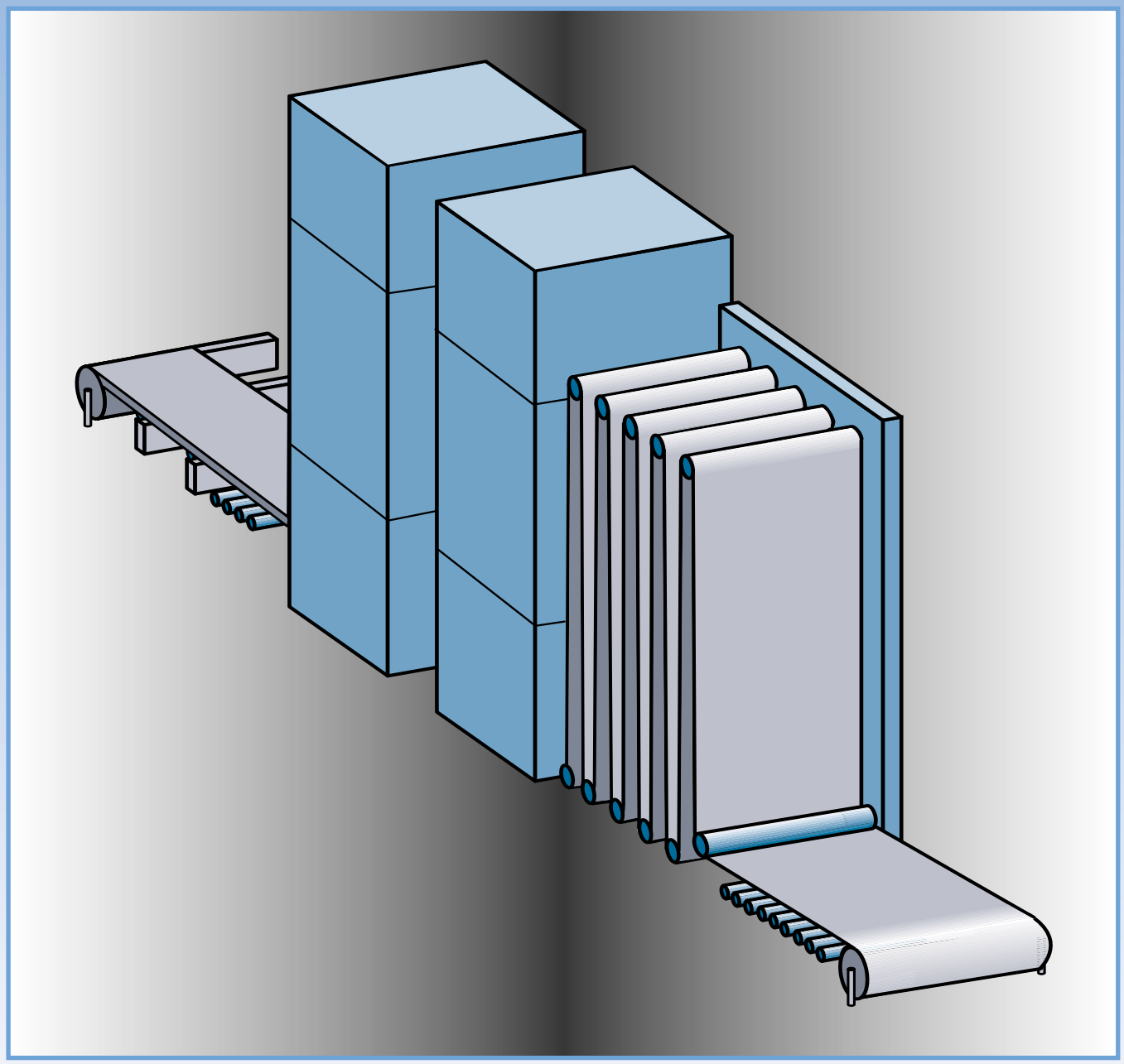
Continuous Annealing Lines

Infrared Thermometers for Strip Temperature Control



Williamson

Innovators in Noncontact Temperature Measurement

TEMPERATURE CONTROL ON ANNEALING LINES

Steel consumers and competitive market conditions are driving steel mills to produce higher quality products more cost effectively. In order to meet these demands, steel mills must implement better controls to manage the temperatures and surface characteristics of the steel strip during the annealing process. For example, high strength steels for the automotive industry require tight temperature control in order to maintain material properties and keep scrap rates and coil reheats to a minimum.

