Noncontact Temperature Measurement Using Infrared Technology

Raytek®

Leaders In Noncontact Temperature Measurement

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Temperature is an important variable in manufacturing, quality control and maintenance processes. Monitoring temperature improves product quality, increases productivity and reduces downtime by insuring that processes are operating consistently under optimum conditions. Infrared technology is not new — it has been successfully used in manufacturing and research applications for years — but recent innovations have lowered costs, increased reliability and reduced sensor size, making this technology available to a new group of users and applications.

Noncontact temperature measurement instruments using infrared technology provide benefits over traditional contact measurement devices, especially in applications where the materials are moving, very hot or inaccessible. There are many applications for noncontact temperature measurement including plastic film processes, printing, food processing and preventative maintenance.

This article provides a basic description of the components of an infrared system including the

- ❒ Object
- ❒ Environment
- ❒ Windows and Optics
- ❒ Detector
- ❒ Display and Output

This background on infrared technology is followed by a discussion of instrument specifications. With a basic understanding of the infrared system and product specifications, you will be able to select the correct instrument for your application.

Advantages of Noncontact Thermometers

Increase Productivity, Reduce Costs, Improve Quality, Eliminate Downtime

Infrared, or noncontact thermometers, measure temperature without physically touching the object, and, thus, offers distinct advantages over contact thermometers. These advantages include:

Noncontact, clean measurement: This is important in applications where the materials may be soft, wet or could be scratched or torn by a contact thermometer.

Small, moving or very hot objects: Infrared thermometers measure only the energy emitted by an object — not the surrounding temperature — making it easier to monitor the temperature of hot spots, small targets and moving bodies more accurately than with contact temperature devices. A range of infrared devices is commercially available including close focus devices that can accurately measure the temperature of small objects. Moving objects are a natural use for infrared temperature measurement since it is difficult to maintain contact with more traditional methods. Infrared thermometers can measure temperatures up to 3000 degrees C (almost 5400 degrees F) without damage to the sensor.

Inaccessible objects: As long as the object is kept within the field of view, it is possible to measure the temperature of objects that are inaccessible or long distances away.

Safety: Noncontact temperature measurement can be made in areas which are unsafe or difficult for a person to take an instrument reading.

Speed: Infrared measurement is much faster than contact methods. Several measurements can be made in less than a second, as compared to contact methods where the same measurement can take several minutes.

Repeatability and reliability: Because the thermometer does not touch the object, noncontact temperature measurement does not draw heat away from the object and affect the temperature of the object being measured. With noncontact temperature measurement, it is possible to achieve the same measurements day after day. Noncontact temperature thermometers have a long life since the sensor and object are not in contact with each other.

Ensuring consistent and accurate temperature through the use of infrared thermometers can increase productivity in industries where throughput depends upon precise temperature control. The use of noncontact temperature measurement is directly related to factors which affect production yields such as moisture, dryness, uniformity, tension, viscosity and thickness. Faced with rising labor and materials costs, increasing productivity is often the only variable available to maintain profitability. Infrared temperature measurement further adds to the bottom line by **reducing energy and maintenance costs**.

By monitoring and controlling the production process, rather than testing the product after it is produced, infrared temperature measurement helps **improve product quality** and reduce the number of production defects. Often this has the additional benefit of increasing durability of the products, which in turn increases customer satisfaction.

Infrared temperature measurement **eliminates downtime** by locating and troubleshooting problems before they cause production shutdowns or safety hazards. Hand-held, portable infrared sensors are used routinely in maintenance applications resulting in early detection of problems that could result in expensive equipment replacement or otherwise shut down production. Other preventative-maintenance applications, particularly on continuously operating equipment, require 24- hour temperature monitoring where online sensors are more appropriate. The cost of implementing noncontact temperature measurement is quickly offset by the reduction in material and labor costs.

The Infrared System

Object, Environment, Optics, Detector, Display and Output

THE INFRARED SYSTEM

While the use of infrared temperature measurement has grown, and the number and variety of applications have expanded — effective use of an infrared system requires a basic understanding of characteristics of the object to be measured, its environment, and the instrument, consisting of optics, detector, display and output.

Infrared thermometers capture the invisible infrared energy naturally emitted from all objects. Energy then passes through the atmosphere or environment before reaching the infrared device. Energy passes through the optical system of the device and is converted to an electrical signal at the detector. This signal is then displayed and/or converted to a standard output.

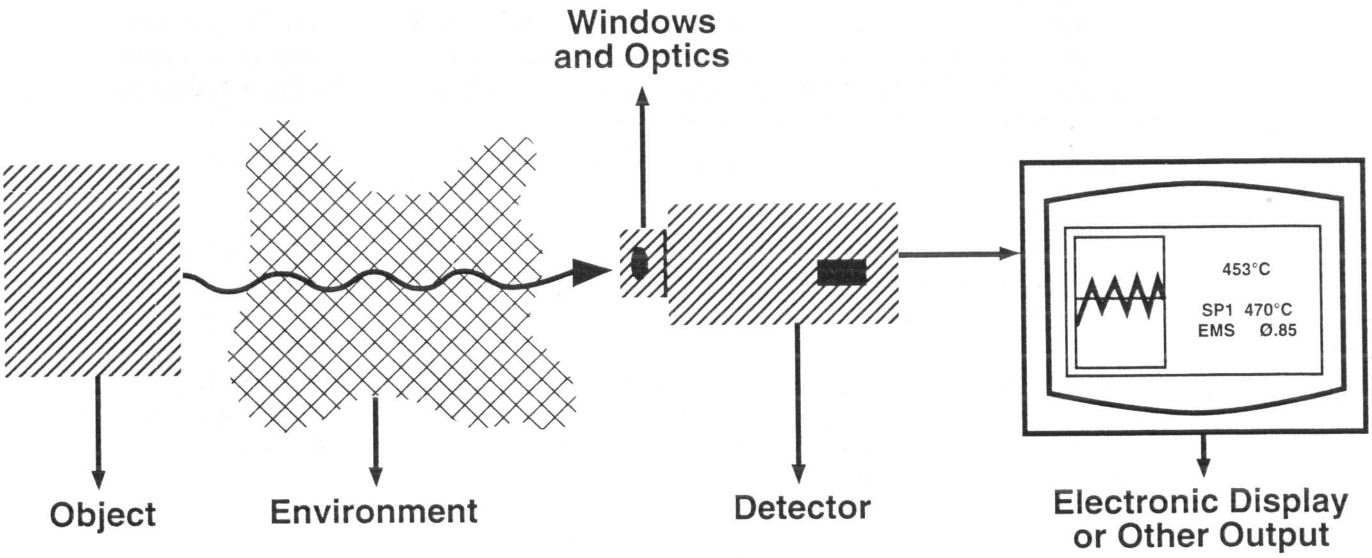


Figure 1: An infrared system consists of the object, its environment, and the instrument, including optics, detector, display and output.

