Thermocouple (T/C) 熱電偶

Construction of thermocouple (熱電偶構造)

熱電偶的動作原理也就是所謂的"席貝克效應"。假使導線兩端有溫度差,將會造成 電流流動。電流的多寡取決於選擇的材質 。

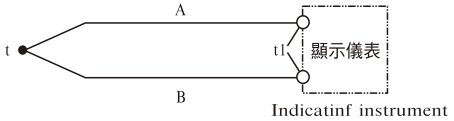
將兩種不同金屬材質連接在一起並加熱此端,導線另兩端將會產生電壓差。若要測量溫接點溫度,導線另兩端的參考溫度需要得知,若導線另兩端參考溫度不能得知,需將導線延伸到可知的溫度點,作為參考點(一般稱為冷接點) 。

此參考點的溫度是可知的係數,將參考點(冷接點)和溫接點溫度相加即是所測的實際溫度。

熱電偶測溫原理

如下圖，選用兩種不同的金屬或合金絲A，B，稱為熱電極，焊接的一端稱為測量端，連線顯示儀表的兩頭稱為參比端。當測量端和參比端溫度不同時，就會產生熱電勢$E_{AB}(t,t1)$。當t=0℃時則有：

$$E_{AB}(t,0)=E_{AB}(t)=f(t)$$



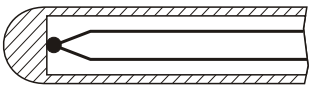
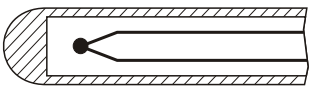
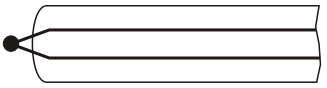
Indicatinf instrument

The effect responsible for the action of thermocouple is the" Seebeck effect " . If a temperature difference exists along a wire , this will causes a displacement of electrical charge . The amount of the charge displacement depends on the electrical characteristics of the chosen material.

If two wires of different materials are joined at one point and then subjected to a temperature , then a voltage difference will be generated between the open ends of the two wires . In order to be able to measure the temperature at the junction, the temperature at the open end must be known. If the temperature of the open end is not known, then it must be extended (by a compensating cable) into the zone of known temperature (reference junction, usually referred to as the "cold junction").

The temperature of the reference junction must be known and constant. the exact temperature is equal joined junction temperature plus cold junction temperature .

TYPE OF MEASURING JUNCTION (測溫接點種類)

TYPE(種類)	SHAPE (形狀)	FEATURE(特長)
Grounded (接第型)		1. This type can withstand 3500kg/cm2 or more 此型能耐壓 3500kg/cm2 以上 2. It is not suitable for location with electromagnetic induction on radio frequency inter-ference 不適用於電磁波干擾之場所
Ungrounded(非接地型)		1. This type has a slower reponse than the grounded type but is more commonly used since it is not restricted by the object to be measured 反應速率比接地型慢,但較為廣泛使用,被測物較不受限制 2. The element is covered with an insulator thereby ensuring a long life span . 元件由絕緣体保護,壽命較長
Exposed (露出型)		1. Since the element is exposed reposed reponse time is very fast 元件是露出型,反應速率非常快 2. This type is suitable for temperature measurment of gases such as automotive exhaust . 非常適用氣体測量,例如:廢氣 3. This type is mechanically weaker than the other. 機械架構比其他類型脆弱

MINERAL INSULATED THERMOCOUPLE (金屬被覆熱電偶)

1. wide application in measuring small diameter is very useful for the place where space is at premium .
   應用範圍廣,受空間限制小直徑特別有用。
2. quick response 反應速率快。
3. easily bent for installation 可撓性大。
4. long life span 壽命長。
5. excellent mechanical strength and pressure resistance 機械強度及耐壓性強。

standard specification of **AEROPAK ®** sheath therm ocouple

	sheath (mm)		wire dia (mm)素線徑	maximum length (M) 最大長度 (米)
	O.D 外徑	t 肉厚		
SINGLE ELEMENT(單組) 	Ø 0.25	0.035	Ø 0.05	138
	Ø 0.5	0.08	Ø 0.1	95
	Ø 1.0	0.17	Ø 0.17	420
	Ø 1.6	0.27	Ø 0.27	185
	Ø 3.2	0.47	Ø 0.51	130
	Ø 4.8	0.72	Ø 0.76	142
	Ø 6.4	0.93.	Ø 1.0	80
	Ø 8.0	1.16	Ø 1.3	50
DOUBLE ELEMENT (雙組) 	Ø 3.2	0.47	Ø 0.51	130
	Ø 4.8	0.72	Ø 0.76	142
	Ø 6.4	0.93	Ø 1.0	80
	Ø 8.0	1.16	Ø 1.3	50
TRIPLE ELEMENT (參組) 	Ø 4.8	0.72	Ø 0.5	142
	Ø 6.4	0.93	Ø 0.72	80
	Ø 8.0	1.16	Ø 0.9	50

