UNITECH INSTRUMENTATION

MUMBAI - 400 077

THERMOCOUPLES

Thermocouples are temperature sensors, which work on principles for flow of electron in closed circuit as described below.

Whenever two dissimilar material are joined at ends and the two ends are subjected to temperature differential, electrons flow in such closed circuit and there is potential difference between cold and hot junction. This potential difference is proportional to the temperature differential and is dependent on the metals joined.

Any two dissimilar metals can be used for this purpose, however there are many standard combinations on metals, which are internationally used and designated for use as thermocouple elements.

Most commonly used thermocouple elements are broadly divided in two categories:
A) Base metal thermocouples (J, K, T, and E type) and B) Precious metal thermocouples (R, S and B type).

TYPE	CONDUCTOR COMBINATIONS		INTERNATIONAL STANDARDS	APPROX EMF CHGANGE/ DEG C WITH REFERENCE JUNCTION AT 0 DEG C {μV/DEG C}			APPROX WORKING TEMP RANGE {CONSIDERING MAX POSSIBLE WIRE DIA IS EMPLOYED}		OUTPUT TOLERANCE AS PER IEC 584.2;1982 & BS EN 60584.2:1993		
				@100 ° C	@500 ° C	@1000 ° C	CONTINUOUS	SHORT TERM	CLASS 1	CLASS 3	CLASS 3
J	Fe (+) Magnetic	Cu-Ni(-) {Constantant}	BS EN 60584.1, Pt3:1996 ANSI/MC96.1: part 3 {J}	54	56	-	+20 ~ +700	-100 ~ +750	±0.004X[t]@ >375	±0.075X[t]@ >333	-
K	Ni-Cr (+) {Chromel}	Ni-Al(-), Magnetic {Alumel}	BS EN 60584.1, Pt4:1996 ANSI/MC96.1: part 4: {K}	42	43	39	0 ~ +1100	-50 ~ +1250	±0.004X[t]@ >350	±0.075X[t]@ >333	±0.15X[t]@ >200
T	Cu (+) {Copperl}	Cu-Ni(-) {Constantant}	BS EN 60584.1, Pt5:1996 ANSI/MC96.1: part 5: {T}	46	-	-	-150 ~ +300	-200 ~ +400	±0.004X[t]@ >350	±0.075X[t]@ >350	±0.15X[t]@ >200
E	Ni-Cr (+) {Chromel}	Cu-Ni(-) {Constantant}	BS EN 60584.1, Pt6:1996 ANSI/MC96.1: part 6 : {E}	68	81	-	0 ~ +750	-40 ~ +850	±0.004X[t]@ >375	±0.075X[t]@ >333	±0.15X[t]@ >200
R	Pt-Rh(13%) (+)	Pt(-)	BS EN 60584.1, Pt2:1996 ANSI/MC96.1: part 2 {R}	8	10	13	0 ~ +1550	0 ~ +1700	±(1+0.003X[t-1100] @ >1100	±0.025X[t]@ >600	-
S	Pt-Rh(10%) (+)	Pt(-)	BS EN 60584.1, Pt1:1996 ANSI/MC96.1: part 1 : {S}	8	9	11	0 ~ +1500	+ ~ +1750	±(1+0.003X[t-1100] @ >1100	±0.025X[t]@ >600	±0.05X[t]@ >800
B	Pt-Rh(30%) (+)	Pt-Rh (6%) (-)	BS EN 60584.1, Pt7:1996 ANSI/MC96.1: part 7:B{}	1	5	9	+100 ~ +1550	+100 ~ + 1820	-	±0.025X[t]@ >600	±0.05X[t]@ >800

THERMOCOUPLE TYPES:

Given below is general description of commonly used thermocouples.

IEC 584-1, PART1: S:

This thermocouples can be used in oxidising or inert atmosphere at temperatures described above.

Recrystallised Alumina beads and protective sheaths are generally used. However, for lower temperatures upto 1100 Deg C metal sheaths with porcelain beads can be used.

Please note that continuous use at elevated temperature may cause fusing of Rhodium in pure Platinum causing reduction in output emf.

IEC 584-1, PART2: R:

This thermocouples can be used in applications similar to S type thermocouples.

The advantage being slightly higher output at same temperature and better stability. This type is preferred over S type thermocouples.

