Monitoring and regulating temperature is an essential part of a wide range of industrial processes. Accurate management of this key parameter can ensure optimal process efficiency, high-quality output and safe operation. There are two broad categories of temperature measurement instruments: contact and non-contact.

Contact temperature measurement instruments include thermocouples, resistance temperature detectors (RTDs), thermistors and probe-type temperature sensors. These devices function by reaching thermal equilibrium with a target after contact with it, matching their own temperature to that of the target. They are generally inexpensive but can have relatively slow response times.

Non-contact temperature measurement instruments sense temperatures from a distance. These include thermal imagers, which are cameras that render the infrared radiation emitted by objects and surfaces in an area as a visible light image to reveal the temperature profile of the entire scene. Pyrometers or infrared thermometers, on the other hand, perform spot measurements, translating the amount of infrared radiation emitted from a specific point into a temperature value.

Non-contact pyrometers have fast response times. They are the instruments of choice for processes that rapidly change in temperature. Pyrometers also work well when measuring the temperatures of moving or inaccessible objects or surfaces that should not be touched. They are capable of non-destructively obtaining the temperature of a particular target without influencing the object or subjecting it to mechanical wear.
Infrared Detection

Infrared pyrometers rely on the detection of energy in the infrared portion of the electromagnetic spectrum. The entire spectrum covers a range of radiated energies spanning wavelengths covering around 23 decimal powers. Infrared radiation occupies a small portion of this spectrum, starting just after the red end of the visible light segment around 0.7 µm and ending just before the microwave section of the spectrum begins around 1,000 µm. Wavelengths ranging from 0.7 to 14 µm are particularly important for infrared temperature measurement. Above this range, energy levels are so low that detector sensitivity is not sufficient to accurately perceive them.

Pyrometers target the infrared portion of the electromagnetic spectrum.

Pyrometers gather infrared radiation emitting from a target. The energy is focused through a lens onto a detector, which generates an electrical signal proportional to the magnitude of the radiation. Passing through electronics that perform amplification and digital signal processing, the signal is transformed into an output proportional to the object’s temperature. To compensate for environmental temperature influences, a second detector records the temperature of the measuring device or its optical channel. The final compensated output can be shown on a display or transmitted as a digital or analog signal for capture by data acquisition systems or use by process control systems.

Emissivity is Key

Emissivity is a key factor for the accurate measurement of temperature by infrared pyrometers. This property measures the ratio of thermal radiation emitted by an object compared to that emitted by a perfect radiator (black body) at the same temperature. Theoretical black bodies are objects that absorb all incoming infrared radiation. Most real materials, by contrast, exhibit some levels of reflection (ρ) and transmission (τ) in addition to absorption (which by Kirchhoff’s law is equivalent to emission, ε). According to the law of conservation of energy, these three coefficients must add up to 1 (ε + ρ + τ = 1).
Emissivity and Wavelength

For a black body, the reflection and transmissivity coefficients are equal to zero, so its emissivity coefficient is equal to one. Real-world objects, however, are not perfect black bodies. The emissivities of real materials depend on their molecular structures and surface characteristics, as well as the wavelengths of energy being measured and the setups of the measuring apparatus, including factors like measuring angle. Furthermore, Planck’s law shows that the wavelength corresponding to maximum black body radiation emission varies with temperature.

For infrared thermometry to produce accurate temperature measurements, the instrument must measure infrared radiation at the specific wavelengths and temperature range at which the emissivity of the target material is high. Emissivity values can either be determined experimentally or referenced in the literature for the particular materials and spectral bands of the application.

Many non-metallic materials, such as enamel and plaster, display high and relatively constant emissivity at high wavelengths. A wavelength range of 8 to 14 µm is a good target for non-metallic surfaces. Metals generally exhibit low emissivities that fall as wavelength increases. For this reason, temperature measurement of metallic materials should target the shortest wavelength of infrared radiation possible to ensure accurate results. This range falls within 0.8 to 1 µm for many metal surfaces.

Plastics (especially thin films) and glass tend to exhibit high transmission over many wavelengths, although there are some ranges where transmissivity is almost zero. It is these regions that should be targeted for accurate temperature measurements. For PTFE, polyurethane, polyester and FEP, a zone of non-transmissiveness occurs at 7.9 µm. For polystyrene, polypropylene, polyethylene and nylon, transmission is...
nearly zero at 3.43 µm. For glass, both reflection and transmissivity must be considered. Optimal wavelengths for the surface temperature measurement of glass occur at 5 and 7.9 µm.

**A Product for Every Application**

Micro-Epsilon offers a wide range of infrared pyrometers featuring spectral detection ranges optimized for various materials used in a number of industries.

In the metal industry, monitoring the temperatures of production processes is critically important to ensure high quality finished products. Micro-Epsilon’s thermoMETER_CTLaser_M5 is specifically designed to measure the temperatures of very hot metal surfaces and molten metals with a spectral range of 0.525 µm. The thermoMETER_CTLaser_M1/M2 infrared thermometers, meanwhile, detect wavelengths of 1.0 and 1.6 µm, making them appropriate for temperature detection of metals, metal oxides and ceramics. For temperature measurement of low temperature metals and composite materials, the thermoMETER_CTLaser_M3 is a good fit with a spectral range of 2.3 µm.

Micro-Epsilon offers a range of pyrometers optimized for temperature measurement of hot metal, glass and plastic production.

In the plastics and glass industries, monitoring material temperatures throughout the extrusion or molding process ensures that defects are minimized. Micro-Epsilon’s thermoMETER-CTP-3 and thermoMETER-CTP-7 infrared thermometers feature extremely narrow-band spectral ranges (3.43 and 7.9 µm, respectively) that are ideal for thin plastic films. With a spectral range of 5.2 µm, thermoMETER_CTLaserGLASS is well-suited for measuring glass temperatures in a variety of situations such as during the manufacture of solar cells, glass containers or vehicle glass.
With so many configurations to choose from, Micro-Epsilon’s thermoMETER infrared thermometers are applicable to almost any field of operation. Regardless of the specific model chosen, Micro-Epsilon infrared pyrometers are designed to be easy to handle and affordable.