thermodynamic-related disciplines such as combustion.

Type of Temperature Measuring Instruments

How can I measure temperature? Temperature can be measured via a diverse array of sensors. All of them infer temperature by sensing some change in a physical characteristic. Six types with which the engineer is likely to come into contact are: thermocouples, resistive temperature devices (RTD and thermistors), infrared radiators, bimetallic devices, Gas filled expansion devices, and change-of-state devices.

1. Thermocouple Temperature Measurement Sensors

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

2. Resistance Temperature Devices (RTD)

Resistive temperature devices capitalize on the fact that the electrical resistance of a material changes as its temperature changes. Two key types are the metallic devices (commonly referred to as RTD), and thermistors. As their name indicates, RTD rely on resistance change in a metal, with the resistance rising more or less linearly with temperature. Thermistors are based on resistance change in a ceramic semiconductor; the resistance drops nonlinearly with temperature rise.

3. Infrared Temperature Measurement Devices

Infrared sensors are non-contacting devices. They infer temperature by measuring the thermal radiation emitted by a material.

4. Bimetallic Temperature Measurement Devices

Bimetallic devices take advantage of the difference in rate of thermal expansion between different metals. Strips of two metals are 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 RTD and they do not readily lend themselves to temperature recording.

5. Gas filled Thermometers

The measuring method of a gas filled thermometer is the expansion of an inert gas in a closed system. Changes in the process temperature will alter the pressure of the gas inside the thermometer stem, and this causes the bourdon tube or spiral tube of the thermometer to move, and this displacement is transmitted to the pointer via the movement mechanism parts, indicating the temperature on the dial.

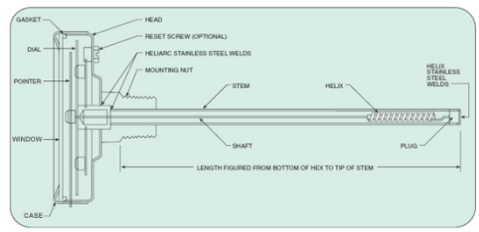
6. Change-of-State Temperature Measurement Devices

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 with 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.

Most industries use 4 devices (thermocouple, RTD, bimetal thermometer and gas filled thermometer) to measure temperature for the sake of convenience and economical reason. So HISCO mainly provide those items. In this section, we introduce bimetal thermometer and gas filled thermometer.

Bimetal thermometer

1. Structure of Bimetal Thermometer



(1) Case and Cover

• 304 stainless steel standard
• 316 stainless steel optional
• All external parts corrosion resistant to most chemicals
• Parts designed for maximum strength to meet requirements of heavy duty industrial applications
• Statistical Process Control QA methods used to assure component quality and process consistency
• Cases may be silicone filled for additional dampening of extreme vibration, or to assure consistent performance in low process temperature/high environmental humidity applications

(2) Window

• Extra heavy duty instrument glass standard
• Shatterproof glass, tempered glass, and plastics optional

(3) Pointer

• Black painted aluminum
• Balanced and precisely assembled to bimetal coil stem
• Direct transfer of coil movement to temperature displayed on dial

(4) Hermetic seal

• Case/cover assembly is a precision interference fit
• Silicone gasket provides dustproof and leak proof seal

(5) Process connection

• 304 stainless steel standard
• 316 stainless steel optional
• Statistical Process Control QA methods used to assure component quality and process consistency

(6) Zero adjustable (Optional)

• Stainless steel pinion is sealed with a silicone "O" ring to maintain integrity of hermetic seal
• Pinion works with gear teeth cut and formed in dial

(7) Dial

• True anti-parallax dial on 3", 4"' 5" models
• Graduations on dial ring are on the same plane as the pointer tip minimizing reading error
• Concave design of dial ring enhances readability
• Graduations for each temperature range are calculated to match deflection data of bimetallic material
• Large easy to read black numerals and graduations are printed on precision pad printing equipment in our factory

