Advantages of Contact Thermometers over Non-Contact/Infrared Thermometers

Introduction

Understanding the difference between contact and non-contact temperature measurements is vital to health, safety and quality issues in a wide range of industries. Thermometers have been used for centuries and temperature is the second-most frequently measured physical quantity after time. Various fields including civil and mechanical engineering, medical, manufacturing, quality control, maintenance, etc., depend heavily on accurate temperature measurements. These measurements provide important information such as the condition of industrial equipment, allow controlling refrigerators and air conditioners, and make it possible for pilots to determine if icing conditions exist. Accurate temperature monitoring ensures that processes are operating consistently under optimum conditions, which results in improved product quality, increased safety, increased productivity, and reduced downtime.

Thermometers are mainly classified into two major categories: contact and non-contact. In contact thermometers, contact sensors measure their own temperature. Contact thermometers measure temperature using the heat transfer phenomenon known as *conduction*. They require physical contact with the object being measured to bring the sensor body to the object's temperature. In contrast, non-contact thermometers use an infrared sensor to measure the temperature of an object by reading its level of infrared emissions.

Contact Thermometers

Contact thermometers are classified based on the sensor type used for the measurement, i.e., the thermocouple, resistance temperature detector (RTD) or thermistor. Selecting the proper sensor type is the first important step and depends mainly on the application and additional factors like size, cost, and accuracy. Most applications have a well-defined measurement range, accuracy requirement, and physical size constraints.

Thermocouples are the most widely used sensors because of their low cost and wide temperature range. They are a perfect fit for applications like oven surface measurements, bedbug extermination, meat and other food processing, etc., where high accuracy is not required. Various probe styles such as gas, surface, general purpose, and penetration probes (*Figure 1*) are available in the market and should be carefully selected based on the application's requirements.

Many applications in healthcare services, fluid temperature measurements, and medical research require higher accuracy, which means RTD/thermistor sensors are often necessary in those areas. RTD/thermistor sensors are not only more accurate than thermocouples but more expensive. The wider temperature range thermocouples offer is sacrificed for higher accuracy. RTDs are among the most precise temperature sensors available, with measurement uncertainties of ±0.1 °C or better. The most popular RTD type is the 100 Ω Platinum RTD.

Figure 1: Thermocouple Probe Styles

Non-Contact Thermometers

Non-contact thermometers, also known as infrared (IR) thermometers, measure temperature from a distance. Every form of matter with a temperature above absolute zero (0K) emits infrared radiation relative to its temperature. This is called *characteristic radiation*. The *emissivity* of a material is the relative ability of its surface to emit energy by radiation. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can be determined most of the time. IR thermometers infer temperature by measuring the amplitude of IR energy being emitted from the surface (*Figure 2*).

Recent innovations have reduced the production cost and increased the reliability of these non-contact thermometers, opening the doors to many new applications. Four primary factors—application, instrument accuracy, reliability and budget—help determine which type of non-contact temperature measurement instrument should be used.

The most common infrared thermometer types are spot infrared thermometers, infrared scanning systems and infrared thermal imaging. The last two of these are more complex and costly than spot infrared thermometers and are mainly used in quality monitoring of manufacturing processes. This application note will mainly focus on spot IR thermometers.

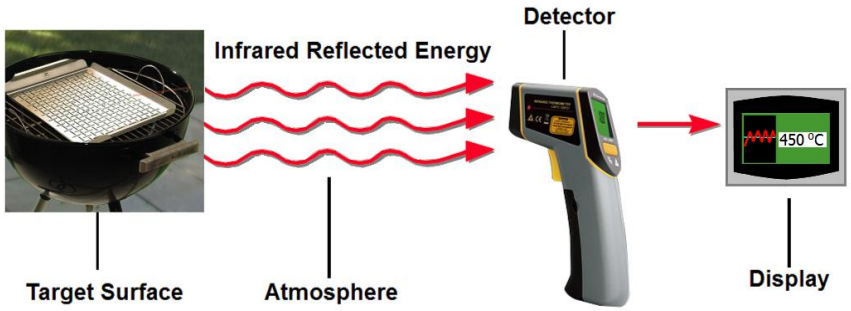

Figure 2: Typical IR Thermometer Measurement

Comparison

It's important to consider a variety of factors before making a thermometer choice.

- Applications – Many factors influence the choice of the appropriate temperature measurement instrument for a given application. Physical factors include:
  - Target temperature range
  - Target material
  - Target size
  - Target distance
  - Interfering gases
  - Ambient temperature

  Infrared thermometers facilitate measurement of moving parts. Instead of judging whether it is safe to work on a machine, the temperature of machines can be detected while they're in operation. There is no risk of contamination and no mechanical effect on the surface of the object. Temperature measurement without process interruption might be important in some applications and IR thermometers are a better fit than conventional thermometers in such cases. However, keep in mind that IR thermometers measure only the surface temperature.