Traditionally, single-wavelength and dual-wavelength infrared thermometers (i.e. ratio or two-color) have been used for strip temperature control within an annealing line. As the graph below illustrates, the fundamental challenge with using these sensors is that their accuracy can vary greatly with the emissivity of the steel strip. Unfortunately in an annealing process, the emissivity of the steel strip can vary significantly and unpredictably due to:

- Changes in alloy, surface texture, surface oxidation, grain growth, and elemental migration
- Abnormal operating conditions, such as a furnace leak, a bad roller, or a reheated coil

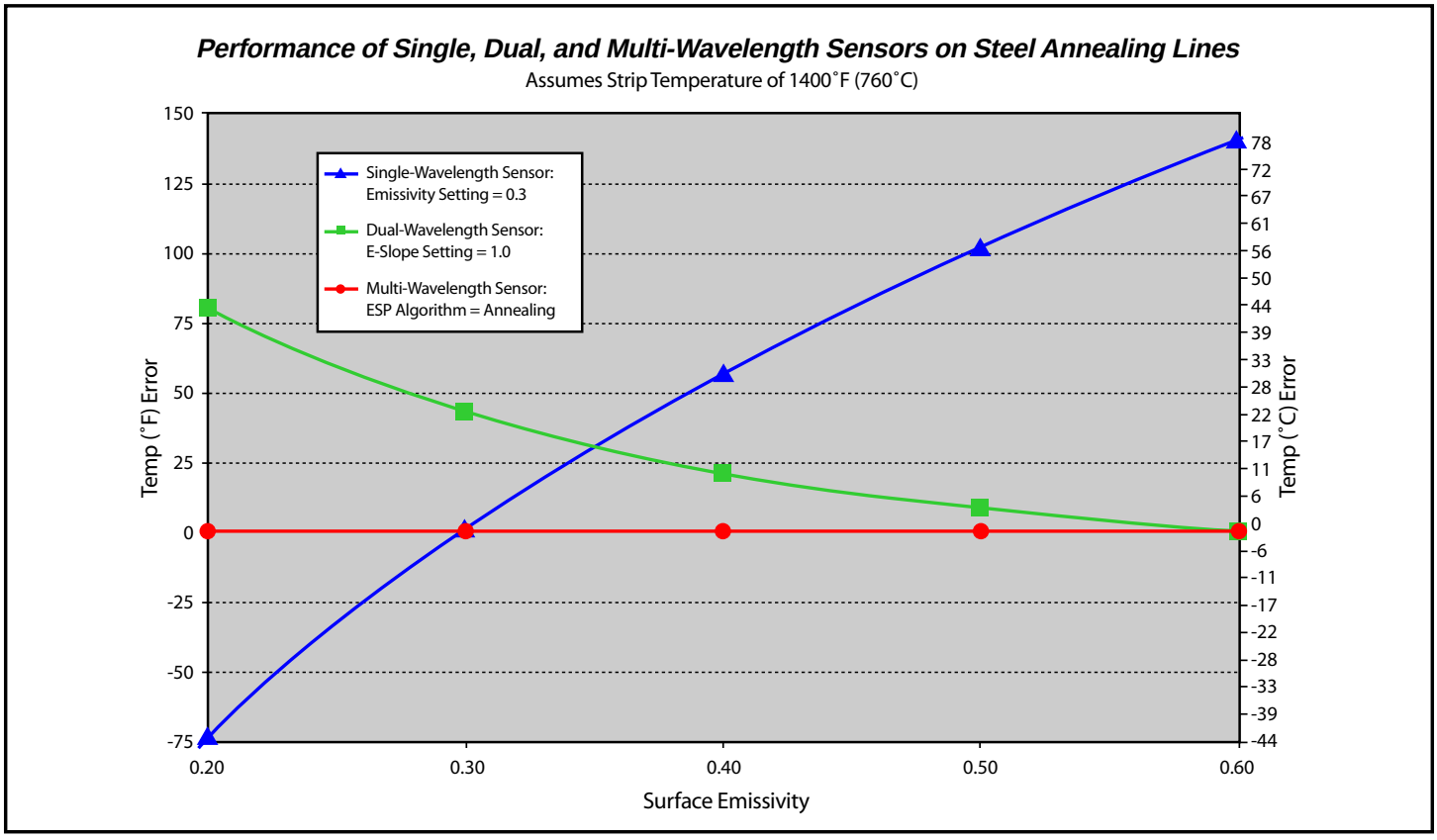
The best illustration that these temperature errors exist is when product properties do not correlate with the measured strip temperatures, or when a phantom temperature change occurs at the welded seam of the strip. With single- and dual-wavelength sensors, the approach to eliminating errors has been to make adjustments to the sensors for each product, but as the table above illustrates, this strategy has limits with being able to satisfy all of the annealing line requirements.

