# Aluminum Processing

## Noncontact Temperature Measurement

**Aluminum Extrusion • Aluminum Rolling Mills**
**Aluminum Forging • Aluminum Rod & Bar Mills**

Williamson

*Innovators in Noncontact Temperature Measurement*

# Infrared Temperature Sensors for Aluminum

Incorporating powerful advances in microprocessor and infrared technology, Williamson's new multi-wavelength sensors accurately measure aluminum temperatures under diverse industrial conditions without any calibration adjustments. With the high performance PRO Series sensors, it is now possible to implement tighter control of process temperatures for improved product quality and process productivity in a wide range of applications such as:

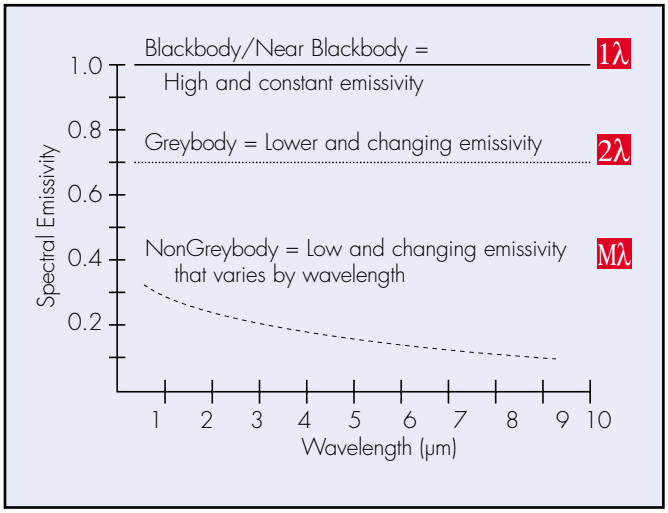
- Aluminum rod and bar mills
- Aluminum forging operations
- Aluminum extrusion plants
- Aluminum rolling mills

### Greater Accuracy for Improved Temperature Control

Infrared thermometers measure the amount of infrared energy emitted by an object's surface, and then convert this signal into a temperature value. While many factors affect the measurement accuracy, the most important consideration is the selection of the sensor design that most effectively compensates for the emissivity characteristics of the measured surface.

Emissivity is a measure of the amount of infrared energy emitted from a surface relative to its theoretical maximum for a given temperature. As the figure illustrates, single- and dual-wavelength infrared thermometers are used for traditional applications that exhibit 'near blackbody' or 'greybody' conditions. However, successful temperature measurement of 'non-greybody' materials, such as aluminum, requires the use of a multi-wavelength sensor to compensate for the complex emissivity characteristics of these materials. For example, aluminum emissivity variations occur with changes in alloy, surface oxidation, surface texture, surface contamination, and crystal structure.

### Surface Emissivity Characteristics




Multi-wavelength PRO Series sensors use ESP algorithms to calculate the accurate temperature and emissivity of aluminum by considering infrared energy, emissivity, and the measured wavelengths. The algorithms are computer-based empirical models that have been developed from extensive on-line trials and off-line process simulations for each application. With no need for field adjustments, the PRO Series sensors accurately measure:

- Hard and soft alloys
- Cut, cast, rolled, forged, sheared, and extruded surfaces
- Billets, ingots, strip, plate, coils, and extruded shapes
- Smooth, rough, oxidized, and oxide-free surfaces

In addition, this new generation of infrared sensors can more effectively tolerate misalignment, dirty optics, and other difficult application issues. With all of these advanced capabilities, the PRO Series sensors provide the most accurate and reliable measurements in a system that is easy to install, operate, and maintain.

