PYROMETER WAVELENGTH

SELECTION GUIDE

Williamson

Where Wavelength Matters

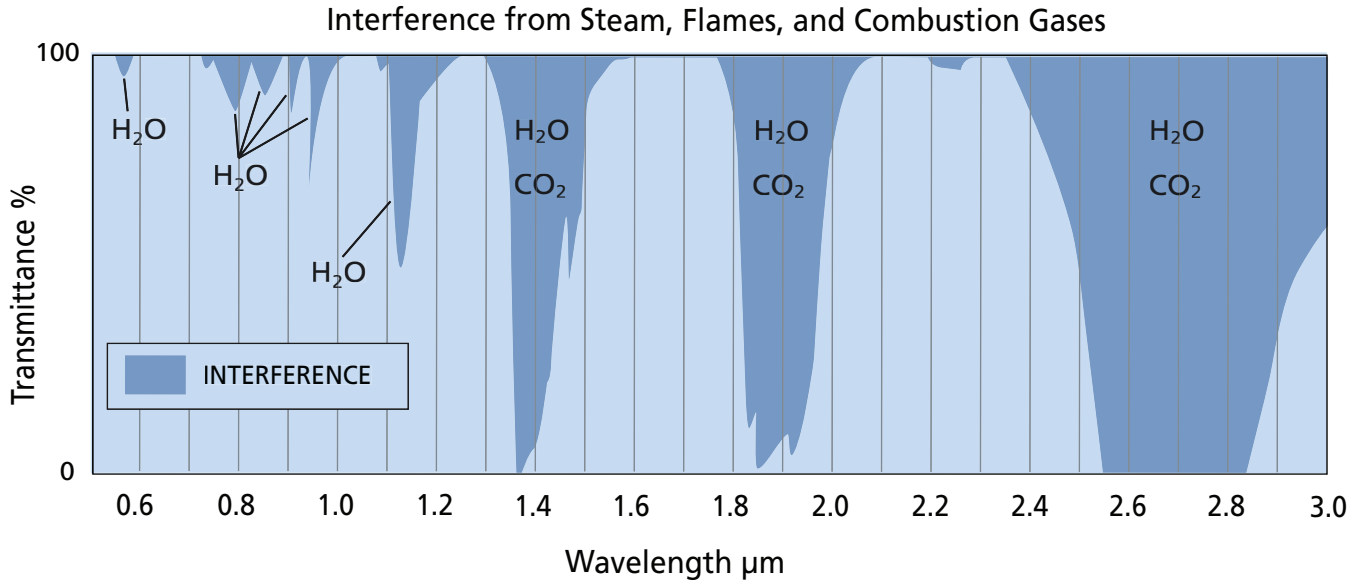
Are All Single-Wavelength Infrared Pyrometers Alike?

Most single-wavelength infrared pyrometers are virtually identical; however, a close look reveals that most sensors are different in one critically important way – the wavelength.

Wavelength is an important parameter when selecting an infrared pyrometer because some optical interferences are highly transparent only in specific wavebands. Infrared energy is an electromagnetic energy just like visible light and x-rays. Visible light does not pass through the human chest while x-rays go right through with wavelength being the only difference. In a similar way, correct wavelength selection allows an infrared pyrometer to view clearly through some types of intervening media, such as steam, flames, combustion gasses, etc., without introducing an error.

Where the below graph is white (shaded), steam, flames and combustion gasses are highly transparent (opaque). Short-wavelength pyrometers with carefully selected wavelengths are able to view clearly through steam, flames or combustion gasses (or long paths of air, for that matter). Therefore, carefully filtered single-wavelength pyrometers provide a significant technical advantage whenever these interferences are present. Wavelength selection is equally critical for other types of optical obstruction.

Williamson single-wavelength pyrometers are the best when oil, water, steam, flames or combustion gasses are encountered.



