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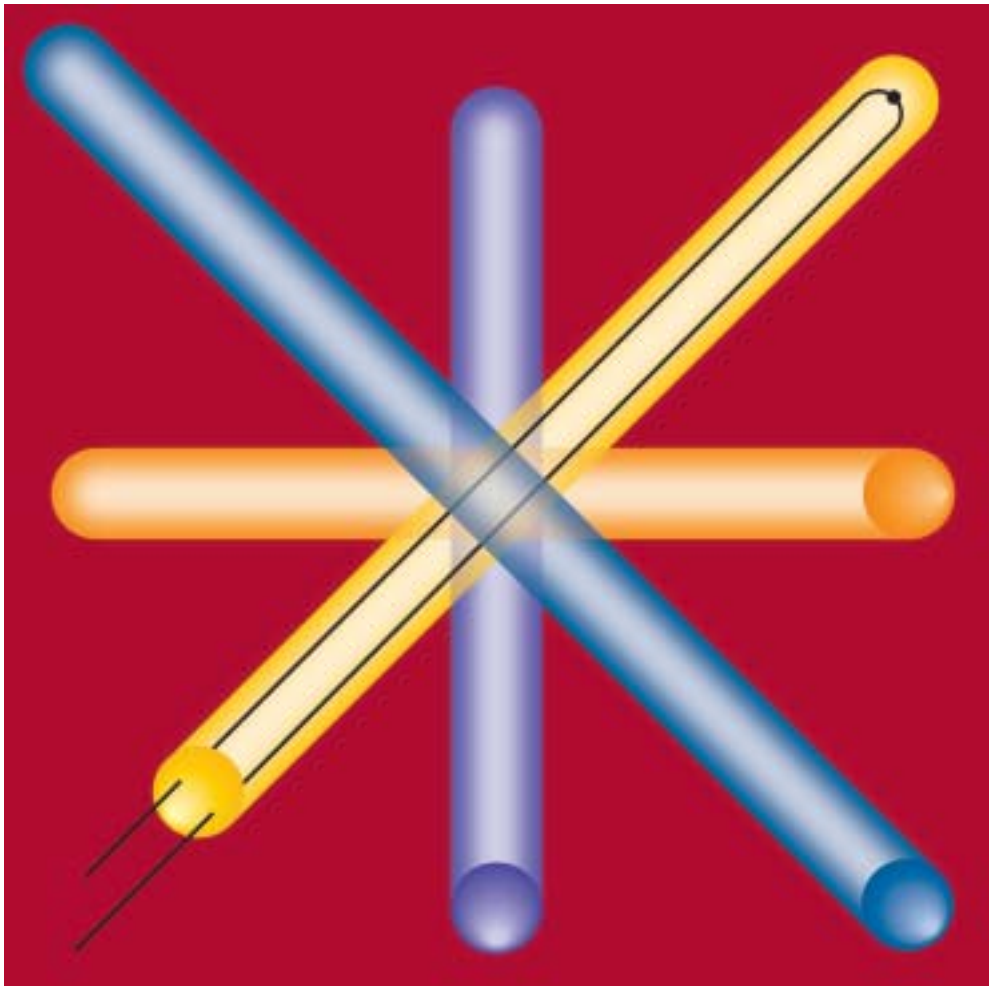

THERMOCOUPLE

WIRES, INSULATORS AND PROTECTION TUBES

THERMIC

METAL SHEATHED THERMOCOUPLE

HT-THERMIC

ULTRA HIGH TEMPERATURE THERMOCOUPLE

THERMOWELL

THERMOWELL

EXTENSION & COMPENSATING CABLES

GENERAL , MULTI-PAIR , ARMOURED , MINERAL INSULATED CABLES

YAMARI INDUSTRIES, LIMITED

LINE OF BUSINESS

Temperature Sensors:

Metal Sheathed Thermocouple, THERMIC
Beaded Type Thermocouple with Protection Tube
Metal Sheathed Resistance Temperature Detector, RESIMIC
Resistance Temperature Detector with Protection Tube
Fine Diameter Resistance Temperature Element, RESICERAM
Tubular Stem Type Resistance Temperature Detector, RESISLIM
Special Thermocouple for Ultra-High Temperature, HT-THERMIC
Special Thermocouple for Temperature Measurement of Tube Skin
Multi-Point Thermocouple

Other Products and Imported Equipment :

Metal Sheathed Heat Tracing Cable and Micro Heater Assembly
Dissolved Oxygen Sensor for Molten Copper Bath, METAL-OX
Aluminum Content Sensor for Hot Zinc Plating Line, AL-SENSOR
AM・FM Turbine Blade Tip Clearance Measuring System
ISOTECH Precision Temperature Calibration Apparatus and Standard Thermometers
Turbine Blade and Aircraft Wing Models for Wind-Tunnel Experiment
Computerized Two & Three Dimensional Fine Traverser
Total, Static and YAW Probes for High Temperatures
Temperature Transmitters

Calibration Services for Temperature Sensors by JCSS Laboratory :

Precision Calibration using Triple Point of Water and Mercury. Fixed Point Standards of Pure Metals and Standard Platinum Resistance Thermometer traceable to National Standard. Comparison Calibration with Standard Platinum Resistance Thermometer and Standard Thermocouple using Liquid Baths, Fluidized Bed Alumina Powder Bath, and Electric Furnace. A Certified Calibration Report shall be issued.

ACCREDITATIONS OF QUALITY ASSURANCE, SAFETY AND P.L. WARRANTY

JQA-0797
Head Office/Takatsuki Factory/Tokyo Branch
Nagoya Sales Office/Fukuoka Sales Office

JQA-EM4107
Takatsuki Factory

ISO 9001:2000 / JQA-0797
ISO 14001:1996 / JQA-EM4107

MRA IAJapan JCSS 037

symbolizes the traceability system in accordance with the measurement law.
The Calibration results may be accepted internationally through ILAC/APLAC MRA.

CENELEC(KEMA)

PA
2000-T163
2000-T164

ISO 9001
Since 1995, we maintain leading position as one of the reliable manufacturers of various temperature sensors under rigid quality assurance system to ISO 9001 which has compatibility with the qualification marks and logos (left).

ISO 14001
Beginning in july, 2004, a key objective of all of Yamari's business operations has been to reduce industrial pollution and minimize damage to the environment. The environmental protection programs we have now established form part of our commitment to continual improvement, subject to a strict environmental management system meeting all the requirements of ISO 14001

JCSS:
In order to certify accuracy and reliability of the temperature sensors, we obtained an accreditation by IA Japan (International Accreditation Japan) in 1994 as a qualified temperature calibration service laboratory through an established traceability with the National Standard. JCSS (Japan Calibration Service System) is in conformity with ISO/IEC 17025 to provide measurement standards and measured quantities, i.e., an authorized certification of the temperature figures.

P.L.
Our products are fully inspected to assure quality and proper functions, but for warranty to the customers, sufficient amount of P.L. Insurance is being covered.

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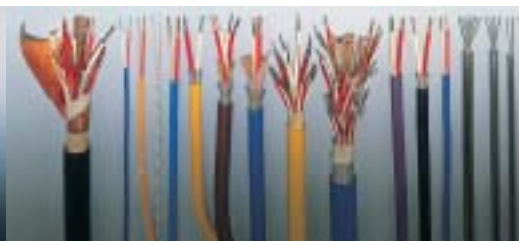
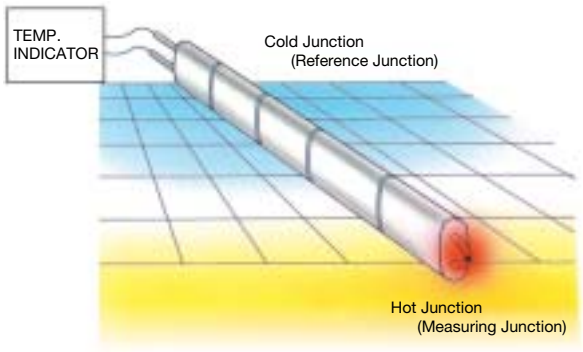


THERMOCOUPLE
(MODEL : TE)

PRINCIPLE AND DESCRIPTIONS OF THERMOCOUPLE

When two dissimilar metal or alloy conductors are connected together to form a closed circuit and the two junctions are kept at different temperatures, thermal electromotive force (EMF) is generated at the temperature gradient zone along the conductors length in the circuit.
Thus, when one end (cold or reference junction) is kept constant at a certain temperature, normally 0℃, and the other end (measuring junction) is exposed to unknown temperature, the temperature at the latter end can be determined by measuring EMF so generated. Such a combination of two dissimilar metal conductors is called "Thermocouple." As described, thermocouple is a "temperature difference sensor" to generate millivolt signal (EMF) only at the temperature gradient segment, which inevitably makes the thermocouple conductor heat treated in accordance with the temperature profile along the insertion depth. It is not correct, therefore, to use such a thermocouple as once heat treated and so stabilized, for measurement of the other location that has different temperature gradient.
Particularly, when measurement is made in shorter insertion depth than previous measurement, it will result in large reading error, since already heat treated segment is exposed to non-temperature gradient zone thus exhibiting spurious EMF, therefore, avoid re-using one thermocouple for measurements at the different locations.

Generally, service life of the thermocouple can not be predicted nor be guaranteed, as the environments of temperature measurement are so various involving handling, installation, corrosion, vibration, thermal cycles and steep change in temperatures.



Features of Thermocouple

Industrial thermocouple, in comparison with other thermometers, has the following features:

1. Quick response and stable temperature measurement by direct contact with the measuring object.
2. If the selection of a quality thermocouple is properly made, wide range of temperature from −270 to 2,300℃ can be measured.
3. Temperature of specific spot or small space can be measured.
4. Since temperature is detected by means of EMF generated, measurement, adjustment, amplification, control, conversion and other data processing are easy.
5. Less expensive and better interchangeability in comparison with other temperature sensors.
6. The most versatile and safe for measuring environments, if a suitable protection tube is employed.
7. Rugged construction and easy installation.

Structure and Measuring Method

Generally, industrial thermocouple is insulated with ceramic beads to prevent thermocouple conductors from short circuit and then inserted into a protection tube to avoid contacting directly to the measuring object or being exposed to the surrounding atmosphere. Our THERMIC Mineral Insulated Metal Sheathed Thermocouple has a pre-assembled construction composed of thermocouple wires, compacted ceramic powder insulation and protection sheath in one pliable, gas tight cable form. Reference junction should be kept or compensated at a constant temperature (ideally at 0℃) for measurement. The EMF generated can be measured with a simple moving coil type, electronic type, potentiometric and other indicators or converted to various data processing signals for computer control.

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.

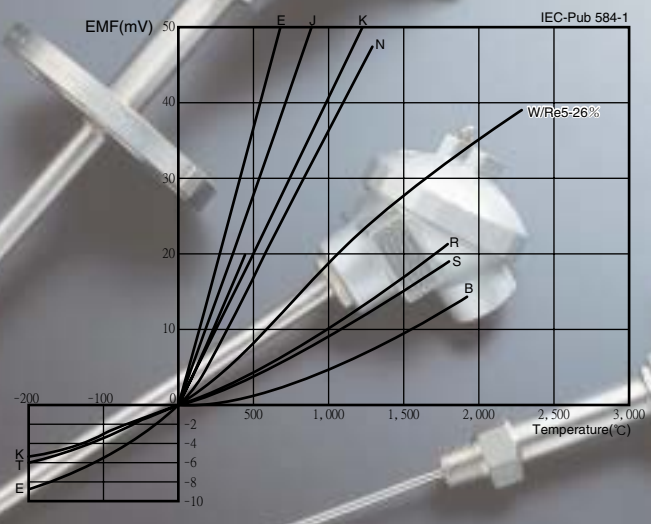
Combination of Standardized Thermocouples

Ref : JIS C 1602-1995
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

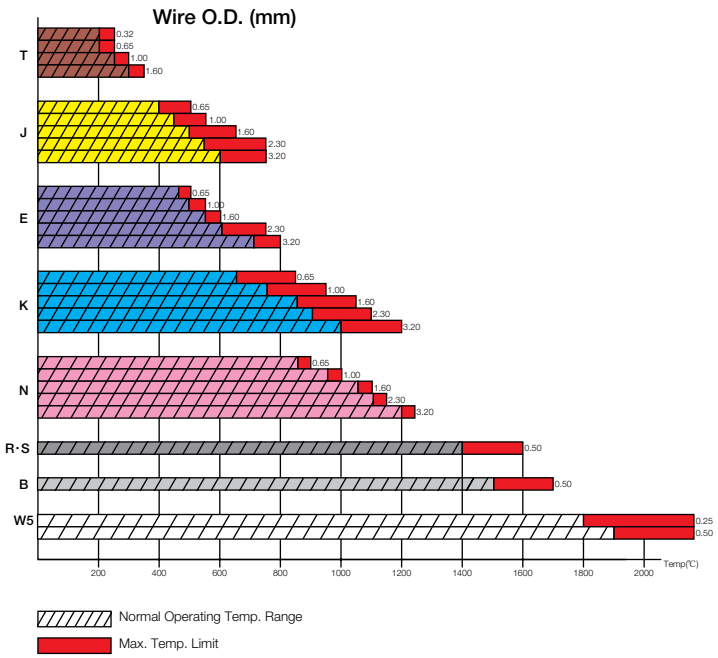
2. Tolerance on Temperature Reading to ASTM E230-1998, E988-1996

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

THERMOCOUPLE
(MODEL : TE)

Standardized Types of Thermocouple

B — Type B (Pt·30%Rh/Pt·6%Rh) Thermocouple 600℃～1700℃

Type B thermocouple has higher melting point and mechanical strength than other Pt/Rh thermocouples because of its higher content of Rhodium in both legs.
Type B thermocouple can be used continuously in oxidizing and neutral atmospheres up to 1600℃ and intermittently up to 1700℃. Even in reducing atmosphere, Type B may be used for fairly longer period than other Pt/Rh thermocouples, but not generally recommended.
Type B thermocouple is recommended especially for the applications requiring precision measurement and durability at high temperatures. This thermocouple has very small EMF up to 100℃, thus for less critical applications, copper leads can be used as a compensating wire.
Precious metal thermocouples are generally sensitive to contaminants and easily be corroded at elevated temperatures. It is essential to keep the thermocouple wire clean and use dust-free high purity (>99.5%) Alumina insulators and protection tubes.

R — Type R (Pt·13%Rh/Pt) Thermocouple 0℃～1600℃

Type R thermocouple has superior mechanical properties to Type S and is recommended for continuous use in oxidizing and inert atmospheres around temperatures up to 1400℃ and intermittently up to 1600℃. However, it should not be used in vacuum, reducing or metallic vapour atmospheres unless properly protected with clean high purity (>99.5%) Alumina insulators and protection tubes. Among precious metal thermocouples, Type R is most widely used.

S — Type S (Pt·10%Rh/Pt) Thermocouple 0℃～1600℃

Type S thermocouple is the first historic thermocouple originally developed by Le Chatelier in 1886. It had been widely used as a standard thermometer as an interpolation means to determine the temperature scale between the fixed (freezing) points ranging from 630.74℃ of Antimony to 1064.43℃ of Gold as defined by the International Practical Temperature Scale (IPTS). Applications are similar to Type R, but it has less mechanical strength.

N — Type N (Nicrosil/Nisil) Thermocouple -200℃～1250℃

This new thermocouple combination of 84Ni-14.2Cr-1.4Si vs. 95.5Ni.-4.4Si-0.1Mg was first developed by Materials Research Laboratory of the Australian Department of Defense. Further research and evaluation have been extensively carried out by NIST (former NBS), ASTM and other research organizations to standardize and establish the present EMF table. Type N thermocouple exhibits superior long-term stability and oxidation resistance over type K when used at high temperatures ranging from 600 to 1250℃. By virtue of fine adjustment of chromium content with additions of Si and Mg, it has less EMF shift in the region of "short range ordering" and also resistant to "Green Rot" corrosion. In comparison with type K, rate of EMF drift is reported to be half or one third over the range of 1000℃ and therefore recommended for use in oxidizing atmosphere of 1000-1200℃ continuous.

K — Type K (Ni·Cr/Ni·Al) Thermocouple -200℃～1250℃

Type K thermocouple was originally developed by Mr. A. L. Marsh of Hoskins Co., U.S.A. in 1906 and, since then, has undergone many improvements. It has linear EMF characteristics and most widely used as industrial thermocouple with high reliability because of its versatile characteristics. It can be used in oxidizing or inert atmospheres at temperatures up to 1250℃.
Type K thermocouple may be used in hydrogen or cracked ammonia atmospheres if the dewpoint is below -42℃. However, it should not be used in reducing, alternatively oxidizing and reducing, sulfurous or "green-rot" corrosive atmospheres unless properly protected.
"Green-rot" can be minimized by increasing oxygen supply through the use of large diameter protection tube or ventilated protection tube. It can also be minimized by inserting a "getter" to absorb the oxygen in a sealed protection tube. For such a special application, consult our factory.

E Type E (Ni·Cr /Constantan) Thermocouple -200℃～900℃

Type E thermocouple has the highest EMF characteristics among industrial thermocouples which allows the best resolution to temperature change. Since it was adopted by ANSI in 1964 and JIS in 1974, type E thermocouple has met rapidly increasing demands and has been widely used even in large scale thermal and nuclear power stations. It can be used up to 750℃ continuously. For practical use, precautions similar to those for type K are required. Careful attention is also needed in selection of the indicator to be connected because type E thermocouple has the highest resistivity among the base metal thermocouples.

J Type J (Iron/Constantan) Thermocouple 0℃～750℃

Type J thermocouple has the second highest EMF characteristics and is recommended for use in reducing, inert, oxidizing or vacuum atmospheres up to 750℃. Because of comparatively less expensive price, type J has been easily accepted for use in various applications. However, it should not be used in sulphurous atmospheres above 538℃ due to formation of the sulfides that leads conductors to embrittlement. The iron element is often rusted under high humidity environment, therefore, type J is less desirable than type T for low temperature measurements.

T Type T (Copper/Constantan) Thermocouple -200℃～350℃

Type T thermocouple has good resistance to corrosion in moist atmospheres and is suitable for sub-zero temperature measurements. It can be used in vacuum and in oxidizing, reducing or inert atmospheres up to 400℃. At higher temperatures, it is susceptible to rapid oxidation by water vapour. Because of its stable and precise EMF characteristics, type T is widely used in laboratories. Type T is the first thermocouple for which tolerance in the sub-zero temperature range has been established. Due to high thermal conductivity of the conductors, care must be exercised to eliminate heat conduction error that often occur on short stem length type T thermocouple unit.

W5 Type W5 (W·5%Re/W·26%Re) Thermocouple 0-2300℃

Although this thermocouple combination is not standardized yet by IEC, JIS, etc.,there is a long proven temperature-EMF table that has been adopted by ASTM E988 in 1990. Tungsten 5% Rhenium-Tungsten 26% Rhenium Type is the best improved alloy combination having higher recrystalization temperature of Tungsten above 1,650℃ which is the only refractory type thermocouple material for regular use at very high temperatures of 1800℃ and intermittently up to 2300 ℃. At this temperature range, any of platinum-Rhodium group thermocouples will rapidly deteriorate and melt down. This thermocouple, however, has a drawback of severe oxidation when exposed to air or other oxygen containing atmosphere at above 400℃. Recommended for high temperature measurements under dry Hydrogen, inert gases and vacuum. Unless properly protected like YAMARI's Model HT-270A, use in oxidizing atmosphere should be avoided.

Note : Types E, J and T have the same negative (-) legs composing of Cu-Ni with an alloy name of "Constantan," but the alloying ratio of Cu-Ni is adjusted to their respective matching positive (+) legs.Therefore, the negative legs of constantan have no Interchangeability between types.

Special Thermocouple Wires

Platinel 0~1300℃ Oxidizing, Inert
Pt40Rh/Pt20Rh 0~1800℃ Oxidizing, Inert
Ni18Mo/Ni0.8Co 0~1200℃ Reducing, Inert
W3Re/W25Re 0-2200℃ Reducing, Inert, Vacuum
Mo5Re/Mo41Re 0-1700℃ Reducing, Inert, Vacuum
Chromel/Au·Fe -273~20℃ All atmospheres

INSULATORS AND PROTECTION TUBES

Thermocouples are widely used for temperature measurements of various gases and liquids. If bare thermoelement wires are exposed directly to detrimental atmospheres and fluid, they are often physically and chemically affected resulting in reducing service life with severe deterioration and corrosion. Thermocouples 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 on the respective operating conditions. This is the most important point in thermometric practice.

INSULATORS

Characteristics

Type	Code	Operating Temp. (℃)	Maximum Temp. (℃)	Features
Aluminous Ceramic Grade 2	PS2	1,400	1,500	Silimanite Grade. Less porosity with reasonable heat load softening and good resistance to thermal shock.
Aluminous Ceramic Grade 1	PS1	1,500	1,600	Mullite Grade. Gas tight structure with less heat load softening. Better than PS2.
Recrystallized Alumina 99.7%	PS0	1,600	1,800	Gas tight structure with excellent resistance to corrosion. Highest purity among alumina ceramics. Very low Alkalis.
Magnesia Ceramic	MG	1,800	2,200	Porous structure but excellent resistance to corrosion. Only suitable for Basic environment.

Note : Operating and maximum temperatures vary depending on the atmospheres and mode of temperature changes.

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

Note : Insulators are available in longer length up to 3,000 mm. Consult factory.

