

# TEMPERATURE MEASUREMENT FOR GLASS

Non-contact temperature sensors for improved process monitoring and greater efficiency in glass production processes



# TRUSTED SOLUTIONS

Advanced Energy delivers trusted temperature measurement solutions for glass production processes.

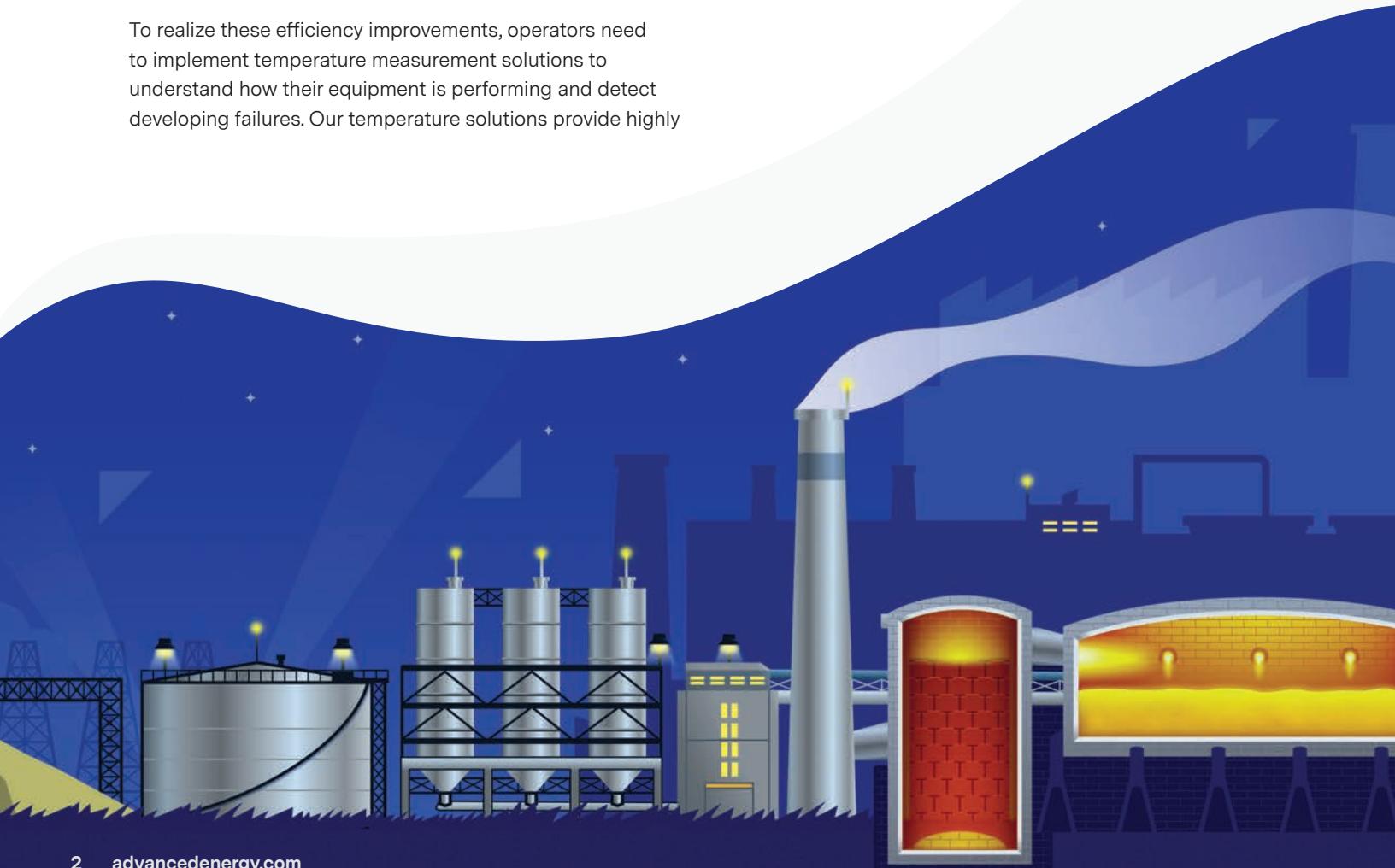
With a 60-year history of creating efficiencies through light-based measurement, Advanced Energy delivers trusted temperature measurement solutions for glass manufacturers. Accurate and precise temperature monitoring is critical for efficient and cost effective melting, glass viscosity control, heat zone adjustment, annealing, and stress reduction.

Temperature measurement is also directly related to glass quality as well as prolonging the life of critical assets such as refractory walls. System solutions involving non-contact thermal imaging combined with pyrometry can help increase production efficiency and reduce waste.

To realize these efficiency improvements, operators need to implement temperature measurement solutions to understand how their equipment is performing and detect developing failures. Our temperature solutions provide highly

accurate data to help professionals realize condition-based maintenance with continuous and remote monitoring.

Our unrivaled passion for excellence is why we have become the one of the world's most trusted sensing solution providers. Beyond providing precision engineered instruments, our customers turn to us knowing our commitment to their success comes first. With expert application understanding and a growing portfolio of products, Advanced Energy can combine several technologies together into novel solutions for the most complex environments.



# COMMON APPLICATIONS

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## Flat glass and solar glass

e.g. for the architectural and automotive sectors



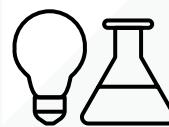
## Thin and thinnest sheet glass

e.g. for smart phones, tablets, flat panel displays, solar panels and safety glass



## Container and utility glassware

e.g. for bottles, containers and drinking glasses



## Technical glass

e.g. lamps, lightbulbs, energy saving lamps and tubes, optical glass fiber, glass wool, and optical instruments



# Process optimization through non-contact temperature measurements

Temperature measurement is key to the monitoring and optimization of energy-intensive glass production processes.

Careful temperature monitoring during glass production is the only way to ensure that product quality will meet the stringent marketplace requirements.

Temperatures during the various production stages are mostly measured without contact, e.g. in the glass melting tank, in the working tank, in the feeder, or in the gob.

The principal advantages of non-contact measurements are:

- Easy handling
- Fast response
- Increased throughput rates
- High flexibility
- Prolonged service life
- No contamination of the molten glass

Digital measuring equipment with compact electronic components guarantees fast and precise temperature measurements with excellent repeatability.

60+ years of experience

Advanced Energy offers more than 60 years of experience in non-contact measuring technologies with two product types:

## PYROMETRY

Choose from a wide range of non-contact thermometers whose ruggedness and precision are tailored to the specific needs of the glass industry.