As an example of the importance of wavelength selection, consider a continuous heat treat furnace with a heating zone, a soaking zone and a cooling zone. When aiming 2 pyrometers, one with a carefully selected short wavelength (Pyrometer A) and one with a long wavelength (Pyrometer B) about 2 meters into the soaking zone (where the combustion gas and the product temperature are about the same) both sensors will read the same temperature value. However, when the two sensors are moved to the heating zone (where the combustion gasses are hotter than the product) Pyrometer A (carefully selected Short wavelength), will measure the true product temperature while Pyrometer B (long wavelength band) will measure about 60˚F / 35˚C too high. Likewise, when the two pyrometers are moved to the cooling zone, Pyrometer A (carefully selected short wavelength), will again produce a true reading while Pyrometer B (long wavelength band) will read about 50˚F / 30˚C too low (because of the cool furnace gases). Through thoughtful wavelength selection, certain short-wavelength pyrometers can view clearly through even the strongest flames, combustion gasses and clouds of steam without interference.

Specialty wavelength pyrometers also use short single-wavelength technology and are best when the target is least reflective and most opaque at a specific wavelength or when obstructions are most transparent at a specific wavelength.

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

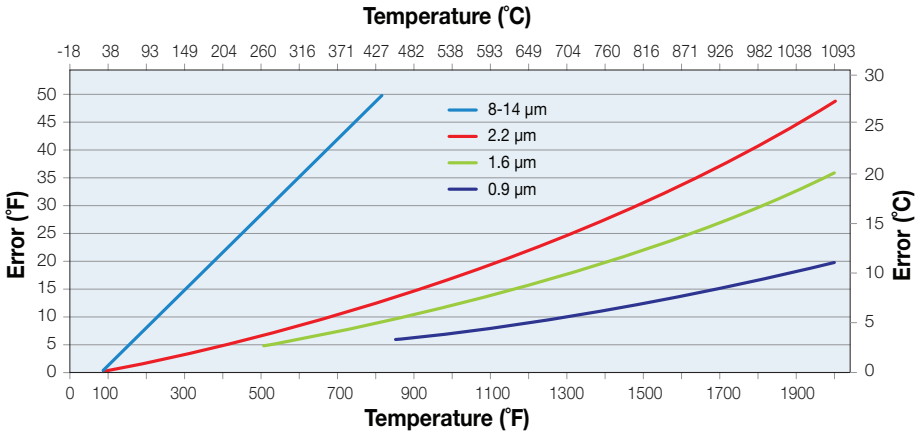
The Advantages of Williamson Short-Wavelength Single-Wavelength Pyrometers

Williamson Short-wavelength infrared pyrometers offer several advantages compared to long-wavelength pyrometers.

- Available in traditional and fiber-optic configurations
- Views through common window materials
- Views clearly through steam, water, flames, combustion gasses, oil, wax, glass, plastic, plasma, laser energy, and other interferences with thoughtful wavelength selection
- Measure low temperature values rivaling long-wavelength sensors
- Measure broad temperature spans rivaling long-wavelength sensors
- Are 4 to 20 times less sensitive to emissivity variation compared to long-wavelength sensors
- Are 4 to 10 times less sensitive to optical obstruction compared to long-wavelength sensors
- Are 4 to 10 times less sensitive to surface scale & cold spots compared to long-wavelength sensors
- Are 4 to 10 times less sensitive to misalignment compared to long-wavelength sensors

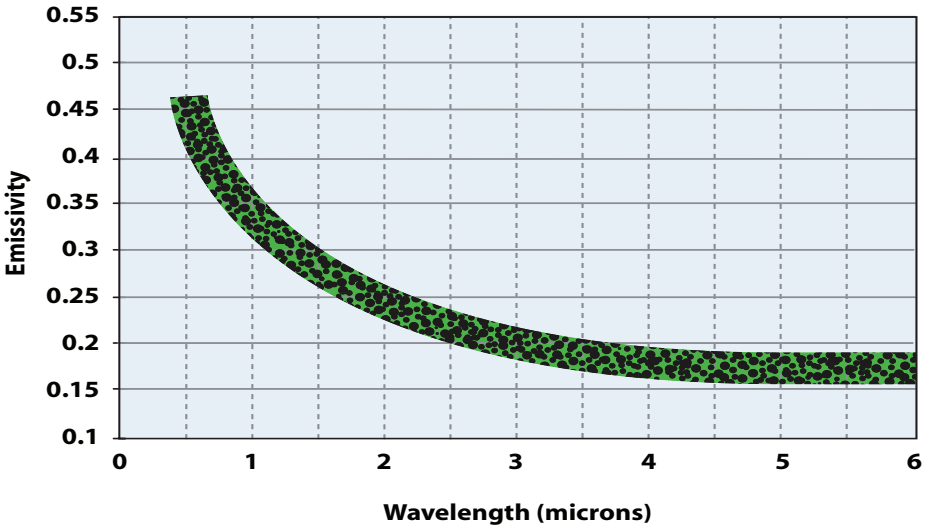
Williamson places a strong emphasis on short-wavelength single-wavelength sensors because of their ability to better tolerate emissivity variation and optical obstruction. As a result, Williamson is able to use these short-wavelength sensors under a wider range of operating conditions. The result is superior sensor performance under real-world operating conditions. Every day, Williamson short-wavelength single-wavelength pyrometers are used to make measurements that are traditionally considered impossible to make.

