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INDUSTRIAL INFRARED **PYROMETERS**



Williamson
Where Wavelength Matters

The Advantages of Infrared Pyrometers

Temperature is commonly measured in manufacturing operations to monitor and control product quality and process productivity. Many applications use contact devices like thermocouples and RTDs, but all too often these devices are inaccurate, too slow, difficult to use, or require frequent replacement creating process downtime and reducing productivity. For many applications, infrared pyrometers are the perfect solution because they can accurately and reliably measure a target's temperature without contact. This capability is ideal for applications involving:

- High Temperatures
- Moving or Inaccessible Targets
- Hostile or Hazardous Environments
- Fast Response Times

With the Silver, Gold, and Pro Series products, Williamson offers the optimal pyrometer for a wide range of applications.



How Infrared Pyrometers Work

Every object emits infrared energy proportional to its temperature. Hotter objects emit more energy; cooler objects emit less energy. Infrared pyrometers collect the infrared energy emitted by an object and convert it into a temperature value. The amount of energy collected by a sensor is influenced by the **emissivity** characteristics of the target and the transmission characteristics of any **intervening optical obstructions** between the sensor and the measured target. The influence of these factors varies significantly at different infrared wavelengths. Selecting a pyrometer filtered at an appropriate wavelength makes all the difference in achieving accurate readings.

Emissivity is a term used to quantify a material's tendency to emit infrared energy. It is related to the reflective and transmissive characteristics of the material and is measured on a scale of 0.0 to 1.0. In practical terms, emissivity is the opposite of reflectivity. For example, a highly reflective surface like aluminum has a low emissivity of 0.1, while a dull surface like refractory brick has a higher emissivity of 0.9.

Intervening optical obstructions such as steam, water vapor, flames, or combustion gasses have the potential to interfere with the amount of energy that is measured by the sensor.

Williamson – Where Wavelength Matters

The most important Williamson difference is our particular emphasis on **wavelength**. By carefully selecting the wavelengths in our pyrometers, we can view through intervening optical obstructions, reduce emissivity variation and provide more stable and accurate temperature measurements.

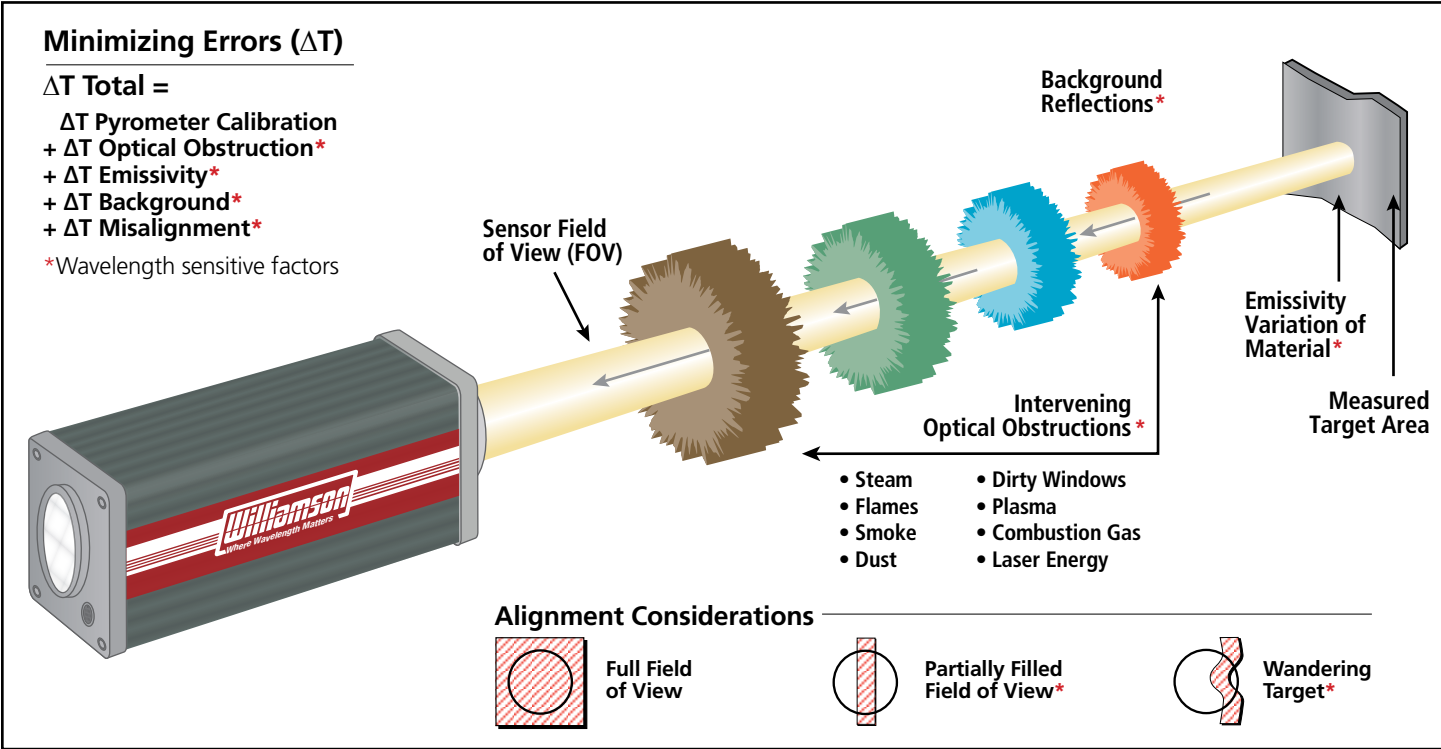
For over 60 years, Williamson has been making the most accurate pyrometers for demanding industrial applications. With a history of engineering customized solutions, our philosophy is that there is a specific pyrometer for every application, not a handful of pyrometers to fit every application.