PROTECTION TUBES

Metal Protection Tubes

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

Material	Code	Operating Temp. (℃)	Features
SS400	400	Oxi. 600 Red. 800	Good resistance to reducing atmosphere but less resistant to oxidation and acids attacks. Thick walled tubes are used in molten aluminium.
304 S.S.	304	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.
304L S.S.	304L	980	Less carbon content (C=0.03%) than 304 S.S. and better resistance to grain boundary corrosion. Subject to stress and "pit" corrosion.
321 S.S.	321	980	Higher corrosion resistance than 304 S.S. because of its Ti content to prevent carbon preticipation. Excellent resistance to grain boundary corrosion after welding due to less carbon preticipation.
316 S.S.	316	980	Contains Mo and has excellent resistance to corrosives, heat, acids and alkalis.
316L S.S.	316L	980	Less carbon content than 316 S.S. and has better resistance to grain boundary corrosion. Resistant to "pit" corrosion.
310S S.S.	310S	1,000	High Ni-Cr content and good high temperature strength with resistance to oxidation at high temperatures. High mechanical strength.
347 S.S.	347	980	Because of its Nb-Ta content, prevents carbon preticipation. Higher corrosion resistance than 304 S.S. and excellent resistance to grain boundary corrosion.
446 S.S.	446	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.
253 MA	253	1,000	Superior oxidation resistance to 310 S.S. at high temperatures due to formation of dense and tight oxide layer by silicon and cerium additions. Can be used under sulphurous atmospheres.
HCF	HCF	1,100	One of the best oxidation and corrosion resistant alloys at high temperatures, particularly durable under carburizing and crude oil burning furnaces. Better resistance to sulphur and vanadium-pentoxide than ordinary Cr-Al-Fe alloys. No embrittlement but less mechanical strength at high temperature.
Carpenter 20 Cb-3	C2CB	1,000	Improved Carpenter 20 Alloy. Cu is newly added to form solid solution with Ni, and Mo content provides enhanced corrosion resistance to non-oxidizing acids, such as Nitric, Fluoric Acid. Virtually immune to pit corrosion.
50Co-30Cr	50	Oxi. 1,150 Red. 1,200	Excellent resistance to heat, corrosion and abrasion. One of the best alloy against high temperature sulphur bearing atmospheres.
Inconel 600	600	1,050	Excellent resistance to oxidizing and reducing atmospheres at high temperatures. But sulphurous atmospheres should be avoided. Immune to stress and "pit" corrosion.
Inconel 601	601	1,050	Superior oxidation resistance at high temperatures to Inconel-600, by virture of strong bonding of metal oxide film.
Inconel 625	625	1,050	Improved strength and stress rupture properties up to 980℃ by Mo and Cb additions, and immune to chloride stress corrosion cracking.
Incoloy 800	800	870	Excellent to high temperature oxidizing atmospheres and thermal shock. About 10 times longer service life than 304 S.S. against high temperature corrosion.

to Next Page

INSULATORS AND PROTECTION TUBES

PROTECTION TUBES

Material	Code	Operating Temp. (℃)	Features
Incoloy 825	825	1,000	An improved version of Incoloy 800. All round superior alloy for high temperature applications, particularly in oil refineries against organic sulfides, hydrogen-sulfide and sulphur combustion products.
Kanthal A1	KA	1,100	Good resistance to high temperature oxidation but becomes brittle due to recrystallization. Poor mechanical strength above 850℃.
80Ni・20Cr	NC	1,100	Good mechanical strength and corrosion resistance at high temperature oxidizing atmospheres but not recommended for use in sulphurizing atmospheres.
Kurimax	KU	1,200	Excellent resistance to molten chemicals and combustion gases. Also good resistance to corrosion by liquid copper.
Hastelloy B	HB	Oxi. 500 Red. 760	Excellent resistance to heat and corrosion, especially to HCl and H_2SO_4.
Hastelloy C-276	HC	1,000	Excellent resistance to high temperature oxidizing and reducing atmospheres and also to $C\ell_2$ gases.
Hastelloy X	HX	1,100	Excellent resistance to oxidizing and carburizing atmospheres at high temperatures. Better machinability and weldability than other Hastelloy alloys.
Haynes Alloy 25	HY	Oxi. 810 Red. 980	High resistance to oxidizing and carburizing atmospheres at high temperatures.
Titanium	TI	Oxi. 250 Red. 1,000	Superior corrosion resistance in cryogenic temperatures but at high temperatures, easily oxidized and becomes brittle.
Monel	MN	Oxi. 500 Red. 600	Excellent resistance to water vapor and sea water at high pressure and corrosion.
Tantalum	TA	Oxi. 300 Red. 2,200	Excellent heat-resistant material with high resistance to all acids but apt to severe oxidation and embrittlement in air at high temperatures.
Molybdnum	Mo	Oxi. 400 Red. 2,000	Excellent mechanical strength up to 1500℃ 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.

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.

NOMINAL ANALYSIS OF METAL PROTECTION TUBES

Material	Code	Chemical Composition(%wt)								
		C	Si	Mn	P	S	Ni	Cr	Fe	OTHERS
STPG370	370	<0.25	<0.35	0.30～0.90	<0.040	<0.040	—	—	Bal	—
SS400	400	—	—	—	<0.050	<0.050	—	—	Bal	—
304 SS	304	<0.80	<1.00	<2.00	<0.045	<0.030	8.00～10.50	18.00～20.00	Bal	—
304L SS	304L	<0.030	<1.00	<2.00	<0.045	<0.030	9.00～13.00	18.00～20.00	Bal	—
321 SS	321	<0.08	<1.00	<2.00	<0.045	<0.030	9.00～13.00	17.00～19.00	Bal	Ti:5×C%
316 SS	316	<0.08	<1.00	<2.00	<0.045	<0.030	10.00～14.00	16.00～18.00	Bal	Mo:2.00～3.00
316L SS	316L	<0.030	<1.00	<2.00	<0.045	<0.030	12.00～15.00	16.00～18.00	Bal	Mo:2.00～3.00
310S SS	310S	<0.08	<1.50	<2.00	<0.045	<0.030	19.00～22.00	24.00～26.00	Bal	—
347 SS	347	<0.80	<1.00	<2.00	<0.045	<0.030	9.00～13.00	17.00～19.00	Bal	Nb:10×C%
446 SS Equiv. *1 SANDVIK P-4	446	<0.20	<1.00	<1.50	<0.040	<0.030	—	23.00～27.00	Bal	<N:0.25
253 MA *4	253	—	1.7	0.6	—	—	11	21	Bal	Ce 0.04 N 0.17
●HCF	HCF	<0.02	- Trace -	—	—	—	—	20	Bal	Al 3.0 Trace Zr+Ti
●Carpenter 20 Cb-3	C2Cb	<0.02	0.4	<1.0	—	—	33	20	Bal	Mo 2.2 Cb+Ta 8×C
●Haynes Alloy 25	HS25	0.1	<1.0	1.5	—	—	32	20	1.5	Co Bal W 15
Kantal A1	KA	—	—	—	—	—	—	22	Bal	Al 5.8
80Ni・20Cr	NC	—	—	—	—	—	75～80	15～20	—	Trace Ti
Inconel 600	600	<0.15	<0.50	<1.00	<0.030	<0.015	>72.00	14.00～17.00	6～10	Trace Co <Cu:0.50
Inconel 625	625	<0.10	<0.50	<0.50	<0.030	<0.015	Bal	21.5	<5.0	Mo9 Nb+Ta:3.7
Incoloy 825	825	<0.05	<0.50	<1.0	<0.030	<0.03	38-46	19.5～23.5	Bal	Al:<0.2 Ti:0.6-1.2 Mo:2.5～3.5
Incoloy 800	800	<0.10	<1.00	<1.50	<0.030	<0.015	30.00～35.00	19.00～23.00	Bal	Trace Cu, Trace Co, Al, Ti
50Co-30Cr (UMCo-50) *2	50	0.05～0.15	<1.00	0.30～1.00	<0.020	<0.020	<3.00	26.00～30.00	Bal	Co 50 Trace Mo
●Kurimax *3	KU	—	—	—	—	—	—	50～65	50～35	W4, Trace Nb, Ti
●Hastelloy B	HB	<0.05	1.0	<1.0	0.04	<0.03	Bal	—	<5.0	Mo:28 Co:2.5 V:0.6
●Hastelloy C-276	HC	<0.02	<0.08	<1.0	<0.04	<0.03	Bal	14.5～16.5	6.0	Mo:15.0～17.0 Trace W, Co, V
Hastelloy X	HX	<0.05	<1.00	<1.00	<0.040	<0.030	Bal	20.50～23.00	18.5	Mo:8.00～10.00 W0.6, Co1.5 Trace B
●Monel 400	MN	<0.3	<0.5	<2.0	—	<0.024	>63.0	—	2.5	Cu:28.0～34.0 Trace Co

●Only available in the form of solid bar stock.

*1: SANDVIK P4 is Sandvik AB's Trade Mark.
*2: UMCo-50 is Mitsubishi Material Co's Trade Mark.
*3: Kurimax is Kurimoto Iron Works Co's Trade Mark.
*4: 253MA is Avesta A.B.'s Trade Mark.
*5: Haynes 25 is Haynes International Corp.'s Trade Mark.
*6: Carpenter 20 Cb-3 is Carpenter Technology Corp.'s Trade Mark.

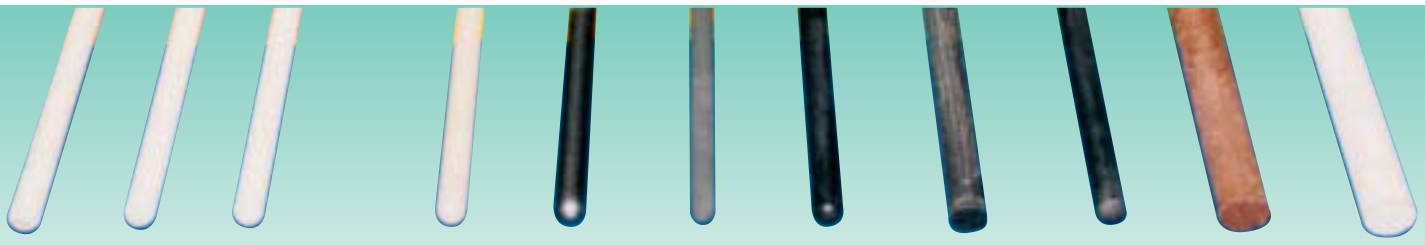
INSULATORS AND PROTECTION TUBES

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.



PT0 PT1 PT2 QT 2040 LT1 SNT Y1 Y2 Y3 Y4

Standard Dimensions of Protection Tubes

Metallic Tubes

Unit : mm

Material	Nominal O.D.	Nominal I.D.	Length
304 S.S.	10.0	8.0	4,000
304L S.S. *1	12.0	9.0	4,000
321 S.S. *1	13.8 *2	9.4	5,500
316 S.S.	15.0	11.0	4,000
316L S.S.	17.3 *2	12.7	5,500
310S S.S.	21.7 *2	16.1	5,500
347 S.S. *1	27.2 *2	21.4	5,500
446 S.S.	21.3	16.0	4,000
	26.9	21.6	4,000
50Co30Cr	22.0	16.0	4,000
80Ni20Cr	27.0	21.0	4,000
INCONEL 600	10.0	8.0	4,000
	13.0	11.0	4,000
	15.0	11.0	4,000
	22.0	16.0	4,000
	26.7	21.0	4,000

Note:
*1 Only scheduled tubes are available.
*2 Dimensions for scheduled tubes.

Non-Metallic Tubes

Unit : mm

Material	Nominal O.D.	Nominal I.D.	Length
PT1 PT2	6.0	4.0	150～1,000
	8.0	5.0	300～3,000
	10.0	6.0	300～3,000
	13.0	9.0	500～3,000
	15.0	11.0	500～2,000
	17.0	13.0	500～2,000
	21.0	16.0	500～2,000
	25.0	20.0	500～2,000
PT0 (Alumina coating is also available.)	6.0	4.0	300～1,400
	8.0	5.0	300～3,000
	10.0	6.0	300～3,000
	13.0	9.0	500～3,000
	15.0	11.0	500～2,000
	17.0	13.0	500～2,000
	21.0	16.0	500～2,000
	25.0	20.0	500～2,000
QT	8.0	6.0	100～1,000
	15.0	13.0	100～2,000
	18.0	15.0	100～2,000
Y1	25.0	17.0	1,000～1,400
	30.0	15.0	1,000～1,700
	35.0	25.0	1,000～1,800
Y2	25.0	12.0	150～ 900
Y3	40.0	20.0	1,000
Y4	40.0	20.0	400～1,000

Corrosion and Abrasion Resistant Coatings

Treatment	Thickness(mm)	Composition	Maximum Temp. (℃)	Features
Glass Lining	1～1.2	Borosilicate glass over plain steel	450	Suitable for protection against oxidation and gas penetration. Poor thermal shock resistance.
Teflon *1	0.3	FEP over metals	120	Suitable for concentrated hydrochloric, sulphuric and nitric acids depending on temperatures.
HARD SURFACING. Flame Spray, Plasma Spray	0.3～0.6	Colmonoy *2 Fukudalloy *3 Stellite W.C. *4	1,000	Suitable for protection from corrosion and abrasion of mother metals or alloys surface.

For other special coating requirements, consult our factory.

*1,2,3,4 Trade Marks of Dupont, Colmonoy, Fukuda Alloy, and Cabot respectively.

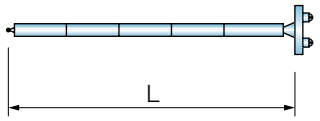
STANDARD MODELS OF BEADED TYPE THERMOCOUPLE (MODEL : TE)

Standard Models of Beaded Type Thermocouple Assembly (Model : TE)

For economy and quicker delivery, 16 popular models were selected in five STANDARD LENGTH of 500, 800, 1000, 1200, 1500 mm through numerous proof in design and installations. It is recommended that the customer specify the probe length longer than actually needed among the above standard length, so that error by heat conductivity is eliminated and the insertion depth can be adjusted as required.

1 TE01

Basic Type with Bead Insulators

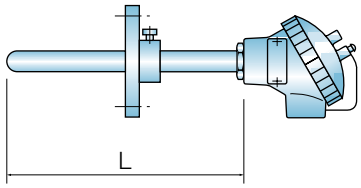


TE01 – K S 32 – L – S

Model No. | Type | No. of Con-ductors | Dia. | Total Length | Terminal Block

2 TE12

Metalic Protection Tube Type with Slide Flange



TE12 – K S 32 – L – KN – 22 /

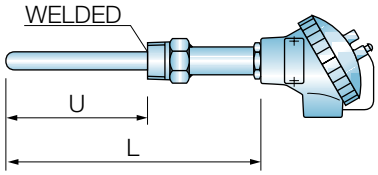
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Terminal Box | Pro. Tube Die.

304 @ JIS10K25AFF / 304

Material | Flange Rating | Material

3 TE13

Screwed-in Metalic Protection Tube Type with Hex. Nipple



TE13 – K S 32 – L / U – KN –

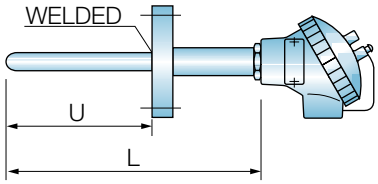
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box

15 / 304 – R1/2 / 304

Pro.Tube Die. | Material | Thread | Material

4 TE14

Metalic Protection Tube Type with Fixed Flange



TE14 – K S 32 – L / U – KN –

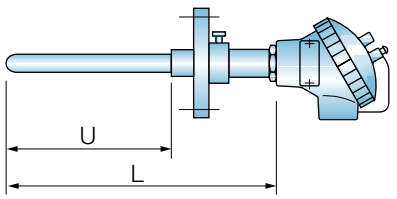
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box

22 / 304 – JIS10K25AFF / 304

Pro.Tube Die. | Material | Flange Rating | Material

5 TE22

Ceramic Protection Tube Type with Metal Support and Slide Flange



TE22 – R S 05 – L / U – KN – 15

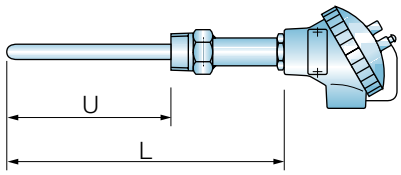
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box | Pro. Tube Die.

/ PT0 – 22 / 304 @ JIS10K25AFF / 304

Material | Supprt Dia. | Material | Flange Rating | Material

6 TE23

Screwed-in Ceramic Protection Tube Type with Hex. Nipple



TE23 – R S 05 – L / U – KN –

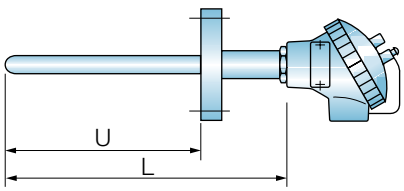
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box

13 / PT0 – R3/4 / 304

Pro.Tube Die. | Material | Thread | Material

7 TE24

Ceramic Protection Tube Type with Fixed Flange



TE24 – R S 05 – L / U – KN –

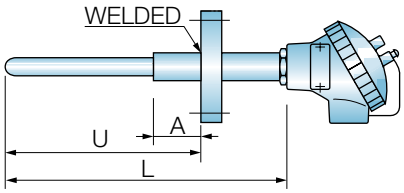
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box

13 / PT0 – JIS10K25AFF / 304

Pro.Tube Die. | Material | Flange Rating | Material

8 TE25

Ceramic Protection Tube Type with Fixed Flange on Metal Support



TE25 – R S 05 – L / U / A – KN –

Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Support Lengyh "A" | Terminal Box

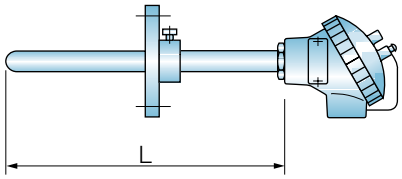
13 / PT0 – 22 / 304 – JIS10K25AFF / 304

Pro.Tube Die. | Material | Support Dia. | Material | Flange Rating | Material

STANDARD MODELS OF BEADED TYPE THERMOCOUPLE

9 TE32

Dual Protection Tube Type Inner Ceramic and Outer Metal Tubes with Slide Flange

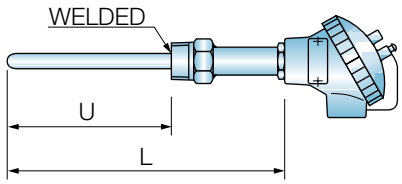


TE32 – R S 05 – L – KN – 13 /
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Terminal Box | Inner Tube Dia.

PT0 – 22 / 304 @ JIS10K25AFF / 304
Material | Outer Tube | Material | Flange Rating | Material

10 TE33

Screwed-in Dual Protection Tube Type Inner Ceramic and Outer Metal Tubes with Hex. Nipple

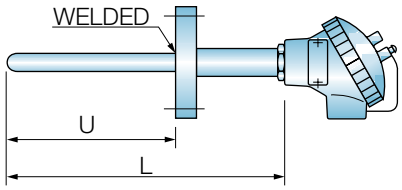


TE33 – R S 05 – L / U – KN –
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box

13 / PT0 – 22 / 304 – R1 / 304
Inner Tube Dia. | Material | Outer Tube | Material | Thread | Material

11 TE34

Dual Protection Tube Type Inner Ceramic and Outer Metal Tubes with Fixed Flange

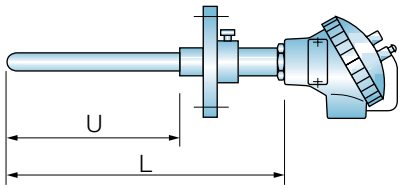


TE34 – R S 05 – L / U – KN – 13
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box | Inner Tube Dia.

/ PT0 – 22 / 304 – JIS10K25AFF / 304
Material | Outer Tube | Material | Flange Rating | Material

12 TE42

Dual Ceramic Protection Tube Type with Slide Flange Optional Metal Support

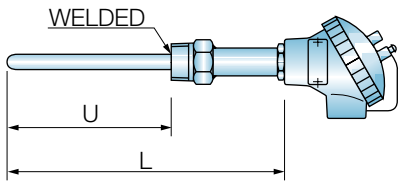


TE42 – R S 05 – L / U – KN – 8 / PT0 –
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box | Inner Tube Dia. | Material

13 / PT1 – 22 / 304 @ JIS10K25AFF / 304
Outer Tube | Material | Support Dia. | Material | Flange Rating | Material

13 TE43

Screwed-in Dual Ceramic Protection Tube Type with Hex. Metal Support

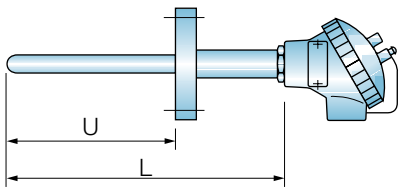


TE43 – R S 05 – L / U – KN –
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box

8 / PT0 – 13 / PT1 – R1 / 304
Inner Tube Dia. | Material | Outer Tube | Material | Thread | Material

14 TE44

Dual Ceramic Protection Tube Type with Fixed Flange Metal Support

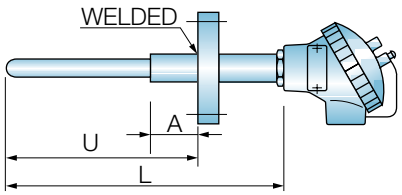


TE44 – R S 05 – L / U – KN – 8
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box | Inner Tube Dia.

/ PT0 – 13 / PT1 – JIS10K25AFF / 304
Material | Outer Tube | Material | Flange Rating | Material

15 TE45

Dual Ceramic Protection Tube Type with Fixed Flange on Metal Support

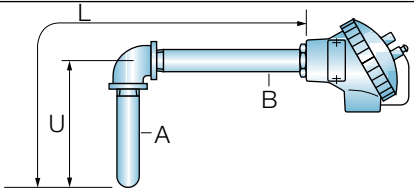


TE45 – R S 05 – L / U / A – KN – 13 /
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Support Length "A" | Terminal Box | Inner Tube Dia.

PT0 – 21 / PT0 – 27 / 304 – JIS10K25AFF / 304
Material | Outer Tube Dia. | Material | Support Dia. | Material | Flange Rating | Material

16 TE62

L-bent Type



TE62 – K D 32 – L / U / KN –
Model No. | Type | No. of Con-ductors | Dia. | Total Length | Insertion Length | Terminal Box

22 / 304 – 22 / 304
Pro.Tube "A" Dia. | Material | Pro.Tube "B" Dia. | Material

THERMIC® METAL SHEATHED THERMOCOUPLE (MODEL : TM)

THERMIC® Descriptions

THERMIC is a trade name of YAMARI's metal sheathed thermocouple that is covered by a heat and corrosion resistant alloy sheath in which high purity MgO powder is tightly compacted around the thermocouple conductors. THERMIC metal sheathed thermocouple has high electrical insulation resistance and excellent compressive strength owing to its compact integral construction. It has also high reliability and accuracy because its EMF tolerance always guaranteed to fall within the limits of error stipulated by IEC, JIS (C 1605-1995), ASTM, BS, DIN, etc.

