Asphalt Temperature Measurement in Road Laying

using the PyroCouple infrared temperature sensor

The PyroCouple Series of infrared temperature sensors is ideal for measuring the temperature of the road surface before and after tarmac is laid.

Tarmac must be compacted while it is still hot to ensure a minimum of air voids for maximum density and strength. If tarmac is too cold when it is laid, then it cannot be fully compacted, resulting in a weak road surface.

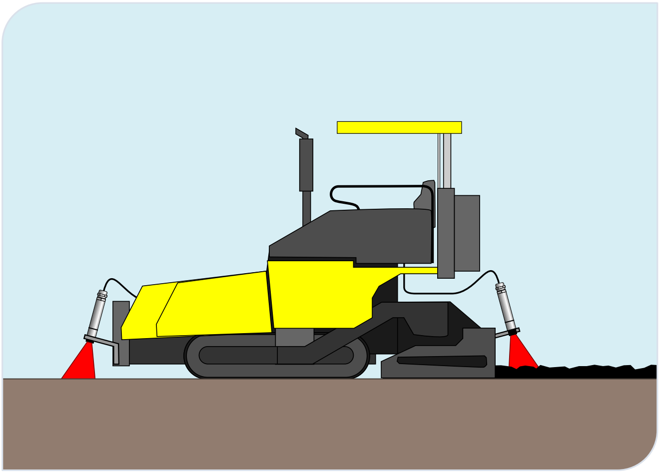
Monitoring the temperature of the surface with a sensor on the paver vehicle after laying the tarmac helps ensure that the temperature is high enough.

The temperature of the road surface is also monitored before the tarmac is laid. This helps predict how much time will be available to compact the surface before it has cooled, and ensure the tarmac in the vehicle is hot enough.

If there is metalwork on the vehicle that could obstruct the sensor's vision, relatively narrow optics should be chosen so that only the road surface is being measured. A sensor with 15:1 optics usually provide a narrow enough field of view at a low cost.

As the tarmac is laid its temperature is typically between 95°C and 190°C, and the minimum rolling temperature is usually above 75°C.

These optical and temperature considerations mean PyroCouple model PC151MT-0 is usually best suited to this application. It has a 4-20 mA output that can be fed into existing instrumentation, or Calex can provide a simple, low-cost indicator.



Two model PC151MT-0 sensors are mounted on the paver and aimed at the road surface, before and after laying the tarmac. A sensor can also be placed on the roller to monitor the tarmac temperature immediately before it is compacted.

PyroCouple sensor, model PC151MT-0

PyroCouple with air purge collar, model APSN

APPLICATION TIPS

The emissivity of road surface materials is typically very high so it is easy to get good results with a fixed-emissivity sensor. This is also true when measuring the surface temperature of a bond or tack coat.

Calex sensors are designed to be used indoors, so as this is an outdoor application the sensors should be sheltered from the weather and from being heated by direct sunlight. They may be used where ambient temperatures are between 0°C and 70°C.

In this application, there is the possibility for condensation and dirt to settle on the lens and, as with any infrared temperature sensor, this could affect the reading. If this becomes an issue, then an air purge collar may be added to help keep the lens clean and dry.

SIMILAR APPLICATIONS

If tarmac is kept at too high a temperature, and for too long, the ability of the bitumen to bind the mixture will degrade. It is important to monitor temperatures for each course of bituminous mixture, at all stages from mixing to compacting. Temperatures may be checked with a handheld infrared thermometer or continuously monitored with a low-cost fixed sensor.

Infrared sensors are also used to measure the temperature of the asphalt stream as it is poured from a mixer into a vehicle, to ensure it will still be hot enough by the time it is laid. A PyroMini sensor with narrow optics may be used; the data logging features of the PyroMini provide traceability.

Infrared Temperature Measurement in Paint Curing

with PyroCouple and PyroMini infrared temperature sensors

In the painting of products such as automobile body panels, long term durability and consumer appeal depend upon the quality of the coating application processes. This quality, determined by adhesion, hardness, corrosion resistance, finish and colour, depends largely upon curing temperature cycles. Calex's non-contact infrared temperature sensors are capable of giving the user or OEM tight control over this cycle, where none existed before.

The automotive painting process generally consists of the application and curing of one or two primer coatings, and another one or two of paint. Both infrared radiant and convection heated ovens are employed to "ramp" the temperature up at a controlled rate, and "soak" (hold the temperature) for a time predetermined to be optimum for proper curing of each part of the coating. Portable IR heaters are also used to cure re-painted areas (pictured right).

Prior to the installation of the IR temperature sensors, indirect measurement methods were used. One consisted of monitoring air temperature in the oven to infer the surface temperature, which was inaccurate, especially in radiant heat sections. Another was a time-consuming, offline spot check, consisting of running a special thermocouple-equipped scrap car body through the ovens on a periodic basis.

The Calex sensors allowed direct, accurate, on-line measurement of the surface temperature. The infrared sensor also allowed separate controls to be introduced for top and side heating. This was valuable, due to the differing thermal masses and therefore heating rates of the automobile roof and sides.

Two important facts emerged during the jobs:
1. Emissivities of different colours of paint did not vary more than 1%. A setting of 0.95 was used.
2. Peak hold and valley hold functions could be used to eliminate the effects of looking at heaters or oven walls in between car bodies.

Certain automobile manufacturers were quick to realise that the value the IR sensors provide, in the form of reduced painting rework, improved adhesion, more consistent colour and greater overall process control and quality, would allow for rapid return-on-investment. An improvement in their competitiveness in the automobile market has resulted.

SUITABLE MODELS

Due to the high emissivity of painted surfaces, the low-cost PyroCouple series of sensors gives good results. They can be positioned in gaps between infrared heaters, and provide an analogue 4-20 mA, millivolt or thermocouple output for measured temperature. They may be used without cooling in areas where the ambient temperature is below 70°C.

The sensing head of PyroMini -HA models may be positioned where the ambient temperature can be up to 180°C, for example inside convection ovens. No cooling is required. The PyroMini is available with analogue or digital outputs, and the optional touch screen interface provides temperature display, alarm relay outputs and data logging to MicroSD Card.

The accurate non-contact temperature measurement ability of these sensors is equally applicable to all other coating and painting applications.

For more information or assistance, please contact Calex.

CALEX
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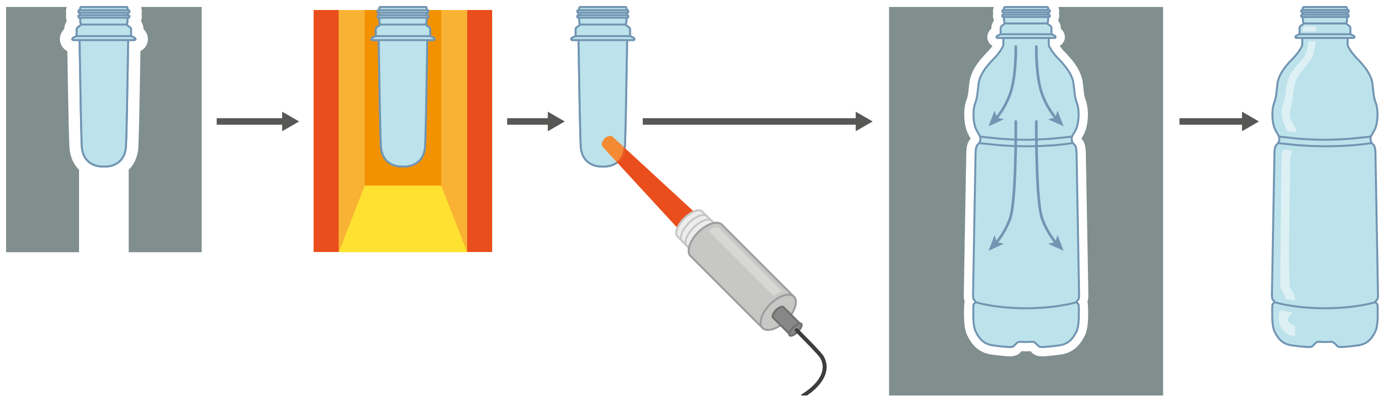
Blow moulding

Preform temperature measurement using non-contact pyrometers

Infrared temperature sensors are helping to provide consistent product quality in the high-speed process of injection blow moulding.



PROCESS OVERVIEW

Blow-moulded objects, such as plastic bottles and similar containers, start as an injection moulded preform (or parison), usually made of poly(ethylene terephthalate) (PET).