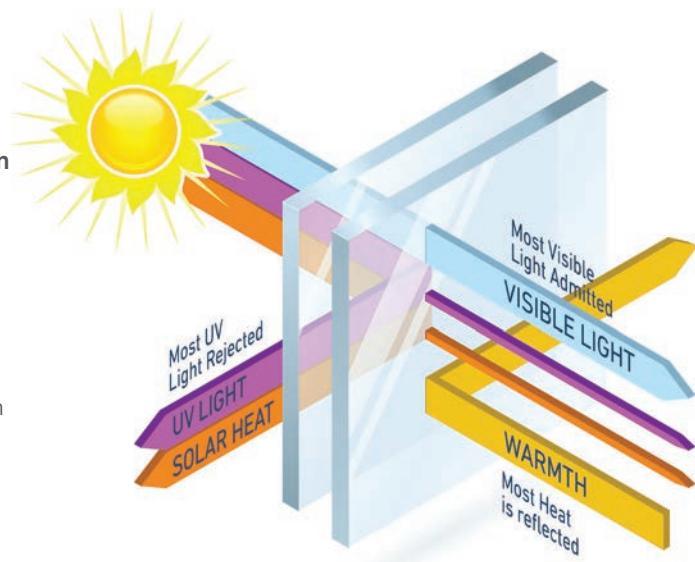
Whether it be for flat glass, solar glass, container glassware, utility glassware, or technical glass, all of our products deliver fast and accurate temperature readings. Customers receive optimum solutions to their specific challenges through intensive consultation with our sales and application engineers.



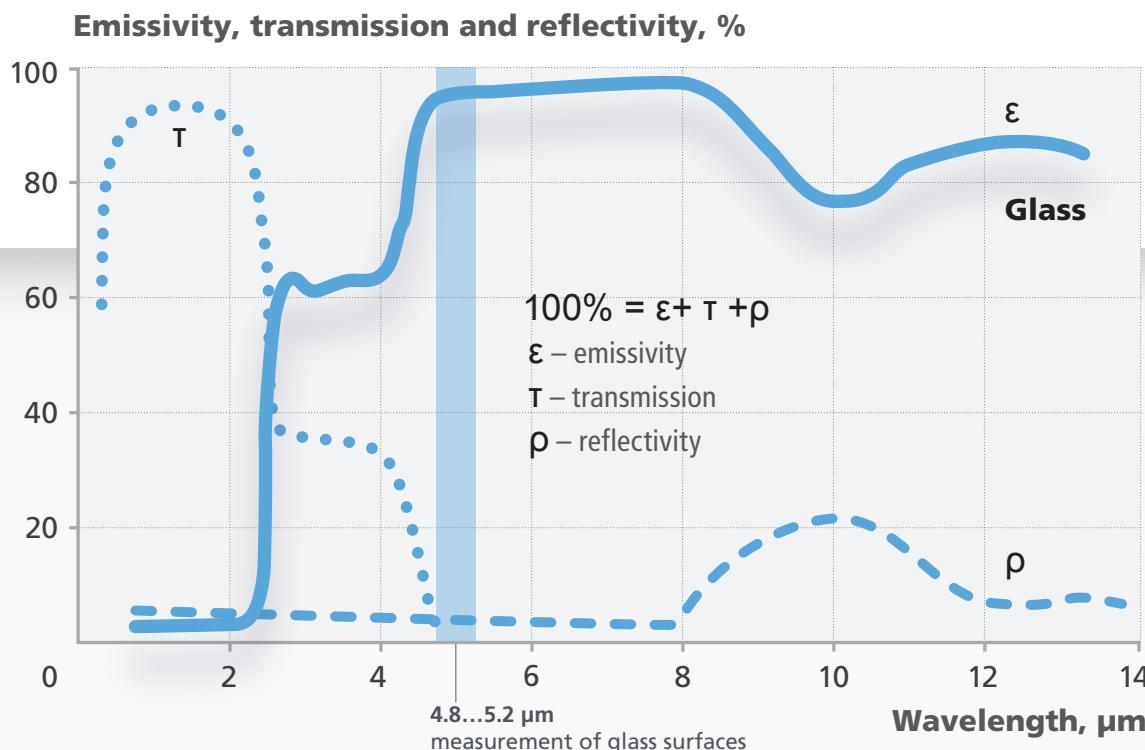
## Emissivity of Glass in the Infrared Spectrum

Many important optical properties of flat glass **transmission** ( $\tau$ ), **reflection** ( $\rho$ ) and **emissivity** ( $\varepsilon$ ) (or **absorption** ( $\alpha$ )) affect the performance in many common applications. The high energy UV portion of the solar spectrum (wavelength less than 400 nm) can be damaging to many materials including human skin. Since the transmission of glass is relatively low in this region, thick glass can be an effective UV block. Visual light (400 to 750 nm) easily passes through glass since the transmission is very high in this region. For the longer wavelength near infrared radiation (NIR) (750 to 2500 nm), which is the heat generating portion of the solar spectrum, a large fraction also passes through glass as the transmission is relatively high. Coatings can be applied to the glass surfaces prior to annealing to raise the reflectivity ( $\rho$ ) of glass in the NIR region. This 'low-E' glass can help to reflect, and retain heat generated inside a building during cool conditions, and reflect heat from the sun during warm days.

During glass manufacturing, accurate control of the process temperatures is critical to ensuring a quality product. For non-contact infrared temperature measurement systems, fully understanding the importance of the parameters is needed to select the correct instruments.



A pyrometer or thermal imager with a detector that is sensitive at 1  $\mu\text{m}$ , can be used to look through thin glass and measure wall temperatures as the glass emissivity is small, and transmission is large. If there is sufficient glass thickness, such as in the melt tank, then the bulk glass temperature can be measured. For thinner glass, selecting detectors that are sensitive in the 5 to 8  $\mu\text{m}$  range will ensure very high emissivity, and accurate measurements on the surface of the plate. A 3.9  $\mu\text{m}$  detector can be used to measure the temperature a few centimeters down into the glass.



# Glass Melting

## Regenerator

Regenerators play an important role in the glass melting process. They enable higher operating temperatures and more efficient melting in the melting tank.