Why Wavelength Matters

For temperature measurements in ideal laboratory settings, all that matters is the calibration accuracy of the pyrometer. However, most industrial applications involve less than ideal operating conditions with a number of interferences and factors that contribute to inaccurate readings. **Thoughtful wavelength selection** can dramatically reduce or even eliminate errors due to optical obstructions, emissivity

variation, background reflections, and misalignment. Most pyrometer manufacturers focus on calibration accuracy, optics, and temperature range but not wavelength selection. At Williamson we emphasize **thoughtful wavelength selection** to ensure our pyrometers provide the most accurate temperature measurement under any operating condition.

Common Causes of Pyrometer Measurement Errors



Pyrometer Technologies

Williamson offers 6 different infrared technologies with a variety of wavelength options, multiple optical configurations, temperature spans and accessories to ensure that each pyrometer can be optimally configured for each application.

Single-Wavelength Technologies		
Short-Wavelength (sw)	Long-Wavelength (LW)	Specialty-Wavelength (SP)
Errors are relatively small for moderate emissivity variation, optical obstruction and misalignment, particularly at lower temperatures. Certain models can view through common interferences.	Low-cost pyrometers ideal for general purpose applications measuring temperatures below 100°C / 200°F.	Used when the target is least reflective and most opaque at a specific wavelength or when optical obstructions are most transparent at a specific wavelength.

Ratio and Multi-Wavelength Technologies		
Two-Color (TC)	Dual-Wavelength (DW)	Multi-Wavelength (MW)
Ratio Pyrometers designed to compensate for emissivity variation and modest optical obstruction or misalignment.	Ratio Pyrometers designed to measure the hottest temperature viewed. Select wavelength sets tolerate water, steam, flames, plasma, and laser energy. More tolerant of scale, misalignment, and optical obstructions than Two-Color.	Used for non-greybody materials such as aluminum, copper, stainless steel, and zinc. Application specific algorithms adjust for complex emissivity characteristics.

Single-Wavelength Technology

Single-Wavelength pyrometers are preferred when appropriate due to simpler, lower-cost technology. For most applications, select the shortest wavelength compatible with

the measurement conditions and desired temperature span. Specialty wavelengths may be necessary depending on the optical and emissivity properties of the target.

Short-Wavelength (SW)

Williamson places a strong emphasis on short-wavelength single-wavelength pyrometers because of their ability to better tolerate **emissivity variation and optical obstruction**. As a result, these short-wavelength sensors are able to provide superior performance over a wide range of real world operating conditions.