Single-Wavelength error due to 10% optical obstruction, misalignment or emissivity variation



Error from 10% emissivity change or 10% optical obstruction. Errors are smaller at lower temperatures and shorter wavelengths produce smaller errors

Normal Spectral Emissivity of Cold Rolled Steel



For low-emissivity materials, emissivity is higher and more stable at shorter wavelengths

Are All Ratio Infrared pyrometers Alike?

Two-Color and Dual-Wavelength

Most ratio infrared pyrometers are virtually identical; however, a close look reveals there are significant differences between a two-color pyrometer (sandwich detector) and a dual-wavelength pyrometer (single detector with 2 unique wavelengths). In fact, there are three distinct differences between the two styles of ratio pyrometer that should be considered for each application

Two-color sensors are an appropriate choice for many common temperature measurement applications. However, when certain conditions are present such as water, steam, scale, severe temperature gradients, severe or intermittent optical obstruction, flames, combustion gases, laser energy, plasma, small targets and low temperatures, dual-wavelength pyrometers are a more appropriate choice.

Consideration #1: Wavelength Selection - Viewing though optical interference

Two-color detector technology dictates a specific wavelength set, while dual-wavelength technology allows for free wavelength selection. Thoughtful wavelength selection permits dual-wavelength pyrometers to better tolerate interference from **water, steam, flames, combustion gasses, plasma and laser energy**. Thoughtful wavelength selection also permits select dual-wavelength sensors to provide broader temperature spans and to measure lower temperature values – as low as 200˚F / 95˚C

Consideration #2: Wavelength Separation - More tolerant of scale and temperature gradients

A bump on the floor causes a table to wobble, but the wobble will be smaller when there is a greater separation between the legs. Similarly, the stability of a ratio sensor is related to the separation between the wavelengths. Because dual-wavelength pyrometers have greater separation between the wavelength sets, they are as much as 20 times less sensitive to temperature gradients and scale compared to two-color sensors. For example, surface scale on a steel target that causes a 40-60 degree error for a two-color sensor would only produce an error of only 2-3 degrees for a dual-wavelength pyrometer. Likewise, dual-wavelength sensors are 20 times better able to measure only the hottest temperature viewed. This is important for applications with a small heated area or a temperature gradient, such as welding or induction heating.

Consideration #3: Detector Design

The two-color detector set includes two separate detectors – one on top of the other, with the bottom detector "blindfolded" by the one above it. Therefore, most of the energy collected by the sensor never reaches the bottom detector. Without this limitation, dual-wavelength pyrometers can tolerate 20 to 100 times more optical obstruction compared to two-color sensors, allowing dual-wavelength pyrometers to better view through dirty windows and severe optical obstructions and to better measure small or wandering targets that do not fill the sensor's field-of-view.