Infrared radiation is part of the electromagnetic spectrum which includes radio waves, microwaves, visible light, ultraviolet, gamma and X-rays. These forms of energy are categorized by frequency or wavelength. The infrared range falls between the visible portion of the spectrum and radio waves. Infrared wavelengths are usually expressed in microns with the infrared spectrum extending from 0.7 microns to 1000 microns. In practice, the 0.7 to 14 micron band is used for infrared temperature measurement.

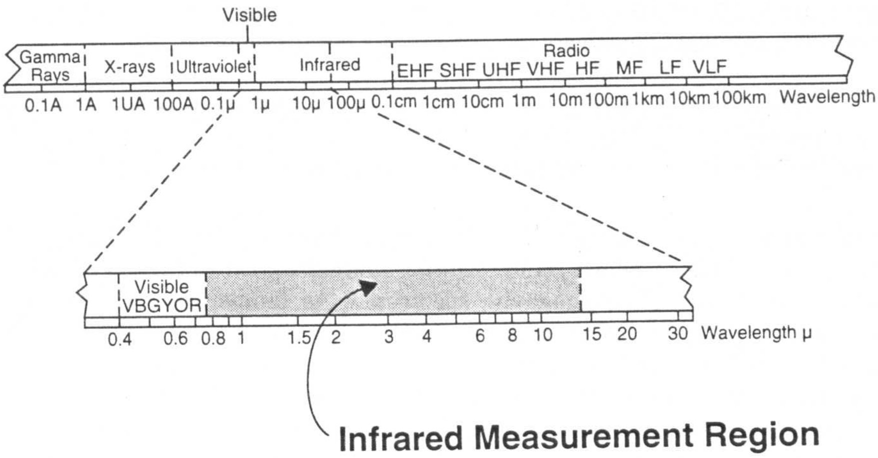


Figure 2: The electromagnetic spectrum. Infrared energy is usually measured in the 0.7 to 14 micron band.

THE OBJECT

Energy that is absorbed by an object will heat it, raising its temperature. This energy is then emitted at the object's surface and can be measured by an infrared thermometer. Absorptivity and emissivity are directly related. Infrared energy is also transmitted through objects from another source and reflected off the surface of an object. The infrared thermometer reads the sum of these energy sources and it assumes that all energy is a function of the temperature of the object. One objective in infrared temperature measurement is to isolate, as much as possible, the emitted energy, since only that energy indicates the temperature of the object.

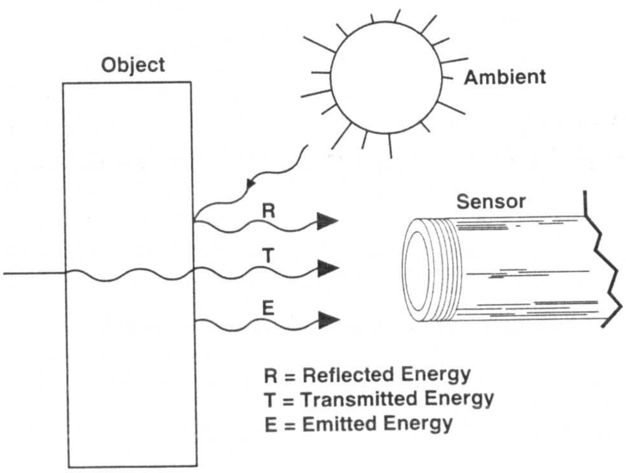


Figure 3: Sources of infrared energy. An infrared sensor reads the total of the energy that is reflected, transmitted, or emitted from an object.

EMISSIVITY AND BLACKBODIES

Emissivity is a term used to quantify the energy emitting characteristics of different materials: it is a function of wavelength, temperature and angle of view. Emissivity is defined as the ratio of the energy radiated by an object at a given temperature to the energy emitted by a perfect radiator, or blackbody, at the same temperature. An ideal blackbody neither reflects nor transmits energy.

When there is no transmitted or reflected energy, the object is a blackbody with an emissivity of 1.0. Blackbodies absorb and re-emit all energy incident upon them and are an ideal surface for infrared temperature measurement. By examining the chart below that illustrates blackbody curves at different temperatures, we notice several things. The curve for a given temperature never crosses the curve of any other temperature, which allows us to calibrate an instrument to measure temperature at any point in the electromagnetic spectrum. As temperature increases, the total amount of energy emitted increases and the peak of the curve shifts to the left of the graph, or the shorter wavelengths. In fact, very hot bodies emit energy in the visible spectrum. Although only 25% of the energy is emitted on the shorter wavelength side of the peak, the slope of the curve on that side is considerably steeper, with more energy difference per degree difference in temperature than on the longer wavelength side. The blackbody concept is important, not only because it is the most efficient radiator, but also because it shows that radiant power depends on temperature.