THERMIC® Features

1) Small Size and Quick Response :
By virtue of its integrated structure comprising of thermoelement wires, insulating powder material and a protection sheath compacted and drawn together into a small size gas-tight tubular cable form, THERMIC has very quick response to temperature changes, without disturbing temperature of the measuring object.

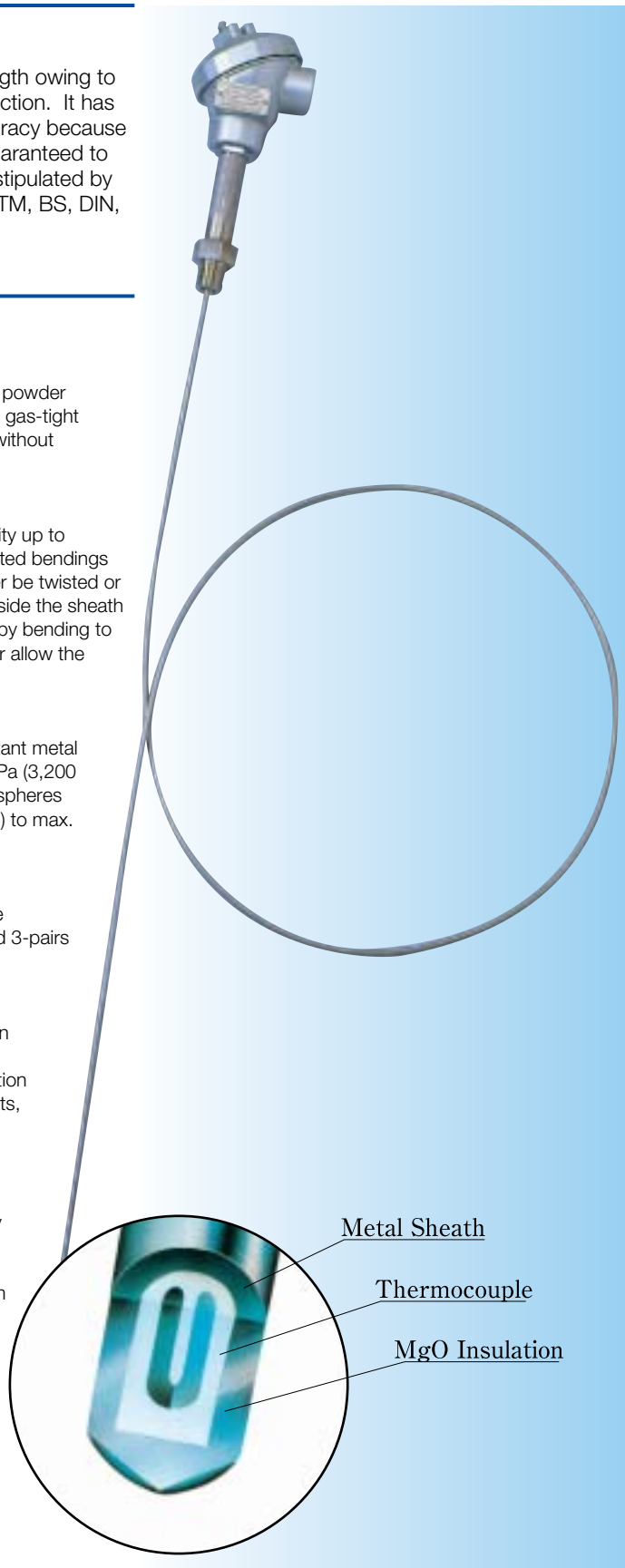
2) High Flexibility and Ease of Installation :
THERMIC can be easily installed owing to its high mechanical strength and pliability up to bending radius equal to 2 times of the sheath O.D., and can stand 4 times' repeated bendings before heating. Once after installed and heated, however, THERMIC should never be twisted or bent to any direction, as the compacted powder insulation is pressure sintered inside the sheath during the measurement, thus changing to solid ceramic which may yield cracks by bending to provide paths for the metal elements to diffuse changing the alloy compositions or allow the thermocouple wires to touch each other.

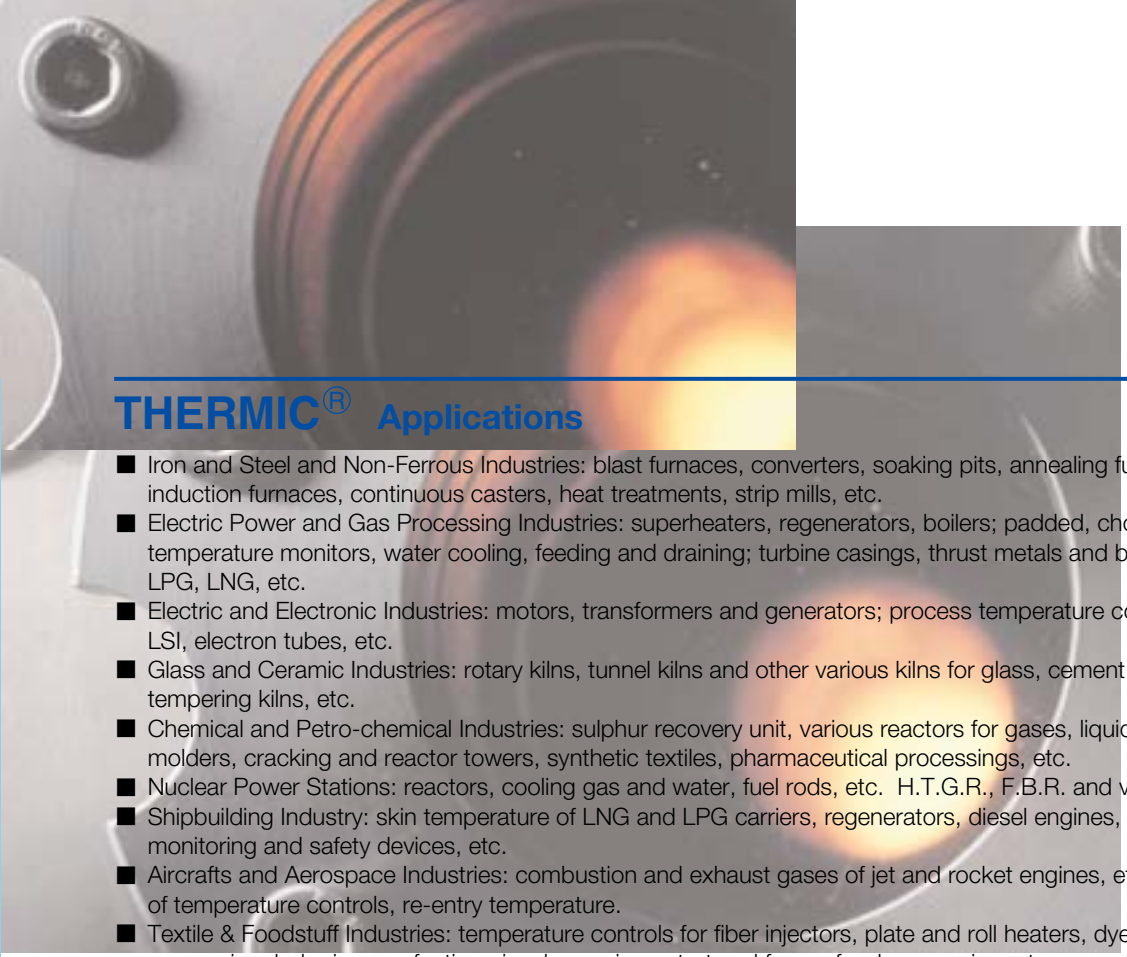
3) Excellent Resistance to Heat, Corrosion, Vibration and Pressure :
Made of high purity MgO powder tightly compacted in a heat and corrosion resistant metal tube, THERMIC is produced by drawing under high pressures in excess of 314MPa (3,200 kgf/cm^2) therefore, it is highly gas-tight, least corrosion against surrounding atmospheres and withstands severe vibration and high pressures from 137MPa (1,400 kgf/cm^2) to max. 196MPa (2,000 kgf/cm^2).

4) Wide Selection of Cable Types :
From very fine sheath O.D. of 0.25 mm to 12. 7 mm, and up to 500 meters in one continuous length are available in some O.D. Thermoelement wires of 2-pairs and 3-pairs are also available.

5)Wide Range of Measuring Temperature :
Available in types T, J, E, K, N and R with a variety of alloy sheath depending upon measuring environments. Temperature range can be extended from cryogenic of –200℃ to high temperature up to +1,250℃ by selecting an appropriate combination of thermocouple type and sheath material. To the customer's special requirements, various exotic Metal Sheathed Thermocouples such as Tantalum sheathed Tungsten-Rhenium and Platinum sheathed Type R and B can be supplied.

6) Longer Service Life :
Despite much smaller overall diameter and light weight, THERMIC has remarkably longer service life over the conventional large beaded type thermocouple. According to our experiment for long-term EMF drift studies of THERMIC thermocouple, 8 mm O.D. Inconel 600 sheathed Type K samples of only 1.30 mm dia. conductors had a service life of over 20,000 hours (2.3 years), at 1,000℃ in air without noticeable drift from an initial calibration.
In contrast, a conventional beaded thermocouple of 3.2 mm O.D. Type K conductors with 21.7 mm O.D. Inconel 600 protection tube failed less than 10,000 hours (approx. 11 months) after deviated from the specified limits of error due to oxidation of Type K conductors.
THERMIC offers more than twice as large saving on the temperature measurement costs.

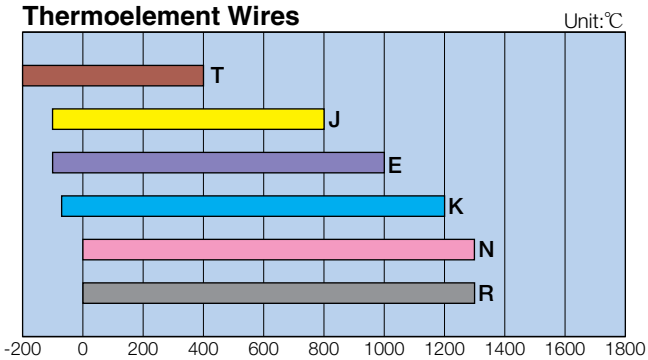


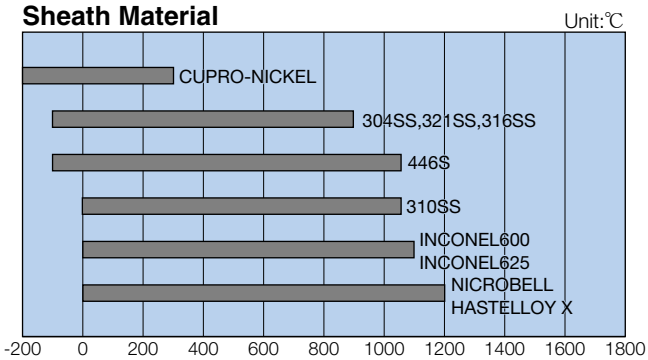


THERMIC® Applications

- Iron and Steel and Non-Ferrous Industries: blast furnaces, converters, soaking pits, annealing furnaces, electric furnaces, vacuum induction furnaces, continuous casters, heat treatments, strip mills, etc.
- Electric Power and Gas Processing Industries: superheaters, regenerators, boilers; padded, chordal and various types of skin temperature monitors, water cooling, feeding and draining; turbine casings, thrust metals and bearings; generator gas, natural gas; LPG, LNG, etc.
- Electric and Electronic Industries: motors, transformers and generators; process temperature controls for semi-conductors, IC, LSI, electron tubes, etc.
- Glass and Ceramic Industries: rotary kilns, tunnel kilns and other various kilns for glass, cement and brick, flues, preheaters, tempering kilns, etc.
- Chemical and Petro-chemical Industries: sulphur recovery unit, various reactors for gases, liquids, etc., plastic injectors and molders, cracking and reactor towers, synthetic textiles, pharmaceutical processings, etc.
- Nuclear Power Stations: reactors, cooling gas and water, fuel rods, etc. H.T.G.R., F.B.R. and various nuclear researches
- Shipbuilding Industry: skin temperature of LNG and LPG carriers, regenerators, diesel engines, etc. associated long-term monitoring and safety devices, etc.
- Aircrafts and Aerospace Industries: combustion and exhaust gases of jet and rocket engines, etc. associated monitoring functions of temperature controls, re-entry temperature.
- Textile & Foodstuff Industries: temperature controls for fiber injectors, plate and roll heaters, dyeing process, sugar refining, meat processing, bakeries, confectioneries, breweries, retort and frozen food processing, etc.
- Others: experimental and laboratory studies on plasma arc, electron beam, laser, single crystal growth, and other physical, electronic, medical properties, biotechnical researches.

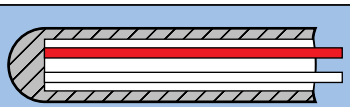
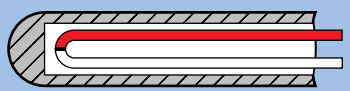
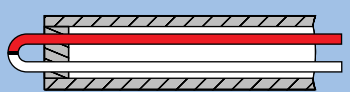
THERMIC® Temperature Range





* Due to limitation of heat resistance of the metal sheath, maximum measuring temperatures may be reduced than those quoted on bare thermocouple wires.

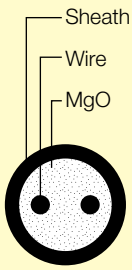
THERMIC® Hot Junctions

 **Type Ⅰ (Grounded)**	Thermoelement wires are welded together directly at hot end of the sheath to form a hot junction. Not recommended for type T and R due to wide difference in melting points between composed metals and alloying compatibility. To overcome such a difficulty, a patented special junction is made on request. Quick response and suitable at high temperature and pressure but not recommended for use in hostile, vibrating and noise generating field.
 **Type Ⅱ (Ungrounded)**	Thermoelement wires are welded together to form a hot junction which is completely isolated both mechanically and electrically from the sheath closure. Slower response than Type I but less deterioration of EMF and suitable for a long term service in critical and noise generating field.
 **TypeⅢ (Exposed)**	Thermoelement wires are welded together to form a bare hot junction by protruding from the sheath. Quickest response and can detect even a slight temperature change instantaneously, but not durable for long time in corrosive, high temperature and high pressure atmospheres. Care must be exercised to prevent from moisture ingress at low temperature or during storage.

Our specifications and procedures of making the above hot junctions conform to ASTM E 235, IEC 1515-1995 and JIS C 1605-1995.

THERMIC® METAL SHEATHED THERMOCOUPLE (MODEL : TM)

THERMIC® Types and Sizes

	Nom.O.D. (mm)	Wire Dia. (mm)	Wall Thick. (mm)	Type	Standard Sheath Material	Max. Length (m)	Weight (g/m)
Single Pair 	0.25	0.04	0.05	K	Inconel 600	5	0.4
	0.5	0.10	0.08	K・E・J	316LSS Inconel 600	300	1.3
	1.0	0.18	0.13	K・E・J・T	316LSS Inconel 600, 310SS	480	5
	1.6	0.25	0.18	N・K・E・J・T・R	316LSS Inconel 600, 310SS	300	13
	2.2	0.36	0.25	N・K・E・J・T	316LSS Inconel 600, 310SS	300	24
	3.2	0.53	0.36	N・K・E・J・T・N・R	316LSS Inconel 600, 310SS	500	51
	4.8	0.79	0.53	N・K・E・J・T・N・R	316LSS Inconel 600, 310SS	200	115
	6.4	1.04	0.74	N・K・E・J・T・N	316LSS Inconel 600, 310SS Hastelloy X	100	193
	8.0	1.30	0.91	N・K・E・J・T・N	316LSS Inconel 600, 310SS Hastelloy X	80	300
Dual Pair 	1.6	0.25	0.18	K・E・J・T	316LSS Inconel 600, 310SS	300	13
	3.2	0.48	0.36	K・E・J・T	316LSS Inconel 600, 310SS	500	45
	4.8	0.74	0.53	K・E・J・T	316LSS Inconel 600, 310SS	200	102
	6.4	0.97	0.74	K・E・J・T	316LSS Inconel 600, 310SS	100	222
	8.0	1.22	0.91	K・E・J・T	316LSS Inconel 600, 310SS	80	350
Triple Pair 	3.2	0.30	0.38	K・E・J・T	316LSS Inconel 600, 310SS	150	33
	4.8	0.53	0.53	K・E・J・T	316LSS Inconel 600, 310SS	200	80
	6.4	0.71	0.74	K・E・J・T	316LSS Inconel 600, 310SS	100	130
	8.0	0.89	0.91	K・E・J・T	316LSS Inconel 600, 310SS	80	210

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.

Conductor twisted type THERMIC eliminates noise interference :
For use under noise generating or RF interference field, conductor twisted type THERMIC is available in calibrations of K, J, E, T and N with stainless steel and Inconel sheath of 1.6 mm to 3.2 mm nominal O.D. This special thermocouple is eminently suited to effectively eliminate normal mode noise. Maximum cable length is 500 meters. This special THERMIC can be handled in the same way as ordinary THERMIC thermocouples, and effectively reduces disturbance on EMF output.

THERMIC® Analysis of Sheath Material

Unit : %

Sheath	C	Si	Mn	P	S	Ni	Cr	Fe	Other
304SS	<0.08	<1.0	<2.0	<0.04	<0.03	8-11	18-20	Bal.	—
321SS	<0.08	<1.0	<2.0	<0.04	<0.03	9-13	17-19	Bal.	>Ti 5×C%
316LSS	<0.03	<1.0	<2.0	<0.04	<0.03	12-16	16-18	Bal.	Mo 2-3
347SS	<0.08	<1.00	<2.00	<0.04	<0.03	9-13	17-19	Bal.	>Nb10×C%
310SS	<0.15	<1.5	<2.0	<0.04	<0.03	19-22	24-26	Bal.	—
446SS	<0.2	<1.0	<1.5	<0.04	<0.03	—	23-27	Bal.	N<0.25
Inconel 600	<0.15	<0.50	<1.0	<0.03	<0.015	>72	14-17	6-10	Cu<0.5
Inconel 625	<0.10	<0.50	<0.50	<0.015	<0.015	Bal	20-23	<5.0	Mo 9 Nb+Ta:3.7
Incoloy 825	<0.05	<0.5	<1.0	<0.03	<0.015	38-46	19.5-23.5	Bal.	Mo 2.5-3.5 Al<0.2 Ti<1.2
Cupro-nickel	—	—	<1.5	—	—	11	—	—	Cu Bal. Fe<1.0 Zn<1.0
Hastelloy X	<0.15	<1.0	<1.0	<0.04	<0.03	Bal.	20.5-23	18.5	Mo 18.5 Co 1.5 W 0.6
Nicrobell B	—	1.4	—	—	—	81	14.5	—	Nb 1.8 Mg 0.15

THERMIC® Insulating Material

Purity

Unit : %

Composite / Grade	MgO	SiO_2	CaO	Fe_2O_3	Al_2O_3	B	Cd	S	C
Standard	96.3～97.3	1.45～2.06	0.73～1.25	0.16～0.30	0.06～0.30	85～1,000ppm	<10ppm	<50ppm	<200ppm
High Purity	99.47～99.72	0.042～0.14	0.14～0.21	0.034～0.104	0.30～0.08	10～20ppm	<10ppm	<50ppm	<200ppm

Physical Properties

Insulating Material	Melting Point (℃)	Resistivity		Coeff. of thermal expansion (E) ℃$^{-1}$		Thermal Conductivity (℃) Ca ℓ・sec^{-1}・cm^{-2}・cm℃$^{-1}$			Moh's Hardness	Density g・cm^{-3}
		℃	Ω・cm	℃	E×10^{-7}	℃	Porosity	C×10^{4}		
MgO	2,800	980	3×10^{7}	20～1,400	140	1,200	22	61	6	3.58

THERMIC® METAL SHEATHED THERMOCOUPLE (MODEL : TM)

Standard Models of THERMIC®
Metal Sheathed Thermocouple Assembly (MODEL : TM)

For economy and quicker delivery, 28 popular models are selected in five STANDARD LENGTH of 500, 800, 1000, 1200, 1500 mm through numerous proof in design and installations. It is recommended that the customer specify the probe length longer than actually needed among the above standard length, so that error by heat conductivity is eliminated and the insertion depth can be adjusted as required.

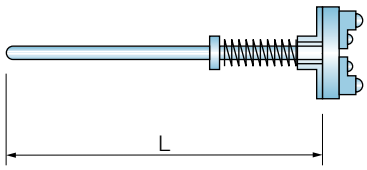
1 TMA

Basic Type, Projected Conductors

TMA	–	K	S	32	II	/	316L	–	L	–	50
Model No.		Type	No. of Con-ductors	Dia.	H.J.		Sheath		Length		

2 TMA TMAS

Basic Type with Terminal Block

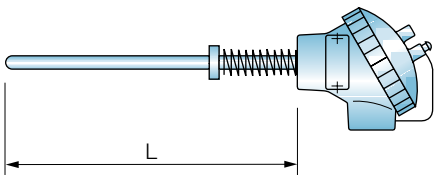


TMA / TMAS	–	K	S	48	II	/	316L	–	L	–	S
Model No.		Type	No. of Con-ductors	Dia.	H.J.		Sheath		Length		Terminal Block

※TMAS···Spring loaded type
(Max.stroke of spring 10mm.)

3 TMAS

Basic Type with Terminal Box

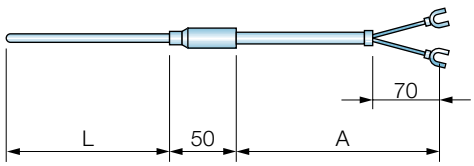


TMAS	–	K	S	48	II	/	316L	–	L	–	KN
Model No.		Type	No. of Con-ductors	Dia.	H.J.		Sheath		Length		Terminal Box

※Spring loaded type
(Max.stroke of spring 10mm.)