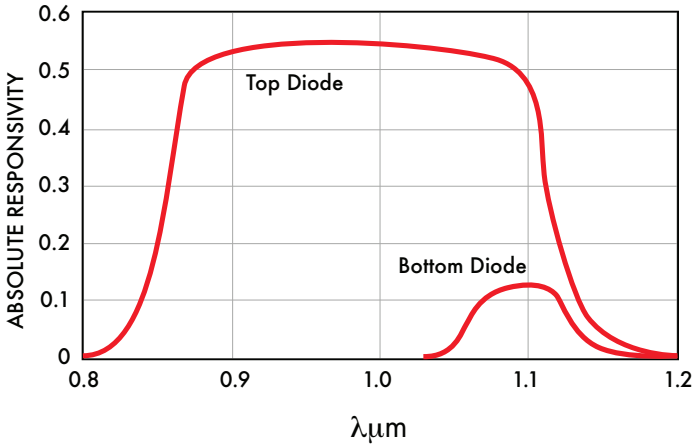
With two detectors, two-color sensors are prone to calibration drift. With only one detector, any detector drift affects both wavelengths equally, and therefore, does not impact the ratio measurement. Dual-wavelength sensors therefore hold their calibration much better than two-color sensors.

The Advantages of Dual-Wavelength pyrometers

Williamson Dual-Wavelength pyrometers offer all of the capabilities of two-color pyrometers plus these added advantages:

- Measure Low Temperatures – as low as 200˚F / 95˚C and above Fiber-Optic 400˚F / 200˚C and above
- Provide a Real-Time Measure of Temperature, Ambient Temperature, Emissivity and Infrared Energy
- Can measure Single-Wavelength and Dual-Wavelength temperature values simultaneously
- Include ESP Filtering to continuously measure intermittent targets or to eliminate intermittent interferences
- Select models uniquely view through Plasma and Laser Energy with thoughtful wavelength selection
- Select models uniquely view clearly through Water, Steam, Flames and Combustion Gasses with thoughtful wavelength selection
- Are 20 times less sensitive to Scale and temperature gradients compared to two-color sensors
- Are 20 to 100 times less sensitive to optical obstruction and misalignment compared to two-color sensors
- Tolerates a partially filled field of view

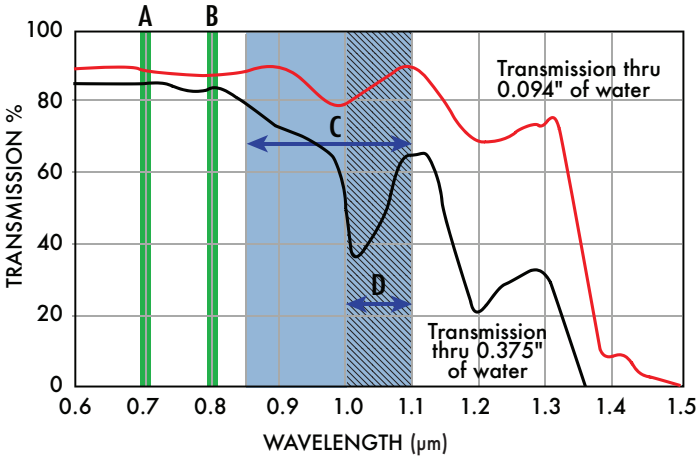
Dual-Wavelength Pyrometers better tolerate emissivity variation, misalignment and optical obstruction.



The Two-Color Detector Design Dictates the Wavelength Set.

Note that the two wavelengths overlap without separation, 1.0-1.1 um is a poor wavelength for water, steam, flames, combustion gasses, and silicon, and the long-wavelength (bottom detector) is weak.

Optical Transmission Through Water by Wavelength



Dual-Wavelength A+B (separate and distinct wavelengths)

Two-Color Wavelength C+D (overlapping wavelengths)

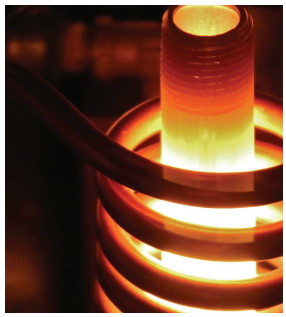
Select Dual-Wavelength Pyrometers View Clearly Through Water and Steam without interference. Two-color Pyrometers do not.

Williamson places a strong emphasis on dual-wavelength pyrometers because of their enhanced ability to tolerate a wide range of common application issues with little or no interference. Dual-wavelength sensors are used every day to make measurements that are traditionally considered impossible to make.