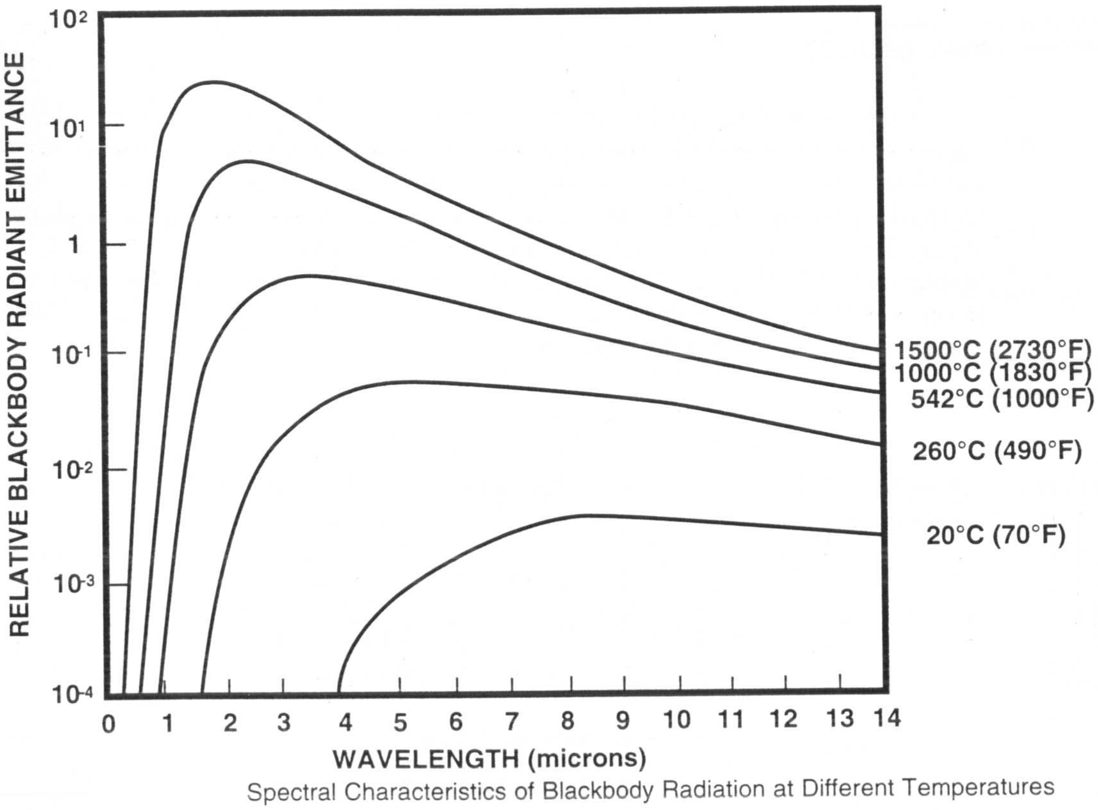
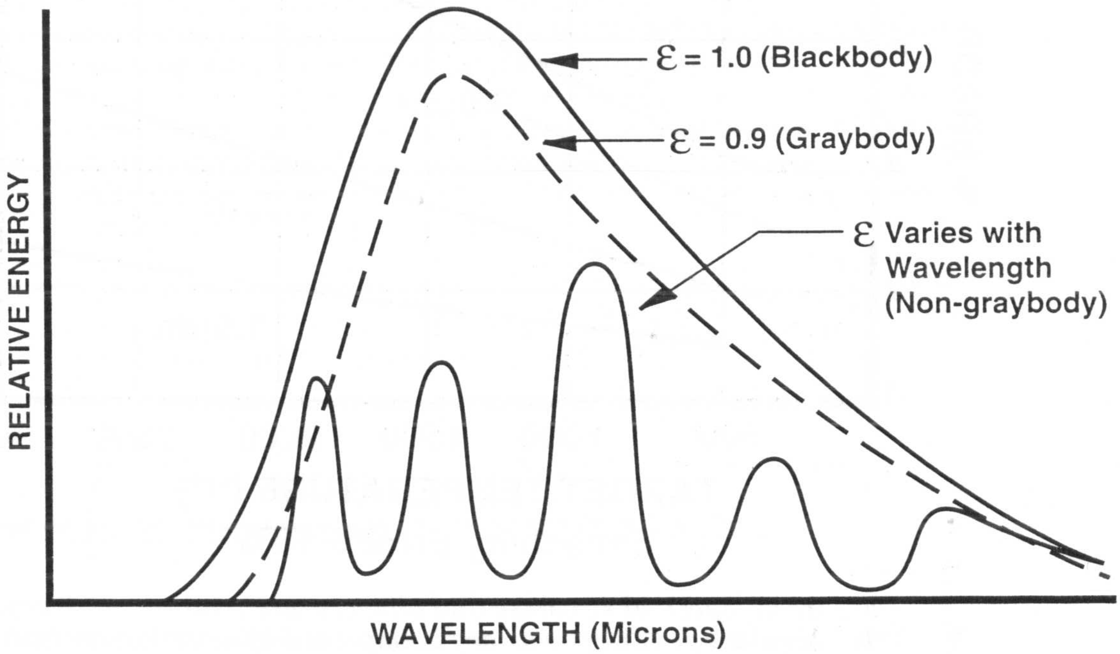


Figure 4: Spectral characteristics of blackbody radiation at different temperatures. As temperature increases, the total amount of energy emitted increases and the peak of curve shifts to the left of the graph, or the shorter wavelengths.

With the exception of blackbodies, all objects have emissivity values of less than 1.0. They are either graybodies, which have a constant emissivity throughout the wavelength, or non-graybodies, whose emissivities vary with wavelength. Most organic objects are graybodies with an emissivity of 0.90 to 0.95. The figure below shows the relative energy curves of blackbodies, graybodies and non-graybodies.



Relative Spectral Distribution Curves of Blackbodies, Graybodies and Non-graybodies

Figure 5: Relative spectral distribution curves of blackbodies, graybodies and non-graybodies.

Blackbody radiation is a theoretical concept and "real" bodies have an emissivity of less than 1.0. Graybodies and most non-metals have high emissivities resulting in accurate temperature measurements. For other objects, correcting for emissivity will improve the accuracy of the temperature reading. For example, an object with an emissivity of 0.7 emits only 70% of the energy that a blackbody emits. Unless correction is made for emissivity, the temperature reading will be lower than the object's actual temperature. Depending upon the absolute accuracy required, emissivity correction should be used when the object emissivity is less than 0.9.

On the shorter wavelength end of the spectrum, energy differences due to temperature will exceed differences due to variation in emissivity. The following illustration shows that for an object at 1000 degrees C, an emissivity error of 10% causes a reading error of 5.5% when measured in the 5.0 micron band and an error of 1.2% when measured at 1.micron. In general, it is better to measure temperature using the shortest wavelength possible.

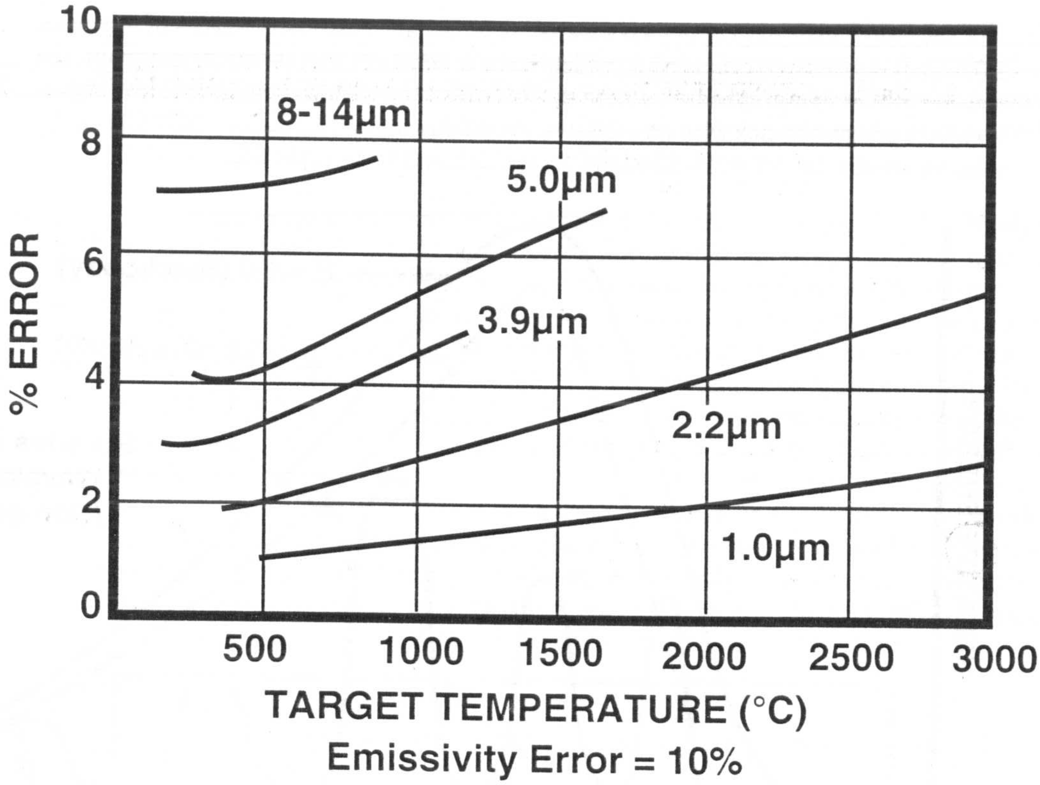


Figure 6: Spectral response and temperature reading accuracy. Temperature reading accuracy is improved by selecting an instrument with as short a wavelength as possible. At the shorter wavelengths, differences in temperature exceed differences due to emissivity.

