Precautions for Practical Applications

There are various types of thermocouple, so it is most important to carefully select an appropriate thermocouple for the specific application. In addition, care should be exercised when selecting protection tube, structure of the assembly and installation method in consideration of resistance to heat, pressure, thermal shock, corrosion and vibration. For the best of temperature measurement with thermocouple, overall measuring loop and components should be carefully designed. Although the importance of reference or cold junction is overlooked and often substituted by a simple electric resistor compensation inside the measuring instrument, stability of the reference junction actually controls measurement accuracy. It is therefore recommended that precision reference devices like our "Zeref V" (18 channels max., 0± 0.01℃ Accuracy) or industrial rack mount model "TRU 100"(100 channels, 0± 0.03℃ Accuracy per 15℃ Ambient Span) should be used and Class 1 extension cables should be used for wiring rather than compensating cables. For guidance, various technical brochures, such as‟ Instruction Manual for Thermocouple”and“ Thermowell and Protection Tube Selection Guide‟ are available upon request.

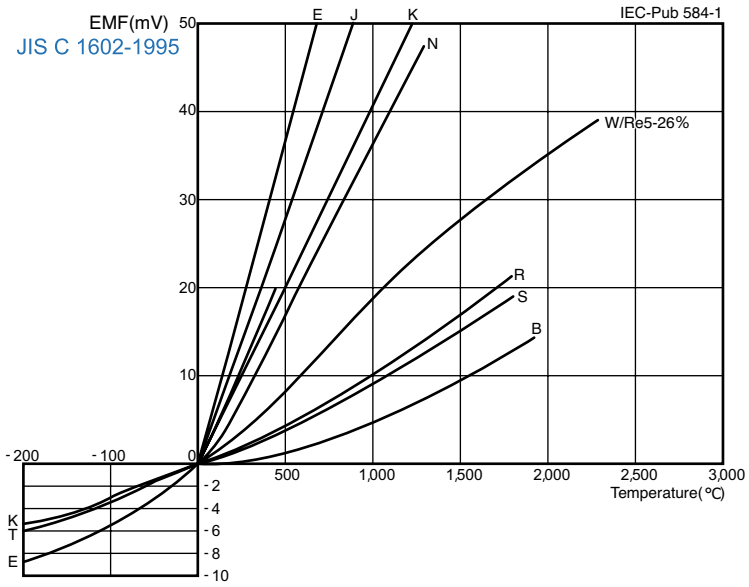
Combination of Standardized Thermocouples

Ref :
IEC-Pub 584-2
ASTM E988-1996

Type	Alloy Composition of the conductors	
	Positive (+) Leg	Negative (-) Leg
W5*	95%Tungsten･5%Rhenium	74%Tungsten･26%Rhenium
B	BP(70%Platinum･30%Rhodium	BN(94%Platinum･6%Rhodium)
R	RP(87%Platinum･13%Rhodium)	RN(100%Platinum)
S	SP(90%Platinum･10%Rhodium)	SN(100%Platinum)
N	NP (84%Ni･14.2%Cr･1.45%Si)	NN (95%Ni･4.4%Si･0.15%Mg)
K	KP (90%Ni･10%Cr)	KN (95%Ni･2%Mn･2%Al)
E	EP (90%Ni･10%Cr)	EN Constantan (55%Cu･45%Ni)
J	JP (99.5% Iron)	JN Constantan (55%Cu･45%Ni)
T	TP (100% Copper)	TN Constantan (55%Cu･45%Ni)

Note : * W5 is not standardlized yet by IEC,JIS,etc.

EMF Curves of Standardized Thermocouples



THERMOCOUPLE
(MODEL : TE)

