Key Terms

Balloon—the basic instrumentation symbol.

Basic equipment symbol—common equipment such as pumps, towers, furnaces, etc. are basic pieces of equipment for most processing facilities and have commonly recognizable, or basic, equipment symbols.

Block flow diagram (BFD)—a flow scheme in a simple sequential block form.

International Society of Automation (ISA)—a global, nonprofit technical society that develops standards for automation, instrumentation, control, and measurement.

Legend—an explanation of what the symbols and codes on a drawing represent; usually located on an individual drawing in a framed area or on a page within a set of drawings.

Line symbols—connectors between the basic pieces of equipment without which process streams could not be moved.

Piping and instrumentation diagram (P&ID)—contains more detail than a PFD to include piping and instrumentation details and the entire control system.

Process flow diagram (PFD)—a pictorial description of an actual process including the major process equipment while providing process information including the heat and material balances; usually developed when initiating the design of a new plant.

Symbology—various graphical representations used to identify equipment, lines, instrumentation, or process configurations

Introduction to the Process Diagrams

The three most likely drawing that a process technician uses are the following:

- Block flow diagram
- Process flow diagram
- Piping and instrumentation diagram

A **block flow diagram (BFD)** shows the flow scheme in a simple sequential block form. Not all, but most block flow diagrams show flow from left to right and tend not to cross over lines any more than necessary.

A **process flow diagram (PFD)** pictorially describe the actual, including the major process equipment, and may provide process variable as well as heat and material balance information. This is one of the first documents developed when initiating tye design of a new plant. The material balance is used in all further flow calculations including main process pumps and compressors, vessels, etc.

A **piping and instrumentation diagram (PID)** is similar to a PFD but contains no process information but much more detail including instrumentation and the entire control system. These drawings provide the basic mechanical design details and operating philosophy for the plant.

Block flow diagram (BFD)

