

**Operational experience with temperature sensors  
In the Egyptian Observing Network**

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**ABSTRACT**

A sensor is a device that receives an input physical property (stimulus, or measurand) and responds with an electrical signal. The stimulus is the quantity, property, or condition that is sensed and converted into electrical signal which is compatible with electronic circuits. We may say that a sensor is a translator of a generally non electrical value into an electrical value. The sensor's output signal may be in the form of voltage, current, or charge. These may be further described in terms of amplitude, frequency, phase, or digital code. This set of characteristics is called the output signal format.

The term sensor should be distinguished from transducer. The latter is a converter of one type of energy into another, whereas the former converts any type of energy into electrical signal. On the other hand sensor does not function by itself; it is always a part of a larger system that may incorporate many other detectors, signal conditioners, signal processors, memory devices, data recorders,

It positioned at the input of a device to perceive the outside effects and to signal the system about variations in the outside stimuli. The sensors are always a part of some kind of a data acquisition system; that collect the data from an object. This object may be temperature, relative humidity, wind speed, wind direction, rain, radiation, etc.

In this paper we will talk about two types of temperature sensors, RTD<sub>s</sub> & thermistors with greater concentration on the most accurate type that is being used for meteorological applications in the Egyptian observing network.

## **INTRODUCTION :-**

The most common meteorological variable that is being measured is air temperature; it is a measure of the average kinetic energy of any object.

Temperature sensors come in a wide variety and have one thing in common, they all measure temperature by sensing change in a physical characteristic. There are different basic types of temperature sensors:- Thermocouples, resistive temperature devices (RTDs), thermistors, infrared radiators, bimetallic devices, liquid expansion devices (Thermometers), molecular change-of-state and silicon diodes.

**Thermocouples consist essentially of two strips or wires made of different metals and joined at one end. Changes in the temperature at this end induce a change in electromotive force (emf) between the other ends. As temperature goes up, this output emf of the thermocouple rises, and it is not necessarily linearly.**

**Resistive temperature devices capitalize on the fact that the electrical resistance of a material changes as its temperature changes.**

**Thermistor is a temperature-sensing element composed of sintered semiconductor material which exhibits a large change in resistance proportional to a small change in temperature..**

**Infrared sensors are non contacting devices; that infer temperature by measuring the thermal radiation emitted by a material.**

**Bimetallic devices take advantage of the difference in rate of thermal expansion between different metals. Strips of two metals that bonded together. When heated, one side will expand more than the other, and the resulting bending is translated into a temperature reading by mechanical linkage to a pointer. These devices are portable and they do not require a power supply, but they are usually not as accurate as thermocouples or RTDs and they do not readily lend themselves to temperature recording.**

**Fluid-expansion devices, typified by the household thermometer, generally come in two main classifications: the mercury type and the organic-liquid type. Versions employing gas instead of liquid are also available. Mercury is considered an environmental hazard, so there are regulations governing the shipment of devices that contain it. Fluid-expansion sensors do not require electric power, do not pose explosion hazards, and are stable even after repeated cycling. On the other hand,**

**they do not generate data that are easily recorded or transmitted, and they cannot make spot or point measurements.**

**Change-of-state temperature sensors consist of labels, pellets, crayons, lacquers or liquid crystals whose appearance changes once a certain temperature is reached. They are used, for instance, with steam traps - when a trap exceeds a certain temperature, a white dot on a sensor label attached to the trap will turn black. Response time typically takes minutes, so these devices often do not respond to transient temperature changes. And accuracy is lower than other types of sensors. Furthermore, the change in state is irreversible, except in the case of liquid-crystal displays. Even so, change-of-state sensors can be handy when one needs confirmation that the temperature of a piece of equipment or a material has not exceeded a certain level, for instance for technical or legal reasons during product shipment.**

Whatever any type of the above sensors we use; we must know that most sensors overlap in temperature range and accuracy so, selection of the sensor depend on how it will be integrated into a system and for **which** application it will be used. EMA has been using different types of temperature sensors for observing purposes but we will concentrate only on the most common used sensors for meteorological applications, Resistive temperature detectors (RTDs) & thermistors.

