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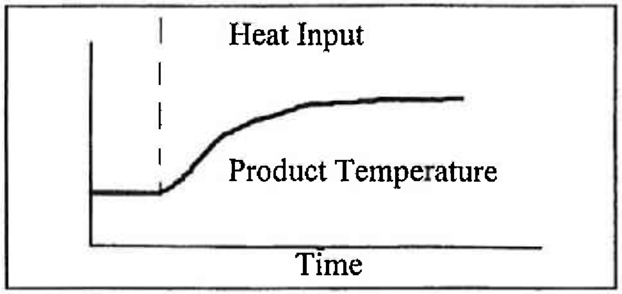
NOTES

Application Note #1
IRt/c Setup with Auto-tune
Temperature Controllers

In many applications, heating elements are employed to heat a product in an oven, furnace, or with jets of hot air. Conventional control devices using contact thermocouples measure and control the oven air temperature, IR heating element temperature, or air jet temperature in an effort to maintain product temperature and therefore, quality; often with less than satisfactory results.

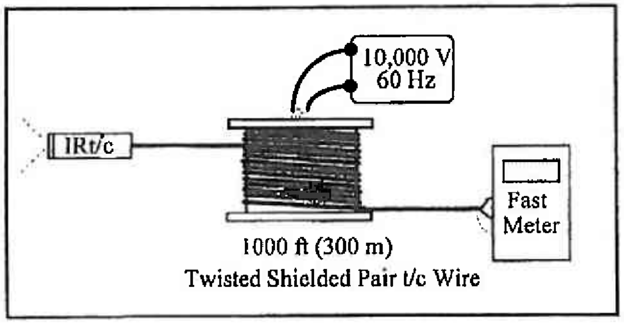
Replacing the contact thermocouple (for example measuring oven temperature) with a non-contact IRt/c measuring product temperature directly will insure that product temperature is maintained. Some readjustment of the controller parameters is required because of differences in sensor response times (an IRt/c is much faster) and time required to heat the product compared to the original sensor (slower). After installing the IRt/c and calibrating the controller reading using an OMEGA OS91 Digital Infrared Temperature Scanner (see Installation Section in the Operator's Manual), initiate the self-tuning cycle of the controller and check to see that the control is stable and accurate. If it will not self tune properly, manually adjust the control coefficients to achieve stable control. Because the product temperature is likely to change temperature more slowly than the original sensor, start with slowly increasing the "D" of the PID coefficients.



Application Note #2
IRt/c Can be Used with Up to 1000 ft (300m) of Thermocouple Wire

With twisted shielded pair thermocouple extension wire, an IRt/c can be mounted as far as 1,000 ft (300 meters) from the readout device, even in a very fierce electrical noise environment. A demonstration test was performed with a 1000 ft (300 m) coil of twisted shielded pair of extension wire, with 100 ft (30 m) unwound, connecting an IRt/c to a fast (100 msec response) A/D conversion module to a computer. As a noise generator, a 60 Hz 10,000 volt transformer and spark generator was set up to spark within 6 inches (15 cm) of the wire.

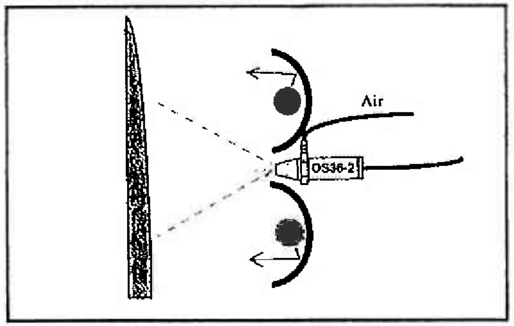
The test results showed less than 0.1°C of noise at any relative position of the wire, spark, and transformer. The extraordinary noise suppression characteristics designed into the IRt/c make it possible to locate it at very long distances, without the necessity of a transmitter. The IRt/c housing is electrically isolated from the signal leads and is connected to the shielded ground of the extension cable. For long distances, the twisted shielded extension cable should be used, and the shield connected to a good electrical ground.



Application Note #3
IRt/c Controls Paint Curing with Radiant Heaters

A rather logical combination of heating method and control is radiant heat with an IRt/c for control. They work extraordinarily well together, since both the heating and measuring occur right at the surface - where the paint is located. The IRt/c reading is unaffected by reflections from the heater, since the spectral response of the 6-14 micron IRt/c lens filters out the shorter wavelengths of the radiant heater energy.

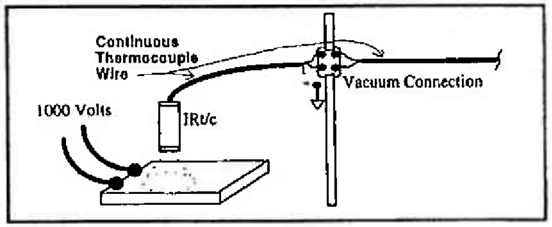
The IRt/c may be mounted in the shroud or reflector of the radiant heater, such that it can see through the elements. Select the IRt/c standard or OS36-2 model, depending on the field-of-view required to see past the elements to the painted surface. Test the location by turning on the heater with no target present. The change in reading should be small. Care should be taken in mounting the IRt/c in such a way as to keep its temperature below 200°F (93°C) and to keep the lens clean. The OS36-2 is the preferred model for this application because of its built-in air purge. It can be used in temperatures to 250°F (121°C) environments when the air purge system is used. It's narrower field-of-view allows more leeway in positioning, and thus more flexibility in installation. For still narrower fields of view, specify the OS36-5 with its 5:1 FOV.



Application Note #4
IRt/c Solves Vacuum Furnace Electrical Isolation Problems

A vacuum furnace manufacturer employs a heat treating process in which the metal parts experience an electrical potential of 1000 volts. To control the heating process to produce the correct metallurgical properties, a conventional thermocouple is embedded in one of the parts to produce the temperature signal for the controller. However, since the parts are at 1000 volts, an elaborate electrical isolation system has to be employed to permit the thermocouple to work safely, at a cost of well over $2,000 for the isolation equipment.

Replacing the contact thermocouple with a non-contact IRt/c, the manufacturer effectively replaced $2,000 worth of equipment with about 1 inch (2.5 cm) of vacuum separation between the IRt/c and test part - which is free. Unlike a contact thermocouple, the IRt/c can easily see the part through the vacuum, measure its temperature without touching, and is completely isolated electrically by the gap between the part and IRt/c. Since the part is heated to 1000°F (538°C), an aluminum clamp is employed as a heat sink to keep the IRt/c itself below 200°F (93°C). Since the part emissivity is low (shiny metal) the test part has a small area painted with Rustoleum Barbecue Black Paint, rated to 1300°F (704°C), to raise the emissivity. At 1000°F (538°C), the IRt/c is outside of its linear range, but well within its repeatability limit of 1200°F (650°C), so a simple calibration of the controller brings the IRt/c signal to an accurate reading.

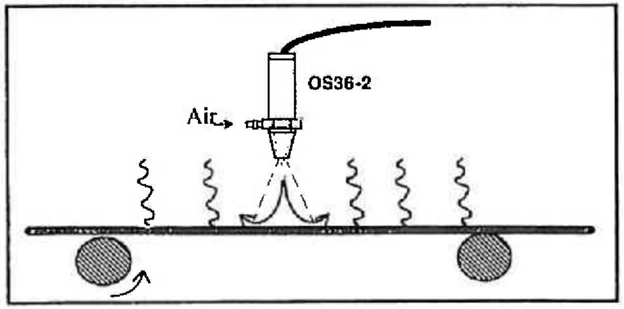


Application Note #5
IRt/c Temperature Measurement in Steaming Environments

A common problem of paper and other material processing is measuring temperature in an area in which steam (water) is used to heat and cool the material. The resulting steam vapor over the material makes it very difficult to use non-contact infrared devices because steam vapor is opaque to infrared wavelengths commonly used, i.e. the sensor cannot see through the vapor fog very well, and thus would report temperatures that were too low. In addition, condensing steam vapor on the sensor lens would render the IRt/c completely blind to IR wavelengths.

The OS36-2 model solves all of the problems in a simple and inexpensive fashion. Employing the built-in air purge, the air jet emerging from the tip will clear a path to the target material by "blowing away" the steam vapor, thus replacing the steam in the optical path with dry air. Care should be taken in the set-up of distance to the target and air pressure employed, to prevent cooling of the target area by the air jet.

The air purge also keeps the lens clean and prevents condensation. The cooling effect of the air purge air should maintain the OS36-2 temperature in a safe range in the steam vapor without any additional measures.

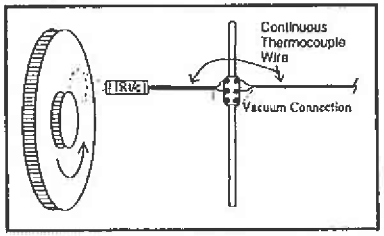


Application Note #6
Rotor Disk Tests in Vacuum

A standard requirement for large steam and gas turbine rotor disks is spin testing to assure mechanical reliability at the high force conditions during full speed operation. This testing is usually conducted in a large vacuum chamber to minimize the required power to drive the rotor. However, the vacuum is not perfect and rotor heating does occur during the test. To properly assess the performance at operating speed, the disk temperature must be known. Standard methods of measuring temperature have included disk-mounted sensors, using slip rings or telemetry to transmit the data - both of which are clumsy and expensive.

The IRt/c provides a simple and elegant solution since it can directly measure the temperature of the rotor under full speed conditions. With its hermetically sealed construction, the IRt/c operates in a vacuum without any requirement for protection. Its thermocouple leads can be connected to a standard thermocouple vacuum connector.

Test installation design considerations should include IRt/c body temperature and target emissivity. To assure that the IRt/c will remain below 200°F (95°C) even with very hot targets, use a solid metal mounting arrangement to heat sink the IRt/c body, since the internal construction is designed to readily conduct away the radiated heat. For emissivity considerations, a shiny metal rotor disk should have black painted stripes in the areas of measurement.For best accuracy, the IRt/c read-out device can be calibrated to the precise surface conditions by using an OMEGA OS91 Digital Infrared Temperature Scanner.

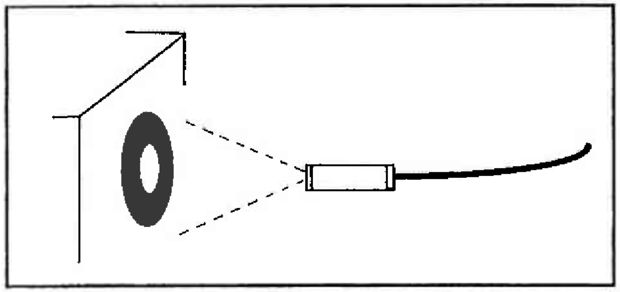


Application Note #7
IRt/c Monitors Plastic Injection Mold Cleaning

A sometimes serious problem in high volume plastic injection molding machinery is a molded part that does not clear the mold. The result is a long down time period to clean up or make repairs.

A particularly useful property of the mold is its shininess, which means low emissivity. Accordingly, the infrared radiation from an open mold is primarily reflected from the room, and thus an IRt/c pointed at the mold would not read much higher than room temperature. However, if a part were still in the mold, the IR radiation is far higher since the high emissivity of the plastic part is easily seen by the IRt/c as the temperature of the hot part. By mounting an IRt/c such that it can view the part as the mold opens, connecting it to a simple t/c controller with alarms interfaced to the mold position, a reliable and inexpensive part detection system can be installed.

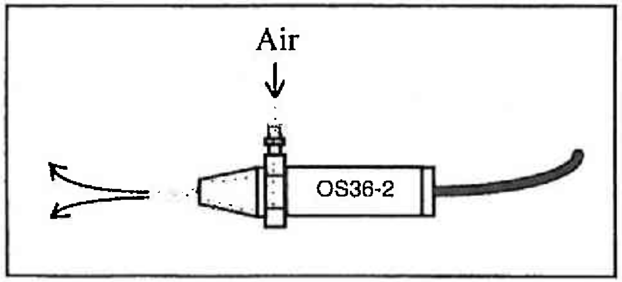
For harsh environments, the OS36-2 or OS36-5 models with narrow field-of-view and built-in air purge are recommended.



Application Note #8
OS36-2 Reduces Air Purge Consumption by Factor of 100

For continuous duty service in many manufacturing operations, infrared temperature sensing heads are provided with an air purge function to keep the lens clean; especially in particularly dirty or oily environments. Even a small amount of dirt or oil coating on a lens can affect the reading: if 5% of the lens area is covered, then 5% of the reading is lost. For conventional IR devices, with lens size of 1" (2.5 cm) or more, upwards of 1 CFM (.03 cubic meter/min.) is required to maintain cleanliness. At typical costs for plant compressed air, a single continuous duty conventional IR sensor uses approximately $100 of air per year. Clearly, if a plant has many IR installations, the cost of air is of considerable concern.

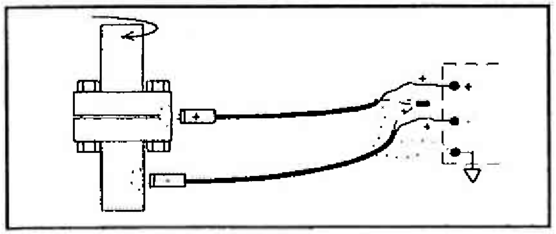
The unique design of the OS36-2, with its extraordinary thermal stability and small 1/4 inch (.6 cm) lens makes it possible to purge with as little as .01 CFM (.0003 cubic meters/min.) of air. With such a small amount of air, it becomes possible to use instrument air, if it is conveniently available, which is already clean and dry, without adding the additional hardware to clean and dry the IR purge air. In addition, the OS36-2 can be air purged with a small air pump (OS36-APK available from OMEGA), thus not requiring a plant air source. At the very low flow rate, the IRt/c air cost is only approximately $1 per year, a 100-fold reduction over conventional IR devices.



Application Note #9
IRt/c Monitors Mechanical Drives
for Impending Failure

For certain highly loaded mechanical drive elements, such as the main rotor drive for a helicopter, it is imperative that impending failure be known before a catastrophe occurs. A central element of the drive, such as a universal joint or coupling, will telegraph its impending failure by displaying an increase in temperature well in advance of failure. For example, if a drive transmitting 1000 hp (750 kW) of shaft power with a universal joint, loses only 0.1% in drive efficiency, the joint will increase in temperature until it is able to dissipate an additional 750 watts of energy as heat. This increase in temperature is a direct and reliable indication of the increased inefficiency, which is in turn caused by a degradation in parts performance.

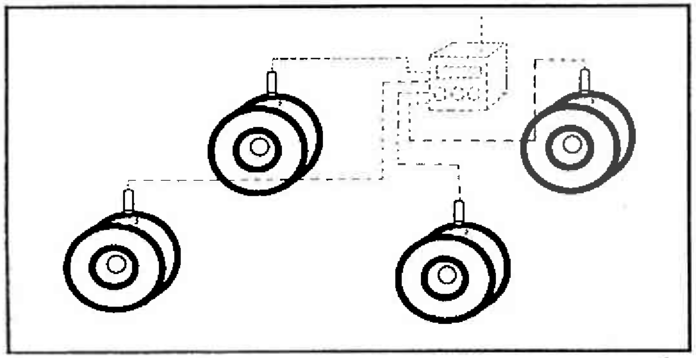
Monitoring the joint with an IRt/c provides a fast and direct indication of joint temperature, and thus the increasing inefficiency due to wear or failure. A more sensitive method of monitoring the joint is to employ two IRt/c's wired differentially (connecting the two minus leads together and measuring across the plus leads, see example), measuring the difference in temperature between the joint and adjoining shaft. This difference is a direct measure of the heat created in the joint and will not be influenced by ambient temperature effects, since the differential pair arrangement cancels those effects. Accordingly, a very high precision can be achieved. The OS36-2 with its built-in air purge is recommended if the environment is oily or dusty.



Application Note #10
IRt/c Monitors Tire Temperatures for Racing Performance

Tire temperature is of critical concern in automotive racing for two reasons: the tire temperature directly affects its adhesion and its wear characteristics; and tire temperature patterns provide valuable information on the set-up and performance of the suspension. For example, excessive loading of a tire caused by out-of-tune suspension will cause that tire to become considerably warmer than the others.

The IRt/c has proven to be an ideal measuring device for on-board data acquisition, due its small size, ruggedness, and low cost. It may be connected to standard thermocouple read-out systems. Installation should include connecting the shield to a suitable ground in order to avoid interference from the electrically harsh environment of a racing automobile. Mechanical installation should include attention to air flow patterns to minimize dirt building on the lens. The OS36-2 or OS36-5 are recommended due to their narrower field of view, thus allowing you to position further away.