(8) Bimetal coil

• Super sensitive bimetallic helix coil
• Fabricated to tight tolerances
• Heat treated for stress relief
• Silicone coated to minimize pointer vibration and maximize heat transfer and response time
• Angular deflection of each coil is tested for perfect match with dial graduation layouts in precision calibration baths designed and built by HISCO with accuracy to ±1/10°F

(9) Accuracy

• Per ASME B40.3 Grade A ±1% full span is guaranteed

• Calibration is to standards traceable to Korea Laboratory Accreditation Scheme (KOLAS)

• HISCO methods:

* Most careful and precise in the industry

* Produces typical accuracy better than ASME B40.3 Grade AA (1%-1⁄2%-1%) full span

(10) BIMETAL BUSHING

• Pressed into groove on stem

• Centers coil in stem

• 302 stainless steel stem wire goes through center of bushing connecting bimetal element to pointer, minimizes coil touching tube wall

• Centering bearings are used at regular intervals on long stem thermometers

(11) TEMPERATURE RANGES

• Standard Celsius ranges from -60 to 55

• Dual scale ranges

• Availability of over 120 ranges developed may vary by dial size

(12) OVER TEMPERATURE LIMITS

• Up to 100%

• to 50%

• to for continuous use, intermittent use over

(13) IMMERSION:

• Groove around stem shows minimum immersion point on each thermometer

• For most accurate reading sensitive portion of stem must be completely immersed

(14) STEM

• 304 Stainless steel tubing is welded/drawn and fabricated to exacting tolerances

• 316 stainless steel optional

• Standard stem diameter is 0.250" (6.4mm) – options include 0.315" (8mm), 0.236" (10mm).

• Stem lengths available from 66mm to 1000mm

• Tip is welded and finished for hermetic seal and unique look

2. Considerations when selecting bimetal thermometers

(1) Materials

• Application? Continuous process flow, static tank, or laboratory testing etc.

• Environmental conditions? Ambient temperature, humidity, or corrosive atmosphere (salt spray etc.)

• Process conditions? Pressure, temperature, media viscosity, rate of flow, and possible vibration

• Wetted material of thermometer compatible with measured medium?

• Window material?

(2) Temperature range

• Operating temperature of process? High and low

• Overall temperature range required? High and low

• Over-Range possibilities? Minimum and maximum

• Accuracy required?

• External reset required?

• Scale - °F, °C or dual?

• Bimetal thermometers should not be used continuously over 450

(3) Stem

• Pipe size or depth of tank?
• Immersion length required?
• Stem length?
• Stem diameter?

(4) Selecting Code

• Dial size
• Location of fitting connection for maximum readability when thermometer is installed in system— Back, adjustable angle, bottom, top, right side or left side connection location?
• Fitting thread size and type

(5) Options and accessories

• Thermowell?
• Silicone filling?
• Minimum and/or maximum indicating pointers?
• Custom or special dial marking or colors?
• Sliding compression fittings— male or female?
• Thread size adapters?
• Project tagging?

3. Gas filled thermometer

Dial	Gas filled thermometers are available with 100mm, 125mm, 150 mm dials, in aluminum, with black markings on a white background.
Case	The case is manufactured from 304 Stainless Steel with a bayonet bezel.
Protection	Gas filled thermometers are designed to be weatherproof to IP-65.
Window	The window is manufactured using shatterproof glass.
Pointer	The pointer is aluminum, and is colored black with micrometer adjustment.
Stem	Manufactured from 316 Stainless Steel, the stem may be specified as 8 mm, 10 mm or 12 mm in diameter.

Thermocouple

General

Instruction

When two dissimilar conductors are connected together to form a closed circuit and the two junctions are kept in different temperatures, thermal electromotive force (EMF) is generated in the circuit. When one end (Cold Junction) is kept constant at a certain temperature, normally at 0, and the other end (Measuring Junction) is exposed to unknown temperature, the temperature at latter end can be determined by measurement of EMF generated. This combination of two dissimilar conductors is called Thermocouple.