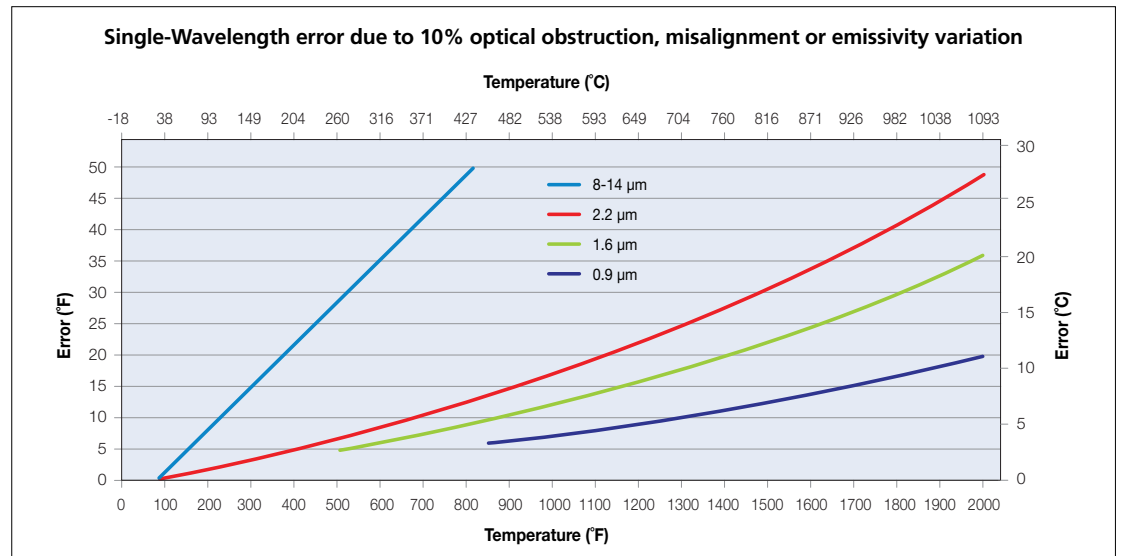
Popular Short-Wavelength Applications

- Low Temp Metals
- Melters
- Furnaces
- Thermal Reactors
- Boilers



Short-Wavelengths Reduce Error from Emissivity Variations

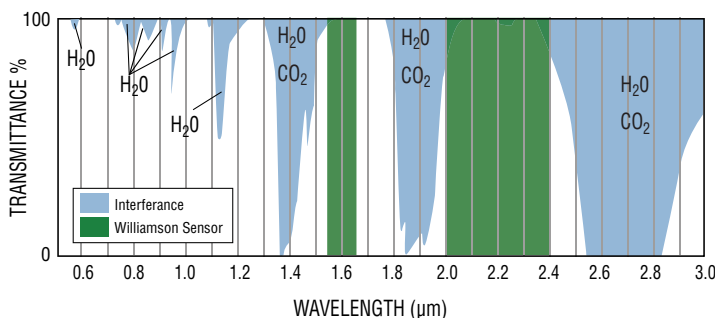
For most applications, selecting the shortest practical wavelength is recommended. As indicated in the chart, shorter wavelengths result in smaller errors. In fact, short-wavelength sensors can be 4-20 times less sensitive to emissivity variation compared to long-wavelength sensors.



Short-Wavelengths Can View Through Optical Obstructions

Wavelength selection is a critical factor in Williamson's short-wavelength technology. By choosing the correct wavelength

span, you can view through water, steam, flames, combustion gasses, plasmas, and other common industrial interferences.



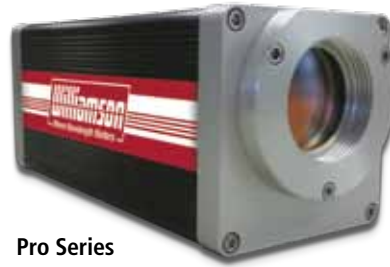
Despite being highly transparent in the visible spectrum, carbon dioxide and water vapor are significantly opaque over a wide range of the infrared spectrum. Williamson's 1.6μm and 2.2μm sensors use unique narrow band filters that avoid these interferences. Competitive products which use much wider infrared filters (typically 1.0-1.7μm and 2.0-2.6μm) cannot view clearly through these common gasses.

Long-Wavelength (LW)

These pyrometers tend to be lower in cost, but when measuring temperatures above 100°C / 200°F, errors can be large due to optical obstructions, misalignment and emissivity variations. These are general purpose sensors used for many low-temperature or near ambient measurements and high emissivity materials.

Popular Long-Wavelength Applications

- Food
- Paper
- Rubber
- Textile
- Plastic
- Liquids
- Ice
- Soil
- Minerals
- Building Materials
- Glass Surface
- General Purpose Measurements



Pro Series

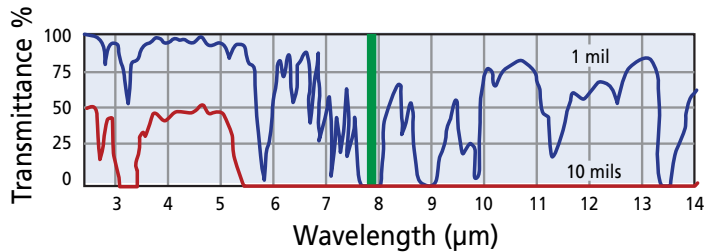
Silver Series



Specialty-Wavelength (SP)

Specialty-wavelength pyrometers are used when the target is least reflective and most opaque at a specific wavelength or when optical obstructions are most transparent at a specific wavelength.

