UTM UNIVERSITI TEKNOLOGI MALAYSIA

Sekolah Pendidikan Profesional dan Pendidikan Berterusan (SPACE)

JABATAN KEJURUTERAAN ELEKTRIK
PUSAT PENGAJIAN DIPLOMA (PPD), SPACE
UNIVERSITI TEKNOLOGI MALAYSIA
KUALA LUMPUR

DDPE 2701 ELECTRICAL ENGINEERING LABORATORY 2

(INSTRUMENTATION)

EXPERIMENT 1 : THEORY
THERMOCOUPLE TYPE K (CA)

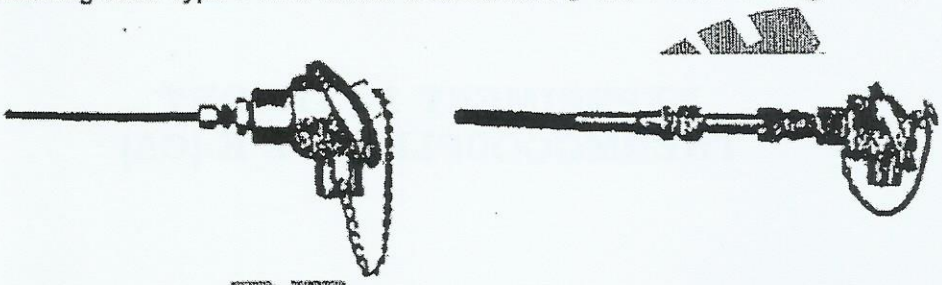
Group members	**1.**
	2.
	3.
	4.
	5.
Lecturer	**:**
Date	**:**

5.1 OBJECTIVES

1. Study the construction of a thermocouple.
2. Study the characteristic of a thermocouple.
3. Study the transduction principle of a thermocouple.
4. Study the application of a thermocouple.

5.2 DISCUSSION OF FUNDAMENTALS

Thermocouples are the most commonly used in industrial temperature-control applications at the present. Figure 5-1 shows configurations of the thermocouple with protecting tube. Type T-96 is usable to about 2000°F and T-5990 to about 3000°F.



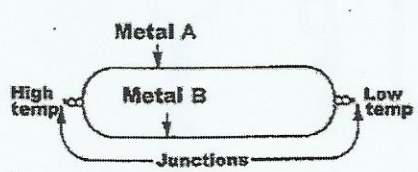
ANSI T-96 ANSI T-5990

Figure 5-1 Thermocouple configurations

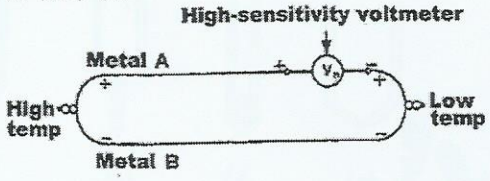
The simplest type of thermocouple is made from two dissimilar metals A and B by being joined at both of their ends to comprise a closed-loop circuit, as shown in Figure 5-2(a). A current will flow in that circuit as long as the two junctions (cold and hot) are at different temperatures, the cold junction at a lower temperature and the hot junction at a higher temperature.

The thermocouple circuit is based on the "Seebeck" effect. The magnitude of the thermoelectric potential (thermal emf) produced by a thermocouple depends on the conductor materials and the temperature difference between the two junctions. The two junctions produce two different voltages with the opposite polarities, as shown in Figure 5-2(b). The high-sensitivity voltmeter connected in this circuit performs the measurement of temperature difference between the two junctions. In Figure 5-2(c) the voltmeter wires are connected across the two cold junctions: one is the

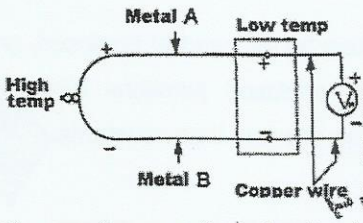
connection of the metal A and one of voltmeter wires, the other is the connection of the metal B and another voltmeter wire. The voltage between these two cold junctions is the same as the voltage on the junction of metals A and B if the cold junctions (reference junction) keep at the same temperature.



(a) basic circuit



(b) temperature measurement



(c) correct connection of voltmeter

Figure 5-2 Thermocouple circuits

When the reference-junction temperature cannot be maintained at exactly the same value, usually because of changes in the ambient temperature, a temperature sensor RT is embedded in the reference-junction block so that the temperature can be monitored and appropriate corrections to the output readings made. The reference-junction compensation circuit is shown in Figure 5-3.

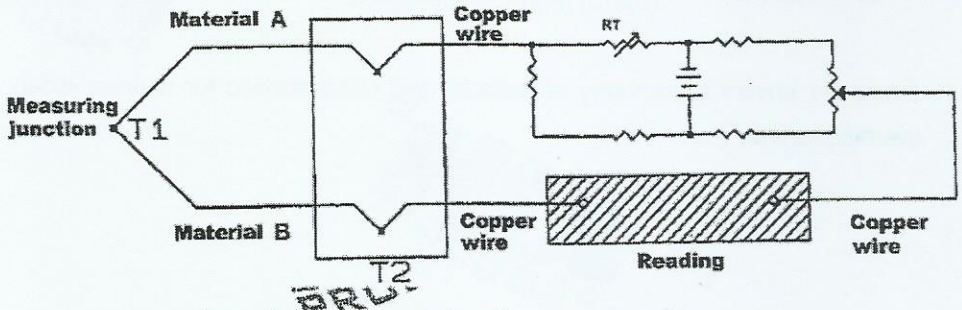


Figure 5-3 Reference-junction compensation

Thermocouple junctions can be made by a number of different techniques of wire joining, as shown in Figure 5-4.