4 TMB

Flexible Shield Lead Type

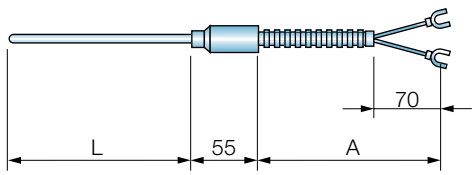


TMB	–	K	S	48	II	/	316L	–	L	–
Model No.		Type	No. of Con-ductors	Dia.	H.J.		Sheath		Length	

VX13	–	A
Lead		Lead Length

5 TMBF

Flexible Tube Armoured Lead Type

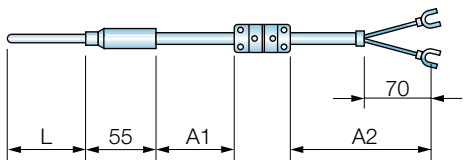


TMBF	–	K	S	48	II	/	316L	–	L	–
Model No.		Type	No. of Con-ductors	Dia.	H.J.		Sheath		Length	

VX13	–	A
Lead		Lead Length

6 TMBDL TMBDS

Flexible Lead Type With Quick Connector



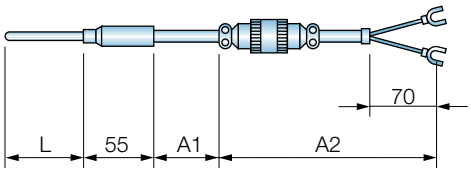
TMBDL / TMBDS	–	K	S	48	II	/	316L	–	L	–
Model No.		Type	No. of Con-ductors	Dia.	H.J.		Sheath		Length	

KX13	–	A1	–	KX13	–	A2
Lead		Lead Length		Lead		Lead Length

※TMBDS···
Miniature connector

7 TMBEL TMBES

Flexible Lead Type with Metal Connector



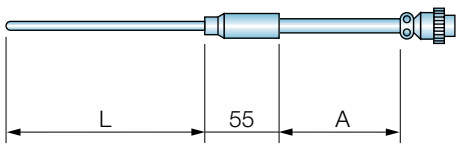
TMBEL / TMBES	–	K	S	48	II	/	316L	–	L	–
Model No.		Type	No. of Con-ductors	Dia.	H.J.		Sheath		Length	

KX13	–	A1	–	KX13	–	A2
Lead		Lead Length		Lead		

※TMBES···
Miniature connector

8 TMBEL TMBES

Flexible Lead Type
with Metal Plug



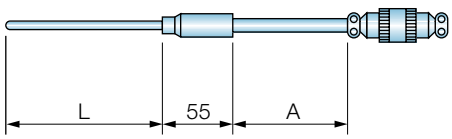
TMBEL / TMBES – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) –
Model No.

KX13 – A (Lead Length)
Lead

※TMBES…Miniature connector

9 TMBEL TMBES

Flexible Lead Type
with Meatal
Plug & Socket



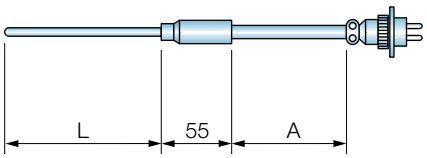
TMBEL / TMBES – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) –
Model No.

KX13 – A (Lead Length) – F (Socket)
Lead

※TMBES…
Miniature connector

10 TMBEL TMBES

Flexible Lead Type
with Meatal
Plug & Receptacle



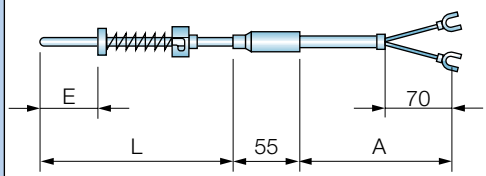
TMBEL / TMBES – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) –
Model No.

KX13 – A (Lead Length) – FC (Receptacle)
Lead

※TMBES…
Miniature connector

11 TMBYL TMBYS

Bayonet Spring
Load Type



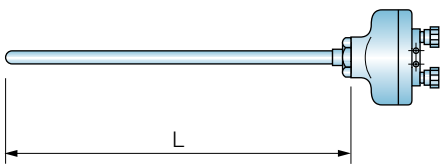
TMBYL / TMBYS – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) / E –
Model No.

KX13 – A (Lead Length)
Lead

※TMBYL…8A nozzle(13.8mm.O.D.)
※TMBYS…6A nozzle(10.5mm.O.D.)

12 TMCL TMCS

Exposed Terminal Type

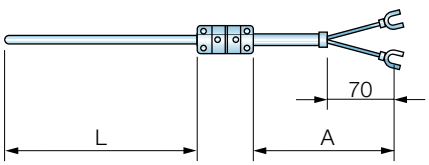


TMCL / TMCS – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length)
Model No.

※TMCL…TL Terminal Box
TMCS…TS Terminal Box

13 TMDL TMDS

Quick Connector Type
(Compensated
Contact pins)



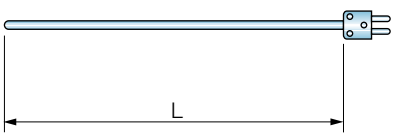
TMDL / TMDS – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) –
Model No.

KX13 – A (Length)
Lead

※TMDS…
Miniature connector

14 TMDL TMDS

Quick Connector
Type with Plug
(Compensated Contact pins)



TMDL / TMDS – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length)
Model No.

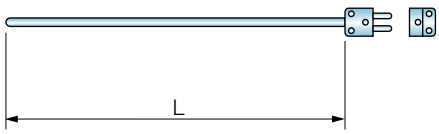
※TMDS…Miniature connector

THERMIC® (MODEL : TM)

METAL SHEATHED THERMOCOUPLE

15 TMDL TMDS

Quick Connector Type
with Plug & Socket
(Compensated Contact pins)

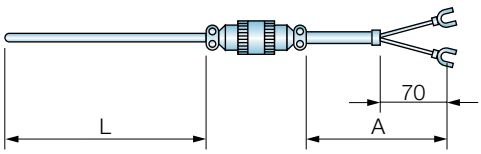


TMDL / TMDS (Model No.) – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length)

※TMDS…Miniature connector

16 TMEL TMES

Metal Connector Type



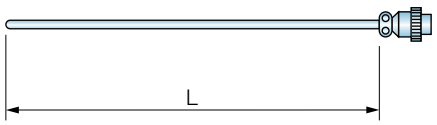
TMEL / TMES (Model No.) – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) –

KX13 (Lead) – A (Lead Length)

※TMES… Miniature connector

17 TMEL TMES

Metal Connector Type
with Plug

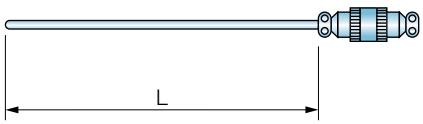


TMEL / TMES (Model No.) – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length)

※TMES…Miniature connector

18 TMEL TMES

Metal Connector Type
with Plug & Socket

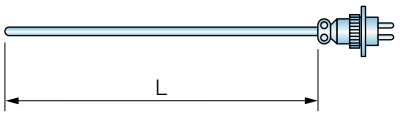


TMEL / TMES (Model No.) – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) – F (Socket)

※TMES…Miniature connector

19 TMEL TMES

Metal Connector Type
with Plug & Receptacle

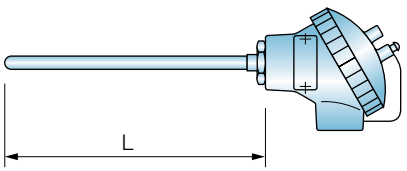


TMEL / TMES (Model No.) – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) – FC (Receptacle)

※TMEL…TL Terminal Box
※TMES…Miniature connector

20 TMH

Terminal Head Type

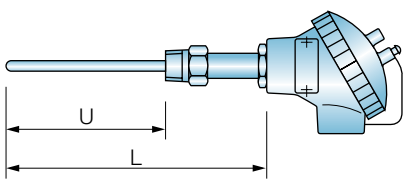


TMH (Model No.) – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) –

KN (Terminal Box)

21 TMNB TMNBS

Screwed-in Hex.
Nipple Type



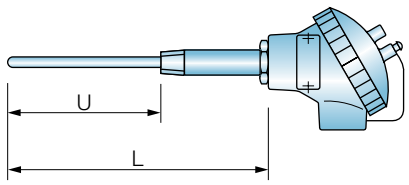
TMNB / TMNBS (Model No.) – K (Type) S (No. of Con-ductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) /

U (Insertion Length) – KN (Terminal Box) – R1/2 (Thread) / 304 (Material)

※TMNBS… Spring-loaded type
(Max.stroke of spring 10mm.)

22 TMN TMNS

Screwed-in Plain Nipple Type (without Bushing)

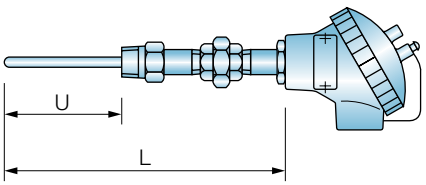


TMN / TMNS (Model No.) – K (Type) S (No. of Conductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) / U (Insertion Length) –
KN (Terminal Box) – R1/2 (Thread) / 304 (Material)

※TMNS…
Spring loaded type
(Max.stroke of spring 10mm.)

23 TMUNB TMUNBS

Screwed-in Hex. Nipple Type with Union

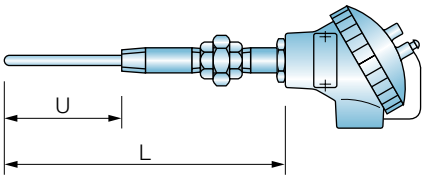


TMUNB / TMUNBS (Model No.) – K (Type) S (No. of Conductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) / U (Insertion Length) –
KN (Terminal Box) – R1/2 (Thread) / 304 (Material)

※TMUNBS…
Spring loaded type
(Max. stroke of spring 10mm.)

24 TMUN TMUNS

Screwed-in Plain Nipple Type with Union

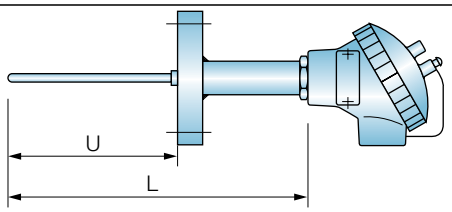


TMUN / TMUNS (Model No.) – K (Type) S (No. of Conductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) / U (Insertion Length) –
KN (Terminal Box) – R1/2 (Thread) / 304 (Material)

※TMUNS…
Spring loaded Type
(Max. stroke of spring 10mm.)

25 TMNF

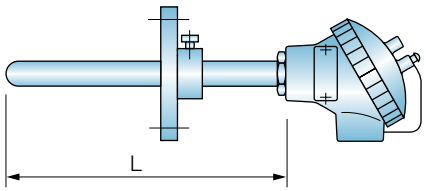
Flanged Nipple Type



TMNF (Model No.) – K (Type) S (No. of Conductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) / U (Insertion Length) –
KN (Terminal Box) – JIS10K25AFF (Flange Rating) / 304 (Material)

26 TMP

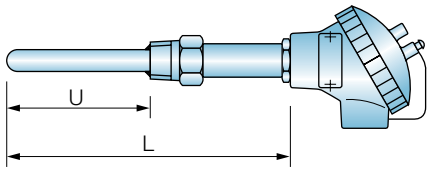
Metal Protection Tube Type with Slide Flange



TMP (Model No.) – K (Type) S (No. of Conductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) – KN (Terminal Box) –
15 (Prot. Tube Dia.) / 316 (Matarial) @ JIS10K25AFF (Flange Rating) / 304 (Material)

27 TMPB TMPBS

Hex. Screwed-in Metal Protection Tube Type

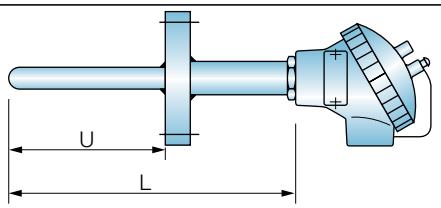


TMPB / TMPBS (Model No.) – K (Type) S (No. of Conductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) / U (Insertion Length) –
KN (Terminal Box) – 15 (Prot. Tube Dia.) / 316 (Matarial) – R1/2 (Thread) / 304 (Material)

※TMPBS…
Spring loaded type
(Max. stroke of spring 10mm.)

28 TMPF TMPFS

langed Metal Protection Tube Type



TMPF / TMPFS (Model No.) – K (Type) S (No. of Conductors) 48 (Dia.) II (H.J.) / 316L (Sheath) – L (Length) / U (Insertion Length) –
KN (Terminal Box) – 15 (Prot. Tube Dia.) / 316 (Matarial) – JIS10K25AFF (Flange Rating) / 304 (Material)

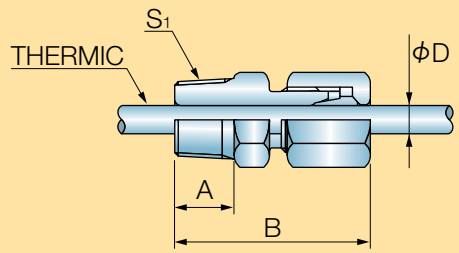
※TMPFS…
Spring loaded type
(Max. stroke of spring 10mm.)

STANDARD METAL FITTINGS

SEALING GLANDS FOR THERMIC AND OTHER TEMPERATURE PROBES

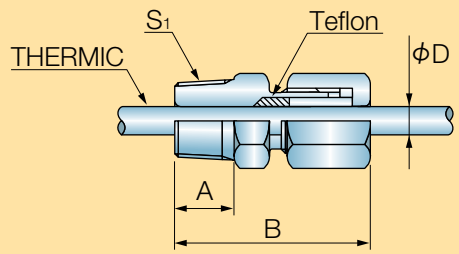
Unit : mm

1. Compression Fitting
Material : 304 S.S.



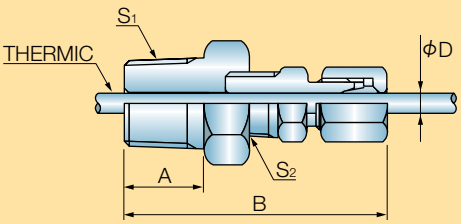
Nominal ϕD	Code	S1	S2	A	B
1.0	CF101	R 1/8	—	10	33
1.6	CF161	R 1/8	—	10	33
	CF162	R 1/4	—	12	35
2.2	CF221	R 1/8	—	10	33
	CF222	R 1/4	—	12	35
3.2	CF321	R 1/8	—	10	33
	CF322	R 1/4	—	12	35
4.8	CF481	R 1/8	—	10	33
	CF482	R 1/4	—	12	35
6.4	CF642	R 1/4	—	12	35
8.0	CF802	R 1/4	—	12	35

2. Compression Fitting with Teflon Cotter
Material : 304 S.S.



Nominal ϕD	Code	S1	S2	A	B
1.0	TCF101	R 1/8	—	10	33
1.6	TCF161	R 1/8	—	10	33
	TCF162	R 1/4	—	12	35
2.2	TCF221	R 1/8	—	10	33
	TCF222	R 1/4	—	12	35
3.2	TCF321	R 1/8	—	10	33
	TCF322	R 1/4	—	12	35
4.8	TCF481	R 1/8	—	10	33
	TCF482	R 1/4	—	12	35
6.4	TCF642	R 1/4	—	12	35
8.0	TCF802	R 1/4	—	12	35

3. Compression Fitting with Bushing Socket
Material : 304 S.S.



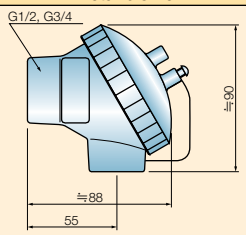
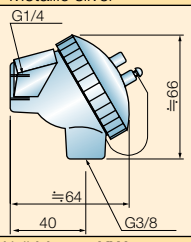
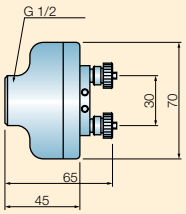
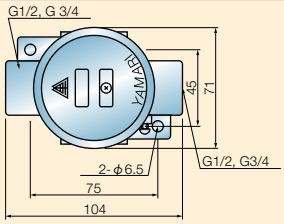
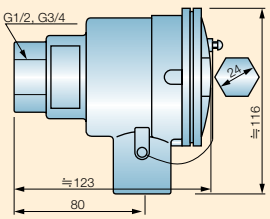
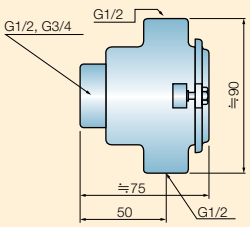
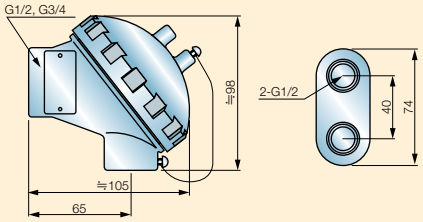
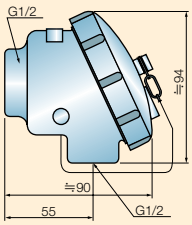
Nominal ϕD	Code	S1	S2	A	B
3.2	CF324	R 1/2	R 1/8	20	59
	CF326	R 3/4	R 1/8	20	59
4.8	CF484	R 1/2	R 1/8	20	59
	CF486	R 3/4	R 1/8	20	59
6.4	CF644	R 1/2	R 1/4	20	59
	CF646	R 3/4	R 1/4	20	59
8.0	CF804	R 1/2	R 1/4	20	59
	CF806	R 3/4	R 1/4	20	59

Standard Ferrule : 304 S.S. (316 S.S. and other alloys are optional.)
Standard Sealant : P.T.F.E. (Neoprene, Lava and Grafoil are optional.)
Bushing Sockets accept all the THERMIC Thermocouples and Sealing glands.

TERMINAL BOXES

Terminal Box

Other entry threads of NPT, R and Metric's can be specified.

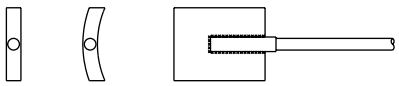
Type	Weather Proof **KN**	Weather Proof **KS**
Material	Al-alloy diecast	Al-alloy diecast
Conduit Dia.	G1/2 ・G3/4	G3/8
No. of Terminal	2・3・4・6	2・3
Terminal Block	Ceramic	Ceramic
Surface Finish	Melamine baked	Melamine baked
Surface Color	Metallic silver	Metallic silver
Dimensions		
Type	Exposed Terminal **TL**	Wall Mount **KW**
Material	Al-alloy diecast	Al-alloy diecast
Conduit Dia.	—	G1/2・G3/4
No. of Terminal	2	2・3・4・6
Terminal Block	Bakelite, Ceramic	Ceramic
Surface Finish	Melamine baked	Melamine baked
Surface Color	Metallic silver	Metallic silver
Dimensions		
Type	*Flame Proof **KG** (d2G4)	Two-Way Entry **KR**
Material	Al-alloy diecast, Stainless Steel	Al-alloy diecast
Conduit Dia.	M16・20・25・G1/2・G3/4	G1/2×2
No. of Terminal	2・3・4・6	4・6
Terminal Block	Bakelite	Ceramic
Surface Finish	Melamine baked	Melamine baked
Surface Color	Metallic silver	Metallic silver
Dimensions		
Type	Dual Cable Entry **KF**	Plastic Model **KP**
Material	Al-alloy diecast	Phenol Resin
Conduit Dia.	G1/2×2	G1/2
No. of Terminal	4・6	2・3・4
Terminal Block	Ceramic	Ceramic
Surface Finish	Melamine baked	—
Surface Color	Metallic silver	Black
Dimensions		

*Approved by KEMA for "II2G EExdIICT6" to CENELEC EN50018. Two-entry model also available.

THERMOCOUPLE FOR TUBE SKIN TEMP. MEASUREMENT

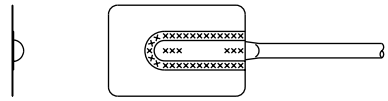
TYPES OF HOT END CONFIGURATION FOR TUBE SKIN TEMPERATURE MEASUREMENT

PADDED TYPE:



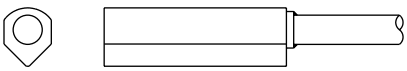
Commonly used for measurements of boiler tube and vessel wall temperatures by attaching the metal pad onto the surface of tube or wall and weld its both sides. Available in flat and curved pads machined to closely fit for radii of the tubes or walls. Welding should be carefully made to get optimum thermal contact avoiding air gap between pad and tube skin. Properly weld-attached thermocouple has reasonable accuracy.

FINNED TYPE :



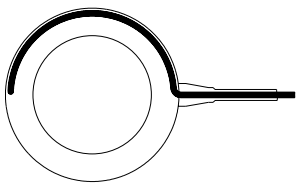
Derived from the above pad type, developed for ease of attachment mainly on water wall tubes and vessel or metal casing of relatively lower temperatures than 600℃. By virtue of very thin square fin of stainless steel, it has a freedom of fitting closely on any curved surface. Welding can be made by a simple portable resistance welding machine with many spot welds over the fin even under water. Has quick response and reasonable accuracy.

KNIFE-EDGE TYPE :



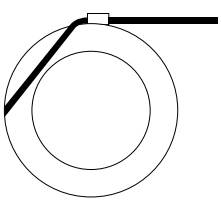
Originally introduced jointly by U.O.P. and Thermo-Couple Products Co., U.S.A., it has an outstanding feature for welding job to allow perfect thermal contact with the tube skin by fine bead welds in the 45 Deg. groove provided at both sides of "Knife-edge" irrespective of outer diameter of the tubes. Robust and longer service life, but the height of knife-edge head must be carefully determined so as to eliminate effect of radiation from the outer heat source. Recommended for hostile and high temperature applications. Reasonable accuracy and few EMF drift on a long term measurement.

FILLED-IN-GROOVE TYPE :



This patented configuration has been developed by YAMARI in collaboration with the Central Research Institute of Electric Power Industry, Japan to measure true temperatures of boiler tube skin. A small groove is provided around the surface of tubes at a depth within the rated positive tolerance of wall thickness of the boiler tube in which 0.5～1.0 mm O.D. THERMIC thermocouple is formed in oval shape and tightly embedded. Protective welding is made to cover both the thermocouple and groove for uniform finish with the tube surface. This method has much better accuracy over other types and can monitor deposition of scale inside the boiler tubes through the pattern of temperatures. Thus, safety of the tubes and timing of plant shutdown for de-scaling can be estimated. It is necessary for the users, however, to send cut pieces of boiler tubing to our factory to fill and weld seal the thermocouples, and after the thermocouples are embedded, the cut tubings are returned and should be re-joined by welding with the existing boiler tubes at the site.

