Piping and Instrumentation Diagrams

Piping and instrumentation diagrams (PI&Ds) are used in process control to represent process control systems graphically. They use standard symbols common to all process industries. Instruments in a system are represented by circles (also called balloons). Balloons can contain numbers, lines, and letters that identify function and location in a process control system. Figure 19–8 shows some of the symbols for various types of devices. A circle represents a stand-alone instrument and is used to represent a transmitter, alarm, or sensor. If the circle is in a square, the device performs multiple functions such as measurement and display and/or control. A diamond in a square represents a PLC. A hexagon represents a computer function.

Lines within the symbols indicate how the devices are mounted (see Figure 19–8). This provides a technician with valuable information about the location and accessibility of the instrumentation. No line in the symbol means that the device is installed in the field, close to the final control element or near where the variable is being measured. A solid line indicates that the instrument is board-mounted in the control room and should be easily accessible to the operator. Double lines indicate that the device is not located by the process. A dashed line indicates that the device is behind a panel (see Figure 19–9). In this case it may be difficult to access.

Tag Numbers

Alphanumeric codes are used to provide information about the instrument for the technician. Letters appear at the top of the symbols. The first letter is used to indicate what the instrument measures, for example, P is pressure. Figure 19–10 shows

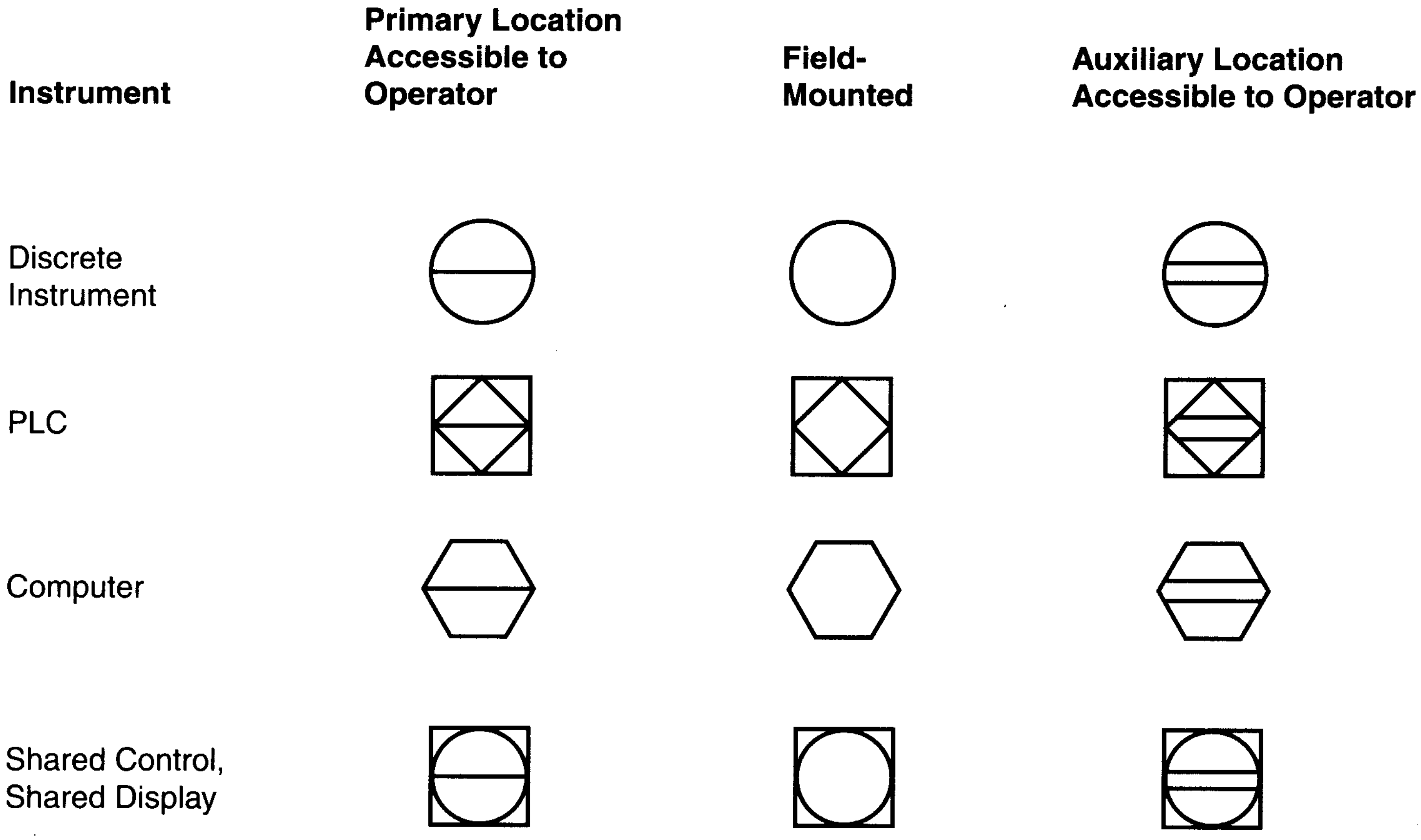

Figure 19–8 Instrument or functional symbols.

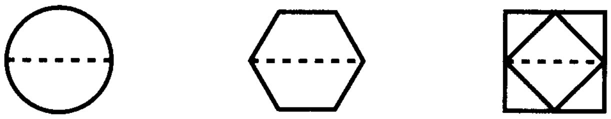

Figure 19–9 A dashed line indicates that the device may be inaccessible or behind a panel.