Example: Emission band for polyester film.



At 7.9μm, polyester film is opaque. Pyrometers filtered at this special wavelength are appropriate for making this measurement.

Pro Series



Popular Specialty-Wavelength Applications	Temperature Range	Specialty-Wavelength
Hydrogen, Ammonia, and Hydro-Carbon based flames	700-3200°F / 375-1750°C	1.86μm
Thin Films of H-C Based Plastics (Polyethylene and Polypropylene)	125-700°F / 50-370°C	3.43μm
Hot Combustion Gas, Carbon Based Flames (CO, CO2 flames)	600-4000°F / 300-2200°C	4.65μm
Glass Surfaces – Inside Furnaces, Ovens, and Quartz IR Heaters	200-4000°F / 100-2200°C	5μm
Thin Film Plastics such as Polyester, Acrylic & Teflon Epoxy, and Painted Surfaces. Applications using IR Heaters	85-2500°F / 30-1375°C	7.9μm

Ratio Pyrometer Technology

Ratio pyrometers are different from single-wavelength pyrometers in that they measure infrared energy at two wavelengths instead of one. The ratio of energy between the two measured wavelengths is then converted into a

temperature value. This method of measurement allows ratio pyrometers to compensate for emissivity variation, partially filled fields of view and optical obstructions.

Two-Color (TC) and Dual-Wavelength (DW)

There are two types of ratio pyrometer technologies, and Williamson is the only company to offer both. Two-Color technology uses a sandwich detector and a fixed set of wavelengths. Dual-Wavelength technology uses a single detector with two unique and selectable wavelengths which allows for all of the benefits of a Two-Color pyrometer plus some significant added capabilities.



Two-Color Pyrometers

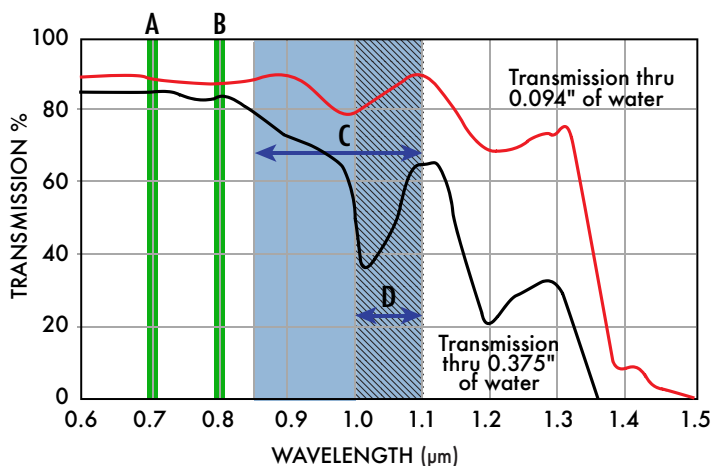
- General purpose wavelength set
- Compensate for variable emissivity and modest optical obstruction or misalignment
- Used when there is a clear optical path between the pyrometer and target
- Measure temperatures above 1100°F / 600°C
- Ideal for scale-free and uniformly heated ferrous metals

Dual-Wavelength Pyrometers



- Carefully selected wavelength set
- Compensate for variable emissivity, temperature gradient, severe optical obstruction, and misalignment
- Wavelength set may be selected to view through water, steam, flames, plasma, etc.
- Measure temperatures above 200°F / 95°C
- Better tolerates scale, temperature gradients, and non-grey interference (20x smaller errors) due to greater separation between wavelengths.