DETERMINING EMISSIVITY OF AN OBJECT

There are several ways to determine the emissivity of an object. Initially, emissivity values of common materials can be looked up in a table. Emissivity tables are used to help select the right instrument by matching the material to the instrument. Secondarily, the emissivity of a specific material can be determined in several ways.

1. Heat a sample of the material to a known temperature determined by a contact thermometer, such as a thermocouple. Then measure the temperature of the object with the infrared thermometer. Adjust the emissivity compensation until the correct temperature reading is displayed. Use this emissivity value when measuring the same material in the future.

2. For relatively low temperatures (up to 250 degrees C or 500 degrees F), place a piece of masking tape on the object and measure the temperature of the masking tape with the infrared thermometer using an emissivity setting of 0.95. Next, measure the object's temperature and adjust the emissivity compensation until the dis-play shows the correct temperature. Use this emissivity value for future measurements of this object.

3. For high temperatures, drill a hole, the depth of which is at least six times the diameter, into the object. This hole must match the instrument spot size. This hole acts as a blackbody with an emissivity of 1.0. The temperature measured looking into the hole will be the correct object temperature. While measuring the object's surface, adjust the emissivity compensation until the temperature matches the temperature reading of the "blackbody" and use this emissivity for future measurements.

4. When the object can be coated, paint a portion of the surface with a dull black paint which has an emissivity of about 0.95. Measure the temperature of the "blackbody" and correct the emissivity value as above.

MEASURING TEMPERATURE OF NON-GRAY BODIES

The emissivity of non-graybodies varies with wavelength and temperature. Non-graybodies are basically of two types: those that reflect energy (such as metals) and those that both reflect and transmit energy (such as glass and thin plastic films). At some wavelengths, these objects may be blackbodies, at others they may be total reflectors or transmitters. While the benefits of infrared temperature measurement make it an attractive solution for measuring these materials, special care is required in the process planning stage to ensure correct temperature measurement. In these cases it is important to choose an instrument that measures the infrared energy at a particular wavelength and temperature range where the materials appear opaque or semi-opaque. However, for best accuracy, it is always better to measure at the shortest wavelength possible.

RECOMMENDED WAVELENGTHS FOR METAL MEASUREMENT

For high temperature metal, use 0.8 to 1.0 micron

Other choices, 1.6, 2.2, and 3.9 microns

METALS

Because metals are often reflective, they tend to have low emissivities which can result in varying and unreliable readings. For most metals, the problem increases at the longer wavelengths so that the shortest possible measurement wavelength available should be used. The optimum wavelength for high-temperature metals is the near infrared, around 0.8 to 1.0 microns. Other choices are 1.6, 2.2 and 3.9 microns.

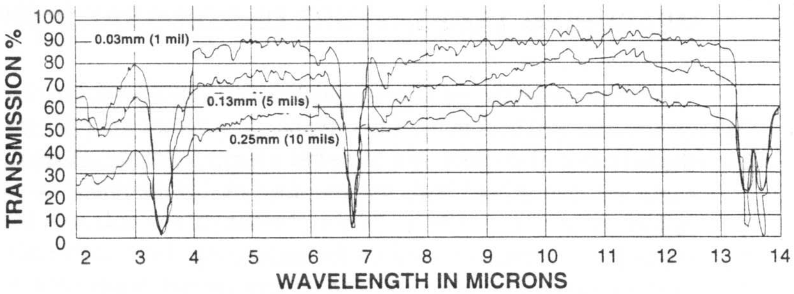
RECOMMENDED WAVELENGTHS FOR PLASTIC MEASUREMENT

For polyethelene, use 3.43 or 7.9 microns, depending on composition

For thick film, over 0.4 mm, use 8 - 14 microns

PLASTICS

Plastic films have transmission rates that vary according to wavelength and are proportionate to their thickness. Thinner materials will transmit more than thicker substances. In order to optimize temperature measurement, it is important to select a wavelength where transmission approaches zero. Some plastics (polyethelene, polypropylene, nylon, and polystyrene) are opaque at 3.43 microns, other plastics (polyester, polyurethane, Teflon[R], FEP, and polyimide) are opaque at 7.9 microns. For thicker, heavily pigmented film, greater than 0.4 mm (0.15 in.), use a wavelength between 8 to 14 microns. If in doubt, test a sample of the plastic material to determine the optimum spectral band to measure. Almost all plastic films have a 4% reflectance.



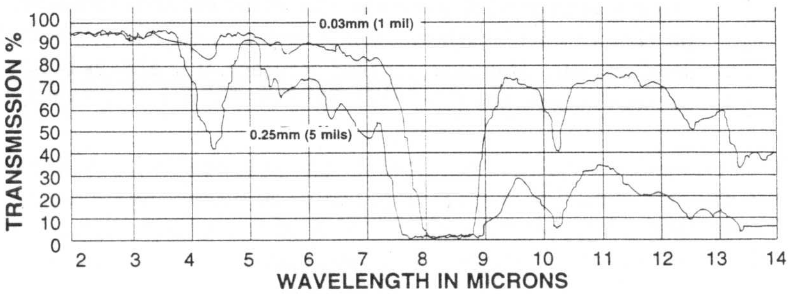


Figure 7: Spectral transmission of polyethelene film. Polyethelene film has almost no transmission at 3.43 microns and polyester has no transmission at 7.9 microns, regardless of the thickness. Similar IR "windows" are found with metal and glass.

GLASS

In measuring the temperature of glass with an infrared thermometer, reflection and transmission must both be accounted for. It is possible to measure both the surface and beneath the surface of a glass object by careful selection of the wavelength. If sub-surface temperature measurement is desired, use a 1.0, 2.2 or 3.9 micron sensor. For surface temperatures, a wavelength of 5 microns is recommended. For low temperatures use 8-14 microns and adjust the emissivity to 0.85 to account for reflectivity. Glass is nearly transparent at short wavelengths, making short wavelengths a poor choice for temperature measurement of an object, but a good choice for a window through which to measure high temperature objects. Because a glass object may change temperature very quickly, an instrument with a fast response time will be valuable.