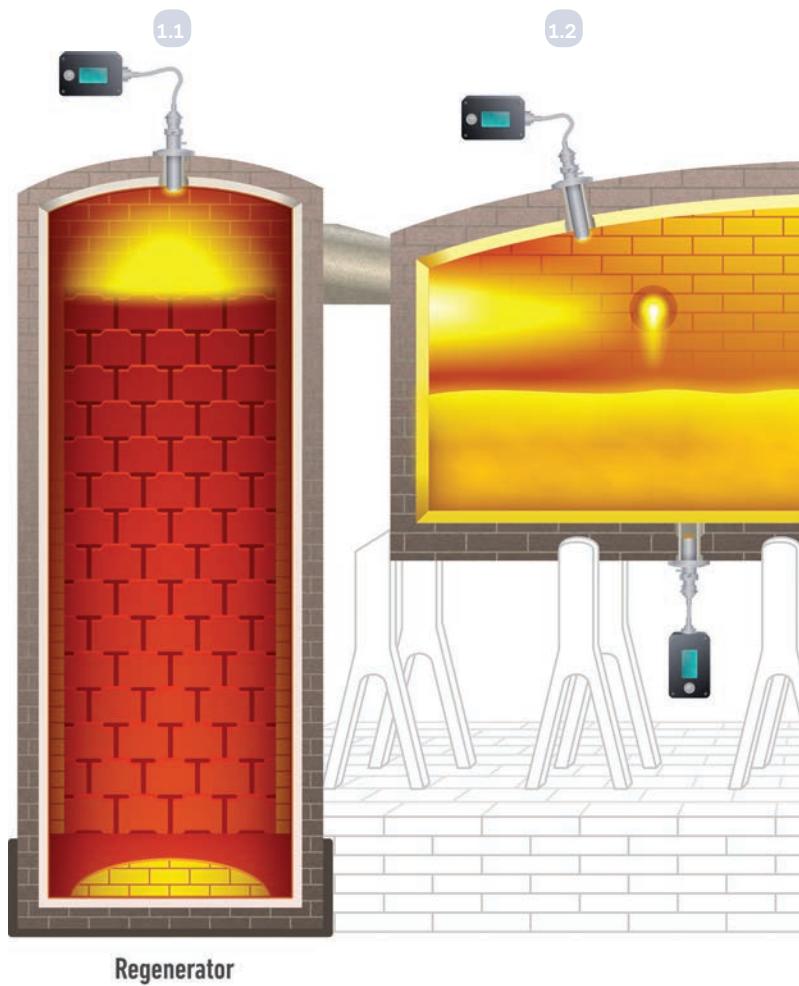
Protecting the expensive regenerator crown refractory using temperature measurement enables operators to maintain efficient and stable operation of the melting tank. Typical thermocouples deteriorate over time and can be unreliable. Infrared pyrometers measure temperature without contact and remain outside high temperature zones, providing long-term stability and reliability.

## Melting Tank

The melting tank is where the process starts with sand, limestone, soda ash, and cullet feed into a furnace for melting.

Because of the high temperatures and corrosive molten glass required for this process, protecting the expensive bottom refractory from excessive temperature is essential for longevity.

Monitoring the temperatures of the bridgewall and port arch can also provide information on the furnace condition.



### PROCESS STAGE

#### 01 Checking the roof temperature

##### Challenges

Ensure the stability of the roof through temperature measurements in this area.

Wear-resistant temperature measuring systems delivering continuous, reliable data.

##### Advanced Energy's solution

Rugged fixed-installation instrument that has a closed ceramic or inconel tube, or with a handheld precision instrument.

##### Customer benefits

Avoiding glass runout due to refractory failure and high costs resulting from loss of production.

##### Roof-mounting

**SOLUTIONS:** Series 50-LO plus pyrometers with closed ceramic or inconel tube



##### Fixed installation pyrometer

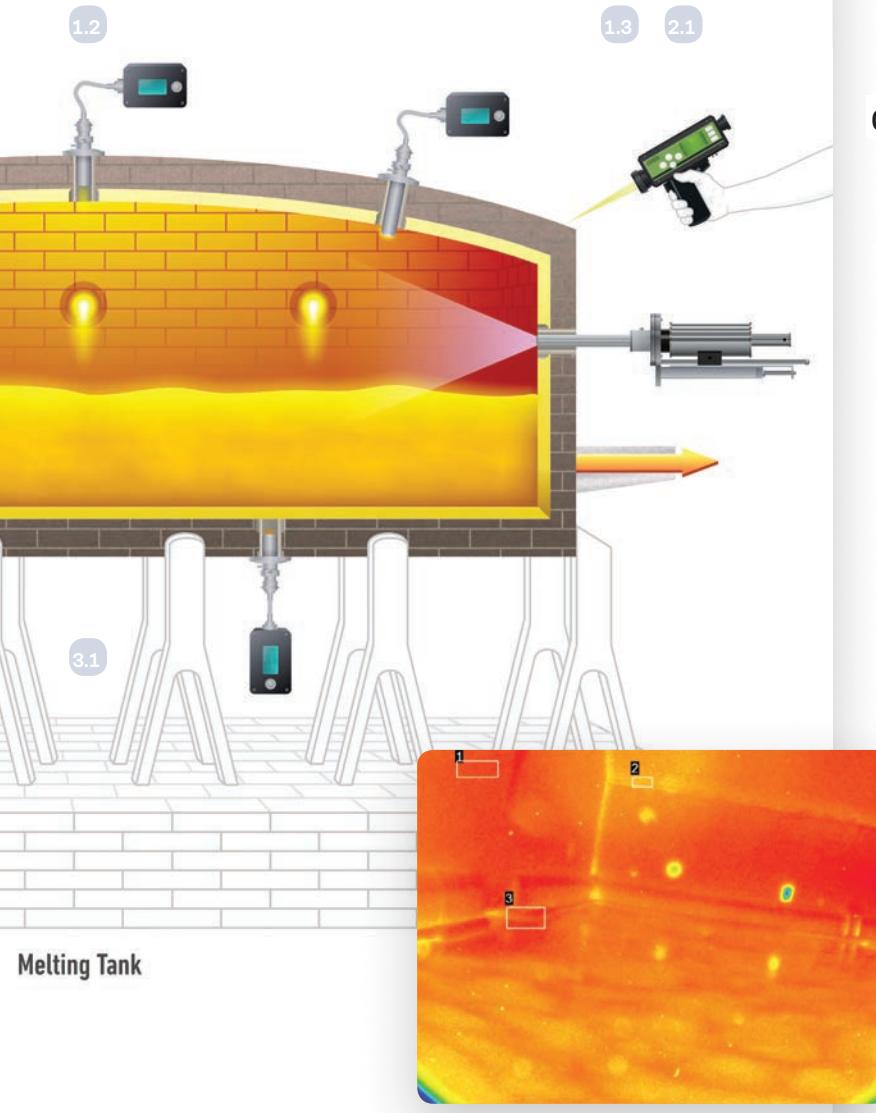
**SOLUTIONS:** Series 50-LO/GL pyrometers with open-ended ceramic or inconel tube



##### Mobile inspection

**SOLUTIONS:** Series 8 pro pyrometers





## SOLUTIONS FOR GLASS APPLICATIONS

### PROCESS STAGE

## 03 Monitoring the tank bottom temperature

#### Challenges

Early detection of elevated temperatures in the bottom area of the melting tank caused by erosion of the refractory lining.

#### Advanced Energy's solution

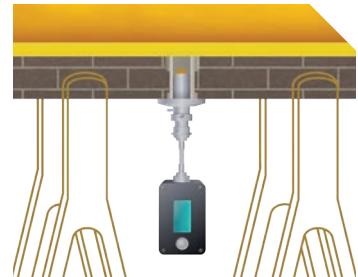
Thermal imager for inspection of the melting tank bottom. By continuously monitoring surface temperature, the condition of the bottom refractory can be calculated and monitored, which enables the prevention of unexpected early failure.

#### Customer benefits

Early detection of wear in insulation materials allows for scheduling of corrective maintenance activities.

Prevention of glass runouts through the tank bottom, resulting in less frequent repairs and expensive stops in production.