Optical Transmission Through Water by Wavelength

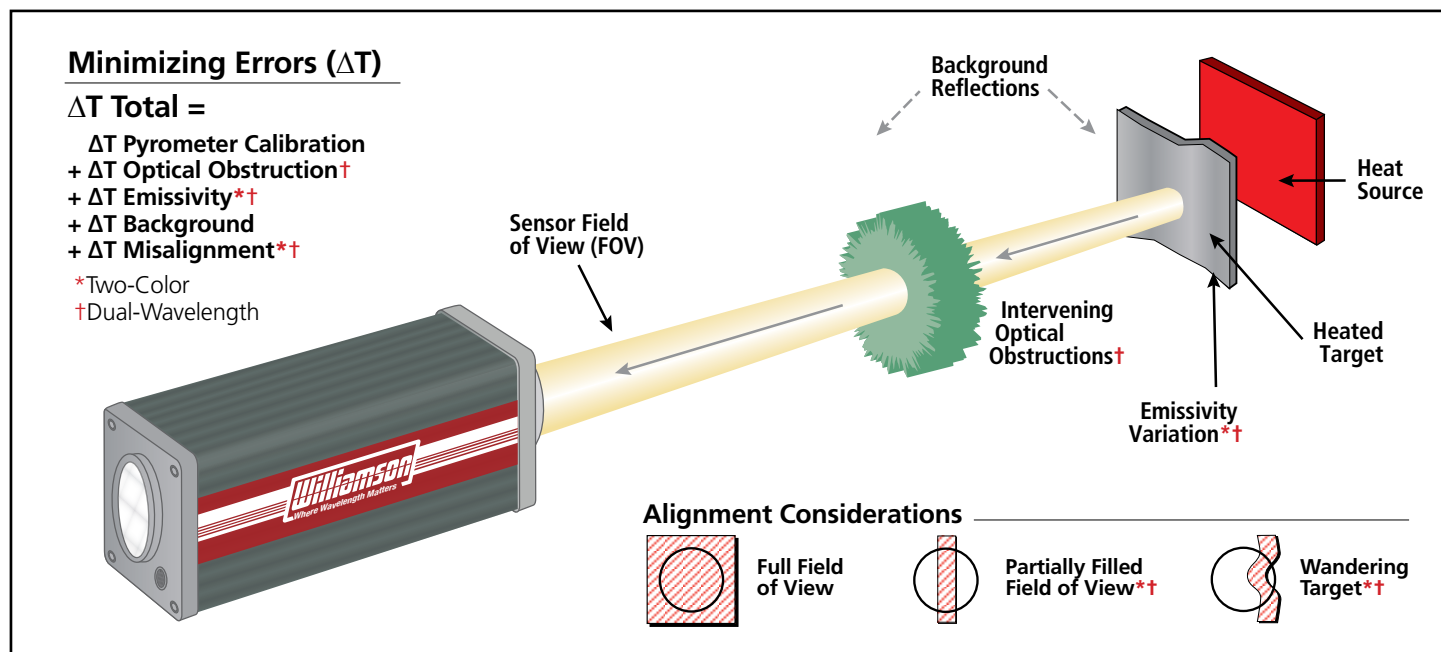


For applications involving water, a dual-wavelength pyrometer is ideal because it uses wavelengths that can clearly view through water. Water interferes with two-color sensors due to its fixed wavelength set.

-  Dual-Wavelength A+B (separate and distinct wavelengths)
-  Two-Color Wavelength C+D (overlapping wavelengths)

Reducing Errors

Ratio pyrometers help reduce total measurement error by automatically compensating for emissivity variation and misalignment.



With the appropriate wavelength selection, Dual-Wavelength pyrometers can eliminate interference from common industrial obstructions like **steam, water, flames, combustion gasses,**

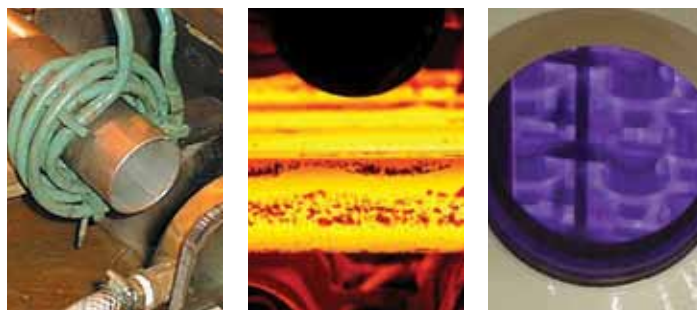
plasma, and laser energy. Two-Color pyrometers, because of their fixed wavelength set, will still experience some error whenever these interferences are encountered.

Capabilities of Ratio Pyrometer Wavelength Sets

Ratio Technology	Wavelength Set	Characteristics
Two-Color (TC)	11	Avoid water, steam, flames, combustion gasses, plasma, and laser energy
Dual-Wavelength (DW)	MS	Specialty Dual-Wavelength set used to measure molten steel/iron and small flames
	08	Able to view through thin layers of water (< 5mm), steam, combustion gasses, small flames, and plasma
	12	Broad temperature spans, but not appropriate for viewing through steam, flames, or combustion gasses
	24	Excellent at viewing through steam, laser energy, and plasma
	28	Measures exceptionally low temperatures, down to 200°F / 95°C, cannot view through common interferences