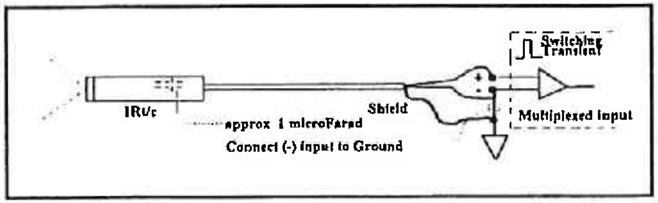


Application Note #11
Multiplexed Datalogging Applications

An occasional problem introduced by switching-type thermocouple dataloggers is signal offset caused by the switching transient. The IRt/c is a completely passive device and produces an electrical signal entirely via thermoelectric effects, but does contain both resistance and capacitance above the levels found with conventional thermocouples. Many interface devices generate a small leakage current, which induces no shift in signal with conventional low impedance (<100 ohm) thermocouples, but may induce an offset with the higher IRt/c impedance (~3K ohm). This type of offset is normally stable and is simply calibrated out by adjusting the device's or ZERO and SPAN adjustments.

However, switching the thermocouple input can also cause offsets in IRt/c readout due to the presence of capacitance, if the signal leads are connected in a differential fashion to the amplifier input. A switching transient voltage stores a charge in the capacitance, which can cause the equivalent of leakage current offset. This offset could also be calibrated out, but may not be stable. A preferred method is simply to ground the negative side of the thermocouple input as shown below.

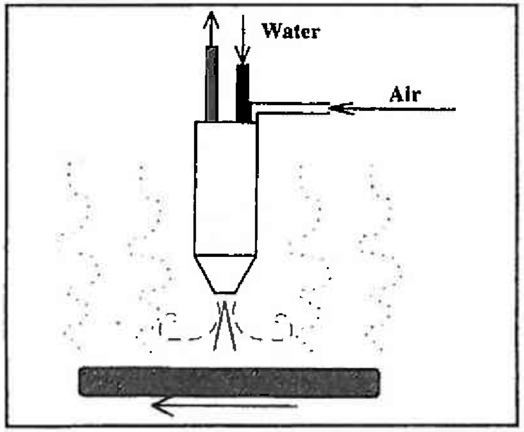
The ground provides a path for the charge caused by the switching transient to dissipate, thus eliminating the offset. The twisted shielded pair wire with shield connected to ground will compensated for any loss of noise rejection, and thus provide a clean signal.



Application Note #12
Air Purging is Recommended When Using Water Cooling

Very often the environment inside an oven contains vapors from the process which may condense on cooler surfaces inside the oven. When an IRt/c is used inside the oven to monitor the temperature of the process, the IRt/c must be cooled if the environment is above 212°F (100°C). Using the convenient OS36-APC (Cooling Jacket) available from OMEGA either air or water may be used. For temperatures above 500°F (260°C) water is required.

However, even if water cooling is selected, a small amount of purge air is recommended to keep the IRt/c lens clear of vapors that would condense on its window, since the window temperature might be below the condensing temperature of some of the vapors of the process. The OS36-2 is particularly suited for this service since the air consumption required to keep its lens clean is as little as 0.01 CFM (300 cc/min). A small convenient self-contained air pump kit (OS36-APK) is available from OMEGA.



Application Note #13
Why Offset are Caused by Leakage Currents with Some Readout Devices

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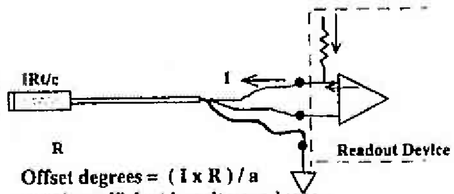
Many thermocouple readout devices produce leakage currents which can cause offsets when using an IRt/c. The current originates from two sources within the device: leakage current actually generated by the input amplifier; and leakage current intentionally injected to the thermocouple circuit to detect an open circuit due to wire breaks. These currents are normally of no consequence with conventional thermocouples with resistances < 100 ohms. However, with the higher resistance of the IRt/c (~ 3KΩ), devices with high currents will create offsets.

As an extreme example, a device producing 1 microamp of current will result in less than one degree offset with an ordinary t/c with 10 ohms resistance. That same device reading an IRt/c at 3KΩ will produce an offset of the order of 100°F (55°C). Most readout devices have considerably smaller leakage currents and consequently smaller offsets. As a general rule, the smaller the offset the better, and readout devices should be chosen accordingly if other factors are equal.

The calibration procedure described in the OS36, OS37, OS38 manual is recommended for field use. For designers of readout devices, it is recommended that both sources of leakage current be reduced to 10 nanoamps or less to minimize offset errors.



Offset degrees = (I x R) / a

a = t/c coefficient in volts per degree

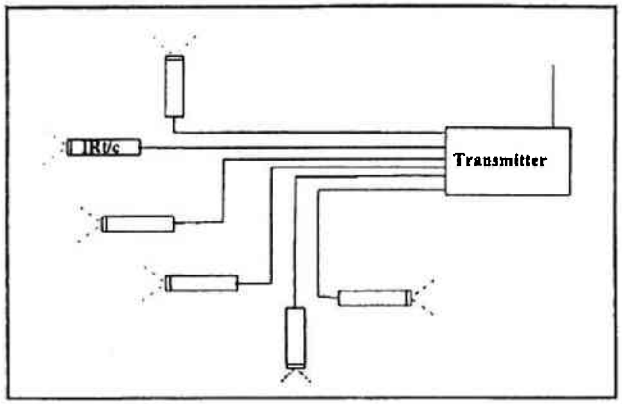
= approx 22 microV / deg F (40 / deg C) for type K

= approx 28 microV / deg F (50 / deg C) for type J

Application Note #14
IRt/c's as Disposable Infrared Sensors

Destructive testing is commonly used in a number of industries, including, for example military weapons testing and fire safety testing. Thermocouples are commonly used for temperature measurement, and are connected to telemetering equipment to transmit the data before the sensor is destroyed in the test. Infrared would be preferred for a number of these measurements because of speed, convenience, and non-contact capability, especially in measuring the radiant temperature. However, the cost, complexity, and general fragility of conventional IR systems have made such applications impractical and prohibitively expensive.

The IRt/c, however, is ideally suited for this type of service. Its compatibility with thermocouple telemetering devices, small size, ruggedness of construction, and overall reliability makes it an excellent replacement for standard thermocouples. At one-tenth the cost of most conventional IR devices, it is economical enough to be used in "disposable" applications.



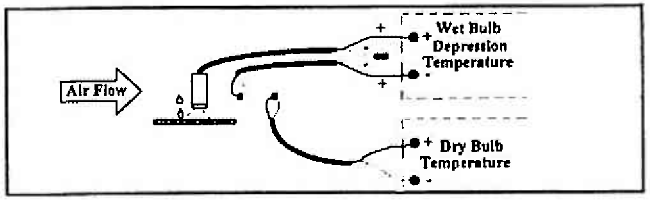
Application Note #15
Relative Humidity Measurement

IRt/c's can be used to measure actual relative humidity in many situations where there is a convenient source of water and flowing air, and measure it accurately and reliably.

An IRt/c aimed at a wet porous surface with ambient air blowing across the wet surface can actually measure what is called "wet bulb" temperature for that ambient area. (More precisely, wet bulb temperature is the equilibrium temperature of the air-water interface when a water film is evaporated. When air is moved over a wet surface, the water cools by evaporation until it reaches wet-bulb temperature, then the cooling stops, no matter how much more air is moved over the surface. The temperature at which the cooling stops is the wet bulb temperature.).

The IRt/c measures the temperature of the air-water interface on a surface directly. The quality of the water or of the absorbing material does not affect the reading, since the IRt/c can directly view the air-water interface, and the wet bulb equilibrium temperature is not materially affected by impurities.

The highest precision method is to employ an IRt/c wired differentially with a conventional thermocouple to measure the quantity "wet bulb depression". The differential pair arrangement guarantees high accuracy, since RH is a strong function of wet bulb depression and a weak function of dry bulb temperature. Standard psychrometric tables, charts, and software algorithms can be used with the data to obtain accurate relative humidity for your environmental measurements.



Application Note #16
Controlling Web Roller Temperature

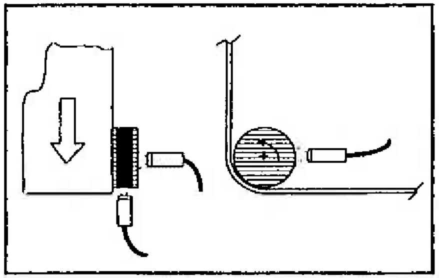
The IRt/c infrared thermocouples have quickly become the sensors of choice for monitoring and controlling both web and roller temperatures. Tips on accurate roller temperature measurement:

1. Uncoated Metal or Chrome Rolls - Shiny, uncoated metal rolls are difficult for any infrared sensor to properly sense the true temperature (the sensor will see too many environmental reflections). The solution to the problem is to simply: paint a small black stripe on an unused end of the roller. Aim the IRt/c sensor at the black paint stripe. It will then measure the temperature accurately and reliably regardless of changes in the surface conditions of the rest of the roller.

If there is very little space on the edge of the roller, move the sensor closer and paint a very small black stripe. The minimum spot size of the IRt/c is 0.3 inches (8 mm) and for the OS36-2 it is 0.16 inches (4 mm) when the sensor is brought close to the surface.

2. Dull Metal Rollers - Dull metal rollers can provide a reliable signal. It is best to test the surface for reliability, though, as the surface emissive properties may shift via dirt, moisture, cleaning, etc. It is best, if in doubt, to simply paint a stripe to eliminate these variations.

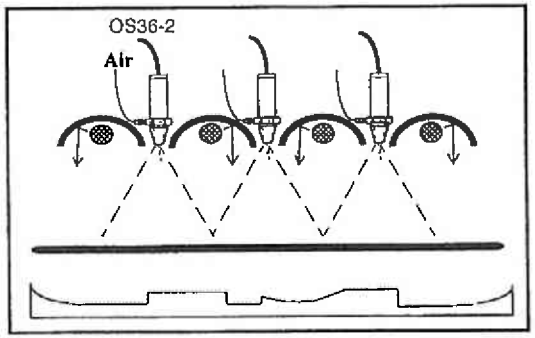
3. Non-metallic Surfaced Rollers - These will provide a reliable IR signal at any point the IRt/c is aimed. No painted stripe is required.



Application Note #17
Controlling Vacuum Forming and Thermoforming Processes

For forming plastics, an excellent combination of heating method and control is radiant heat with an IRt/c for control. They work extraordinarily well together, since both the heating and measuring occur right at the surface - where the plastic is located. The IRt/c reading is unaffected by reflections from the heater, since the spectral response of the 6-14 micron IRt/c lens filters out the shorter wavelengths of the radiant heater energy.

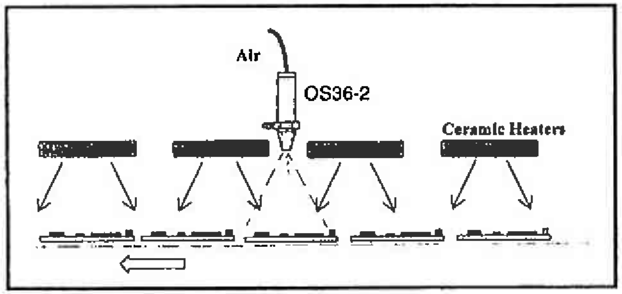
The IRt/c may be mounted in between ceramic heaters, or in the shroud or reflector of the radiant heater, such that it can see in between the elements. Select the IRt/c standard, OS36-2 or OS36-5 model, depending on the field-of-view required to see past the elements to the painted surface. Care should be taken in mounting the IRt/c in such a way as to keep its temperature below 200°F (93°C) and to keep the lens clean. The OS36-2 is the preferred model for this application because of its small physical size with built-in air purge. It can be used in temperatures to 250°F (121°C) environments when the air purge system is used. It's narrower field-of-view allows more leeway in positioning, and thus more flexibility in installation. For still narrower fields of view, specify the OS36-5 with its 5:1 FOV.



Application Note #18
IR t/c Controls Printed Circuit Board Preheat During Wave Soldering

An excellent solution to the problem of proper heater control for PC board preheat is an IRt/c. They work extraordinarily well together, since both the heating and measuring occur right at the surface - where the solder must flow. The IRt/c reading is unaffected by reflections from the heater, since the spectral response of the 6-14 micron IRt/c lens filters out any shorter wavelengths of the radiant heater energy.

The IRt/c may be mounted in between ceramic heaters, or in the shroud or reflector of the radiant heater, such that it can see in between the elements. Select the IRt/c standard, OS36-2 or OS36-5 model, depending on the field-of-view required to see past the elements to the PC boards. Care should be taken in mounting the IRt/c in such a way as to keep its temperature below 200°F (93°C) and to keep the lens clean. The OS36-2 is the preferred model for this application because of its small physical size with built-in air purge. It can be used in temperatures to 250°F (121°C) environments when the air purge system is used. It's narrower field-of-view allows more leeway in positioning, and thus more flexibility in installation. For still narrower fields of view, specify the OS36-5 with its 5:1 FOV.



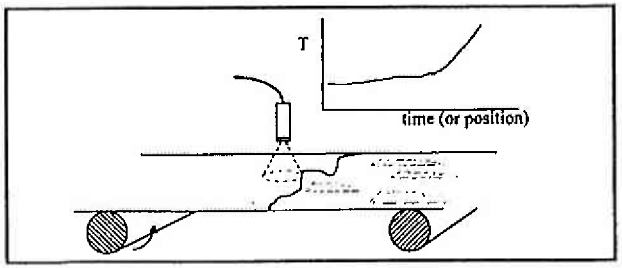
Application Note #19
IR t/c Controls Product Drying
(Paper, Wood, Texiles, Film, etc.)

In many processes such as paper, wood and textile products, it is important to be able to determine quickly when the products are sufficiently dry.

The surface temperature of a "wet" product will change (rise) very slowly as constant heat is applied to the product. This occurs because the moisture in the product absorbs much of the heat energy as it evaporates. At the point that the product becomes "dry", however, the same constant heat supply will quickly raise the temperature until it reaches the same as the surrounding air, or higher if the heat source is radiation. If temperature vs. time is plotted for a heated drying process, the target "dry" temperature point can clearly be seen as the beginning of a rapid rise in surface temperature.

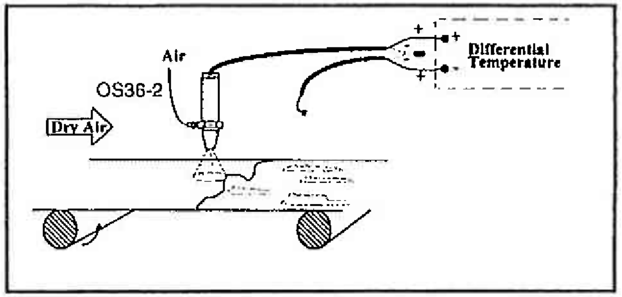
The IRt/c's can be used to monitor these changes in surface temperature. With their fast 80 ms response time, the IRt/c's can quickly detect when the surface temperature begins to rise rapidly, an indication that the products have reached a low moisture content.

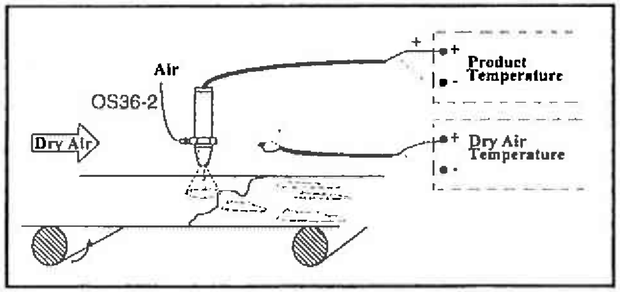
A simple implementation method is to measure the difference in temperature between the product and the ambient air. Determine the delta T that results in the correct dryness, and set the control system to maintain that delta T.



The IRt/c is particularly convenient in that it can be wired differentially with an ordinary thermocouple and the combined signal fed to a single control channel. Alternatively, if absolute temperature is preferred, the IRt/c and t/c can be read and controlled independently.

For hot, humid, dusty environments, the OS36-2 is recommended because of its small size and super-efficient purge air system.



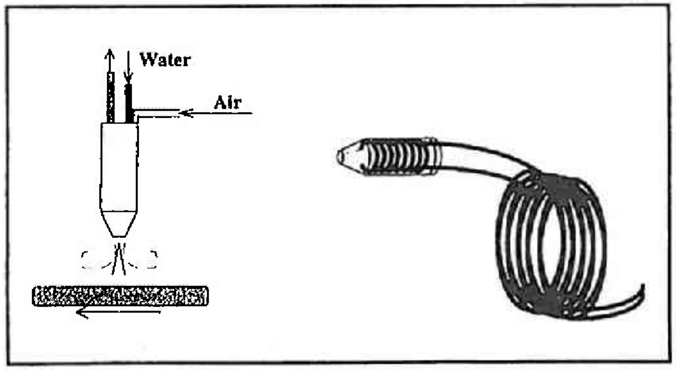


Application Note #20
IR t/c Cooling Jacket Kit for Environments to 1000°F (540°C)

A convenient and inexpensive kit makes it possible to use either the IRt/c or OS36-2 with air, water, or both for service in harsh environments. Measuring only 4" x 1" (100 x 25 mm) overall, the Cooling Jacket (OS36-APC) is physically small enough to fit into tight areas and closely monitor process temperatures from the optimum position - up close. With its all stainless steel housing, it can withstand the harshest environments.