Ratio Applications

- Molten Metal Stream (Al, Cu, Fe, Ag, Au, etc…)
- Sinter Furnace
- Coke Guide
- Continuous Caster
- Reheat / Heat Treat Furnace
- Rolling Mill Descaler
- Rolling Mill Stands
- Rolling Mill Cooling
- Rolling Mill Coiler
- Annealing Line Wedge
- Forging Die
- Wire and Rod
- Ultra-Fine Wire
- Oilfield Tubular Products
- Induction Heating
- Severe Optical Obstruction
- Induction Brazing
- Plasma Diamond Growth
- Plasma Ion Nitriding
- Carbon Densification
- Engineered Ceramics
- Silicon CVD
- Fly Ash
- Flames





Williamson's Unique Multi-Wavelength Technology

The most significant challenge for many infrared pyrometer applications is contending with the complex emissive character associated with the measured material or with challenging measurement conditions. Single-wavelength sensors measure a significant error whenever the emissivity value is highly variable and they cannot tolerate a significant optical obstruction. Dual-wavelength sensors measure a significant error whenever the change in emissivity is inconsistent at the two measured wavelengths and they assume that any optical obstruction impacts both measured wavelengths equally. When the emissive character of the measured material or when the transmission characteristic of any intervening media does not allow a single- or dual-wavelength sensor to produce an accurate reading, then multi-wavelength technology is recommended.

Multi-wavelength pyrometers are used for a variety of applications where traditional infrared pyrometer technologies prove inadequate. Multi-wavelength sensors use ESP Algorithms to adjust for the unique emissive character associated with the specific measured material or measurement condition to produce an accurate measure of temperature and emissivity. Different algorithms exist for different materials and for different measurement conditions. The iterative ESP Algorithm is used to first measure the spectral emissive character of the measured material, and then to calculate a measure of both temperature and emissivity. Each Williamson multi-wavelength sensor can hold as many as eight ESP Algorithms. The ability to hold multiple algorithms means that each Williamson sensor can be used for multiple measurement applications.

A Long History of Multi-Wavelength Measurement

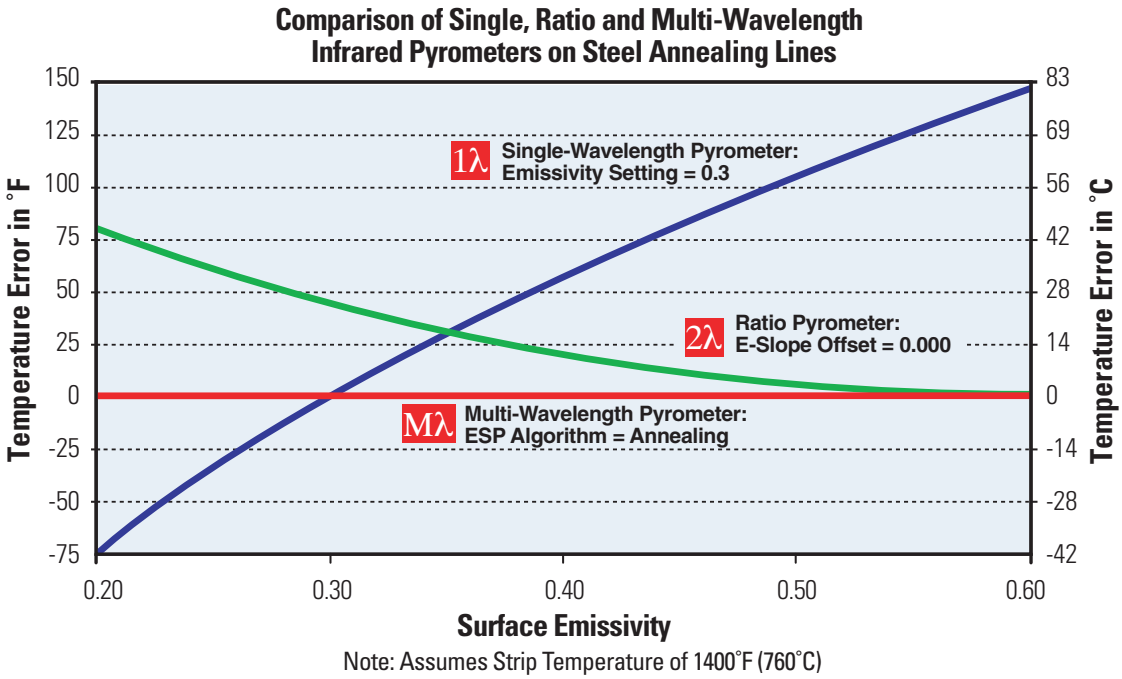
Williamson multi-wavelength infrared pyrometers represent the culmination of four decades of refinement and perfection to the world's first and most robust commercial multi-wavelength product line. Originally introduced in the 1970s, no other multi-wavelength sensor is as precise, as accurate, as robust, as reliable, as versatile, as innovative, or as easy to use. No other infrared pyrometers equal the features or performance of the Williamson multi-wavelength. No other product can measure such a wide range of materials under such a wide range of conditions over such a wide temperature span in such a wide range of environments. Williamson multi-wavelength sensors are truly without peers. There are a number of temperature measurement applications for which the Williamson multi-wavelength pyrometer represents the only viable and accurate solution.