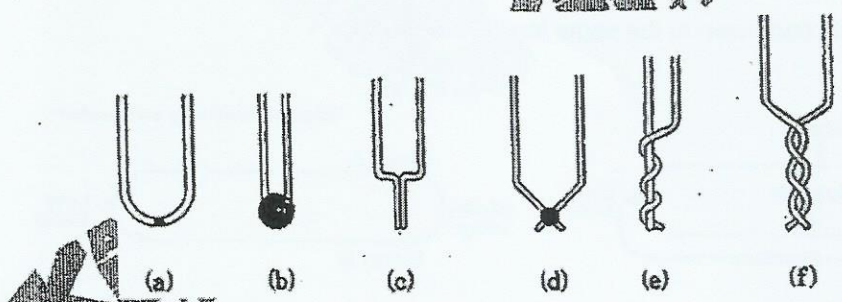


Figure 5-4 Thermocouple junctions: (a) butt welded; (b) beaded; (c) lap welded; (d) cross wire; (e) coiled wire;(f) twisted wire

Thermocouple junctions can be exposed or enclosed, grounded or ungrounded (see Figure 5-5). Ungrounded enclosed junctions have the longest time constants. Exposed junctions have the shortest time constants.

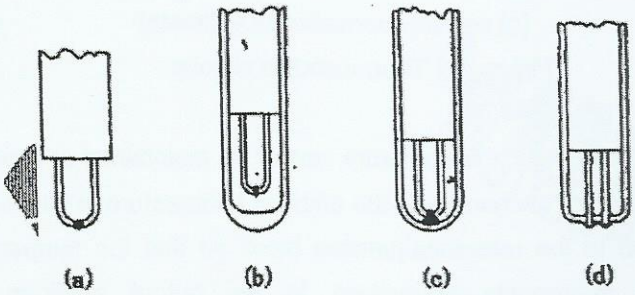


Figure 5-5 Examples of thermocouple junction packages: (a) ungrounded exposed; (b) ungrounded enclosed; (c)&(d) grounded enclosed

Table 5-1 shows a summary of material and characteristic for various widely used thermocouples.

Table 5-1 Material and characteristic of thermocouples (JIS Standard)

Type	Old Type	Material P	Material N	Accuracy Grade	Measuring Temp.	Tolerance
W5	—	W-5%Re	W-26%Re	—	400℃~2,300℃	±1%
W3	—	W-3%Re	W-25%Re	—	400℃~2,800℃	±1%
B	—	Pt-30%Rh	Pt-6%Rh	0.5	600℃~1,700℃	±4℃ or measuring ±0.5% temp.
R	—	Pt-13%Rh	Pt	0.25	0℃~1,600℃	±1.5℃ or measuring ±0.25% temp
S	—	Pt-10%Rh	Pt			
K	CA	Chromel	Alumel	0.4	0℃~1,000℃	±1.5℃or measuring ±0.4% temp
				0.75	0℃~1,200℃	±2.5℃or measuring ±0.75% temp
				1.5	-200℃~0℃	±2.5℃or measuring ±1.5% temp
E	CRC	Chromel	Constantan	0.4	0℃~800℃	±1.5℃or measuring ±0.4% temp
				0.75	0℃~800℃	±2.5℃or measuring ±0.75% temp
				1.5	-200℃~0℃	±2.5℃or measuring ±1.5% temp
J	IC	Fe	Constantan	0.4	0℃~750℃	±1.5℃or measuring ±0.4% temp
				0.75	0℃~750℃	±2.5℃or measuring ±0.75% temp
T	CC	Cu	Constantan	0.4	0℃~350℃	±0.5℃or measuring ±0.4% temp
				0.75	0℃~350℃	±1.0℃or measuring ±0.75% temp
				1.5	-200℃~0℃	±1.0℃or measuring ±1.5% temp

The thermal emf-vs.-temperature curves for various commonly-used thermocouples are shown in Figure 5-6.

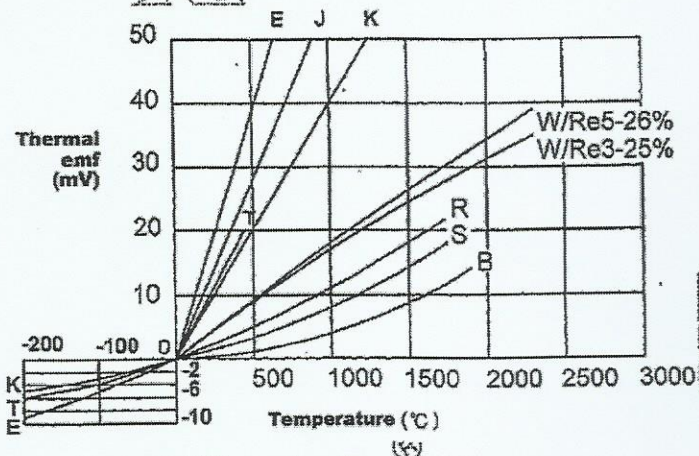


Figure 5-6 Thermal emf curve of thermocouples