**Temperature sensors help us determine how cold or how hot a substance is. Temperatures in science are measured and reported in degrees Celsius ( $^{\circ}\text{C}$ ). or in degrees Fahrenheit ( $^{\circ}\text{F}$ ). On both of the Celsius and Fahrenheit scales the temperature at which ice melts (water freezes) and the temperature at which water boils, are used as reference points .**

**On the Celsius scale, the freezing point of water is defined as  $0^{\circ}\text{C}$ , and the boiling point of water is defined as  $100^{\circ}\text{C}$ . On the Fahrenheit scale, the water freezes at  $32^{\circ}\text{F}$  and the water boils at  $212^{\circ}\text{F}$ . On the Celsius scale there are *100 degrees* between freezing point and boiling point of water, compared to *180 degrees* on the Fahrenheit scale. This means that  $1^{\circ}\text{C} = 1.8^{\circ}\text{F}$ .**

**Another scale (common in science) is Kelvin, or the Absolute Temperature Scale. On the Kelvin scale the coldest temperature possible,  $-273^{\circ}\text{C}$ , has a value of *0 Kelvin (0 K)* and is called the absolute zero. Units on the Kelvin scale are called Kelvins (*K*) and no degree symbol is used.**

Because there are no lower temperatures than 0 K, the Kelvin scale does not have negative numbers.

**Absolute Zero:** Temperature at which thermal energy is at a minimum. Defined as 0 Kelvin, calculated to be -273.15 °C

For calibration purposes, the International Temperature Scale (ITS-90) was defined, it is an equipment calibration standard for making temperature measurements on the Kelvin and Celsius temperature scales.

ITS-90 is an approximation of the thermodynamic temperature scale that facilitates the comparability and compatibility of temperature measurements internationally.

ITS-90 offers defined calibration points ranging from 0.65 K to approximately 1358 K (-272.5 °C to 1085 °C) and is subdivided into multiple temperature ranges which overlap sometimes.

*ITS-90 is designed to represent the thermodynamic (absolute) temperature scale (referencing absolute zero) as closely as possible throughout its range.*

ITS-90 is not a scale; it is an equipment calibration standard. Temperatures measured with equipment calibrated per ITS-90 may be expressed using any temperature scale such as commonly Celsius and Kelvin (Fahrenheit).

### Reference temperatures

We cannot build a temperature divider as we can a voltage divider, nor can we add temperatures as we would add lengths to measure distance. We must rely upon temperatures established by physical phenomena which are easily observed and consistent in nature. The International Temperature Scale (ITS) is based on such phenomena. Revised in 1990, it establishes seventeen fixed points and corresponding temperatures. A sampling is given in the following table,

<i>ITS-90 fixed points</i>		Temperature	
Element	Type	K	oC
(H <sub>2</sub> ) Hydrogen	Triple Point	13.8033 K	-259.3467°C
(Ne) Neon	Triple Point	24.5561 K	-248.5939°C
(O <sub>2</sub> ) Oxygen	Triple Point	54.3584 K	-218.7916°C
(Ar) Argon	Triple Point	83.8058 K	-189.3442°C
(Hg) Mercury	Triple Point	234.315 K	-38.8344°C
(H <sub>2</sub> O) Water	Triple Point	273.16 K	+0.01°C
(Ga) Gallium	Melting Point	302.9146 K	29.7646°C
(In) Indium	Freezing Point	429.7485 K	156.5985°C
(Sn) Tin	Freezing Point	505.078 K	231.928°C
(Zn) Zinc	Freezing Point	692.677 K	419.527°C
(Al) Aluminum	Freezing Point	933.473 K	660.323°C
(Ag) Silver	Freezing Point	1234.93 K	961.78°C

(Au) Gold                      Freezing Point      1337.33 K              1064.18°C

Since we have only these fixed temperatures to use as a reference, we must use instruments to interpolate between them. But accurately interpolating between these temperatures can require some fairly exotic Transducers, many of which are too complicated or expensive to use in a practical situation.