a list of the function identifiers. The second letter is used to indicate the actual function of the instrument; for example, a C indicates that the device is used for control. If there are three or four letters, the second letter is used to provide additional information about the first identifier; for example, PDT indicates a pressure differential (differential pressure) transmitter. A four-letter example would be PDAL, which indicates a pressure differential alarm that is activated if pressure falls too low.

	First Letter		Succeeding Letters		
	Measured or Initiating Variable	Modifier	Readout or Pasive Function	Output Function	Modifier
A	Analysis		Alarm		
B	Burner or Combustion		User's CHoice	User's CHoice	User's CHoice
C	User's Choice			Control	
D	User's Choice	Differential			
E	Voltage		Sensor		
F	Flow Rate	Ratio			
G	User		Glass Viewing DEvice		
H	Hand				High
I	Current		Indicate		
J	Power	Scan			
K	Time	Time Rate of Change		Control Station	
L	Level		Light		Low
M	User's CHoice	Momentary			
N	User's CHoice		User's CHoice	User's CHoice	User's CHoice
O	User's CHoice		Orifice Restriction		
P	Pressure or Vaccum		Point Connection		
Q	Quantity	Integrate			
R	Radiation		Record		
S	Speed or Frequency	Safety		Switch	
T	Temperature			Transmit	
U	Multivariable		Multifunction	Multifunction	Multifunction
V	Vibration or Mechanical Analysis			Valve or Damper	
W	Weight or Force		Well		
X	Unclassified	X Axis	Unclassified	Unclassified	Unclassified
Y	Event or State	Y Axis		Relay or Compute	
Z	Position or Dimension	Z Axis		Final Element, Actuator, or Driver	

Figure 19–10 Function identifiers.

Loop Identifiers

Numbers under the letters in symbols identify which process loop the device is in. A process loop contains one or more instruments used to control the process. All instruments in the loop are given the same identifier. The loop number can be used to indicate the location and specific information about a device. These numbers are often listed on the actual device to make identification easily available.

Line and Actuator Symbols

Figure 19–11 shows some of the more common symbols for different types of connection lines in a process system. Figure 19–12 shows some of the common actuator symbols.

