LAND

AMETEK®

MONO, RATIO, OR APPLICATION PYROMETER SELECTION FOR METAL APPLICATIONS

APPLICATION NOTE

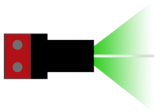
AMETEK Land offers a wide range of single-spot pyrometer types – Mono, Ratio, and Application – at a choice of several different and multiple wavelengths. The best choice for a particular application will depend on the application, the product to be measured and its surface conditions, and the process environment.

More than 70 years of expert knowledge and thousands of global installations ensure that the ideal solution can be applied to a temperature measurement and process.

THREE TYPES OF PYROMETERS

In broad terms, pyrometers can be divided into three types – Mono, Ratio and Application:

MONO



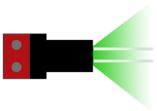
ONE-CHANNEL – ONE-COLOUR PYROMETER

Mono (or monochromatic) pyrometers operate on a single wavelength. To obtain accurate temperature measurements, you must have a clear view of the product and know the emissivity of the surface.

Mono pyrometers are band-pass radiation pyrometers detecting the radiation intensity within a (usually) narrow spectral (wavelength) band. Obtaining correct temperature measurements requires a clear and full view of the object to be measured and knowledge of the actual spectral surface emissivity.

Depending on the spectral response of the pyrometer, the influence through surface emissivity changes decreases with shorter wavelength instruments and vice versa. Typically, the shortest possible instrument wavelength (spectral response) is recommended to be used.

RATIO



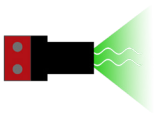
TWO-CHANNEL – TWO-COLOUR PYROMETER

Ratio pyrometers operate at two separate wavelengths and can correct for dust, dirty windows, obstacles in its optical path and slightly changing object emissivity, as long as both wavelength signals are affected proportionally by emissivity or process changes.

Ratio pyrometers are often used if the measuring spot is not fully placed on the object or the object is smaller than the pyrometer spot size, if changing transmissions are present in the optical path of the pyrometer – like dust, steam, obstacles – or if the object surface emissivity is changing within a certain amount.

Ratio pyrometers are also capable of monitoring the actual signal strength, e.g. the amount of dirt on view port windows, increasing absorption or obstructions in the optical path.