## temperature sensing methods

Generally, There are two different temperature sensing methods:-  
Contact and Non-contact method

Contact sensing method brings the sensor in physical contact with a substance or object. It can be used with solids, liquids or gases.

Non-contact method is used to sense the temperature of solids and liquids but cannot be used on gases due to their transparent nature.

So, Temperature sensors can be simply classified into two groups, contact and non-contact sensors.

Contact temperature sensors measure their own temperatures . One infers the temperature of the object to which the sensor is in contact by assuming or knowing that the two are in thermal equilibrium, that is, there is no heat flow between them.

Contact temperature sensors, (aside from capillary/bulb thermometers and bi-metal sensors), use varying voltage signals or resistance values.

Thermocouple sensors generate varying voltage signals. The different metal and alloy combinations in the thermocouple's legs produce a predictable voltage for a given temperature.

Resistance temperature detectors (RTDs) generate varying resistance values. RTDs as a class is divided into two types, Resistance wire RTD and thermistors

RTDs work by producing a predictable resistance value at a given temperature. Resistance wire RTDs (generally platinum) have a positive coefficient by increasing resistance with temperature increase.

Thermistors are generally negative coefficient by decreasing resistance with temperature increase. Each of these three contact sensor types (RTDs, thermocouples, and thermistors) have advantages and disadvantages depending on application, desired response time and accuracy. A presentation of general benefits can help determine the most suitable contact sensor type for required application

**Noncontact temperature sensors** measure the thermal radiant power of the Infrared or Optical radiation that they receive from a known or calculated area on its surface, or a known or calculated volume within it. One then infers the temperature of an object from which the radiant power is assumed to be emitted (*some may be reflected rather than emitted*).

A non-contact (infrared) sensor intercepts and converts emitted infrared heat into a voltage signal.

Non-contact sensors use a lens to concentrate radiated infrared energy onto a thermopile. The voltage signal produced by the thermopile is sent onto an electronics package for amplification and conditioning before being retransmitted as either a voltage or current signal. Non-contact temperature sensors generally react and register (respond) faster than contact temperature sensors.

The reasons for using non-contact over contact temperature sensing are:

- When physical contact with the object or substance would deface or Contaminate
- The process or object moves
- A process requires a faster response than is possible with a contact Sensor
- Can be isolated from contaminated or explosive environments by Viewing through a window

## **Temperature sensing sensors :-**

*A number of technologies are available to designers who need to measure temperature within a system.*

*Thermistors, thermocouples and RTDs, each have their own technologies and its advantages and disadvantages in any given situation.*

Sensors are often used within electronic systems to monitor temperature; the most common technologies for use within systems are RTD<sub>s</sub> & thermistors

### **1 - Resistance Temperature Detectors RTD<sub>s</sub>**

Resistance temperature detectors, popularly known as RTDs, are one of the conventional types of temperature sensors. Their working is based upon the “physical principle of the positive temperature coefficient of electrical resistance of metals” which means that as the temperature of

a material increases, its electrical resistance will also increase in the direct proportion. In other words, RTDs have a property according to which their electrical resistance varies as a function of temperature.

Resistance temperature detectors are basically wire wound and thin film devices. Materials used for construction of RTDs mainly include: -

Platinum, Nickel, Copper, Balco, Tungsten

However, the last two materials are rarely used.

### **Main Features for resistance temperature detectors:**

- RTDs are basically active devices which need an electrical signal to generate a voltage drop across the sensor. This voltage drop is then determined with the help of a calibrated read-out device.
- Due to lead wires which are usually employed to connect the RTD to readout device, errors can take place in temperature measurement results. Particularly in remote temperature measurement locations where longer lead wires are used, chances of errors are more frequent.
- As per requirement, three wire and four-wire circuit designs are available for compensation of lead wire errors.
- Besides, the lead error can be limited by means of a temperature transmitter which is installed in proximity of the RTD element. These transmitters are competent enough to transform resistance measurement into analog or digital signals. These signals can then be communicated over long distances by wire or radio frequency (to a data acquisition or control system).
- Unlike thermocouples, resistance temperature detectors operate in quite small temperature domain. Their temperature span ranges from about -200 °C to a maximum temperature of around 650 to 700 °C.
- Although, Copper and Nickel are the cheapest materials, they are considered unsuitable for construction of RTDs because of non-linearity problems (in case of Nickel) and wire oxidation problems (in case of Copper).
- The most suitable material for accurate temperature measurements is considered to be Platinum, since its temperature Coefficient of Resistance is nearly linear for its pure form.