  Food processing applications like measuring the core temperature of meat (*Figure 3*), monitoring multiple points in a heated room, measuring closed containers or a hot oven surface measurement require making physical contact with the surface. In high temperature applications, such as bedbug extermination, which can require reaching temperatures of 150-160 °F, a probe can be placed and monitored over a long period. Continuous temperature monitoring and data collection is the key in some applications, which is easily achieved with contact thermometers. For example, a thermometer with Bluetooth or Wi-Fi connectivity can record the temperature data and send it to a PC or smartphone for further analysis.

Figure 3: A Penetration Probe Measuring the Core Temperature of a Piece of Meat

- Accessibility – IR thermometers make it possible to measure the temperature of hazardous or physically inaccessible objects, such as the operating temperature of motor or blower bearings. However, internal motor winding temperatures are not obtainable with an IR thermometer and require using an embedded thermocouple or RTD.

- Accuracy – Accuracy is an important factor when selecting a thermometer to ensure product yields and quality. A contact thermometer's accuracy is typically better than an IR thermometer's. Few high accuracy IR meters are available, but the cost versus accuracy ratio is much better in contact thermometers (*Table 1*).

	Contact			**Non-Contact**	
	Thermocouple	RTD	Thermistor		
Typical Accuracy	± 0.6 °F	± 0.4 °F	± 0.8 °F	± 2 °F	± 1.5 °F
Temp. Range	-300 to 2200 °F	-100 to 1100 °F	-40 to 300 °F	-20 to 930 °F	-25 to 1600 °F
Avg. Cost	$145 - $400	$325	$225	$200	$925

Table 1: Comparison of Contact and Non-Contact Thermometers

Infrared thermometers will read all the energy within their field of view. Various materials and operating environments, such as flames, gases or other obstructions in the instrument's field of view can negatively impact measurement accuracy. Any hot objects near the measured object will radiate energy that can be reflected or transmitted by the measured object into the thermometer field of view, affecting the measurement. The optical system of an infrared thermometer picks up the infrared energy emitted from a circular measurement spot and focuses it on a detector.

The target must be optically visible and larger than the spot size in the IR thermometer. High levels of dust, condensing liquid or smoke can reduce measurement accuracy. The target must completely fill this spot; otherwise, the IR thermometer will 'see' other temperature radiation from the background, producing an inaccurate measured value.

The *Distance to Spot* ratio is another very important feature to consider. The D/S ratio is the size of the area being evaluated by the infrared thermometer as it relates to distance. In simple words, the area being measured becomes larger as the distance increases. This has a big impact on the accuracy of the measurement. For example, if the target is 5 inches in size, and the infrared thermometer has a D/S ratio of 8:1, then the maximum distance from which one can reliably measure the temperature of the target is 40 inches (*Figure 4*). Beyond this distance, not only is the target being measured, but whatever else falls within the measurement spot is being measured as well. This means that, if a very hot object is the target, but it is surrounded by a cooler area, measurements taken beyond the maximum distance will include the cooler area, lowering the average temperature from that of the spot. In these cases, contact thermometers are at an advantage because they eliminate the need to worry about spot and focus.