IEC 584-1, PART3: J:

This thermocouples are commonly known as iron/constantant thermocouples and can be used in reducing or inert atmosphere at temperatures described above.

Restrict use in oxidizing atmosphere to temperatures up to 400 deg C, otherwise degradation will be rapid.

Avoid using for application where condensation temp is often reached otherwise Fe {+leg} will rust rapidly.

IEC 584-1, PART4: K:

This is most commonly used thermocouple ind is are commonly known as chromel/Alumel thermocouple

These are designed primarily for use in Oxidising atmosphere at temperatures described above.

Great care should be taken when using for any other atmosphere.

These thermocouple will get oxidised when used continuously at temp above 1000 Deg C and cause drift.

For temp range from 250 to 600 Deg C stability is suspect. Cyclic temperature changes can cause error of several degrees at these temperatures. Other base metal thermocouples are better bet at this temp range.

IEC 584-1, PART5: T:

This is commonly used in laboratory applications where sub zero temperatures are often maintained.

Repeatability at -200 + 200 Deg C is excellent. However at temp above this Copper arm rapidly oxidizes causing drift.

Note that the negative arm of T and J type are not same and are not interchangeable.

IEC 584-1, PART6: E and IEC 584-1, PART7: B

These thermocouples are not in much use presently.

E type is more stable in -250 + 200 Deg Range than K type and can be preferred over K in this range.

Type B thermocouple can be used at temperature upto 1600 Deg c. Interesting point is that in this type cold junction compensation is not normally required as emf change from 0 to 50 is negligible.

TYPE	COMMONLY USED WIRE GAUGES (SWG)	STANDARD SHEATH MATERIALS	STANDARD SHEATH DIAMETERS	STANDARD PROCESS CONNECTIONS	STANDARD TERMINAL ENDS
J K T E	22, 20, 18,16, 14, 12 & 10 {0.7, 0.9, 1.2, 1.6, 2.0, 2.6 AND 3.3 mm}	TYPE SPECIFICATION 304 : SS 304 316 : SS 316 310 : SS 310 446 : SS 446 600 : INCONELL 600 800 : INCOLOY 800	6, 8, 10, 12, 16, 19, 22. HIGHER DIAMETERS SUCH AS 32, 38, 42 mm CAN BE PROVIDED WITH SS 446 BARSTOCK SHEATH FOR MOLTEN METAL BATH APPLICATION	TYPE SPECIFICATIONS 11 ½" BSP(M) ADJ. 12 ½" BSP(M) Fix. 21 3/4" BSP(M) ADJ. 22 3/4" BSP(M) Fix. 31 1" BSP(M) ADJ. 32 1" BSP(M) Fix. 41 90 MM OD ADJ FLANGE 42 90 MM OD Fix. FLANGE 51 25 NB BS 10 T "D" FLANGE 61 25 NB ASA #150 FLANGE	TYPE SPECIFICATIONS 11 MINIATURE IP-55 HEAD. 12 STANDARD IP-65 SCREWED HEAD. 13 SPHERICAL HINGED LID IP-65 HEAD 14 LARGE VOL. IP-67 SIMPLEX HEAD. 15 LARGE VOL. IP-67 DUPLEX HEAD 16 FLAME PROOF HEAD 21 FLYING LEADS 22 QUICK DISCONNECT PLUG SOCKET 23 BNC CONNECTOR
R S B	30, 29, 27, 26 & 25 {0.32, 0.34, 0.4, 0.45 AND 0.5 mm}	TYPE SPECIFICATION 310 : SS 310 510 : PORCELAIN 610 : CERAMIC 710 : RECRYSTALLISED ALUMINA	6, 8, 10, 12, 15, 20, 24 mm.		

STYLES OF THERMOCOUPLE ASSEMBLIES

FIG-1 

Basic element in all common types with welded junction in various wire gauges and lengths.

FIG-2 

Basic element with ceramic twin bore insulators suiotable for replacement for industrial / high temp thermocouples.

FIG-3 

Suitable for general application up to 400 Deg C. J, K,T, E type element in Seamless SS316 sheath with extension lead wire. Grounded/ungrounded junction as required.

FIG-4 

Suitable for extruder nozzle, motor and pipe temperature measurement. Available in J and K type element embedded in any standard bolt size with extension lead wire. Suitable for Temp up to 225 Deg C.