**Features of Multi-Wavelength Sensors**

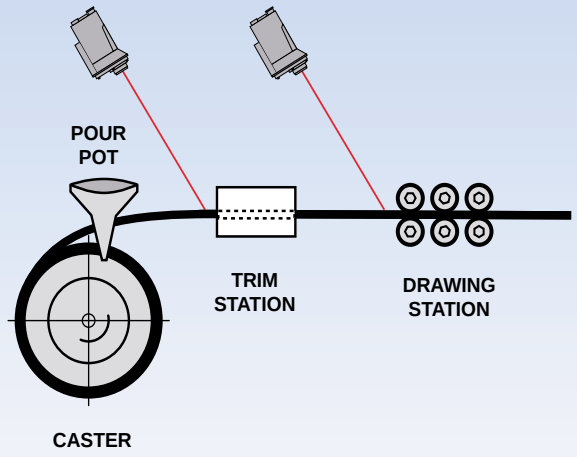
- Real-time measurement of aluminum temperature and emissivity for process verification and optimization.
- Accurate temperature measurement with no sensor adjustments for common aluminum alloys, surface conditions and shapes.
- Automatic compensation for complex emissivity characteristics.
- Robust algorithms to compensate for common application issues, such as misalignment and dirty optics.

*PRO 120 measuring extrusion profile temperature*

# UNEQUALLED PERFORMANCE IN DIFFICULT APPLICATIONS

## ALUMINUM ROD AND BAR MILLS

**PRO 100s with Laser Aiming for Rod & Bar Temperature Control**




### Temperature Applications

- Cast Strand Measurement
- Rolled Shape Measurement
- Coiler Temperatures, where applicable

### Application Highlights

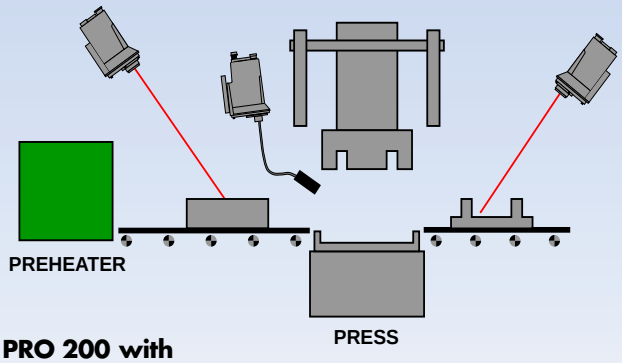
In the production of aluminum rod and bar, molten aluminum is first cast into a continuous strand using a caster wheel. This strand is subsequently reduced through multiple rolling stands until it has reached its final shape. The PRO 120-20 infrared sensor is used to measure aluminum temperature at the caster wheel exit and the entry to each rolling stand. The PRO 42-20 sensor with auto null technology is used to accurately measure the lower temperatures at the coiler and/or shearing station.

Optimal temperature control is essential for the efficient and effective operation of an aluminum rod or bar mill. At the caster wheel and at each rolling stand, temperature feedback is used to prevent cracking and surface blemishes as well as to adjust the reduction settings. The temperature at each roll stand should be balanced for optimal line speed and product quality.

The temperature at the coiler is another important process parameter. The aluminum can mark or stick if not adequately cooled, and the metal can become too brittle if it is cooled too quickly. Continuous temperature measurement at the coiler assures consistent product properties.

