means that electrical terminals and solder connections can be used as long as both terminals are located on an isothermal block.

A thermocouple signal conditioner is illustrated in Figure 8.9. Signal conditioning of the emf output of a thermocouple has four major concerns.

1. Reference junction temperature
2. Low-level output voltage
3. Electrical noise
4. Protection from thermocouple burnout

Three techniques are used to establish the *reference junction temperature* of a thermocouple circuit without using the traditional ice water bath.

1. A constant temperature reference block is heated or cooled to remain at some specified temperature. All thermocouple outputs are terminated in the reference block. This method is practical when many thermocouples are used and there is a suitable location for the reference box. The measuring instruments can be adjusted to use any convenient reference temperature as long as its value is known and constant.
2. A compensation circuit senses the actual reference junction temperature and makes the thermocouple output behave as if the reference junction is at 0°C. Most thermocouple transmitters provide reference junction (or cold junction) compensation.
3. A digital computer makes the reference correction. In digital systems, both the thermocouple output voltage and the reference junction temperature are converted to digital form for input to a computer. The computer is programmed to compensate for the reference junction temperature when it converts the thermocouple voltage into the measured temperature.

The *low-level output voltage* of a thermocouple (see Table 8.4) is not suitable for use by a control system. A high-gain instrumentation amplifier is used to amplify the thermocouple output voltage, and a voltage-to-current converter is used to convert the amplified voltage to a 4- to 20-mA current output signal. Current signals are relatively easy to transmit, and most commercial controllers are designed to receive a current input from the measuring transmitter. Table 8.5 shows a typical output from a thermocouple transmitter.

◆ **TABLE 8.5** Typical Values for a Type J Thermocouple
Temperature Transmitter (see Exercise 8.17)

Temperature (°C)	EMF (mV)	Output Signal (mA)
0	0.00	4.00
20	1.02	5.51
40	2.06	7.06
60	3.11	8.62
80	4.19	10.22
100	5.27	11.82
120	6.36	13.44
140	7.45	15.06
160	8.56	16.71
180	9.67	18.35
200	10.78	20.00