APPLICATION

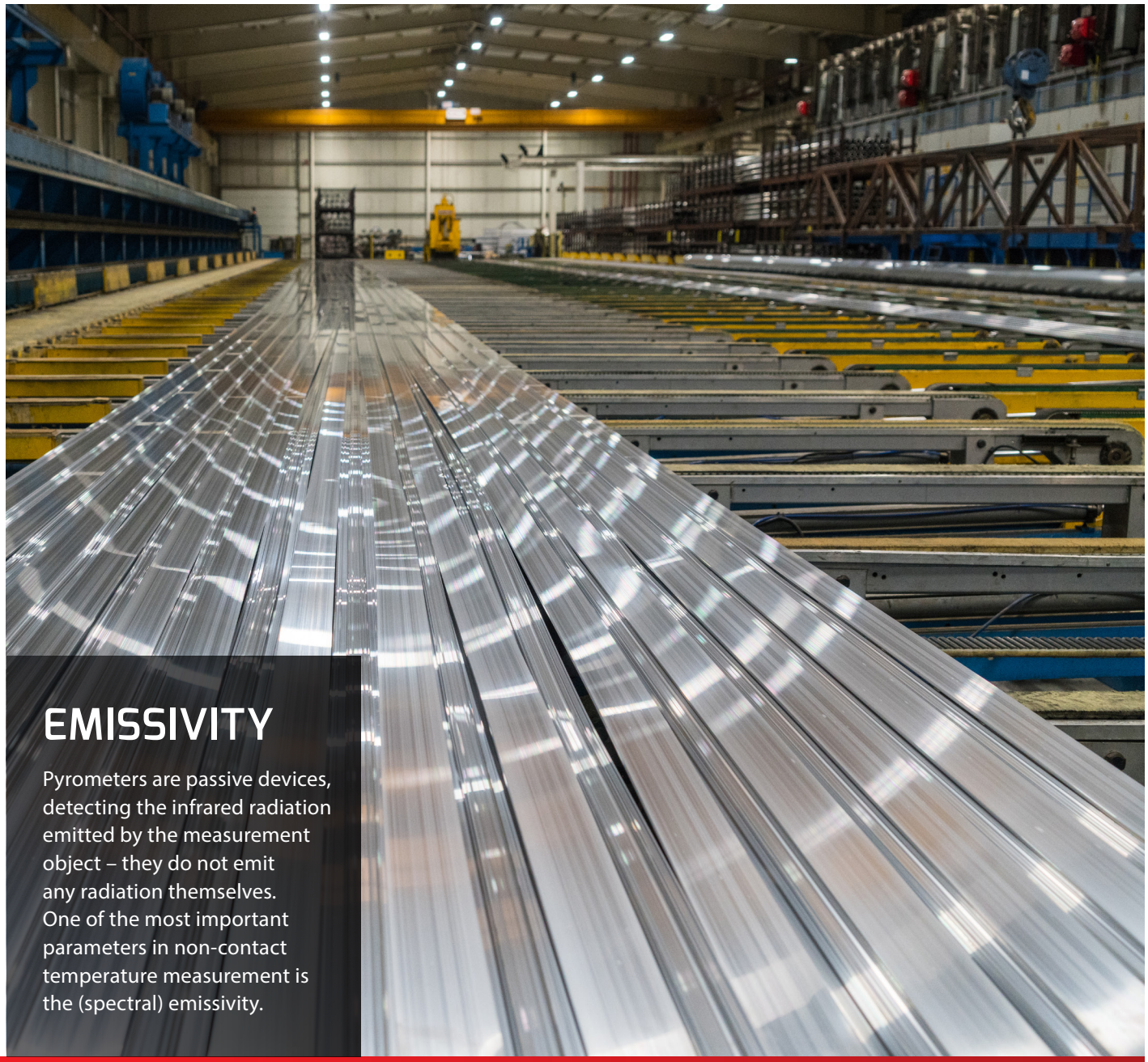


MULTI-MODE APPLICATION PYROMETER

Multi-Mode Application pyrometers are multi-band spectral radiation pyrometers with specific modes to automatically detect and compensate for emissivity changes during industrial processes. They detect infrared radiation within multi-spectral bands and automatically calculate the real emissivity and resulting non-greyness values.

Different specific application modes are selectable, such as aluminium processing, annealing, coating, galvanising processes or silicon and electrical steel or similar. These smart multi-mode pyrometers can be adapted to additional applications, based on optimised application modes, too.

MEASUREMENT CHALLENGES



EMISSIVITY

Pyrometers are passive devices, detecting the infrared radiation emitted by the measurement object – they do not emit any radiation themselves. One of the most important parameters in non-contact temperature measurement is the (spectral) emissivity.

FACT

The (spectral) emissivity ε is defined as the ratio of the emitted radiation of a real object to the emitted radiation of a black body at the same temperature.

$$\varepsilon = \frac{I_{\text{Real object}}}{I_{\text{Black body}}}$$

A surface that emits all its radiation is described as 'black', and the maximum theoretical radiation is termed 'blackbody radiation'. However, all real materials have emissivity less than 1 (100 %); real surfaces are not truly black.

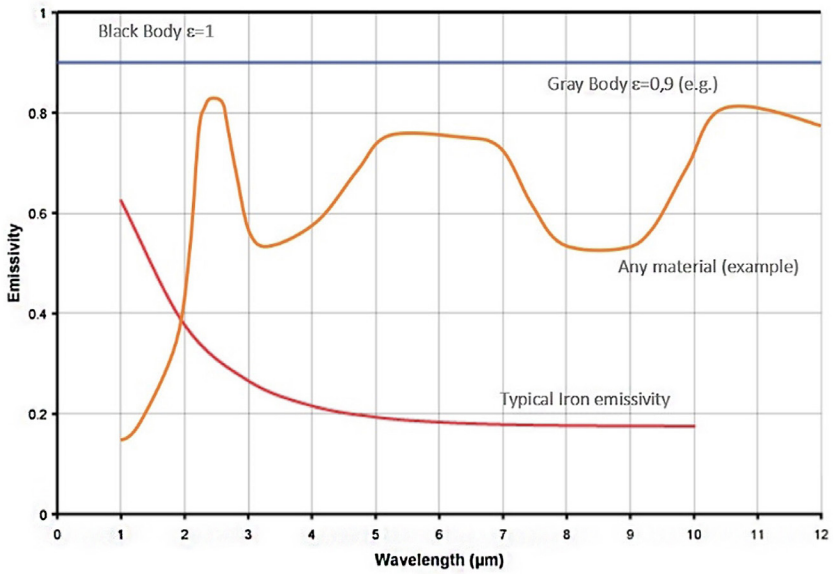
For any given spectral range or wavelength, the sum of absorption, reflection and transmission for an object will always result in a value of 1 or referred to as 100%. Kirchhoff's Radiation Law says that absorption and emission are the same at the same wavelength, resulting in:

Absorption λ (α) = Emission λ (ε).
In combination, it results in one of the most important equations for non-contact temperature measurement:

1 (100%) = Emission (ε) + Reflection (γ) + Transmission (τ)

1 (100%) = Emission (ε) + Reflection (γ) (for non-transparent materials – (τ =0)

With non-transparent materials – such as metal and steel – the emissivity is the opposite of reflectivity, so a highly reflective, smooth, mirror-like surface will have a very low emissivity, while a rough, dark, matt surface will have a comparatively high emissivity. If two objects have the same temperature but one is bright-shiny while the other is dark-matt, the dark surface will typically appear much warmer. This is because the object with a higher emissivity also radiates more heat.



When using mono pyrometers, the spectral emissivity value for the object to be measured must be known, so that the pyrometer can determine the correct object temperature. Emissivity tables are available, but emissivity can vary with temperature, measurement wavelength, and surface conditions such as oxide film structure.

Ratio and Application pyrometers measure radiation at more than one wavelength to partially compensate for surface emissivity, while Application pyrometers can calculate and report the emissivity value as well.

PROCESS CONDITIONS

If the process atmosphere contains vapour, dirt and dust that will obscure the view of a pyrometer, it has a similar effect on the measurement as reduced emissivity – it reduces the amount of radiation collected.

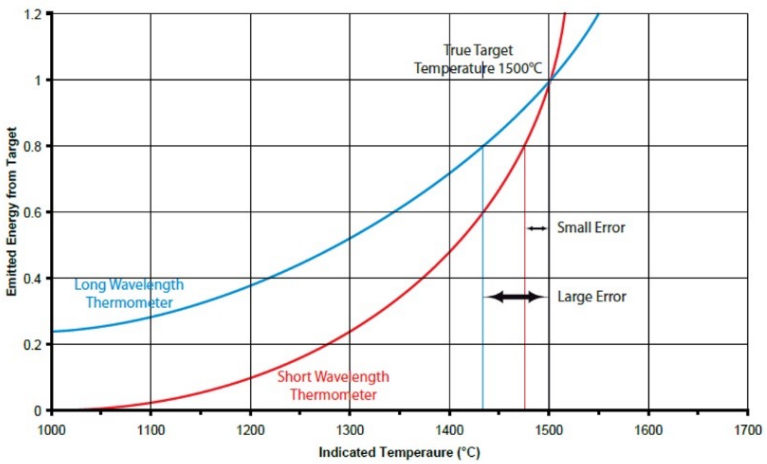
If the process atmosphere contains dirt, dust or vapour in the field of view of the pyrometer to the measured object, this has an effect on the measurement, reducing the amount of radiation collected and thus on the measurement signal. In these cases, a Ratio pyrometer is the correct choice, as it is less sensitive to such contamination.

With certain application conditions, such as measuring in/through a furnace and flame atmosphere, special wavelength pyrometers are used, being mostly unaffected by these atmospheres and absorptions.

CHOOSING THE BEST SOLUTION

The hotter an object is, the more short-wave radiation is emitted. This can be clearly seen when an object emits visible glowing colours (light) from red, orange, yellow and white – with increasing temperature, starting at approx. 600 °C / 1112 °F.

An important parameter for selecting the spectral range of a pyrometer is the process temperature range. Shorter wavelength pyrometers typically cover higher temperatures, while longer wavelength pyrometers cover lower temperatures.



At shorter wavelengths, the intensity of the emitted radiation increases faster with an increase in temperature than at longer wavelengths, so at shorter wavelengths the effect of changing emissivity on the temperature measurement is less.