AEROPAK ® OPERATING TEMPERATURE RANGE (IN AIR) 大氣中使用溫度範圍

SHEATH O.D 外徑 (mm)	SN	SK			SE	SE	SJ	ST
Ø 0.25	-	500 °C *1)			-	-	-	-
Ø 0.5	-	600 °C (1)			-	-	-	-
Ø 1.0	900 °C (*3)	650 °C		900 °C (*3)	650 °C	450 °C	450 °C	300 °C
Ø 1.6	1200 °C (*3)	650 °C		1200 °C (*3)	650 °C	450 °C	450 °C	300 °C
Ø 3.2	1260 °C (*3)	750 °C		1260 °C (*3)	750 °C	650 °C	650 °C	350 °C
Ø 4.8	1260 °C (*3)	800 °C		1260 °C (*3)	800 °C	750 °C	750 °C	350 °C
Ø 6.4	1260 °C(*3)	1000 °C (*1)	600 °C (*1)	900°C (*2)	800 °C	750 °C	750 °C	350 °C
Ø 8.0	-	1050 °C (*1)	600 °C (*1)	1000°C (*2)	800 °C	750 °C	750 °C	350 °C

(*1) sheath material : NCF 600 (*2) sheath material : SUS310 (*3) sheath material : H2300 OTHERS : SUS316
(*1) sheath 材質 : NCF 600 (*2) sheath 材質 : SUS310 (*3) sheath 材質 : H2300 未註記 : SUS316