**Fixed-installation instruments at multiple locations**  
**SOLUTIONS:** thermal imaging, Series 520 pyrometers



## 02 Monitoring the end-wall temperature

#### Challenges

Continuous measurement of end-wall temperatures for early detection of potential refractory failures.

#### Advanced Energy's solution

Robust handheld instrument with through-the-lens sighting for direct readings, high grade optics for detection of contours, and ultra-small measuring spots.

Alternative: Stationary measurement with IS 50-LO/GL

#### Customer benefits

Flexible inspection capabilities to monitor critical areas and prevent dangerous refractory failures at the end wall.



#### Mobile inspections

**SOLUTIONS:** Series 8 pro pyrometers for end-wall temperature

# Flat Glass

## Tin Bath

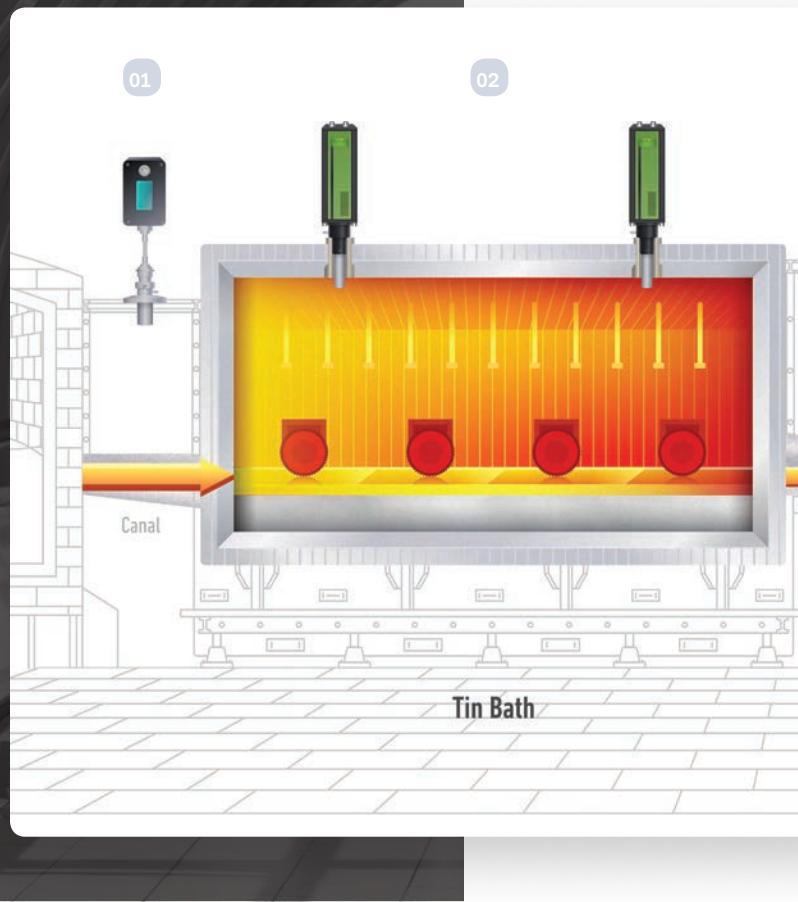
The tin bath is the key component in the modern float glass process. Molten glass from the melting tank enters the tin bath through a canal and floats on top of the molten tin.

Near the entrance of the controlled chamber, the temperature is kept high to allow the molten glass to spread and smooth out. The glass is then allowed to cool in the various heating/cooling zones. Ensuring proper temperature of these cooling zones is essential to maintaining uniformity.

## Annealing Lehr

After the glass ribbon is properly formed, it is moved through the lehr. The lehr allows the glass to cool slowly for annealing. Thermal imagers have the advantage of being able to monitor a larger installation space to obtain optimal performance.

Considerable mechanical stresses may develop in the glass as it cools down. Advanced Energy supplies proven pyrometers and thermal imagers that enable optimum monitoring and control of the cooling rate of flat glass.



### PROCESS STAGE

#### 01 Reviewing the glass temperature in the canal

##### Challenges

Before the molten glass enters the tin bath, the optimum glass transition temperature must be present.

##### Advanced Energy's solution

A monitoring solution with a long fiber optic cable and open-ended ceramic or inconel tube as a radiation shield.

##### Customer benefits

Reliable adjustment of correct starting temperature for the complete down-stream process.

Adjustment of glass flow rate via its viscosity.

Cost reductions through closed-loop temperature control within tight tolerances.

##### SOLUTIONS:

Series 50-LO/GL  
pyrometers with  
open-ended ceramic  
or inconel tube



### PROCESS STAGE

#### 02 Measuring temperature distribution in the heating zone of the tin bath

##### Challenges

Ensure the requisite temperature distribution in the molten glass contained in the tin bath.

##### Advanced Energy's solution

A monitoring solution with an open-ended ceramic or inconel tube to shield the sensor against interfering radiation and to ensure the repeatability of readings.

##### Customer benefits

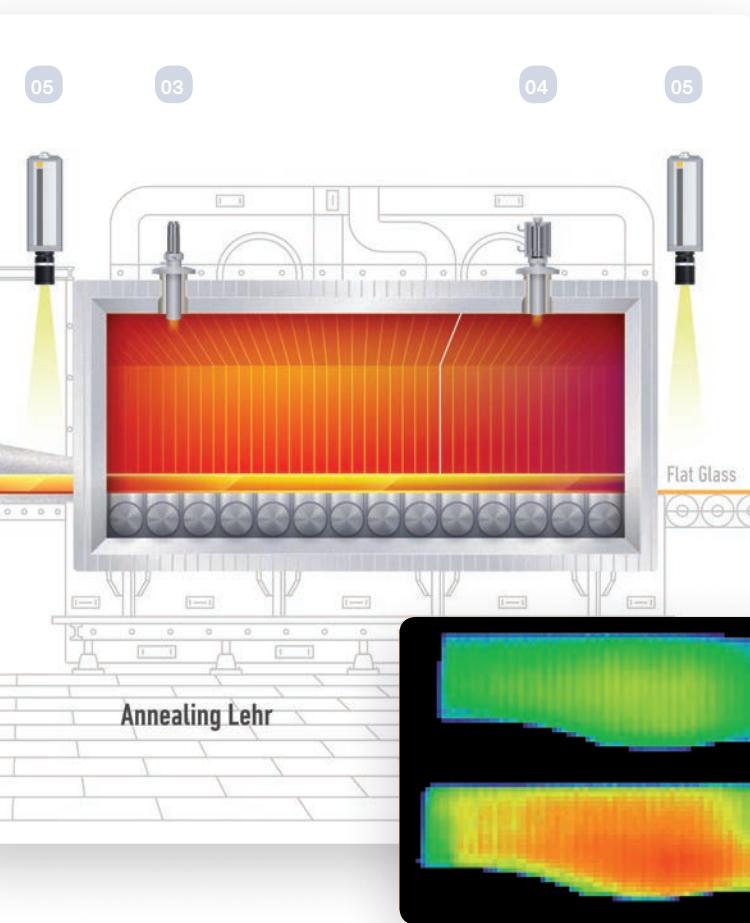
Reliable implementation of correct cooling rates and closed-loop control of heat input.