In the one-stage stretch blow moulding (SBM) process, the preforms are blow-moulded quickly after forming while they are above their glass transition temperature (typically about 75°C to 85°C).

In the two-stage SBM process the preforms are cooled and stored, before being reheated by an infrared oven just before being blow-moulded.

In both the one-stage and two-stage processes, the preform temperature is measured with a non-contact infrared sensor before it is inflated to its final shape inside the mould cavity.

The temperature measurement is used to help control the infrared oven, optimise the speed of the process, and ensure repeatable product quality.

ACCURATE MEASUREMENTS

Infrared temperature sensors measure the average temperature within a spot whose size depends on the measurement distance and the sensor's field of view. Preforms have a slender shape that requires a sensor with narrow, focused optics to ensure that only the temperature of the plastic is captured, and not the background. The sensor is positioned at its focal distance to achieve the smallest possible measured spot size.

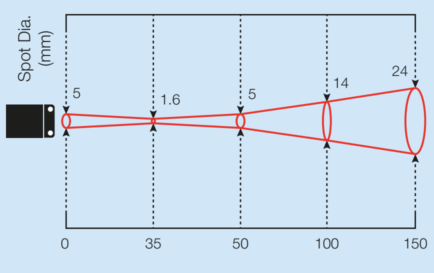
SUGGESTED MODELS

A choice of general-purpose infrared temperature sensors is available, offering increasingly fast response times:

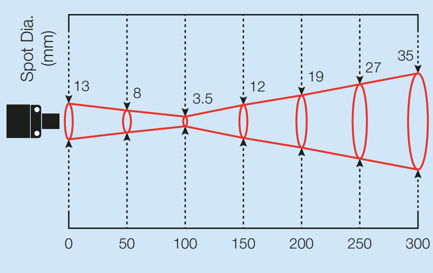
Fast

PyroMiniBus model PMBXCF measures a small spot, 3.5 mm in diameter, at a distance of 50 mm from the lens of the sensor. This sensor withstands ambient temperatures of up to 120°C and has a response time of 125 ms.

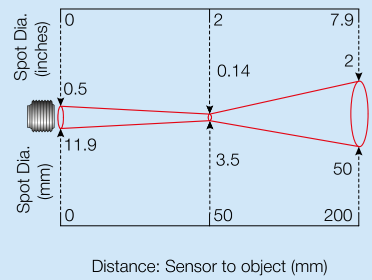
PyroMiniBus sensors communicate digitally via RS485 Modbus RTU. They can be used with an optional Calex touch screen interface, and/or with any third-party Modbus Master. Multiple sensors are connected to the same network to simplify installations and reduce the cost of cabling.



PCU-S1.6



PCU-F3.5



PMBXCF

Faster

For fast-moving production lines where a 125 ms response is not fast enough, the PyroCube is the solution.

PyroCube S model PCU-S1.6 has a response time of 10 ms. It measures an even smaller spot, 1.6 mm in diameter, at a distance of 35 mm. If close access is difficult and the sensor must be positioned further away, a range of alternative models are available to measure larger areas at longer distances. The PyroCube may be used in ambient temperatures of up to 50°C, or higher if used with an optional cooling jacket.

An optional touchscreen display and configuration interface is available, or the sensor can be connected directly to a PLC or PID controller via its analogue output.

The PyroCube offers the added advantage of a built-in focused LED light showing the exact position and size of the measurement area for certain and convenient aiming. All PyroCube models have this as standard.

Fastest

The fastest response times can be achieved with the PyroCube F series. This sensor has a lightning-fast response time of 1 millisecond, making it possible to accurately measure the temperature of every individual preform as it moves past the sensor, such as on one-stage rotary blow-moulding machines.

If the preform moves longitudinally in front of the sensor, it is possible to measure a linear temperature profile, ensuring the correct heat distribution in the preheat stage for optimum inflation and even thickness distribution.

The PyroCube F has all the advantages of the PyroCube, including the aiming light and optional touch screen interface, and a similar choice of optics.

Our engineers and distributors are available for more information and technical assistance.

CALEX
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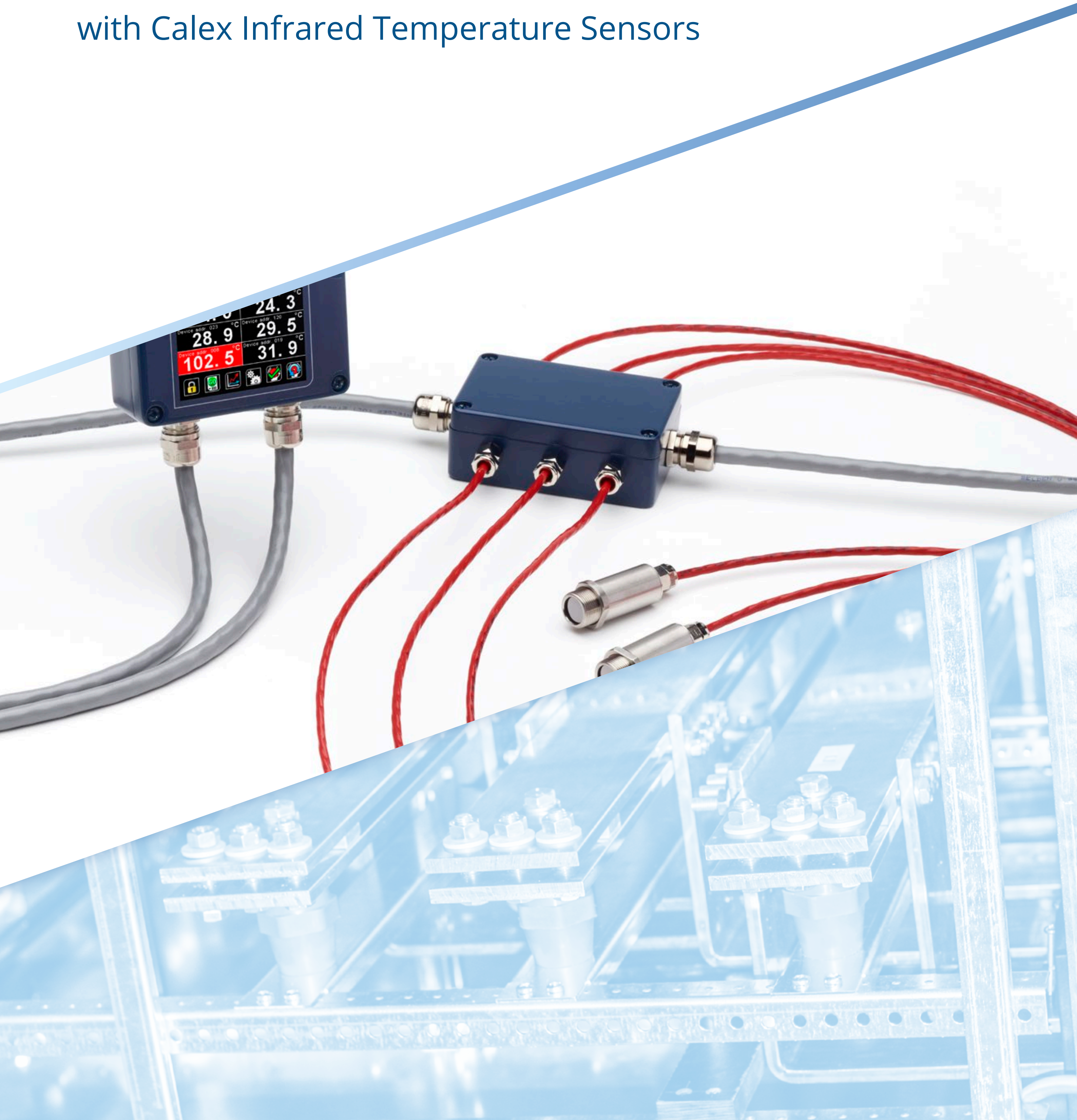
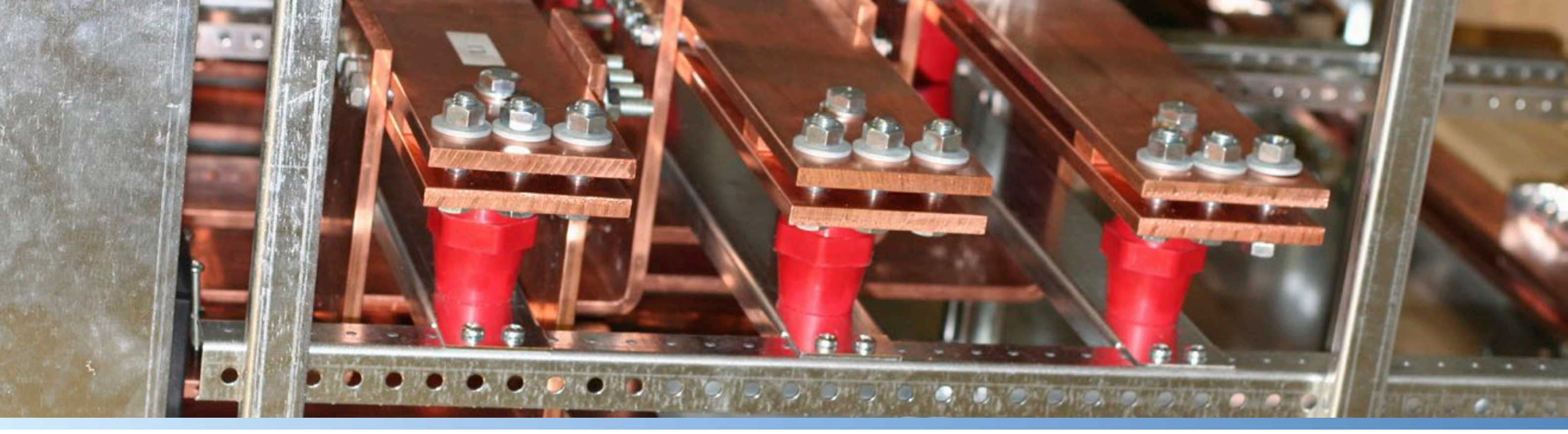
Busbar Temperature Monitoring in Switchgear Cabinets