Tolerances on Temperature Reading

1. JIS C1602-1995 IEC 584-2-1982 (Amendment 1-1989) BS/EN 60584-2-1993 DIN/IEC 584-2-1992

Type		Classification of Tolerances		
		Class 1	Class 2	Class 3
B	Temp. Range	—	—	Above 600℃ Below 800℃
	Tolerance	—	—	± 4℃
	Temp. Range	—	Above 600℃ Below 1700℃	Above 800℃ Below 1700℃
	Tolerance	—	± 0.0025 | t |	± 0.005 | t |
	Previous Class	—	—	Class 0.5
R	Temp. Range	· Above 1100℃ Below 1600℃	Above 0℃ Below 600℃	—
	Tolerance	± [1 0.003 t-1100]	± 1.5℃	—
S	Temp. Range	Above 0℃ Below 1100℃	Above 600℃ Below 1600℃	—
	Tolerance	± 1℃	± 0.0025 | t |	—
	Previous Class	—	Class 0.25	—
N	Temp. Range	Above -40℃ Below 375℃	Above -40℃ Below 333℃	Above -167℃ Below 40℃
	Tolerance	± 1.5℃	± 2.5℃	± 2.5℃
	Temp. Range	Above 375℃ Below 1000℃	Above 333℃ Below 1200℃	Above -200℃ Below -167℃
	Tolerance	± 0.004 | t |	± 0.0075 | t |	± 0.015 | t |
K	Temp. Range	Above -40℃ Below 375℃	Above -40℃ Below 333℃	Above -167℃ Below 40℃
	Tolerance	± 1.5℃	± 2.5℃	± 2.5℃
	Temp. Range	Above 375℃ Below 1000℃	Above 333℃ Below 1200℃	Above -200℃ Below -167℃
	Tolerance	± 0.004 | t |	± 0.0075 | t |	± 0.015 | t |
	Previous Class	Class 0.4	Class 0.75	Class 1.5
E	Temp. Range	Above -40℃ Below 375℃	Above -40℃ Below 333℃	Above -167℃ Below 40℃
	Tolerance	± 1.5℃	± 2.5℃	± 2.5℃
	Temp. Range	Above 375℃ Below 800℃	Above 333℃ Below 900℃	Above -200℃ Below -167℃
	Tolerance	± 0.004 | t |	± 0.0075 | t |	± 0.015 | t |
	Previous Class	Class 0.4	Class 0.75	Class 1.5
J	Temp. Range	Above -40℃ Below 375℃	Above -40℃ Below 333℃	—
	Tolerance	± 1.5℃	± 2.5℃	—
	Temp. Range	Above 375℃ Below 750℃	Above 333℃ Below 750℃	—
	Tolerance	± 0.004 | t |	± 0.0075 | t |	—
	Previous Class	Class 0.4	Class 0.75	—
T	Temp. Range	Above -40℃ Below 125℃	Above -40℃ Below 133℃	Above -67℃ Below 40℃
	Tolerance	± 0.5℃	± 1℃	± 1℃
	Temp. Range	Above 125℃ Below 350℃	Above 133℃ Below 350℃	Above -200℃ Below -67℃
	Tolerance	± 0.004 | t |	± 0.0075 | t |	± 0.015 | t |
	Previous Class	Class 0.4	Class 0.75	Class 1.5

Note :

1. Tolerance denotes the maximum allowable value obtained by subtracting the temperature reading or the temperature at the hot junction from the standard temperature converted from the applicable temperature EMF table.
2. Tolerance Class 1 for Types R and S only apply to the Standard or Reference thermocouple.
3. \| t \| denotes the value of temperature (℃) irrespective of positive (+) or negative (-) sign.
4. Tolerances listed in this page apply to the new thermocouple wires.

· not standardized yet by JIS

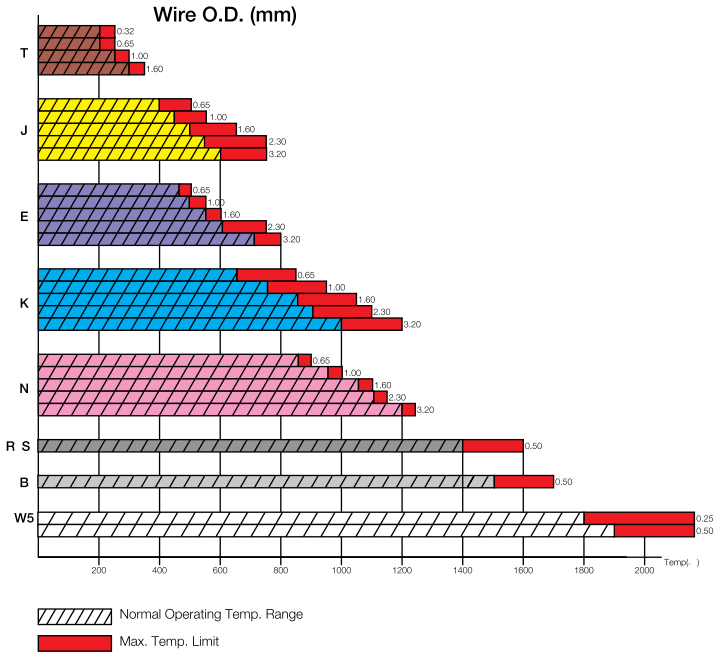
2. Tolerance on Temperature Reading to ASTM E230-1998, E988-1996