Application Requirement	Single Wavelength	Dual Wavelength	Multi Wavelength
Accurate Measurement of Carbon Steel Alloys	YES	YES	YES
Compensate for Abnormal Operating Conditions	NO	YES	YES
Accurate Measurement of Advanced Steel Alloys	NO	NO	YES

With advances in technology, Williamson has developed a new multi-wavelength sensor that is specifically designed to meet the challenging requirements of the annealing lines. Without the need to make any adjustments, this new sensor provides more accurate and reliable temperature measurements across a wide range of steel alloys under a variety of operating conditions. With these high performance sensors, it is now possible to obtain tighter control of physical properties, as well as reduce scrap rates, coil reheats, and costly coil downgrades.

Features of Multi-Wavelength Sensors

- Accurate temperature measurements without any adjustments to the sensor on Carbon Steels, Tool Steels, High Strength Steels, Electrical Steels, Stainless Steels, and High Temperature Steels
- Automatic compensation for strip emissivity and e-slope variation
- Real-time measurement of strip temperature and surface emissivity for process verification and optimization
- Dramatic reduction in sensitivity to warm furnace wall reflections



UNEQUALED PERFORMANCE FOR A DIFFICULT APPLICATION

Williamson's new PRO Series multi-wavelength sensor was specifically developed to compensate for the challenging requirements of a steel mill annealing line. The sensor uses an ESP Algorithm that considers infrared energy, emissivity, and the measured wavelengths to accurately calculate the strip temperature and the surface emissivity. The algorithm is a computer based empirical model that was developed from extensive data that was collected from off-line simulations and on-line tests. As the sample data below illustrates, one ESP Algorithm can be used for accurate measurements on most steel alloys including, carbon steels, tool steels, dual-phase steels, and high strength steels. Additional ESP Algorithms exist for stainless steels, electrical steels, coated steels, and high temperature steels.

Sample Multi Wavelength Field Data

Low Silicon Alloys (greater than 0.2% Si)			
Alloy Set	Emissivity	Average Variation (1)	Standard Deviation
1	0.248	-3˚ C	4˚ C
2	0.315	3˚ C	6˚ C
3	0.481	-1˚ C	5˚ C

High Silicon Alloys (less than 0.2% Si)			
Alloy Set	Emissivity	Average Variation (1)	Standard Deviation
4	0.329	4˚ C	6˚ C
5	0.342	3˚ C	4˚ C
6	0.465	14˚ C (2)	3˚ C

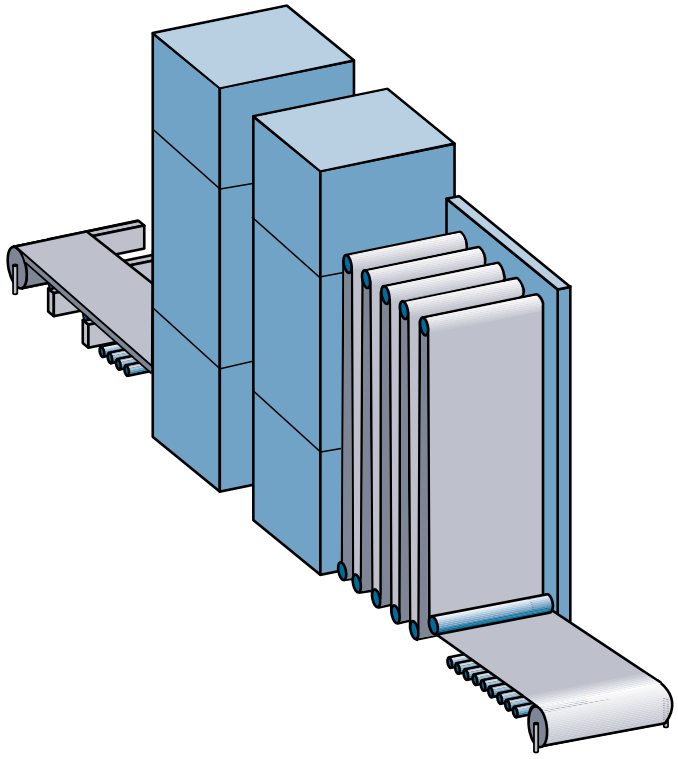
Note 1: The sample data represented a wide range of surface and operating conditions, including reheated coils, background temperature variations and dew point variation.