Cost reductions through optimized use of energy.

##### SOLUTIONS:

IPE 140/39 or  
IN 5/5 plus  
pyrometers





#### PROCESS STAGE

### 03 Measuring surface temperatures in the annealing lehr

#### Challenges

Relieve all mechanical stresses induced in the glass before further processing and packing. Process optimization through closed-loop control of the heating elements in the annealing lehr.

#### Advanced Energy's solution

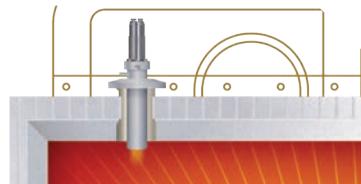
Proven pyrometers with rugged sensors and a flat glass calibration feature tailored to the specific mounting conditions and ambient radiation.

#### Customer benefits

Closed-loop control of heating elements with accurate acquisition of flat glass temperature.

Quality assurance and efficient use of energy.

**SOLUTIONS:** Series 5/5 and 210/5 incl. special flat glass calibration and for ultra-thin glass sheets: IN 6/78-L



## SOLUTIONS FOR GLASS APPLICATIONS

#### PROCESS STAGE

### 05 Measuring the temperature distribution across the flat glass ribbon

#### Challenges

Ensure homogeneous temperature distribution in the ribbon as the flat glass leaves the working tank.

#### Advanced Energy's solution

Thermal imagers for fast and full coverage temperature monitoring across the entire width of the flat glass ribbon.

#### Customer benefits

Rapid visualization of temperature distribution by means of thermal imaging software for easy, manual readjustment of heat input. Automatic alarms when limit values are exceeded.

#### SOLUTIONS:

Thermal imaging

Thermal image of two glass panes



#### PROCESS STAGE

### 04 Monitoring of annealing lehr discharge temperature

#### Challenges

Ensure the requisite glass temperature after the cooling phase.

#### Advanced Energy's solution

A reliable low-temperature pyrometer in a stainless steel protective enclosure. Rugged two-wire system with analog signal transmission.

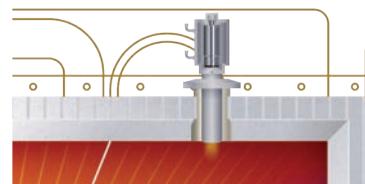
#### Customer benefits

Observance of correct material cooling rate for production of flat glass with few internal stresses.

Prevention of glass breakage due to thermal shock on entry into normal atmosphere.

#### SOLUTIONS:

Series 5/5 incl. special flat glass calibration and protective enclosure



# Container Glass

In the production of container glassware, closely controlled temperatures are key to shaping the glassware and to achieving energy savings. Advanced Energy's pyrometers and thermal imagers facilitate the adjustment of the temperature distribution and closed-loop control of the feeder temperature.



## PROCESS STAGE

## 01 Measuring the temperature distribution in the working tank

**Challenges**

Ensure homogeneous temperature distribution in the molten glass exiting the working tank. Optimum adjustment of the temperature profiles in material flow direction.

**Advanced Energy's solution**

A monitoring solution with an open-ended ceramic or inconel tube to shield the sensor against interfering radiation and to ensure the repeatability of readings.

**Customer benefits**

Reliable implementation of correct cooling rates.

Adjustment of glass flow rate via its viscosity.

Cost reductions through optimized use of energy.

## PROCESS STAGE

## 03 Measuring the gob temperature

**Challenges**

Ensure the desired container wall thickness via the core temperature of the gob.

**Advanced Energy's solution**

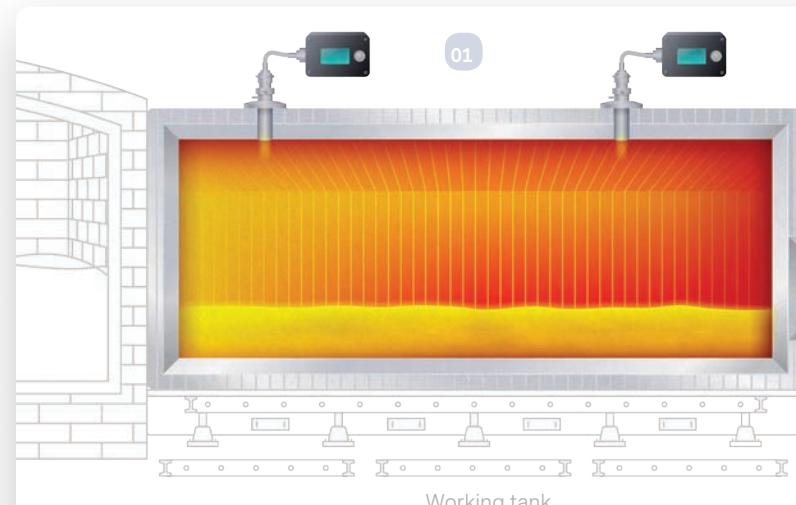
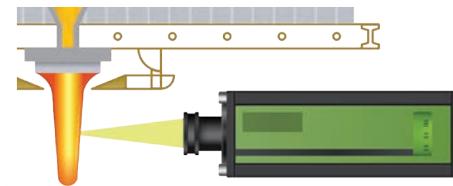
Rapid ratio pyrometer with small measuring spots.

**Customer benefits**

Reliably achieving the correct gob temperature prior to the next step in the process (IS machine).

**SOLUTIONS:**

Series 6  
pyrometer  
including  
protective  
enclosure



## PROCESS STAGE

## 02 Measuring the temperature gradient in the feeder

**Challenges**

Continuous measurement and control of the material flow. Minimized energy costs in the heating process.

**Advanced Energy's solution**

Proven application packages featuring high measuring accuracy, excellent repeatability and long service lives.

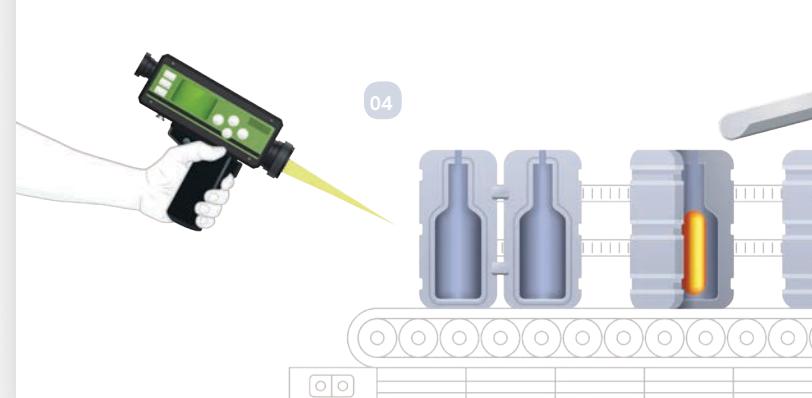
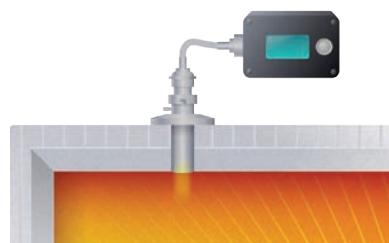
**Customer benefits**

Quick installation thanks to easy and reliable integration of components.