Applications

- Specially designed for control of electric circuits, alarm
- General and explosion proof type head available
- Wide selection ranges for protection tube material
- Single and double element available

Features

- Quick response and stable temperature measurement by direct contact
- Wide range of temperature from -270 to 2,300°C
- Specific spot or small space can be measured
- Rugged construction and easy installation
  -Stainless Steel (304SS, 316SS, 310SS, 446SS, 347SS & 321SS)
  -Inconel 600, Inconel 800
  -Hastelloy-C, Hastelloy-B, Titanium, Monel, Tantalum and so on for Metallic

Types of Thermocouples

Type	Combinations of Element Wires		Temperature	Class
	(+) Leg	(–) Leg	Range(°C)	
B	70% Pt. / 30% Rhodium	94% Pt. / 6% Rhodium	600 ~ 1,700	0.5
R	87% Pt. / 13% Rhodium	100% Pt.	0 ~ 1,600	0.25
S	90% Pt. / 10% Rhodium	100% Pt.	0 ~ 1,600	0.25
K	Chromel	Alumel	0 ~ 1,250	0.75
			-200 ~ 0	1.5
E	Chromel	Constantan	0 ~ 800	0.75
			-200 ~ 0	1.5

J	Iron	Constantan	0 ~ 750	0.75
T	Cooper	Constantan	0 ~ 350	0.75
			-200 ~ 0	1.5
N	Nicrosil	Nisil	0 ~ 1,250	0.75

Insulators and protection tubes

Insulators

Thermocouples are widely used for temperature measurements of various gases and liquids. If bare thermoelement wires are exposed directly to detrimental atmospheres and fluid affected resulting in reducing service life with severe deterioration and corrosion.

Thermcouples are, therefore, usually protected with insulators and protection tubes. In selection of suitable insulators and protection tubes, consideration should be given to the materials especially of heat resistance, mechanical strength, chemical stability, etc. depending in the respective operating conditions. This is the most important point in thermimetric pratice.

Characteristics

Type	Code	Operating Temp.(℃)	Maxium Temp. (℃)	Features
Aluminous Ceramic Grade 2	PS2	1400	1500	Silimanite Grade. Less porosity with reasonable heat load softening and good resistance to thermal shock
Aluminous Ceramic Grade 1	PS1	1500	1600	Mullite Grade. Gas tight structure with less heat liad softening. Better than PS2.
Recrystallized Alumina 99.7%	PS0	1600	1800	Gas tight structure with excellent resistance to corrosion. Highest purity among alumina ceramics. Very low Alkalis
Magnesia Ceramic	MG	1800	2200	Porous structure but excellent resistance to corrosion. Only suitable for Basic environment.

Dimensions

Unit:mm

Model	Code	Nom.O.D	Nom.I.D	Length	T/C Wire	Material
Round 1 bore	SH-1	1	0.4	100	3.2	PS1
	SH-2	2	1	100	0.5 0.65	PS1 PS0
	SH-3	3	2	100	1.0 1.6	PS1
	SH-5	5	3	100	2.3	PS1
	SH-6	6	4	100	3.2	PS1
Round 2 bores	DH-3	3	0.8	100	0.5	PS1 PS0
	DH-4	4	1	100	0.5 0.65	PS1 PS0
	DH-4A	4	0.8	2000	0.5	PS0
	DH-4B	4	1.2	2000	0.5 0.65	PS0
	DH-6	6	1.5	100	0.65 1.0	PS2
	DH-8	8	2	100	0.65 1.0 1.6	PS2
Round 3 bores	TH-4	4	1	100	0.5 0.65	PS1 PS0
	TH-6	6	1.5	100	0.65 1.0	PS1
Round 4 bores	QH-3	3	0.8	100	0.5	PS1
	QH-8	8	2	100	0.65 1.0 1.6	PS1
	QH-12	12	3	50	1.0 1.6 2.3	PS2
	QH-14	14	4	50	2.3 3.2	PS2

Round 6 bores	HH-6	6	1	100	0.5 0.65	PS2
Oval 2 bores	DE-10	10×7.5	3	34	1.0 1.6 2.3	PS1 PS0
	DE-12	12×7.5	4	34	2.3 3.2	PS1

 Round 6 bores  Round 6 bores  Round 6 bores  Round 6 bores  Round 6 bores  Round 6 bores