## ALUMINUM FORGING OPERATIONS

**PRO 100s with Laser Aiming for Billet and Product Measurements**




**PRO 200 with Fiber Optic Aiming for Die Measurement**

### Temperature Applications

- Billet Measurement
- Die Measurements
- Product Measurements

### Application Highlights

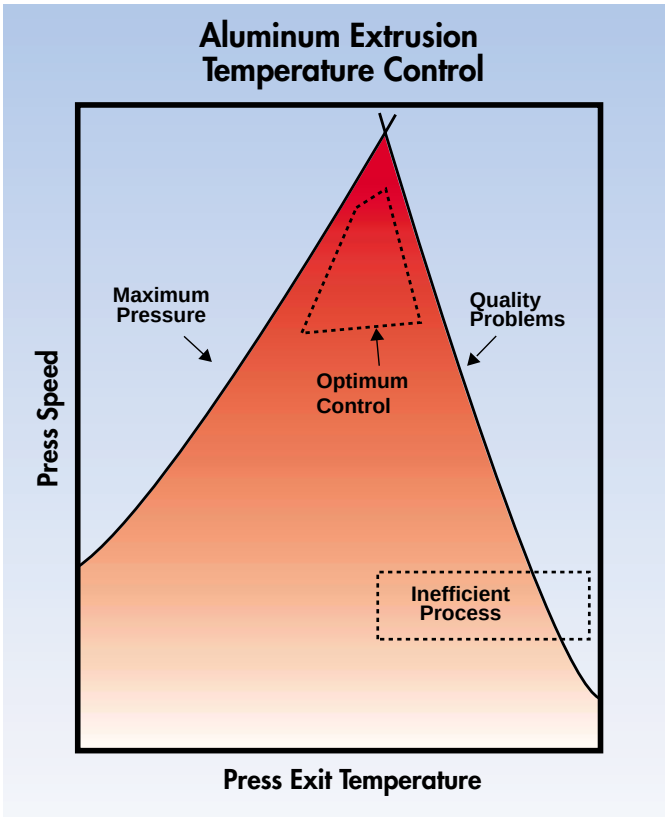
In a forging operation, aluminum billets are preheated prior to insertion into the forging press. Billet and die temperatures are two of the most critical process parameters associated with the forging process. A cold billet or die prevents the forged part from flowing properly, resulting in a cracked or malformed product and excessive die wear. A hot billet or die causes surface melting during the forming process, and may cause the aluminum to stick to the die. Properly heated billets and dies form a consistent quality product without excessive die wear, and without excessive die lubrication.

The multi-wavelength PRO 120-20 is used to measure the billets as they come out of the pre-heater, and the products as they come out of the press. This sensor automatically compensates for the diverse surface characteristics of the aluminum billets and products which can vary from dull and oxidized to shiny and oxide-free, and everything in between.

Die temperatures may be measured using a fiber optic dual- or multi-wavelength sensor. By using the advanced ESP filters, these sensors are able to accurately measure the die temperature without interference from smoke, flames, and other sources associated with this demanding application.

# Aluminum Extrusion Temperature Control

Aluminum extrusion applications present many unique challenges for infrared thermometers. The relationship between press exit temperature, press speed, and extrusion quality is critical to the optimization of the aluminum extrusion process. As the figure below illustrates, the range of press exit temperatures that produces quality product narrows as the speed of the press increases. Therefore, a thermal management system that is able to monitor or control billet, press exit, and quench zone temperatures is an essential element of the modern aluminum extrusion operation.




With its advanced capabilities, the PRO 120 has proven to be the most accurate and reliable sensor available for measuring aluminum temperatures. It is the ideal aluminum extrusion sensor because it:

- Compensates for aluminum's low and variable emissivity
- Automatically aligns to small, wandering profiles
- Compensates for dirty optics, smoke, and steam
- Survives the demanding industrial environment
- Offers one model for all applications

The following table provides typical accuracy values of billet, press exit, and quench measurements on several alloys without any adjustments to the sensor. In addition, the average emissivity values can be used to verify process conditions and provide an indication of the profile's surface quality.

**Sample Multi-Wavelength Field Data**

| Alloy Set | Average Emissivity | Average Variation(1) | Standard Deviation(2) |
|---|---|---|---|
| **Billet Face Measurements** | | | |
| 2024 | 0.043 | 5°F | 4°F |
| 6061 | 0.065 | -3°F | 3°F |
| 7075 | 0.051 | 4°F | 5°F |
| **Profile Measurements** | | | |
| 2024 | 0.032 | 6°F | 4°F |
| 6061 | 0.059 | 5°F | 3°F |
| 7075 | 0.027 | -4°F | 7°F |
| **Quench Measurements** | | | |
| 6061 | 0.083 | 5°F | 4°F |
| 6063 | 0.079 | -2°F | 5°F |

**Note 1:** The sample data represents a wide range of surface and operating conditions, including data from several extrusion plants on a wide range of shapes.