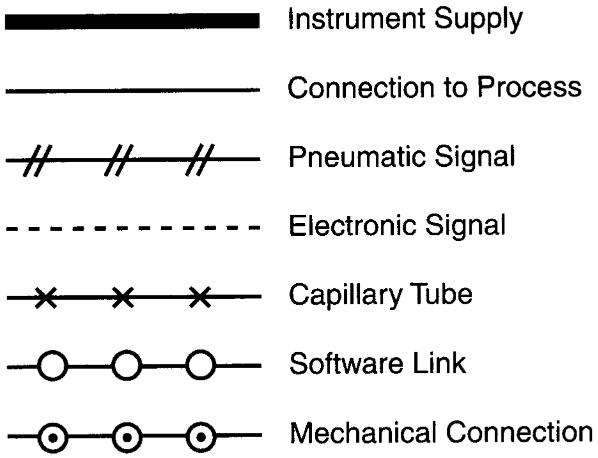

Figure 19–11 Connection line symbols.

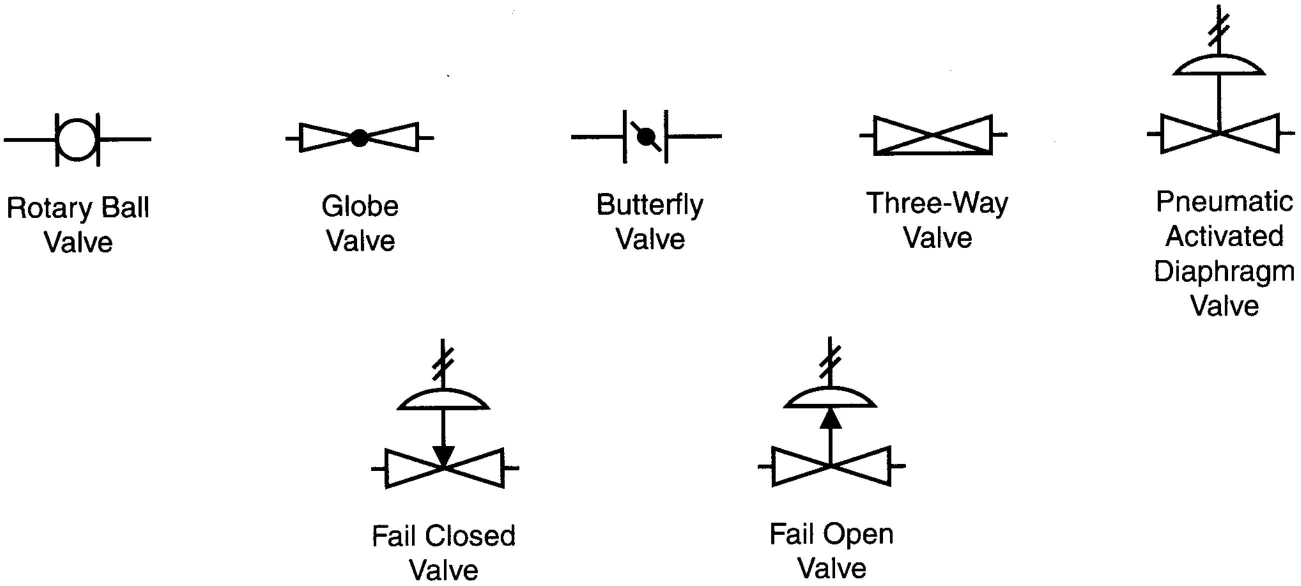

Figure 19–12 Common actuator symbols.

Flow Control System Example

Consider a system that measures differences in pressure to approximate the flow rate. If a restriction is placed in a pipe with flow, the pressure on the downstream side of the restriction will be lower than the pressure on the upstream side of the restriction. An orifice plate used in the system shown in Figure 19–13, can be used to create the pressure differential. If we measure that difference in pressure, we can approximate the flow. The higher the flow, the greater the pressure difference between the two.