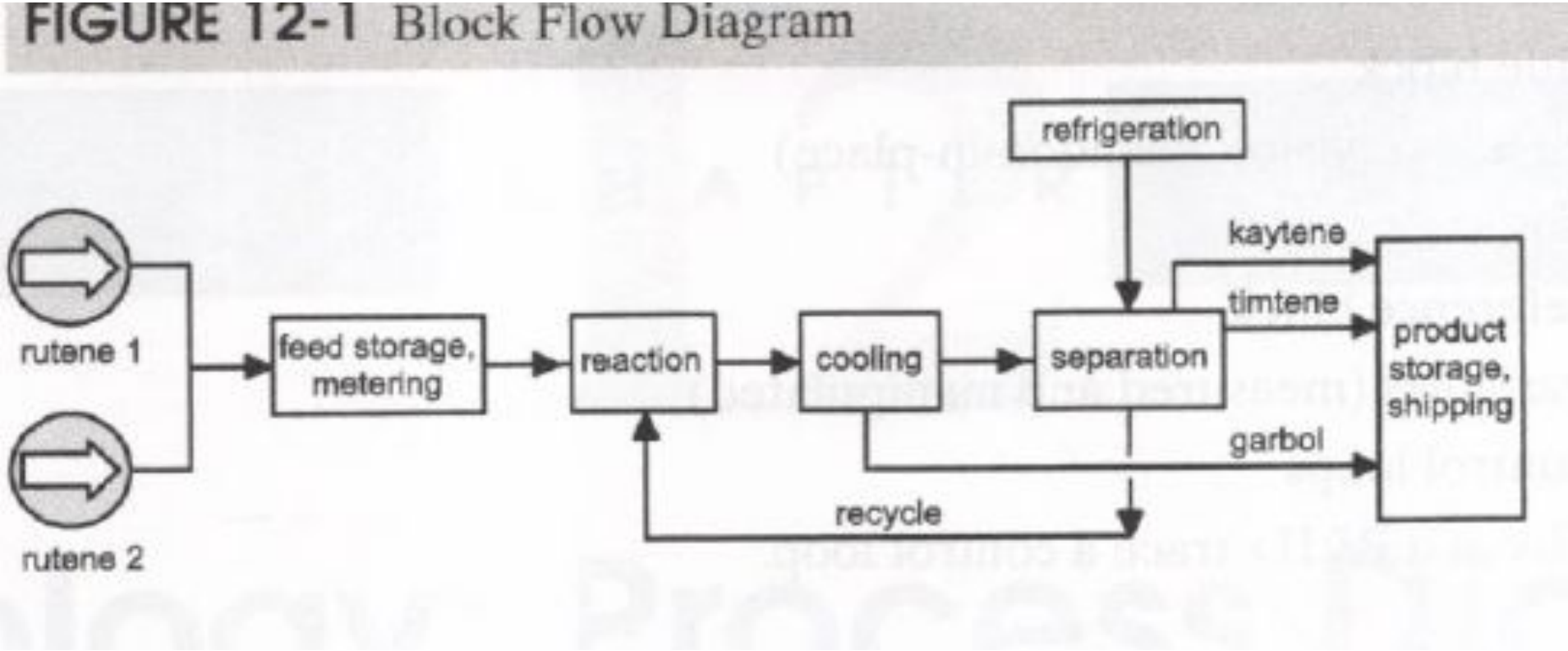
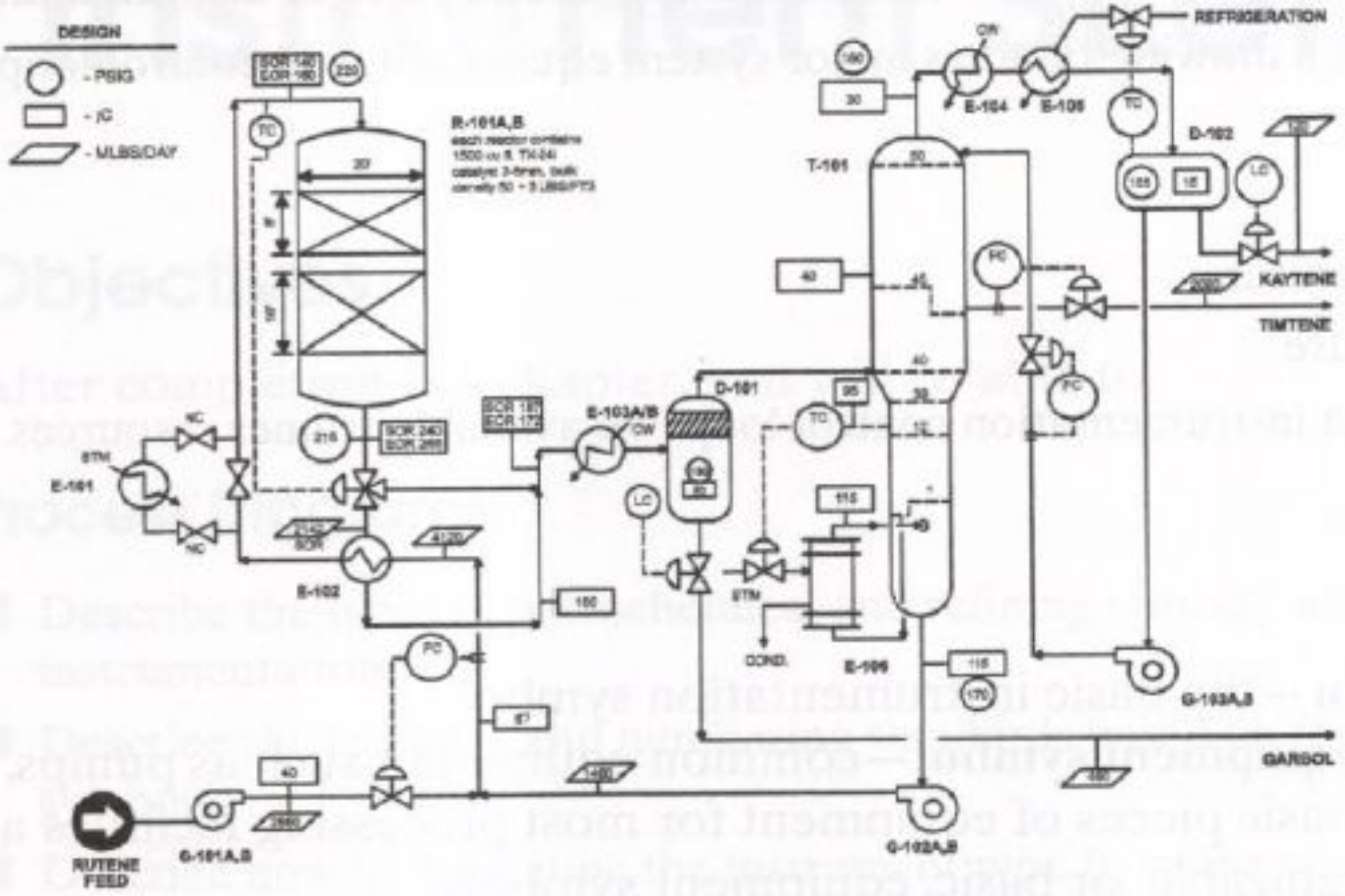