FEATURE OF THERMOCOUPLE 熱電偶特性

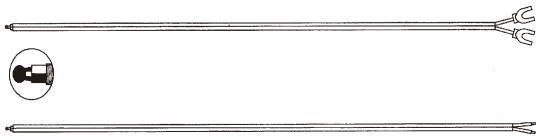
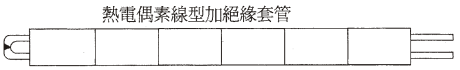
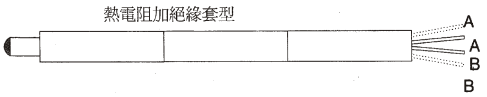
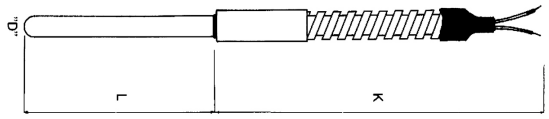
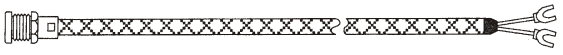
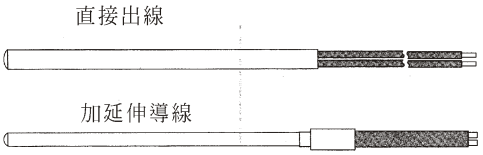
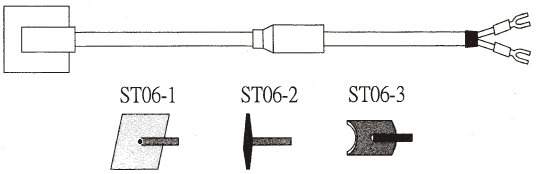
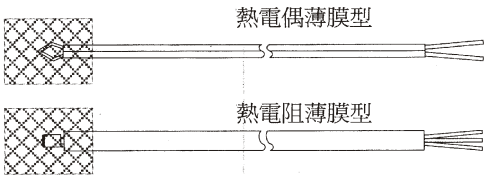
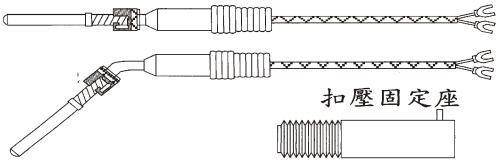
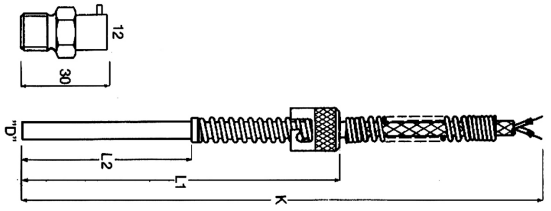
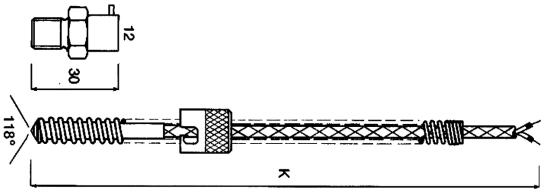
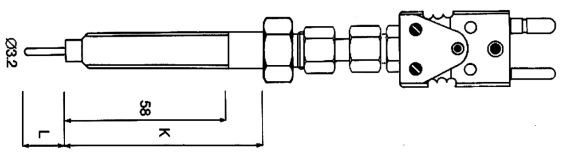
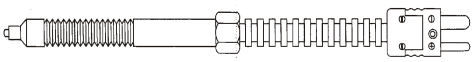
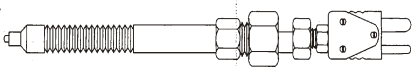
type	feature	優點	缺點
B	Thermocouple which combines a positive wire of a platinum-rhodium alloy containing 70% platinum and 30% rhodium with a negative wire of platinum rhodium containing 94% platinum and 6% rhodium. Type B is more resistant to heat and mechanical stress than type R, and withstands 1800^{O}C Max. Other features are the same as those of type R.	1. 適用 1000^{O}C 以上至 1800^{O}C 之高溫測定。 2. 在常溫環境下熱電動勢非常小，不需補償導線。 3. 耐氧化、耐藥品性良好。 4. 耐熱性與機械強度較 R 型優良。	1. 在中低溫域之熱電動勢極小，600^{O}C 以下測定溫度不準確。 2. 感度不佳(熱電動勢值小)。 3. 熱電動勢之直線性不佳。 4. 價格高昂。
R & S	Thermocouple which combines a positive wire of a platinum and rhodium alloy containing 87% platinum and 13% rhodium with a negative wire of pure platinum. This thermocouple is highly accurate, excellent in heat resistance and stability, generally used in oxidizing atmospheres. It is not recommended for use in reducing atmospheres or where metal vapors are present. Thermocouple which combines a positive wire of a platinum rhodium alloy containing 90% platinum and 10% rhodium with a negative wire of pure platinum. Other features are the same as those of type R.	1. 耐熱性、安定性、再現性良好及較優越的精確度。 2. 耐氧化、耐藥品性良好。 3. 可以做為標準使用。	1. 感度不佳(熱電動勢值小)。 2. 在還元性氣體環境較脆弱。(特別是氫、金屬蒸氣) 3. 補償導線誤差大。 4. 價格高昂。
N	This is called Nicrosil (positive leg) / Nisil (negative leg) Thermocouple, and its composition and characteristics are very similar to those of type K Thermocouple. It is an improved type of Type K Thermocouple and has more Si additive, higher heat resistance.	1. 熱電動勢之直線性良好。 2. 1200^{O}C 以下耐氧化性良好。 3. 為 K 型之改良型，受 Green Rot 之影響較小，耐熱溫度較 K 型高。	1. 不適用於還元性氣體環境。 2. 熱電動勢與貴金熱電偶相比較經時變化較大。
K	Thermocouple which combines a positive wire of an alloy consisting mainly of nickel and chromium with negative wire of an alloy consisting mainly of nickel. This thermocouple widely used for many particularly should not be used in carbon monoxide, sulfurous acid gas or sulfur bearing hydrogen atmospheres.	1. 熱電動勢之直線性良好。 2. 1000^{O}C 以下耐氧化性良好。 3. 在卑金屬熱電偶中安定性屬良好。	1. 不適用於還元性氣體環境，特別是一氧化碳、二氧化硫、硫化氫等氣體。 2. 熱電動勢與貴金屬熱電偶相比較經時變化較大。受 ShortRange Ordering 之影響會產生誤差。
E	Thermocouple which combines a positive wire of thermocouple K with a negative wire of thermocouple J. This thermocouple has a high thermal emf and is suitable for use in oxidizing atmosphere.	1. 現有熱電偶中感度最佳者。 2. 與 J 熱電偶相比耐熱性良好。 3. 兩腳不具磁性。 4. 適於氧化性氣體環境。	1. 不適用於還元性氣體環境。 2. 稍具履歷現象。
J	Thermocouple which combines a positive wire of iron with thermocouple is resistant in reducing atmospheres and is also resistant to hydrogen and carbon. However it should not be used in atmospheres that will oxidize iron. It is relatively low in cost and often used for medium temperature range applications.	1. 可使用於還元性氣體環境。 2. 熱電動勢較 K 熱電偶大 20%。 3. 價格較便宜，適用於中溫區域。	1. (+)腳易生銹。 2. 再現性不佳。
T	Thermocouple which combines a positive wire of copper with a negative wire of an alloy mainly of copper and nickel. High accuracy is obtained at under 300^{O}C, and it is suitable for low temperatures from -200^{O}C to +100^{O}C. It is suitable for use in weak oxidizing and reducing atmospheres.	1. 熱電動勢之直線性良好。 2. 低溫之特性良好。 3. 再現性良好、高精度。 4. 可使用於還元性氣體環境。	1. 使用溫度限度低。 2. (+)腳之銅易氧化。 3. 熱傳導誤差大。