Popular Applications

- Steel Mills
- Casting, Forming, Joining, and Heat Treating of Metals
- Induction, Resistance, Friction, Flame, and Laser Heating
- Forging Plants: Billet, Die, Heat Treat
- Wire, Rod, and Bar Mills
- Rotary Kilns, Thermal Reactors, and Solid Fuel Power Boilers
- Engineered Materials: Silicon Crystals, CVD Diamonds, Carbon Densification, High Temperature Ceramics



Multi-Wavelength (MW)

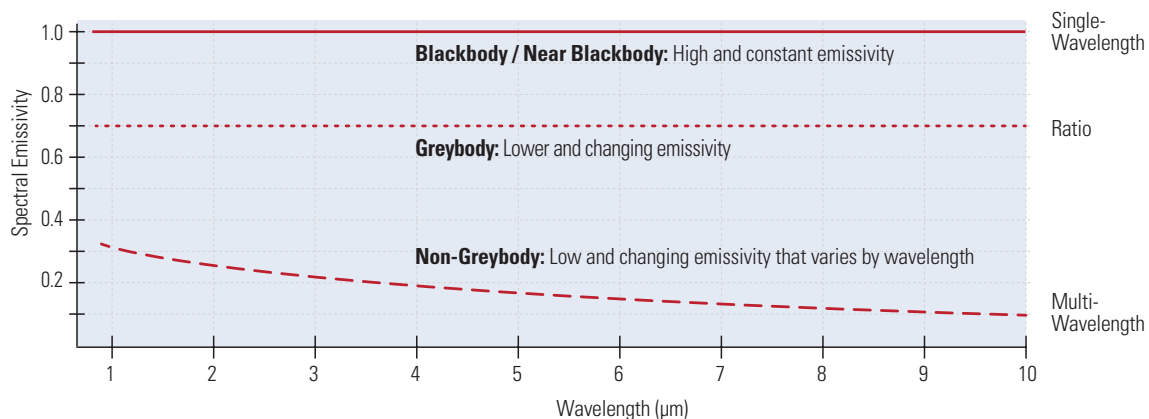
Certain materials can be difficult or near impossible to measure with precision using single-wavelength or ratio pyrometers because of their complex emissivity characteristics. These types of materials are called non-greybody materials and their emissivity varies with **wavelength**.

Typical Non-Greybody Materials Include:

- Aluminum
- Magnesium
- Stainless Steel
- Brass
- Bronze
- Copper
- Silicon
- Zinc



Surface Emissivity Characteristics



Williamson's Multi-Wavelength Advantage

With over four decades of refinement and improvement since our first multi-wavelength pyrometer, Williamson has a long history of making accurate temperature measurements for the most challenging and difficult applications.

To compensate for the unique emissivity characteristics of non-greybody materials, Williamson has developed a series of multi-wavelength pyrometers that incorporate application specific algorithms.

How Multi-Wavelength Pyrometers Work

Multi-wavelength pyrometers use application specific algorithms to characterize infrared energy and emissivity across the measured wavelengths to accurately calculate both the actual temperature and emissivity of these complex non-greybody materials. These algorithms have been developed and