**Note 2:** As illustrated by the standard deviation values, a single ESP algorithm for each application provides an accurate and repeatable measurement across all alloys.

## Advantages of the PRO100 for Aluminum Extrusion Applications

**Accurate**

- Selectable ESP algorithms for Billet, Press Exit, and Quench measurements eliminate the need for field calibration of common hard and soft alloys and shapes
- Advanced design enables broad temperature ranges for extrusion applications with greater accuracy and stability

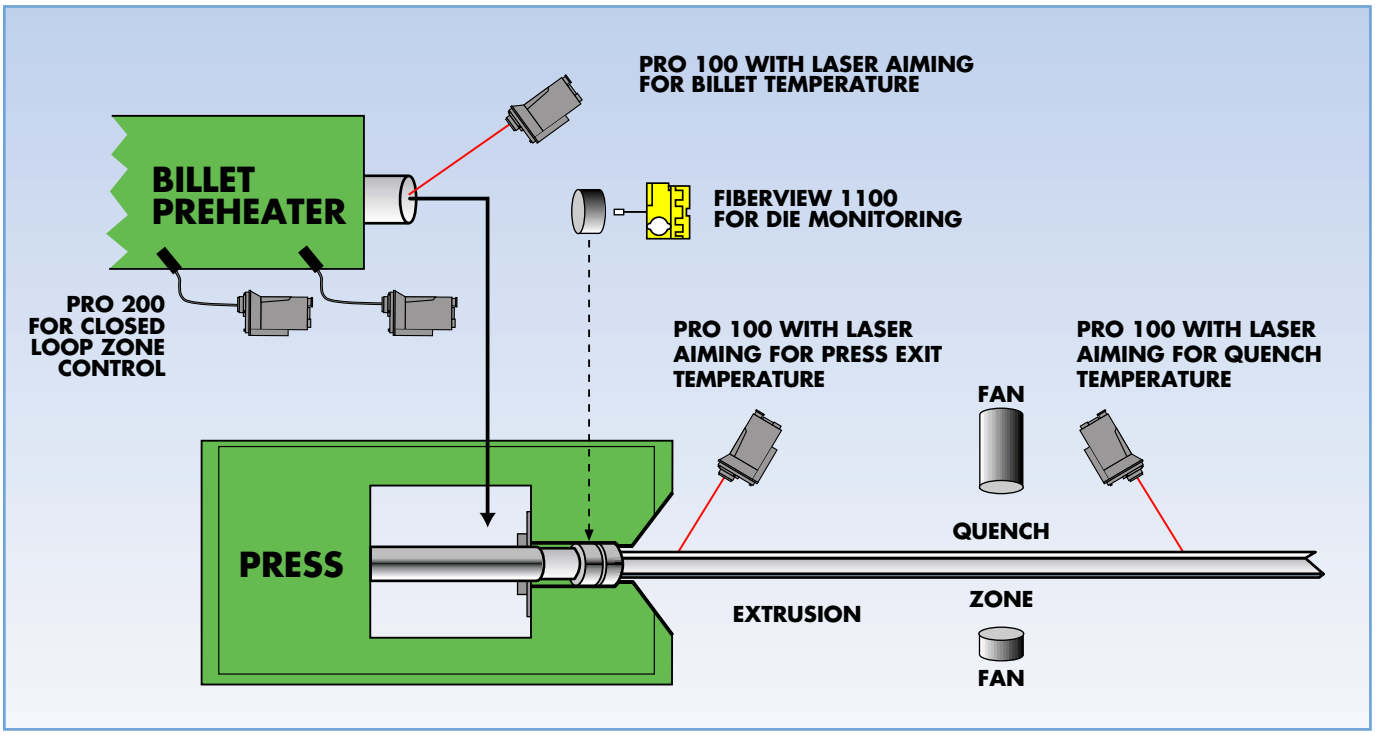
**Reliable**

- Industry-leading signal dilution factor ensures easy alignment to extruded profiles
- Requires less than 20% of the target area to be filled
- Tolerates more than 80% optical obstruction due to dirty optics, smoke or steam
- No mechanical scanning is required for small profiles at the exit of the press