FIG-5 

Washer type Suitable for surface temperature measurement. Available in J and K type element embedded in any standard washer size with extension lead wire. Suitable for Temp up to 325 Deg C.

FIG-6 

Bayonate type suitable for plastic machinery, bearing chokes etc. Available in J and K type element with SS 316 sheath and extension lead wire. Suitable for Temp up to 650 Deg C.

FIG-7 

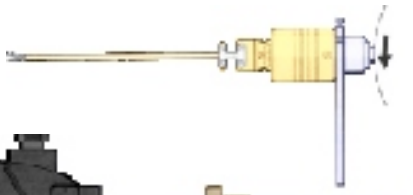
Self adhesive patch thermocouples are suitable for flat or curved surfaces. Available in J and K type element with Teflon insulation. Suitable for Temp up to 200 Deg C.

FIG-8 

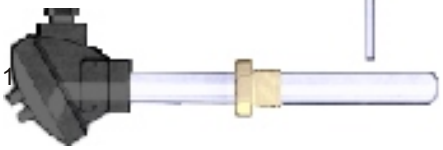
Adjustable ring thermocouples are suitable for large pipe surface temp measurement. Available in J and K type MI element with SS armour over Fibreglass cable. Suitable for Temp up to 500 Deg C.

FIG-9 

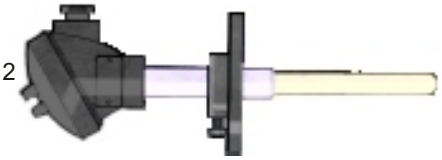
Hand held thermocouples are suitable for liquid, semi solid, leaf type for surface. Available in J and K type MI element with SS Sheath and Ebonite handle with PVC extension cable Suitable for Temp up to 1100 Deg C.

FIG-10 

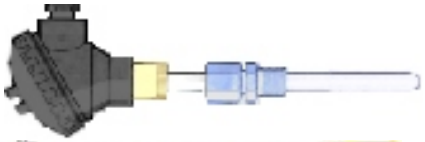
Suitable for moving surfaces such as calender rolls or motor shafts upto 225 Deg C and 200 MPM speeds. Available with spring loaded detection head extension leads and mounting brackets. Available in J and K type element.

FIG-11 

Heavy duty metal sheathed industrial thermocouples are suitable for most arduous industrial environment suchas furnaces, kilns, ovens Zinc Baths etc. Available in J, K, R & S type element with variety of sheaths such as SS 316, Inconell 600, and SS 310.

FIG-12 

High temperature ceramic sheathed thermocouples are suitable for temperatures upto 1600 Deg C Available in K, R & S type element with variety of sheaths such as SS SS 310, Porcelain, Ceramic and Recrystallised Alumina.

FIG-13 

Mineral insulated metal sheathed thermocouples are suitable for spaces which are difficult to reach. Available in J and K type element with variety of sheaths such as SS 316, Inconell 600, and SS 310..

FIG-14 

L shape thermocouples are suitable for molten metal baths. Hot are is manufactured from solid barstock for better life. Available in K type element with variety of sheaths such as Inconell 600, and SS 446.

TYPES OF THERMOCOUPLE HEADS

FLAME PROOF

BIG, IP-67 DUPLEX

BIG, IP-67 SIMPLEX

SPHERICAL IP-65

STANDARD IP-65

MINIATURE IP-55

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FIG-11
METAL SHEATHED INDUSTRIAL

FEATURES :

Heavy duty industrial metal sheathed thermocouple assemblies are available with thick walled protective sheath in SS 304, SS 316, SS 310, Inconell 600 and SS 446.

These assemblies are suitable for temperatures upto 1150 Deg C.

Typical area of application are Furnace, Kilns, Ovens, Boilers, Stack temp, Flue Gas Application.

Depending upon selection of sheath these assemblies are suitable for Oxidising, reducing or neutral atmosphere.