with Calex Infrared Temperature Sensors



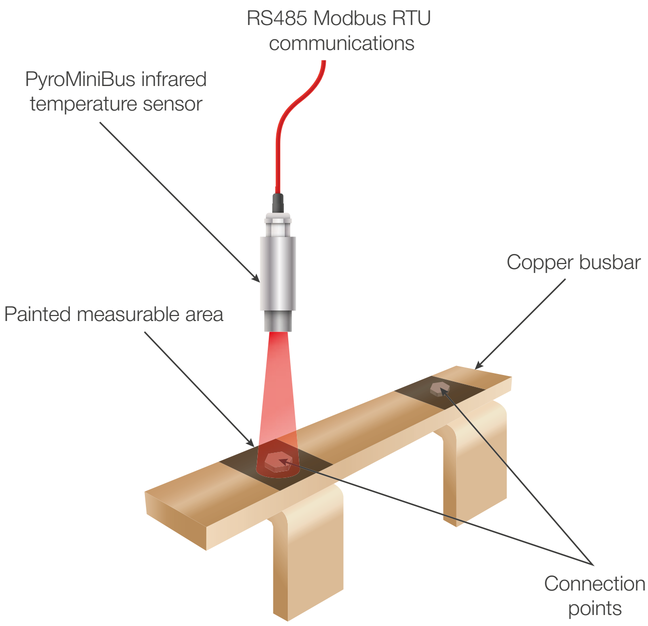


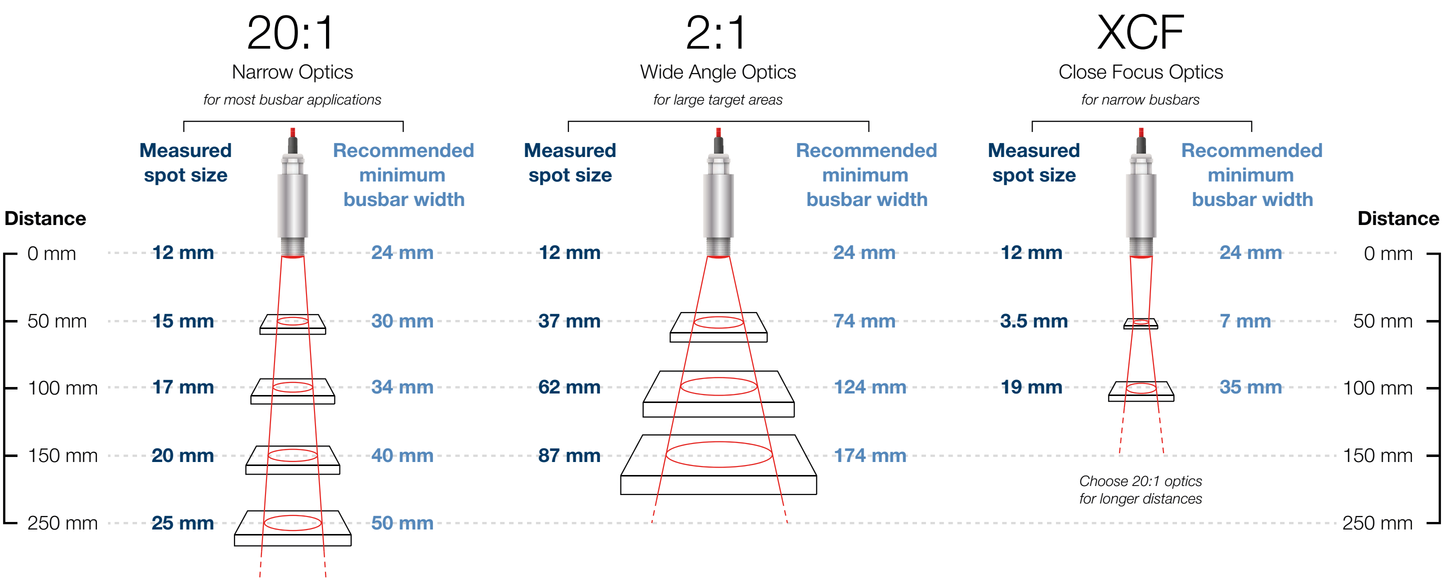
The temperature of electrical connections in power distribution systems is an important indicator of their condition. As connections degrade and fail, their resistance increases and their temperature can rise, causing further damage and a potential fire or explosion risk.

Most large industrial sites have a room containing the electrical switchgear, transformers and panels that distribute electricity around the site. Faults in this equipment can develop gradually over a long period of time, or very quickly in case of the sudden failure of a component. To prevent costly downtime and help plan preventative maintenance, it is crucial that temperatures are continuously monitored.

Calex non-contact infrared temperature sensors, in conjunction with a centralised monitoring system, are an ideal way of measuring these temperatures. They provide an accurate, instant reading of the surface temperature of the conductor, while remaining physically isolated from the voltage it carries.

The PyroMiniBus sensor is ideal for switchgear applications where the available space for mounting the sensor is limited. It withstands ambient temperatures up to 120°C, and can measure object temperatures from -20°C to 1000°C.





Measuring the Temperature

Inside the switchgear cabinets, power is transferred by copper busbars that are bolted together at connections. This is the area most susceptible to failure.

The first symptom of deterioration is an increase in joint temperature, which can be detected quickly by continuously monitoring the temperature of each joint using low-cost IR temperature sensors mounted permanently inside the switchgear cubicles. The surface of the busbar should be painted, coated or shrinkwrapped at the measurement location to make it non-reflective. This makes it extremely easy to achieve accurate temperature measurements.

The sensor is positioned at a safe distance from the busbar to avoid the risk of an electric arc, and will measure the surface temperature within a small spot. The size of the measured spot depends on the chosen optics and the measurement distance.

At short distances, the wide-angle 2:1 optics may be best suited; for higher voltages, narrower 20:1 optics allow a much longer measurement distance to be used for a given busbar width. Focused optics are available for measuring narrow busbars, or for measuring thicker busbars edge-on.

Temperature Monitoring Systems

General-purpose PyroMiniBus sensors and local displays provide temperature measurement and display functionality. They can be incorporated into a switchgear temperature monitoring, alarm and data logging system.

Sensors

PyroMiniBus sensors have RS485 Modbus RTU communications, and can be connected directly to a Modbus Master, or optional local displays. The sensor body is made of 316 stainless steel to maximise shielding from electromagnetic interference.

Local displays

With optional PM180 6-channel touch screen terminals positioned close to the sensors, maintenance engineers can quickly and easily locate the high temperature reading.

The PM180 provides local temperature display, sensor configuration, data logging to MicroSD Card, and on-screen alarm indication. Alarm outputs are available locally via a connected module. The PM180 may in turn be networked with PM180 units in other switchgear cabinets.