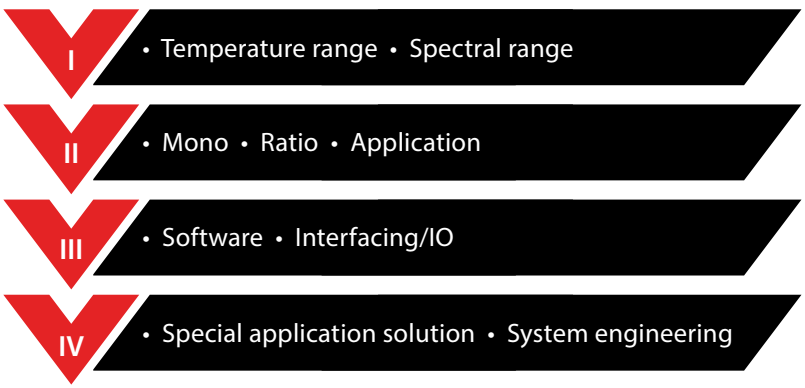
Specific process and environmental conditions must also be considered when selecting the correct spectral range. While the atmosphere (air) between the pyrometer and the measurement object is usually transparent and therefore has no influence on the temperature measurement, different types of pyrometers are used for different atmospheres, gases, smoke, and gas concentrations – such as in industrial furnaces.

If the process temperature range can be covered by pyrometers of different wavelengths, the pyrometer with the shortest wavelength should usually be selected in order to achieve the most accurate measurement results.

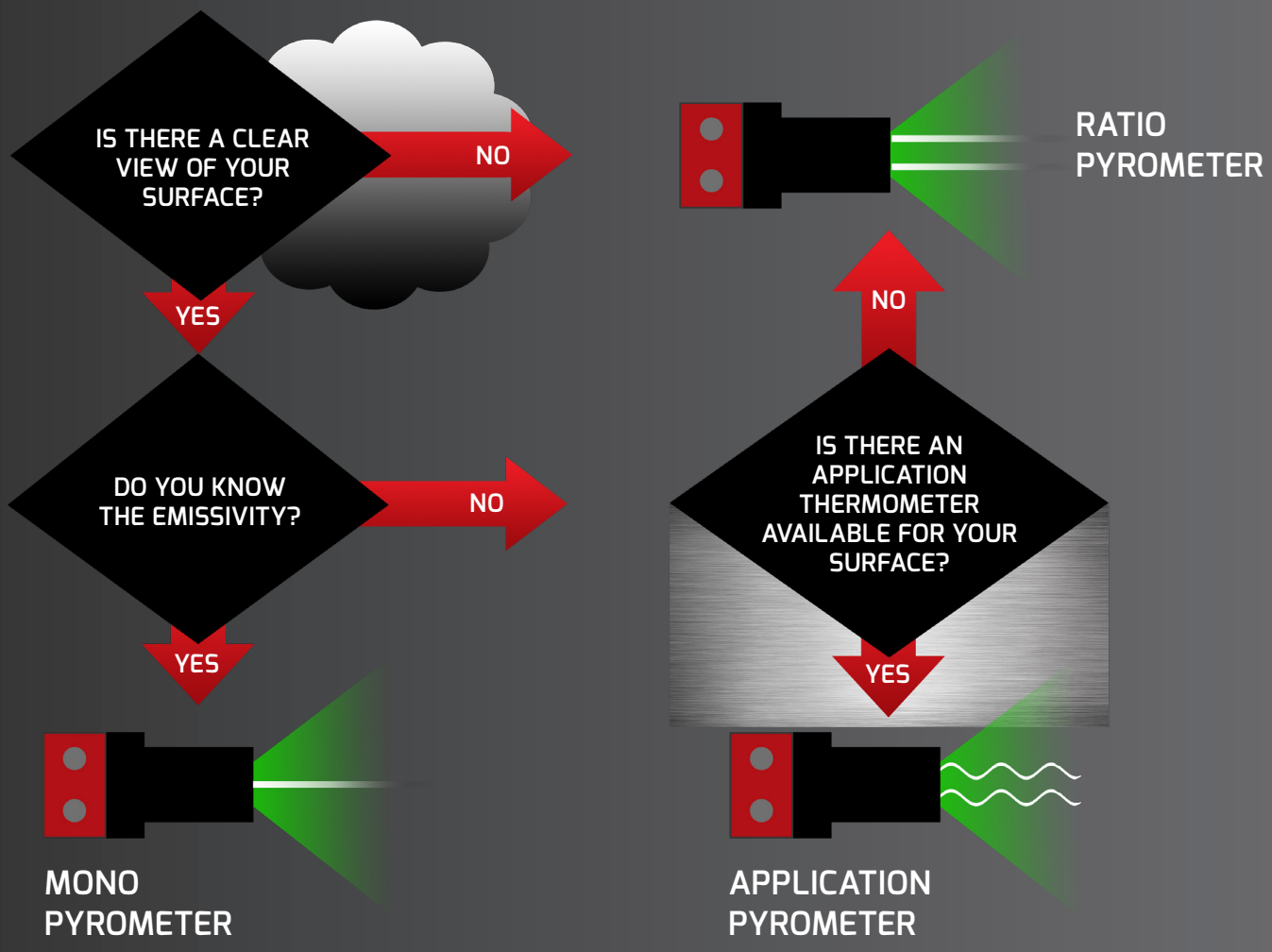
HOW TO CHOOSE THE BEST WORKING PYROMETER