Some of the more popular multi-wavelength applications include the following materials.

Aluminum & Copper
- Extruded Surface
- Rolled Surface
- Cast Surface
- Sheared Surface
- Forged Surface
- Brazing Operations
- Coating Preheat
- Billet Heating

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

Glass & Plastic
- Molds
- Plungers
- Streams & Gobs



Note: Assumes Strip Temperature of 1400°F (760°C)

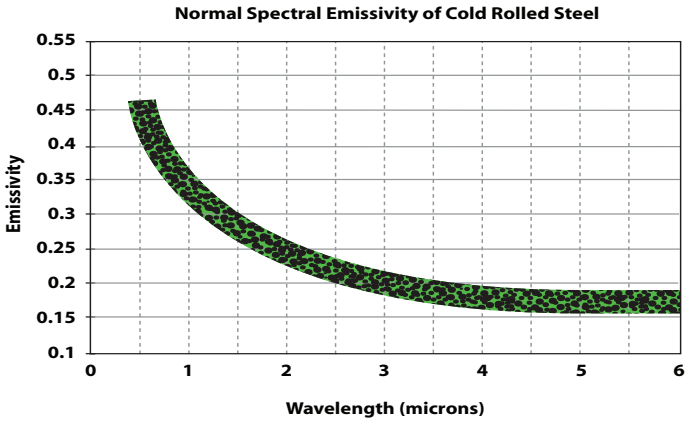
Williamson specializes in advanced technologies to compensate for the low and variable emissivity character associated with many industrial applications.

Williamson multi-wavelength infrared pyrometers offer several advantages and as a result multi-wavelength sensors can make "impossible" measurements of challenging materials (Aluminum, Zinc, Stainless Steel, Copper, High Alloy Steel, Electrical Steel, Cold Rolled Steel, Molds and Plungers, etc.).

Williamson Multi-Wavelength Pyrometers –

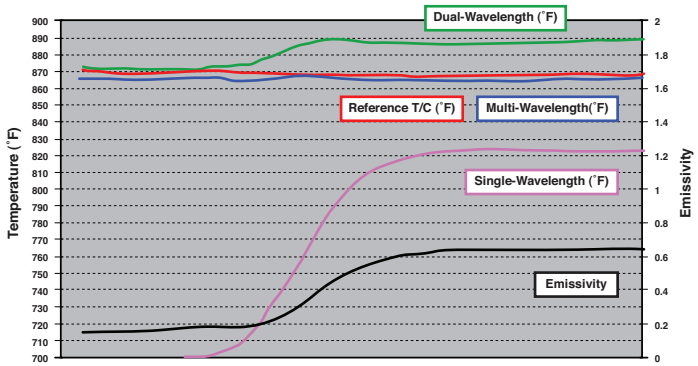
- Produce a highly accurate temperature reading for all low emissivity materials
- Are available in traditional and fiber-optic configurations
- View through common window materials
- Measure low temperatures – as low as 300˚F / 150˚C and above; fiber-optic 400˚F / 200˚C and above
- Provide a real-time measure of temperature, ambient temperature, emissivity and signal dilution
- Can measure single-wavelength and dual or multi-wavelength temperature values simultaneously
- Include advanced ESP filtering to measure intermittent targets or to eliminate intermittent interferences
- Measure broad temperature spans ideal for most heating applications
- Select models uniquely view clearly through water, steam, flames and combustion gasses
- Select models uniquely view through plasma and laser energy
- Tolerate misalignment and dirty optics (select application algorithms)
- Tolerate non-greybody emissivity variation and optical interference
- Store as many as eight application specific algorithms for use in as many as eight applications for extreme versatility