### **Basic Types of construction of RTD<sub>s</sub> :-**

RTD's are manufactured in 3 basic types of construction. Each of these different types has advantages and disadvantages.

### **Platinum Thin Film RTD:-**

The thin film style of RTD is probably the most popular design because of their rugged design and low cost. The thin film element is manufactured by coating a small ceramic chip with a very thin (.0001") film of platinum and then laser cutting or chemical etching a resistance path in the platinum film. The element is then coated with a thin layer of glass to protect it from harmful chemicals and gases. Larger extension lead wires are spot welded to the chip and this junction is then covered with a drop of epoxy to help hold the wires to the element.

This type of detector is the most widely used resistance temperature detectors. It meets the requirements of precision thermometry in the best possible way. It is also referred to as PRTs & PRT100s. These RTDs provide excellent linearity and stability. Besides, their repeatability and accuracy also happens to be best amongst all RTD's. Their response is very fast i.e. a fraction of a second and almost linear over a broad span of temperatures.

### **Inner Coil Wire Wound RTD:-**

This type of element is normally manufactured using platinum wire. Very small platinum wire (.0002") is coiled and then slid into a small 2 hole ceramic insulator. Larger extension leads are then spot welded to the ends of the platinum wire and cemented in place. Some manufacturers backfill the bores of the insulator with ceramic powder once the coils have been inserted. This keeps the coils from moving and shorting against each other. The end opposite the extension leads is capped with ceramic cement also.

### **Outer Wound RTD Element:-**

The outer wound RTD element is made by winding the sensing element wire around a center mandrill, which is usually made of ceramic. This winding is then coated with glass or some other insulating material to protect and secure the windings. The winding wires are then spot welded to extension leads and secured to the body with ceramic cement or epoxy. Each of the types has their advantages. The thin film is the least expensive to manufacture and also the most rugged. They also can be manufactured in very small sizes. The inner coil wire wound style is the most accurate. It is however, more expensive to manufacture and does not perform well in high vibration applications. The outer wound element is similar in cost to the inner coil element. It is not as accurate as the inner coil style but is more rugged.



**CLASIFICACIONES OF RTD<sub>s</sub>** :-The highest accuracy of all PRTs is the *Standard platinum Resistance Thermometers* (SPRTs). This accuracy is achieved at the expense of durability and cost. The SPRTs elements are wound from reference grade platinum wire. Internal lead wires are usually made from platinum while internal supports are made from quartz or fuse silica. The sheaths are usually made from quartz or sometimes Inconel depending on temperature range. Larger diameter platinum wire is used, which drives up the cost and results in a lower resistance for the probe (typically 25.5 ohms). SPRTs have a wide temperature range (-200°C to 1000°C) and approximately accurate to ±0.001°C over the temperature range. SPRTs are only appropriate for laboratory use.

Another classification of laboratory PRTs is *Secondary Standard platinum Resistance Thermometers* (Secondary SPRTs). They are constructed like the SPRT, but the materials are more cost-effective. they commonly use reference grade, high purity smaller diameter platinum wire, metal sheaths and ceramic type insulators. Internal lead wires are usually a nickel based alloy. Secondary SPRTs are limited in temperature range (-200°C to 500°C) and are approximately accurate to ±0.03°C over the temperature range.

*Industrial PRTs* are designed to withstand industrial environments. They can be almost as durable as a thermocouple. Depending on the application industrial PRTs can use thin film elements or coil wound elements. The internal lead wires can range from PTFE insulated stranded nickel plated copper to silver wire, depending on the sensor size and application. Sheath material is typically stainless steel; higher temperature applications may demand Inconel. Other materials are used for specialized applications.