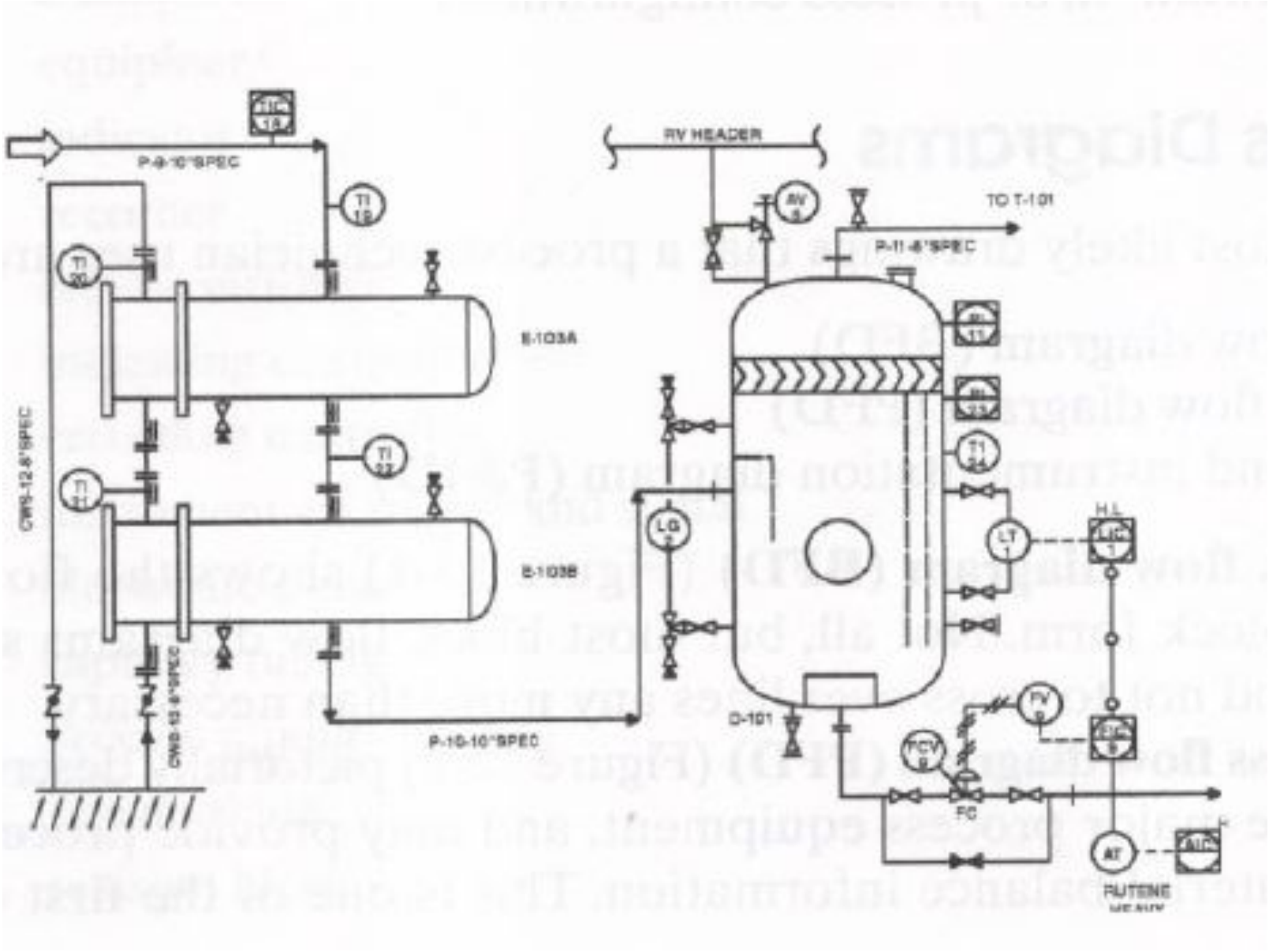