**Easy to Use**

- Text-based menu system assures easy setup and operation
- Unique integrated laser aiming provides quick, easy alignment verification at all distances, and assures long laser life
- Built-in signal strength/emissivity measurement provides information for process verification and optimization
- Versatility– one sensor model for all applications

# Aluminum Extrusion Applications




### Billet Temperature Measurement

Improper billet temperatures make precise press exit temperature management difficult and can lead to excessive die wear and variations in product quality. Typical billet temperature measurements include:

- **Billet Zone Temperature:** The fiber optic PRO 220 sensor is installed to view through existing thermocouple ports for closed loop control of billet temperatures inside gas fired furnaces. These sensors replace troublesome thermocouples, and are designed with fiber optics to mount easily onto the existing mechanical assemblies and to interface with the existing PLC controls.
- **Billet Feed Temperature:** The PRO 120 may be aligned to view the side or the face of the billet between the preheat furnace and the container. This measurement is used for a go/no go confirmation of billet temperature, and to adjust furnace setpoint temperatures.
- **Induction Heating Furnace:** The PRO 120 is usually aligned to the face of the billet while it is in the induction furnace. This measurement is used for real-time closed-loop control of the induction heating system.
- **Tapered Heating:** The PRO 120 is aligned to the side of the billet to monitor and control the temperature taper introduced along the billet length. The sensor may be stationary as the billet travels past, or the sensor may be scanned across a stationary billet.

### Press Exit Temperature Measurement

The extruded profile temperature at the exit of the press is the most important process parameter that can be used to optimize the efficiency and quality of the extrusion operation. By maintaining consistent and optimal operating temperatures at the exit of the press, it is possible to optimize the speed of the press while eliminating problems with soft metal, cracks, and blemishes. In addition, the sensor's emissivity measurement can be used for process verification as well as an indication of the surface quality of the profile.

### Quench Zone Temperature Measurement

Ever-tightening quality control requires verification of proper quench rates. Quench rates that are too slow can result in soft metal, while quench rates that are too fast can sacrifice dimensional tolerances.

Williamson's broad temperature span allows accurate and reliable temperature measurement in the quench zone. To provide a complete quench management system, the quench sensor may be configured to communicate with the press exit sensor to automatically calculate and display the real-time quench rate which is an indication of the profile tensile properties.

# Temperature Control for Aluminum Rolling Mills

Consumers and competitive market conditions are driving aluminum rolling mills to produce higher quality products more cost effectively. In order to meet these demands, the rolling mills must implement better controls to manage the temperature and the surface characteristics of the aluminum strip during the rolling process.

The traditional approach to measuring temperatures in the rolling mills has been to use a combination of thermocouples and infrared sensors, but as the graph below illustrates, the fundamental challenge with using the traditional single and dual-wavelength sensors is that their accuracy can vary greatly with the emissivity of the aluminum strip. Unfortunately in a rolling operation, the emissivity of the 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 dirty lens, coolant on the strip, or stray background reflections.

The best illustration that these temperature errors exist is when product properties do not correlate with the measured strip temperatures. The traditional approach to minimizing these errors has been to make adjustments to the sensors or to use redundant sensors to verify the sensor's measurement. In either case, the effectiveness of these strategies has been limited.

Using advanced technology, Williamson has designed a new multi-wavelength sensor specifically to meet the challenging requirements of the aluminum rolling mills. Without the need to make any adjustments, this new sensor provides more accurate and reliable temperature measurements across a wide range of aluminum alloys under a variety of operating conditions (see sample data). With these high performance sensors, it is now possible to obtain tighter control of physical properties, as well as reduce scrap rates and costly coil downgrades.