### **CALIBRATION OF RTD<sub>s</sub>** :-

Calibration of RTD<sub>s</sub> must be performed at temperatures other than 0°C and 100°C. Two common calibration methods are the fixed point method and the comparison method.

- **Fixed point calibration**, used for the highest accuracy calibrations, uses the triple point, freezing point or melting point of pure substances such as water, zinc, tin, and argon to generate a known and repeatable temperature. These cells allow the user to reproduce actual conditions of the **ITS-90** temperature scale. Fixed point calibrations provide extremely accurate calibrations (within ±0.001°C) A common fixed point calibration method for industrial-grade probes is the ice bath. The equipment is inexpensive, easy to use, and can accommodate several sensors at once. The ice point is designated as a secondary standard because its accuracy is ±0.005°C (±0.009°F), compared to ±0.001°C (±0.0018°F) for primary fixed points.

- **Comparison calibrations**, commonly used with secondary SPRTs and industrial RTDs, the thermometers being calibrated are compared to calibrated thermometers by means of a bath whose temperature is uniformly stable Unlike fixed point calibrations, comparisons can be made at any temperature between  $-100^{\circ}\text{C}$  and  $500^{\circ}\text{C}$  ( $-148^{\circ}\text{F}$  to  $932^{\circ}\text{F}$ ). This method might be more cost-effective since several sensors can be calibrated simultaneously with automated equipment. These, electrically heated and well-stirred baths, use silicone oils and molten salts as the medium for the various calibration temperatures.

## **RTD TOLERANCES**

The tolerance for RTD sensors is stated at one point only, which is usually  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ). ASTM publications recognize 2 *grades* of platinum RTD elements while DIN (Europe's version of ASTM) recognizes 2 *classes* of elements. They are as follows:

ASTM E-1137 grade B =  $\pm .10\%$  @  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ )

ASTM E-1137 grade A =  $\pm .05\%$  @  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ )

DIN 43760 class B =  $\pm .12\%$  @  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ )

DIN 43760 class A =  $\pm .06\%$  @  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ )

## **TEMPERATURE RATING OF RTD**

The maximum temperature rating for RTD's is based on 2 different factors. First is the element material. Platinum RTD's can be used as high as  $650^{\circ}\text{C}$  ( $1202^{\circ}\text{F}$ ). Other materials are much lower in temperature rating and vary from material to material.

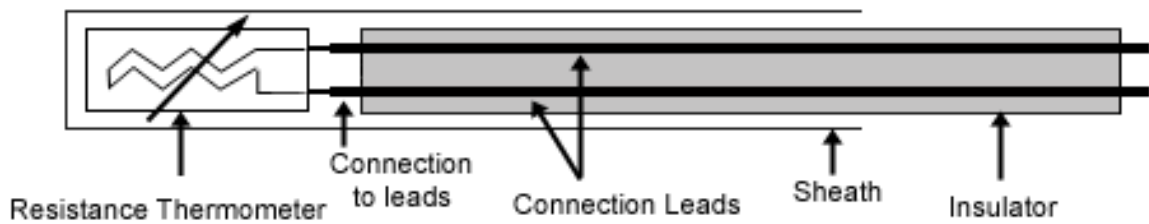
The other determining factor for temperature rating is probe construction.

There are different constructions for maximum temperatures of  $200^{\circ}\text{C}$  ( $392^{\circ}\text{F}$ ),  $450^{\circ}\text{C}$  ( $842^{\circ}\text{F}$ ) and  $650^{\circ}\text{C}$  ( $1202^{\circ}\text{F}$ ). There are construction considerations used in each of these different styles making them ideal for use in each of those ranges. No one style is good for all ranges.