SPECIFICATIONS:

Type : K, J, E, T, simplex or duplex
Junction : Grounded/ Ungrounded Exposed
Tolerance : ANSI/ MC 96.1 Cl 2
Error Limit : 0.0075[t] @ > 350 Deg C
Sheath : SS 304, SS 316, SS 310, Inconell 600, SS 446
Sheath Dia.: 12, 16, 19, 22 and 25 mm
Insulation : Ceramic/ Alumina Beads Optionally secondary protection sheath of Ceramic can be provided when additional protection is desired.
Head : Weatherproof IP67 Flame proof suitable for Gas group I, IIA & IIB
Mounting : Screwed connection or flanged connection
Conn. Size : 1/2" & 3/4" BSP/NPT
Element : 1.6, 1.8, 2, 2.5 and 3 mm

Sheath	Max Op. Temp
SS 304/SS 316	800 Deg C
SS 310	1000 Deg C
Inconell 600	1100 Deg C
SS 446	1150 Deg C

FOR DEAILED SPECS OF OTHER ASSEMBLY TYPES SUC AS FIG1 TO FIG10 PLEASE CONTACT.

FIG-12
CERAMIC SHEATHED HIGH TEMP

FEATURES :

These ceramic sheathed assemblies are used for temperature measurement from 1200 to 1750 Deg C and above in Glass industries, Furnaces, Kilns Etc.

Ceramic sheathed thermocouple assemblies are available with protective sheath in Alumina Porcelain (Gr 510), Mullite (Gr610) and Recrystallised Alumina (Gr 710). All these sheaths are impervious. Heavy walled metallic holding tube is standard feature.

Ceramic sheathed thermocouple uses upto 10 (3.2 mm) SWG basemetal element or upto 25 SWG (0.5mm) Precious metal element.

Assemblies can be supplied with secondary ceramic shath for added safety of precious metal element.

Wide range of process connection are available.

SPECIFICATIONS:

Type : K, R, S, B, simplex or duplex
Junction : Ungrounded
Tolerance : ANSI/ MC 96.1 Cl 2
Error Limit : 0.0075[t] @ > 350 Deg C {K}
0.0025[t] @> 350 Deg C {R,S,B}
Sheath : Porcelain, Ceramic, Recrystallised Alumina
Sheath Dia.: 10, 15, 18, 20 and 24 mm
Insulation : Ceramic/ Alumina Beads
Head : Weatherproof IP67 Flame proof suitable for Gas group I, IIA & IIB
Mounting : Screwed connection or flanged connection
Conn. Size : ½", 3/4" & 1" BSP/NPT
Element : 2.5 and 3 mm {K}
0.33, 0.4, 0.45, 0.5 mm {R,S,E}

Sheath	Max Op. Temp
Gr 510	1300 Deg C
Gr 610	1500 Deg C
Gr 710	1750 Deg C

FIG-13
MINERAL INSULATED METAL SHEATHED FLEXIBLE

FEATURES :

Mineral insulated assemblies are used where fast response, high integrity and mechanical flexibility is desired.

Available in J and K element from 1.6 to upto 8 mm OD.

The conductors are insulated from each other and sheath by tightly compacted MgO powder offering insulation resistance upward of 50 m-Ohms.

Flexible metal sheathed thermocouple assemblies are available with protective sheath in SS 304, SS 316, SS 310 and Inconell 600.

These assemblies are suitable for temperatures upto 1050 Deg C.

Depending upon selection of sheath these assemblies are suitable for Oxidising, reducing or neutral atmosphere.

SPECIFICATIONS:

Type : K, J, simplex or duplex
Junction : Ungrounded
Tolerance : ANSI/ MC 96.1 Cl 2
Error Limit : 0.0075[t] @ > 350 Deg C
Sheath : SS 304, SS 316, SS 310, Inconell 600
Sheath Dia.: 1.6, 3, 6 and 8 mm
Insulation : Compacted MgO.
Head : Weatherproof IP67 Flame proof suitable for Gas group I, IIA & IIB
Mounting : Screwed connection or flanged connection
Conn. Size : 1/2" & 3/4" BSP/NPT
Element : 0.4, 0.8 1.0 and 1.2 mm

Sheath Dia	Response time	Note
1.6 mm	0.6 Sec	Response time is time taken for thermocouple to achieve 65% of the instantaneous step when plunged from air at 30 Deg C to boiling water.
3 mm	1.2 Sec	
6 mm	3.5 Sec	
8 mm	8 Sec	

Response time for un Grounded tip, response for grounded tip is 30% faster.