CHORDAL TYPE :



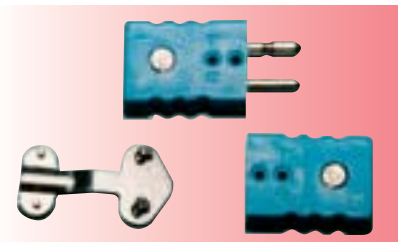
This type has been first adopted by Babcock Wilcox, U.K. for similar objective and concept with the above "Filled-in-Groove" configuration using small diameter THERMIC thermocouple, and can measure skin temperatures of boiler tubes very accurately. Installation job of thermocouple is not easy to do at the site, and also drilling deep straight bores may reduce mechanical strength of the boiler tubes involving some danger during operation.

CONNECTORS FOR THERMOCOUPLE

CONNECTORS FOR THERMOCOUPLE

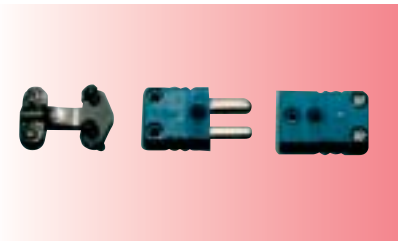
Thermocouple connectors have been developed for retaining an original accuracy of the thermocouple by minimizing EMF error that may arise at the connection mainly due to ambient and different thermal conductivity of each thermocouple leg and the resultant temperature difference between positive and negative leg connections. Recommended for THERMIC and relatively small diameter thermocouple probes.

Standard Quick Connectors, Model DL:



Solid pin plug and socket are made of extension and compensating grade alloys which are housed in colour coded heat resistant plastic shells of 220℃ rating. Automatically polarized to correct connection, and will mate with any of other manufacturers' plug and socket. Unless otherwise specified, connectors will be supplied to JIS colour codes. Recommended for THERMIC assemblies up to 8.0 mm O.D. For special high temperature applications, 645℃ rated ceramic shell type connector is available, however, compensating temperature of plug and socket is limited to 270℃ max.

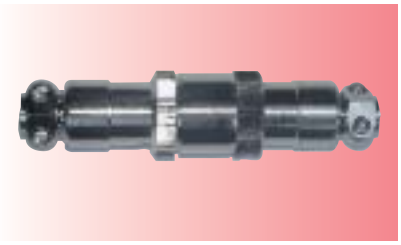
Miniature Quick Connectors, Model DS

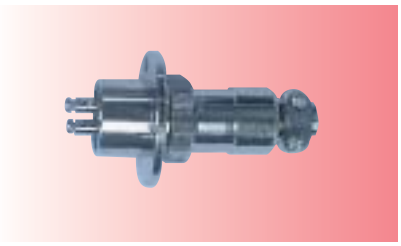


Excepting smaller flat bar plug is used and the temperature rating is limited to 200℃, construction is similar to that of heavy duty connector Model DL including automatic polarization and colour coded plastic shell. Recommended for small size THERMIC assemblies up to 3.2 mm O.D.

Probe and cable clamp, panel mounting bracket and other adapters are available on request.

Metal Connectors





Automatically polarizing plug and socket terminal is protected in a rugged cylindrical metal enclosure, and a thread in a knurled outer ring will tighten to ensure optimum connection.

Standard Type,
Model EL :
24 mm O.D.× 85 mm long
Model ES :
20 mm O.D.× 80 mm long

Water-proof Type, Model ELW :
24 mm O.D.× 75 mm long

Consent Type Connector, Model EP :
20 mm O.D.× 36 mm long
Mounting Plate 30 mm O.D.
(3.5 mm screw Hole×3)
Construction is same as Model EL but has a round plate for panel mounting.

MULTI-POINT THERMOCOUPLE

For many critical processes from tall reactor vessels, catalytic crackers, flare stacks to small horizontal diffusion furnaces used in semi-conductor industry, monitoring of temperature profile and distributions at each required location is one of the most important parameters for efficient control and safety of the process. Our Multi-Point thermocouples are an ideal solution on such temperature measuring requirements, particularly in case the installation space is limited and yet reliability is of prime concern. Multi-Point Thermocouple assembly consists of already proven THERMIC Metal Sheathed Thermocouple units in calibrations of Types T, J, E, K and N up to 1200℃ with all grades of stainless steel, Inconel 600 and 625, Incoloy 825 sheath, etc. Outer protection thermowell, heat resistant terminal connections and dust or explosion-proof terminal enclosure can be supplied connected with extension neck and flange for the ease of installation even at hostile environments. Most of Multi-Point thermocouples are custom designed to the user's specific requirements. Please consult factory specifying the model number, type of thermocouple, number of measuring point, protection sheath or tube material and dimensions.

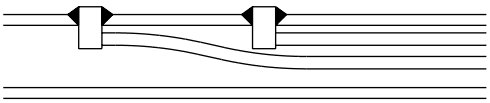
Standard Designs of Multi-Point Thermocouple :

1. Free Hanging Type :

Generally consists of small diameter outer tubes and THERMIC Thermocouples.
2～12 measuring points, Assembly length 20 meters max. Temperature readings may be affected by convection and radiation inside the protection tube. Economical but slower response and rather low accuracy. Not recommended for applications where continuous vibration is encountered.

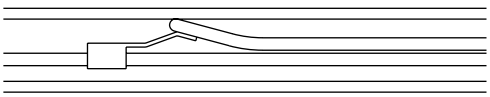
2. Multi-Guide Plug Type :

Robust construction and most common for vessel and cracking tower. Each hot junction is held in a guide plug. 2～10 measuring points, Assembly length 20 meters max. Long life and less maintenance. Better sensitivity and reasonable accuracy.



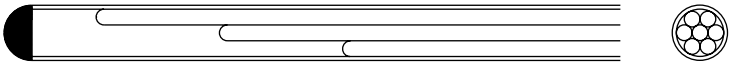
3. Spring or Thermostat Loaded Type :

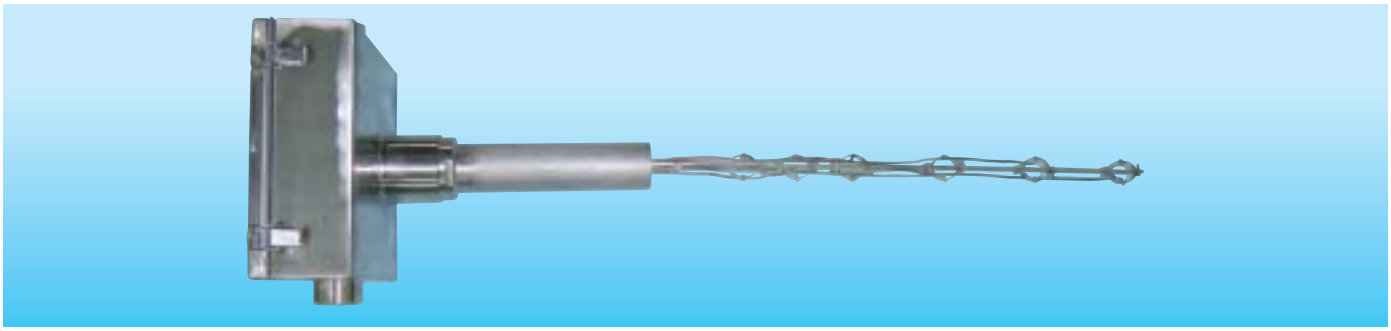
A heat resistant plate spring or thermostat presses to contact each hot junction to inner wall of the protection tube. Rugged, stable construction.
2～10 measuring points, assembly length 20 meters max. Reasonable life and less maintenance. Quicker response and good accuracy.



4. Swaged-in Type :

Numbers of THERMIC Metal Sheathed Thermocouples having different location of hot junction are over-sheathed by heat and corrosion resistant alloy tube and then swaged down to an integrated tight multiple assembly of minimal heat mass.
Smallest diameter assembly, recommended for narrow installation space. Can be bent for easy installation. Assembly length 30 meters max. 3～20 measuring points, Robust, quick response, long service life and good accuracy.





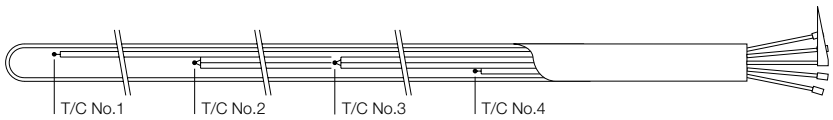
HIGH TEMPERATURE MULTI-POINT THERMOCOUPLE

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 :

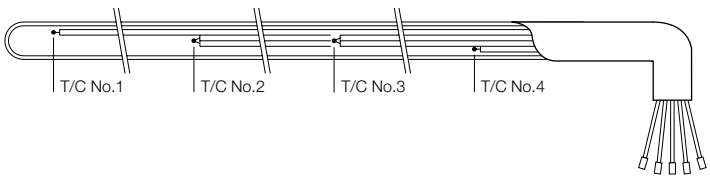
1. Straight Quartz or Alumina Tube protected Type :

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.



HT-THERMIC®
(MODEL : HT, HT-270A)

ULTRA HIGH TEMPERATURE THERMOCOUPLE

MODEL HT

- Max. Temp. 2,000℃, 1% Accuracy of the Reading
- For use in Inert, Reducing (H_2) and Vacuum Applications
- Patented Special Hot Junction
- Electron Beam weld closed Protection Tube, filled with Pure Dry Argon Gas
- Perfectly Integrated Robust Construction

MODEL HT 270A

- Max. Temp. 1,500℃, A Heavy Duty, Flame-Proof Version of already proven Model HT
- 1% Accuracy of the Reading
- The only High Temperature Thermocouple for use both in dry Oxidizing and Reducing environments where all the platinum group thermocouples fail
- No need of expensive gas purging, successfully be used for a long-term under dry stagnant atmospheres
- Unique Triple protection and Flame-Proof Safety Construction
- Avoid use under wet or water-vapour rich conditions

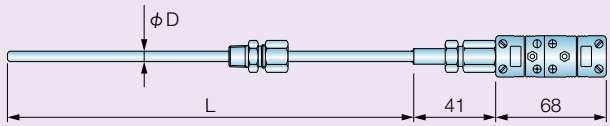
ULTRA-HIGH TEMPERATURE THERMOCOUPLE FOR 1,500℃ AND 2,000℃ MAX.

Descriptions of HT-THERMIC

HT-THERMIC is a trade name of inert gas filled thermocouple for use under super-high temperatures. HT-THERMIC was first developed in Japan by YAMARI through unique process and is enjoying good reputation as a prominent sensor for the use in high temperature heat treatments and sinterings, etc. because of its capability of measuring temperatures up to 2,000℃ for a long-term with an excellent stability. Based-on the technology of HT-THERMIC, YAMARI manufactures various sophisticated thermocouples for high temperature measurement to the customer's needs. HT-THERMIC will exceed foreign products in all respect of cost merit, quality and performance.

Standard Types of HT-THERMIC

HT. 1

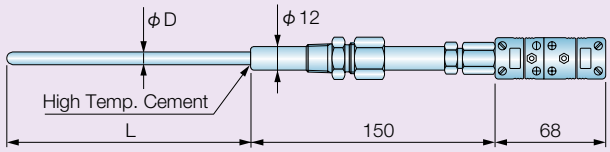


Unit : mm

Code Sample : HT1 – W5 – BE300(PS0) – MO 64 –
L / TCF642

HT1	W5	BE300(PS0)	MO	64	L	TCF642
Type	Wire	Insulation Material (Tip300mm, Rest PSO)	Protection Tube Material	O.D.	Length	Compression Fitting

HT. 2

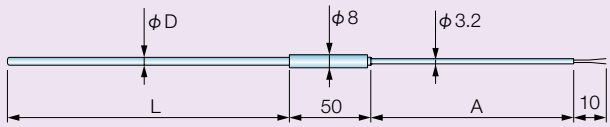


Unit : mm

Code Sample : HT2 – B – PS0 – PT0 8 –
L / MCF123

HT2	B	PS0	PT0	8	L	MCF123
Type	Wire	Insulation Material	Protection Tube Material	O.D.	Length	Compression Fitting

HT. 3

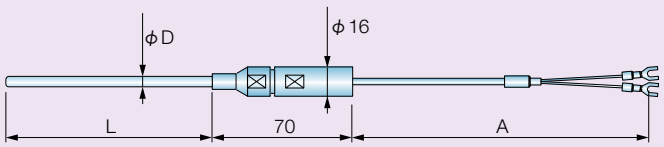


Unit : mm

Code Sample : HT3 – W5 – PS0 – MO 48 –
L / A

HT3	W5	PS0	MO	48	L	A
Type	Wire	Insulation Material	Protection Tube Material	O.D.	Length	MI Cable Length

HT. 4



Unit : mm

Code Sample : HT4 – W5 – PS0 – NB 16 –
L / A

HT4	W5	PS0	NB	16	L	A
Type	Wire	Insulation Material	Protection Tube Material	O.D.	Length	MI Cable Length

HT-THERMIC®
(MODEL : HT, HT-270A)

1 Thermocouple conductors

Type	Composition		Standards	Operating Temperature	Class	Tolerance	Wire Dia. (mm)	Applicable Ass'y Type
	+leg	-leg						
W5	W5%Re	W26%Re	ASTM E 988-1990	0～2,300℃		±1.0% of reading	0.5	HT1・HT2・HT3
							0.25	HT4
B	Pt30%Rh	Pt6%Rh	JIS C 1602	600～1,700℃	0.5	±4℃ or 0.5%	0.5	HT2
			ASTM E 230	870～1,700℃	Standard	±0.5%		

2 Insulators

Code	Material	Max.Temp.
PSO	Recrystallized Alumina (Al_2O_3)	1,800℃
BE	Recrystallized Beryllia (BeO)	2,200℃
MG	Sintered Magnesia (MgO)	2,200℃

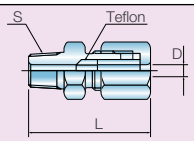
※Max. Temp. varies depending on operating atmospheres.

3 Protection Tubes

Unit : mm

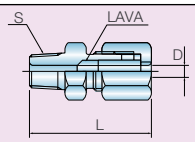
Code	Material	Max. Temp.	Max.Length	O.D.	Ass'y Type
MO	Molybdenum	1,700℃	1,000	6.4	HT1・HT3
				4.8	HT1・HT3
				1.6	HT4
TA	Tantalum	2,200℃	1,000	4.8	HT1・HT3
				1.6	HT4
NB	Niobium	2,000℃	1,000	4.8	HT1・HT3
				1.6	HT4
PTO	Recrystallized Alumina (Al_2O_3)	1,800℃	1,000	8.0	HT2
BE	Recrystallized Berylia (BeO)	2,200℃	500	6.4	HT2
ZR	Non-porous Zirconia	2,200℃	600	6.4	HT2

4 Compression Fittings



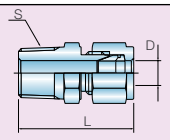
Mat : 304S.S. Ass'y : HT1

Code	D	S	L
TCF 481	4.8	R1/8	33
TCF 482	4.8	R1/4	35
TCF 642	6.4	R1/4	35



Mat : 304S.S. Ass'y : HT1

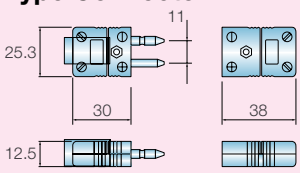
Code	D	S	L
LCF 481	4.8	R1/8	33
LCF 482	4.8	R1/4	35
LCF 642	6.4	R1/4	35



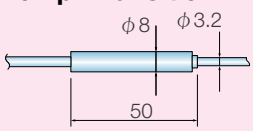
Mat : 316S.S. Ass'y : HT2

Code	D	S	L
MCF 123	12	R3/8	52
MCF 124	12	R1/2	60
MCF 126	12	R3/4	60

5 D-Type Connector

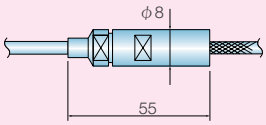


6 Mid. Temp. Transition



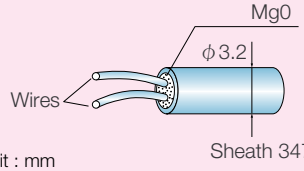
For use in vacuum or atmospheric gases.
Max. 260℃

7 Low Temp. Transition



For use in the air outside furnaces.
Epoxy resin is filled in S.S. sleeve to prevent moisture absorption.
Max. 120℃

8 MI Compensating Cable



Unit : mm

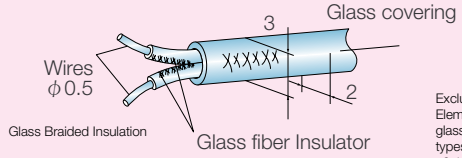
Metal sheathed compensating cable exclusive for W/Re thermocouples. Excellent heat and corrosion resistance.

Bendable up to 4 times of its radius. Can compensate emf as high as 260℃ within tolerance of ±0.11 mV (±8℃).

Type	Oper. Temp.	Tolerance
W5	0～260℃	±0.11 mV

9 Compensating Cable

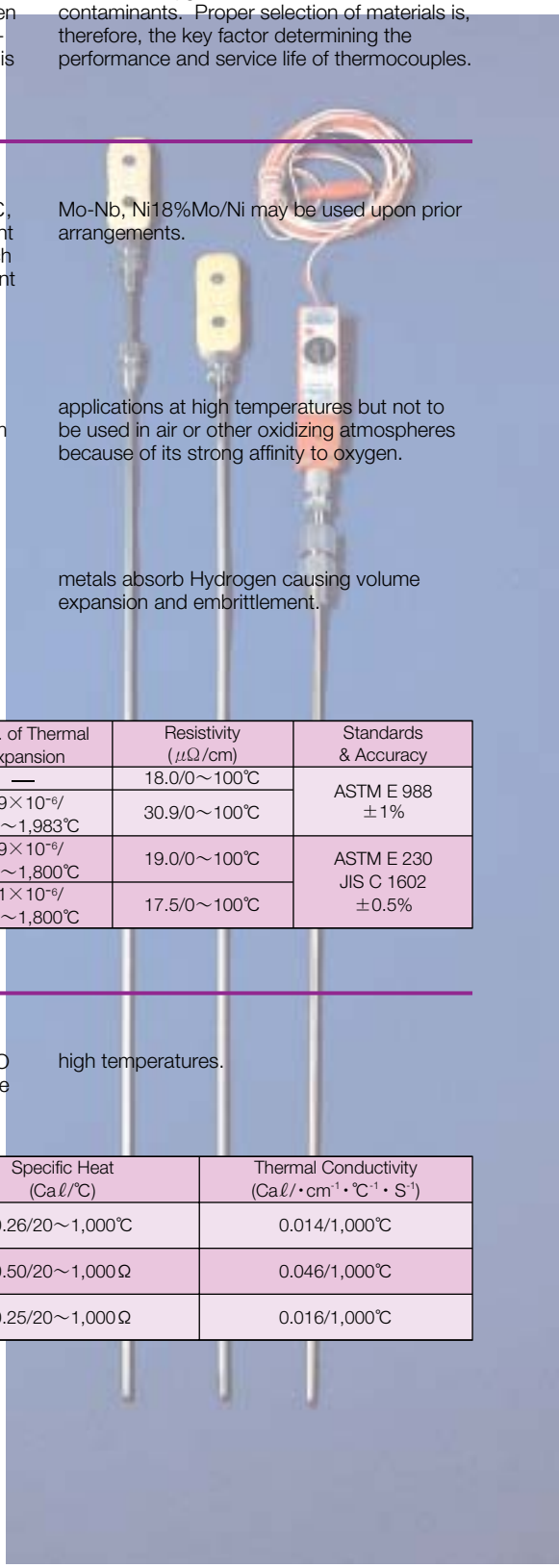
Unit : mm



Exclusive use for W/Re thermocouples. Element wires are covered with braided glass yarn. Capable of connecting to types HT1, HT2, or HT3. tolerance : ±0.11 mV for W5. Max. 200℃.

HT-THERMIC Thermoelement Wires, Insulators and Protection Tube

It is common that between constituent materials and elements, unexpected chemical reactions and dissociations repeatedly occur in various furnaces and vessels at high temperatures, and even at low temperatures, vacuum or reducing atmospheres often facilitate formation of unstable compounds. On the side of thermocouple itself, contact reactions between constituent materials either in solid or vapour-phase often occur and, finally, thermocouple is deteriorated. These phenomena are greatly accelerated by the presence of even a trace amount of oxygen, moisture, and contaminants. Proper selection of materials is, therefore, the key factor determining the performance and service life of thermocouples.



Thermoelement Wires

Thermoelement wires for HT-THERMIC are carefully selected by considering the measuring conditions and temperature range. For temperatures up to 1,700℃, Type B (Pt30%Rh/Pt6%Rh) thermoelement wires are used, and for the temperatures up to 2,000℃, Tungsten/Rhenium (Types W5) thermoelement wires are used. For critical environments such as nuclear applications, special thermoelement wires, Pt5%Mo/Pt0.1%Mo, Pt6%Ru/Pt, Mo-Nb, Ni18%Mo/Ni may be used upon prior arrangements.

W5 (W5%Re/W26%Re) : For reducing, inert, vacuum atmospheres.

In order to prevent embrittlement and improve mechanical strength, Rhenium was added to the both legs. Type W5 thermoelement wires are not embrittled up to 1,650℃ and, by annealing, problem of initial EMF shift as experienced with the early Tungsten-Rhenium wires (W/W26%Re) is solved. Type W5 thermocouple can be used in nuclear applications at high temperatures but not to be used in air or other oxidizing atmospheres because of its strong affinity to oxygen.

B (Pt30%Rh/Pt6%Rh) : For oxidizing and inert atmospheres.

As to details of Type B, refer to Page 7. Type B thermocouple is recommended for use under air and oxidizing atmospheres, but not suitable for any nuclear application because Rhodium has a large neutron absorption cross section and easily transmutes to Palladium. Type B should not be used under reducing atmosphere, as constituent platinum group metals absorb Hydrogen causing volume expansion and embrittlement.