RECOMMENDED WAVELENGTHS FOR GLASS MEASUREMENT

For subsurface temperatures, use 1.0, 2.2 or 3.9 microns

For surface temperatures, use 5 microns

For low temperatures, use 8 - 14 microns, with ϵ = 0.85

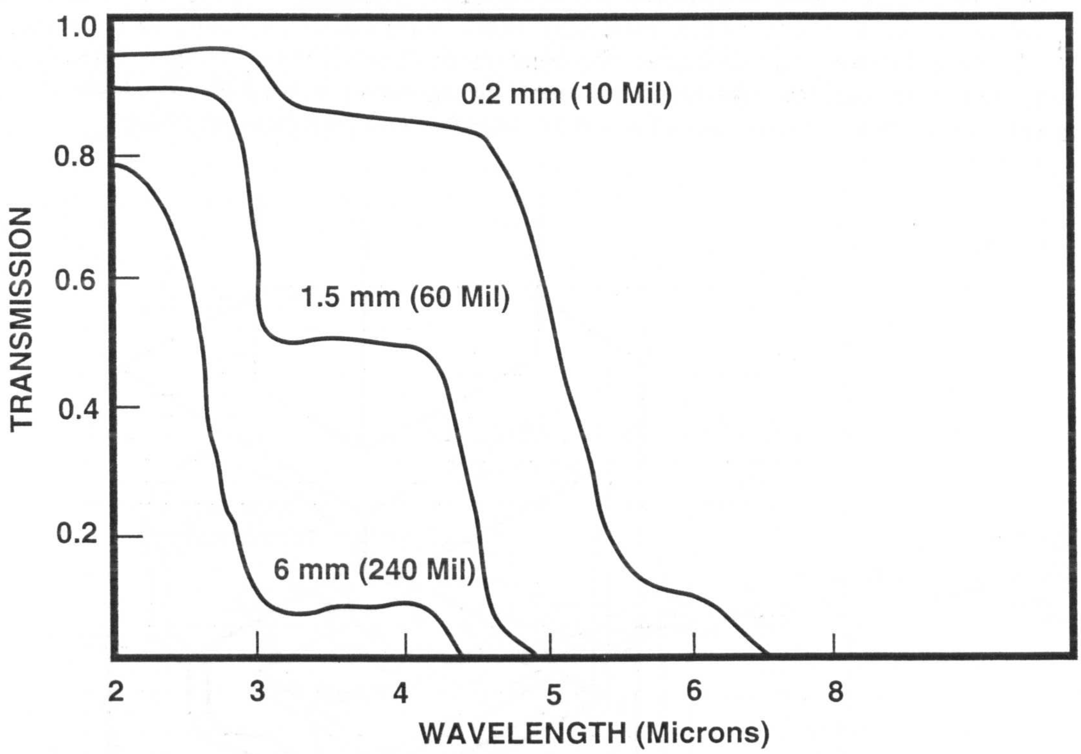


Figure 8: Spectral Transmission of Glass.

THE ENVIRONMENT

Atmospheric absorption is another consideration in selecting the spectral response of a device since certain components of the atmosphere, such as water vapor and CO_2, absorb infrared energy at certain wavelengths and cause transmission losses. If these absorbents are ignored, the displayed temperature may be lower than the actual temperature of the object. Fortunately, there are "windows" in the infrared spectrum which avoid these absorption bands. Manufacturers have largely removed the need for end users to worry about atmosphere by building atmosphere correction into products. Once again, it is best to use the shortest wavelength possible, since small changes in energy due to temperature will be greater than small changes in atmospheric transmission.

Also important to consider are sources of energy in the object's environment. Heat sources near the object may transmit or reflect energy. For example, measuring the temperature of tubes in a furnace may be affected by the higher temperature of the furnace walls. This is called the "T-ambient" effect. Many infrared instruments have a T-ambient correction: if the higher T-ambient temperature of the environment is not taken into account, the temperature reading of the object may be too high. The highest accuracy is achieved by using the correct emissivity and T-ambient corrections.

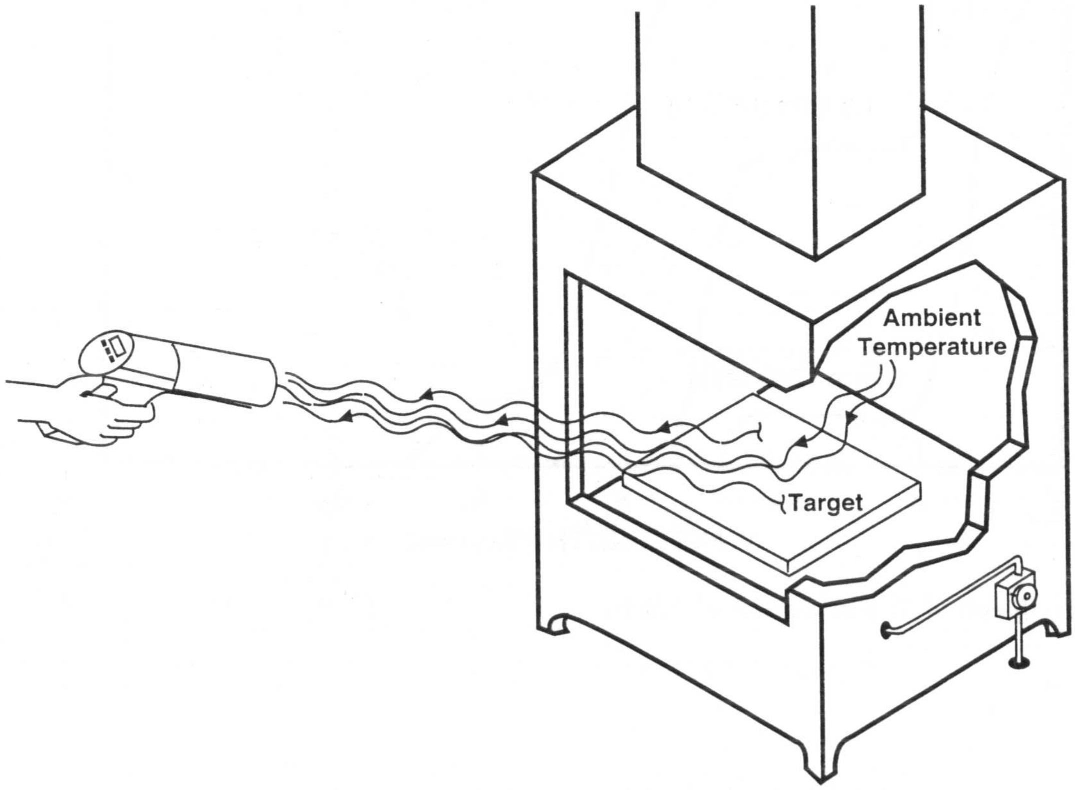


Figure 9: Ambient Energy. High ambient energy in applications such as ovens or furnace walls may result in a temperature reading that is higher than the object. Instruments include a T-ambient function to correct for high ambient energy.