## **TEMPERATURE COEFFICIENT OF RTD**

Another common term used with RTD's is *temperature coefficient*. This refers to the change in resistance vs. change in temperature. There are 2 common coefficients for platinum RTD's' and several others for the copper and nickel types. The most common platinum RTD has a temperature coefficient of  $.00385$  ohms/ohms/ $^{\circ}\text{C}$ . This means that a 100 ohm platinum RTD will increase in resistance  $.385$  ohms for every  $1^{\circ}\text{C}$  increase in temperature.

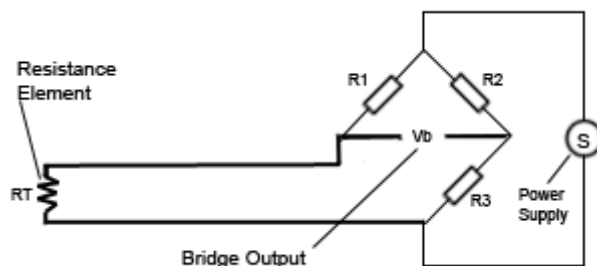
## CONSTRUCTION OF RTD<sub>s</sub>



These elements nearly always require insulated leads attached. At temperatures below about 250 °C PVC, silicon rubber or PTFE insulators are used. Above this, glass fibre or ceramic are used. The measuring point, and usually most of the leads, require a housing or protective sleeve, often made of a metal alloy which is chemically inert to the process being monitored. Selecting and designing protection sheaths can require more care than the actual sensor, as the sheath must withstand chemical or physical attack and provide convenient attachment points.

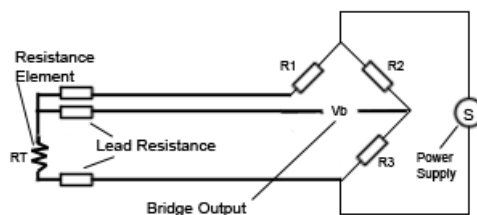
## WIRING CONFIGURATION OF RTD<sub>s</sub>

### - 2 wire configuration

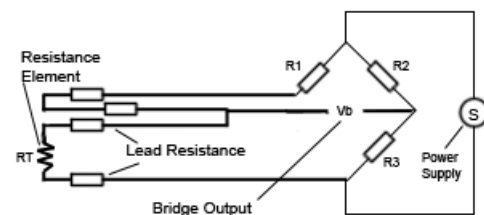


The simplest resistance thermometer configuration uses two wires. It is only used when high accuracy is not required, as the resistance of the connecting wires is added to that of the sensor, leading to errors of measurement.

### 3 wire configuration



### 4 wire configuration



## **ELEMENT RESISTANCES OF RTD**

RTD'S are manufactured with a base resistance at some temperature point. This temperature is most commonly 0°C (32°F). The most common base resistance is 100 ohms, which means that if the RTD is at 0°C, the resistance would be 100 ohms. There are other resistances and temperatures. Some of these are:

10 ohm copper @ 25°C	1000 ohm platinum @ 0°C
200 ohm platinum @ 0°C	500 ohm platinum @ 0°C

## **MATERIALS OF CONSTRUCTION OF RTD**

RTD's are manufactured using several different materials as the sensing element. The most common by far is the Platinum RTD. Platinum is used for several different reasons including high temperature rating, very stable, and very repeatable. Other materials used to make RTD's are nickel, copper, and nickel-iron. These materials are becoming less common now that the cost of platinum RTD's is coming down.

### **advantages of resistance temperature detectors:-**

- operational experience proved that RTDs are the most accurate temperature sensors. They provide very accurate measurements even over comparatively narrow temperature spans.
- RTD<sub>s</sub> give excellent stability and repeatability and they tend to provide Stable output for longer periods of time.
- RTDs provide immunization against electrical noise. Therefore, they are considered ideal for temperature measurements in industrial environments. For example, around motors, generators and other high voltage equipments.
- RTDs are very simple to recalibrate.

### **Disadvantages of resistance temperature detectors::-**

- Their temperature range is very small compared to that of thermocouples.
- Their application involves high initial cost.
- They are not rugged enough to be used in high vibration environments.

**2- Thermistors :-** a thermistor is a type of resistor whose resistance varies significantly with temperature more than in standard resistors.