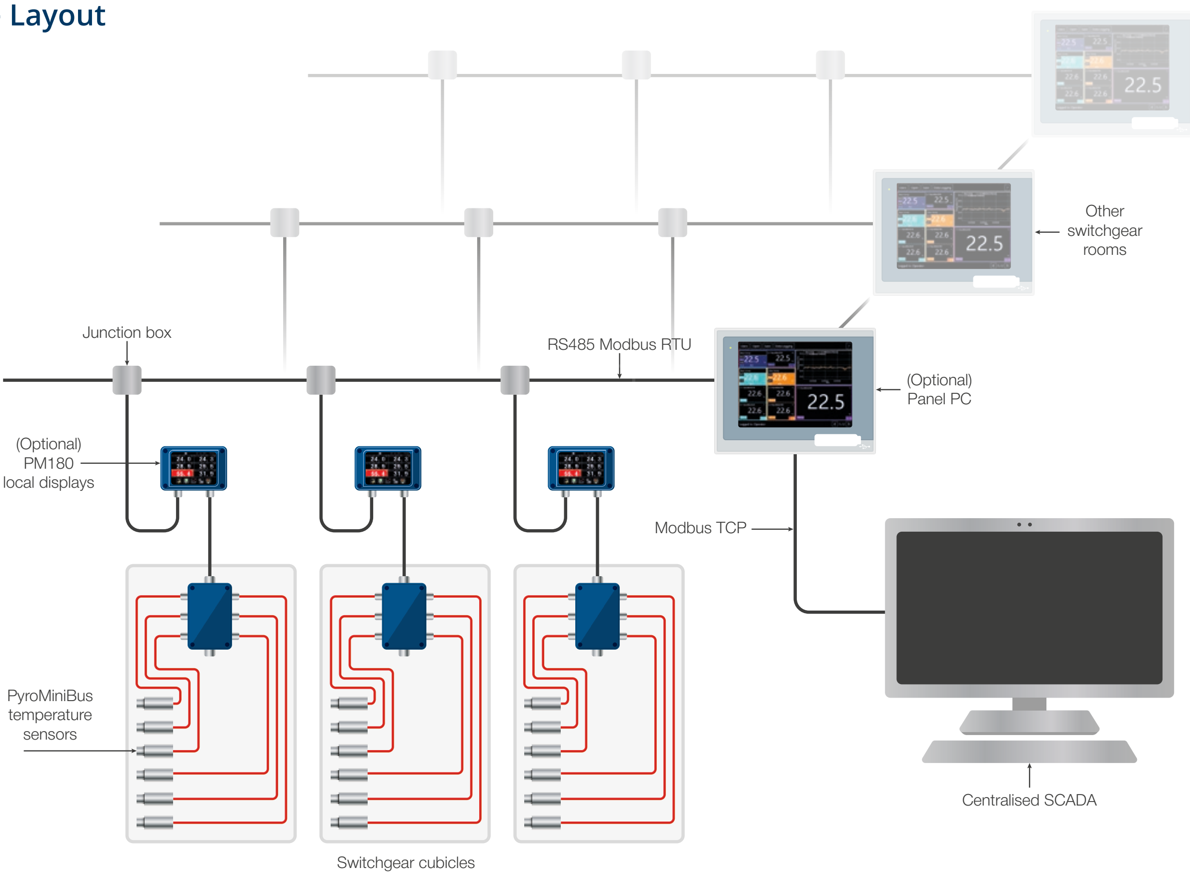
Measuring Many Locations

Optional Calex Panel PCs, with Windows Embedded, are capable of running software to display temperature data from multiple PM180 sub-networks, or from groups of sensors connected directly. Each panel PC can display temperatures from all the sensors in a switchgear room, and the panel PC's Ethernet interface allows real-time access to the data.

Centralised SCADA

Sensors, PM180 units and Panel PCs can be connected to an external Supervisory Control and Data Acquisition (SCADA) system, or a Building Management System (BMS). It is possible for an entire power distribution network to be monitored centrally using third-party software.

Example Layout



Measurement Angle

When measuring painted surfaces, the angle of the sensor relative to the surface does not usually affect the measurement accuracy. This is because non-reflective surfaces emit infrared radiation relatively evenly at a wide range of angles.

Please note: when measuring at a 90-degree angle, the measured spot is circular, and at lower angles it is elliptical.

Alternative Sensors

Sensors with other output types, and sensors for ambient temperatures up to 180°C, are also available. Contact Calex to see how we can help you choose a sensor for your application.

Temperature Monitoring in Flour Milling

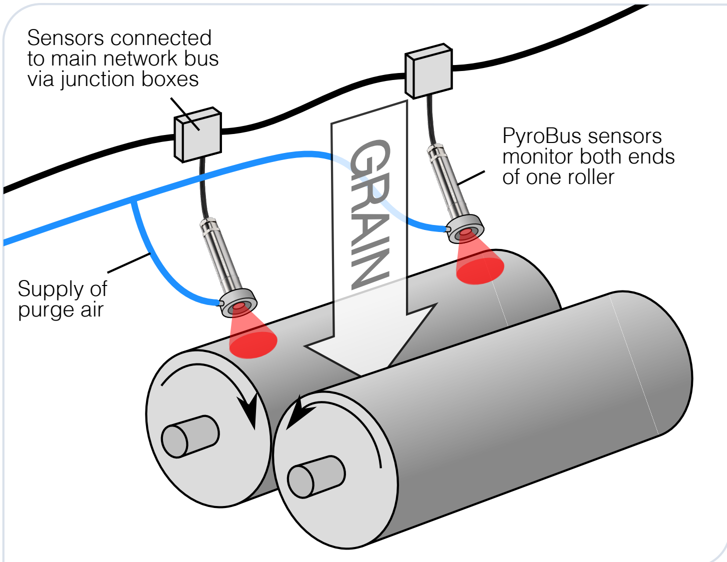
with the PyroBus Infrared Temperature Sensor

Calex has designed a temperature monitoring and alarming system for a leading flour milling company to help prevent fires and explosions.

Grain passes through a series of pairs of rollers that grind it progressively more finely into flour. The rollers are finely adjusted to an optimum separation; if they are too close together, excessive heat is generated by friction, which if left unchecked, can cause the roller temperature to become critically high. The highly combustible flour dust can then ignite, causing a fire or a devastating explosion. As well as the safety risk, this can lead to costly downtime.

Calex has worked closely with this customer to specify a system of 120 PyroBus infrared temperature sensors, with two sensors monitoring each of the 60 machines in the milling room. All 120 pyrometers are connected via an RS485 network to a PC, which provides temperature indication, alarming and data logging.

The system was selected for the customer's safety programme as part of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).



Two PyroBus sensors (model PB21) are aimed at the milling surface of one roller in each machine. Monitoring both ends of the roller helps ensure a hazardous temperature at only one end is properly caught.

The sensors are connected in four groups of thirty, in a daisy-chain arrangement using junction boxes. Each group of sensors has its own power supply and is connected to an isolated RS485 repeater, so a power fault or surge in one group will not affect the rest of the network. All four groups are connected to a PC via an RS485/RS232 converter.

Four alarm relay output modules are provided, one for each group of sensors. Each module provides four alarm relay outputs: audible and visible alarms for both warning and critical alarm temperature levels. One module has a single relay output that is triggered by any alarm; this may be connected to a control room beacon and/or a text-message notification system.

Bespoke CalexSCADA software is installed on the PC. This software reads from every sensor, controls the alarm outputs and displays all 120 measured temperatures simultaneously.

The user can click a temperature reading to view a pop-up window displaying detailed information on each pair of sensors and temperature history graphs.

The software also logs measured temperature, sensor temperature and alarm state at 5-minute intervals to the PC hard disk.