Following the key rule to measure at the shortest possible wavelength (spectral response) to minimise the reading error by incorrect or changing emissivity, the lowest measuring temperature in an application is the first parameter to determine the optimum wavelength for the measuring instrument.

Followed by the type of the pyrometer – Mono, Ratio, or Application pyrometer – according to the application and environmental conditions.



PYROMETER TYPE SELECTION



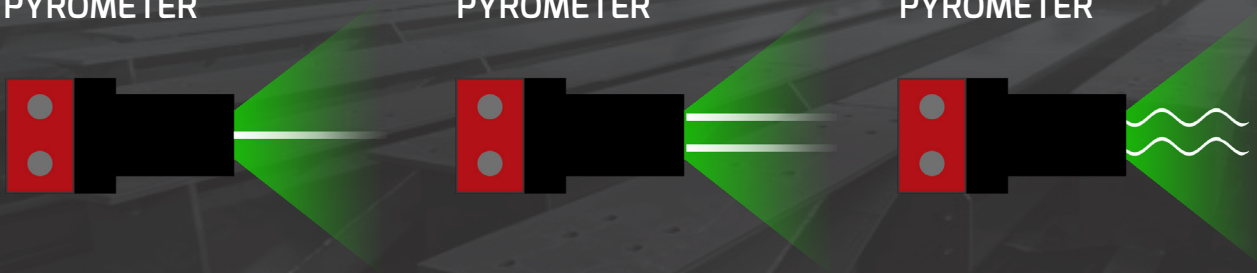
INTRODUCING SPOT PYROMETER RANGE

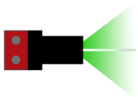
SUMMARY

MONO PYROMETER

RATIO PYROMETER

APPLICATION PYROMETER





Mono Pyrometers provide the best general-purpose temperature measurement solution for most applications. Using the shortest possible wavelength minimises the reading error in case of an emissivity change.

Mono pyrometers can be used on surfaces of low or high emissivity, as long the emissivity is constant or changes slightly. The value of that emissivity is set within the pyrometer as a correction factor. Emissivity tables are available or, in the SPOT range of pyrometers, the emissivity can be automatically configured from the settings page of the webserver by entering a reference temperature measurement, or via an instrument input.

The limitation of Mono pyrometers is that changes in radiation intensity from bigger emissivity variation, dust, steam, or other obscuration of the optical path can have a significant effect on the temperature reading.

