-115). These can be entered into the instrument to estimate the material's emissivity value.



TEMPERATURE MEASUREMENT THROUGH GLASS

I want to measure the temperature through a glass or quartz window; what special considerations are there?

Transmission of the infrared energy through glass or quartz is an important factor to be considered. The pyrometer must have a wavelength where the glass is somewhat transparent, which means they can only be used for high temperature. Otherwise, the instrument will have measurement errors due to averaging of the glass temperature with the desired product temperature.

MOUNTING

How can I mount the infrared pyrometer?

The pyrometer can be of two types, either fixed-mount or portable. Fixed mount units are generally installed in one location to continuously monitor a given process. They usually operate on line power, and are aimed at a single point. The output from this type of instrument can be a local or remote display, along with an analog output that can be used for another display or control loop.

Battery powered, portable infrared "guns" are also available; these units have all the features of the fixed mount devices, usually without the analog output for control purposes. Generally these units are utilized in maintenance, diagnostics, quality control, and spot measurements of critical processes.

RESPONSE TIME

What else should I take into account when selecting and installing my infrared measurement system?

First, the instrument must respond quickly enough to process changes for accurate temperature recording or control. Typical response times for infrared thermometers are in the 0.1 to 1 second range. Next, the unit must be able to function within the environment, at the ambient temperature.

Other considerations include physical mounting limitations, viewing port/window applications (measuring through glass), and the desired signal processing to produce the desired output for further analysis, display or control.



SPECTRAL RESPONSE

What is spectral response, and how will it affect my readings?

The spectral response of the unit is the width of the infrared spectrum covered. Most general purpose units (for temperatures below 1000°F) use a wideband filter in the 8 to 14 micron range. This range is preferred for most measurements, as it will allow measurements to be taken without the atmospheric interference (where the atmospheric temperature affects the readings of the instrument). Some units use wider filters such as 8 to 20 microns, which can be used for close measurements, but are "distance-sensitive" against longer distances. For special purposes, very narrow bands may be chosen. These can be used for higher temperatures, and for penetrations of atmosphere, flames, and gases. Typical low band filters are at 2.2 or 3.8 microns. High temperatures above 1500°F are usually measured with 2.1 to 2.3 micron filters. Other bandwidths that can be used are 0.78 to 1.06 for high temperatures, 7.9 or 3.43 for limited transmissions through thin film plastics, and 3.8 microns to penetrate through clean flames with minimum interference.