Extraordinarily efficient in design, the Cooling Jacket (OS36-APC) requires only .05 gpm (190 cc/min) to protect an IRt/c at 1000°F (540°C).

The water cooling system consists of a seamless monotube, in order to eliminate the possibility of leaking joints. For convenience, the seamless tubing includes an extra 3 ft (1 m) tubing length.

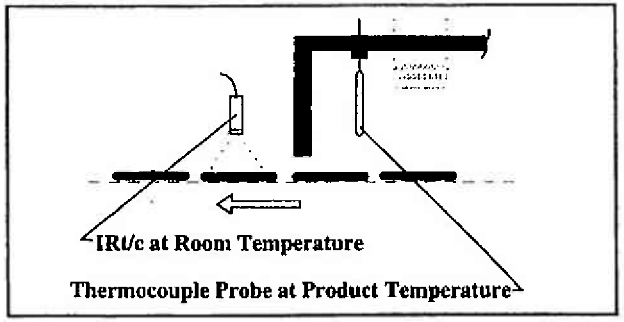


Application Note #21
IR t/c Repeatability and Long Term Accuracy

Of fundamental interest in temperature control is the ability of the measuring device to maintain its calibration under service conditions, and over a long period of time. The IRt/c is rated at 1% (of reading) repeatability and to have no measurable long term calibration change, which makes it well suited for reliable temperature control. These attributes are inherent in the basic design and construction of each IRt/c.

Repeatability is defined as the ability of a measuring device to reproduce its calibration under identical conditions. The IRt/c is a solid, hermetically sealed, fully potted system that does not change either mechanically or metallurgically during service. There are no active electronic components and no power source to produce the signal - only the thermoelectric effects that produce a thermocouple signal. The 1% rating is a conservative value based on the practical difficulty of demonstrating tighter tolerances under test conditions, rather than a true limitation of the device.

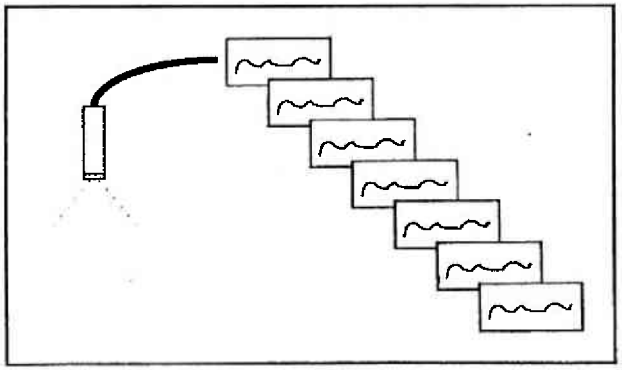
Long term accuracy is influenced by the same things that influence repeatability: mechanical changes and metallurgical changes. It is well known that thermocouples can change calibration over time due to these effects.



Mechanical changes occur because conventional thermocouples are constructed generally as small and light as possible to enhance response time, thus making them vulnerable to deformations that can change the thermoelectric properties. More importantly **the conventional thermocouple must operate at elevated temperature since it merely measures its own temperature.**

The metallurgical changes which affect thermoelectric properties are a strong function of temperature, being negligible at room temperature, and of serious concern at high temperature.

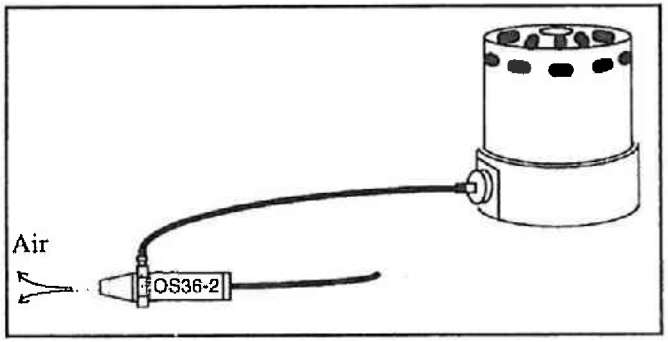
The IRt/c solves both problems by its design and basic operation. Its solid fully potted construction in a mechanically rigid stainless steel housing, and operation at near room temperature conditions, essentially eliminate the classical drift problems of conventional thermocouples. Every IRt/c is double annealed at temperatures above 212°F (100°C) to ensure long term stability, and tested 5 times prior to packaging. Barring a small percentage of failure, the IRt/c has essentially unlimited long term calibration accuracy.



Application Note #22
Air Pump Accessory Keeps IR t/c's Clean and Cool

For IRt/c installations in which a purge air source is not convenient, or is too expensive to install, The Air Pump Kit (OS36-APK) is ideal. The air pump is rated for continuous duty and produces 120 cubic inches/minute (2000 cc/min) air flow, which is more than sufficient for purging; and will cool an OS36-2 in environments up to 240°F (115°C). The pump is available in both 120 Vac and 12Vdc versions, and is supplied with 10 ft (3 m) of vinyl tubing, and horizontal/vertical mounting system.

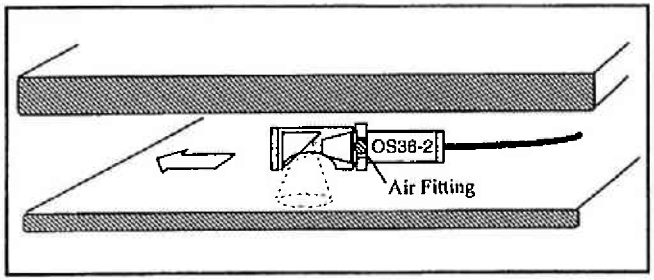
The Air Pump Kit is recommended for installations in which dust, dirt, or vapors are present which might coat the IRt/c lens, or for situations in which long term operation has been a problem due to fouling of the lens. At less than $100; requiring only a few minutes to install; and its small 5" x 3.3" (13 x 8 cm) size; the Air Pump Kit provides you a convenient and inexpensive assurance of long term, trouble-free operation of your IRt/c temperature control system.



Application Note #23
Periscope Accessory Lets OS36-2 Look Around Corners

For tight installations, where the IRt/c will not physically fit to view the desired target, the Periscope accessory attaches to the OS36-2 to provide a right-angle view. The fitting is constructed entirely of stainless steel, including a polished stainless steel mirror. The Periscope is designed in such a way that the air purge of the OS36-2 automatically keeps the Periscope mirror clean in when used in harsh environments. The air pressure may be adjusted to clear an optical path to the target, as well as keep the mirror clean (see Application Note # 5).

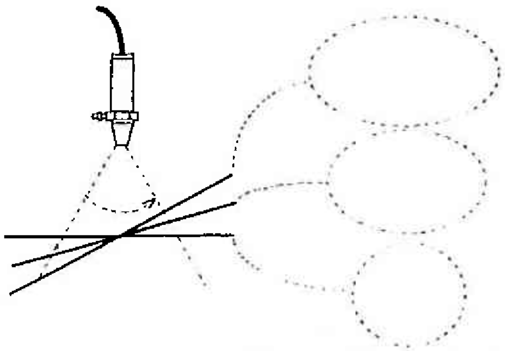
Since there is a small reflection loss from the mirror assembly, the set-up calibration setting is slightly different from the setting for the bare IRt/c. The difference is approximately the same as a change in target emissivity from 0.9 to 0.8. The normal installation set-up (refer to the OS36, OS37, OS38 Operator's Manual) should be performed with the periscope in place.



Application Note #24
IRt/c Can Measure Obliquely

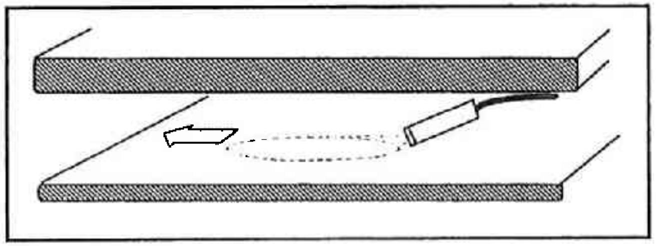
Often, an area needs to be temperature monitored, but because of space limitations, the IRt/c cannot be placed to view the target area squarely. In such situations the IRt/c can be angled obliquely to view the target area. The field-of-view then becomes elliptical instead of circular, and the IRt/c averages the temperature it sees.

Tilting the OS36 increases the area view proportional to the cosine of the viewing angle and the radiation from a diffused surface decreases the energy by the same cosine of the angle, thus cancelling out. This makes the radiation detected essentially independent of the viewing angle.



Shape of Measuring Area

To apply this method, be sure to estimate the size of the field-of-view footprint, and confirm that the IRt/c is measuring the area you wish to measure.

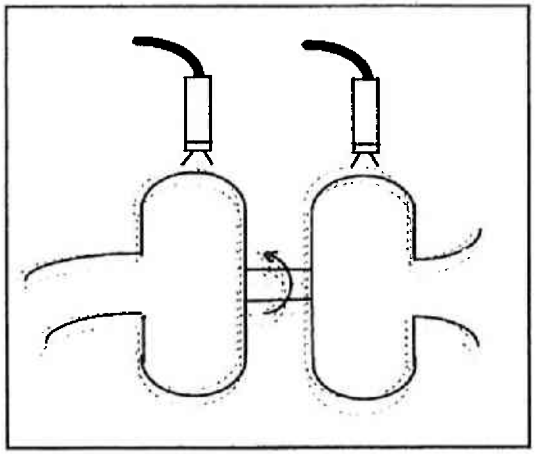


Application Note #25
IR t/c Measures Vibrating Objects

Measuring the temperature of objects that are nominally stationary, but vibrate, can be a difficult problem because of mechanical fatigue of any contact device. For example it is desired to measure the casing temperature of both the turbine and compressor side of a turbocharger and monitor them continuously. Thermocouples or other contact devices fail after only a few hours due to the high frequency vibration present during turbocharger operation.

The IRt/c provides a simple and inexpensive solution. Mounting the IRt/c's to a non-vibrating surface, they can monitor the turbocharger temperature without being subject to the destructive vibration.

Wherever there is a requirement for machinery monitoring, temperature should be included; and for machines that vibrate the best solution is the IRt/c.

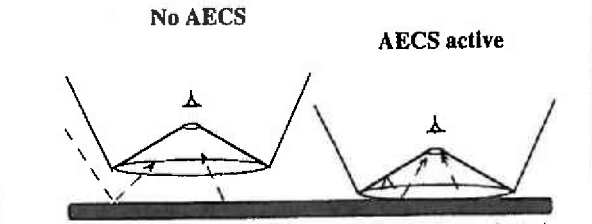


Application Note #26
Why the OS91, OS92 Digital Infrared Temperature Scanner is Recommended for IR t/c Temperature Control Calibration

Because of its speed, accuracy, and its patented Automatic Emissivity Compensation System (AECS).

As in all infrared temperature control systems, IRt/c installations should be calibrated to the characteristics of the materials and the process being controlled, in order to insure that the control temperature is accurate. Accordingly, the calibration reference must be selected such that its accuracy is independent of the variables that influence the temperature control accuracy. In the case of infrared temperature control, the major variables are emissivity and ambient reflections.

The OS91, OS92 Digital Infrared Temperature Scanner has the necessary accuracy and independence from emissivity and reflection errors, due to its AECS feature. The reflective cup configuration of the sensing head automatically corrects for emissivity by creating a tiny blackbody at its point of measurement. By "trapping" the **emitted** radiation, and excluding the ambient radiation (thereby replacing the reflected ambient radiation with reflected emitted radiation) the sensing eye sees a blackbody; and thus can report the temperature precisely.

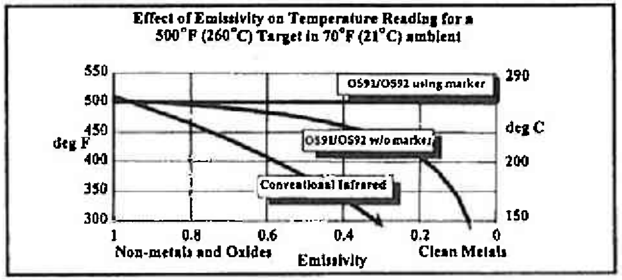


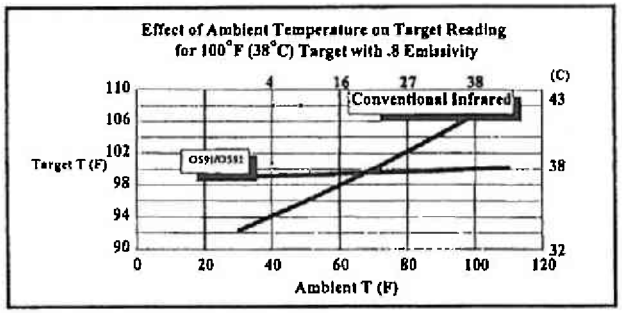
When AECS is active, ambient radiation is excluded and replaced by reflections of emitted radiation.

The result of AECS is illustrated below.

Conventional infrared devices are strongly influenced by both emissivity and ambient variation, while the OS91/OS92 series units remain accurate.

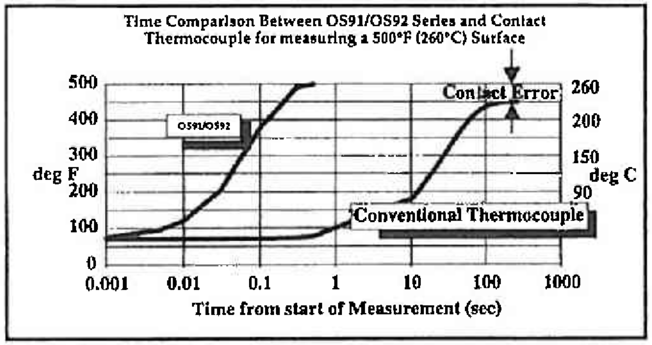
Additional factors in calibration accuracy are speed and contact error when using conventional thermocouples. The OS91, OS92 Digital Infrared Temperature Scanner overcomes both problems, and makes it possible to complete the temperature control set-up very quickly and accurately.

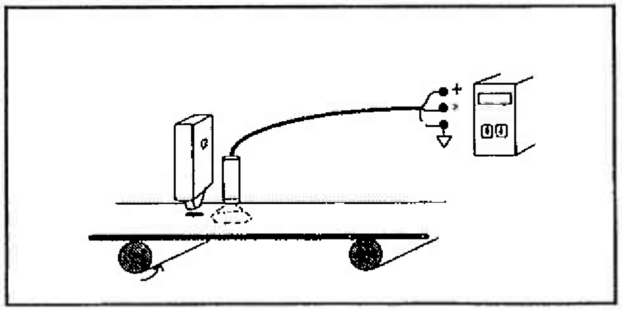




For further information on OMEGA's OS91, OS92 Infrared Scanner/Thermometers call OMEGA.

The OS91, OS92 are available in the compact 1-piece standard model.





Application Note #27
Air Purge and Air Cooling Requirements

The limiting air flow restriction for all of the IRt/c models and Cooling Jacket (OS36-APC) is the air fitting supplied with the unit. Accordingly, the OS36-2, OS36-5, and Cooling Jacket all have essentially the same pressure vs. air flow characteristics, and the air flow chart applies to all. However, the air consumption requirements for purging or cooling for each are somewhat different due to size and operation variables. Refer to the table or chart for specific model requirements for minimum pressure for purging, or for cooling in elevated ambient conditions. If water cooling is used with the Cooling Jacket, air purge pressure only is required.

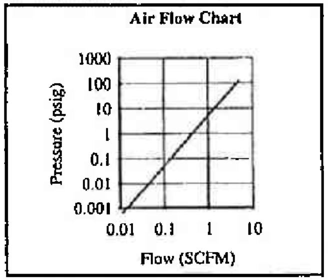
Model	Air Purge Pressure
OS36-2	≥ 0.001 PSIG
OS36-5	≥ 5 PSIG
Cooling Jacket	≥ 0.1 PSIG

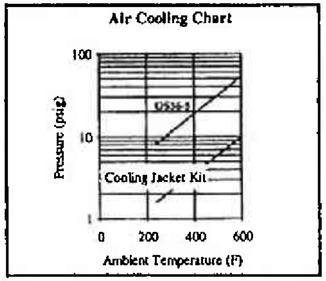
To convert to metric units the following may be used:

deg C = (deg F-32) x (5/9)

kPa = PSIG /0.15

m^3/min = SCFM/35

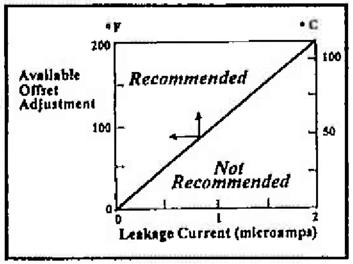




IR t/c infrared thermocouples are designed to be used with all thermocouple readout devices and controllers, but due to the higher impedance levels of the IRt/c compared to standard t/c's, some controllers are better suited than others. Leakage current generated by the controller (see Application Note #13) creates an offset in reading which should be adjusted out for accurate temperatures. If the offset produced by the leakage current is larger than the available offset adjustment of the controller, the IRt/c will still produce repeatable readings and control accurately, but the temperature indication will be incorrect. Accordingly, recommended controllers are those which have low leakage currents and/or sufficient offset adjustment to produce an accurate IRt/c reading (see chart for relationship between leakage current and offset).