Protection Tubes (Metal Protection Tubes)

Material	Operating Temp.(℃)	Features
SS400	Red. 800 Oxi. 600	Good resistance to reducing atmosphere but less resistant to oxidation and acids attacks. Thick walled tubes are used in molten aluminum.
304SS	980	Widely used as a common protection tube against heat and corrosion but not recommended for use in the presence of sulphur or reducing flame. Subject to stress and "pit" corrosion.
304LSS	980	Less carbon content (C=0.03%) than 304SS and better resistance to grain boundary corrosion. Subject to stress and "pit" corrosion
321SS	980	Higher corrosion resistance than 304SS because of its Ti content to prevent carbon preticipation. Excellent resistance to grain boundary corrosion after welding due to less carbon preticipation
316SS	980	Contains Mo and has excellent resistance to corrosives, heat, acids and alkalis.
316LSS	980	Less carbon content than 316SS and has better resistance to grain boundary corrosion. Resistant to "pit" corrosion
347SS	980	Because of its Nb-Ta content, prevents carbon preticipation. Higher corrosion resistance than 304SS and excellent resistance to grain boundary corrosion.
446SS	980	Excellent resistance to oxidizing and reducing flames containing sulphur. Suitable for use in non-ferrous molten metals and other high temperature applications, but less mechanical strength.
Inconel 600	1050	Excellent resistance to oxidizing and reducing atmospheres at high temperature. But sulphurous atmospheres should be avoided. Immune to stress and "pit" corrosion.
Inconel 601	1050	Superior oxidation resistance at high temperatures to Inconel-600, by virture of strong bonding of metal oxide film.
Inconel 800	870	Excellent to high temperature oxidizing atmospheres and thermal shick. About 10 times longer service life than 304SS against high temperature corrosion.
Hastelloy B	Oxi. 500 Red. 760	Excellent resistance to heat and corrosion, especially to HCl and H2SO4.
Hastelloy C-276	1000	Excellent resistance to high temperature oxidizing and reducing atmospheres and also to Cℓ2 gases.
Titanium	Oxi. 500 Red. 1,000	Superior corrosion resistance in cryogenic temperatures but at high temperatures, easily oxidized and become brittle.
Monel	Oxi. 500 Red. 600	Excellent resistance to water vapor and sea water at high pressure and corrosion.
Tantalum	Oxi. 300 Red. 2,200	Excellent heat-resistance material with high resistance to all acids but apt to severe oxidation and embrittlement in air at high temperatures.
Molybdenum	Oxi. 400 Red. 2,000	Excellent mechanical strength up to 1500°C for applications under inert, reducing and vacuum atmospheres. Resistant to metal vapours at high temperatures but reacts with carbon or graphite. Should not be used in air or oxygen containing gases.

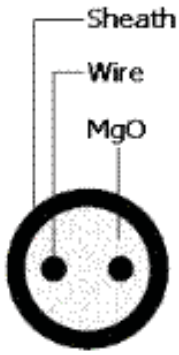
Caution : Due to high thermal conductivity of the metal bubes, minimum insertion length should be more than twenty five times of its overall diameter to eliminate heat conduction error.

Note: Operating and maximum temperatures of the above tubes vary depending on the measuring environments. Special protection tubes such as Inconel-X750, Nimonic 75□80, other alloy tubes, etc are also available upon request. Stainless steels as listed above table are in conformity with JIS Specifications and equivalent to those of AISI, U.S.A.