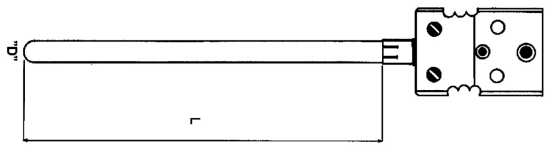
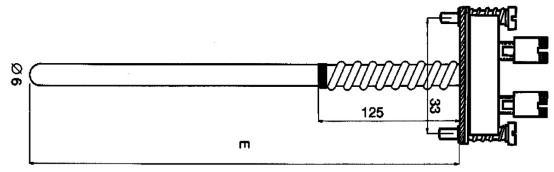
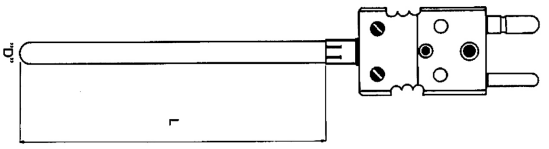
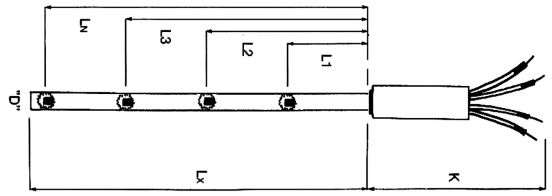
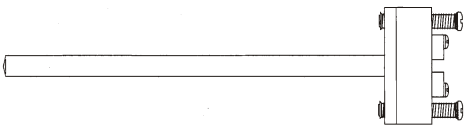
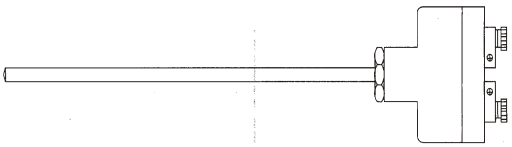
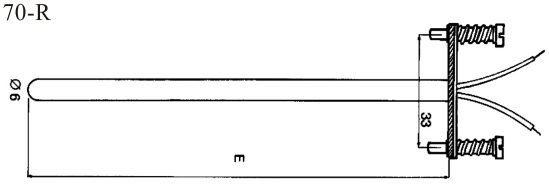
Thermocouple tolerance and applicable standards (熱電偶精確度及應用標準)