Following is a list of controller and meters which are known to have sufficient offset adjustment to produce an accurate IRt/c reading and are recommended for use with the IRt/c.

Controllers	Meters
CN9000A Series	DP41-TC
CN76000 Series	HH80 Series
CN1600 Series	HHM57
–	450 Series

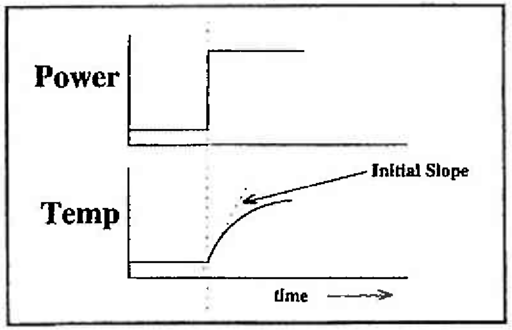


Application Note #29
A Software Method of Self Testing IRt/c's

For many OEM applications, it is a desirable feature to be able to test the IRt/c for proper operation each time the system is started in order to assure the user that all systems are functioning, much the same way that a microprocessor can be programmed to check itself when powered up. This feature is especially useful to check for cleanliness of the lens in applications where a user of the equipment might inadvertently spill something on its surface.

The test is performed by applying a known power input to the target to be heated, and monitoring the initial rate of change of temperature of the target as seen by the IRt/c. **This rate of change is dependent only on the power level and independent of the initial temperature of the target, as long as the target began at a uniform temperature** (allow sufficient time since the previous powerdown).

If the IRt/c is clean and functioning normally, it will report the correct rate of change, and the machine becomes operational. If the rate of change is lower than normal, the user is alerted to clean the lens. If this still does not produce the desired response, service is required on the IRt/c or heater, target, control, etc.



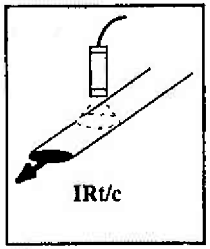
Application Note #30
Monitoring Plastic Extrusions

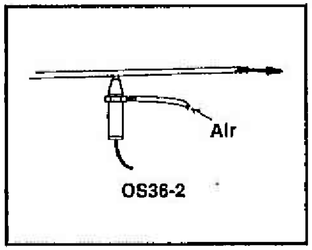
IRt/c's are well suited for monitoring the temperature of plastic extrusions: either at the point of extrusion to monitor correct extrusion temperature; or after air cooling to monitor/control the cooling process prior to cutting to length. The model recommended depends on the monitoring geometry.

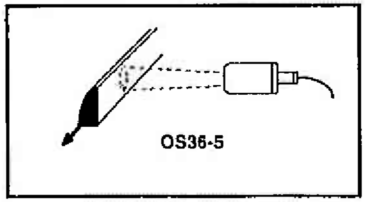
For extrusions of 1" (2.5 cm) width or more, the standard IRt/c may be used at a distance of 1/2" (1.3 cm), which is sufficient to keep the lens clean in a reasonably clean environment.

For smaller extrusions, or for up-reading; the OS36-2 is preferred due to its smaller minimum spot size (.16" [4 mm]), and built-in air purge, which will maintain cleanliness even when very close to the hot plastic and pointed up.

For larger extrusions, in which more convenient positioning at greater distance is desired, the OS36-5 is recommended, due to its narrow 5:1 field-of-view.



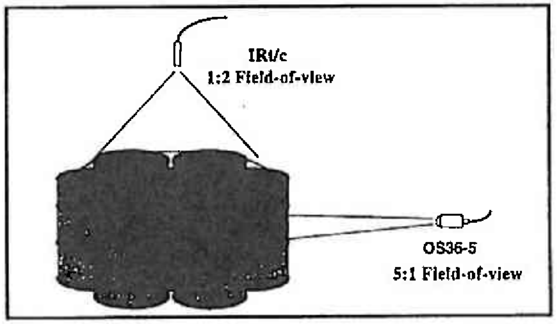




Application Note #31
Monitoring Dangerous
Chemical/Hazardous Environments

Handling, processing, or storage of certain materials involves an element of risk of fire, chemical damage, or explosion. Many times these materials are monitored using pyroelectric, air temperature, or ultraviolet devices to detect a fire situation, in order to activate alarms and extinguishing systems. These devices do not, however, provide the earliest possible indication of a problem, since they are incapable of detecting the initial heat **prior** to the fire.

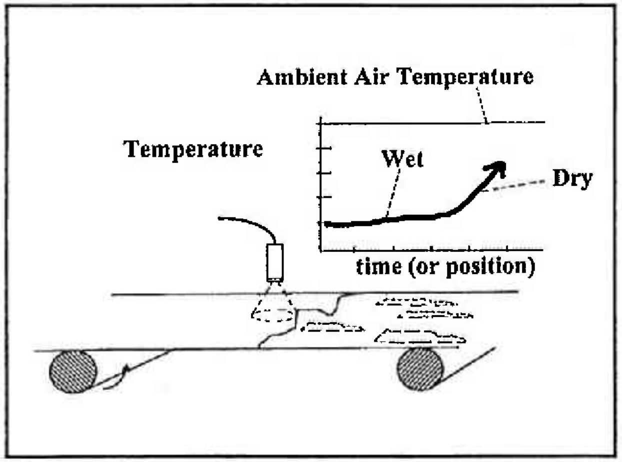
The IRt/c, however, is capable of detecting even the smallest temperature rise which must occur before a fire starts, and transmit the information in as little as 80 milliseconds to the thermocouple monitoring device, thus providing the maximum time to initiate extinguishing or cooling measures. The wide field-of-view standard IRt/c can average a wide area for broad coverage of heat build-up, or the narrower OS36-2 and OS35-5 models can monitor specific areas from greater distances. Actual fire types and special conditions should be evaluated prior to applying IRt/c's.



Application Note #34
Printing - Ink Drying

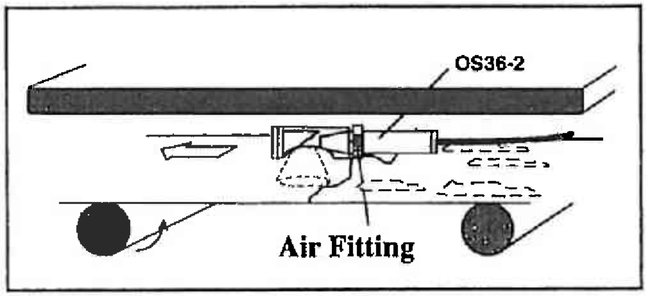
For high speed printing processes, the limiting factor for productivity of the equipment is usually drying time for the ink. With non-contact monitoring of the inked surface temperature, press production can be maximized while assuring top quality.

The surface temperature of freshly inked paper will be considerably cooler than ambient air temperature, and will rise very slowly as the paper absorbs heat. This occurs because the ink solvent absorbs much of the heat energy as it evaporates. At the point that the product becomes "dry", however, the same constant heat supply will quickly raise the temperature until it reaches the same as the surrounding air, or higher if the heat source is radiation. If temperature vs. time is plotted for a heated drying process, the target "dry" temperature point can clearly be seen as the beginning of a rapid rise in surface temperature.



For tight areas, the OS36-2 with Periscope Accessory is recommended.

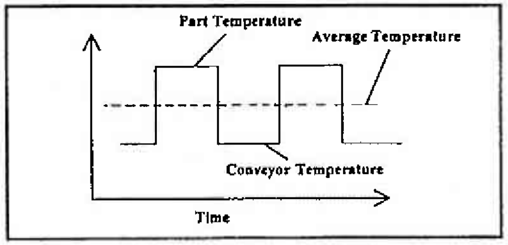
The OS36's can be used to monitor these changes in surface temperature. With their fast 80 ms response time, the OS36's can quickly detect when the surface temperature begins to rise rapidly, an indication that the ink has dried, thus allowing press speeds to be maximized.

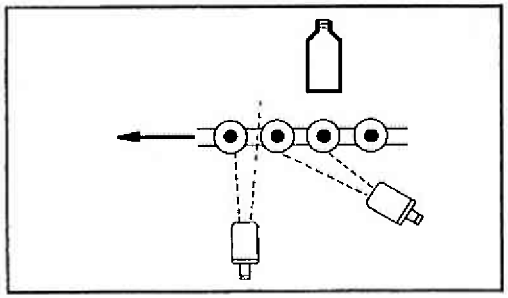


Application Note #35
Discrete Parts Monitoring

Parts on a moving conveyor can be monitored for temperature either continuously - measuring an average of conveyor and part; or discretely - measuring each individual part. For parts which completely or nearly completely, cover the conveyor, measuring continuously will give good results.

A powerful method of improving the optical density of the product, as seen by the IRt/c, is to angle the IRt/c such that it cannot see between the products. By doing this, temperature monitoring and control can be performed continuously with simple controllers, without the requirement for additional logic.

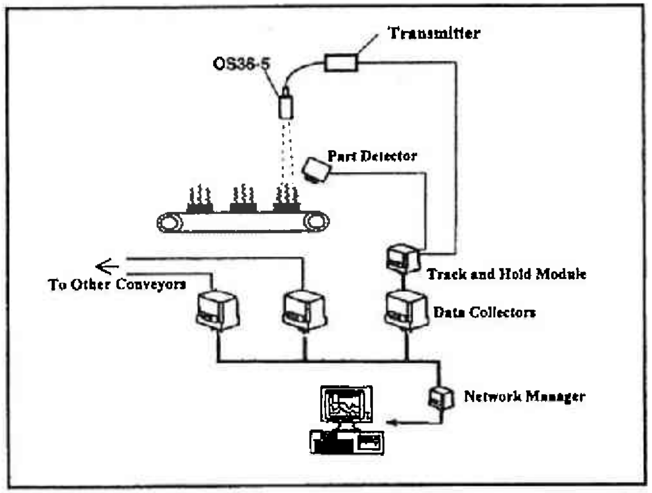




Angling the IRt/c permits it to continuously monitor bottle temperatures

However, for applications in which each individual part must be measured for communication to a central process control computer, additional devices are required. The most important are the part detection device, which detects when the part is within the field of view of the IRt/c; and the sample and hold device, which holds the previous reading when the part is not in view. Suitable control modules are available from various manufacturers to provide the necessary logic.

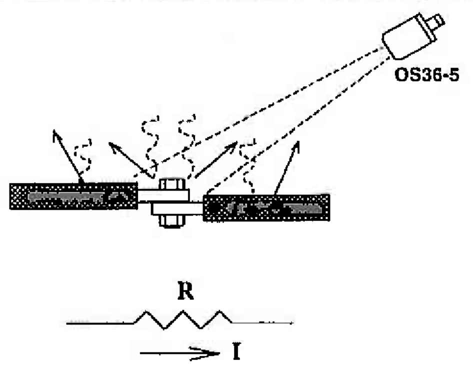
Typical recommended system for discrete part monitoring with IRt/c's is shown below.



Application Note #36
Electric Power Transmission and Distribution Control

Highly loaded electric power conductors, especially switching and transforming equipment, are capacity limited by the temperature rise characteristics caused by the slight resistive losses. Accordingly, equipment utilization capacity is a direct function of the local temperature at critical points in the equipment.

By continuously monitoring in real time with IRt/c's, critical equipment can be used much more effectively. If the temperature is below operating limits, additional power may be safely routed through the equipment. With the non-contact capability of the IRt/c, installation is simple, and live conductors may be safely and easily monitored. Inexpensive standard thermocouple transmitters and data collection equipment may be used to transmit the information to a central office where load switching decisions are made.



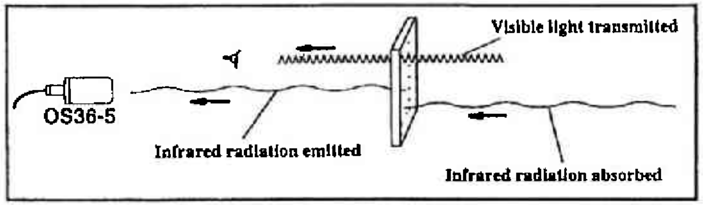
Heat = Energy Dissipated = I^2R

Application Note #37
Glass Temperature Monitoring

Glass processing, whether as sheets, bottles, or other forms usually involves temperature as a primary control variable. Since glass is impossible to measure by contact means, plants must use either ambient temperature as an indirect approximation, or an infrared device to measure the glass directly. An often asked question is whether infrared devices can measure glass correctly, since to the eye the glass is transparent.

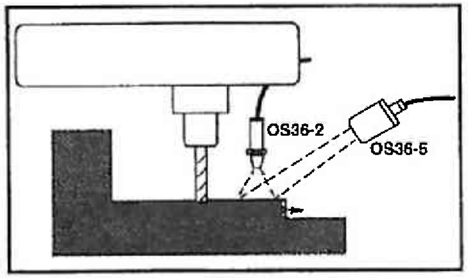
The answer lies in the physics of glass causing the well known "greenhouse effect". The short wave radiation of visible light that we can see (~ .3 - .8 microns) can pass through glass essentially unaffected. The much longer infrared wavelengths that are normally measured for temperature assessment (~ 5 - 20 microns) cannot pass through the glass, and are absorbed. As a consequence of the inability of glass to transmit the long wavelengths of infrared, the glass will emit those wavelengths created by its temperature, and thus can be measured with an IRt/c. At much higher temperatures the infrared wavelengths become shorter, and some transmission occurs.

As a recommendation, if the glass is within the temperature range of the IRt/c, then it will measure its temperature accurately - just as if the IRt/c were looking at an opaque material surface. Follow the normal installation and calibration procedures. The glass will have emissivity in the range of 0.9 and above, and therefore will provide good results.



Application Note #38
Improving Machining Tolerance

Precision machining tolerances of metal and non-metal parts are substantially impaired by uncertainty in part temperature, due to the dimensional changes which occur with temperature. For example, most metals have thermal expansion coefficients of approximately 10 ppm per °F (approx 20 ppm per °C). If a 10 inch (25 cm) part undergoing machining increases in temperature by only 10°F (5°C) from the set-up, the part will have increased in size by 0.001 inch (0.025 mm). Accordingly, the best that the machine can do, **regardless of the machine's quality**, is + 0.0005 " (+ 0.012 mm). If the temperature uncertainty is higher, the tolerance increases in direct proportion. This effect is especially important as the tool wears, and significantly more frictional energy is imparted to the part.

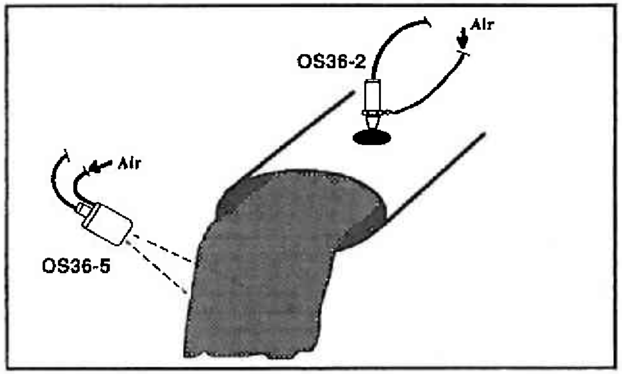


The IRt/c solves the problem by monitoring the part temperature continuously, and reporting the temperature to the computer, which in turn adjusts the position of the cutting tool accordingly. An additional benefit is detection of worn tools, due to the higher than anticipated part temperatures, or rate of change of temperature. Any of the IRt/c models can be used, with the OS36-2 and OS36-5 being preferred due to their narrower fields of view and built-in air purge. Emissivity of the metal parts is normally not a problem due to the presence of cutting oils and coatings. If the parts are completely clean, then a thin coating of oil will be sufficient to increase the emissivity for accurate measurements.

Application Note #39
Asphalt Temperature Monitoring

Asphalt properties are particularly sensitive to temperature, and it is important that the asphalt is applied at the correct temperature in order to perform to its specifications. Accordingly, temperature monitoring is a common requirement, but the thermocouples normally used have severe breakage problems due to the harsh abrasiveness of the material, and must constantly be replaced at high cost and interruption of production.

The IRt/c solves this problem directly, since the temperature is monitored without contact. The normal thermocouple controller can be used - simply calibrate offset if necessary. The OS36-2 and OS36-5 models are recommended due to their built-in air purge, which will keep the lens clean by preventing vapors from condensing on the lens. The OS36-2 can be mounted in the chute to view the asphalt through a small hole, while the OS36-5 can be mounted some distance away due to its narrow 5:1 field of view.

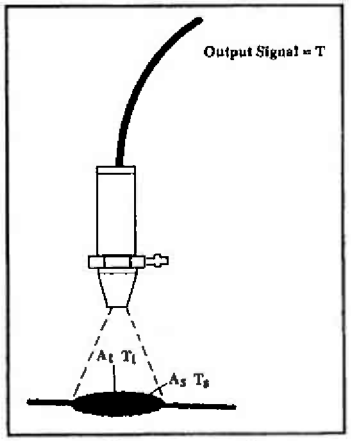


Computing the results for the equation gives:

$$T = (200)(.5)(.1)/\left[\pi(.25)^2\right] + (80)\left[\pi(.25)^2 - (.5)(.1)\right]/\left[\pi(.25)^2\right]$$

and T≅ 111°F (44°C).