FIGURE 12-2 Process Flow Diagram



Piping and instrumentation diagram (PID)



All PFDs and P&IDs should have an associated legend. A legend is an explanation of what the symbols and codes represent. The legend may be located in a small box or area located in the margin of the drawing or it may be so large that it occupies an entire page.

The PFD primarily illustrates the flow of material through the process. To do this, a PFD must include process equipment and piping symbols. PFDs may also include process flow notations and even some instrumentation. Generally, any piece of equipment that moves fluids or comes in direct contact with the flowing process is on the PFD.

The P&ID by comparison has the most of the items as a PFD with the addition of the control instrumentation and considerable mechanical details. A P&ID shows the entire control loop in proximity to the field instrumentation. Again, this is the a schematic representation of the loop, not drawing. A P&ID does not represent the actual physical placement of the components as they are situated within a plant or unit.

ISA Instrument Tag Number

- An instrument tag number should identify the measured variable, the function of the specific instrument, and the loop number. Accordingly, ISA instrument tag number is described with both letters and numbers and should be unique since most plants now use a global database to identify devices.
- The first letter identifies the measured or initiating variable and the following letter describe the function of the instrument. Loop numbers are unique numbers assigned locally by the plant –engineering group. If loop has more than one instrument in the loop with the same functional identification, then suffix is added.

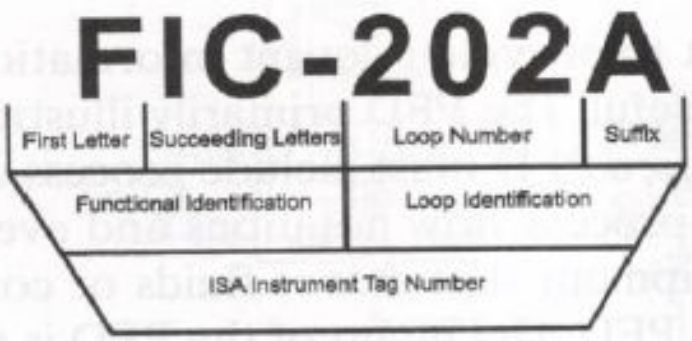


FIGURE 12-6 Instrument Tag Number

TABLE 12-1 ISA Table 1–Identification Letters

	FIRST-LETTER		*SUCCEEDING-LETTERS*		
	Measured or Initiating Variable	***Modifier***	***Readout or Passive Function***	***Output Function***	***Modifier***
A	Analysis		Alarm		
B	Burner, Combustion		User's Choice	User's Choice	User's Choice
C	User's Choice			Control	
D	User's Choice	Differential			
E	Voltage		Sensor (Primary Element)		
F	Flow Rate	Ratio (Fraction)			
G	User's Choice		Glass, Viewing Device		
H	Hand				High
I	Current (Electric)		Indicate		
J	Power	Scan			
K	Time, Time Schedule	Time Rate of Change		Control Station	
L	Level		Light		Low
M	User's Choice	Momentary			Middle, Intermediate
N	User's Choice		User's Choice	User's Choice	User's Choice
O	User's Choice		Orifice, Restriction		
P	Pressure, Vacuum		Point (Test) Connection		
Q	Quantity	Integrate, Totalize			
R	Radiation		Record		
S	Speed, Frequency	Safety		Switch	
T	Temperature			Transmit	
U	Multivariable		Multifunction	Multifunction	Multifunction
V	Vibration, Mechanical Analysis			Valve, Damper, Louver	
W	Weight, Force		Well		
X	Unclassified	X Axis	Unclassified	Unclassified	Unclassified
Y	Event, State or Presence	Y Axis		Relay, Compute, Convert	
Z	Position, Dimension	Z Axis		Driver, Actuator, Unclassified Final Control Element	