TYPE	Temp. Range	Tolerance Grades	
		Standard	Special
W5	Above 426℃ Below 2315℃	± 1%	—
B	Above 870℃ Below 1700℃	± 0.5%	± 0.25%
R S	Above 0℃ Below 1480℃	± 1.5℃ or ± 0.25%	± 0.6℃ or ± 0.1%
N	Above 0℃ Below 1260℃	± 2.2℃ or ± 0.75%	± 1.1℃ or ± 0.4%
K	Above -200℃ Below 0℃	± 2.2℃ or ± 2%	—
	Above 0℃ Below 1260℃	± 2.2℃ or ± 0.75%	± 1.1℃ or ± 0.4%
E	Above -200℃ Below 0℃	± 1.7℃ or ± 1%	—
	Above 0℃ Below 870℃	± 1.7℃ or ± 0.5%	± 1.0℃ or ± 0.4%
J	Above 0℃ Below 760℃	± 2.2℃ or ± 0.75%	± 1.1℃ or ± 0.4%
T	Above -200℃ Below 0℃	± 1.0℃ or ± 1.5%	—
	Above 0℃ Below 370℃	± 1.0℃ or ± 0.75%	± 0.5℃ or ± 0.4%

Note :
The above colour codes are in accordance with ASTM E 230-1998.

Operating and Maximum Temperature Limits to Conductor Diameter (mm)

Note :
(1) Operating temperature limit means the upper temperature where thermocouple can be used continuously in air.
(2) Maximum limit means the upper temperature where thermocouple can be used temporarily for short period of time owing to unavoidable circumstances. This graph is given as a guide only, and not to be guaranteed.



TYPE	Wire Dia.(mm)	Normal Operating Temp. Range (℃)	Max. Temp. Limit (℃)
W5	0.25	1,800	2,300
	0.50	1,900	2,300
B	0.50	1,500	1,700
R S	0.50	1,400	1,600
N	0.65	850	900
	1.00	950	1,000
	1.60	1,050	1,100
	2.30	1,100	1,150
	3.20	1,200	1,250
K	0.65	650	850
	1.00	750	950
	1.60	850	1,050
	2.30	900	1,100
	3.20	1,000	1,200
E	0.65	450	500
	1.00	500	550
	1.60	550	600
	2.30	600	750
	3.20	700	800
J	0.65	400	500
	1.00	450	550
	1.60	500	650
	2.30	550	750
	3.20	600	750
T	0.32	200	250
	0.65	200	250
	1.00	250	300
	1.60	300	350

This table is made in reference to JIS C 1602-1995 and ASTM E988-1996

Code	No.of Conductors
S	Single pair, 2 conductors
D	Dual pair, 4 conductors
T	Triple pair, 6 conductors

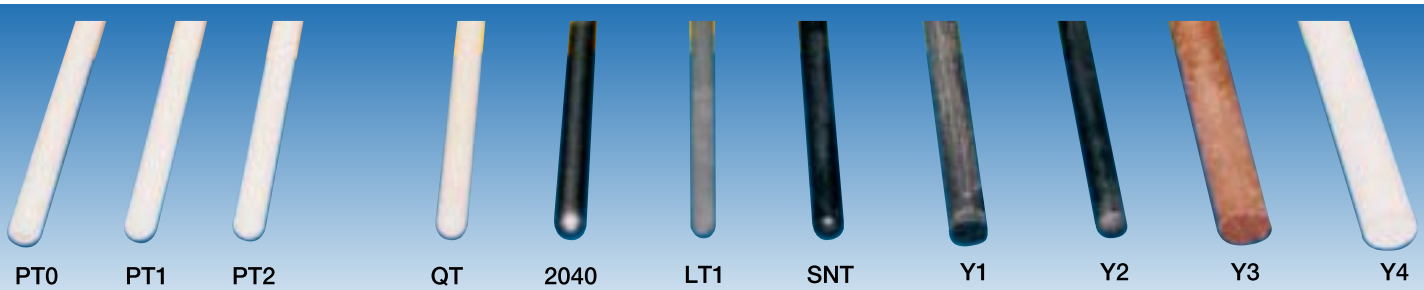
INSULATORS AND PROTECTION TUBES

Non-Metallic Protection Tubes

Caution :

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 preheating around 80 100 will be adequate.
2. Minimum insertion length of the non-metallic 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.