This result shows that the average signal will be 31°F (17°C) above the surroundings temperature, compared to an actual object temperature of 120°F (67°C) above surroundings, or approximately one-fourth, which is the ratio of object area to surroundings area measured. Therefore, if the surroundings are expected to be repeatable to 1°F (.6°C), the IRt/c signal will be repeatable to 4°F (2°C). For the final display on a controller, or other read-out device, calibrate in standard fashion by using the available offset adjustment. If the object is to be controlled over a wide range of temperatures, calibrating with a span adjustment will yield greater accuracy.



To select the best temperature range model for the IRt/c, use the average temperature rather than the object temperature. This same technique can be used to measure objects which are much hotter than the available IRt/c rating.

Application Note #42
Measuring High Temperatures with Immersion Thermowells

Like ordinary thermocouples, the high temperature IRt/c models can be used with immersion "thermowells" to measure high temperature gases or liquids, while maintaining the integrity of the vessel. However, the IRt/c has significant advantages over ordinary thermocouples, RTDs, etc. in this application.

Survivability

Since the IRt/c sensor elements are positioned in a non-contact mode, outside of the heated area, and kept at a low temperature, the entire temperature sensing system can be designed to survive for a much, much longer period of time than conventional thermocouples or RTD's. The only part requiring maintenance is the thermowell itself, an inexpensive and easy replacement part. The overall savings to users includes (1) no replacement thermocouple parts, (2) no replacement labor, and (3) no production losses from downtime for sensor replacement.

Sensor Stability and "Drift"

Even worse than sensor failure is to have a sensor that reads incorrectly, feeding inconsistent or inaccurate information to your control systems. Sensor stability and drift can be significant problems with standard thermocouples when measuring high temperatures, due to chemical and metallurgical changes created by long exposure to high temperatures. The OS36, however, is essentially immune to those effects, since the sensor remains at a low temperature - far below that of the contact device, and below the levels which are the major sources of drift.

Sensor Speed

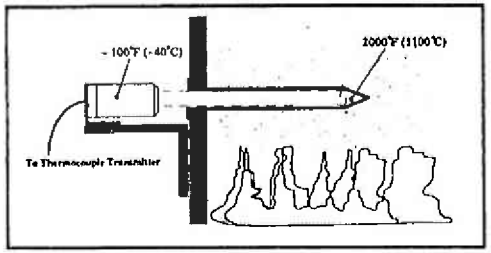
With its 80 msec response time, the IRt/c is far faster than any conventional thermocouple or RTD placed inside a well. Accordingly, for all practical purposes, the temperature measurement speed is the same as that of the well itself.

How To Use The IRt/c With A Thermowell

The technique is to mount an IRt/c sensor so that it aims directly into a hollow thermowell. The well should have a minimum .8 inch (20 mm) inner diameter to accommodate the minimum spot size of the high temperature sensors. Choose the appropriate sensor for the temperature range and length of the well you are using. For example:

> To measure up to 2000°F (1100°C), 6 feet (2 m) into a stack, use an OS37-100 sensor looking into a thermowell of that length with an inside diameter of at least .8 inches (20 mm). The spot diameter for the OS37-100 at 72 inches distance is .8 inches (at 2 meters distance, the spot diameter is 20 mm.) The sensor can then "see" all the way into the hollow well tube and monitor the tip end temperature, ignoring the sidewall temperatures.

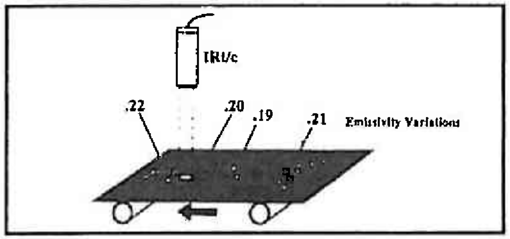
Choose appropriate thermowell material (stainless steel, Hastelloy, Inconel, ceramic, etc.) to withstand the temperature, oxidation and other rigors of the environment where it is to be placed.

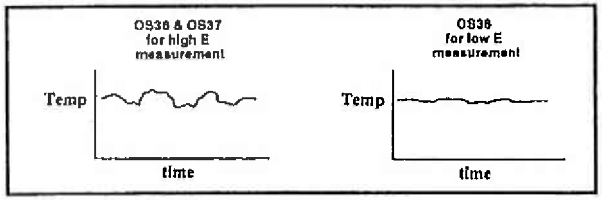


Application Note #43
How the OS38 Series Thermometers Reduces Errors Due to Emissivity Variations

Emissivity is the property of a material's surface that describes its "efficiency" at emitting thermal radiation. An emissivity value of 1.0 represents emission at 100%, and 0 describes emission at 0%.

For non-metals and coated metals this efficiency of emission, that we call emissivity, is very high: 0.8 and greater, and variations are usually not a problem. For example, for a production process in which a non-metallic material is to be controlled, and normal material variations cause emissivity variations of ±0.01, the associated temperature error will be of the order of 0.01 divided by 0.9, or ~1% of reading, an acceptable variation. In contrast, if we are to control the temperature of a metal with emissivity 0.2, then variations of ±.01 will produce an error of the order of (0.01/0.2), or ~ 5% of reading. Additionally, metal finishes, which play a significant role in emissivity, tend to cause more variations than changes in finish in non-metals.





The OS38 filters out the effects of these emissivity variations on measured temperature by approximately a factor of four, and thus reduces the errors by a factor of four. Thus, with the OS38, the errors are of the same order as those commonly experienced for high emissivity targets.

The method takes advantage of the basic physics of thermal radiation, in which the mathematical description of the energy distribution is by a formula called the Planck function:

$$q_\lambda = \varepsilon \frac{2\pi hc^2 \lambda^{-5}}{e^{ch/k\lambda T} - 1}$$

where q_λ is radiated energy at a given wavelength, ϵ is the emissivity, T the absolute target temperature, λ the wavelength, and the other symbols are for various physical constants. The Planck function integrates to the more familiar Stefan-Boltzman equation:

$$\text{Radiant Energy} = q = \int_0^\infty q_\lambda d\lambda = \varepsilon\sigma T^4$$

when all wavelengths are measured.

The OS38 works by measuring the energy content of the radiation, as described by the Planck function, over wavelengths that are more selectively sensitive for temperature variations, and therefore proportionately less sensitive to emissivity variations, as follows: (see the next page)

$$\text{Filtered Radiated Energy} = \int_{\lambda_1}^{\lambda_2} q_\lambda \, d\lambda = \varepsilon\sigma T^x$$

where $x >> 4$

If we compute the partial derivative of each expression with respect to emissivity and temperature, we obtain the following relations for the slope of the signal with respect to temperature divided by the slope of the signal with respect to emissivity:

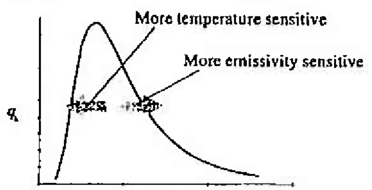
$$\frac{\partial}{\partial\varepsilon}\left(\varepsilon\sigma T^4\right) = \sigma T^4 \quad , \quad \frac{\partial}{\partial T}\left(\varepsilon\sigma T^4\right) = 4\varepsilon\sigma T^3 \Rightarrow \frac{4\varepsilon\sigma T^3}{\sigma T^4} = \frac{4\varepsilon}{T}$$

$$\frac{\partial}{\partial\varepsilon}\left(\varepsilon\sigma T^x\right) = \sigma T^x \qquad \frac{\partial}{\partial T}\left(\varepsilon\sigma T^x\right) = x\varepsilon\sigma T^{(x-1)} \Rightarrow \frac{x\varepsilon\sigma T^{(x-1)}}{\sigma T^x} = \frac{x\varepsilon}{T}$$

where $x >> 4$

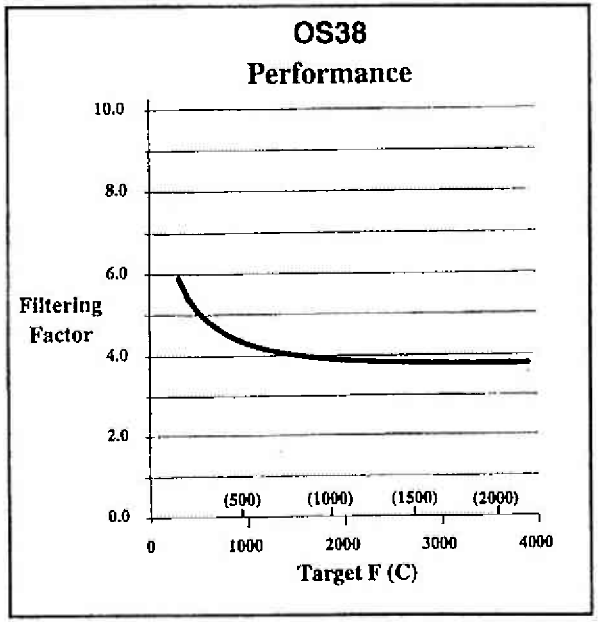
Accordingly, by optimum selection of the wavelengths to be measured, the sensitivity to emissivity variations can be significantly reduced, i.e. *filtered*, by enhancing the relative sensitivity to temperature. In practice, the best wavelengths are the shorter ones, since they provide the most sensitivity to temperature, and the least sensitivity to emissivity, as is predicted by the integration of the Planck function.

Planck Function - Radiated Energy vs Wavelength



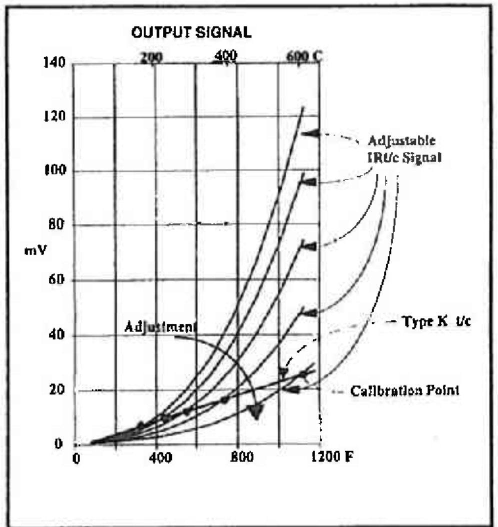
The "filtering factor" for the OS38's is based on the selection of .1 to 5 micron for the measured wavelengths, and results in a factor of from four to six error reduction, depending on target temperature.

As an additional benefit of the OS38's, errors due to such factors as smoke, dust, moisture, etc. which may partially block the optical path to the target, are also filtered. These factors behave mathematically identically to emissivity, and therefore will be filtered by the same factor of four to six.



Application Note #44
How the Adjustable OS37/OS38 Models Work

All adjustable IRt/c's can be field calibrated for the specific requirements of the application to precisely indicate the actual temperature of the target, and to correct for reflective errors caused by ambient variations (see Application Note #47).



The basic operation of the adjustable IRt/c is to rescale the signal output until it matches the actual temperature for the thermocouple type in use. In the vicinity of the calibration point, the output will match the linearity of the t/c. When the adjustment is made to actual temperature, the Automatic Ambient Compensation System is automatically correctly scaled.

The chart shows the actual performance of an OS37-10 model as an illustration of the effect of adjustment on the signal.

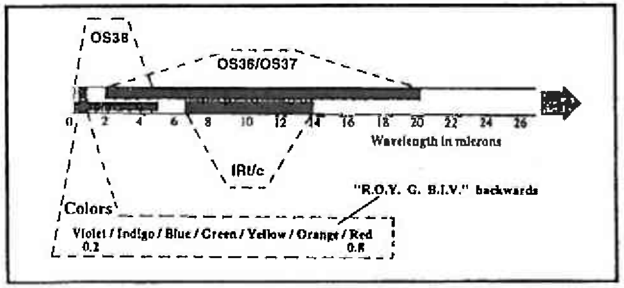
Application Note #45
Why Color Does Not Affect Readings

For many IRt/c installations, for example: paint curing, web drying, printing, etc.; the temperature control system must be able to accurately measure materials with a variety of colors with a given piece of equipment. It is preferable that the same calibration set-up is used for all colors, rather than having to recalibrate each time a new color is run.

Because the IRt/c measures the radiated wavelengths that indicate temperature, which are generally ten times longer than the wavelengths that indicate color, color changes do not influence temperature readings. Even for situations in which the target temperature is sufficiently high such that appreciable energy is radiated at visible wavelengths, all IRt/c models except OS38 completely filter out the visible wavelengths.

Except to the extent that color might indicate a change in surface texture, and thereby affect emissivity, there will be no effect of color on the reading.

The energy contained in the radiation we see as color has nothing to do with the temperature (except if the target is hot enough to be incandescent), and is simply a function of which particular wavelengths are reflected to our eyes.



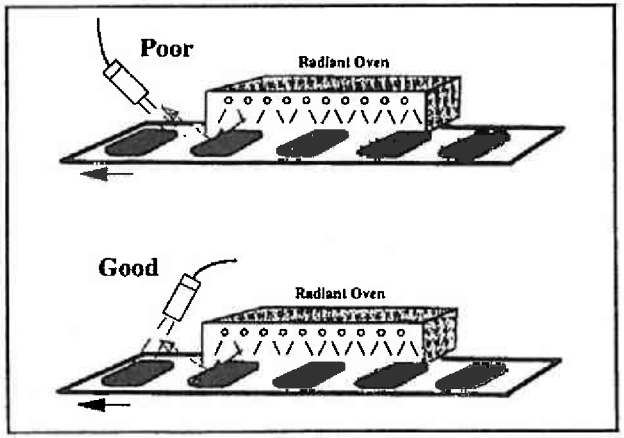
Application Note #46
Potential Errors Caused by Ambient Temperature Effects

If the ambient temperature of a temperature control installation changes significantly, there are several sources of potential inaccuracies that can be minimized by attention to installation details.

Reflective Errors

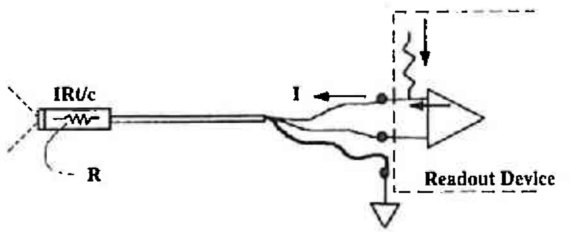
For situations in which the IRt/c itself is at the same temperature as ambient sources of radiated energy, the patented design of the IRt/c will compensate for reflected energy and maintain accuracy. See Application Note #47 for discussion.

If the ambient source of radiant energy is too hot for an uncooled OS36, the principal precaution to employ is to take advantage of the generally **specular** characteristics of reflected energy. The term specular means "mirror-like," and reflective errors can be minimized by avoiding viewing angles in which the surface can reflect a hot source.



Leakage Current Effects

For installations in which the readout device generates appreciable leakage current there is a potential inaccuracy due to small shifts in IRt/c impedance with ambient temperature. For example, if the readout device leakage current generates an offset of 100°F (55°C), which is calibrated out at installation, and sometime later the ambient temperature for the IRt/c is much hotter, the IRt/c impedance might be a few percent different than it was at calibration. Accordingly, the temperature offset caused by the leakage current will also shift by a few percent. If the original offset requirement is 100°F (55°C), then a shift of ~ 5% impedance will cause a shift in reading of ~ 5°F (~ 3°C). As a general recommendation, always choose a readout device with the lowest leakage current available to avoid this potential problem. See Application Note numbers 11, 13, and 28 for further discussions of leakage current effects.



Offset degrees = (I x R) / a
a = t/c coefficient in volts per degree
= approx 22 microV / deg F (40 / deg C) for type K
= approx 28 microV / deg F (50 / deg C) for type J

Application Note #47
OS37/OS38 Compensate for Reflective Errors with Automatic Ambient Compensation Feature

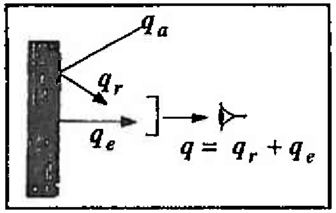
For high precision temperature control in applications where the ambient temperature varies, reflective effects may cause unacceptable errors under some operating conditions. For example, an incubator is designed to warm a baby by measuring the child's skin temperature, and modulate the ambient temperature inside the incubator to maintain the skin within the desired range. Even though skin has a high emissivity (> 0.9), there is potentially an error of ±1°F (0.6°C) caused by changes in the reflective component of the radiation as the ambient is modulated ±10°F.

The basic principles can be understood by considering the radiation leaving a surface, as measured by any detector (including an eye). The total radiation q is made up of the reflected and emitted radiation components as follows:

q_a = ambient radiation = $\sigma (T_a)^4$

q_r = reflected radiation = $\rho\, q_a$

q_e = emitted radiation = $\varepsilon\, \sigma (T_s)^4$



where ρ is reflectivity, ϵ is emissivity, σ is the Stefan-Boltzman constant, and T_a and T_s are absolute ambient and surface temperature respectively.