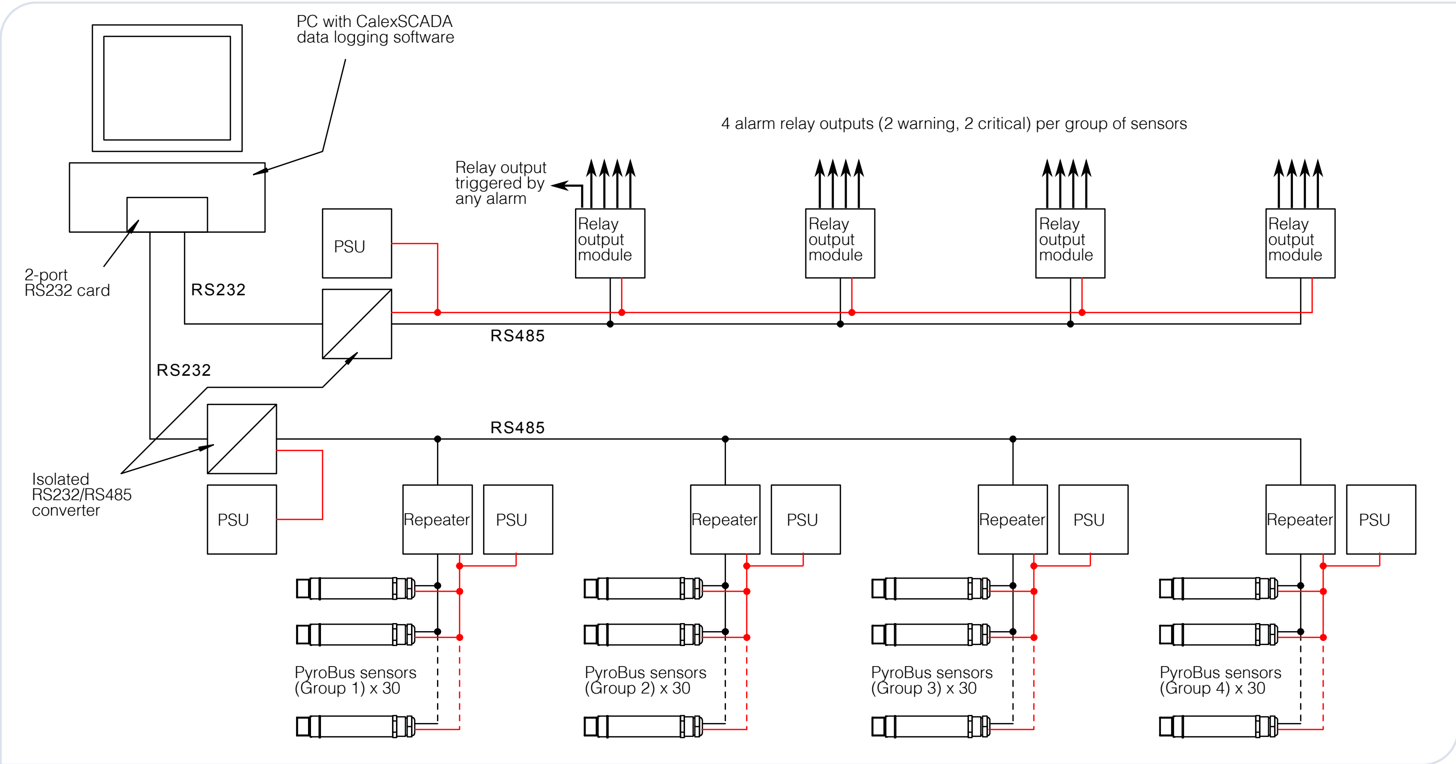
As the sensors may be positioned very close to the roller surface, the wide 2:1 field of view of the lowest-cost model PB21 gives good results.

Like all infrared temperature sensors, readings can be affected by contamination on the lens, so to help keep the lens clean and ensure maximum accuracy, an air purge collar is used with each sensor. This customer has designed a special mounting to fit the internal thread at the opening of the air purge.

For more information, please contact Calex.

PyroBus infrared temperature sensor with air purge collar

NETWORK DIAGRAM



SOFTWARE

Screenshot showing the main screen of CalexSCADA:

MAIN SCREEN FEATURES

- Temperature and alarm indication for all sensors simultaneously
- Sensors displayed in colour-coded groups as per the network layout
- Indication of alarm relay output state
- Acknowledge and reset all alarms
- Access the Alarm Test screen and the Alarm Summary screen
- Click any temperature gauge to access the Sensor Detail screen

ADDITIONAL FEATURES

- Sensor Detail screen (not shown) displaying temperature readings, sensor type, serial number and Modbus address
- Alarm setpoint adjustment for all sensors, per sensor or per group
- Acknowledge and reset alarms per group
- Graphs showing temperature history for the past hour, per sensor
- Data and alarm logging
- Many more features are available. Contact Calex to discuss your requirements.

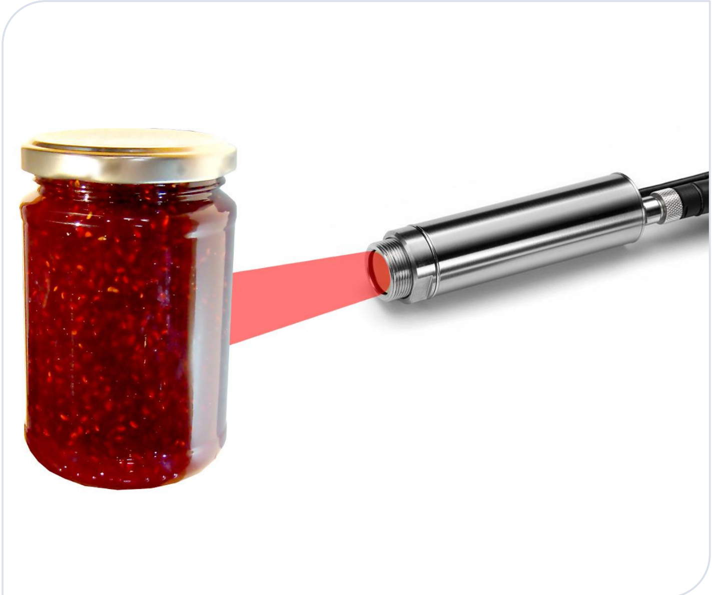
Measuring Hot Food Temperature Through Glass Jars

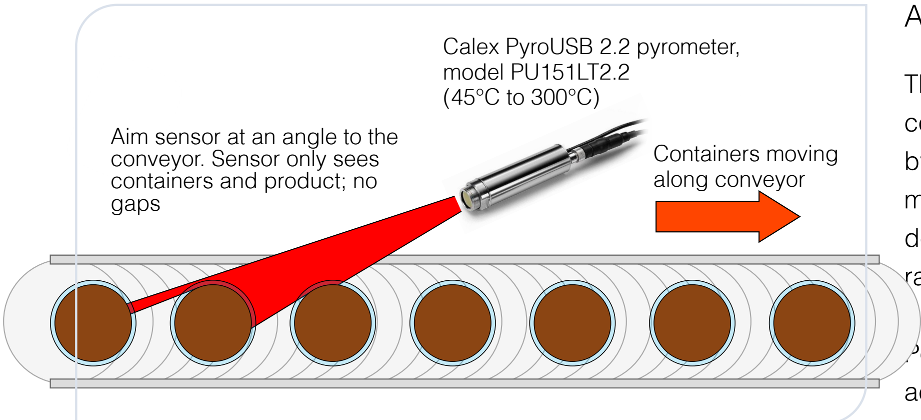
using the PyroUSB 2.2 infrared temperature sensor

The new PyroUSB 2.2 Series of infrared temperature sensors is ideal for measuring the temperature of hot food products through glass containers.

After a food product is filled into glass jars, samples are usually taken from the production line and manually probed to check the product temperature. The PyroUSB 2.2 now makes it possible to check product temperatures without taking samples from the production line, and without even touching the samples at all.

Glass is highly transmissive to infrared radiation at wavelengths around 2.2 microns, so the PyroUSB 2.2 can effectively see though a glass container and measure the temperature of the food product inside. Model PU151LT2.2 is capable of measuring the temperature of high-emissivity targets, such as food, as low as 45°C.





APPLICATION TIPS

The emissivity setting should be adjusted to compensate for the small amount of energy absorbed by the glass. Please see the PyroUSB 2.2 manual for more information. The required emissivity setting will depend on the thickness of the glass, as more infrared radiation is absorbed by thicker glass.

Position the sensor as close as possible to the target to achieve the smallest possible measured spot size.

The PyroUSB 2.2 sensor should be positioned level with the containers if possible, and aimed at an angle to the conveyor so that its field of view is always filled with product containers. This way, the sensor cannot see any gaps.

Provided the sensor cannot see through gaps in the stream of containers, the speed of the conveyor will not affect the accuracy of the measured temperature.

The selectable 0-20 mA or 4-20 mA output of the PyroUSB 2.2 is ideal for connection to existing process instrumentation, or Calex can provide a suitable indicating controller. The USB connection also provides temperature monitoring, alarm and data logging via the included CalexSoft software.