Non-Metallic Protection Tubes

Material	Operating Temp.(℃)	Features
Translucent Quartz	1000	99.99%Quartz Excellent to thermal shock but fragile. Poor resistance to alkalis but good to acids. Less gas-tightness in hydrogen and reducing gases. High thermal conductivity.
Transparent Quartz	1000	
Silimanite	1400	High alumina ceramic. Good resistance to thermal shock. Recommended for use in coal or oil burning and electric furnaces. Slightly porous.
Mullite	1500	60%Alumina-40%Silica Sintered alumina. Better than PT2 but slightly less thermal shock resistance. Recommended for use in heating furnace and regenerator, impervious.
Recrystallized Alumina	1600	99.5%Alumina Superior chemical stability and better than PT1. Recommended for use in molten steel, slag and molten glass, impervious.
Cermet (Chrome-Alumina)	1300	77%Alumina-23%Chrome Excellent resistance to heat and abrasion. Recommended for temperature measurements of molten copper and other nonferrous metals.
Cermet (Cermotherm)	1600	60%Mo-40%ZrO2 High heat conductivity, good thermal shock resistance and corrosion resistance in molten metals. Recommended for continuous use in molten steel but not suitable for use in oxidizing atmosphere at high temperatures.
Static Press Sintered Alpha-SiC	1650	Pure fine grain Alpha SiC, 99.9% Highest Grade among SiC material. Gas Tight. Low friction, high hardness. Five times as higher thermal conductivity of Alumina. Suitable for all the dry atmospheres but attacked by water vapour.
Recrystallized Silicon Carbide	1400	99% SiC Porous but good resistance to acids and alkalis. Recommended for use in air neutral atmospheres up to 1,400°C and also in high temperature stagnant furnace atmosphere as an outer protection tube, etc. Attacked by water vapour.
Self-bonded Silicon Carbide	1650	99% SiC Very low porosity. Excellent resistance to thermal shock, corrosion and abrasion at high temperatures. Recommended for use in oxidizing and reducing atmospheres up to 1,650°C. but attacked by water vapour.
Clay-bonded Silicon Carbide	1500	89%SiC+8.5%SiO2+0.7%Al2O3+0.7%Fe2O3 Good heat conductivity. Better resistance to thermal shock than oxide ceramic tubes. Like Other SiC types, use under water vapour must be avoided.
Nitride Bonded Silicon Carbide	1550	78%SiC+3%SiO2+18%Si3N4(Si2ON2) Excellent performance superior to Y3 SiC but contains Si3N4. Most suitable for use in molten aluminum, reheating. Attacked by water vapour.
Silicon Nitride (Si3N4)	1350	Excellent thermal shock resistance. Less corrosion to acids and alkalis. High hardness. Fairly good resistance against most of molten metals.
Sialon	1250	Good oxidation and thermal shock resistance. Better corrosion resistance to molten metals, especially good for molten Aluminum bath than Silicon-Nitride. Durable to iron and steel up to 1,600°C.

Zirconia	1800	MgO Stabilized ZrO2 Gas-tight and exceptionally good thermal shock resistance. Chemically stable against molten metals other than alkalis. Recommended for use in molten special metals, slag and glass up to 1,800°C. Suitable for use in high temp. protection tube up to 1,900°C where PT0 Alumina softens.

	Nom. O.D (mm)	Wire Dia. (mm)	Wall Thick. (mm)	Type	Standard Sheath Material	Max Length (m)	Weight (g/m)
Single Pair  	0.3	0.04	0.05	K	Inconel 600	5	0.4
	0.5	0.1	0.08	K · E · J	316L SS Inconel 600	300	1.3
	1.0	0.18	0.13	K · E · J · T	316L SS Inconel 600, 310SS	480	5
	1.6	0.25	0.18	N · K · E · J · T · R	316L SS Inconel 600, 310SS	300	13
	2.2	0.36	0.25	N · K · E · J · T	316L SS Inconel 600, 310SS	300	24
	3.2	0.53	0.36	N · K · E · J · T · N · R	316L SS Inconel 600, 310SS	500	51
	4.8	0.79	0.53	N · K · E · J · T · N · R	316L SS Inconel 600, 310SS	200	115
	6.4	1.04	0.74	N · K · E · J · T · N	316L SS Inconel 600, 310SS HastelloyX	100	193
	8.0	1.3	0.91	N · K · E · J · T · N	316L SS Inconel 600, 310SS HastelloyX	80	300
Dual Pair 	1.6	0.25	0.18	K · E · J · T	316L SS Inconel 600, 310SS	300	13
	3.2	0.48	0.36	K · E · J · T	316L SS Inconel 600, 310SS	500	45
	4.8	0.74	0.53	K · E · J · T	316L SS Inconel 600, 310SS	200	102
	6.4	0.97	0.74	K · E · J · T	316L SS Inconel 600, 310SS	100	222
	8.0	1.22	0.91	K · E · J · T	316L SS Inconel 600, 310SS	80	350
Triple Pair 	3.2	0.3	0.38	K · E · J · T	316L SS Inconel 600, 310SS	150	33
	4.8	0.53	0.53	K · E · J · T	316L SS Inconel 600, 310SS	200	80
	6.4	0.71	0.74	K · E · J · T	316L SS Inconel 600, 310SS	100	130
	8.0	0.89	0.91	K · E · J · T	316L SS Inconel 600, 310SS	80	210