Since emissivity plus reflectivity is always unity for non-transparent surfaces, the total radiated energy can be written as:

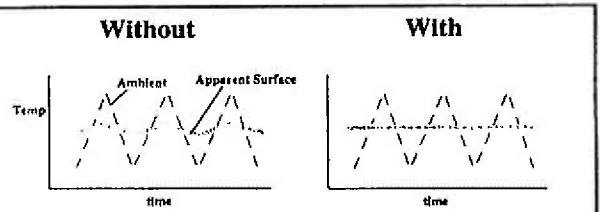
$$q = q_r + q_e = (1-\varepsilon)\sigma (T_a)^4 + \varepsilon\, \sigma (T_s)^4$$

This expression can be further simplified into a linear approximation that applies to the ambient temperatures over which the IRt/c can operate uncooled:

$$T = (1 - \varepsilon)T_a + \varepsilon T_s$$

where T is the apparent surface temperature measured by radiation. As indicated by the final result, if the emissivity is 1.0, the effect of ambient temperature is zero. If the emissivity is 0.9, the effect of ambient temperature is 10%, etc. (As an aside, this expression can be used to obtain the actual emissivity.)

Non-adjustable OS36's are designed and calibrated to automatically compensate for this effect when the emissivity is 0.9, a good general assumption for most non-metallic materials, and sufficient for good accuracy under most conditions. **With the adjustable models (OS37 and OS38), however, when the IRt/c is calibrated in place it automatically compensates for the reflective errors as indicated in the above equation for any emissivity within its normal operating range.** This patented automatic ambient compensation feature significantly improves the IRt/c control accuracy under real world conditions of varying ambient temperatures.



Effect of IRt/c Automatic Ambient Compensation

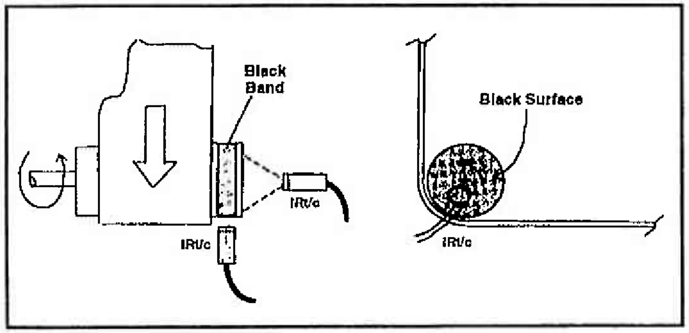
Application Note #48
Painting Metal Surfaces to Increase Emissivity

Even with the availability of OS38's, as a general rule higher emissivities require less careful attention to set-up details and calibration, and are more "forgiving" in long term service using any IR temperature measuring device. Accordingly it is recommended that where possible, surface emissivity should be increased. If it is not possible to increase emissivity, then use an OS38.

As an example, to control a metal roller temperature, paint either the end or an unused edge, and monitor with an IRt/c.

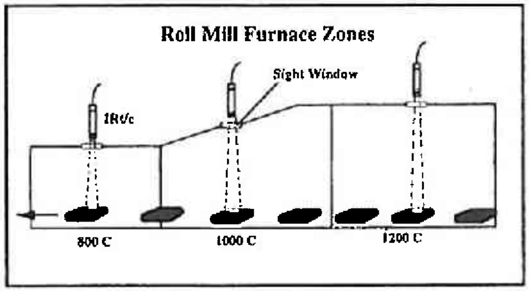
A recommended paint for most service is

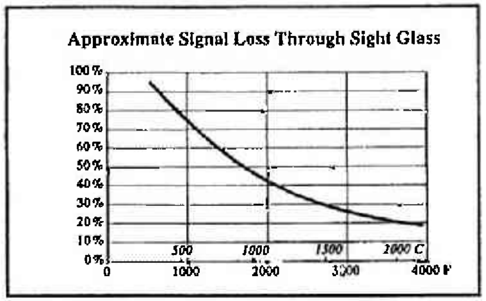
RUST-OLEUM
7778
BAR-B-Q-BLACK
Rated to 800°F (427°C)



Application Note #49
Looking Through Sight Windows with OS38's

Commonly, many types of furnaces are equipped with sight windows to permit visual inspection of the processing of the materials. These windows would conveniently provide a means for monitoring the temperature if the IR sensor could deliver reliable readings through the glass. Such glass can be normal window glass, tempered glass, quartz, etc.





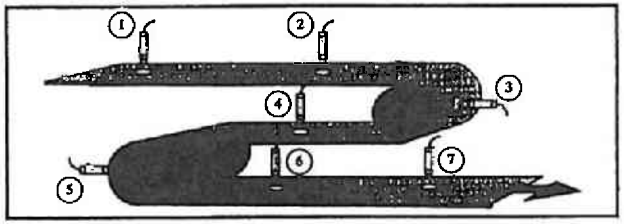
OS38's can "see through" such windows and will provide reliable readings if the losses are not too great. The adjustability feature of these models allow them to be calibrated to include the loss through the window. As a general recommendation, targets above about 500°C should provide good results, but the only way to be sure is to actually install the appropriate IRt/c and monitor results. If there is insufficient signal to read out the correct temperature, the ZERO adjustment on the readout device may be used to add signal.

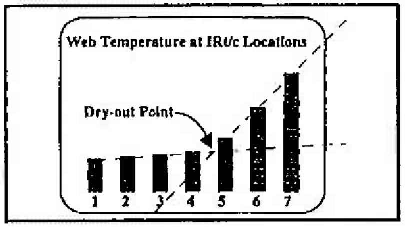
Application Note #50
Measuring Location of Dry-out Point in Web Production

For many types of continuous web production processing, such as paper, printing, photographic film, textiles, etc., an important parameter for quality and throughput rate is knowledge of the point at which "dry-out" occurs. More important even than the absolute temperature, the location of this point provides a highly precise indication of the rate of heat input into the product, and lends itself to direct control of the energy input to force the dry-out point to a specific spot in the drying process.

The IRt/c is particularly well suited to this application due to its small size, low cost, outstanding speed, hermetically sealed construction, and its intrinsically safe character.

Connected to inexpensive multi-channel thermocouple input cards for PLC's or computers, the dry-out point is easily calculated by the intersection of the slopes of the temperature vs. position data provided by the IRt/c's.





Application Note #52
Applications with Printing Presses

IRt/c infrared thermocouples are revolutionizing the printing industry because their small size allows them to be mounted in the tight spaces typical of both web and sheet fed presses, and their low cost allows economical installation and control on even the smallest of presses. Additionally, since many presses are already equipped with thermocouple controllers and PLC thermocouple inputs, the IRt/c is a simple installation.

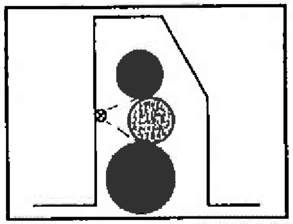
Applications include not only printing onto paper, but also cloth, plastic, and any other printing web application.

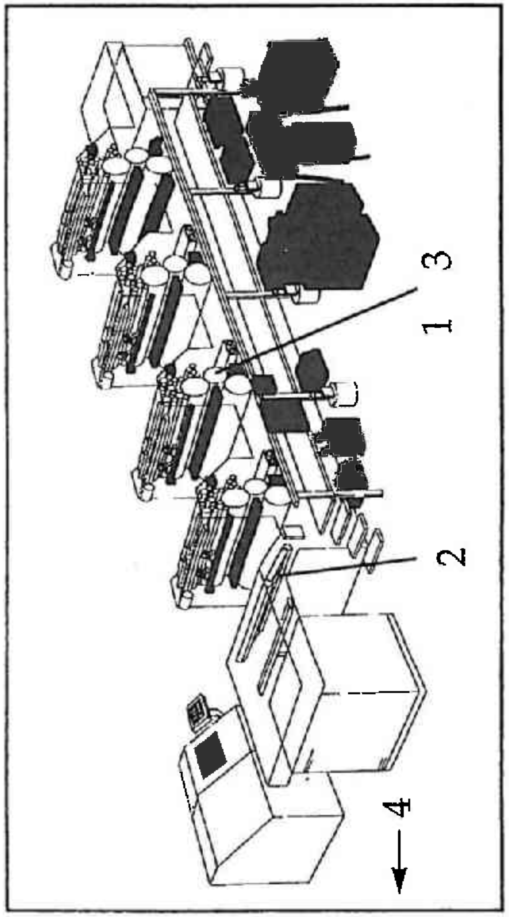
Location 1: Ink Rollers, Platens

Conventional Presses (water/ink)

On conventional presses (water/ink processes), the quality of the process is very dependent on the difference in surface tension between water and ink, and this surface tension is highly temperature sensitive. When presses operate, heat is generated due to friction in the pressing area. Heat build-up can significantly alter the surface tension of the water/ink resulting in a deterioration in print quality.

IRt/c sensors easily monitor any roll surface temperatures within presses. Connected to a display with alarm signal, they can alert the operator of deteriorating temperature conditions before poor quality impressions are made.





This picture relates to the following pages.

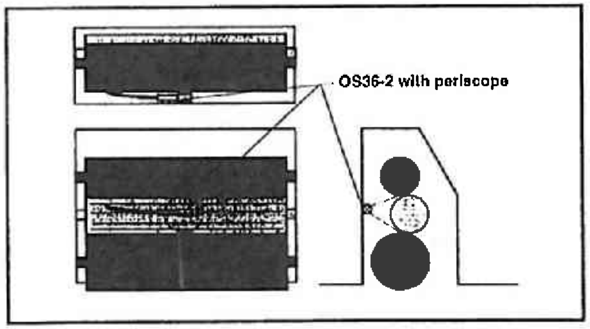
Press Locations for IRt/c:
1. Ink Rollers, Platens
2. Drying/Curing
3. Chill Rollers
4. Bindery

Connected to a temperature controller, PLC or computer, the IRt/c quickly signals an installed press temperature control system to provide cooling to the press area, or signal cooling systems to provide cooling to the ink and/or water supplies to maintain proper surface tension.

Temperature is also important when there is risk of thin wall cylindrical platen(s) becoming loose or sloppy due to thermal expansion (or contraction). On large diameter metal cylinders, a small temperature change can result in a significant change in the circumference of the roll, and thus affect the proper "fit." By measuring the surface temperature of the roll, the proper fit of the plate can be maintained by either (1) cooling the area or (2) slowing down the press so friction heat decreases to a low enough level to maintain print quality.

WATERLESS INK PRESSES and CONVERSIONS

"Waterless" ink technology involves the use of special inks to eliminate the need for the water/ink combination.



Small size of the IRt/c with its Periscope accessory fits into tight press areas.

This technology has significant cost and performance advantages for the printer in elimination of waste treatment, and higher quality product. The waterless ink technology can be applied to virtually all types (web and sheet fed) and sizes of presses from large multi-color presses down to the small presses.

Conventional presses can be converted to use these inks by providing a method to control the surface temperature of the rolls where the ink is applied to the platens. This is typically done by using hollow rolls and supplying chilled water through the rolls to keep the surface at a desired temperature. The IRt/c is a key component of the package required to convert a press, since waterless inks are very temperature sensitive and must be applied with strict ink and surface temperature control.

The surface temperatures are easily monitored by an IRt/c. The output signal is sent to a discrete temperature controller, PLC, or custom computer control system to regulate the refrigerated circulators providing cooling water.

The IRt/c sensing system is precise enough to also allow manipulation of color characteristics for waterless printing. For example, running a particular waterless ink at different temperature extremes allows for choosing between brilliant or softer colors.

Location 2: Drying and Curing

After ink is applied to the paper (or cloth, plastic, etc.) in the printing area, the web (or sheet) typically travels through a drying/curing process. IRt/c sensors are used where they (1) "look" directly at the web or sheet while it is inside the dryer or (2) at the web just as it exits the dryer. Either method can be used to control drying temperature or UV curing.

For web presses, a much more accurate way is also possible. By using multiple IRt/c sensors along the web while in the dryer, the actual "Dry-Out" point can be located and controlled within the dryer. See Application Note #50.

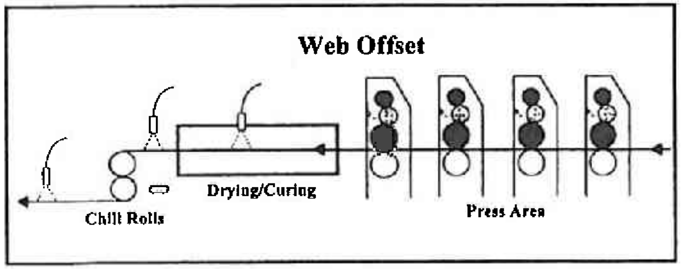
Location 3: Chill Rollers

For web offset printing, as the web leaves the dryer, it runs through a chill roller(s) to cool the web so that the paper (cloth, plastic, etc.) can be cut and stacked, or rolled, without the material sticking together.

By using IRt/c sensors to measure the surface temperature of the web at the point where it is being chilled, the IRt/c signal can control the amount of chilling. This control will eliminate "over chilling" (condensation problems due to high ambient humidity common in press rooms) and "underchilling" problems, automatically.

Location 4: Bindery

Hot melt glue guns and applicators periodically "plug up" or run out of glue. Properly used IRt/c sensors instantly alert machine operators prior to products being glued improperly.

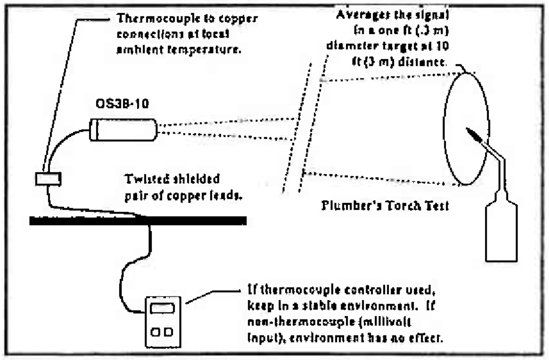


Application Note #53
Flame Detection

Many industrial processes involve highly flammable materials and are a constant potential hazard. As a result, for safety and loss prevention, flame detection devices are specified to alert or shut down the process in the event of a fire. The IRt/c, alone or in conjunction with other devices can provide a good solution. *Since the IRt/c is intrinsically safe, it can be mounted in the hazardous area* when used with the appropriate barrier, thus making it suitable for locations not possible with other flame detection devices.

The recommended model is the OS38-10. With spectral sensitivity of 0.1 to 5μ, this model will measure the short wave radiation created by a flame, while filtering out the changes in ambient target temperature.

It is strongly recommended that the system be tested for the desired response and control set-up. For example, the ability of the system to detect a plumber's propane torch flame at 10 ft (3 m) can be tested, resulting in an indicated temperature rise of the order of 50°F (30°C). The monitor/controller can be set appropriately, and all flames that are larger or more luminous than the torch will alarm. Customary testing, redundancy, etc. should be observed, as required for the application.



For many OEM and general temperature control applications it is sometimes desirable to test sensors before being placed into service, or to conduct routine checking while they are in service. Accordingly, recommended procedures are presented to allow easy checking with commonly available equipment. However, prior to testing, it is important to understand what indications an actual IRt/c failure might cause.

Factory Calibration

The non-adjustable IRt/c sensors (models without the "A" suffix that indicates user adjustability) are calibrated under conditions that optimize performance in actual use: target emissivity = 0.9 (a good general value for non-metals), and ambient temperature elevated to approximately 1/4 of the elevation of target temperature above room temperature (accurately simulates the effect of reflected energy). Since this type of test would require specialized devices, the procedures outlined have test standards that are slightly different, since they use blackbodies, or test surfaces/ambients whose properties vary to some extent.

What to Look For When Testing

Open Circuit: An open circuit (resistance > 15 KΩ) indicates a broken wire, and open circuit detection systems will perform normally to detect it.

No Response to Thermal Radiation: Sensor reads ambient temperature accurately, but does not respond when pointed at a hot target. This fault is similar to a short circuit with an ordinary thermocouple, in that the circuit is complete, but is measuring the ambient temperature at the short, and not at the measuring junction. For the IRt/c, this fault is the same as if the sensor were covered with foil, thus blinding it.

Sensor Reads Low: There are only two ways an IRt/c can shift after factory calibration: the lens becomes dirty; or the sensor loses its hermetically sealed Xenon gas.

- If the lens becomes dirty, the signal loss is directly proportional to the amount of dirt on the lens. Infrared energy is a form of light and therefore the situation is similar to ordinary window glass becoming dirty and blocking out sunshine. If considerably dirty before cleaning, the window will let more light through after cleaning, thus increasing the signal. If it was already clean, additional cleaning doesn't let any more light through, and the signal remains the same.
- If the durable IRt/c hermetic seal somehow fails, the Xenon gas will immediately escape. For even a small leak, the Xenon will escape quickly, within seconds. It is a "fail-safe" design. The Xenon gas will not leak gradually. If this occurs, the mV output sensitivity will immediately drop to approximately 50% or less of normal signal. For example, if a Type K-180°F/90°C sensor looks at a high emissivity 212°F (100°C) surface and reads correctly on a thermocouple meter, or gives you 3.3 mV on a DVM, then the sensor is within specifications. If the signal is only approximately 1.7 mV, or reads in the neighborhood of 140°F (60°C) with a thermocouple meter (and the lens is clean), the fail-safe gas seal has been compromised.