IR Thermometry

in Food Safety

Food safety is important to all of us. Both consumer and supplier should feel confident that their food is unspoiled and free from contamination. Since food product safety is ultimately a management responsibility, it is not surprising that considerable effort has been devoted to monitoring and controlling conditions at all stages of food processing from initial production through distribution, storage, display to point-of-sale. A preventative approach involving control of the ingredients, production process, and storage environment is the preferred method of ensuring uncontaminated and safe supplies. The procedure known as HACCP (Hazard Analysis and Critical Control Points) provides a logical and systematic basis for such an approach. It has been used to establish effective control systems in the food and catering industries. In any HACCP system, temperature plays an important role in maintaining quality throughout the process but particularly at the critical control points, or CCPs, which occur at certain stages in the production, distribution, and sale of foodstuffs.

Conventional contact or penetration probes using thermocouple or RTD sensors are often not the most appropriate means to measure food temperatures. They are slow due to the time required for the probe to reach thermal equilibrium with the food. This usually takes several minutes and can be a source of error if the user is pressed for time to do the measurement. Also, with any contact method, unless stringent and, ultimately, expensive precautions are taken, there is always the possibility of contamination and damage to the product. Furthermore, a contact measurement may not be possible because the item is not accessible, for example on a moving conveyor or out of reach on a high shelf. However, these problems can be overcome by using infra-red (IR) thermometers which are capable of rapid non-contact measurement of the temperature of solids and liquids at a distance.

An IR thermometer's action is based on the principle that all objects emit electro-magnetic energy according to their temperature. At low temperature, most of this energy is in the form of long wavelength (infra-red) radiation which cannot be detected by the eye and, therefore, cannot be seen but which, in some cases (eg. radiant energy from a warm radiator), can be felt. The rate of emission increases rapidly with temperature so that, at temperatures above 600°C, the amount of short wavelength energy (light) being emitted is sufficient to be detected by the eye. At first, the object appears dull red but, as its temperature increases, its colour changes from red to orange/yellow, and then white as more and more visible light is emitted. In this way, it has been determined that the surface temperature of the sun is 5900°C.

The optical components in an IR thermometer focus the emitted radiation on to a detector and signal processing electronics then convert the detector response into a digital reading of the object's surface temperature. IR thermometers are fast reading instruments because the response time of the detector and electronics is typically measured in milliseconds (thousandths of a second).

The Calex range of handheld IR thermometers includes the Pyropen series of pen-style units for use in the food industry. Cleverly designed to fit into one's pocket like a pen, and incorporating the latest advances in detector and electronics technology, the Pyropen is the ideal tool for all food professionals concerned with quality control. Checking temperatures could not be easier. Just point the Pyropen at the product - the built-in laser pointer highlights the target - and read its temperature immediately on the digital display. With a wide temperature range from -20°C to +500°C, the Pyropen can be used to check both food storage and cooking temperatures. What's more, not only food but the operating temperature of equipment such as ovens, deep fryers, dishwashers and electrical and rotating machinery can all be monitored quickly and safely.

Infrared Pyrometry
in the Glass Industry

Terms used in Glass Industry

Distributor: Distributes glass from melt tanks to forehearths. One melt tank typically feeds 2-4 forehearths.

Forehearth: Allows homogenization of glass and controls decrease of melt temperature to provide proper viscosity for "gobs".

Gob: A viscous volume of semi-molten glass which is cut from a stream of molten glass flowing from the forehearth. Gobs are continually cut into the proper volume and weight for the vessel being formed in a mould.

Lehr: Large annealing furnace for bottles which controls cool-down rate after mould station

Mould: A metal shell (usually in two halves) with the inside in the shape of the desired vessel into which the "gobs" are directed. They are discharged when sufficiently cooled to retain their shape. Typical mould interior surface temperatures are 300 - 500°C.

Orifice: Drain holes at the end of forehearth which are sized to produce the proper volume of molten glass (gob) to produce the desired vessel.

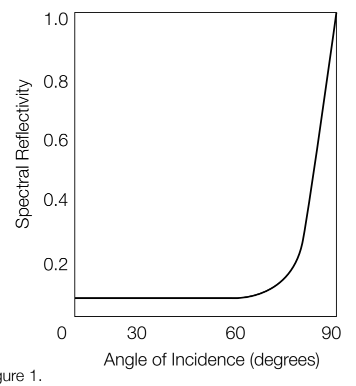


Figure 1.

In the molten state, glass becomes mostly opaque in the visible spectrum. Infrared pyrometers operating in the near infrared, 1 micron (µm) can get a good average temperature over several centimetres into the glass.Instruments filtered for 2.2 µm can read 5 or 6 centimetres into a "gob" or melt, and 3.9 µm is recommended for smaller gobs and thin stream pours.

For sheet glass work, or at lower temperatures, glass is too transparent for shorter wavelength measurements. 8 to 14 µm is commonly used when reflectance is not a problem. One problem in the 8 to 14 µm region is reflectance (not a problem at 5 µm or 7.9 µm) which runs about 15% (r = 0.15) and requires special attention to ensure that heaters or other objects significantly hotter than glass cannot be read by reflection. Plate glass annealed between a double row of heaters, for example, would preclude the use of an instrument with this 8 to 14 µm spectral range. Instead, an instrument sensitive at 5 µm could read temperature without errors due to reflection. The 5 µm instrument would read to a depth of about 1 mm, the 7.9 µm instrument would read the surface only.

Approximate Depth of Measurement in Clear Glass vs. Wavelength

Wavelength (µm)	Depth of Measurement (mm)
0.7 to 1.0	100 to 125
2.2	50 to 75
3.9	10
5.1	1.5
7.9	Surface
8 to 14	Surface

Application	Temp	Fixed sensor	Portable sensor
Melt tanks & Furnaces Distributors Hearths	1180-1300°C	TL-GAI-18	Thermosight GL
Gobs	1100-1200°C	Convir TL-TI5-12	Thermosight GL
Bottle moulds	250-500°C	PU301	PyroPen
Lehrs	100-200°C	PU301	PyroPen
Plate Glass Annealing & Heat Treating	500-800°C	TL-TI5-12	Thermosight GL
Refractories	Any	Any appropriate temperature range	Any appropriate temper-ature range
Plant Maintenance	10-200°C		Pyropen

In a float line, the 8 to 14 µm portable units have proven to be excellent tools for measuring the uniformity of the sheets. If reflections from hot refractories or flames, such as in melt tanks, etc., cause false readings, a 5 or 7.9 µm unit should be used. The 5 µm is desirable because it measures a very short distance into the glass and is relatively unaffected by air currents, etc.

Sensors operating in the 2.2 µm region are excellent for monitoring and contributing to the control scheme of melt tanks, distributors and forehearths. This wavelength is somewhat impervious to flame impingement. It also lends itself well to the measurement of clamshell mould interiors, although an oxidised exterior or the inner surface of paste moulds can be read with instruments of any wavelength.

Bottles exiting a lehr can be read with 8 to 14 µm units employing an averaging mode with an emissivity of 0.85. A 5 µm or 7.9 µm instrument would have an emissivity of 0.98. Readings would be more accurate using 5 µm or 7.9 µm because emissivity changes less as a function of angle of incidence at these wavelengths. (Reflectance increases as the angle between the plane of the glass and the line of sight decreases). See Figure 1.

Recent experience at a glass company provided the following information:

1. A Pyropen using an emissivity setting of 1.0 is excellent for clamshell moulds in bottle plants. Emissivities are much lower on finely polished moulds such as those used to create smooth surfaces on kitchenware. This type of application is not advised.
2. "Gobs" can be difficult, as many plants use a two-orifice (per forehearth) system. Job changes often result in the distance between orifices changing, and if the job changes are too frequent, operators may find re-aiming the sensing heads a nuisance. The best wavelength for gobs seems to be 3.9 µm. The TL-TI4-10 provides accurate gob temperature measurements using a 3.9 µm filter. Alternatively, a TL-TI5-12 will measure from 100 to 1200°C with a spectral range of 5.1 µm.
3. A TL-TI5-12 was tested on annealing and tempering operations, such as bottles exiting from the lehr and plate glass tempering. Good results were achieved measuring thin glass with this sensor.

Non-Contact Measurements in Tyre Manufacturing
using the PyroCouple infrared temperature sensor

Infrared temperature sensors from the Calex PyroCouple Series are being used by a major tyre manufacturer to detect the presence of hot rubber tyre material as it passes a point on a conveyor.