Characteristics of Thermoelement Wires

Type	Composition	Operating Temp.	Melting Point	EMF (μV)	Coeff. of Thermal Expansion	Resistivity ($\mu\Omega$/cm)	Standards & Accuracy
W5	W5%Re W26%Re	0～ 2,300℃	3,350℃	8.8/℃ at 2,316℃	—	18.0/0～100℃	ASTM E 988 ±1%
			3,120℃		3.9×10^{-6}/ 20～1,983℃	30.9/0～100℃	
B	Pt30%Rh Pt6%Rh	600～ 1,700℃	1,927℃	11.7/℃ at 1,600℃	8.9×10^{-6}/ 20～1,800℃	19.0/0～100℃	ASTM E 230 JIS C 1602 ±0.5%
			1,826℃		9.1×10^{-6}/ 20～1,800℃	17.5/0～100℃	

Insulators

For use at high temperatures (over 1,200℃), sintered high purity insulating tubes of Alumina or Beryllia are used because resistivity of MgO or Al_2O_3 powder insulator drops badly at these high temperatures.

Characteristics of Insulating Tubes

Code	Composition	Purity	Maximum Temperature	Melting Point (℃)	Specific Heat (Caℓ/℃)	Thermal Conductivity (Caℓ/·cm^{-1}·℃$^{-1}$·S^{-1})
PSO	Recrystallized Alumina	>99.7%Al_2O_3	1,800℃/1KΩ·cm	2,050±20	0.26/20～1,000℃	0.014/1,000℃
BE	Recrystallized Beryllia	>99.5%BeO	2,000℃/1KΩ·cm	2,550±20	0.50/20～1,000Ω	0.046/1,000℃
MG	Sintered Magnesia	>99.5%MgO	2,200℃/1KΩ·cm	2,800±20	0.25/20～1,000Ω	0.016/1,000℃

HT-THERMIC®
(MODEL : HT, HT-270A)

Protection Tubes

Selection of appropriate protection tube is the most important factor that practically determines reliability and service life of the thermocouple. Therefore, extensive knowledge is required on environmental conditions especially at high temperatures where complicated and serious chemical reactions often occur between thermocouple materials and environments.

Materials and Their Characteristics

Code	Material	Melting Point (℃)	Linear Coeff. of Expansion ($\times 10^{-6}$)	Thermal Conductivity ($Ca\ell/\cdot cm^{-1}\cdot ℃^{-10}\cdot S^{-1}$)	Max. Temp.℃	Compatible Atmosphere
MO	Molybdenum (Mo)	2,622±10	7.2/2,000℃	0.328	2,100	V・R・N
TA	Tantalum (Ta)	2,850±10	6.6/2,000℃	0.130	2,100	V・N (Ar・He)
NB	Niobium (Nb)	2,415±15	9.0/2,000℃	0.132	2,000	V・N (Ar・He)
PT0	Recrystallized Alumina (Al_2O_3)	2,050±20	8.6/1,000℃	0.014	1,800	R・N・O
BE	Recrystallized Beryllia (BeO)	2,550±20	8.9/1,000℃	0.046	2,200	V・R・N・O
ZR	Non-Porous Zirconia (ZrO_2)	2,300±20	10.0/1,000℃	0.010	2,100	N・O

Note : V=Vacuum, R=Reducing, N=Inert, O=Oxidizing.

Stability of Heat-Resistant Metals in Various Atmospheres

Atmosphere	Molybdenum	Tantalum	Niobium
Air or oxygen contained gases	400～500℃ : Oxidized. Over 800℃ : Vaporized	Over 500℃ : Oxidized and nitrides grow	Over 200℃ : Oxidized and nitrides grow.
Dry hydrogen (abt 0.5g H_2O/m^3)	No reaction up to melting point.	400～800℃ : Hydrides grow. No corrosion up to melting point.	200℃ : Hydrogen absorbed. 1,900℃ : Hydrides grow and embrittled.
Damp hydrogen (abt 20g H_2O/m^3)	Up to 1,400℃ : No oxidizing but hence, needle crystals grow.	Over 450℃ : Hydrides grow heavily and oxidized.	200℃ : Hydrogen absorbed. 1,900℃ : Hydrides grow and embrittled.
Cracked dry NH_3	No corrosion up to melting point.	Over 400℃ : Nitrides and hydrides grow. Then, completely nitrized.	Over 200℃ : Hydrides and nitrides grow. Over 200℃ : Hydrides grow.
Incompletely combusted dry NH_3	〃	〃	Over 400℃ : NH3 decomposed and nitrized.
Dry inert gases (argon, helium, etc.)	〃	No corrosion up to melting point.	In helium at 1,900℃ : Crystals grow and embrittled.
Vacuum : 10^{-3} torr 10^{-4} torr	Up to 1,700℃ : No corrosion. Over 1,800℃ : Heavily vaporized.	Embrittled due to "getter effect". Over 2,200℃ : Heavily vaporized.	Embrittled due to "getter effect". Small evaporation up to melting point.
Compatible Atmospheres	High temperature reducing and inert gases and low vacuum (no oxygen).	Inert gases, high temperature high vacuum (no oxygen).	Inert gases, high temperature and vacuum up to 900℃, especially in Na and Li.

Reactions between Metals and Refractories (Insulators) at high temperature

Refractories or Insulators	Molybdenum	Tungsten	Tantalum
Graphite	Over 1,200℃ : Rapidly carbides grow.	Over 1,400℃ : Rapidly carbides grow.	Over 1,000℃ : Rapidly carbides grow.
Al_2O_3	Up to 1,900℃ : No reaction.	Up to 1,900℃ : No reaction.	Up to 1,900℃ : No reaction.
BeO	Up to 1,900℃ : *No reaction.	Up to 2,000℃ : No reaction.	Up to 1,600℃ : No reaction.
MgO	Up to 1,800℃ : *No reaction.	Up to 2,000℃ : No reaction but heavily MgO vaporized.	Up to 1,800℃ : No reaction.
ZrO_2	Up to 1,900℃ : *No reaction but hevily Mo vaporized.	Up to 1,600℃ : No reaction.	Up to 1,600℃ : No reaction.
ThO_2	Up to 1,900℃ : *No reaction.	Up to 2,200℃ : No reaction.	Up to 1,900℃ : No reaction.
Silimanite	Up to 1,700℃ : No reaction.	Up to 1,700℃ : No reaction.	Up to 1,600℃ : No reaction.
Chamotte Brick	Up to 1,200℃ : No reaction.	Up to 1,200℃ : No reaction.	Up to 1,200℃ : No reaction.
Magnesite Brick	Up to 1,600℃ : No reaction.	Up to 1,600℃ : No reaction.	Up to 1,500℃ : No reaction.

Note : *Values in 10^{-4} torr vacuum. In protective atmospheres, lower by 100～200℃.

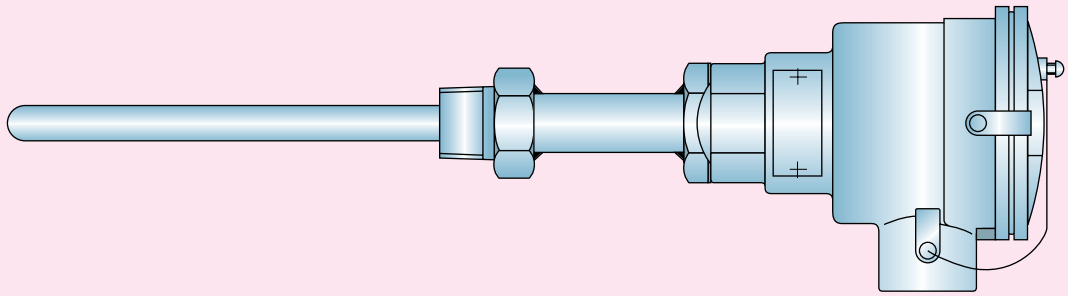
MODEL HT-270A, A NEW FLAME-PROOF TYPE HIGH TEMPERATURE THERMOCOUPLE COMPATIBLE WITH ALL THE DRY ATMOSPHERES

Since introduction of Model HT High Temperature Thermocouple in 1972 for long term use under high temperature reducing and inert atmospheres, continued research work has been made to develop more versatile, heavy duty thermocouple Model HT-270A as based on the technology and expertise accumulated through the success of HT Series.

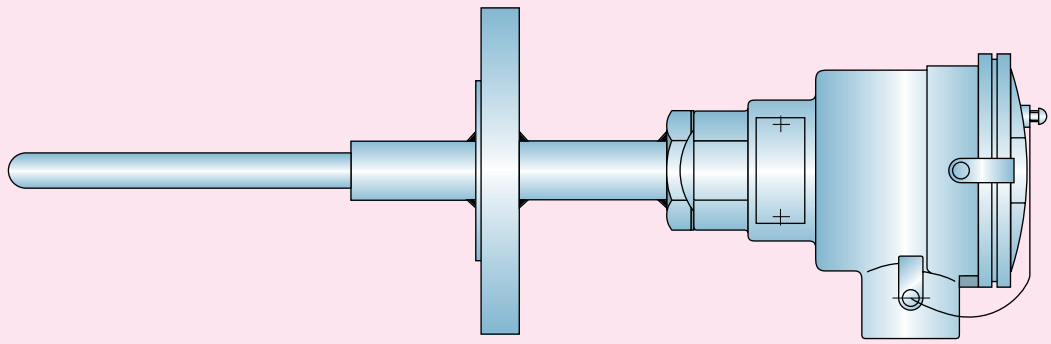
New patented Model HT-270A has greatly enhanced safety and reliability for high temperature measurement up to 1500℃ under various hostile environments. If only the gas is dry, it can be used successfully in Oxidizing, Reducing, Inert and Sulphur or Chlorine bearing atmospheres without complicated costly gas-purge system hitherto needed on Platinum-Rhodium group thermocouples.

If water vapour is not present, virtually there is no limitation in atmospheres at the location. It was reported that two units of HT-270A had been used in a Sulphur Recovery Plant of the leading Petroleum Refinery, and after two years service, they were still within the specified tolerance, whereas competitions had all failed in a few months.

CODE : HT-270A Screwed-in Type



CODE : HT-270A Flanged Type



Specifications :

Thermocouple Wire	:	Tungsten 5% Rhenium vs. Tungsten 26% Rhenium, 0.5 mm O.D.
Hot Junction	:	Non-embrittled Cold Forming
Insulating Tubes	:	High Purity BeO and Alumina
Protection Tubes	:	Pure Dry Argon filled Mo/Alumina/Impervious ceramic
Terminal Enclosure	:	Flame-proof, Equivalent to Cenelec Exd II CT6
Metal Fittings	:	Stainless Steel
Measuring Temp.	:	0～1500℃(Oxidizing) 0～1600℃(Reducing, Inert and Vacuum)
Rated Accuracy	:	1% of Reading

THERMOWELL
(MODEL : WL)

Thermowells which are made of solid bar stock of various heat and corrosion resistant alloys by drilling are usually preferred over the tip welded protection tubes for critical applications where high mechanical strength and longer service life are required. If the alloy bar material is correctly selected and designed properly, the Thermowell lasts long against corrosives, high pressure, high temperature, mechanical shock and vibration that may result from high velocity of fluids. In order to offer the best and safest Thermowells against Kármán's Turbulence and other stresses, automatic calculations of mechanical strength to fluid pressure and flow velocity to estimate frequency of critical resonance are made by a specially developed computer programme as based upon operating conditions at the site. At YAMARI, thermowells are manufactured by a genuine Two-Shaft Gun Drilling Machine of 2- metre max. depth and the latest NC Turning Machines.

Standard Bores and Depths

Bore Dia. (mm)	Max. Depth (mm)
4.0	500
5.5	700
7.0	800
8.5	1000
10.0	1200
11.0	1200
12.0	1200
16.0	1200

Standard Alloy Bar Materials :
Stainless Steel* 304, 321, 316, 347, 310, 446, 253MA
Inconel 600, 601, 625, X-750
Incoloy 800, 825
Hastelloy B, C276, X
Others Haynes 25, Carpenter 20Cb, Nichrome, HCF, 50Co-30Cr, Monel, Brass, Bronze, Titanium, Tantalum, Molybdenum
*Low carbon types of Austenite S.S. are available on request.

Standard Sizes of Solid Bar Materials :
Round Bars : mm O.D.
25, 26, 28, 30, 32, 34, 36, 38, 40, 46, 48, 50, 55

Hexagonal Bars : mm Width across Flats
26, 29, 32, 35, 38, 41, 48, 50, 55

Tests and Inspections

- Pressre Test :
  N_2 gass pressure test up to 10MPa is conducted upon request.

- Hydrostatic Pressure Test :
  Internal pressure test up to 40MPa is conducted upon request.

- X-Ray Inspection :
  X-ray inspection for uniformity in wall thickness, eccentricity of bore and smooth inner finish are also conducted upon request.

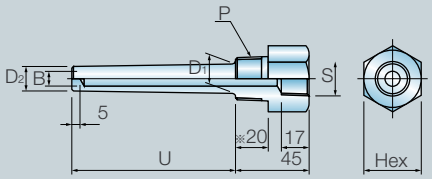
- Optional :
  Helium leak Test
  Dye penetrant Test
  Cross checking of material with Mill Certificate

THERMOWELL
(MODEL : WL)

Models of Solid Bar-stock Thermowell Model:WL

1 WL•01

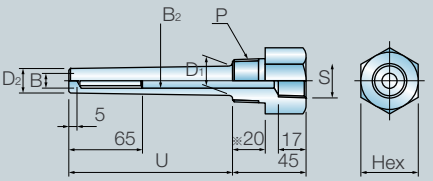
Hexagonal Screwed-in Type



Order Code : WL•01 / 316 – 250 / R1/2 – 9 / 15 ×
Model No. | Material 316SS | "U" Length | "P"Thread Std. | "B"Bore | "D2"Dia.
18 – 45/※20/29×33.5Hex – Rc1/2
"D1"Dia. For Tapered Well Only | Factory Standard Unless Otherwise Specified | "S"Thread Std.
※Thread Allowance

2 WL•11

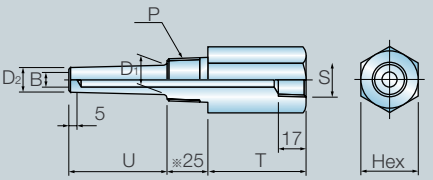
Hexagonal Screwed-in Type



Order Code : WL•11 / 304 – 300 / R3/4 – 8.5×65 / 11
Model No. | Material 304SS | "U" Length | "P"Thread Std. | "B"×Length Bore Size | "B2"Dia.
/ 17 × 21 – 45/※20/35×40.4Hex – Rc1/2
"D2"Dia. | "D1"Dia. For Tapered Well Only | Factory Standard Unless Otherwise Specified | "S"Thread Std.
※Thread Allowance

3 WL•12

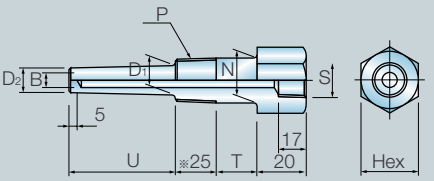
Hexagonal Lagging Extension Type



Order Code : WL•12 / 310 – 450 / R1 – 11 / 17 ×
Model No. | Material 310SS | "U" Length | "P"Thread Std. | "B" Bore | "D2"Dia.
/ 26 × 75 – ※25/38×43.9Hex – Rc1/2
"D1"Dia. For Tapered Well Only | "T" Length | Factory Standard Unless Otherwise Specified | "S"Thread Std.
※Thread Allowance

4 WL•02

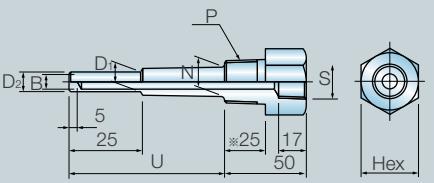
Hexagonal Lagging Extension Type



Order Code : WL•02 / 321 – 300 / NPT1 – 11 / 17 ×
Model No. | Material 321SS | "U" Length | "P"Thread Std. | "B" Bore | "D2"Dia.
/ 26 × 75 × 34 – ※25/34/41×47.3Hex – Rc3/4
"D1"Dia. For Tapered Well Only | "T" Length | "N"Dia. | Factory Standard Unless Otherwise Specified | "S"Thread Std.
※Thread Allowance

5 WL•21

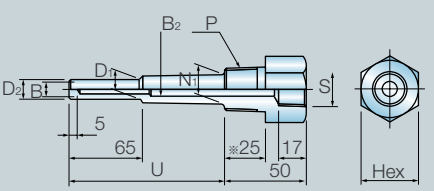
Hexagonal Heavy Duty Type



Order Code : WL•21 / 321 – 350 / R1 1/2 – 11 / 17
Model No. | Material 321SS | "U"Length | "P"Thread Std. | "B" Bore | "D2"Dia.
× 26 × 34 – ※50/25/50×57.7Hex – Rc3/4
"D1"Dia. For Tapered Well Only | "N"Dia. | Factory Standard Unless Otherwise Specified | "S"Thread Std.
※Thread Allowance

6 WL•22

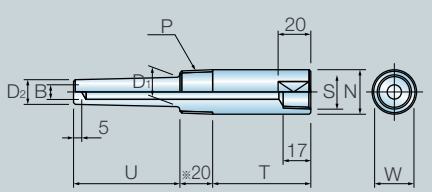
Hexagonal Heavy Duty Type



Order Code : WL•22 / 316 – 400 / R1 – 7×65 / 11
Model No. | Material 316SS | "U"Length | "P"Thread Std. | "B"×Length | Bore Size
/ 17 × 26 × 34 – ※50/25/35×40.4Hex – Rc1/2
"D2"Dia. | "D1"Dia. For Tapered Well Only | "N"Dia. | Factory Standard Unless Otherwise Specified | "S"Thread Std.
※Thread Allowance

7 WL•04

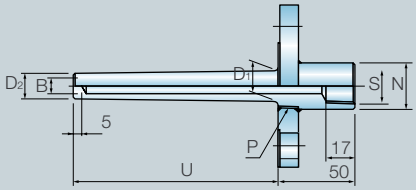
Screwed-in Weld Type



Order Code : WL•04 / 304 – 300 / R3/4 – 11 / 17 ×
Model No. | Material 316SS | "U" Length | "P"Thread Std. | "B"Bore | "D2"Dia.
21 – 75 × 28–※20 – Rc1/2
"D1"Dia. For Tapered Well Only | "T"Length | "N"Factory Standar Unless Otherwise Specified | "S"Thread Std.
※Thread Allowance

8 WL•05

Flanged (Screwed-in) Type

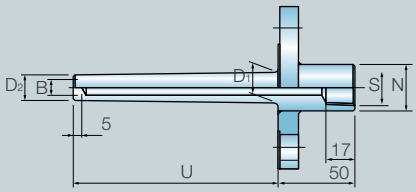


Order Code : WL•05 / 304 – 500 / R3/4 / -JIS10K25ARF /
Model No. | Material 304SS | "U" Length | "P"Thread Std. | Flange Rating

304 / 11 / 17 × 21 – 50×34 – Rc1/2
Material 304SS | "B"Bore | "D2"Dia. | "D1"Dia. For Tapered Well Only | Neck Dimension Length×"N"Dia. | "S"Thread Std

9 WL•06

Flanged (Weld) Type

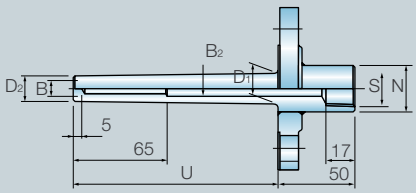


Order Code : WL•06 / 316 – 1250 / JIS10K20ARF / 316
Model No. | Material 316SS | "U" Length | Flange Rating | Material 316SS

/ 9 / 15 × 18 – 50×28 – Rc1/2
"B"Bore | "D2"Dia | "D1"Dia. For Tapered Well Only | Neck Dimension Length×"N"Dia. | "S"Thread Std

10 WL•61

Flanged (Weld) Type

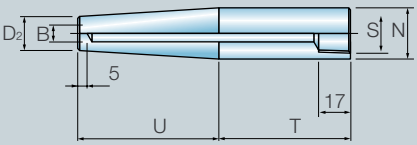


Order Code : WL•61 / 316 – 600 / ANSI1"600LBRF / 316 –
Model No. | Material 316SS | "U" Length | Flange Rating | Material 316SS

8.5×65 / 11 / 17 × 26 – 50×34 – Rc1/2
"B"×Length Bore Size | "B2"Bore | "D2"Dia | "D1"Dia. For Tapered Well Only | Neck Dimension Length×"N"Dia. | "S"Thread Std

11 WL•07

Plain Weld Type

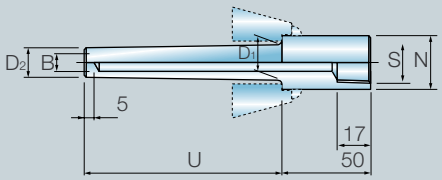


Order Code : WL•07 / 304 – 300 – 9 / 17 –
Model No. | Material 304SS | "U" Length | "B"Bore | "D2"Dia.