The fail-safe feature is quite important, since a breach of the sensor gas seal would permit contaminants to enter the sensitive detection system and cause unpredictable drift.

Conducting Pass/Fail Testing

For your convenience, 212°F (100°C) is recommended as a test target temperature, even though it might be outside the 2% linear range of the IRt/c being tested, since the strict repeatability of the IRt/c permits it to be tested at any temperature within its specified range. A digital volt meter (DVM) with at least 0.1 mV resolution is recommended instead of a thermocouple readout, since the DVM will be faster, and will not generate a leakage current that can cause readings to vary from sensor to sensor due to resistance variations. An ice point reference (real or electronic) is desirable, but not necessary for pass/fail testing.

Equipment

Best: Accurate Blackbody at 212°F (100°C).

Good Alternative: Pot of boiling water.

Procedure

1. Make sure the sensor window is clean.

   If it is not, then clean with a mild solvent such as alcohol and wipe dry.

2. Clip the DVM test leads to the IRt/c and point at the target, bringing the IRt/c as close as possible to be sure that the IRt/c sees only the target, taking care that the clip lead connections (the effective cold junctions) remain at room temperature.

3. Immediately read the DVM for the correct reading. For details of test set-up for the boiling water, see pages 5 through 8 in this Application Note.

In-Service Inspection Methods

Measure the surface temperature of the target (with the target at normal operating temperature) with an OS91/OS92 infrared thermometer. Make note of the temperature. Check the IRt/c display device and make sure the reading reproduces the original value that was obtained at installation calibration. If the IRt/c reading is incorrect, clean the lens with a cotton swab and alcohol (or similar cleaner) and recheck the display. If the reading is significantly lower, the fail-safe Xenon charge has escaped, indicating that the sensor should be replaced.

Calibration Values

Name____

Company______________________________________

Tel______________________Fax___________________

IRt/c model____________________________________

Target material and temperature___________________

For specifications for the mV signals that should be obtained for the test conditions obtained above, for any given model IRt/c, contact OMEGA.

Checking Calibration of IRt/c models or OS91/OS92 Series with Boiling Water

OS91/OS92 models are designed as highly accurate and reliable temperature references as well as fast easy-to-use infrared scanners. Since all components making up the OS91/OS92 models are drift-free *there is never a requirement to calibrate the instrument once it leaves the factory,* and no calibration means is provided on the instrument (except certain high temperature models). Accordingly, if the OS91/OS92 calibration has shifted from its factory setting, it requires repair since a component has failed. Similarly, non-adjustable IRt/c models are factory calibrated for life, and if they do not reproduce their calibration, they should be considered failed.

Unless you have technical experience with and have a laboratory infrared " blackbody ", this calibration checking technique is recommended by the factory. Boiling water is a physical constant, easily used, and requires no technical set-up of elaborate equipment or checking of traceable standards.

Boiling Point of Water

The open boiling point of (reasonably pure) water is affected by only one factor: barometric pressure. The standard 212°F (100°C) boiling point is for a barometric pressure of 30.00 inches of Hg (mercury), or in metric terms, 1 Bar (1000 millibars). This is "normal" at sea level. Barometric pressure can be affected by:

(1) Elevation Above Sea Level

(2) Weather Conditions

Elevation Correction: The boiling point of water is lowered by approximately 2°F (1°C) for every 1000 ft (300 m) above sea level with no unusual weather conditions. If your weather is "normal" and you are not using the barometric pressure method, you can simply use the following corrections.

Elevation	Boiling Temperature	
Sea level	212°F	100°C
1000 ft (300 meters)	210	99
2000 ft (600m)	208	98
3000 ft (900 m)	206	97
4000 ft (1200 m)	204	96
5000 ft (1500 m)	202	95

Weather Conditions: If you use this method, you do not need to put in a correction for elevation above sea level. It will be automatic by using the current barometric pressure dominating your area. Barometric pressure can be much lower during especially stormy conditions (low pressure areas), and much higher during extremely cool and dry conditions (high pressure areas). Consult the weather reports on TV, in your local newspaper, or call a weather service office for current barometric conditions in your area. Barometric pressure correction factors:

2°F / inch Hg (1°C / 30 millibars) change from 30.00 in. Hg (1 Bar)

- Add to the boiling temperature for higher than normal pressure.
- Subtract for lower than normal pressures.

Checking Calibration

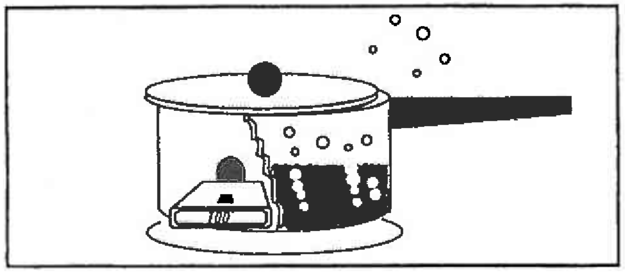
Necessary Equipment:

> **NOTE**
> Always clean the sensor lens prior to calibration testing. A cotton swab with a mild cleaner such as alcohol works well.

Metal pot with cover, minimum 4" (10 cm) tall.

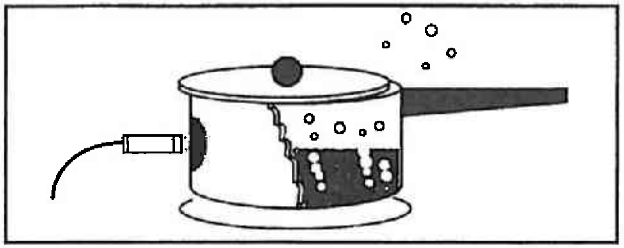
Solid paint marker or thin opaque tape.

1. Use a metal pot, with cover, for boiling water.
2. Fill the pot at least 1/2 fill with water.
3. Use the solid paint marker supplied with your OS91/OS92, or a piece of opaque (non-see through) tape, or a thin electrical tape, to put a measuring spot at least 1in. (25 mm) in diameter on the outside surface of the pot. Make sure the measuring spot is at, or slightly below, the water level.



OS91/OS92Checking

4. Bring the water to a RAPID boil. Tilt the cover SLIGHTLY so that the water does not boil over. The condensing steam on the inside of the pot along with the rapidly boiling water will force the outside surfaces of the pot to be within a fraction of a degree of the temperature of the boiling water. (The temperature drop through the wall thickness of the average pot for boiling water is very small and can be ignored.)



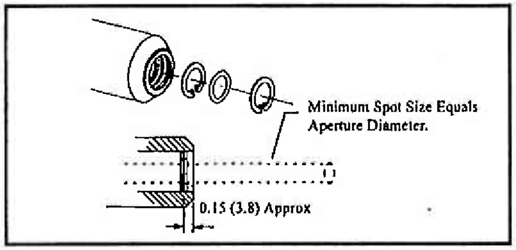
IRt/c Checking

5. Briefly touch the nosepiece flat onto the black mark and note the temperature reading. For an IRt/c, bring the sensor as close as possible without touching.

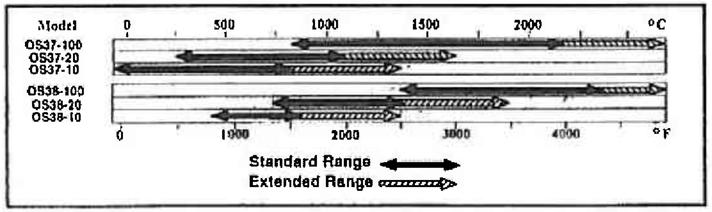
The reading should be within ±2% of the actual boiling point (for example ±2°C for 100°C boiling point). If the reading is not within these limits, the instrument has a failed component and should be returned to OMEGA for repair. For the IRt/c refer to Application Note #53 for specifications.

Application Note #55
Increasing Temperature Range, Improving Adjustment Sensitivity and Reducing the Minimum Spot Size with the Aperture Kit

For all IRt/c adjustable models (O37 & OS38) an Aperture Kit is provided to offer the ability to extend the target temperature range, improve the adjustment sensitivity of the adjustment potentiometer, and reduce the minimum spot size to as small as 1/4" (6 mm).



The kit consists of one 1/2" (13 mm) and one 1/4" (6 mm) stainless steel apertures and two retaining rings. The apertures and retainers are installed as shown, taking care that the retainers sit and lock between the internal threads. The precise axial location is not critical. Install only one aperture, based on the requirements of your application as specified below.



The function of the aperture is to reduce the quantity of radiated energy entering the IRt/c optical system, thus increasing the rated maximum target temperature before burn-out.

In addition, since less signal is produced at a given temperature, the adjustment will be less "tweaky" when calibrating the IRt/c installation. The table below lists the range of temperatures for each model recommended with and without the apertures. These recommendations are approximate, since the actual signal level will depend on the actual target characteristics (emissivity, etc.). If there is insufficient adjustment range available with the small aperture installed, simply replace it with the large one, or remove it. If the adjustment is too sensitive, install an aperture. Use the table below to set up your installation initially, to make sure that the IRt/c is not damaged by excessive radiation, then adjust up or down as required to meet your calibration requirements.

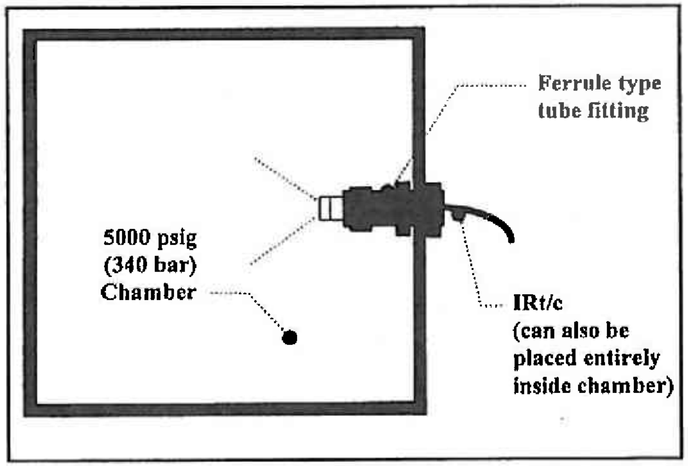
Model	No Aperture	1/2"(13mm) Aperture	1/4"(6mm) Aperture
OS37-10	-50° to 500°F	500° to 1500°F	1500° to 2500°F
	-45° to 260°C	260° to 820°C	820° to 1370°C
OS38-10	800° to 1200°F	1200° to 1600°F	1600° to 2500°F
	430° to 650°C	650° to 870°C	870° to 1370°C
OS37-20	500° to 1000°F	1000° to 2000°F	2000° to 3000°F
	260° to 540°C	540° to 1100°C	1100 to 1650°C
OS38-20	1300° to 1800°F	1000° to 2000°F	2500° to 3500°F
	700° to 980°C	540° to 1100°C	1370° to 1930°C
OS37-100	1500° to 2500°F	2500° to 4000°F	4000° to 5000°F
	800° to 1370°C	1370° to 2200°C	2200° to 2760°C
OS38-100	2500° to 3500°F	2500° to 4500°F	4500° to 5000°F
	1370° to 1930°C	1930° to 2500°C	2500° to 2760°C

** Type J or K

Application Note #56
IRt/c Tested at 5000 PSIG (340 bar) Pressure

For some types of processes, it is necessary to monitor temperatures of materials subjected to high gas pressures, without contact. Conventional contact devices are difficult to employ under these conditions and conventional IR devices are unsuitable due to the inability of their optical and electronic components to withstand high pressures.

With its elegant simplicity and solid construction, the IRt/c can be used, and has been tested, at pressures up to 5000 PSIG (340 bar). A simple ferrule type tubing fitting may be used to provide a pressure-tight seal around the IRt/c housing. If using an IRt/c model with a lensed optical system (OS36-5; OS36-10; etc.) pierce the lens at its edge with a needle to provide pressure equalization.



Application Note #57
IRt/c Tested for Vacuum and Microwave Compatibility

Tests for compatibility performed by customers contribute greatly to our understanding of how IRt/c's perform in unusual environments, where non-contact temperature measurements are required. This series of tests was performed by a customer who required the performance, and had the facility to test the IRt/c. The test was conducted in a 4 ft by 4 ft (1.2 m by 1.2 m) chamber in the following sequence:

First Test

1. Vacuum exposure 15 minutes at 40 Torr
2. Microwave Exposure 5 minutes 3 KW at 2450 MHz
3. Chamber load 15 pounds H_2O

Second Test

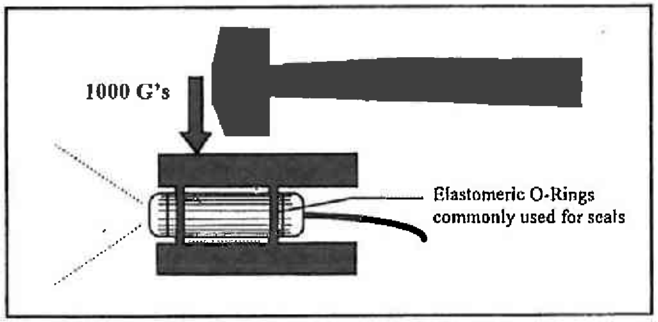
1. Vacuum exposure 10 minutes
2. Microwave Exposure 30 seconds 3 KW at 2450 MHz
3. Microwave Exposure 10 seconds 3 KW at 2450 MHz
4. Chamber load 1 pint H_2O

The IRt/c showed no ill effects and operated flawlessly when checked after the test sequence.

Application Note #58
IRt/c's Withstand 1000G Shock

With simple "O-ring" mechanical supports, IRt/c's can withstand up to 1000 g shock without damage, and *without shift in calibration.* Such robustness makes them well suited to heavy duty applications where high levels of shock and vibration are common.

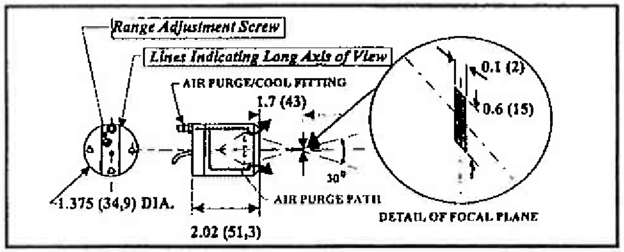
More modest forces of 10 g can be withstood on a continuous basis, but fatigue of the cable can be a problem. Mechanical support, coiling, or other appropriate cable management is recommended.

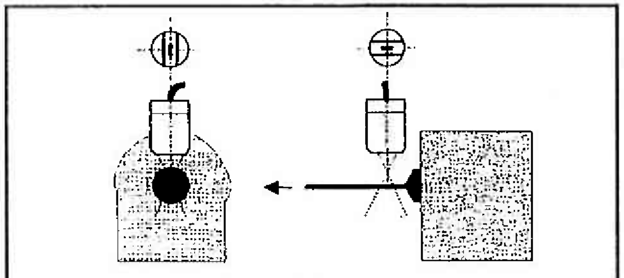


Application Note #59
Unique Slit Spot Size IRt/c's Measure Small Rectangular Spots
OS37A-CF for Non-Metal Targets, 0°F to 2500°F (-18°C to 1370°C)
OS38A-CF for Metal Targets, 800°F to 2500°F (430°C to 1370°C)

Specifically designed for measuring temperatures of very small objects, the unique slit shape makes it possible to monitor and control such difficult targets as small extrusions, yarn, thread, wire, glass fiber, etc.

To use, follow all of the standard set-up and calibration instructions in the Operator's Manual. Use the lines scribed on the back of the sensor to align the field-of-view on the target. The alignment can be fine-tuned by moving the sensor (closer, farther, rotate slightly) until a maximum signal is obtained. For convenience a handheld t/c meter or millivolt meter can be used. The sensor is positioned optimally when the maximum signal is obtained on the meter.





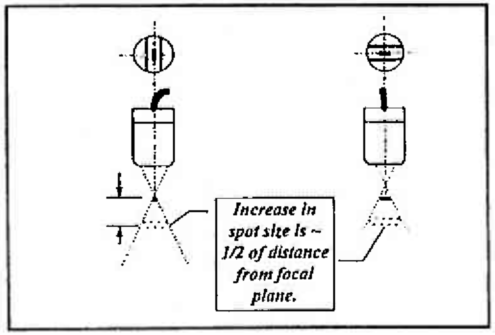
Slit Spot IRt/c Monitors Extrusion Temperature

The Aperture Kit provided with the sensor may be used to extend the temperature range, or improve the resolution of adjustment. The wide linear range calibration technique specified in the manual is recommended. Following are the temperature limits with each aperture:

Target Temperature Ranges

Aperture	None	1/2" (13 mm)	1/4" (6 mm)
OS37A-CF	0° to 500°F	500° to 1500°F	1500° to 2500°F
(Non-Metal Targets)	(-18° to 260°C)	(260° to 820°C)	(820° to 1370°C)
OS38A-CF	800° to 1200°F	1200° to 1600°F	1600° to 2500°F
(Metal Targets)	(430° to 650°C)	(650° to 870°C)	(870° to 1370°C)

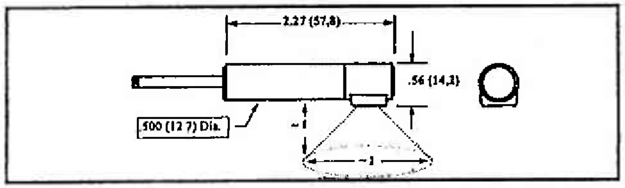
For monitoring targets which are outside the focal plane, the field-of-view can be approximated by intersecting planes in both views with included angle of approximately 30°. This results in one-half of the distance from the focal plane to be added to each dimension. For example, if the target is 1" (25 mm) from the focal plane, 1/2" (13) would be added to both dimensions, resulting in a spot size of 1.1" (28) long by 0.6" (15) wide.

