

Thermocouple Reference Junction Principles

THEORY: When accurate thermocouple measurements are required, it is common practice to reference both legs to copper lead wire at the ice point so that copper leads may be connected to the EMF readout instrument. This procedure avoids the generation of thermal EMF's at the terminals of the readout instrument. Changes in reference junction temperature influence the output signal, and practical instruments must be provided with a means to cancel this potential source of error. The EMF generated is dependent on a difference in temperature, so, in order to make a measurement, the reference must be known. This is shown schematically in Figure 1 and can be accomplished by placing the reference junction in an ice water bath at a constant 0°C (32°F). Because ice baths are often inconvenient to maintain and not always practical, several alternate methods are often employed.

ELECTRICAL BRIDGE METHOD: This method usually employs a self-compensating electrical bridge network as shown in Figure 2. This system incorporates a temperature sensitive resistance element (R_T), which is in 1 leg of the bridge network and thermally integrated with the cold junction (T_2). The bridge is usually energized from a stable dc power source. The output voltage is proportional to the imbalance created between the pre-set equivalent reference temperatures at the cold junction (T_2) and the hot junction (T_1). In this system, the reference temperature of 0°C or 32°F may be chosen.

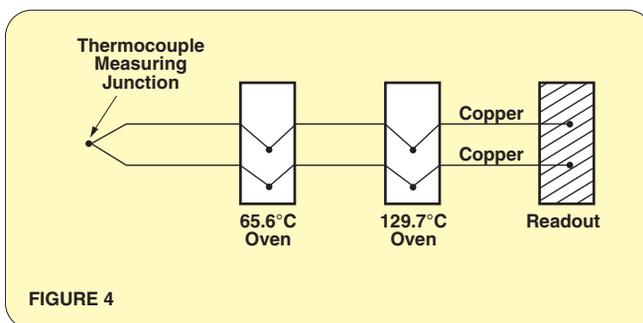
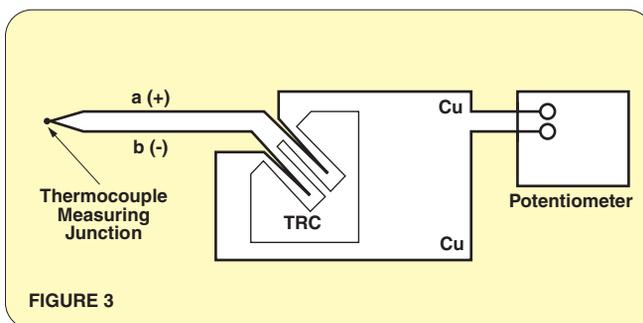
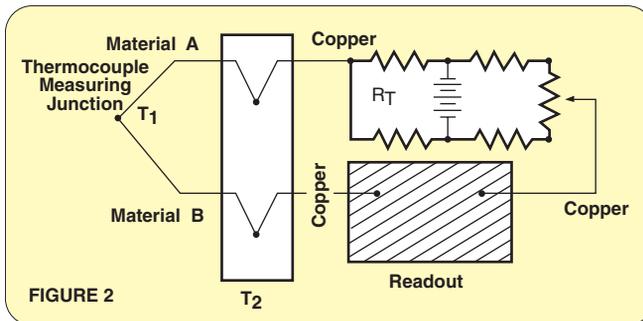
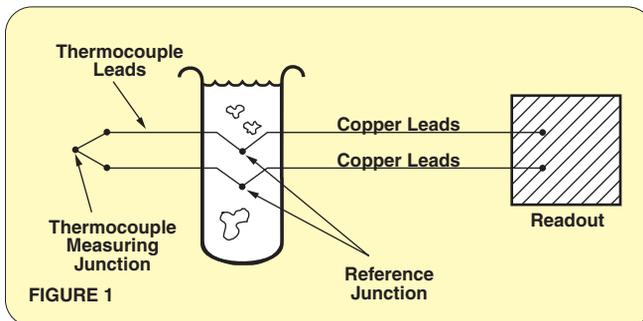
As the ambient temperature surrounding the cold junction (T_2) varies, a thermally generated voltage appears and produces an error in the output. However, an automatic equal and opposite voltage is introduced in series with the thermal error. This cancels the error and maintains the equivalent reference junction temperature over a wide ambient temperature range with a high degree of accuracy. By integrating copper leads with the cold junction, the thermocouple material itself is not connected to the output terminal of the measurement device, thereby eliminating secondary errors.

THERMOELECTRIC REFRIGERATION METHOD: The OMEGA® TRC Thermoelectric ice point™ Reference Chamber relies on the actual equilibrium of ice and distilled, deionized water and atmospheric pressure to maintain several reference wells at precisely 0°C. The wells are extended into a sealed cylindrical chamber containing pure distilled, deionized water. The chamber outer walls are cooled by thermoelectric cooling elements to cause freezing of the water in the cell. The increase in volume produced by freezing an ice shell on the cell wall is sensed by the expansion of a bellows which operates a microswitch, de-energizing the cooling element. The alternate freezing and thawing of the ice shell accurately maintains a 0°C environment around the reference wells. An application schematic is shown in Figure 3.

Completely automatic operation eliminates the need for frequent attention required of common ice baths. Thermocouple readings may be made directly from ice point reference tables, such as those listed in the technical section, without making corrections for reference junction temperature. Any combination of thermocouples may be used with this instrument by simply inserting the reference junctions in the reference wells. Calibration of other types of temperature sensors at 0°C may be performed as well.

HEATED OVEN REFERENCES: The double-oven method employs 2 temperature-controlled ovens to simulate ice-point reference temperatures as shown in Figure 4. Two ovens are used at different temperatures to give the equivalent of a low reference temperature differing from the temperature of either oven. For example, leads from a Type K thermocouple probe are connected with a 66°C (150°F) oven to produce a CHROMEAGA®-ALOMEGA® and an ALOMEGA-CHROMEAGA junction at 66°C (150°F) (2.66 mV each).

The voltage between the output wires of the first oven will be twice 2.66 mV, or 5.32 mV. To compensate for this voltage level, the output leads (CHROMEAGA and ALOMEGA) are connected to copper leads within a second oven maintained at 265.5°F. This is the precise temperature at which CHROMEAGA-Copper and ALOMEGA-Copper produce a bucking voltage of differential of 5.32 mV. Thus, this voltage cancels out the 5.32 mV differential from the first oven, leaving 0 mV at the Copper output terminals. This is the voltage equivalent of 0°C (32°F).



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