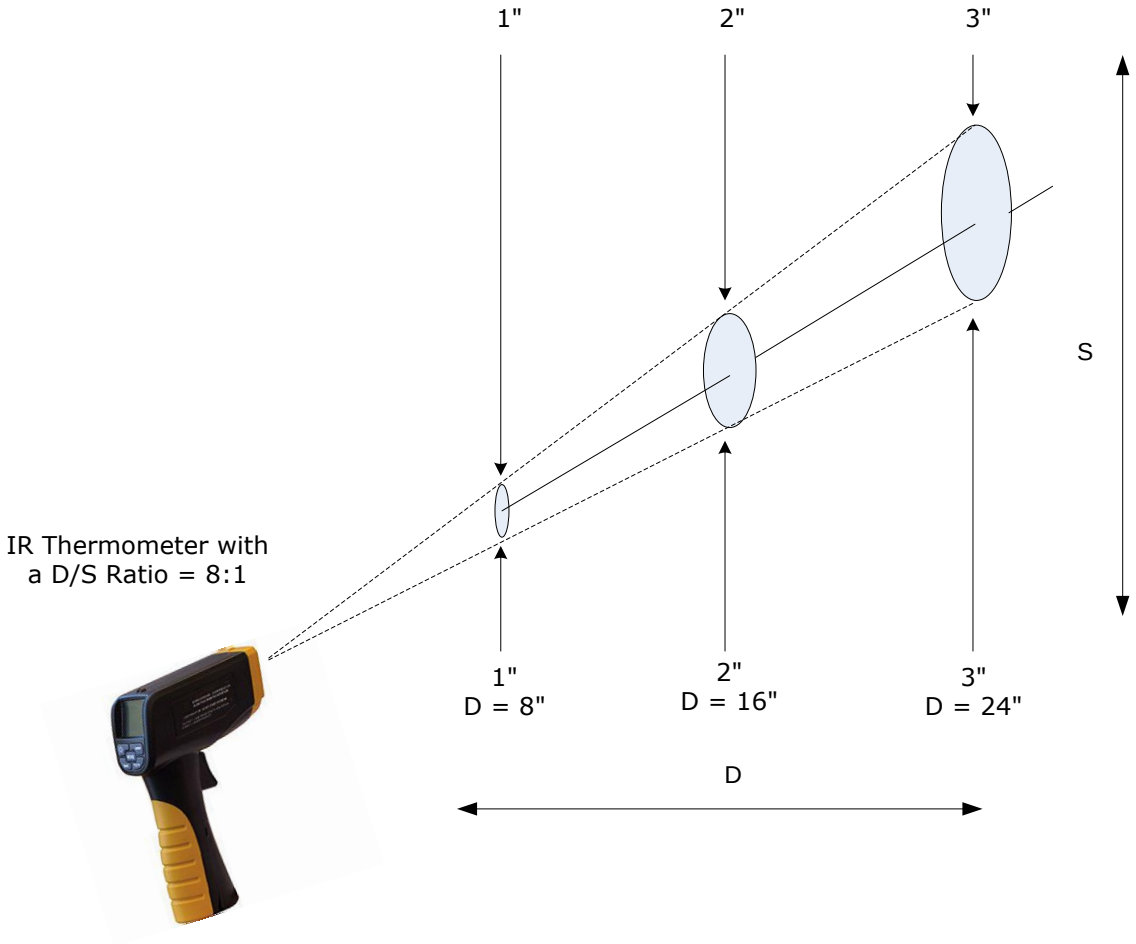

Figure 4: Distance to Spot Ratio

- Response Time – The response time of infrared thermometers is in milliseconds, allowing for faster measurements. In contact thermometers, the probe response time slows down the measurement. The microcontroller reads the signal from the sensor and the temperature is displayed. The whole process typically takes 1-2 seconds.

- Temperature Range – Infrared thermometers typically have a smaller temperature span (-4 °F to 500 °F) than contact thermometers. Contact thermometers with thermocouple sensors can measure temperatures as high as 2700 °F. IR thermometers with very wide ranges are the costliest type of these and thermocouples are a better choice in very high or very low temperature applications.

- Durability – Because of their non-contact design, infrared thermometers have advantages over contact thermometers, but it's important be very careful with the IR sensor by protecting its the optics from dust and condensing liquids to allow a good reading. With a contact thermometer, the probe makes physical contact with the surface, requiring periodic replacement or maintenance.

Table 2 outlines some critical factors that can clarify the most appropriate choice of thermometer for a specific application.

	Select Contact Thermometer	Select Non-Contact Thermometer
Measurements involve surface and non-surface measurements	✓	✗
Target size is very small or target is very far from the thermometer	✓	✗
Accuracy requirement is less than 1 °F	✓	✗
Application needs response in milliseconds	✗	✓
Temperature required is very high (>1000 °F) or very low (<-4 °F)	✓	✗

Table 2: Thermometer Selection Guide

What Does TEGAM Offer?

TEGAM manufactures a complete line of handheld digital thermometers in thermocouple, thermistor and RTD calibrations. They are designed to match probes that fit the needs of discerning auditors and QC professionals working in environments subject to wide temperature swings and varying humidity levels.

Figure 5: TEGAM 911A and 912A Thermocouple Thermometers

Figure 6: TEGAM 931A and 932A Data Collection Thermometers

For example, the single-channel 911A and dual-channel 912A (*Figure 5*) are K, J, T and E thermometers with 0.04% rdg + 0.3 °C basic accuracy and selections for °F, °C with 0.1°/1° resolution. Both include MIN, MAX, AVG, RNG, and STDEV statistics for each channel, plus T1-T2 on the 912A. They have competitive features such as high accuracy, simple one-button function selection, and thermocouple fault monitoring. They also have a single-piece keyboard that not only resists water but is easily cleaned to remove dirt or food particles. The 911A and 912A offer the best combination of price, durability and accuracy available.

The 931A and 932A (*Figure 6*) include all the same great features of the 911A and 912A, plus *Bluetooth*®[1] wireless temperature data collection. When used with the free TEGAM Thermometer Link™ mobile application and TEGAM Cloud™ data storage, they make a comprehensive, easily-implemented temperature data management solution.

Like all TEGAM products, we back these durable thermometers with a standard 3-year warranty and a 2-year calibration guarantee to ensure that your instrument is ready to use when you need it.

When your measurement matters . . . **Be Certain with TEGAM!**

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