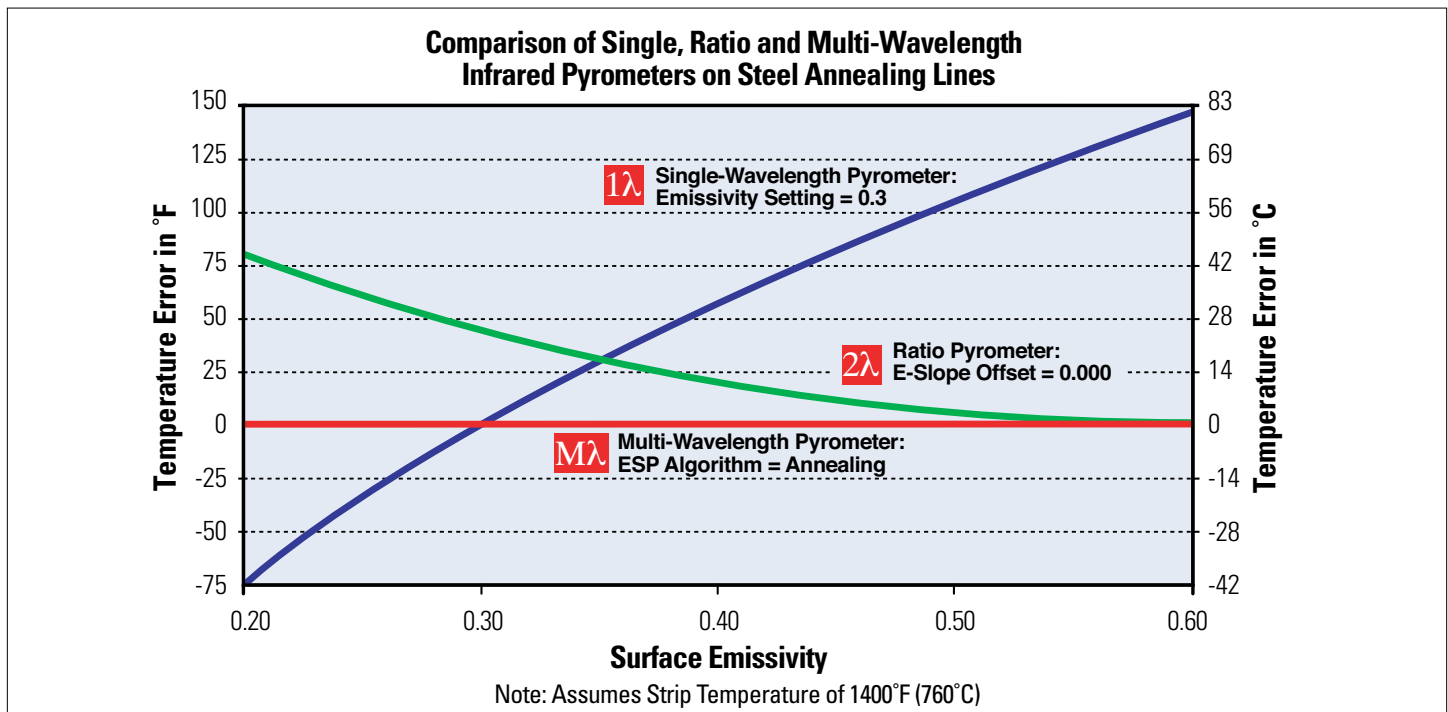
refined from extensive data collected from off-line simulations and on-line trials. Each multi-wavelength sensor can hold up to eight selectable algorithms, so that the same pyrometer can be used for multiple applications.

How Does a Multi-Wavelength Compare to a Ratio and Single-Wavelength Pyrometer?

A popular multi-wavelength application is for a continuous steel annealing line. As the graph below illustrates, single-wavelength and ratio pyrometers can produce significant errors as the surface emissivity varies. The multi-wavelength technology is able to accurately correct for these variations which are due to:

- Changes in alloy, surface texture, surface oxidation
- Abnormal operating conditions such as a furnace leak, bad roll, or a reheated coil.

With a multi-wavelength pyrometer, consistent and accurate readings are achieved under a wide range of operating conditions, with no sensor adjustments.



Popular Applications

Aluminum & Copper

- Extruded Surface
- Rolled Surface
- Cast Surface
- Sheared Surface
- Forged Surface
- Brazing Operations
- Coating Preheat
- Dies and Molds

Steel & Zinc

- Cold Rolled Steel
- High Alloy Steels
- Electrical Steel
- Zinc-Coated Steel
- Shot-Blasted Pipe
- High Strength Bearings
- Motor Rotors

Other

- Glass Molds and Plungers
- Magnesium Strip
- All other non-greybody materials previously listed