250×30 / Rc1/2
Neck Dimension Length×"N"Dia. | "S"Thread Std

12 WL•08

Weld Type

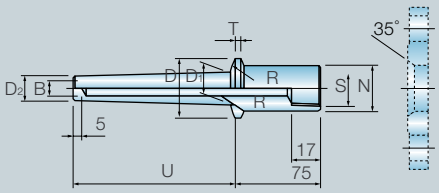


Order Code : WL•08 / 321 – 500 – 11 / 22 – 25 –
Model No. | Material 321SS | "U" Length | "B"Bore | "D2"Dia. | "D1"Dia. For Tapered Well Only

50×41 / Rc1/2
Neck Dimension Length×"N"Dia. | "S"Thread Std

13 WL•09

Ball Joint Type

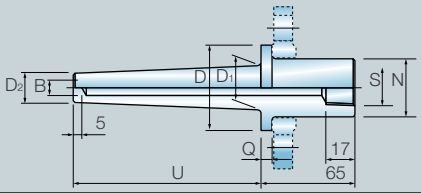


Order Code : WL•09 / 316 – 1300 / 25.4R×34.9D×3.2T –
Model No. | Material 316SS | "U" Length | Ball Joint Dimension "R"×"D"×"T"

10 / 14.3 / 19 – 75×26.6 – NPT1/2
"B"Bore | "D2"Dia. | "D1"Dia. For Tapered Well Only | Neck Dimension Length×"N"Dia. | "S"Thread Std

14 WL•10

Van Stone Type



Order Code : WL•10 / 304 – 250 / 50×6.5 – 11 /
Model No. | Material 304SS | "U" Length | Raised Face "D"×"Q" | "B"Bore

17 / 26 / 65×34 – Rc1/2
"D2"Dia. | "D1"Dia. For Tapered Well Only | Neck Dimension Length×"N"Dia. | "S"Thread Std

Other special types are also available upon request

THERMOWELL
(MODEL : WL)

BLIND FLANGES

JIS FLANGE

FLAT FACE (FF)

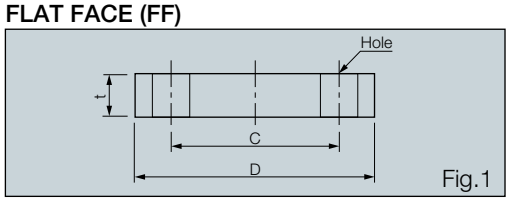


Fig.1

RAISED FACE (RF)

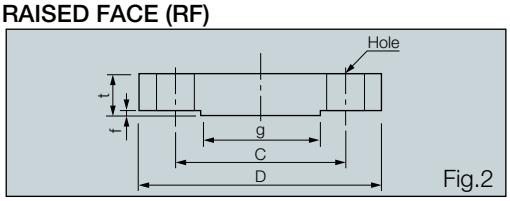


Fig.2

Dimensional Specifications

Unit : mm

Flange Rating	Size A	Size B	D	t	f	g	C	f	No. of Bolt Holes	Hole Dia.	Bolt Size	Nom. Weight(kg)
JIS 5K	15	1/2	80	9	1	44	60	1	4	12	M10	0.32
	20	3/4	85	10	1	49	65	1	4	12	M10	0.41
	25	1	95	10	1	59	75	1	4	12	M10	0.52
	32	11/4	115	12	2	70	90	2	4	15	M12	0.91
	40	11/2	120	12	2	75	95	2	4	15	M12	0.99
JIS 10K	15	1/2	95	12	1	51	70	1	4	15	M12	0.63
	20	3/4	100	14	1	56	75	1	4	15	M12	0.78
	25	1	125	14	1	67	90	1	4	19	M16	1.22
	32	11/4	135	16	2	76	100	2	4	19	M16	1.66
	40	11/2	140	16	2	81	105	2	4	19	M16	1.80

ANSI FLANGE

RAISED FACE (RF)

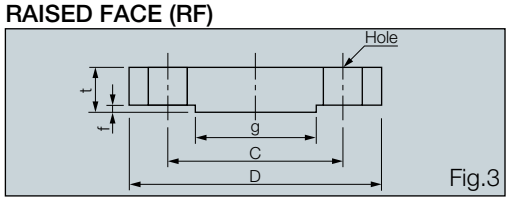


Fig.3

RING JOINT (RTJ)

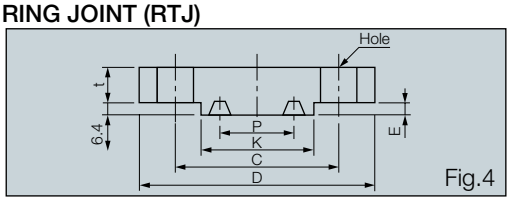


Fig.4

RAISED FACE (RF)

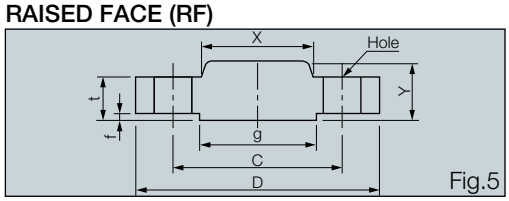


Fig.5

RING JOINT (RTJ)

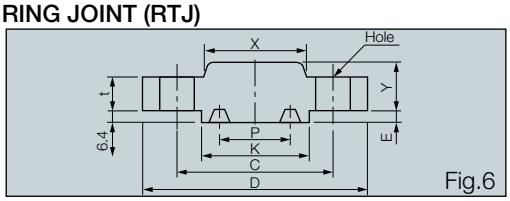


Fig.6

Dimensional Specifications

Unit : mm

Flange	Size A	Size B	D	Min.t	f	g	C	No. of Bolt Holes	Hole Dia.	Bolt Size (inch)	Nom. Weight (Kg)	Hub		RTJ		
												X	Y	Min.K	P	E
ANSI 150lbs	15	1/2	89	11.5	1.6	35.1	60.5	4	15.8	1/2	0.43	30.2	16.0	--	--	--
	20	3/4	99	13.0	1.6	42.9	69.9	4	15.8	1/2	0.62	38.1	16.0	--	--	--
	25	1	108	14.5	1.6	50.8	79.2	4	15.8	1/2	0.87	49.5	18.0	63.5	74.62	6.4
	32	11/4	117	16.0	1.6	63.5	88.9	4	15.8	1/2	1.16	58.7	21.0	73.5	57.15	6.4
	40	11/2	127	18.0	1.6	73.2	98.6	4	15.8	1/2	1.54	65.1	22.4	83.0	65.07	6.4
ANSI 300lbs	15	1/2	95	14.5	1.6	35.1	66.5	4	15.8	1/2	0.65	38.1	22.4	51.0	34.14	6.4
	20	3/4	117	16.0	1.6	42.9	82.5	4	19.0	5/8	1.09	48.0	25.4	63.5	42.88	6.4
	25	1	124	18.0	1.6	50.8	88.9	4	19.0	5/8	1.38	54.0	27.0	70.0	50.80	6.4
	32	11/4	133	19.5	1.6	63.5	98.6	4	19.0	5/8	1.82	63.5	27.0	63.5	60.32	6.4
	40	11/2	155	21.0	1.6	73.2	114.5	4	22.4	3/4	2.70	70.0	30.3	90.5	68.28	6.4

Dimensional Specifications

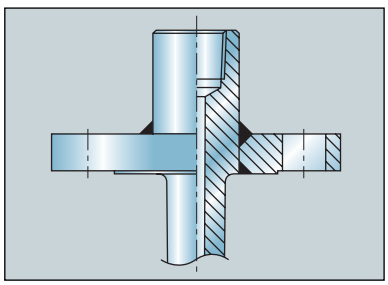
Unit : mm

Flange	Size A	Size B	D	Min.t	f	g	C	No. of Bolt Holes	Hole Dia.	Bolt Size (inch)	Nom. Weight (Kg)	Hub		RTJ		
												X	Y	Min.K	P	E
ANSI 400lbs & 600lbs	15	1/2	95	14.5	6.4	35.1	66.5	4	15.8	1/2	0.76	38.1	22.4	51.0	34.14	6.4
	20	3/4	117	16.0	6.4	42.9	82.6	4	19.0	5/8	1.27	48.0	25.4	63.5	42.88	6.4
	25	1	124	18.0	6.4	50.8	88.9	4	19.0	5/8	1.59	54.0	27.0	70.0	50.80	6.4
	32	11/4	133	21.0	6.4	63.5	98.5	4	19.0	5/8	2.24	63.5	28.5	79.5	60.32	6.4
	40	11/2	155	22.5	6.4	73.2	114.5	4	22.4	3/4	3.30	70.0	32.0	90.5	68.28	6.4
ANSI 900lbs & 1,500lbs	15	1/2	121	22.5	6.4	35.1	82.5	4	22.4	3/4	1.79	38.1	32.0	60.5	39.67	6.4
	20	3/4	130	25.5	6.4	42.9	88.9	4	22.4	3/4	2.40	44.5	35.1	67.0	44.45	6.4
	25	1	149	28.5	6.4	50.8	101.6	4	25.4	7/8	3.44	52.5	41.2	71.5	50.80	6.4
	32	11/4	159	28.5	6.4	63.5	111.3	4	25.4	7/8	3.95	63.5	41.2	81.5	60.32	6.4
	40	11/2	178	32.0	6.4	73.2	124.0	4	28.5	1	5.41	70.0	44.5	92.0	68.28	6.4

Types of Jointing Flanges with Thermowell

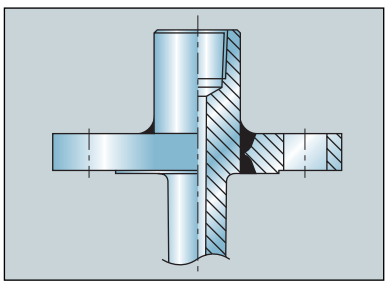
For the rigorous weld-joining requirements, skilled technicians are selected among the TIG welding workers at our factory who all have qualifications and license granted by Japan Welding Association and Japan Stainless Steel Society, and are exclusively engaged in this precise job. The welding procedures and requirements generally follow to ASME Boiler Code QW 201.1～2, WPS and PQR, JPI 7S-31, etc. Grooves on each flange are carefully determined and machined to primary "J" or secondary Bevel shapes to enable perfect fillet welding. A serrated flange face can be machined. Please consult factory.

1. Groove welded Type



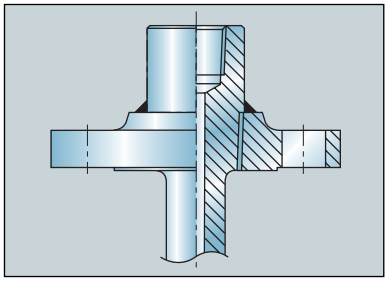
Commonly made to weld relatively lower rating flanges. At the upper edge or the both edges of center hole of the flange, groove(s) for fillet welding is provided. TIG or Plasma Arc Welders are normally used. It is essential that the clearance between center hole of the flange and neck of the thermowell be kept minimal in diameters.

2. Full Penetration Weld Type



Suitable for flanges of medium to high rating. This fully welded joint has an excellent strength to high pressure and perfect integrity to liquid and gas leak. High degree of welding technique is employed for void-free welding job. For some of Stainless Steel and alloy combinations, additional costs of post-weld heat treatment may be necessary for stress relief and restoring the original metal structure.

3. Threaded and Enlarged Neck Weld Type



Where the installation space permits, neck of the thermowell is machined to a larger diameter to provide curved edge at its bottom and positioned flush with flange face, so that the welded part may be shifted outward to prevent possible fatigue from concentration of mechanical stress due to bending and vibration by virtue of the curved edge prepared on a heavier solid neck. This special design can be applied to the other types of welding joint.

EXTENSION & COMPENSATING CABLES

Nowadays, thermocouples are being widely used in every industrial field from various chemicals, petro-refineries, metals, ceramics and electronics, nuclear to aerospace. Although 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. YAMARI have a large stock of various wires and cables as listed below and on pages 45.

Types

Tolerances to JIS C1610-1995, IEC 584-3-1989

Thermo-couple Symbol		Codes	Code of YAMARI	Temp. Range ℃	Tolerance μV(℃)	INSULATION COLOR CODES					
						JAPAN JIS(DIV.2) C1610-1995	U.S.A ASTM E230	U.K. BS 1843・1981	GERMANY DIN 43714	FRENCE NF NFE 18001	INTERNATIONAL IEC 584-3 (JIS DIV.1)
B	IEC	—	BX	0～+100	{±40(±3.5)}	+ Red − White Gray	+ Gray − Red Gray		+ Red − Gray Gray		+ Gray − White Gray
	JIS	BC			—						
R & S	IEC	RCA-2	RX	0～+100	±30(±2.5)	+ Red − White Black	+ Black − Red Green	+ White − Blue Green	+ Red − White White SX only	+ Yellow − Green Green SX only	+ Orange − White Orange
	JIS	RCB-2		0～+200	±60(±5.0)						
	IEC	SCA-2	SX	0～+100	±30(±2.5)						
	JIS	SCB-2		0～+200	±60(±5.0)						
N	IEC	NX-1	NX	−25～+200	±60(±1.5)		+ Orange − Red Orange	+ Orange − Blue Orange			+ Pink − White Pink
	JIS	NX-2			±100(±2.5)						
		NC-2		0～+150	±100(±2.5)						
K	IEC	KX-1	KX	−25～+200	±60(±1.5)	KX + Red − White Blue	+ Yellow − Red Yellow	+ Brown − Blue Red	+ Red − Green Green	+ Yellow − Purple Yellow	+ Green − White Green
	JIS	KX-2			±100(±2.5)						
	IEC	KCA-2	—	0～+150	±100(±2.5)						
	JIS	KCB-2	WX	0～+100	±100(±2.5)	WX + Red − White Blue				+ Yellow − White White	+ Green − White Green
	JIS	KCC-2	VX	0～+100	±100(±2.5)	VX + Red − White Blue		+ White − Blue Red		+ Yellow − Brown Red	+ Green − White Green
E	IEC	EX-1	EX	−25～+200	±120(±1.5)	+ Red − White Purple	+ Purple − Red Purple	+ Brown − Blue Brown	+ Red − Black Black		+ Purple − White Purple
	JIS	EX-2			±200(±2.5)						
J	IEC	JX-1	JX	−25～+200	±85(±1.5)	+ Red − White Yellow	+ White − Red Black	+ Yellow − Blue Black	+ Red − Blue Blue	+ Yellow − Black Black	+ Black − White Black
	JIS	JX-2			±140(±2.5)						
T	IEC	TX-1	TX	−25～+100	±30(±0.5)	+ Red − White Brown	+ Blue − Red Blue	+ White − Blue Blue	+ Red − Brown Brown	+ Yellow − Blue Blue	+ Brown − White Brown
	JIS	TX-2			±60(±1.0)						

Insulation Resistance shall be more than 5MΩ/10 m.

Notes : (1) BX has positive and negative legs of the same material (Cu), so no tolerance is stipulated.
(2) These figures do not represent actual measuring error because Types R and S have non-linear EMF characteristics.

* These color codes normally relate only to the compensating wire for use with the appropriate thermocouple conductor combination type code.

Electrical Resistance

Unit : Ω/m.

Nom. Cross-sec. area A (mm^2)	Core No. / Dia.	BX	RX SX	NX	KX	WX	VX	EX	JX	TX
0.5	20/0.18	0.034	0.034	1.92	1.38	0.24	0.034	1.38	0.24	0.034
		0.034	0.10	0.76	0.56	0.46	0.98	0.98	0.98	0.98
		0.068	0.13	2.68	1.94	0.70	1.01	2.36	1.22	1.01
0.75	30/0.18	0.023	0.023	1.28	0.92	0.16	0.023	0.92	0.16	0.023
		0.023	0.067	0.50	0.37	0.31	0.65	0.65	0.65	0.65
		0.046	0.090	1.78	1.29	0.47	0.67	1.57	0.81	0.67
1.25	7/0.45	0.014	0.014	0.77	0.55	0.096	0.014	0.55	0.096	0.014
		0.014	0.040	0.30	0.22	0.18	0.39	0.39	0.39	0.39
		0.028	0.054	1.07	0.77	0.28	0.40	0.94	0.49	0.40
1.3	4/0.65 or 1/1.3	0.013	0.013	0.74	0.53	0.092	0.013	0.53	0.092	0.013
		0.013	0.038	0.29	0.22	0.18	0.38	0.38	0.38	0.38
		0.028	0.051	1.03	0.75	0.27	0.39	0.91	0.47	0.39
2.0	7/0.6 or 1/1.6	0.0085	0.0085	0.49	0.35	0.060	0.0085	0.35	0.060	0.0085
		0.0085	0.025	0.19	0.14	0.12	0.25	0.25	0.25	0.25
		0.017	0.034	0.68	0.49	0.18	0.26	0.60	0.31	0.26
2.3	7/0.65	0.0074	0.0074	0.42	0.30	0.052	0.0074	0.30	0.052	0.0074
		0.0074	0.022	0.16	0.12	0.10	0.21	0.21	0.21	0.21
		0.015	0.029	0.58	0.42	0.15	0.22	0.51	0.26	0.22

Note : Upper column indicates positive leg resistance ; middle column for negative leg resistance ; and lower column for loop resistance.

INSULATION MATERIALS FOR COMPENSATING WIRES AND CABLES

PVC Sheath :

PVC insulation sheath has been widely used as a good substitute for rubber insulator. At YAMARI, PVC is used as an insulating material of standard compensating cables for general use.
Recommended Temperature Range : -20～+90℃

Glass Fiber Sheath :

Glass fiber is known as a traditional high temperature insulation material because it has excellent incombustibility, heat resistance, electric insulation, and chemical stability.
Although single glass fiber is not hygroscopic, bundled cover are somewhat hygroscopic. So, silicon or other resin is impregnated and baked over them to prevent moisture absorption.
Recommended Temperature Range : 0～150℃

Silicon Rubber Sheath :

Silicon rubber has been widely used as an excellent insulation material with less deterioration physical properties even under hostile conditions.
It has almost same electric properties as natural rubber and no serious change in voltage withstanding value occur over recommended temperature range. It has also good resistance to chemicals (except for concentrated Alkalis), oils and grease, outdoor and ozone environments.
Recommended Temperature Range : -25～+180℃

Teflon* (fluoric resin PTFE, FEP) Cover :

Teflon is the best insulation material among organic materials in respect of heat resistance, chemical resistance, electrical insulation, high frequency resistance, weather resistance, etc. High mechanical strength and, especially, high pressure resistance over wider range of operating temperatures.
Recommended Temperature Range : -25～+200℃
*Teflon is the registered trade mark by Dupont, U.S.A.

Metal Sheathed Compacted Mineral Insulation :

The insulation material is fine grain MgO which is similar insulant to THERMIC Metal Sheathed Thermocouples. Inorganic ceramic powder insulation tightly holds extension or compensating wires inside the Metal Sheath, composing perfectly integral construction. This M.I. Extension or Compensating cable can withstand fire or high temperature, corrosion and mechanical shock and is approved as the only non-inflammable safety cable. Available in all calibrations with various metal sheath such as Copper, Cupro-Nickel, Stainless Steels, etc. Cable Sizes 1.6 mm～8.0 mm O.D. Temperature Range : 20～270℃, but the cable withstands high temperatures up to 900℃. Recommended for wiring at hazardous location without conduit tube.

EXTENSION & COMPENSATING CABLES

Standard Extension & Compensating Cables

Extension and compensating cables listed below are manufactured in conformity with JIS C 1610-1995
Cables can be supplied to other color codes and standards of ASTM, BS and DIN.

Appearance	Code	Color Coding	Dimensions (mm)	Covering
	BX1	Grey	Core 0.65/7 Nom. finish 8×5.2	Heat-resistant PVC insulating sheath.
	RX1	Black		
	SX1			
	NX1	Pink		
	KX1	Blue		
	WX1			
	VX1			
	EX1	Purple		
	JX1	Yellow		
	TX1	Brown		
	BX1A	Grey	Core 0.65/7 Nom. finish 8.6×5.8	Outer : Heat-resistant PVC sheath. Inner : Copper shield.
	RX1A	Black		
	SX1A			
	NX1A	Pink		
	KX1A	Blue		
	WX1A			
	VX1A			
	EX1A	Purple		
	JX1A	Yellow		
	TX1A	Brown		
	BX1B	Grey	Core 0.65/7 Nom. finish 8.5×5.35	Inner : Heat-resistant PVC sheath. Outer : Copper shield.
	RX1B	Black		
	SX1B			
	NX1B	Pink		
	KX1B	Blue		
	WX1B			
	VX1B			
	EX1B	Purple		
	JX1B	Yellow		
	TX1B	Brown		
	BX3	Grey	Core 0.65/7 Nom. finish 6.5×3.4	Glass braided insulating sheath.
	RX3	Black		
	SX3			
	NX3	Pink		
	KX3	Blue		
	WX3			
	VX3			
	EX3	Purple		
	JX3	Yellow		
	TX3	Brown		
	BX3A	Grey	Core 0.65/7 Nom. finish 7.1×4.0	Outer : Glass braided insulating sheath. Inner : Copper shield.
	RX3A	Black		
	SX3A			
	NX3A	Pink		
	KX3A	Blue		
	WX3A			
	VX3A			
	EX3A	Purple		
	JX3A	Yellow		
	TX3A	Brown		
	BX3B	Grey	Core 0.65/7 Nom. finish 6.8×4.3	Inner : Glass braided insulating sheath. Outer : Copper shield.
	RX3B	Black		
	SX3B			
	NX3B	Pink		
	KX3B	Blue		
	WX3B			
	VX3B			
	EX3B	Purple		
	JX3B	Yellow		
	TX3B	Brown		
	BX4	Black	Core 0.2/40 Nom. finish ϕ9.8	Heat-resistant rubber insulating sheath
	RX4			
	SX4			
	KX4			
	WX4			
	VX4			
	EX4			
	JX4			
	TX4			

EXTENSION & COMPENSATING CABLES

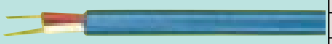
Appearance	Code	Color Coding	Dimensions (mm)	Covering
	BX4A RX4A SX4A KX4A WX4A VX4A EX4A JX4A TX4A	Black	Core 0.2/40 Nom. finish ϕ 11.4	Outer : Heat-resistant rubber insulating sheath.
	BX4B RX4B SX4B KX4B WX4B VX4B EX4B JX4B TX4B	Black	Core 0.2/40 Nom. finish ϕ 11.2	Inner : Heat-resistant rubber sheath. Outer : Copper shield.
	BX5 RX5 SX5 NX5 KX5 WX5 VX5 EX5 JX5 TX5	Grey Black Pink Blue Purple Yellow Brown	Core 0.65/4 Nom. finish 4.8×7.5	Heat-resistant PVC insulating sheath
	BX6 RX6 SX6 KX6 WX6 VX6 EX6 JX6 TX6	Grey Black Blue Purple Yellow Brown	Core 0.45/7 Nom. finish 4.6×7.1	〃
	BX7 RX7 SX7 NX7 KX7 WX7 VX7 EX7 JX7 TX7	Grey Black Pink Blue Purple Yellow Brown	Core 0.65/4 Nom. finish 5.6×3.3	Glass braided insulating sheath
	BX8 RX8 SX8 KX8 WX8 VX8 EX8 JX8 TX8	Grey Black Blue Purple Yellow Brown	Core 0.45/7 Nom. finish 5.0×3.0	〃
	BX13 RX13 SX13 NX13 KX13 WX13 VX13 EX13 JX13 TX13	Grey Black Pink Blue Purple Yellow Brown	Core 0.3/7 Nom. finish 4.6×2.8	Inner : Glass braided insulating sheath. Outer : Stainless steel shield.