Multi-Wavelength Sensors tolerate non-greybody emissivity variation and optical obstruction.

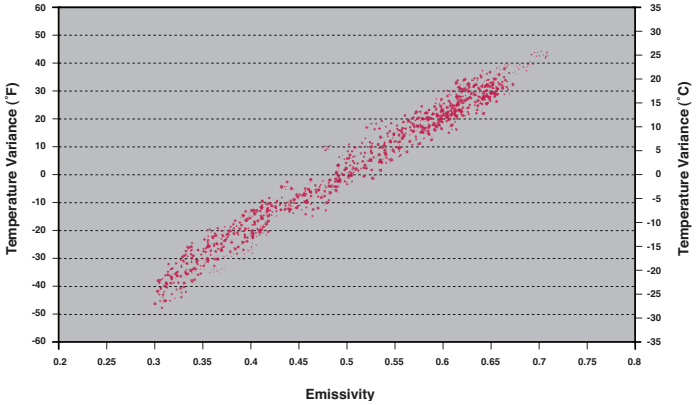


Non-Greybody: Emissivity is different and changes differently at different wavelengths.

Single, Dual and Multi-Wavelength Readings Compared to a Reference Thermocouple



Single-Wavelength Error vs Emissivity Steel Strip Annealing Line, Emissivity Setting =0.460



Williamson Overview

6 Technology Buckets over 3 Different Classes of Products

With the Silver, Gold, and Pro Series sensors, WIlliamson offers a complete range of infrared pyrometers to provide accurate and reliable measurements for traditional and challenging applications.

- The Silver Series offers a choice of miniature, low cost configurations for many general purpose applications.
- The Gold Series offers a complete selection of wavelengths, optics, and configurations for traditional and challenging applications including heavy industrial environments.
- The Pro Series offers the most advanced capabilities with a complete selection of wavelengths, optics, and configurations for traditional and challenging applications including heavy industrial environments.

Class	Sighting
Single-Wavelength Sensors	
Silver C, M, & U	Line of Sight
Gold 20	Line of Sight or Laser
Gold 30	Fiber optic w/ Aim Light
Pro SW	Visual or Laser
Pro SWF	Fiber optic w/ Aim Light
Dual-Wavelength Sensors	
Pro DW	Visual or Laser
Pro DWF	Fiber optic w/ Aim Light
Multi-Wavelength Sensors	
Pro MW	Visual or Laser
Pro MWF	Fiber optic w/ Aim Light

For more details on Single-Wavelength models, see Williamson's Single-Wavelength Industrial Infrared Thermometers brochure and data sheets.

SAMPLE INDUSTRIES SERVED

- Iron and Steel
- Nonferrous Metal
- Industrial Heating, Thermal Surface Treatment
- Engineered Materials, Semiconductor
- Glass and Ceramics including Bricks, Cement, Glass, and Refractory
- Incinerators, Boilers, Rotary Kilns, Flares, Thermal Reactors
- Paper, Textile, Plastic, Rubber
- Pharmaceutical
- Food
- Aggregate, Ores, Soil and Asphalt

A Complete Range of Infrared Pyrometers for Every Application

Silver U Class

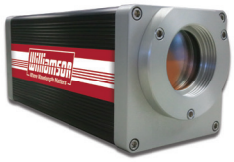
Silver M Class

Silver C Class

Gold 20

Gold 30

Pro Series
Single, Ratio, & Multi-Wavelength



Pro Series
Fiber Optic

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