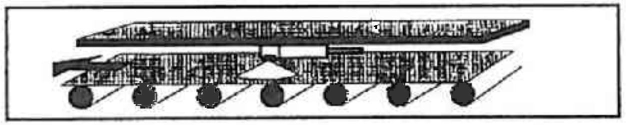


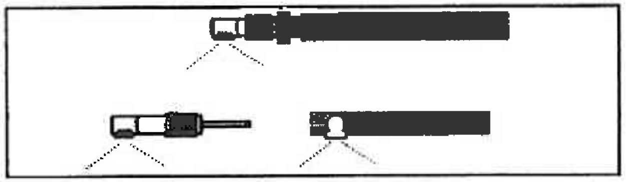
Application Note #60
OS36-RA Designed for Monitoring Web Processes

In heating, drying, coating, cooling, or any other thermal processing of webs of paper, plastic, metals, film, etc, often there is very little space available for a sensor to monitor web temperature. In a space as small as 0.56" (14.2 mm) the OS36-RA Infrared Thermocouple can be installed to monitor temperature of the moving web, and reliably control the process to maximize quality and throughput of the product.

The OS36-RA has all of the same specifications as the standard IRt/c, including no power requirement, rugged stainless steel hermetically sealed construction, intrinsically safe, full electrical shielding, 80 msec response time, and ability to operate uncooled in environments up to 200°F (93°C). It is available in J,K,T,E thermocouple types, with linear range selections the same as the standard IRt/c. The solid filled 1/2" (12.7 mm) tubular housing can be held securely with convenient tube fittings or standard clamps to mount the sensor over the target area.







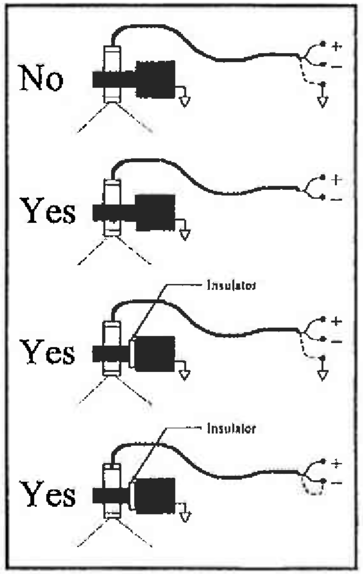
Application Note #61
Grounding and Shielding for Electrostatic Protection and Noise Suppression

Applies to All Models With Stainless Steel Housing

All IRt/c models with stainless steel housing are built with complete electrical shielding of both the housing and cable, with the measuring elements electrically isolated from the housing (as in a conventional **ungrounded** thermocouple). By adhering to standard good practice in grounding and shielding techniques, IRt/c's can provide outstanding performance in the most severe electrical environments commonly found in production processes.

Q. When is attention to grounding and shielding required?

A. If the IRt/c must operate in extreme environments, employ long thermocouple cable runs, the measuring system is utilizing the high speed capability of the IRt/c, or if the process can generate high static electricity fields. For most installations, the built-in noise rejection characteristics of the IRt/c are sufficient to insure good performance, especially if the readout device is heavily filtered with a long input time constant.

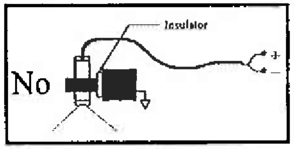


Q. Can I Operate Ungrounded?

A. Yes, but it is not recommended, especially in applications where the process can generate high static electricity fields. Examples are web processes of all types, including printing, laminating, film drying, etc. Without either the housing or shield grounded to drain away the charge, a static charge can build in the housing, which may eventually discharge through the IRt/c sensing elements, and can cause damage to the sensor.

Q. How do I use the shield correctly ?

A. The most important rule is to be sure the shield is grounded at only one point, preferably at the signal input ground. Keep in mind that the housing is connected to the cable shield, and if the housing is electrically in contact with machinery at the mounting point, that point will be a ground, and the shield wire should not be connected at the instrument end. For best possible performance, electrically isolate the IRt/c at the mounting point and ground the shield at a suitable ground on the readout instrument.



Q. Can I ground the shield to the negative (red) thermocouple lead instead of to a chassis ground?

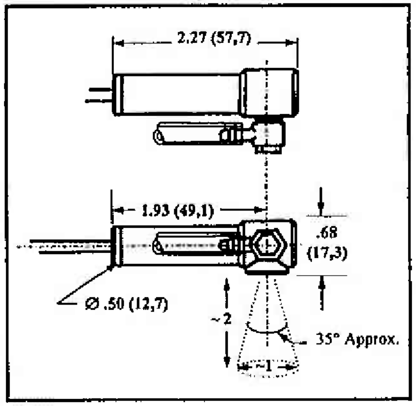
A. Yes, but test both alternatives in your application and use the one that gives the cleanest signal. Be sure that the housing is electrically isolated, otherwise ground loop currents may cause errors.

Q. Should the extension cable be shielded?

A. As indicated above, if the installation requires high speed performance, twisted shielded extension cable and connectors with ground straps should be used throughout. Aluminum foil is a suitable material to complete a shield if their are gaps in the shield coverage.

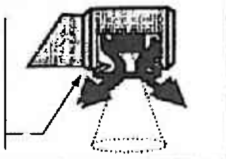
Application Note #62
OS36-2RA Designed for Monitoring Temperature in Dirty or Vapor-Filled Environments

In heating, drying, coating, cooling, or any other thermal processing of webs of paper, plastic, metals, textiles, film, etc., often there is very little space available for a sensor to monitor web temperature, and the harsh environment requires a highly efficient air purge design to prevent fouling of the IR lens. In a space as small as 0.7" (18 mm), and in areas where ink or paint are being applied, the OS36-2RA Infrared Thermocouple can reliably control the process to maximize quality and throughput of product.



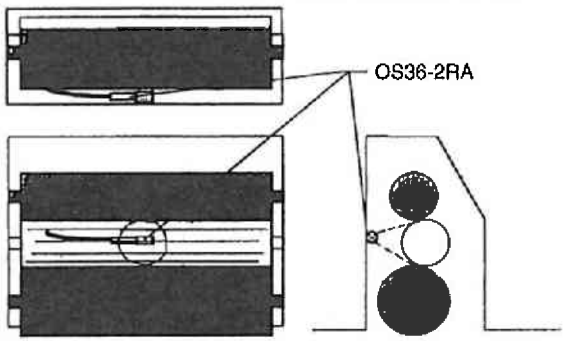
The OS36-2RA has all of the same specifications as the standard IRt/c, including no power requirement, rugged stainless steel hermetically sealed construction, full electrical shielding, 80 msec response time, and ability to operate uncooled in environments up to 200°F (93°C). It is available in J,K,T,E thermocouple types, with linear range selections the same as the standard IRt/c. The solid filled 1/2". (12.7 mm) tubular housing can be held securely with convenient tube fittings or standard clamps to mount the sensor over the target area.

Air Chamber Design requires only 5 psig (.3 bar) air pressure to prevent any directly sprayed paint or ink to adhere to the lens.

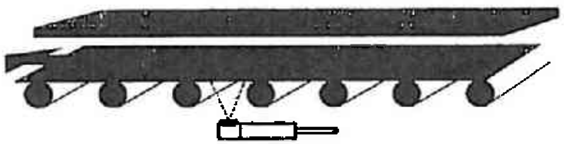


Ideal applications are offset printing, where the presence of inks and physically tight locations make the OS36-2RA the sensor of choice. Targets that must be monitored "upside down" are also ideal applications, since the narrow field of view and air purge will prevent debris from blocking the lens.

Only 5 PSIG (.3 bar), which consumes less than 1 SCFM (.03 m³/min) is required for direct paint spray environments.



Printing Press Application



Upside-down Application

Application Note #63
Using the OS36-01 in a High Electrical Noise Area

Applies to All Models With ABS Plastic Housing

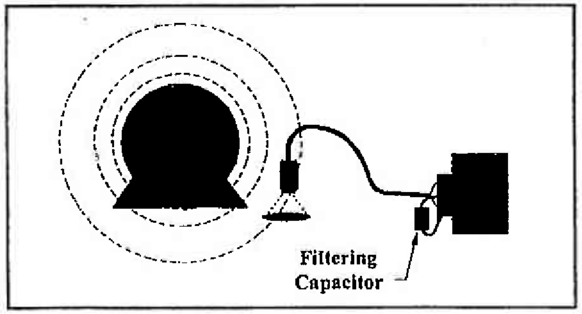
In applications where the low cost of the OS36-01 is important, and the other performance requirements are met by the sensor, there are occasional concerns that electrical noise in the environment can affect the readings. By employing one or more standard techniques, OS36-01 's can provide outstanding performance in the most severe electrical environments commonly found in machinery.

- **Employ Filtering Available in the Readout Device.**

If the readout device is heavily filtered with a long time constant, there is normally never a problem with noise. Response time constants in the range of 1 second are in common use in temperature controllers, and are usually more than enough to prevent any significant noise interference.

- **Add a Filtering Capacitor the Thermocouple Input Terminals.**

By adding a capacitor across the thermocouple input terminals, any electrical noise can be reduced to insignificance, but at the expense of sensing speed.



For convenience, the table below tabulates the effect of different size capacitors, the approximate noise reduction factor, and the increase in temperature response time constant.

Capacitor Size in Microfarads	Noise Reduction Factor	Increase in Time Constant in msec.
10	10	30
50	50	150
100	100	300

- **Add a Shield to either the OS36-01 or the EMI Source.**

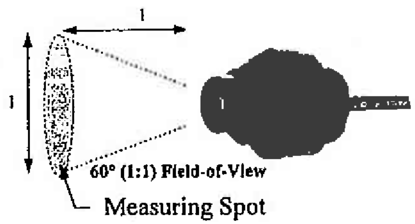
With aluminum foil, conduit, etc. the OS36-01 can be shielded from the source of electromagnetic radiation directly. Be sure to properly ground the shield. Refer to Tech Note No. 61 for recommendations.

- **Consider Substituting a Fully-Shielded IRt/c Model**

If none of the above options provide the necessary performance, especially for high speed applications, select one of the fully shielded stainless steel IRt/c models for your application.

To assist you in specifying an OS36-01 for your application, the following sequence of steps is recommended:

- Locate the OS36-01 close enough to make the measurement accurately.



Referring to the 1:1 field-of-view specification, be sure that the target is large enough, or the sensor close enough such that the target is larger than the measuring spot. The OS36.01 can be physically close as to nearly touch the target, and is limited only by physical space and local temperature. Normal mounting is with the locknuts (2 supplied), but alternative methods may be used to hold the cylindrical section or the flats,whichever is more convenient in locating as close as practical. For hot targets in close proximity (~ 1 inch or 2.5 cm) permit adequate ventilation of the mounting to keep the OS36.01 below its 160°F (70°C) rating. If the sensor face is likely to become dirty, mount in such a fashion to permit occasional cleaning with a mild solvent such as alcohol.

- Select the linear range required.

Referring to the Temperature Selection Guide, choose the model that has the center of its linear range closest to the control point for your application, and select the thermocouple type you prefer.

If your application includes monitoring and control over a range of more than ~ 100°F (~ 50°C), and your thermocouple interface has computational ability, request a copy of the IRt/c Signal Output Table for your model, which has the data necessary to linearize over the entire operating range of the OS36-01.

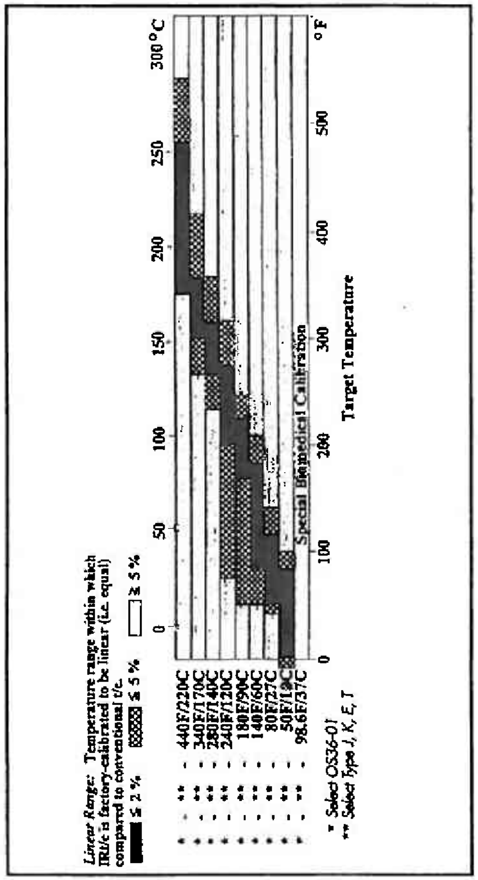
- Calibrate the initial installation.

Referring to the Operator's Manual, the best practice is to install the OS36-01, operate the process under normal conditions, and calibrate the read-out system based on the reading from a reliable reference (the OS91/OS92 models are recommended). As long as the target materials are consistent, and there is no leakage current offset from the electronics, the initial calibration will be valid for all subsequent installations.

Other specifications not listed on Page B-3 in the Operator's Manual.

Accuracy (Linearity):	±2% of nominal vlaue (target with emissivity of 0.9), or ±2°F (1°C)

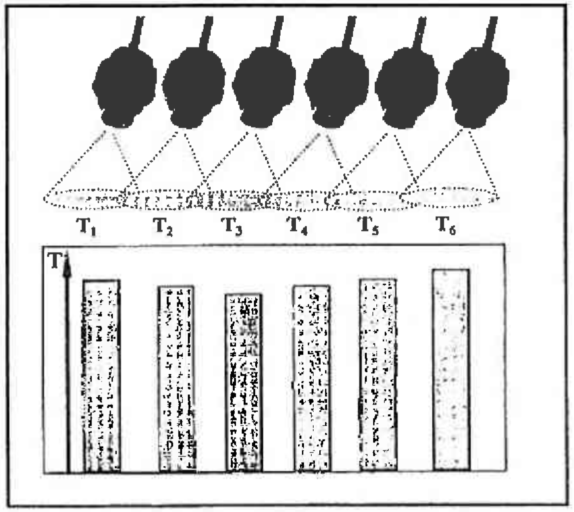
Temperature Selection Guide and Linear Range Chart



Application Note #65
Inexpensive Infrared Scanning Arrays with OS36-01

With the low cost and direct compatibility of the OS36-01 with inexpensive, widely available thermocouple input devices, powerful infrared scanning arrays can now be considered for applications in which thermal signatures are desired for process monitoring and control. Such applications include web drying, printing, laminating, paint curing, and any other thermal processing of moving material. Multiple input monitoring and control include data acquisition systems, personal computers, PLC's, and custom OEM cards.

By taking advantage of the low cost performance of the OS36-01 and standard available components, infrared scanning arrays can be put to work controlling your process for well under $100 per channel.



Some tips on setting up an IRt/c infrared scanning array:

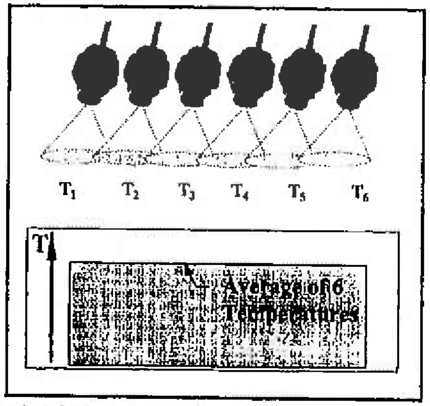
Be sure to use identical models for each sensor in an array.

This will keep all of your signals internally consistent within the software you use, and avoid any interpretation errors. Also, if you employ the available IRt/c Signal Output Tables, one table or curve will apply to all the sensors in an array. IRt/c's of the same model are interchangeable to ±2% of reading.

Investigate low cost thermocouple interfaces.

Prices per channel for computer A/D cards and PLC input cards for thermocouples have fallen to well under $100, and are available for as little as $30 for some systems. If the application is for high volume OEM equipment, consider using a board-level chip such as the Analog Devices AD594/5, available at under $7.

For single channel use, consider IRt/c's in parallel.



Wired in parallel to a single input channel, an array of IRt/c's produces an output signal which indicates the *average temperature* of the targets scanned. This attribute is particularly convenient for monitoring and controlling wide webs, which cannot easily be covered by a single sensor. To use, simply wire all of the red t/c leads to the negative input terminal, and the other leads to the positive input.

NOTES