Aluminum Billet




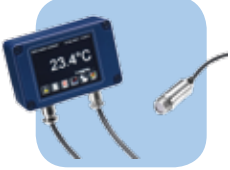



Aluminum Press Exit

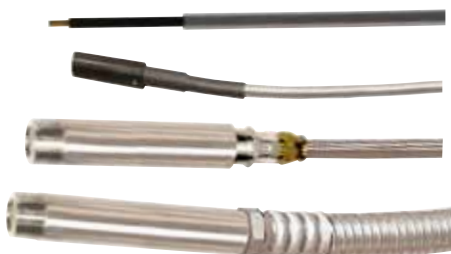


Steel Annealing Line



Shot Blasted Steel Pipe

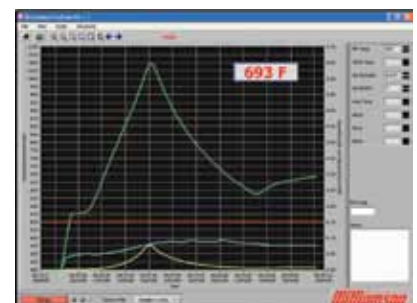
Silver Series			Gold Series	
				
Single-Wavelength			Single-Wavelength	
C-Class	M-Class	U-Class	20-Class	30-Class
Available with fixed settings or 4-20mA / Modbus input for emissivity adjustment	Two piece design with a sensing head and separate electronics	4-20mA output and adjustable settings via USB connection and SilverView PC software	Laser aiming single-wavelength pyrometer	Fiber optic single-wavelength pyrometer with optional aim light
Aiming Option			Aiming Option	
Line of Sight	Line of Sight	Line of Sight	Line of Sight, Laser Aiming	Fiber Optic
Spectral Response			Spectral Response	
8-14µm	2-2.6µm, 8-14µm	2-2.6µm, 8-14µm	0.9µm, 1.6µm, 2.2µm	0.9µm, 1.6µm, 2.2µm
Temperature Limits			Temperature Limits	
-4 to 932°F -20 to 500°C	-4 to 1832°F -20 to 1000°C	-40 to 3632°F -40 to 2000°C	300-4500°F 150-2475°C	300-4500°F 150-2475°C
Optical Resolution			Optical Resolution	
2:1, 15:1, 30:1, CF	2:1, 15:1, 20:1, 30:1, CF	15:1, 25:1, 30:1, 75:1, CF	D/50, D/100	D/2, D/15, D/35, D/60
Accuracy			Accuracy	
±1% , ± 1°C	±1% , ± 1°C	±1% , ± 1°C	0.25%, 2°C	0.25%, 2°C
Repeatability			Repeatability	
±0.5% , ± 0.5°C	±0.5% , ± 0.5°C	±0.5% , ± 0.5°C	< 1°C	< 1°C
Update Time			Update Time	
240ms	240ms	240ms	5ms	5ms
Outputs			Outputs	
4-20mA, 0-50mV Thermocouples type T/J/K RS485 Modbus	4-20mA RS485 Modbus	0/4-20mA USB	0/4-20mA Optional: RS485, RS232	0/4-20mA Optional: RS485, RS232



Fiber Optic Cables

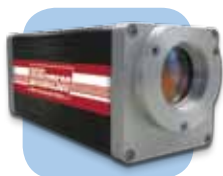


Gold Series Local Interface



ProView PC software adjusts sensor parameters and log data.

Pro Series



Single-Wavelength			Ratio		Multi-Wavelength
SW / SWF	LW	SP	TC / TCF	DW / DWF	MW / MWF
Short-Wavelength pyrometer views through common interferences	Long-Wavelength pyrometer used for general purpose applications	Specialty-Wavelength pyrometer for selective materials	Two-Color pyrometer compensates for emissivity variation	Dual-Wavelength pyrometer views through interferences, better tolerates scale	Multi-Wavelength pyrometer used for complex emissivity materials
Aiming Option			Aiming Option		Aiming Option
Thru the Lens, Laser Aiming, Fiber Optic	Thru the Lens, Laser Aiming	Thru the Lens, Laser Aiming	Thru the Lens, Laser Aiming, Fiber Optic	Thru the Lens, Laser Aiming, Fiber Optic	Thru the Lens, Laser Aiming, Fiber Optic
Spectral Response			Spectral Response		Spectral Response
0.9 μ m, 1.6 μ m, 2.2 μ m, 2.9 μ m	8-12 μ m	1.15 μ m, 1.86 μ m, 3.43 μ m, 4.65 μ m, 5 μ m, 7.9 μ m	1.1 μ m	0.8 μ m, 1.2 μ m, 2.4 μ m, 2.8 μ m	1.5 μ m, 2 μ m, 2.5 μ m
Temperature Limits			Temperature Limits		Temperature Limits
100 to 5500°F 40 to 3035°C	0 to 1000°F 0 to 550°C	125 to 4000°F 50 to 2200°C	1100-5500°F 600-3035°C	200-5500°F 95-3035°C	200-4500°F 95-2475°C
Optical Resolution			Optical Resolution		Optical Resolution
D/0.75 to D/150	D/50	D/14 to D/100	D/15 to D/150	D/0.75 to D/150	D/2 to D/110
Accuracy			Accuracy		Accuracy
0.25%, 2°C	0.5%, 2°C	0.5%, 2°C	0.25%, 2°C	0.25%, 2°C	0.25%, 2°C
Repeatability			Repeatability		Repeatability
< 1°C	< 1°C	< 1°C	< 1°C	< 1°C	< 1°C
Update Time			Update Time		Update Time
5 or 50ms	5ms	5 or 50ms	5ms	25ms	25ms
Outputs			Outputs		Outputs
0/4-20mA Optional: RS485, RS232	0/4-20mA Optional: RS485, RS232	0/4-20mA Optional: RS485, RS232	0/4-20mA Optional: RS485, RS232	0/4-20mA Optional: RS485, RS232	0/4-20mA Optional: RS485, RS232



Protective Cooling Jacket



Pro Series Local Sensor Interface



Remote Interface Module Power Supply

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