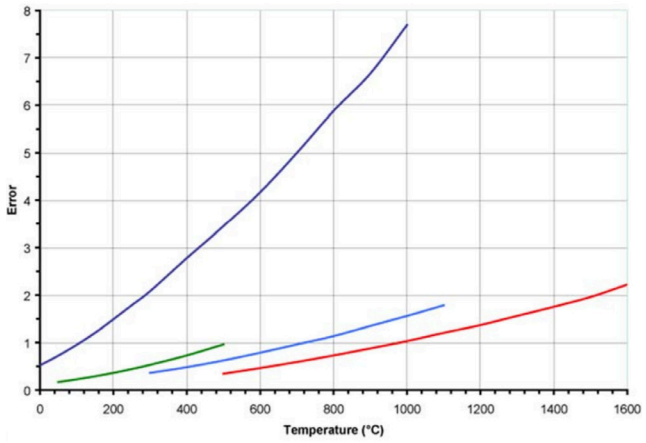
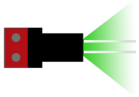


Fig.1 The graph shows shows the measurement error of a single-channel pyrometer with an emissivity deviation of 1% (red: shortest wavelength, blue: longest wavelength).



Ratio Pyrometers measure infrared radiation in two wavebands and calculate target temperature from a ratio of the two signals.

If the surface emissivity or transmission of the optical path change, but both wavebands are affected equally, their ratio will remain nearly unchanged. Thus, given two measurement wavebands, a Ratio pyrometer can measure temperature accurately despite changing emissivity or obscuration and small objects.

A Ratio pyrometer compensates for the 'non-greyness', 'e-slope' or 'ratio factor' – the ratio between emissivities for the instrument wavelengths.

In the same way that the emissivity is adjusted for a Mono pyrometer, either the emissivity for each waveband or the non-greyness (ratio) must be configured for accurate temperature readings from a Ratio pyrometer.

In the SPOT range of pyrometers, both emissivities can be automatically configured from the settings page of the webserver by entering a reference temperature measurement or by an instrument input. SPOT Ratio pyrometers also provide the signal % as an output, which can be configured with an alarm as a 'dirty window alert'.

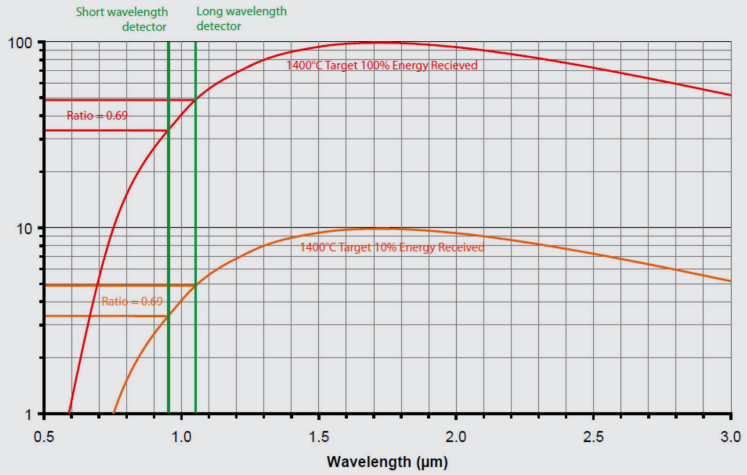
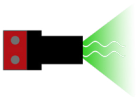


Fig.2 The graph shows the behaviour of the ratios for a quasi-fully transparent beam path (1400 ° C target 100% energy received) and for a partially disturbed beam path (1400 ° C target 10% energy received).



Application Pyrometers are more complex variants of Ratio/Multi-Wavelength pyrometers. They are required for materials whose low emissivity and resulting non-greyness changes with temperature or during the process/measurement, i.e. whose emissivity changes with wavelength and temperature in a non-linear way.

In this case, there are multiple unknowns: the temperature, the emissivity at each wavelength, and the complex relationship between the emissivity change at those different wavelengths.

For each temperature measured by an Application pyrometer, the instrument calls on a huge '3D dataset' of historically measured values of temperature, emissivity and radiance at each waveband of the instrument. This is why Application pyrometers are available for specific industrial process and materials that have been thoroughly researched, such as aluminium, galvanised/ galvannealed steel or silicon/electrical steels.

The SPOT smart multi-mode pyrometers can be adapted to additional applications, based on optimised application modes, too.