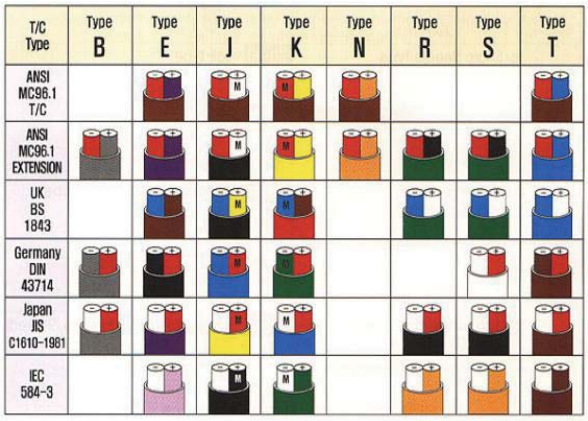
1. Operating and maximum temperatures vary depending on the heat pattern and atmosphere. For low thermal conductivity ceramic tubes, preheating and slow insertion into the furnace are recommended. Generally, insertion speed of 100 to 150 mm per minute after.
2. Minimum insertion length of the nonmetallic tube should be more than fifteen times of its overall diameter, excepting those of higher heat conductivity materials like SiC and Cermet which need twenty five times or more.

Metal Sheathed Thermocouple

Special sheath material : 304, 304L, 321, 347, 316, Inconel 625, Incoloy 825, Hastelloy X, Cupro-nickel, etc. are available.
Optional O.D. Size : 1.5mm, 2.0mm, 3.0mm, 4.5mm, 6.0mm, 9.5mm, 10.5mm, 12.7mm, 15.9mm, and 19.1mm can be supplied.

Extension and compensation cables

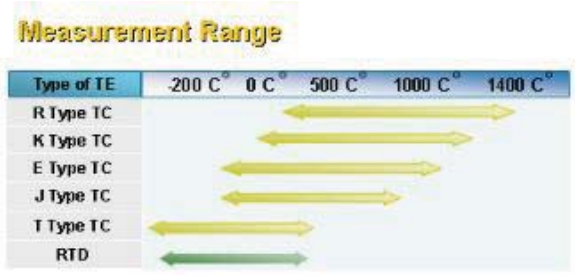
It is theoretically ideal to have thermocouple connected directly to the instrument, long distance between them often makes the wiring cost prohibitive and causes some trouble in the measuring circuit. Therefore, it is desirable to use extension or compensating wires or cables that have same or similar EMF characteristics to those of thermocouples at ambient temperatures. It is also necessary to select insulation materials in accordance with the operating conditions.
HISCO have large stock of various wires and cables as listed below.



RTD (Resistance Temperature Detectors)

Instruction

Resistance Temperature Detector (RTD) operates under a principle that the electrical resistance of certain metals increases or decreases in a repeatable and predictable manner with a temperature change. RTD may have a lower temperature range than some thermocouples and a slower response time, but it lasts stability and repeatability for a long time. RTD is designed for chemical and petrochemical industry, pulp and paper industry. RTD is available in the same configurations as thermocouple to suit applications.