Optimized use of energy and adjustment of glass flow rate.

**SOLUTIONS:**

Series 50-LO/GL  
pyrometer with  
open-ended  
ceramic or inconel  
tube



### PROCESS STAGE

#### 04 Measuring the mold temperature inside the IS machine

##### Challenges

Precise control of the air flow rate used for blowing and adjustment of the temperature distribution in the water-cooled mold. This forms the gob of glass into the desired shape with the requisite wall thickness.

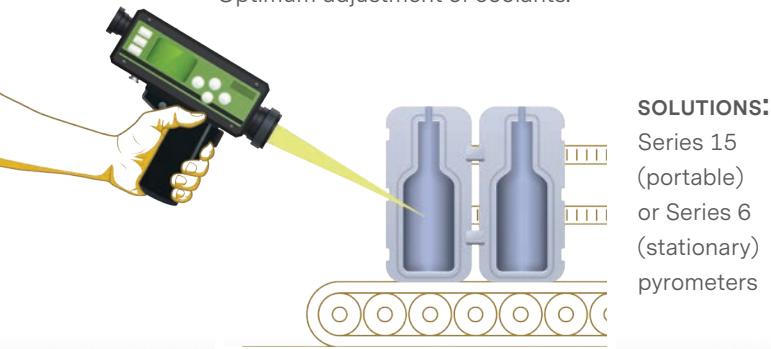
##### Advanced Energy's solution

Portable pyrometer for mobile inspections or fixed installed pyrometer.

##### Customer benefits

Optimum uniformity of container wall thickness.

Optimum adjustment of coolants.



### PROCESS STAGE

#### 05 Final check and control of material distribution

##### Challenges

Save raw materials with a view to optimizing energy efficiency throughout the complete forming process.

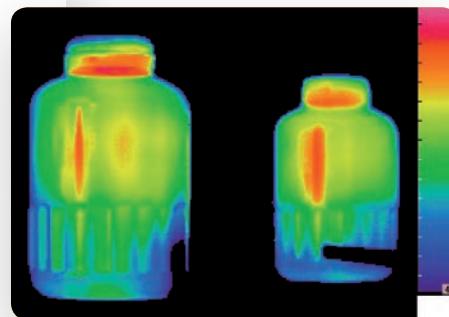
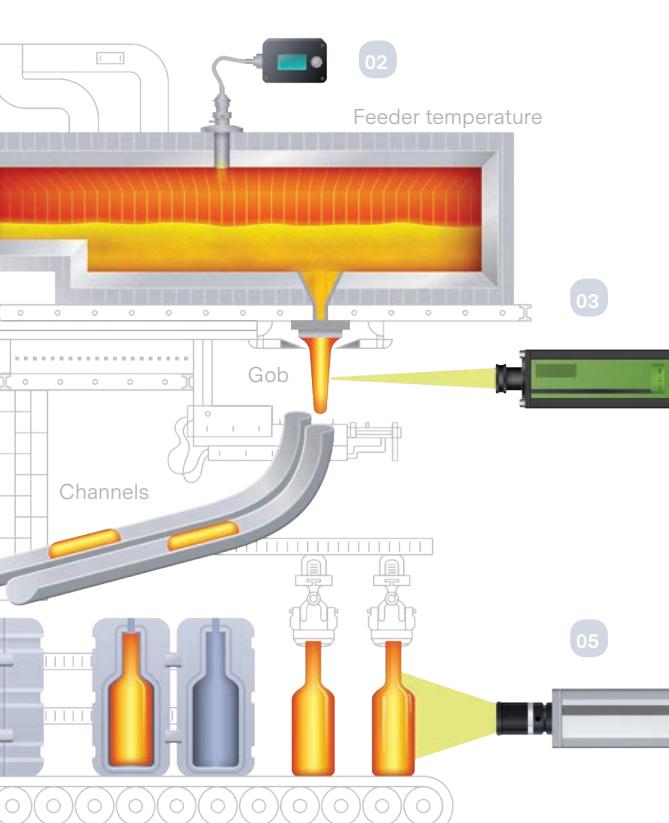
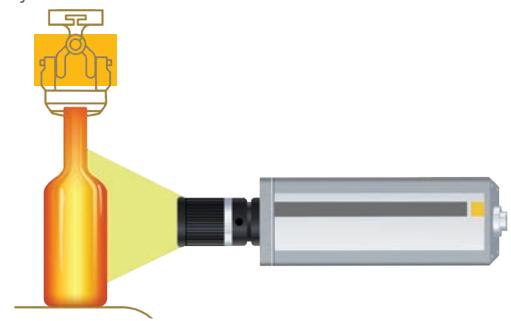
##### Advanced Energy's solution

High resolution thermal imager with a spectral filter for glass surfaces and image processing software for automatic detection of defects.

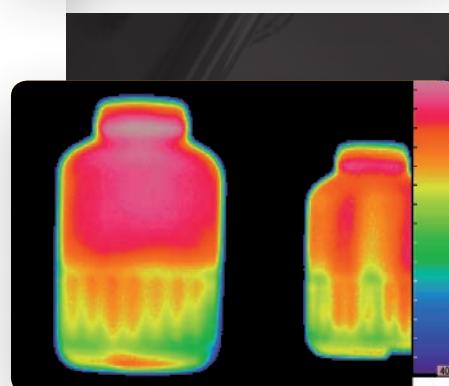
##### Customer benefits

General optimization of molds through visualization of glass wall thicknesses and localization of thin container walls.

Automated mold parameter set-up through optional coupling of the system to the PLC for data correlation.



◀ Thermal image taken without spectral filter for glass surfaces. The interference from resulting ambient reflections causes direct measuring errors.