## Sample Multi-Wavelength Field Data

| Alloy Set | Emissivity | Average Variation (1) | Standard Deviation (2) |
|---|---|---|---|
| **Strip Measurements** | | | |
| 2000 | .091 | 4˚F | 5˚F |
| 3000 | .115 | -1˚F | 3˚F |
| 5000 | .121 | 1˚F | 4˚F |
| 6000 | .105 | 3˚F | 5˚F |
| 7000 | .090 | -4˚F | 4˚F |

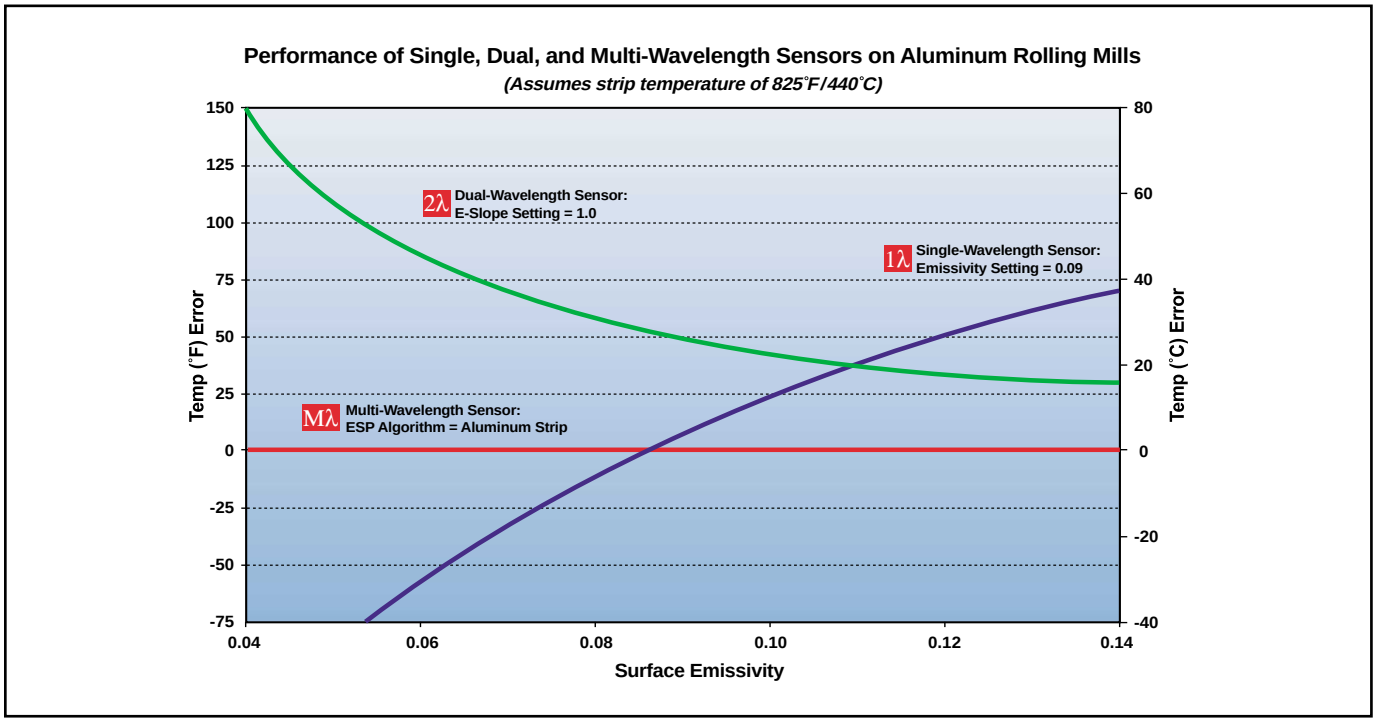
**Note 1:** The sample data represents a wide range of surface and operating conditions, including data from several rolling mills.

**Note 2**: As illustrated by the standard deviation values, a single ESP algorithm provides an accurate repeatable measurement across all alloys.