standard 規格 / symbol 種類	COMPOSITION 構成材料 (+ / -)	JIS C 1602-1995			IEC 584-2-1982		ASTM E230-1996		
		TEMP RANGE 溫度範圍	CLASS 等級	TOLERENCE 誤差 °C	CLASS 等級	TOLERENCE 誤差 °C	TEMP RANGE 溫度範圍	CLASS 等級	TOLERENCE 誤差 °C
B	Pt-30Rh / Pt-6Rh 鉑-30%銠 / 鉑-6%銠	600°C ~ 1700°C	2	± 0.0025|t|	2	± 0.0025|t|	870°C ~ 1700°C	STD	± 0.5 %
		600°C ~ 800°C	3	± 4	3	± 4			
		800°C ~ 1700°C		± 0.005|t|		± 0.005|t|			
R & S	(R)Pt-13Rh / Pt 鉑-13% 銠 / 鉑	0°C ~ 1100°C	1	± 1	1	± 1	0°C ~ 1450°C	STD	± 1.5 OR ± 0.25 %
	(S)Pt-10Rh / Pt 鉑-10% 銠 / 鉑	0°C ~ 600°C	2	± 1.5	2	± 1.5		SP	± 0.6 OR ± 0.1 %
		600°C ~ 1600°C		± 0.0025|t|		± 0.0025|t|			
N & K	(N) Ni-Cr-Si / Ni-Si 鎳-鉻-矽 / 鎳-矽	-40°C ~ +375°C	1	± 1.5	1	± 1.5	0°C ~ 1260°C	STD	± 2.2 OR ± 0.75 %
		+375°C ~ 1000°C		± 0.004|t|		± 0.004|t|			
	(K)Ni-Cr / Ni-Al 鎳-鉻 / 鎳-鋁	-40°C ~ +333°C	2	± 2.5	2	± 2.5		SP	± 1.1 OR ± 0.4 %
		+333°C ~ +1200°C		± 0.0075|t|		± 0.0075|t|			
		-167°C ~ +40°C	3	± 2.5	3	± 2.5	-200°C ~ 0°C	STD	± 2.2 OR ± 2 %
		-200°C ~ -167°C		± 0.015|t|		± 0.0015|t|			
E	Ni-Cr / Cu-Ni 鎳-鉻 / 銅-鎳	-40°C ~ +375°C	1	± 1.5	1	± 1.5	0°C ~ +870°C	STD	± 1.7 OR ± 0.5 %
		+375°C ~ 800°C		± 0.004|t|		± 0.004|t|			
		-40°C ~ +333°C	2	± 2.5	2	± 2.5		SP	± 1 OR ± 0.4 %
		+333°C ~ +900°C		± 0.0075|t|		± 0.0075|t|			
		-167°C ~ +40°C	3	± 2.5	3	± 2.5	-200°C ~ 0°C	STD	± 1.7OR ± 1 %
		-200°C ~ -167°C		± 0.015|t|		± 0.015|t|			
J	Fe / Cu-NI 鐵 / 銅-鎳	-40°C ~ +375°C	1	± 1.5	1	± 1.5	0°C ~ +760°C	STD	± 2.2OR ± 0.75 %
		+375°C ~ 750°C		± 0.004|t|		± 0.004|t|			
		-40°C ~ +333°C	2	± 2.5	2	± 2.5		SP	± 1.1 OR ± 0.4 %
		+333°C ~ +750°C		± 0.0075|t|		± 0.0075|t|			
T	Cu / Cu-Ni 銅 / 銅-鎳	-40°C ~ +125°C	1	± 0.5	1	± 0.5	0°C ~ +370°C	STD	± 1.1 OR ± 0.4 %
		+125°C ~ +350°C		± 0.004|t|		± 0.004|t|			
		-40°C ~ +133°C	2	± 1.0	2	± 1.0		SP	± 0.5 OR ± 0.4 %
		+133°C ~ +350°C		± 0.0075|t|		± 0.0075|t|			
		-67°C ~ +40°C	3	± 1.0	3	± 1.0	-200°C ~ 0°C	STD	± 1 OR ± 1.5 %
		-200°C ~ -67°C		± 0.015|t|		± 0.015|t|			