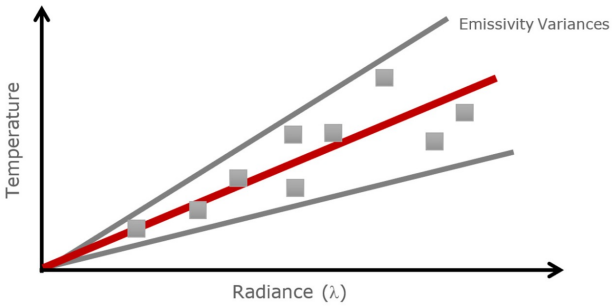


Fig. 3 The graph shows the principal slope correction, done by an Application pyrometer to correct for different and changing emissivity e.g. in coating, galvanising or silicon/electrical steel applications

PICK THE RIGHT SPOT FOR YOUR PROCESS

AMETEK Land's high-precision pyrometers for non-contact infrared spot temperature measurements are available in a range of operating wavelengths and temperature ranges to match process requirements.

FIXED SPOT THERMOMETERS

SPOT MONO PYROMETERS (ONE-CHANNEL)

The M-Series (MONO) SPOT pyrometers provide wide measurement ranges:

M100 500 to 1800 °C (932 to 3272 °F)
M160 250 to 1600 °C (482 to 2912 °F)
M210 50 to 1100 °C (122 to 2012 °F)

Proven, reliable electronics and a precision optical system combine to give a pyrometer that delivers accurate, repeatable temperature measurement, together with an integrated visible camera.

The **M100 F.O.** and **M160 F.O.** are also available as light fibre instruments, being used in narrow-space, high-temperature or strong electromagnetic field applications.

SPOT RATIO PYROMETERS (TWO-CHANNEL)

The R-Series (RATIO) SPOT pyrometers have a wider choice of measurement ranges:

R100 400 to 1800 °C (752 to 3272 °F) – overall
R160 250 to 1600 °C (482 to 2912 °F) – overall
R210 125 to 1100 °C (257 to 2012 °F)

They offer different operating modes selectable from the set-up menu – such as:

Mono 1/Mono 2 – signal from detector 1/2 only
Duo – uses detector 2 at low temperatures, detector 1 at high temperatures
Ratio – combined ratio signal from both detectors
Multi – extended measurement range with low-temperature monochromatic and high-temperature ratio signal

The **R100 F.O.** and **R160 F.O.** are also available as light fibre instruments, being used in narrow-space, high-temperature or strong electromagnetic field applications.

SPOT GS APPLICATION PYROMETER

The SPOT GS is a smart advanced pyrometer combining SPOT technology with specialised software algorithms, specifically designed for continuous, highly accurate measurement of coated steel strip temperature during galvanising and galvannealing and can accurately read temperatures of liquid zinc during coating and other applications like silicon or electrical steel.

It provides the accuracy needed for close monitoring, enabling automated furnace management that in turn delivers tighter control of product quality, also in silicon and electrical steel processing.

SPOT AL APPLICATION PYROMETER

This highly accurate and stable digital pyrometer uses cutting-edge SPOT technology, and unique, advanced data-processing algorithms, to measure aluminium temperature at an extruder press exit, quench and billets, strip mill, forging/forming applications, forging/forming applications with high-magnesium content alloys and liquid aluminium, e.g. during pouring.

With measurements ranging from 130 to 800 °C (392 to 1472 °F), a single pyrometer offers all measurement modes, using dedicated pre-set algorithms which provide the most accurate digital temperature readings of low and variable emissivity aluminium.

PYROMETER SELECTION FOR METALS

AMECARE® PERFORMANCE SERVICES

Our global service centres provide after-sales services to ensure you get the best performance from your system. This includes technical support, certification, calibration, commissioning, repairs, servicing, preventative maintenance and training. Our highly trained technicians/engineers can also attend your site to cover planned maintenance schedules and repair emergency breakdowns.

SPOT

SPOT is a family of fully featured, high-performance pyrometers for fixed non-contact infrared spot temperature measurements. Available in range of operating wavelengths, temperature ranges and process requirements.

FIXED SPOT THERMOMETERS

SPOT AL

Designed for continuous, highly accurate temperature measurement in aluminium production and processing industries.

FIXED SPOT THERMOMETERS

SPOT GS

Designed for continuous, highly accurate temperature measurement of coated steel strip during galvanising, galvannealing, silicon and electrical steel processing.

FIXED SPOT THERMOMETERS

SPOT Actuator

Provides remotely controlled target alignment of a SPOT pyrometer for industrial processing applications and is ideal for aluminium applications using the SPOT AL pyrometer.

FIXED SPOT THERMOMETERS

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