Note 2: As illustrated by the standard deviation values, a single ESP Algorithm provides a repeatable measurement across all alloys, but some alloys may require a small offset adjustment to obtain absolute accuracy.

With the capability of providing real-time emissivity measurements, the PRO 110 can be used to verify measurement conditions, as well as optimize the radiant heat transfer and line speeds throughout the furnace. All combined, these capabilities help to produce better quality steel more consistently and more efficiently.

Advantages of Emissivity Measurements

- High emissivity strip absorbs heat more efficiently, resulting in faster line speeds at lower zone temperatures.
- Low emissivity strip has a smoother surface texture resulting in a smoother finish.
- Stable and reasonable emissivity values validate operating conditions, surface texture, and crystal structure.
- Increasing emissivity values indicate oxide growth or surface defects that could be caused by changes in the hydrogen levels of the furnace.



With the ability to make more accurate temperature measurements under a wide range of operating conditions, the multi-wavelength PRO 110 provides the flexibility to install the sensors in more locations along the annealing line for greater control of process temperatures.

- **For straight-pass furnaces,** one or more sensors can be placed at the exit of the flame-heating section, the exit of the radiant-heating section, and at the exit of the cooling zone.
- **For serpentine-pass furnaces,** multiple sensors can be placed within several heating and cooling zones.
- **For hot dip lines,** a sensor is placed at the snout.
- **For galvaneal lines,** sensors are placed at the exit of the heating zone (often an induction heating system) and just before the "turn roll" where the coated strip must be below 650˚F (350˚C) before it contacts the roll and causes surface damage.

Recommended Locations for PRO 110

- *Direct Flame & Radiant Tube Heating Zones:* Installation requires a cooled viewing tube to eliminate interference from reflections off the hot furnace walls.
- *Cooling Zones:* No special mounting provisions required.
- *Inter-Connecting Ductwork:* For low-emissivity strips or advanced alloys, this location requires a cooled viewing tube. For high emissivity or carbon steels, no special mounting provisions are required because the multi-wavelength sensor is less sensitive to hot background reflections.
- *Nip Measurement Technique:* Single-, dual-, or multi-wavelength sensors may be used. Dual- and multi- wavelength sensors tolerate misalignment to the roller nip.

With an advanced infrared and microprocessor based design, the PRO 100 surpasses traditional single and dual-wavelength sensors for annealing applications

Sensor Selection Guidelines (1)

COMPLETE MODEL NUMBERS		
Carbon Steel Lines	110-10F-FOV5FT/75-WCAP-23-FM-ESPS3-40C	
Stainless Steel Lines	110-15F-FOV5FT/75-WCAP-23-FM-ESPS2-40C	
Galvaneal Lines	120-26-F-FOV10FT/25-WCAP-23-SB-ESPS1-40C	
SENSOR SPECIFICATIONS		
Type of Sensor	110 / 120	Multi Wavelength Sensor with ESP Technology
Temperature Range	10F	700-2100˚F (375-1150˚C)
	15F	750-2500˚F (400-1375˚C)
	26F	600-1200˚F (315-1375˚C)
Field Of View	FOV 10ft/75	1.6" @ 10' (4cm @ 3m)
	FOV 10ft/25	4.8" @ 10' (12cm @ 3m)
Accessories	23	Remote Interface Module with Universal Power Supply
	WCAP	Water Cooling and Purge Port
	FM	Flanged Mounting Accessory (option: FMQ w/IR window)
	SB	Swivel Mounting Bracket
	ESPS1/2/3	ESP Algorithms for the respective applications
	40C	40 foot electrical interconnect cable
Specification for the Cooled Viewing Tube	The multi wavelength sensor is significantly less sensitive to background influences than either the single or the dual wavelength sensors. Therefore, it is possible to install the sensor without a cooled viewing tube in the holding zones or the connecting duct work where the background temperatures are 200˚F (100˚C) cooler than the strip. For measurements in the heating zones, a cooled viewing tube is required with the following specifications; • The tube diameter must be at least twice the distance from the end of the tube to the strip plus about 1in or 25mm • The cooled surface of the tube that is close to the strip must be at least 200˚F (100˚C) cooler than the strip temperature	

(1) Consult with Williamson regarding other sensor models that are available for temperature measurements, the welder, the preheat zone, the temper mill/cold mill, as well as the paint lines and organic coating lines.

WILLIAMSON CORPORATION
70 Domino Drive, Concord, Massachusetts 01742
TEL: (978) 369-9607 • FAX: (978) 369-5485 • (800) 300-8367 (USA)
www.williamsonir.com

Williamson
Innovators in Noncontact Temperature Measurement