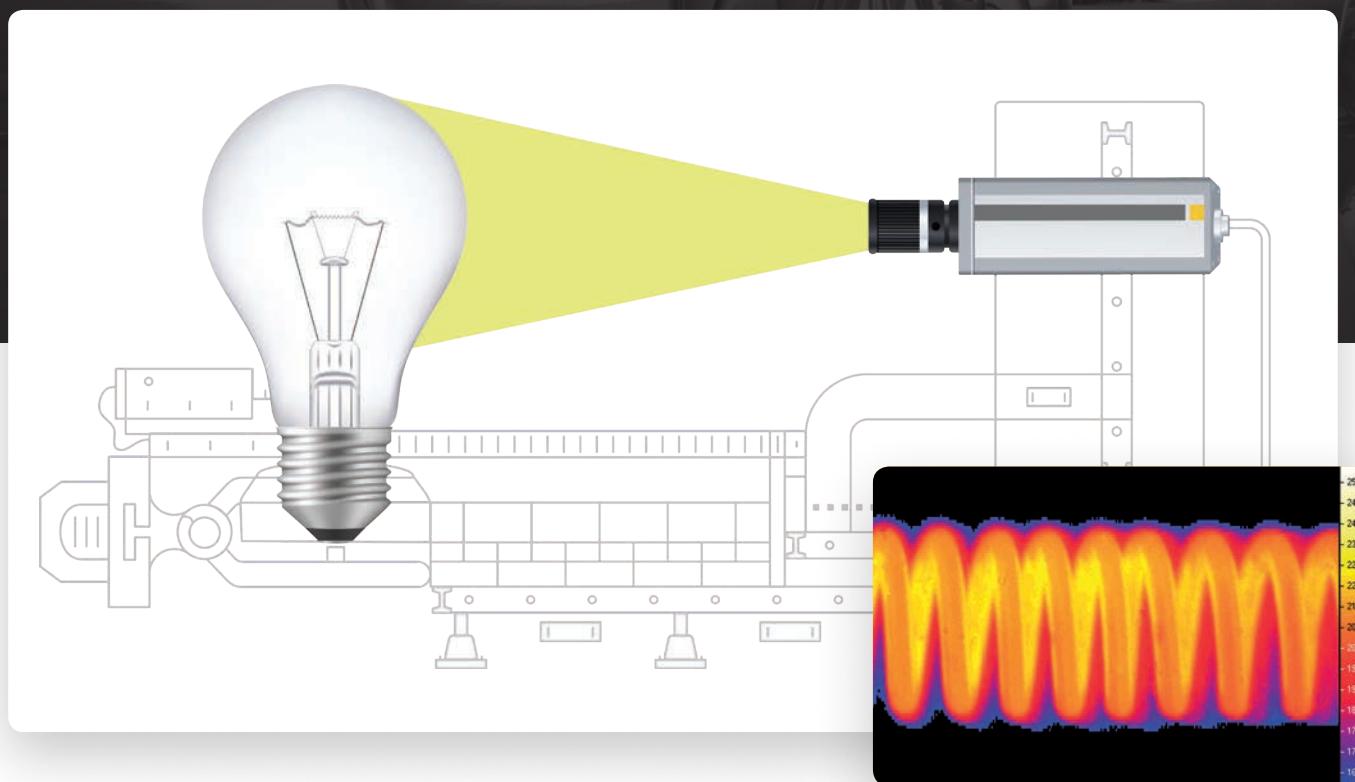


◀ Thermal image taken with spectral filter for glass surfaces at 5  $\mu\text{m}$ . Ambient reflections are filtered out to minimize direct measuring errors.

# Technical Glass

Manufacturing of technical glass is subject to particularly stringent quality requirements. The only way to achieve the desired quality and required service life of the product is to observe very close tolerances with regard to material temperatures throughout the entire process.

Pyrometers and thermal imagers from Advanced Energy are highly accurate temperature sensors and fulfill all prerequisites for successful compliance with quality requirements.



## PROCESS STAGE

### 01 Measuring incandescent coils

#### Challenges

Optimization of temperature distribution in the incandescent coil.

#### Advanced Energy's solution

A fixed-installation thermal imaging system designed to measure very high temperatures on metals.

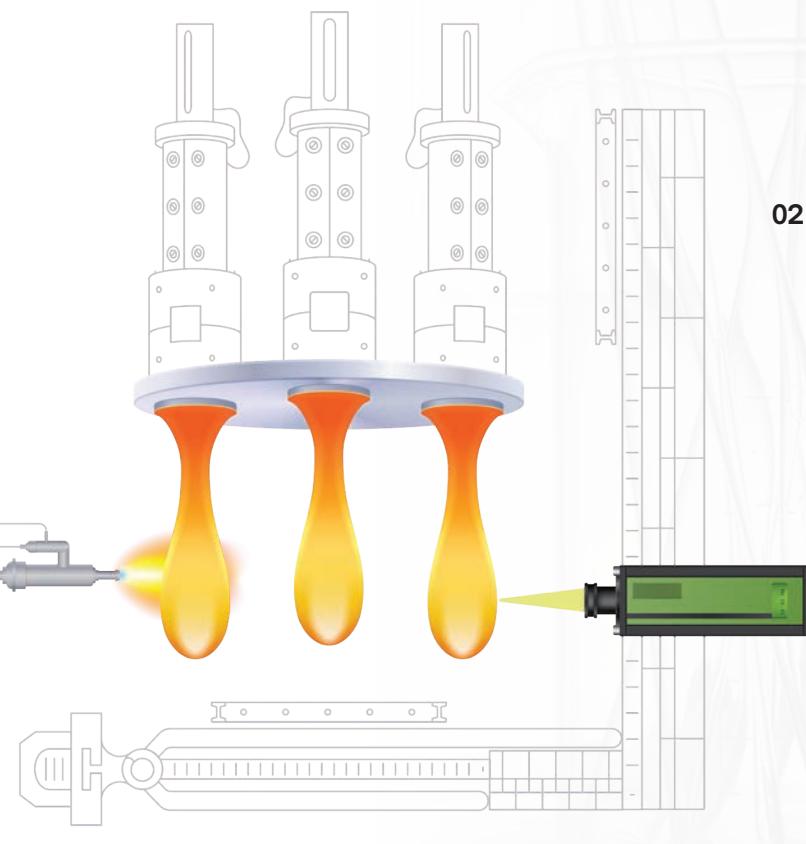
Real-time thermal imagery of temperature distribution and comprehensive data analysis and reporting features.

#### Customer benefits

Precise temperature measurements during the development phases of lamps and luminaires enable optimization of material properties and performance parameters.

This helps to considerably improve the service life of series production articles.

**SOLUTIONS:** Thermal imaging



PROCESS STAGE

## 02 Rotary blow-molding machine

### Challenges

Detection of the glass mold temperature to ensure optimum shaping of the hollow glass body.

### Advanced Energy's solution

Measurement of the glass mold temperature while the mold is open.

### Customer benefits

Direct monitoring of the glass mold temperature and thus an exact control of the wall thickness of the glass body.

The main advantage of monitoring the mold temperature is ensuring a constant shape of the glass item.

**SOLUTIONS:** Series 140, IGAR 320, and IGAR 6 Advanced pyrometers

PROCESS STAGE

## 03 Measuring the temperature of glass dishes before entering the cooling lehr

### Challenges

The temperature of the dishes must be measured to guarantee the desired material properties.