EXTENSION & COMPENSATING CABLES

Appearance	Code	Color Coding	Dimensions (mm)	Covering
	BX13D	Grey	Core 0.3/7 Nom. finish ϕ5.3	Inner : Glass braided insulating sheath. Outer : Stainless steel shield.
	RX13D	Black		
	SX13D			
	NX13D	Pink		
	KX13D	Blue		
	WX13D			
	VX13D			
	EX13D	Purple		
	JX13D	Yellow		
	TX13D	Brown		
	BX14	Grey	Core 0.3/7 Nom. finish 4.0×2.3	Glass braided insulating sheath.
	RX14	Black		
	SX14			
	NX14	Pink		
	KX14	Blue		
	WX14			
	VX14			
	EX14	Purple		
	JX14	Yellow		
	TX14	Brown		
	BX14D	Grey	Core 0.3/7 Nom. finish ϕ4.5	〃
	RX14D	Black		
	SX14D			
	NX14D	Pink		
	KX14D	Blue		
	WX14D			
	VX14D			
	EX14D	Purple		
	JX14D	Yellow		
	TX14D	Brown		
	BX15	Grey	Core 0.3/7 Nom. finish 4.1×2.4	Heat-resistant PVC insulating sheath.
	RX15	Black		
	SX15			
	NX15	Pink		
	KX15	Blue		
	WX15			
	VX15			
	EX15	Purple		
	JX15	Yellow		
	TX15	Brown		
	BX15D	Grey	Core 0.3/7 Nom. finish ϕ5	〃
	RX15D	Black		
	SX15D			
	NX15D	Pink		
	KX15D	Blue		
	WX15D			
	VX15D			
	EX15D	Purple		
	JX15D	Yellow		
	TX15D	Brown		
	BX15A	Grey	Core 0.3/7 Nom. finish 5×3.6	Outer : Heat resistant PVC insulating sheath Inner : Copper shield.
	RX15A	Black		
	SX15A			
	NX15A	Pink		
	KX15A	Blue		
	WX15A			
	VX15A			
	EX15A	Purple		
	JX15A	Yellow		
	TX15A	Brown		
	BX15AD	Grey	Core 0.3/7 Nom. finish ϕ5.5	〃
	RX15AD	Black		
	SX15AD			
	NX15AD	Pink		
	KX15AD	Blue		
	WX15AD			
	VX15AD			
	EX15AD	Purple		
	JX15AD	Yellow		
	TX15AD	Brown		

Note : Other Color codings to ANSI or BS are available. Consult factory.

Thermocouple Duplex Wire

Appearance	Code	Conductor Material		Color Coding	Dimensions (mm)	Covering
		+leg	-leg			
	DN301	Nicrosil	Nisil	Pink	Core Single0.32 Nom. finish 3.2×2.1	Heat-Resistant PVC insulating sheath.
	DK301	Chromel	Alumel	Blue		
	DE301	Chromel	Constantan	Purple		
	DJ301	Iron	Constantan	Yellow		
	DT301	Copper	Constantan	Brown		
	DN651	Nicrosil	Nisil	Pink	Core Single0.65 Nom. finish 4.0×2.6	〃
	DK651	Chromel	Alumel	Blue		
	DE651	Chromel	Constantan	Purple		
	DJ651	Iron	Constantan	Yellow		
	DT651	Copper	Constantan	Brown		
	DN303	Nicrosil	Nisil	Pink	Core Single0.32 Nom. finish 2.3×1.4	Glass braided insulating sheath.
	DK303	Chromel	Alumel	Blue		
	DE303	Chromel	Constantan	Purple		
	DJ303	Iron	Constantan	Yellow		
	DT303	Copper	Constantan	Brown		
	DN653	Nicrosil	Nisil	Pink	Core Single0.65 Nom. finish 3.4×2.0	〃
	DK653	Chromel	Alumel	Blue		
	DE653	Chromel	Constantan	Purple		
	DJ653	Iron	Constantan	Yellow		
	DT653	Copper	Constantan	Brown		
	DK803	Chromel	Alumel	Brown ANSI Color	Core Single0.8 Nom. finish 3×1.7	〃
	DK10TT	Chromel	Alumel	Blue	Core Single0.1 Nom. finish 1.2×0.8	Teflon insula ting sheath.
	DE10TT	Chromel	Constantan	Purple		
	DT10TT	Copper	Constantan	Brown		
	DK20TT	Chromel	Alumel	Blue	Core Single0.2 Nom. finish 1.4×0.9	〃
	DE20TT	Chromel	Constantan	Purple		
	DJ20TT	Iron	Constantan	Yellow		
	DT20TT	Copper	Constantan	Brown		
	DN30TT	Nicrosil	Nisil	Pink	Core Single0.32 Nom. finish 1.6×1.0	〃
	DK30TT	Chromel	Alumel	Blue		
	DE30TT	Chromel	Constantan	Purple		
	DJ30TT	Iron	Constantan	Yellow		
	DT30TT	Copper	Constantan	Brown		
	DN65TT	Nicrosil	Nisil	Pink	Core Single0.65 Nom. finish 2.5×1.5	〃
	DK65TT	Chromel	Alumel	Blue		
	DE65TT	Chromel	Constantan	Purple		
	DJ65TT	Iron	Constantan	Yellow		
	DT65TT	Copper	Constantan	Brown		
	DK30CE	Chromel	Alumel	Blue (Spiral)	Core Single0.32 Nom. finish 2.8×1.9	Ceramic braided insulating sheath.
	DK65CE				Core Single0.65 Nom. finish 3.6×2.6	
	DK100CE				Core Single1.0 Nom. finish 4.6×3.1	
	DK30SI	Chromel	Alumel	White	Core Single0.32 Nom. finish 2.8×1.9	Silica braided insulating sheath.
	DK65SI				Core Single0.65 Nom. finish 3.6×2.6	
	DK100SI				Core Single1.0 Nom. finish 4.6×3.1	

Note : Other special thermocouple Duplex wires are also available upon request.

EXPLOSION PROTECTION

Depending on the Class of hazardous area and the type of explosives, the following explosion protection can be specified with the thermocouple assembly by considering installation space and measurement circuit wiring.

1. Flame-Proof Enclosure

Material : ADC, Cast Iron & Cast SS

Approved by KEMA:
No. KEMA 03A TEX2002 X, Ⅱ2G EEx de ⅡC T6...T1(for Temperature Sensors)
No. KEMA 03A TEX2003, Ⅱ2G EEx d ⅡC T6 (for Temperature Transmitters and Terminal Enclosure)
To: EN 50014:1997, General requirements
EN 50018:2000, Flameproof enclosure "d"
EN 50019:2000, Increased safety "e" (for Temperature Sensors)

Approved by Research Institute of Industrial Safety, Ministry of Labor, Japan (R.I.I.S):
Exd ⅡC T6
No. C13997~C14002(for Temperature Sensors)
No. C14391~C14396(for Temperature Sensors with Transmitters)


KEMA
EC-TYPE EXAMINATION CERTIFICATE


KEMA
EC-TYPE EXAMINATION CERTIFICATE

Caution : Yamari's Flame-Proof Enclosure Model KG (Ⅱ2G EEx d ⅡC T6/Ex d ⅡC T6/d2G4) has an approval label and certificate but limited in combination with Yamari's thermocouple assembly. We can supply model KG Enclosure only, however, a certificate of approval and the safety label shall not be provided.

OVERSEAS AFFILIATED COMPANIES

M.I. CABLE TECHNOLOGIES, INC. (MICT)

Establishment	:	October 1995
Annual Turnover	:	CA$6,100,000
Address	:	Bay6, 5905-11th Street S.E. Calgary Alberta Canada T2H2A6 TEL: 403-571-8266 FAX: 403-571-8267 http://www.mict.ab.ca
Capital	:	CA$1,350,000.00
Number of Employees	:	33
Major Businesses	:	Manufacturing and Sales of Various Kinds of MI Thermocouple Cable, MI Extension Cable, MI Heat Tracing Cable

THERMOSENSOR TECHNOLOGIES PTE. LTD. (TST)

Establishment	:	November 1997
Annual Turnover	:	S$4,500,000
Address	:	61 Tuas View Walk 2 Westlink Techpark Singapore 637630 TEL: 065-268-0090 FAX: 065-262-0013 http://www.thermosensor.com
Capital	:	S$800,000.00
Number of Employees	:	33
Major Businesses	:	Manufacturing and Sales of Thermocouples, Resistance Temperature Detectors and Thermowells
Sales Area	:	Southeast Asia except P.R.China, Taiwan, Korea

INSPECTIONS AND TESTS

As one of the most important functions of Quality Assurance at YAMARI to comply with ISO 9001 Qualification, we are always striving for the improvement of Inspection and Test systems with their procedures including those of in-process quality check and control. We maintain quality and accuracy records of our temperature products under established traceability with national standards as illustrated on page as the "Traceability System of Temperature Laboratory" accredited by J.C.S.S. (Japan Calibration Service System). Specifications and procedures of inspection and testing generally follow or refer to the International Standards and Recommended Practices.

All the thermocouple units including beaded Type, THERMIC®, HT-THERMIC and other custom-manufactured assemblies are inspected and tested before delivery in accordance with the following procedures.

1. Appearance and Structure Check :

Visual inspection is made to confirm that the thermocouple assembly is in conformity with the specifications, drawing and constituent materials. Visual checkings are conducted on the finish of joints, junctions, welds, name/tag plates and other parts to confirm that there is no error, flaw, dirt or irregularity on the surface finish.
If necessary, dye penetration check, hydrostatic pressure test and X-ray inspection shall be made on welded and joint parts.

2. Dimensional Check :

Unless otherwise specified, dimensional check is made in accordance with the following tables using Caliper, Straight Measure and Gauges.

Beaded Type Unit : mm

Nominal Length	Tolerance
Below 1,000	±3.0
1,000～2,000	±5.0
Over 2,000	±7.0

THERMIC® Unit : mm

Nominal Length	Tolerance
Below 250	±3.0
250～1,000	±5.0
Over 1,000	±1.0%

Note :
In case of the THERMIC fabricated with protection tube or thermowell, the length within the tolerance of giving no functional trouble shall be regarded as passed.

3. Insulation Resistance Test

Insulation Resistance Test is conducted using a Super Megohmeter (max. scale 5 million MΩ) by applying steep temperature gradient on THERMIC Thermocouple assembly immersed in a deep boiling water bath so as to accelerate condensation of moisture that might be entrapped in the assembly at the cold end. This enables to measure insulation resistance of the assembly very precisely between thermocouple conductors and sheath.

Thermocouple	Voltage	Insulation Resistance	I.R. In-Process at YAMARI
Beaded Type	DC 500V	More than 10MΩ	More than 1,000MΩ
THERMIC® φ2.0 and below	DC 100V	More than 20MΩ	More than 1,000MΩ
THERMIC® φ2.2 and above	DC 500V	More than 100MΩ	More than 1,000MΩ

4. Identification Test on the Thermocouple Type and Polarity

Either by dipping THERMIC thermocouple assembly into the above boiling water bath or applying hot air-blow/flame heat on the Beaded Thermocouple at its hot or cold end to have it generate EMF, which allows to indicate specific type of thermocouple through Temperature vs. EMF Table. A high resolution D.C. circuit testing instrument is used to identify the type of thermocouple and polarity of the thermocouple leg and terminal.

5. EMF Calibration Test

Under the J.C.S.S. Accreditation and ISO 9001 Q.A. Program referring to ASTM E220-1986, E563-1997, E1350-1997, JIS C1602-1995, C1605-1995, etc., tests are made either by comparison method with standard thermocouples or absolute method using fixed point standards on every unit or batch at the pre-set three temperature points depending on the types of thermocouple. The first simple test on THERMIC® Thermocouple is made on all the units at boiling point of water (100℃).
A special comparison test ranging from –50℃ to +1,100℃ and precise calibration at fixed points of pure metals (Hg, Ga, In, Sn, Cd, Zn, Sb, Al, Ag, Cu, Pd) are also performed upon prior arrangements.
For high temperature calibration requirements, special precision measurement and certification can be made within uncertainty of 0.6℃/Type R (or 10 microV) up to Freezing point of Cu (1084.62℃) by Type S or R Standard Thermocouples traceable to National Standard.
In addition, a unique ultra-high temperature calibration in a High Temperature Vacuum Furnace can be conducted for Tungsten-Rhenium group thermocouples up to 2,000℃. Please consult our laboratory for details.

Applicable National Standards

Calibration test shall be made at respective temperatures in accordance with the following National Standards and combinations of thermocouple wires.

Applicable standard can be specified by the customer. Most of the following specifications have now been coordinated by I.E.C. for international unification.

Unless otherwise specified, JIS C1602 and C1605-1995 are applied.

Country	Standards	W5	B	R	S	K	E	J	T	N
Japan	JIS	–	C1602	C1602	C1602	C1602 C1605	C1602 C1605	C1602 C1605	C1602 C1605	C1602 C1605
U.S.A.	ASTM	E988	E230	E230	E230	E230	E230	E230	E230	E230
IEC(E.U.)	IEC	–	584	584	584	584	584	584	584	584

Note : Thermocouple assemblies with insertion length of less than 200 mm can not be accurately calibrated at above 400℃, due to heat conduction error along the probe stem which cannot reach the minimum depth of uniform temperature zone in a calibration apparatus.

Metal		Freezing Poin(℃) ITS-90	Accuracy(℃)
Indium	(In)	156.5985	※
Tin	(Sn)	231.928	±0.01
Cadmium	(Cd)	321.069	※
Zinc	(Zn)	419.527	±0.001
Antimony	(Sb)	630.63	※
Aluminium	(Al)	660.323	±0.2
Silver	(Ag)	961.78	※
Copper	(Cu)	1084.62	±0.5

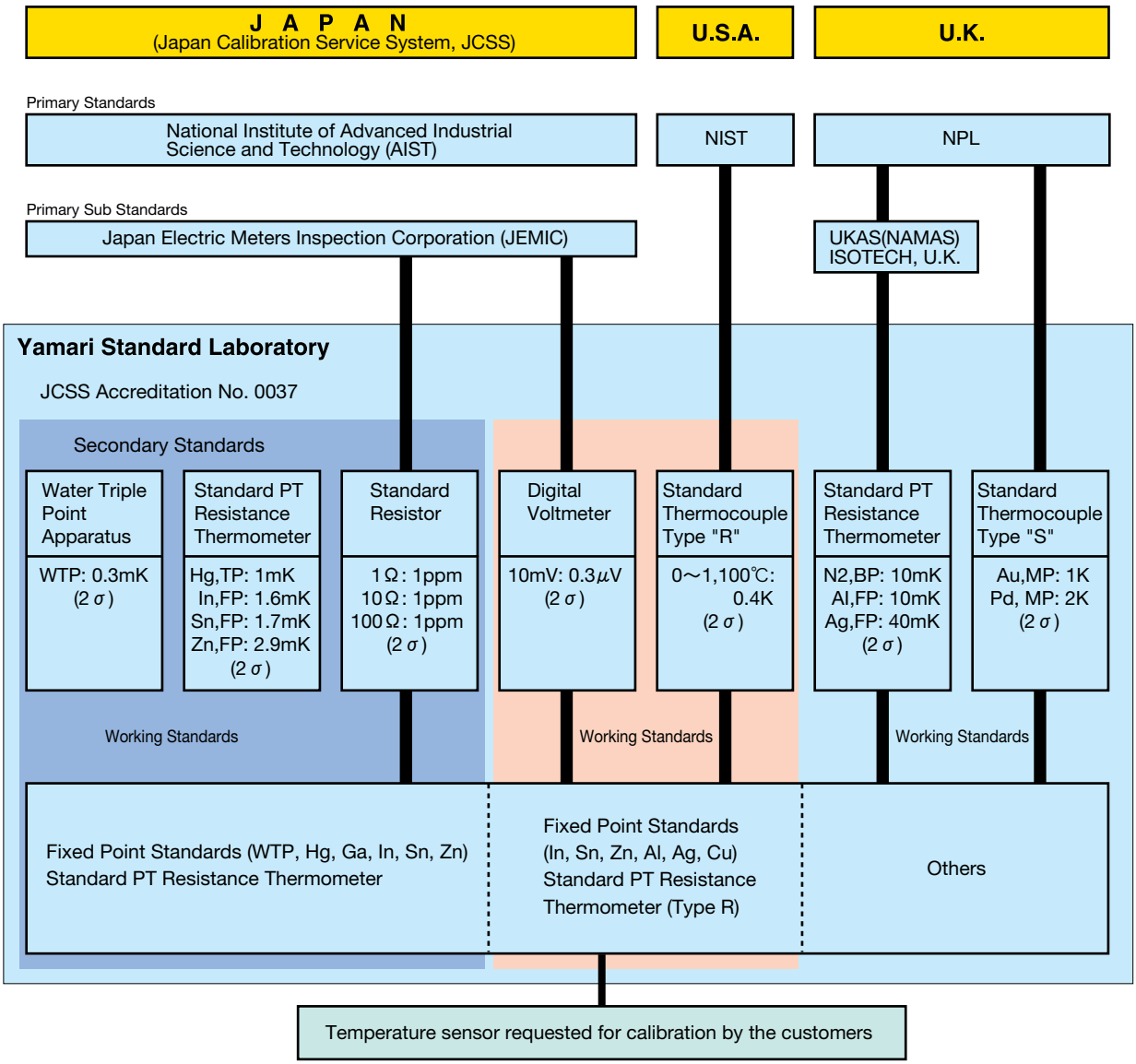
*There are some differences in accuracy depending on purity of the metal used.

6. Others

Loop Resistance test, voltage withstand test, X-ray test, vibration test, pressure test, Helium leak test, etc. are also conducted upon request.

TEMPERATURE CALIBRATION SERVICES

TRACEABILITY SYSTEM OF TEMPERATURE LABORATORY



AIST : National Institute of Advanced Industrial Science and Technology
NIST : National Institute of Standards and Technology
NPL : National Physical Laboratory
UKAS : United Kingdam Accreditation Service
NAMAS : National Measurement Accreditation Service
JEMIC : Japan Electric Meters Inspection Corporation
JCSS : Japan Calibration Service System

CALIBRATION TEMPERATURES AND THE HIGHEST CALIBRATION ACCURACIES FOR THE THERMOMETER SAMPLES OF WHICH TRACEABILITY CAN BE ASSURED

Samples	Calibration Method	Calibration Temperatures	Highest Calibration Uncertainty(2σ)	Reference Probe
Thermocouples	Fixed Point	Indium (156.5985℃)	±0.6℃	Type R Standard Thermocouple
		Tin (231.928℃)		
		Zinc (419.527℃)		
		Aluminum (660.323℃)		
		Silver (961.78℃)		
		Copper (1084.62℃)		
	Comparison	0～1,100℃	±0.9℃	
Temperature Indicator combined with Thermometer(*1)	Comparison	0～1,100℃	±0.9℃	
Portable Calibration Apparatus(*1)	Comparison	0～1,100℃	±0.7℃	
Fixed Point Apparatus	Fixed Point	Aluminum (660.323℃)	±0.5℃	
		Silver (961.78℃)		
		Copper (1084.62℃)		
		Water Triple Point (0.01℃)	±0.0006℃	Standard Platinum Resistance Thermometer
		Mercury Triple Point (−38.8344℃)	±0.002℃	
		Gallium (29.7646℃)	±0.002℃	
		Indium (156.5985℃)	±0.003℃	
		Tin (231.928℃)	±0.003℃	
		Zinc (419.527℃)	±0.005℃	
Platinum Resistance Thermometer (4-Wire Connection)	Fixed Point	Mercury Triple Point (−38.8344℃)	±0.002℃	
		Gallium (29.7646℃)	±0.002℃	
		Indium (156.5985℃)	±0.003℃	
		Tin (231.928℃)	±0.004℃	
		Zinc (419.527℃)	±0.006℃	
	Comparison	0～232℃	±0.009℃	
Temperature Indicator Combined with Thermometer	Fixed Point	Water Triple Point (0.01℃)	±0.003℃	
		Gallium (29.7646℃)	±0.003℃	
		Indium (156.5985℃)	±0.004℃	
	Comparison	0～232℃	±0.010℃	
Portable Calibration Apparatus(*2)	Comparison	0～232℃	±0.4℃	
		0～232℃(*3)	±0.1℃	
Glass-in-Mercury Thermometer	Comparison	0℃	±0.03℃	
		−50℃＜t≦50℃(except 0℃)	±0.04℃	
		50℃＜t≦200℃	±0.05℃	
		200℃＜t≦250℃	±0.06℃	
		250℃＜t≦300℃	±0.07℃	
		300℃＜t≦350℃	±0.11℃	

Note: *1: Thermometer combined with Temperature Indicator or Calibration Apparatus is Thermocouple.
*2: Thermometer combined with Calibration Apparatus is Platinum Resistance Thermometer.
*3: This is applicable to portable Calibration Apparatus with a large equalizing block and the function of temperatare preset.

YAMARI INDUSTRIES, LIMITED
山里産業株式会社

Head Office : 1-5-4, Mishimae,
Takatsuki-shi, Osaka, Japan, 569-0835
Tel: +81-72-678-4897 Fax: +81-72-678-3516
E-mail: overseas_sales@yamari.co.jp
URL: http://www.yamari.co.jp

Takatsuki Factory : 1-5-4, Mishimae,
Takatsuki-shi, Osaka, Japan, 569-0835
Tel: +81-72-678-1313 Fax: +81-72-679-2006

Subsidiary
in Canada : M.I. CableTechnologies, Inc. (MICT)
Tel: +1-403-571-8266 Fax: +1-403-571-8267
URL: http://www.mict.ab.ca

in Singapore : Thermosensor Technologies Pte. Ltd. (TST)
Tel: +65-628-0090 Fax: +65-6262-0013
URL: http://www.thermosensor.com

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