The orifice plate (see Figure 19–14) is placed in the pipe. The pressure is then measured on each side of the restrictor plate; it is lower on the downstream side of the plate. One pipe is connected to the upstream side and another is connected to the downstream side. These two pipes are then connected to a device called a *differential pressure transducer (DPT).* The DPT is shown as FT-101 (flow transmitter 101) in Figure 19–13. A DPT has two inputs: a high pressure side and a low pressure side. Imagine a membrane in the center of these two pressure ports. If there is a pressure difference between the two, the membrane yields to the low pressure side. If the membrane has a strain gage, it can measure the difference in pressure. The DP then converts the strain gage signal into a 4–20 mA signal. The dotted line in the system drawing shows that the signal from FT-101 is connected to FC101 (flow controller 101). The 4–20 mA becomes the feedback signal to a controller. This measures pressure with the DPT but we really want to measure flow. This would not be a problem if a linear relationship exists between pressure and flow, but it does not. The pressure increase is the square of the flow increase. Fortunately, we can buy DPTs or signal conditioners *square root extractors* that take the pressure reading and the square root of the difference and convert the result to a 4–20 mA signal.

Next, the flow controller (FC-101) must control the flow rate. We can use a proportional valve to control the flow rate (see Figure 19–15). We have now added a proportional valve to the flow control system. The proportional valve opens between 0 and 100 percent, depending on the input it receives. The valve in this system requires a 4–20 mA input signal. At 4 mA, the valve is closed; at 20 mA, it is 100 percent open. The 4–20 mA signal is converted to air pressure to move a shaft and control the position of the valve.

Density Control Example

To explain density control, we use chocolate milk as our product. The process is quite simple: mix milk with chocolate syrup. The densities of milk and chocolate syrup are quite different. This is a good example of a density control system. Accomplishing this task requires measuring and controlling the density of the product. First, we mix batches until we find the perfect taste. Then we measure the density of the perfect batch and use that as our setpoint.

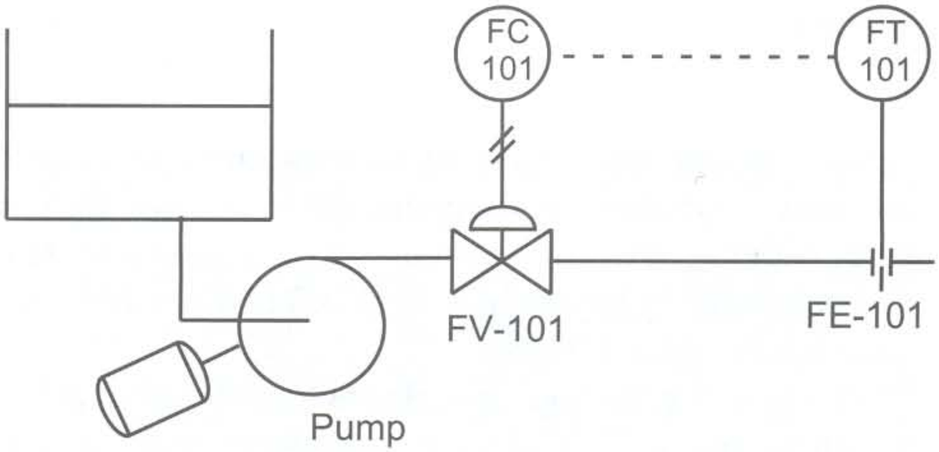

Figure 19–13 Measurement of flow rate by differential pressure measurement.

Figure 19–14 Orifice plate.

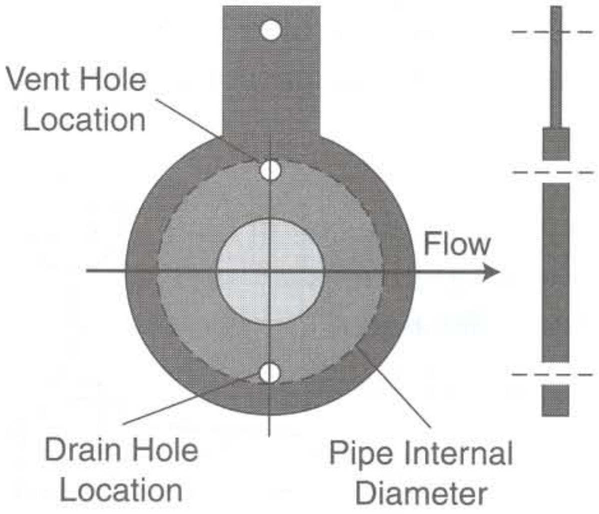

Figure 19–15 Proportional valve.