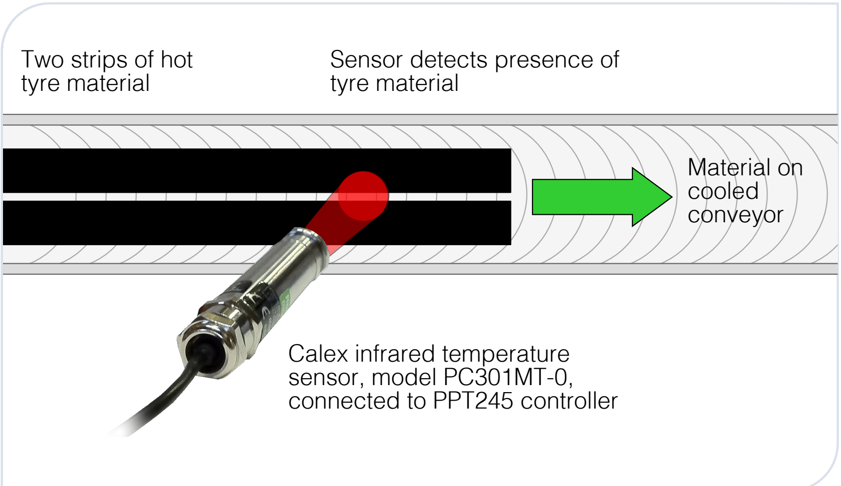
The tyre material is transported in two thin bands on a cooled aluminium conveyor. A Calex PyroCouple model PC301MT-0 infrared temperature sensor is positioned above the conveyor, and is aimed so that both bands are contained in its field of view.

The temperature of the tyre material is normally 75°C and the cooled conveyor surface temperature is typically 20°C.

The sensor is connected to a DIN rail-mounted controller with a relay output that will switch at a chosen measured temperature (e.g. about 45°C).

The relay setpoint temperature is low enough that the relay will be triggered reliably despite the tyre material not completely filling the sensor's field of view. The system can therefore detect the presence of the tyre material, and the time that the material starts and stops being present can be logged.

Speed data from the conveyor drive system is combined with the timings from the sensor and the total length of tyre material passing the sensor can be calculated over each manufacturing period.




PPT245 controller with PyroCouple infrared temperature sensor

APPLICATION TIPS

This system can also be used to detect the presence of a single band of product. If the sensor's field of view is completely filled by the tyre material, then the temperature reading will also be accurate.

Tyre rubber has a high emissivity, so the low-cost, fixed-emissivity PyroCouple Series of infrared temperature sensors is perfectly suitable. For other materials, please contact Calex for advice on the most suitable sensor.

The sensor measures an average temperature across its field of view. Because the sensor can also "see" the cool conveyor as well as the hot tyre material, the measured temperature will be lower than the true temperature of the tyre material, however the reading is sufficiently accurate that the sensor may be used to detect whether or not it is present.

The PPT245 DIN rail-mounted controller will indicate the measured temperature and the setpoint temperature, and can also be configured to retransmit the measured temperature as a linear 0-10 V DC or 4-20 mA signal for connection to a data logger or instrumentation. It has another relay output that can be configured for control or alarm.

For more information, advice on choosing the most suitable sensor for your application, and for a quotation, please do not hesitate to contact Calex.

Plastic Temperature Measurement

using Infrared Thermometers

Techniques for selecting and applying non-contact temperature measurement instruments for use in the plastics industry involve several factors. One is evaluation of the spectral emission characteristics of the plastic to be measured. Others are the optical performance, required elimination of interference sources, environmental parameters, and control interface requirements. It is most effective to design an installation which results in using the highest emissivity value possible. The spectral response of the instrument should thus be matched to the type of plastic to be measured.

PLASTIC INFRARED EMISSION CHARACTERISTICS

Infrared thermometers calculate plastic temperatures by detecting emitted energy from the plastic, then processing the resulting electronic signal. A major factor in this process is emissivity (∊) a measure of an object's effectiveness in radiating thermal energy. However, spurious energy can come from radiation transmitted from a hotter object behind it, or reflected from a hotter object in front of it.

The energy emitted by a plastic is not evenly distributed. By observing the wavelengths at which peak energy is emitted, an instrument sensitive to that wavelength can be selected. This selection is most critical for thin-film plastics, since they tend to be transparent at many wavelengths. For example, polyethylene is partially transparent (about 75% or t = 0.75) at most wavelengths between 2 and 16 microns (µm) except for a few wavelengths at which strong absorption bands exist (see Figure 1.) An absorption band at about 3.4 µm causes transmission to be zero, so 25 µm thick polyethylene is opaque at this wavelength. Since most plastics have reflectance (r), of about 0.04, ∊ can be calculated for polyethylene at 3.4 µm as follows:

$$\epsilon = 1 - r - t = 1 - 0.04 - 0 = 0.96$$

An instrument with a spectral response of 3.4 µm is the best choice to measure temperature of thin polyethylene films. Since t decreases and ∊ increases as thickness increases, spectral response becomes less important with thicker plastics. Pigmentation also reduces transmission and improves emissivity of thin films. In general, thickness of less than 2.5 mm require consideration of spectral emission, which should be analysed with a spectrophotometer to determine the best wavelengths for non-contact temperature measurement.

In general, two spectral response narrow-bands, 3.4 µm and 7.9 µm are best for measuring thin films.

Some thin films can be measured only at 3.4 µm, some can only be measured at 7.9 µm, while others can be measured at either wavelength.

Calex instruments with a 3.4 µm filter can be used to measure thin films of polyethylene. Instruments with a spectral response at 7.9 µm are used to measure Teflon and other thin films.

Plastics thicker than 2.5 mm can also be measured accurately using general-purpose 8 to 14 µm instruments.

These infrared pyrometers offer the advantage of lower cost, broader temperature range, and better availability compared to narrow band instruments.

OPTIMUM MEASUREMENT WAVELENGTHS FOR 25µ THIN FILMS

Wavelength		
3.4 µm	**3.4 µm or 7.9 µm**	**7.9 µm**
Polyamide	Polyvinyl Chloride (PVC)	Polyesters
Polyethylene	Acrylic	Teflon
Polypropylene	Polyurethane	Polyimide
Polystyrene	Polycarbonate	Cellophane
Nylon		Cellulose Acetate
		Fluroplastics

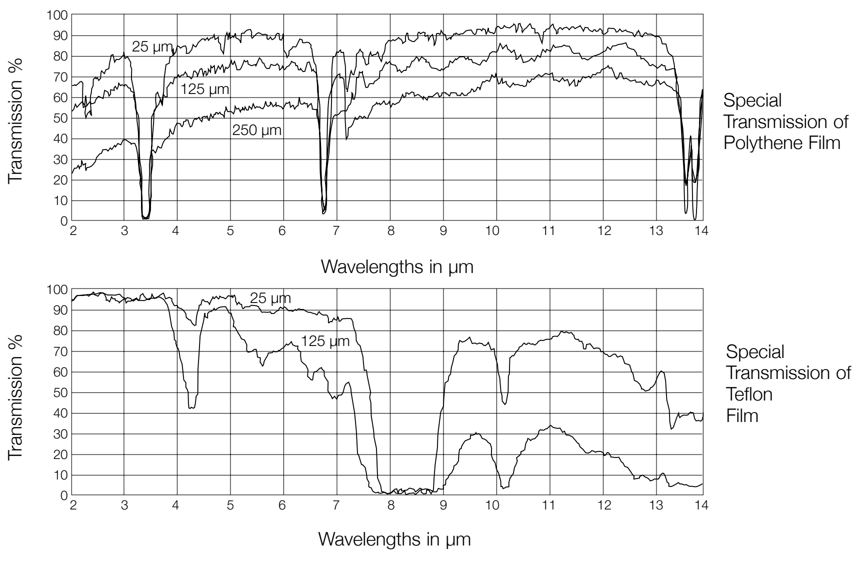


Figure 1.

Infrared Temperature Sensor for Food Applications

with Right Angled Sensing Head and Protective Plastic Window

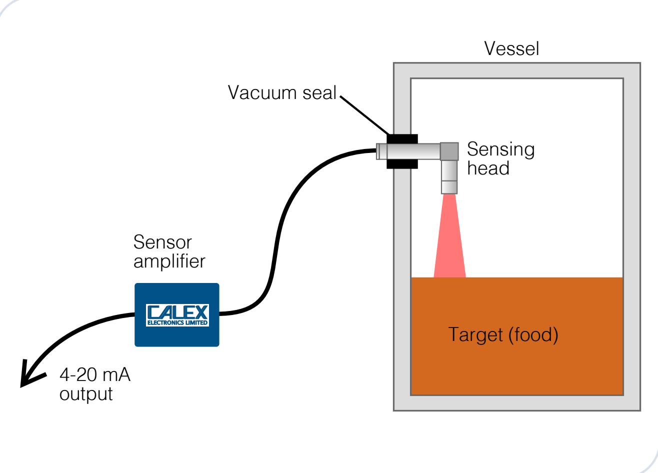
Calex has been approached by a leading manufacturer of food processing equipment with a specific requirement for non-contact infrared temperature measurement.