TABLE 12-2 Instrument Tag Examples

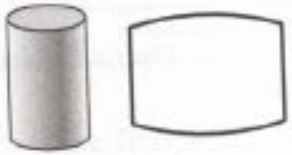
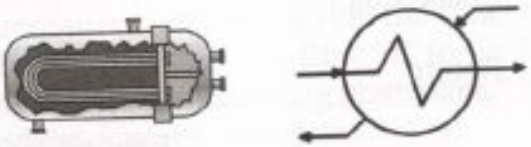
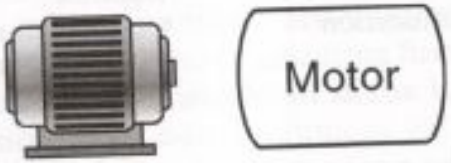
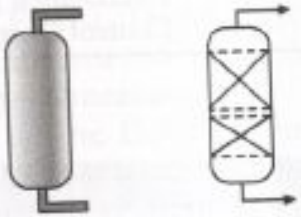
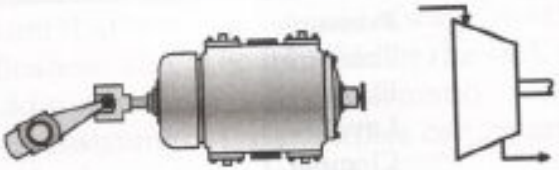
Letters	*Functional Interpretation*
P	Pressure
T	Temperature
F	Flow
L	Level
E	Element
I	Indicator
C	Controller
CV	Control Valve
Y	Transmitter/Transducer
R	Recorder
PT	Pressure Transmitter
TT	Temperature Transmitter
FRC	Flow Recording Controller

TABLE 12-2 *Continued*

PIC	Pressure Indicating Controller
LV	Level Valve (preferred way of identifying a control valve in a loop; may also be expressed as PV, FV, TV)
PY	Pressure Relay or Compute (convert) (e.g., could be an I/P transducer in a pressure loop)
TE	Temperature Element (e.g., could be a thermocouple, RTD, or filled thermal system)
LI	Level Indicator
PC	Pressure Controller (since this controller does not have an indicator or recorder function, it would probably be behind the panel out of the sight of the operator)
FFIC	A Flow (Ratio) Indicating Controller

Basic equipment symbols

TABLE 12-3 Basic Equipment Symbols

Equipment Symbol	*Equipment Name*
	Tank
	Heat Exchanger
	Motor
	Pump and Motor
	Tower or Column
	Compressor