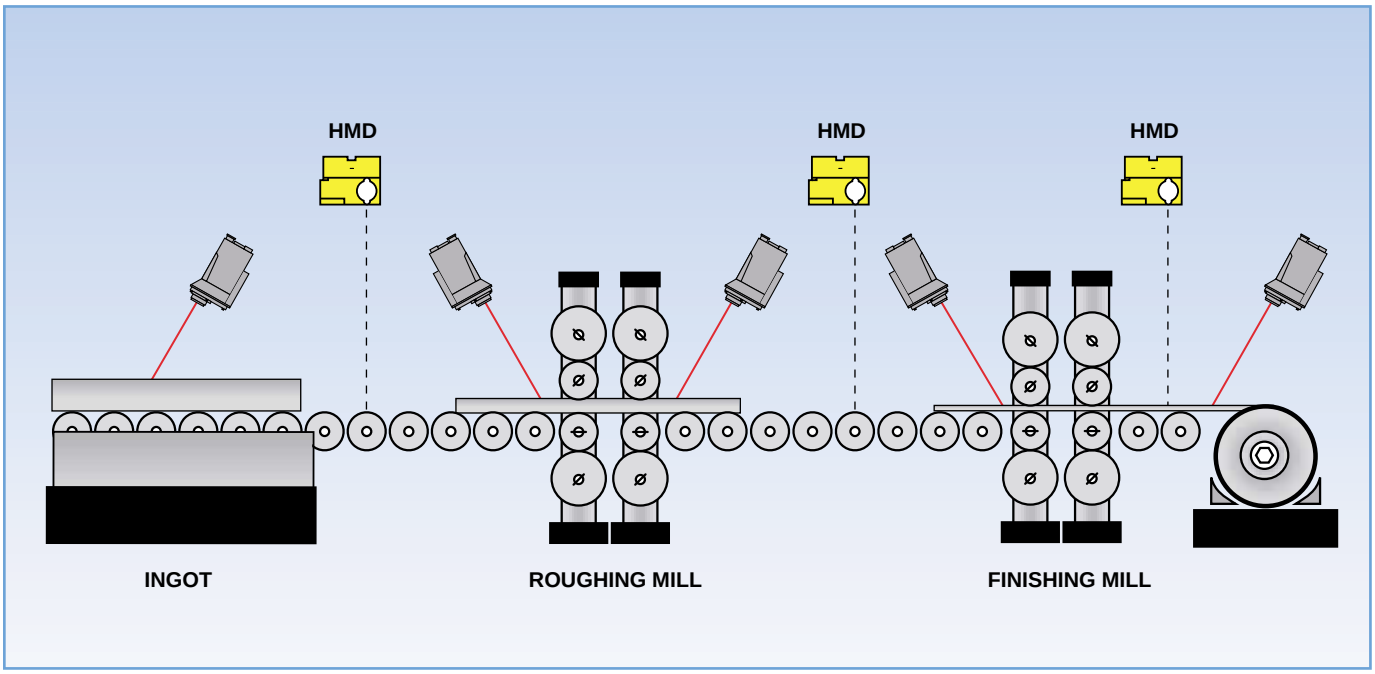
**Note 3**: Contact Williamson regarding additional data for ingot and coil measurements.

## Advantages of the PRO 100 for Aluminum Rolling Mill Applications

- Selectable ESP algorithms for the ingot, strip, and coil eliminates the need for field calibration on most alloys
- Advanced design enables broad measurement ranges with temperatures as low as 300˚F (150˚C)
- With an industry leading signal dilution factor, the sensor can tolerate significant optical obstruction due to dirty optics, smoke or steam
- Less sensitive to reflected light energy than other infrared thermometers
- Built-in signal strength/emissivity measurement provides information for process verification and optimization



# Aluminum Rolling Mill Applications




## Hot Mill

### Hot Mill Measurements

- Ingot entry
- Roughing mill entry and exit
- Finishing mill entry and exit
- Coiler (strip or side-of-coil)

Aluminum temperature is a critical parameter required for process optimization in the hot mill. Ingot and strip temperatures are used to control the speed and reduction throughout the rolling process.