AMBIENT ENERGY

Dust, steam, and particulate which are in the atmosphere can impact the radiated energy which reaches the sensor. In these environments it may be necessary to keep the lens clean by using an air purge collar. If the environment exceeds the specified operating temperature of the sensor, the instrument may need to be protected from the high ambient temperature through careful mounting, water or air cooling, air purging, and high temperature cables and conduits. With water cooling, it may be necessary to use an air purge collar to prevent condensation on the lens.

SPECTRAL RANGE GUIDELINES

1. Choose the shortest wavelength for the temperature range.
2. Use a longer wavelength if a lower temperature is required or the emissivity of the object is higher at the longer wavelength.
3. Be aware of potential problems arising from atmospheric absorption or target transmission.

THE USE OF WINDOWS IN INFRARED MEASUREMENT

Physical windows may be needed in certain applications, such as vacuum furnaces, to isolate the sensor from the environment in order to improve the temperature reading. In choosing a window, it is important to match the transmission qualities of the window to the sensor's spectral response. Fused silica or quartz is the most common material used for high temperature applications. For low temperatures in the 8 to 14 micron band, it is necessary to use special infrared transmitting materials such as germanium, Amtir, or zinc selenide. In addition to matching the window to the sensor's spectral response, window design criteria include window diameter, temperature requirements, maximum window pressure differential, environmental conditions, and the ability to keep it clean on both sides. Adding an anti-reflecting coating to a window may be important to increase transmission capabilities. Finally, it is necessary to consider whether one must visually see through the window.

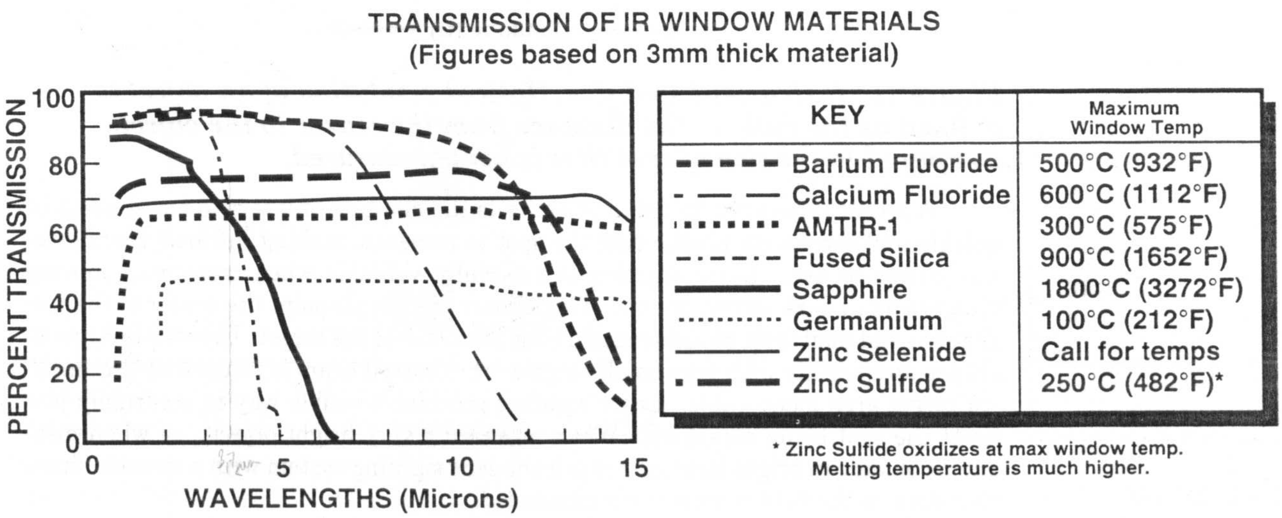


Figure 10: Transmission of window materials. Physical windows may be constructed in order to isolate the sensor from an extreme environment. Window materials should be matched to the instrument's spectral response.

THE INFRARED DEVICE: OPTICS

So far we have reviewed characteristics of the object and its environment as they related to infrared temperature measurement. The first element of the infrared thermometer itself to consider is the optics.

The optical system in an infrared thermometer collects the infrared energy from a circular measurement spot and focuses it on a detector. The optics are similar to those used in photography. The optical system must be positioned so that background infrared radiation does not enter the optics field of view. The highest optical resolution and the smallest spot size that can be measured are obtained at the focused measurement spot that is part of the instrument's specifications. The spot size increases before and beyond the focused spot distance. Optical resolution is defined by the ratio of the distance from instrument to the object, compared to the size of the spot being measured (D:S ratio). The larger the ratio number, the better the instrument's resolution, and the smaller the spot size that can be measured.

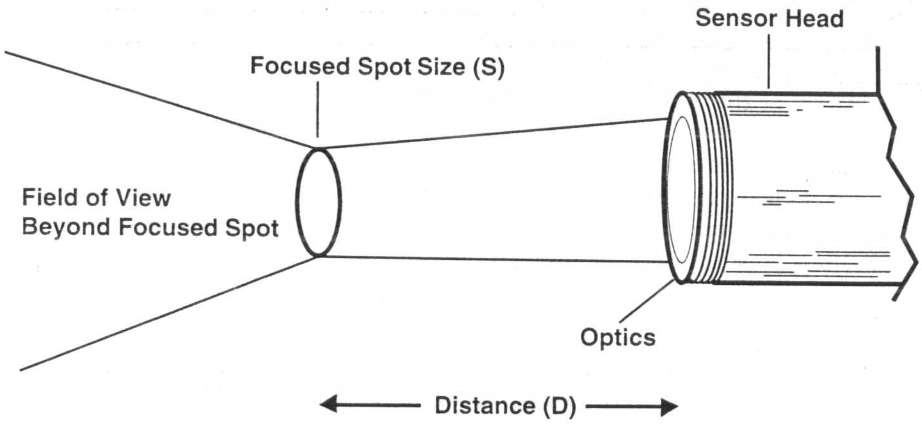


Figure 11: Instrument spot size. Optical resolution of an object is defined as the ratio of the distance from the sensor to the object, compared to the size of spot that is being measured.

A recent innovation in infrared optics is the addition of lasers to assist users in quickly and accurately pinpointing the spot to measure, making infrared thermometers easier to use. Laser sighting is especially valuable when measuring moving objects and in dark environments. Single laser models pinpoint the center of the target area and dual laser models measure the diameter of the target. Crossed laser models are appropriate with very small targets; the crossed beam is focused on the smallest target area measurable. Laser sighting provides a visible way to accurately pinpoint the spot being measured. When measuring very bright objects, or when measuring outside in bright light, a through-the-lens sighting system with a circular shape that defines the field of view is recommended.