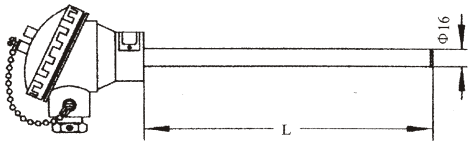
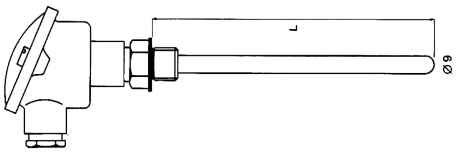
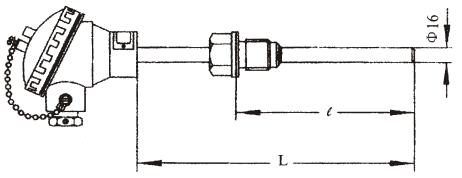
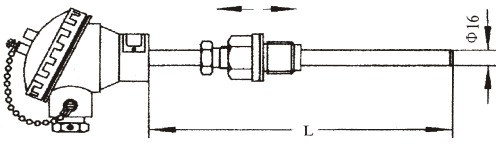
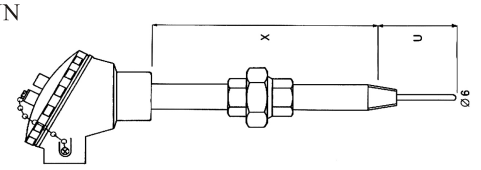
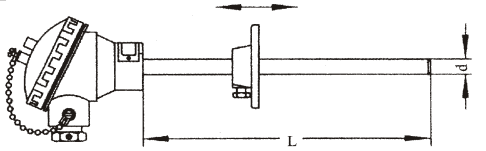
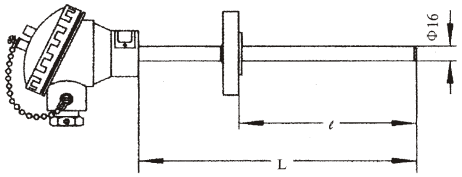
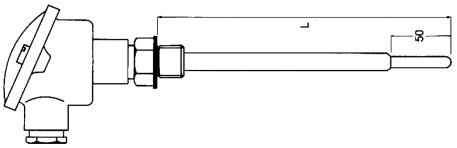
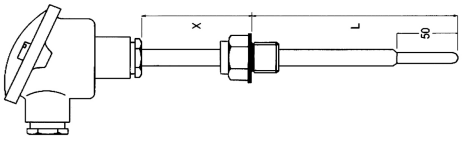
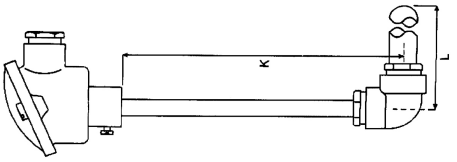
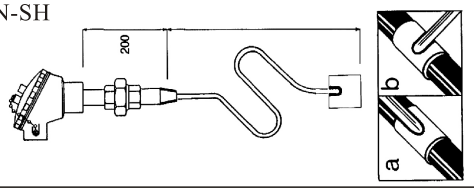
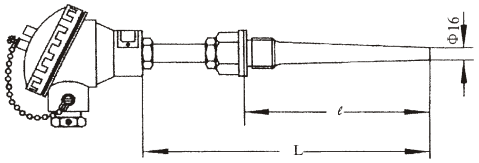
(1)Tolerance is referred to as the maximum allowable deviation between measuring junction temperature and the temperature derived from the emf table.
(2)ASTM tolerance is °C or % value for the measured temperature, whichever is greater
(3)ltl means measuring temperature indicated with the temperature (°C) having no connection with the positive or negative mark.
(4) Classes 1, 2, 3 correspond to former JIS Classes 0.4, 0.75, 1.5 respectively.
.(5)JIS, BS, DIN standards are same as IEC . standard.
(6)ASTM standard is former ANSI standard.

1. 容許差為熱電動勢依基準熱電動勢表所換算之溫度減去測溫接點之溫度之容許最大限度。
2. ASTM 之容許差為 °C 或是測定溫度之百分比(%)中之最大值。
3. t 表測定度其無關 +、- 符號之溫度(°C)絕對值。
4. CLASS1、2、3 對應於舊 JIS 之 0.4、0.75、1.5 級。
5. JIS、BS、DIN 規格與 IEC 規格相同。
6. ASTM 規格為舊 ANSI規格。

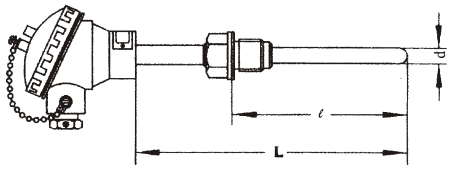
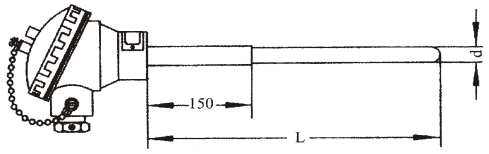
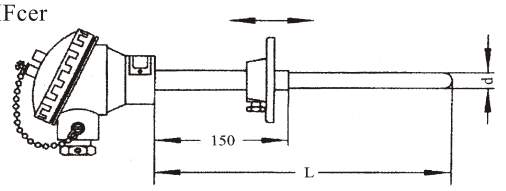
melt bolt thermocouple 尖端點焊型	thermocouple wire with ceramic insulator 素線外覆絕緣瓷管
CMT 100 	CMT 007  CMT 027 
armor thermocouple extension 金屬蛇管延長型	screw Thermocouple 螺絲崁入型(1)
CMT 103 	CMT 101B 
flexible thermocouple extension 延長型	spade thermocouple 片狀型
CMT 101-6 	ST 30-PAD 
Ring Thermocouple 扣環型	spring adjustable immersion thermocouple 彈簧可調浸入型
CMT 101R CMT 201R 	CMT 105 
spring ajustable immersion T/C 彈簧可調浸入型	spring adjustable immersion T/C 彈簧可調浸入型
CMT 101-8 	CMT 101-26 
Plug T/C 快速接頭熱電偶	plug thermocouple 快速接頭熱電偶
ST 70-1 	CMT 101C1  CMT 101C2 