Material	Code	Operating Temp. ( )	Features
Translucent Quartz Transparent Quartz	QT	1,000	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.
Silimanite	PT2	1,400	High alumina ceramic. Good resistance to thermal shock. Recommended for use in coal or oil burning and electric furnaces. Slightly porous.
Mullite	PT1	1,500	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	PT0	1,600	99.5%Alumina Superior chemical stability and better than PT1. Recommended for use in molten steel, slag and molten glass, impervious.
Cermet (Chrome-Alumina)	LT1	1,300	77%Alumina-23%Chrome Excellent resistance to heat and abrasion. Recommended for temperature measurements of molten copper and other nonferrous metals.
Cermet (Cermotherm)	2040	1,600	60%Mo-40%ZrO_2 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	Y0	1,650	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	Y1 (GK)	1,400	99% SiC Porous but good resistance to acids and alkalis. Recommended for use in air neutral atmospheres up to 1,400 and also in high temperature stagnant furnace atmosphere as an outer protection tube, etc. Attacked by water vapour.
Self-bonded Silicon Carbide	Y2 (KT)	1,650	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 . but attacked by water vapour.
Clay-bonded Silicon Carbide	Y3 (NF)	1,500	89%SiC+8.5%SiO_2+0.7%Al_2O_3+0.7%Fe_2O_3 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	Y4 (RF)	1,550	78%SiC+3%SiO_2+18%Si_3N_4(Si_2ON_2) Excellent performance superior to Y3 SiC but contains Si_3N_4. Most suitable for use in molten aluminum, reheating. Attacked by water vapour.
Silicon Nitride (Si_3N_4)	SNT	1,350	Excellent thermal shock resistance. Less corrosion to acids and alkalis. High hardness. Fairly good resistance against most of molten metals.
Sialon	SLN	1,250	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 .
Zirconia	ZR 1706	1,800	MgO Stabilized ZrO_2 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 . Suitable for use in high temp. protection tube up to 1,900 where PT0 Alumina softens.



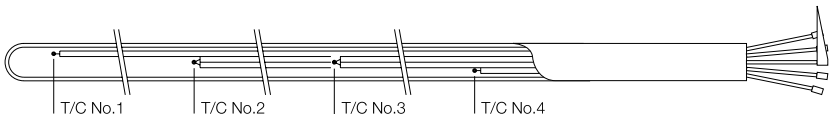
HIGH TEMPERATURE MULTI-POINT THERMOCOUPLE

For temperature range of above 1200℃ upto 1450℃ , where metal sheathed compacted MgO type thermocouple can no longer be used as well as any of super-alloys, Platinum-Rhodium group thermocouples of Types S, R and B are used with high purity Quartz protection tubes and Alumina insulators. At present major applications of such a High Temperature Multi-point Thermocouple seems to be concentrated for use on measurement of temperature profile in a diffusion furnace of semi-conductor industry. Due to limitation of the furnace inlet, 2~5 points assembly is prevailed. For special applications, Silicon Carbide outer protection tube can be used. Please consult our factory.

Standard Designs of High Temp. Multi-Point Thermocouple :

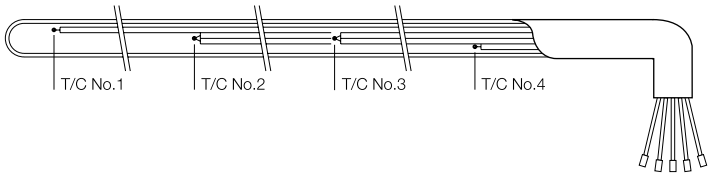
1. Straight Quartz or Alumina Tube protected Type :

Protection Tubes	High Purity Quartz, Alumina and Special SiC tube
Thermocouple	Type R, S and B
Measuring points	2~5 max.
Measuring range	Type R and S 1200℃ (Quartz Tube), Type B 1600℃ (Alumina Tube)
Length of Assembly	1~2 meters
Overall Dia. of Assembly	12~25 mm.
Accuracy	Standard Grade ± 0.25% of Reading. Premium Grade ± 0.1% of Reading (Type R only) *SiC tube is optional, but sometimes needs to protect thermocouple wires from contamination by inner protective coating or clean Alumina inner tube, etc.



2. Bent protection Tube Type :

Specifications are same as above, but the cold end of the protection tube is bent approx. 90 Deg. to fit for limited installation space.



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