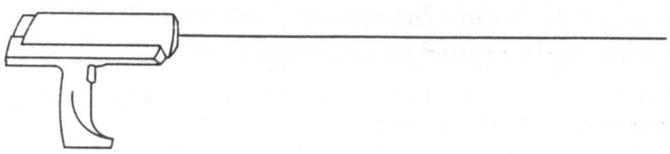


Figure 12: Laser sighting helps pinpoint the spot being measured.

DETECTORS

Detectors are the heart of the infrared sensor. Detectors convert the infrared energy measured into a linear, electrical signal, in this case temperature measured in degrees C or F. Recent innovations in electronics have increased stability, reliability, resolution and speed while lowering the cost of infrared thermometers.

There are four types of infrared detectors: photoconductive, photovoltaic, pyroelectric and thermovoltaic. Photoconductive and photovoltaic detectors are used primarily in imaging and line scanning systems. Single point infrared thermometers most commonly use either pyroelectric or thermovoltaic detectors. These have a lower but uniform spectral response. Pyroelectric detectors, which are essentially rate detectors, must use "choppers" in order to obtain a continuous signal. Chopping frequency influences the response time and must be synchronized to the electronic system. Thermovoltaic detectors, such as thermopiles, are usually gas-purged in order to maintain stability. They are somewhat equivalent to multiple thermocouples layered upon each other. They provide a voltage output directly proportional, although non-linear, to the incident infrared radiation. These detectors require spectral filtering to avoid atmospheric and visual influences.

EXAMPLES OF INFRARED DETECT

Type	Exam
Photoconductive	•Merc Cadmi Telluri
Photovoltaic	•Silicon •Indiun Gallium Arseni
Pyroelectric	•Lithium Tantila
Thermovoltaic	•Therm

DISPLAY AND OUTPUT

The last element of an infrared thermometer is the instrument display and output. Displays may be used as the primary output from the unit, especially in monitoring applications, or they may also be used to enter parameters into the unit. Outputs are used to drive the primary displays and can be sent to meters, recorders, printers, or computer software programs for data logging, tracking and analyzing.

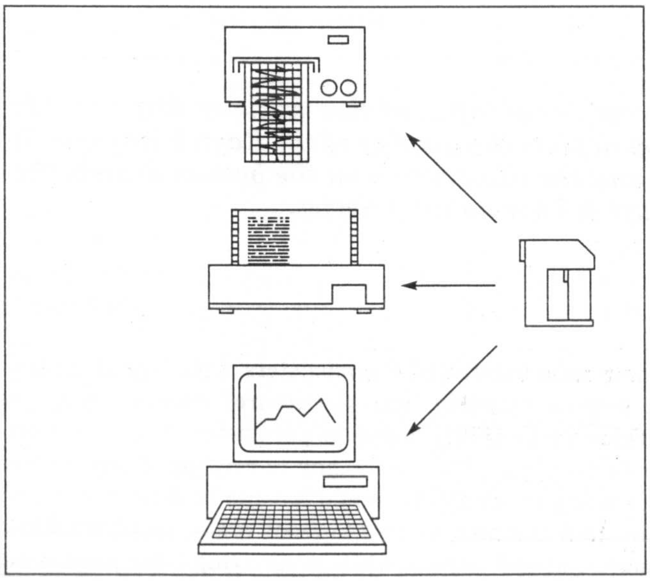
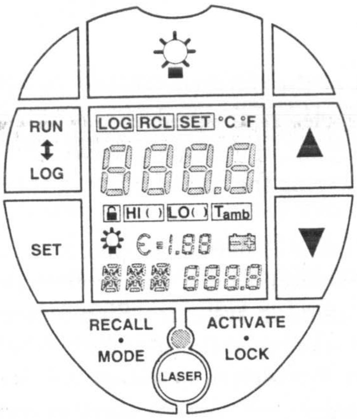


Figure 13: Data outputs of infrared thermometers provide a direct interface to chart recorders or printers. Customized temperature graphs and tables can be created and displayed with software programs running on personal computers.

RAYTEK RAYNGER 3 i



RAYTEK THERMALERT 4 SERIES

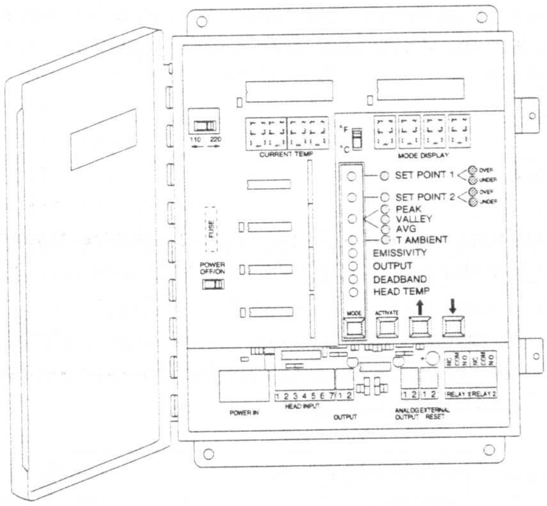


Figure 14: Examples of infrared thermometer displays. The illustration on the top depicts the display of the Raytek Raynger 3i portable thermometer and the illustration on the bottom depicts the online display of the Raytek Thermalert 4 Series.

A recent innovation in infrared thermometers is the "smart sensor" which allows users to adjust sensors remotely from the control room without interrupting the process and provides the flexibility to change parameters as different products are run on the same production line. Previously, any re-ranging of any instrument, such as adjusting for emissivity or set points, would have to be done manually at the sensor. Since sensors are often mounted in hard-to-reach areas, smart sensors ensure consistent process monitoring and control, while minimizing labor requirements. If something goes wrong with the process, such as a high ambient condition, cut cable, or failed components, fail-safe conditions are automatically employed. Smart infrared monitors can read and accept sensing heads of different spectral responses or optical characteristics.

Selecting an Infrared Thermometer

Matching the Instrument to the Application

PORTABLE AND ONLINE PRODUCTS

Both handheld portable and fixed online infrared thermometers are commercially available. Sometimes critical points are measured using online instruments, while other areas in the plant are measured on a periodic basis using portable instruments.

Portable units are most often used for preventative maintenance, trouble shooting and quality control functions. Concerns for portable instruments are product weight, ruggedness, ease-of-use, easy-to-read displays and long battery life.

Online instruments are generally installed in one location to continuously monitor or control a given process. Online sensors provide fast, noncontact, and reliable measurement of objects which may be moving, inaccessible or damaged by traditional methods. Online sensors may measure a single point or several points in the process. Data can be incorporated directly into the process or monitored for future adjustments. In some applications where the environment is extreme or hazardous for operators, a sensor head may be chosen that is separate from the output/display. Concerns for online thermometers are sensor size, environment, display and output requirements. A range of accessories is available for installation, cooling, and sighting to customize the online sensor to the target application.