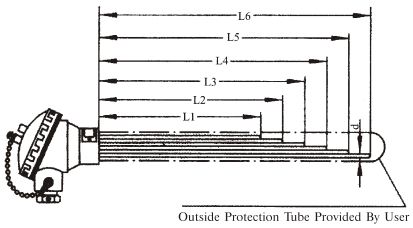
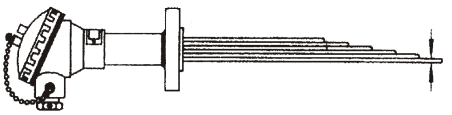
plug T/C 快速接頭熱電偶	Flxible fitting with D coector thermocouple 活動牙口加D型接頭
ST 70-FE 	ST 60 
DIN terminator T/C DIN端子板熱電偶	plug T/C 快速接頭熱電偶
SF 70-S 	ST 70-M 
Muti points T/C 多點感熱電偶	DIN terminator thermocouple DIN端子板 T/C
ST 703 	ST 70-DIN 
T terminator thermocouple T型接線端子	Round plate T/C 圓板熱電偶
ST 70-T 	ST 70-R 

model 型號 CMT		100, 007, 103, 101B, 101-6, ST 30-PAD, 101R, 105, 101-26, 101-8, 101-C1, 101-C2, ST 60, ST 70-1, ST 70-M, ST 70-FE, ST 70-DIN, ST 70-S, ST 70-T, ST 703, ST 70-R
type of element 類 型		J=J type , K=K type ,E =E type , T=T type , R =R type ,S =S type , N =N type , B=B type
element quantity 測溫點數量		S=Single , D=DUAL , O=OTHER
process connection parts 製程接和附件		5 =None , 7=fixed type bushing , 8=compression fitting , 9=compression fitting with bushing 10=compression fitting with bayonet cap and spring (Page 20,21) if need connection parts , please note connection size : ____ inch (PT , NPT, G , R)
terminal connector 接線端子		O=O type Y=Y type, T=T connector, S=standard connector, M=mini connector (Page 18,19)
probe material 外管材質		S4=SUS304 , S6=SUS316, S10 = SUS310 , NCF=INCONEL 600 , CERA=ceramic
probe diameter 外管直徑		Ø1.0 mm , Ø1.6 mm , Ø2.3 mm , Ø3.2 mm , Ø4.8 mm , Ø6.4 mm , Ø 9 mm , Ø12.7 mm , Ø21.7 mm ,specify
probe length 外管長度		_____ mm
lead wire length 導線長度		flexible SUS316 tube armor length (if need) + leadwire length
lead wire insulated material 導線絕緣材質		PVC, fiber glass, teflon (page 25,26,27)
measuring junction 測溫點型式		G=Ground , UG=Ungrounded , EPS=Exposed type
CLASS等級		01=JIS0.4 , 02=JIS0.75 , 03=JIS1.5 , 04=ASTM standard , 05=ASTM special

無固定裝置式金屬保護管熱電偶Non-fixed Type TC With Metallic Protection Tube	固定螺栓式熱電偶 Fixed Screw-In Type T/C
CMT 107 	CMT 106 
固定螺栓式熱電偶 Fixed Screw-In Type T/C	活動螺栓式熱電偶 Movable Screw-In T/C
CMT 106-1 	CMT 106-M 
延長型熱電偶 extensio Type TC	活動法蘭式熱電偶 Movable Fiange Type TC
CMT 106-UN 	CMT 107-MF 
固定法蘭式熱電偶 Fixed Flange Type Tc	固定螺栓變徑型熱電偶 Fixed Screw-in type T/C With Variable diameter
CMT 107-F 	CMT 106-IV1 
固定螺栓變徑型熱電偶 Fixed Screw-in type T/C With Variable diameter	角尺式熱電偶 Right angle Type T/C
CMT 106-IV2 	CMT 106-L 
延長型sheath熱電偶 extensio sheath Type T/C	固定螺栓錐形保護管式熱電偶 Fixed Screw-In Type TC With Tapered Drilled Thermowell
CMT 106-UN-SH 	CMT 107-TW 