In other words a thermistor is a temperature-sensing element composed of sintered semiconductor material which exhibits a large change in resistance proportional to a small change in temperature.

Technically, all resistors are thermistors - their resistance changes with temperature. Thermistors are made so that the resistance changes

drastically with temperature so that it can be 100 ohms or more of change per degree.

Thermistors can be classified into two types, If the resistance increases with increasing temperature, the device is called a positive temperature coefficient (PTC) thermistor, and. If the resistance decreases with increasing temperature, the device is called a negative temperature coefficient (NTC) thermistor. Resistors that are not thermistors are designed to have a *TEMPERATURE COEFFICIENT* close to zero as possible, so that their resistance remains nearly constant over a wide temperature range

Thermistors differ from resistance temperature detectors (RTD) in that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response in thermistors is much better than in RTD; also RTDs are useful over larger temperature ranges (-200 °C to 700 °C), while thermistors typically achieve a higher precision within a limited temperature range, typically -90 °C to 130 °C

### **TYPES OF THERMISTORS:-**

**Thermistor element** : it is the simplest form of thermistor. Because of their compact size, thermistor elements are commonly used when space is very limited. There are wide varieties of thermistor elements which vary not only in form factor but also in their resistance versus temperature characteristics. Since thermistors are non-linear, the instrument used to read the temperature must linearize the reading.

#### **Linear Response Thermistor Elements** :

These for applications requiring thermistors with linear response to temperature change, they contain linear components. These unique devices consist of a thermistor composite for temperature sensing and an external resistor composite for linearizing.

**Thermistor Probes** : The standalone thermistor element is relatively fragile and can not be placed in a rugged environment. There are thermistor probes which are thermistor elements embedded in metal tubes. Thermistor probes are much more suitable for industrial environments than thermistor elements.

### **Choosing of suitable temperature sensor :-**

RTDs are more stable than thermocouples. On the other hand, as a class, their temperature range is not as broad: RTDs operate from about -250 to 850°C whereas thermocouples range from about -270 to 2,300°C. Thermistors have a more restrictive span, being commonly used between -40 and 150°C, but offer high accuracy in that range.

Thermistors and RTDs share a very important limitation. They are resistive devices, and accordingly they function by passing a current

through a sensor. Even though only a very small current is generally employed, it creates a certain amount of heat and thus can throw off the temperature reading. This self-heating in resistive sensors sometimes can be significant. Also this problem does not arise with thermocouples, which essentially zero-current devices.

Infrared sensors, that relatively expensive, are appropriate when the temperatures are extremely high. They are available for up to 3,000°C (5,400°F), far exceeding the range of thermocouples or other contact devices. The infrared approach is also attractive when one does not wish to make contact with the surface whose temperature is to be measured. Thus, fragile or wet surfaces, such as painted surfaces coming out of a drying oven, can be monitored in this way. Substances that are chemically reactive or electrically noisy are ideal candidates for infrared measurement. The approach is likewise advantageous in measuring temperature of very large surfaces, such as walls that would require a large array of thermocouples or RTDs for measurement.

## **CONCLUSION :-**

- Resistive temperature detectors (RTDs) & thermistors are the most Common used temperature sensors for meteorological applications,.
- The most important process after acquiring and operating of such temperature sensors Is scheduling a system for regular maintenance
- It is necessary to calibrate these sensors to maintain the quality of data and to make sure it matches with the WMO requirements.
- there must be a calibration laboratory of sufficient Standard and staffing to act as the country's national standard for meteorological observations and to possess linkages to the WMO Regional Instrument Centre and other National laboratories.
- The Technicians and maintenance team should have basic Knowledge of meteorology and calibration procedures with the Knowledge of related science.
- Such sensors require periodic maintenance and Technical service to maintain the system in operation properly.
- Observers in the field should be trained on how to properly use And maintain these kinds of sensors.
- National Meteorological services all over the world should share Their experiences in dealing with such sensors.
- laboratory inter comparisons should be scheduled for the national Standard between the designated RIC and the related meteorological Services to guarantee accurate measurements.