- A hotter ingot or strip must be processed more slowly, or with a smaller reduction, in order to assure that the aluminum does not overheat.
- A colder ingot or strip must be run through at a faster speed, or with a greater reduction, in order to generate more heat during deformation so that the metal will remain mailable as it passes through the entire line.

By making the appropriate adjustments on each pass, each subsequent pass may be run under more optimized conditions. Strip temperatures at the finishing mill and at the coiler are most critical to ensure that the proper material properties are obtained.

The multi-wavelength PRO 120-20 sensor is used throughout the aluminum hot rolling mill to monitor these critical process parameters. With advanced ESP Algorithms, these sensors provide unparalleled accuracy by compensating for emissivity variation, alloy changes, surface contamination, and dirty optics without requiring any adjustments to the sensor.

## Cold Mill

At the cold mill, aluminum strips are reduced to tight mechanical tolerances, and cold worked to impart a hardness to the metal. If the metal or the roll is allowed to heat, then the thermal expansion can threaten the mechanical dimensions of the strip, and the heat buildup can soften the metal. Likewise, a strip that is well below the optimal temperature can be run faster without concern for a loss of properties. The model 120-03 or 42-30 provide a continuous measure of strip temperature to assure optimization of the process.

## Hot Metal Detection

Hot metal detectors are used to identify the leading and trailing edges of the strip to activate cooling sprays and handling equipment. Traditional hot metal detectors are not designed for the low temperature and low emissivity characteristics of aluminum.

The Williamson model 1100LT hot metal detector has been developed specifically to sense low-temperature, low-emissivity metals. With a response time of under 10 ms, this system provides exceptional performance in a compact and robust enclosure at a reasonable cost.


*With an advanced infrared and microprocessor-based design, the PRO 120 sensor provides unequalled accuracy, reliability and ease-of-use for aluminum applications*

## High-Performance Sensors and Systems

The PRO Series is a complete line of noncontact temperature sensors featuring advanced capabilities to enable accurate, reliable, and repeatable measurements for challenging applications. Features include:

- Single-, dual-, and multi-wavelength models
- Broad temperature ranges and precise optics
- Visual, fiber optic, and laser aiming options
- Intuitive text-based user interface
- Multiple programmable outputs and alarms for measured temperature, emissivity, and ambient temperature
- ESP filtering and ESP algorithms
- Advanced system diagnostics and status messages
- Rugged, corrosion-resistant NEMA4X (IP65) enclosures
- Field-selectable stand-alone and system configurations
- Wide selection of accessories

**Overview of PRO Series Models**

| Sensor Model | Type of Sighting | Type of Sensor | Temperature Limits |
|---|---|---|---|
| 40 | Visual | Single-Wavelength | 100 to 4500°F<br>35 to 2500°C |
| 50 | Fiber Optic | | |
| 80 | Visual | Dual-Wavelength | 200 to 4500°F<br>100 to 2500°C |
| 90 | Fiber Optic | | |
| 100 | Visual | Multi-Wavelength | |
| 200 | Fiber Optic | | |

## PRO 120 for Aluminum Applications

The PRO 120-20 is the most common model used for aluminum applications. This multi-wavelength sensor is supplied with as many as four pre-programmed ESP algorithms for accurate, out-of-the-box measurement in several process locations. The typical sensor configuration includes:

- Temperature range: 400-1100˚F (200-600˚C)
- Remote interface module with universal power supply
- Water cooling, air purge, laser aiming, and swivel mounting bracket

Following is a partial list of common aluminum applications for which the multi-wavelength PRO 120-20 is recommended.

**Common Aluminum Applications**

**Aluminum Extrusion**

- Extruded profile • Cut, shear, and side of billet
- Quench temperature and rate • Die temperature

**Aluminum Rolling Mills**

- Top of ingot • Strip and plate • Side of coils
- Cold mill • Hot metal detector (Model 1100)

**Aluminum Forging**

- Cut, shear, and side of billet
- Die • Product

**Aluminum Rod & Bar Mills**

- Cast surface • Rolled surface • Coiler (Model 42)

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