Line scanners are a step up in sensor complexity and are appropriate for noncontact temperature profiling applications. Line scanners measure temperature across a moving web or other target, rather than a single point, and create graphical thermal profiles that ca stored and analyzed on con er. With a line scanner, u analyze data against kn standards in real time.

RAYTEK THERMALERT MP4 LINE SCANNER

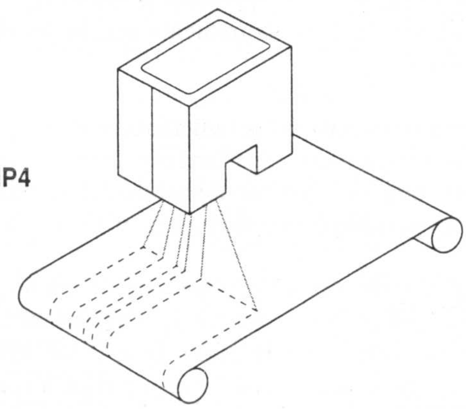


Figure 15: Line scanners are a step up in scanner complexity. They measure temperature across a moving web, rather than at a single point.

TYPICAL APPLICATION FOR INFRARED THERMOMETERS

Portable Applications

Electrical inspection

Maintenance

Refractory and insulation inspection

Food storage

Online Applications

Plastics, paper, textiles processing

Printing

Pre-coat metal

Food processing

Kiln refractory

INSTRUMENT SPECIFICATIONS

Temperature Range: Select an instrument whose temperature range most closely matches the target range. Consider whether it will be important to monitor the start-up temperatures, or just the temperatures while the process is in operation. Lower temperature applications may need to be measured at longer wavelengths. Some infrared thermometers now provide adjustable temperature ranges, a feature which allows tighter temperature monitoring and control.

Spectral Response: In general, use shorter wavelengths when measuring objects with changing or unknown emissivity. When measuring plastic or glass, use wavelengths where the material is opaque to avoid transmission problems. Day-to-day differences in humidity or CO_2 may affect the repeatability of temperature readings. Most instruments use spectral ranges that avoid atmospheric absorption, but some instruments — especially those used for close measurement and specialized, narrow band instruments — may need to account for atmospheric factors. Two color ratio instruments, where temperature is determined from the ratio of the radiated energies in two separate wavelength bands, are a good choice when the field of view is only partially filled.

D:S: The distance to size ratio is determined by dividing the distance from the object to the sensor by the size of the spot being measured. Larger D:S ratios are better, providing measurement of smaller objects at longer distances. The object should fill, and remain in, the field of view during the measuring period. If the object is smaller than the spot size, the sensor will be influenced by background objects or an energy source to one side of the object. Inaccuracy may also occur if the object is much larger than the spot size. It is critical to match the target size or spot to the manufacturer's specifications.

Accuracy: 1% of the reading at a specified ambient temperature is a common specification. At lower temperatures an absolute temperature is often also specified since a percentage specification is not valid as temperatures start approaching zero. Accuracy is often compared to the "actual" value as determined by a thermocouple or other contact thermometer. High accuracy is not always required. In many cases it is only necessary to know whether the temperature is deviating from the baseline. High accuracy is important, however, if measurements will be taken in different locations with different instruments.

Repeatability: The ability to repeat the temperature reading under the same conditions, time after time, is often a more important consideration than accuracy. Ambient temperature, emissivity, and background (for incompletely filled fields of view) must be controlled as much as possible from measurement to measurement.

Response Time: Response time specifications should only be used as a guideline. In evaluating the response time of an instrument, it is important to understand the application and how it will be used. Fast response time is not always necessary or even desirable. If the instrument is being used for monitoring, a rapidly changing or flashing display may provide more information than necessary and irritate the operator. If there is significant thermal lag in heating a process, speed in the instrument may be useless. On the other hand, some applications, such as moving or quickly heated objects, do need a fast response time. Most manufacturers define response time as the time to reach 95% of the final temperature value.

Ambient Operating Temperatures: If ambient temperatures exceed the rating of the instrument, it is necessary to add a water, air or other cooling jacket. Any necessary cabling, as well as the instrument, must be rated for the ambient temperature.

Displays: Digital displays are gradually replacing the traditional analog displays, although both are still available. Digital displays provide the benefits of averaging and the ability to show long term trends. They are generally easier to read and can minimize operator error. LED displays are easier to read in low light situations, but can be difficult to read in sunlight. LCD displays offer users the ability to view multiple variables simultaneously. The addition of back lighting to an LCD display improves readability. Graphic displays are available which show trends of temperature information over time. These are often hooked up to personal computers for online monitoring.

Data Outputs: Infrared thermometers provide a choice of outputs allowing users to connect to existing controllers, monitors, recorders and data acquisition systems.

Current: The most common type of output is the 4-20 mA current loop. If the signal is to be used with a voltage input instrument, it must be converted and scaled. A specification that must be verified with the current output is the drive capability, frequently specified as the maximum impedance.

Voltage: Voltage outputs are more noise sensitive than current outputs, but are sometimes easier to use. Instruments commonly provide fixed voltage (such as 1 mV for each degree) so that the output can be displayed directly on a common voltmeter without scaling or translation. Simulated thermocouple output is often a useful voltage output that can be used to replace, or duplicate an existing thermocouple.

Digital: Digital outputs, such as an RS-232 or RS-485, are increasingly used. RS-232 connections can be enhanced to RS-485 for longer distances, faster transmission and support of multiple instruments on one line.

Computer: Data may be input directly to a computer for analysis and monitoring by a software program. Data can be input via RS-232 connections or a data acquisition board for voltage or current output.

On/Off Setpoints: On/Off setpoints allow users to set a normal range for the process. If the process falls outside the setpoints, an alarm or other action occurs.

Signal processing:

Peak/Valley Hold: An example of peak hold is hot bottles on a conveyer belt with the thermometer output fed into a controller. Without peak hold, the thermometer would read the lower temperature between the bottles and respond by increasing the process temperature. With peak hold, the instrument electronic response time is set to slightly longer than the time between bottles. Since the interval is longer than the time between bottles, there will always be at least one bottle represented in the temperature measurement. A manual reset is useful in applications where random objects need to be measured.

Averaging: Averaging is useful for smoothing noise in temperature inputs. If a sensitive control system is used, averaging the temperature output can be used to fine-tune the system.

Raytek and Noncontact Temperature Measurement

Noncontact temperature measurement using infrared technology has been used successfully in many process and control applications, from plastics manufacturing to food processing, and in maintenance applications, from refinery maintenance to diesel repair. New, smaller and less expensive sensors have opened this technology to users that could not have considered it before. On the other end of the market, infrared sensors are being tightly integrated with sophisticated computer software to provide online temperature analysis with immediate correction of error conditions. The addition of infrared temperature measurement to a process can immediately effect the bottom line by improving product quality, increasing production yields, reducing costs and eliminating process downtime.

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