The CI5234, a special sensor based on the existing two-piece PyroCouple M, is designed specifically for this customer's requirements. This sensor has features that also make it ideal for many other applications.

The standard PyroCouple M sensing head is replaced by a right-angled head as shown in the photograph. The long, cylindrical stainless steel section is designed to be mounted in a gland or seal in the wall of a vessel, eliminating the requirement for an additional flange or window. The right angle allows the surface of the material in the vessel to be monitored from above.

A protective plastic window is fitted to the nose of the sensor inside a stainless steel holder. This protects the sensor's lens from damage and helps contain lens fragments in case damage occurs.

CI5234 infrared temperature sensor with right-angled head



INSTALLATION

The CI5234 sensing head is installed in the wall of a vessel and aimed at the surface of the food. Its narrow 15:1 field of view helps ensure that it cannot "see" the vessel walls.

The separate electronics box amplifies the signal from the sensing head and converts it to a linear 4-20 mA output. The CI5234 may be supplied with a cable of up to 3 m between the sensing head and the electronics box. Screw terminals in the electronics box allow easy connection to a four-core shielded copper cable.

If mixing paddles or blades are present in the vessel, then output processing should be applied to the 4-20 mA signal to ignore fluctuations in measured temperature when the paddle or blade is visible to the sensor.

APPLICATION TIPS

The fixed emissivity setting of the CI5234 gives good results on almost all foods, and is also ideal for measuring other high-emissivity surfaces, such as wood, paper, fabric, thick plastics, asphalt and painted surfaces.

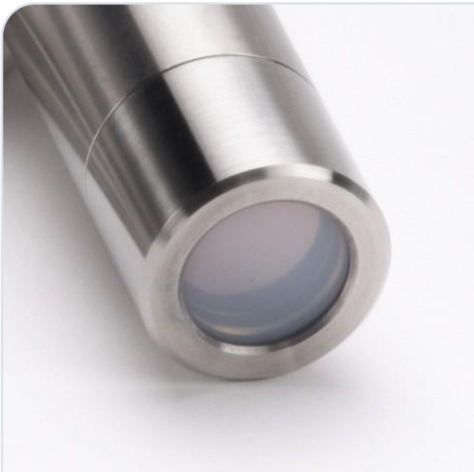
Like all infrared temperature sensors, readings can be affected by steam or contamination on the lens, so both of these should be minimised for maximum accuracy.

The sensor can withstand temperatures of up to 70°C in the vessel.

If the protective plastic window is not required, this sensor can be supplied without it.

The protective plastic window in stainless steel holder can be supplied separately for use with adjustable-emissivity sensors, such as the PyroEpsilon, which has emissivity adjustment via 4-20 mA input, the PyroBus, which is equipped with an RS485 Modbus RTU interface, or the PyroUSB, which has USB communications as well as a 4-20 mA output.

For more information or assistance, please contact Calex.


Protective window in stainless steel holder

Thermoforming Temperature Control

using the PyroMini infrared temperature sensor

In vacuum forming and thermoforming processes, an extruded plastic sheet is heated to make it pliable, before being moulded into shape by a vacuum or high pressure. Plastic bath tubs, car trim panels and plastic pallets, among many other products, are all manufactured by thermoforming. The process depends critically upon temperature.

Leading manufacturers of thermoforming machinery have been using Calex pyrometers to control heaters and cooling fans in thermoforming for more than ten years, with the following benefits:

- Minimising the preheat time and cooling time allows an increase in the production rate
- Reduction in cost and energy used to heat the plastic
- Alarm signals can be provided to warn of critical temperatures
- Increase in product quality and consistency

PyroMini with optional touch screen interface

HEATING

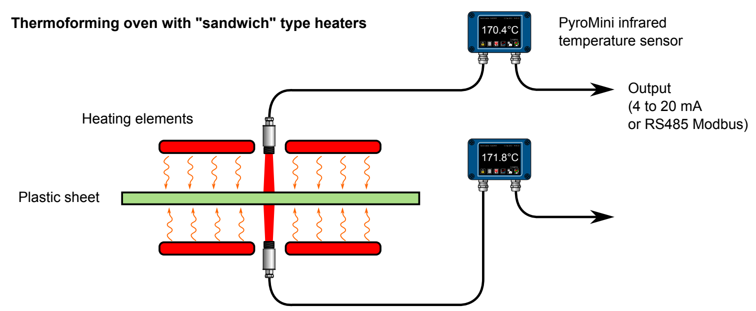
Forming temperatures typically range from 120°C to 370°C, and the optimum temperature depends on the type of plastic. Some plastics may be formed at any temperature within a relatively wide band, whereas others require much more critical temperature measurement. For example, polypropylene is best formed just below its melting point, a very narrow temperature window that depends on its molecular structure and crystallinity. Precise temperature control is required, and the high performance of the PyroMini infrared temperature sensor makes it ideal for the task.

The plastic sheet is heated by banks of infrared heaters above the sheet. In some thermoforming ovens, especially for thicker sheets, the sheet is heated with "sandwich" type heaters, both above and below it. Radiant heating element types such as quartz, halogen and ceramic are frequently being installed to replace older radiant tubes in thermoforming ovens.

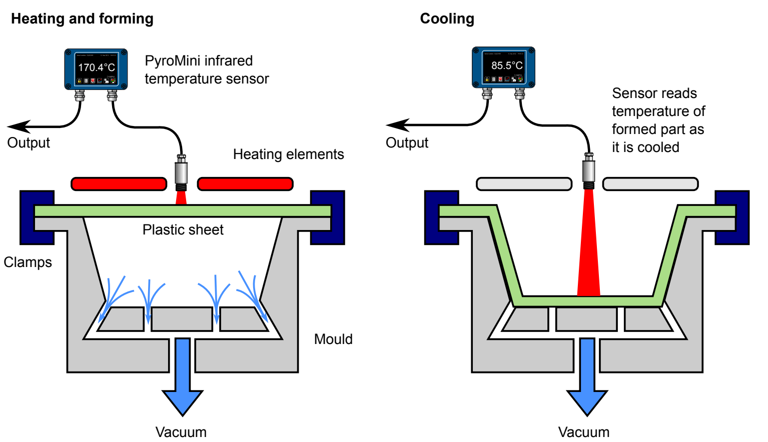
One sensor is used to measure the temperature of each heating zone, so an even temperature profile is ensured throughout the whole sheet. For good temperature uniformity, at least ten points should be measured: all four corners and the centre of the sheet, on both the top and bottom surfaces.

The sensing head is positioned between the heating elements so it has an unobstructed view of the plastic surface. High ambient temperatures mean that PyroMini -JA (for ambient temperatures up to 120°C) and -HA (for ambient temperatures up to 180°C) models are most suitable. There is no need to cool the sensing head, which helps cut down on energy usage and cost.

Thermoforming oven with "sandwich" type heaters



Thermoforming machine with stationary heater



COOLING

In many cases, the production rate is limited by how quickly the formed part can be cooled before being removed from the mould. Another PyroMini sensor monitors the surface temperature of the formed part as it is cooled by fans and by the cooling system in the mould itself. The PyroMini has an instantaneous 240 ms response time, so the operator or automatic control system can see straight away when the part is cool enough, switch off the cooling fans and mould cooling system, and clear the mould for the next part as quickly as possible.

The optional touch screen display provides a large, bright indication of the PyroMini sensor's measured temperature, two alarm relay outputs, and data logging to a built-in MicroSD Card slot. The sensor is fully configurable via the intuitive interface.

For connection to existing instrumentation such as PLCs or temperature controllers, two output types are available: a linear 4 to 20 mA output for measured temperature, or full RS485 Modbus communications.

Calex can also provide systems ranging from a single sensor with a PID controller, to a digital network of tens or even hundreds of sensors, providing display, control, alarm, analogue output and data acquisition functions.

APPLICATION TIPS

Sheet thicknesses from approximately 1 to 2 mm upwards, in medium to heavy gauge thermoforming applications, are easy to measure with infrared temperature sensors because they are opaque to infrared radiation, and the sensor cannot "see" through them.

Thin gauge plastics, below a millimetre in thickness, may be partially transmissive to infrared radiation and therefore more difficult to measure.

For more information on choosing a suitable system for your application, please contact Calex.