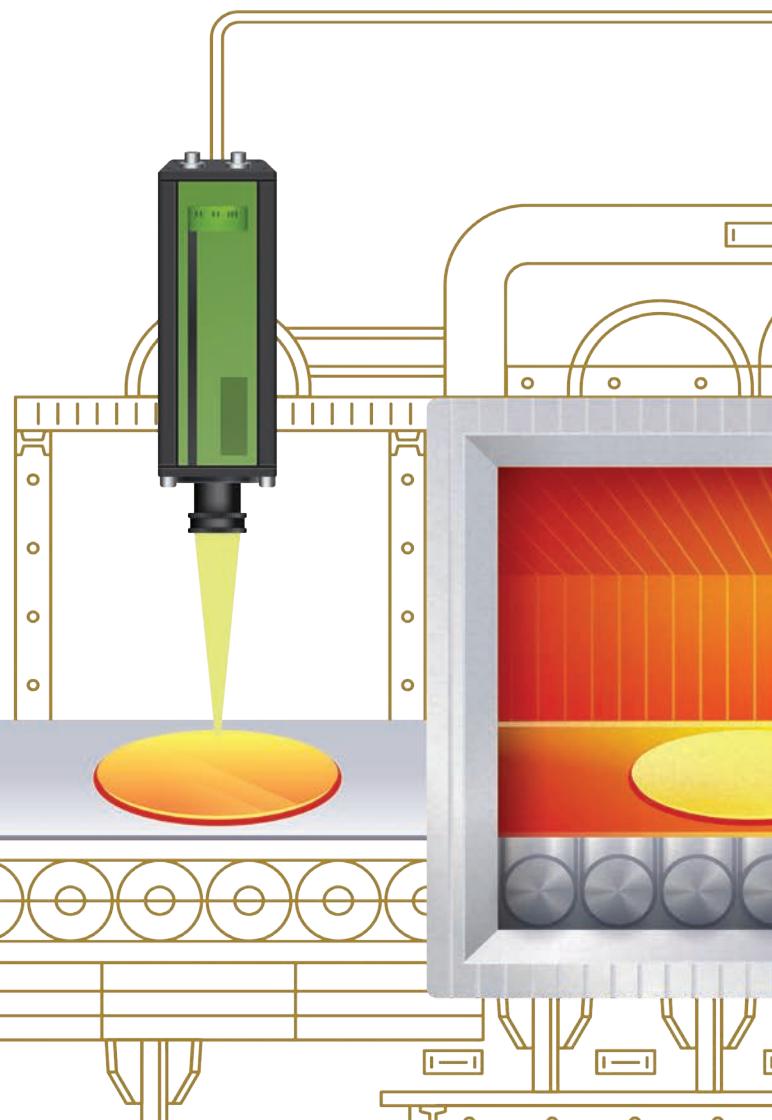
### Advanced Energy's solution

Pyrometers for rapid data acquisition with small measuring spots and reliable data transfer. The use of a fast measuring instrument allows for scanning of a large number of measuring points on the dish as it passes on the conveyor.

### Customer benefits

Optimized use of energy in the forming process and monitoring of dish temperatures.

**SOLUTIONS:** Series 140 pyrometers



## SOLUTIONS FOR GLASS APPLICATIONS

Our product lines include virtually hundreds of different non-contact temperature measuring instruments to suit nearly every industrial application. Using our comprehensive experience in this field, we have developed a wide range of high-end products specifically for the glass industry.

### GLASS INDUSTRY SOLUTIONS

# PYROMETERS

When you install our infrared detection instruments, you are investing in proven experience, superior performance, and trusted quality.

### IN 5/5, IPE 140/39 & IN 140/5

**Compact, highly accurate, fast digital pyrometers with variable focusing optics and integrated display.**

The IN 5/5, IPE 140/39, & IN 140/5 are suitable for measuring the glass surface at the Tin float tank to control viscosity and temperature. The IN 140/5 and IN 5/5 can also be used in the Lehr bath and in the bending and heat treatment processes. The IPE 140/39 and IN 140/5 instruments features superior focusable optics while the IN 5/5 is an economical pyrometer with fixed optics.



### IN 6/78

**Robust digital pyrometer designed for non-contact temperature measurement of the thinnest glass surfaces.**

The IN 6/78 pyrometer uses a special 7.8 µm wavelength for non-contact temperature measurements on the thinnest (below 1 mm thickness) of glass surfaces accurately and reliably. The IN 6/78 also uses specially designed and coated high-end optics, which reduce the effects of ambient reflectance and guarantee the best possible accuracy.



### Series 8

**Rugged, high-end handheld units for medium to high temperatures**



### Series 520

**Digital infrared pyrometers with temperature-resistant miniature sensor head (for up to 180°C)**



### Series 15

**Portable, cost effective pyrometers for measuring tasks involving low to medium temperatures**



### Series 12

**Extremely rugged industrial pyrometer for fixed installation in harsh environments**



### Series 50-LO plus & IS 50-LO/GL

**Digital infrared thermometer with fiber optic cable for industrial use.**

The IS 50-LO/GL is designed for temperature measurement of bulk melt glass in the melt tank, working end, forehearth, and feeder. Series 50-LO plus instruments are also useful for the measurement of brickworks in the regenerator and melt tank. Using a robust fiber optic cable enables the use of the instrument in an ambient temperature up to 250°C without cooling.



# THERMAL IMAGING

Automated, continuous thermal and visual imaging to identify thermal abnormalities within industrial and petrochemical pipelines.



## FurnaceSpection

Thermal imaging system designed for continuous monitoring inside a furnace.

FurnaceSpection is designed to continuously monitor through natural flames, the temperature of the liquid glass and refractory inside the melt tank. This system helps operators monitor and control process temperature uniformity through streaming images and powerful software for analysis and historical trending.

## MC320 Series Thermal Imaging Camera

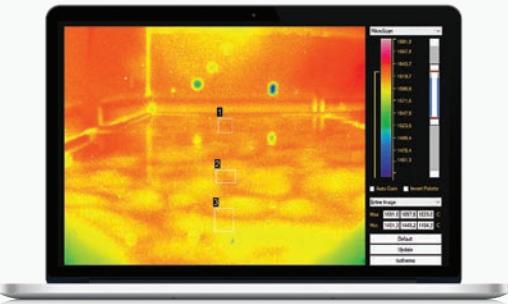
Thermal imagers for fixed-installation cameras for process quality monitoring.

- Temperature ranges between 150 and 1600°C
- Application-specific wavelength 3 to 5 µm, 3.9 µm, or 5 µm
- 9 to 60 frames per second, depending on the model
- User-friendly analysis programs and report generators (offline) as well as analysis and process control (online)



## LumaSpec RT

Windows-based thermal imaging software that offers high-speed, real-time data acquisition and image analysis capabilities.



## MC640 Series Thermal Imaging Camera

Thermal imagers for fixed-installation cameras for process quality monitoring.

- Temperature ranges between 600 and 3000°C
- Application-specific wavelength of 0.85 µm
- 60 frames per second
- User-friendly analysis programs and report generators (offline) as well as analysis and process control (online)



## ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

AE's power solutions enable customer innovation in complex semiconductor and industrial thin film plasma manufacturing processes, demanding high and low voltage applications, and temperature-critical thermal processes.

With deep applications know-how and responsive service and support across the globe, AE builds collaborative partnerships to meet rapid technological developments, propel growth for its customers and power the future of technology.



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PRECISION | POWER | PERFORMANCE

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