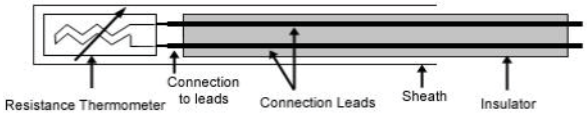
- TE : Temperature Element (Thermocouple & Resistance Temperature Detectors)
- TC : Thermocouple
- RTD : Resistance Temperature Detectors

Applications

- Pt 100 at 0
- General and explosion proof type head available
- Wide selection ranges for protection tube material
- Single and double element available

Features

- Good sensitivity
- Excellent stability and reproducibility
- High accuracy
- Suitability for precision applications
- Sheath type extension lead wire RTD, Multi RTD and Skin RTD also available
- -Stainless Steel (304SS, 316SS, 310SS, 446SS, 347SS & 321SS)
- -Inconel 600, Inconel 800
- -Hastelloy-C, Hastelloy-B, Titanium, Monel, Tantalum and so on for Metallic



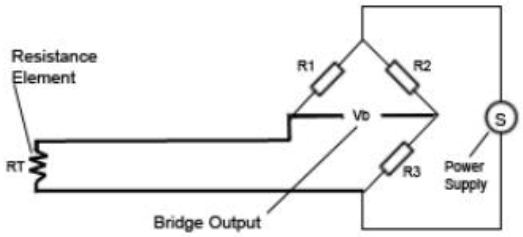
Structure and Measuring Methods

These elements nearly always require insulated leads attached. At low temperatures PVC, silicon rubber or PTFE insulators are common to 250 °C. Above this, glass fibre or ceramic are used. The measuring point and usually most of the leads require a housing or protection sleeve. This is often a metal alloy which is inert to a particular process. Often more consideration goes in to selecting and designing protection sheaths than sensors as this is the layer that must withstand chemical or physical attack and offer convenient process attachment points.

Resistance thermometer wiring configurations

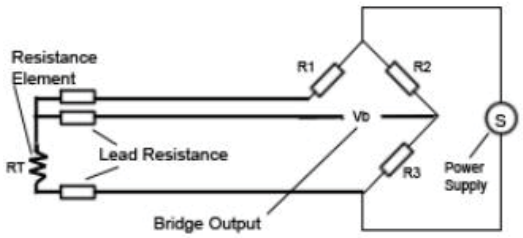
Two-wire configuration

The simplest resistance thermometer configuration uses two wires. It is only used when high accuracy is not required as the as the resistance of the connecting wires is always included with that of the sensor leading to errors in the signal. Using this configuration you will be able to use 100 meters of cable. This applies equally to balanced bridge and fixed bridge systems. The values of the lead resistance can only be determined in a separate measurement without the resistance thermometer sensor and therefore a continuous correction during the temperature measurement is not possible.



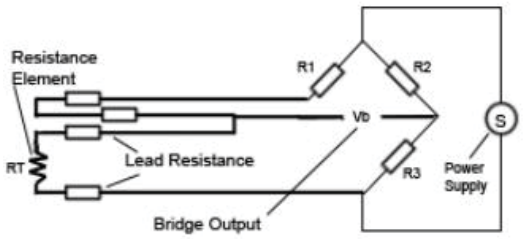
Three-wire configuration

In order to minimize the effects of the lead resistances a three wire configuration can be used. Using this method the two leads to the sensor are on adjoining arms, there is a lead resistance in each arm of the bridge and therefore the lead resistance is cancelled out. High quality connection cables should be used for this type of configuration because an assumption is made that the two lead resistances are the same. This configuration allows for up to 600meters of cable.



Four-wire configuration

The four wire resistance thermometer configuration even further increases the accuracy and reliability of the resistance being measured. In the diagram above a standard two terminal RTD is used with another pair of wires to form an additional loop that cancels out the lead resistance. The above Wheatstone bridge method uses a little more copper wire and is not a perfect solution. Below is a better alternative configuration four-wire Kelvin connection that should be used in all RTD's. It provides full cancellation of spurious effects and cable resistance of up to 15 Ω can be handled.



TC VS. RTD

Choosing RTD and thermocouples

General

The two most common ways of measuring industrial temperatures are with RTD and thermocouples. But when should control engineers use a thermocouple and when should they use an RTD?

The answer is usually determined by four factors: Operating temperature, time, size, and overall accuracy requirements.