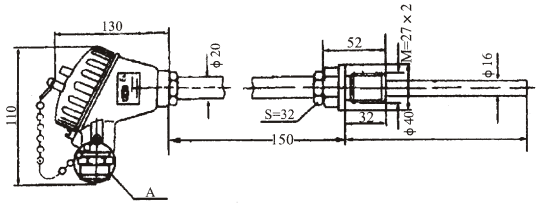
非金屬保護管 Non-Metalic protection tube

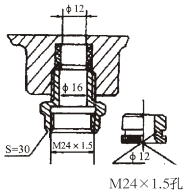
固定螺栓式瓷保護管熱電偶 Fixed Screw-In Type TC With Protection Type	無固定裝置式瓷保護管熱電偶 Non-Fixing Type TC With ceramic Prorection Tube
CMT 106cer 	CMT 107cer 
	活動法蘭式瓷保護管熱電偶Movable Flange Type TC With Ceramic Protection Tube
	CMT 107MFcer 

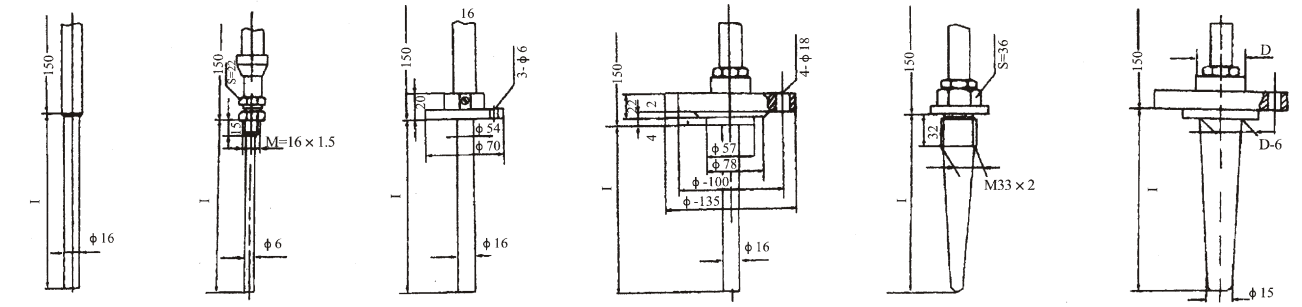
型 號	無固定裝置多點式 Non-Fixed Type Multiple Point	型 號	固定法蘭多點式 Fixed Flange Type Multiple Point
CMT 307		CMT 307F	

註：各點長度均可任意選擇，點數可根據需要增減，一般多點式熱電偶分三點、四點、五點、六點四種規格。

Note: Length and / or measuring points can be chosen as needed. Regularmultiple TC has four specifications:







無固定裝置　固定卡套螺紋　活動法蘭　固定法蘭　高壓螺紋　高壓法蘭

model 型 號 CMT		106, 107, 106-1, 106M, 106UN, 107MF, 107F, 106-IV1, 106-IV2, 106-L, 106-UNSH, 106-ITW, 106 cer, 107 cer, 107MF cer, 307, 307F
type of lement 種　類		J=J type , K=K type ,E =E type , T=T type , R =R type ,S =S type , N =N type B=B type
element quantity 測溫點數量		S=Single , D=DUAL , O=OTHER
probe extension & connection type 測溫管接和方式		5 =None , 6NUN=nipple-union-nipple , 6N=Nipple, 6NU=nipple-union 7=fixed type bushing , 8=compression fitting , 9=compression fitting with bushing (Page 19,20,21) if need extension parts , please note extension length = ___ mm & connection size : ____ inch PT (or other) ,
spring loaded 彈簧伸縮		0=with , 1=without
terminal head 接線盒		KB , KNC , KI , KD , KT , LS, 1080AE(explosion) ,1080SE(explosion) Page(18)
PROBE MATERIAL 測溫管材質		S4=SUS304 , S6=SUS316, S10 = SUS310 , NCF=INCONEL 600 CERA : Ceramic, other
probe diameter 測溫管直徑		Ø1.0 mm , Ø1.6 mm , Ø2.3 mm , Ø3.2 mm , Ø4.8 mm , Ø6.4 mm , Ø9 mm , Ø12.7 mm , Ø21.7 mm ,specific
probe length 測溫管長度		_____ mm
measuring junction 測溫點種類		G=Ground , UG=Ungrounded , EPS=Exposed type
CLASS 等級		01=JIS0.4 ,02=JIS0.75 03=JIS1.5 , 04=ASTM standard , 05=ASTM special
THERMOWELL 保護套管		TW=with thermowell NTW=without thermowell (see page 22,23,24)