Operating Temperature

If process temperatures fall from -200 to 500°C (-328 to 932°F), then an industrial RTD is an option. But for extremely high temperatures, a thermocouple may be the only choice.

Response Time

If the process requires a very fast response to temperature changes--fractions of a second as opposed to seconds (i.e. 2.5 to 10sec) -then a thermocouple is the best choice.

Keep in mind that time response is measured by immersing the sensor in water moving at 3 ft/sec with a 63.2% step change.

Size

A standard RTD sheath is 3.2mm to 6.4mm. dia., while sheath diameters for thermocouples can be less than 1.6mm.

Accuracy

If the process only requires a tolerance of 2°C or greater, then a thermocouple is appropriate.

If the process needs less than 2°C tolerance, then an RTD is the only choice.
Keep in mind, unlike RTDs that can maintain stability for many years, thermocouples can drift within the first few hours of use.

Although not a technical point, price may be another consideration. Cost of extension wire must also be considered. Thermocouples require the same type of extension wire material as the thermocouple Standard nickel-plated, teflon-coated RTD wire.

Accuracy Table

1) Temperature Tolerance

Measuring Temp.(℃)		-200	-100	0	100	200	300	400	500	600	650
Tolerance(℃)	Class A	±0.55	±0.35	±0.15	±0.35	±0.55	±0.75	±0.95	±1.15	±1.35	±1.45
	Class B	±1.3	±0.8	±0.3	±0.8	±1.3	±1.8	±2.3	±2.8	±3.3	±3.6

2) Class and Rated Current

Code	Class	Tolerance(℃)	Rated Current(mA)
Pt 100	A	±(0.15℃ 0.002 | t |)	0.5, 1, 2
(JPt 100)	B	±(0.3℃ 0.005| t |)	0.5, 1, 2, (5)

| t | means the measurement temperature expressed by a temperature (°C) unrelated to signs +, -.

3) Temperature/Resistance Table

℃ Std.	Pt100	JPt100	℃ Std.	Pt100	JPt100	℃ Std.	Pt100	JPt100	℃ Std.	Pt100	JPt100	℃ Std.	Pt100
-200	18.52	17.14	0	100	100	200	176	177.1	400	247.1	249.6	600	313.7
-190	22.83	21.46	10	103.9	104	210	180	180.9	410	250.5	253.1	610	316.9
-180	27.1	25.8	20	107.8	107.9	220	183	184.6	420	254	256.6	620	320.1
-170	31.34	30.12	30	111.7	111.9	230	187	188.3	430	257.4	260	630	323.3
-160	35.54	34.42	40	115.5	115.8	240	190	192	440	260.8	263.5	640	326.5
-150	39.72	38.68	50	119.4	119.7	250	194	195.7	450	264.2	266.9	650	329.6
-140	43.88	42.91	60	123.2	123.6	260	198	199.4	460	267.6	270.4	660	332.8
-130	48	47.11	70	127.1	127.5	270	201	203	470	270.9	273.8		
-120	52.11	51.29	80	130.9	131.4	280	205	206.7	480	274.3	277.2		
-110	56.19	55.44	90	134.7	135.3	290	208	210.3	490	277.6	280.6		
-100	60.26	59.57	100	138.5	139.2	300	212	213.9	500	281	284		
-90	64.3	63.68	110	142.3	143	310	216	217.5	510	284.3	287.4		
-80	68.33	67.77	120	146.1	146.9	320	219	221.2	520	287.6			
-70	72.33	71.85	130	149.8	150.7	330	223	224.7	530	290.9			
-60	76.33	75.91	140	153.6	154.5	340	226	228.3	540	294.2			
-50	80.31	79.96	150	157.3	158.3	350	230	231.9	550	297.5			
-40	84.27	83.99	160	161.1	162.1	360	233	235.5	560	300.8			
-30	88.22	88.01	170	164.8	165.9	370	237	239	570	304			
-20	92.16	92.02	180	168.5	169.6	380	240	242.5	580	307.3			
-10	96.09	96.02	190	172.2	173.4	390	244	246.1	590	310.5			