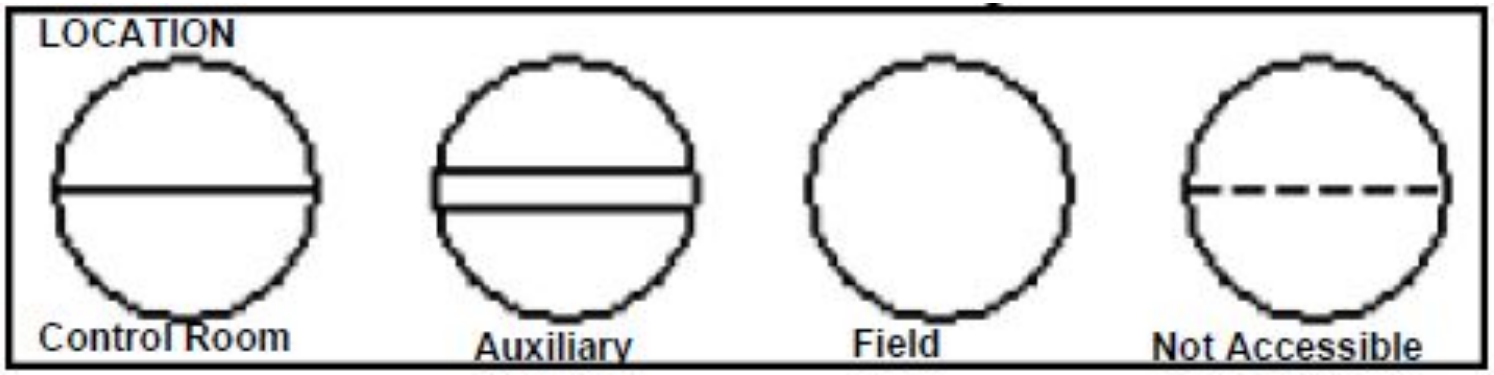
Standard Line symbols

TABLE 12-4 Standard Line Symbols

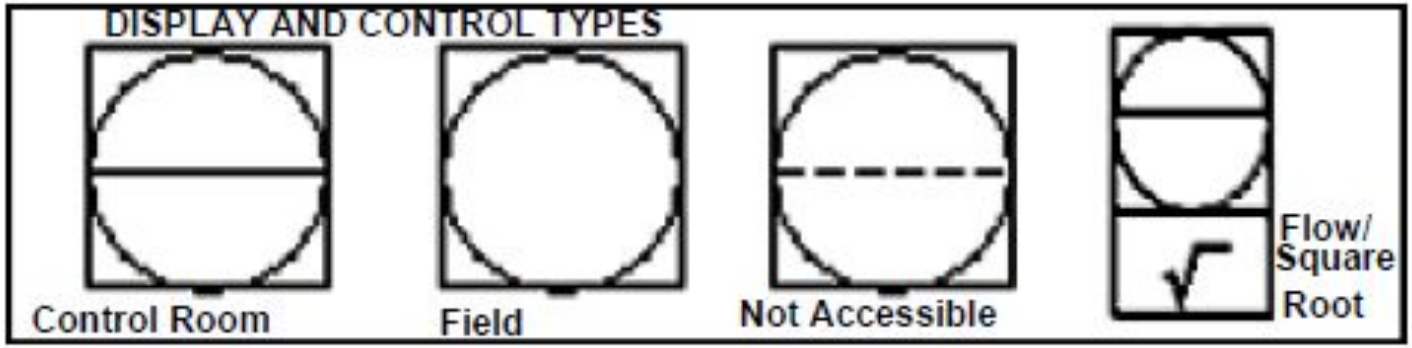
Line Symbol	*Line Type*
	Pneumatic Signal
	Electrical Signal
	Electomagnetic or Sonic Signal
	Capillary Tubing
	Hydraulic Signal
	Software Link
	Connection to Process; Secondary Line; Utility Line
	Process Line
	Mechanical Link

SYMBOLS

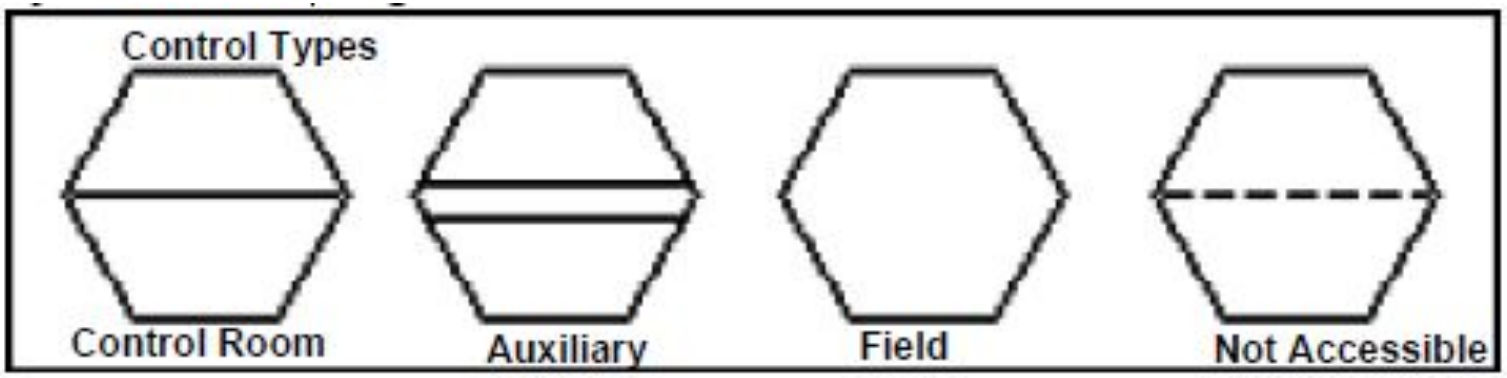
In a P&ID, a circle represents individual measurement instruments, such as transmitters, sensors, and detectors



A square with a circle inside represents instruments that both display measurement readings and perform some control function

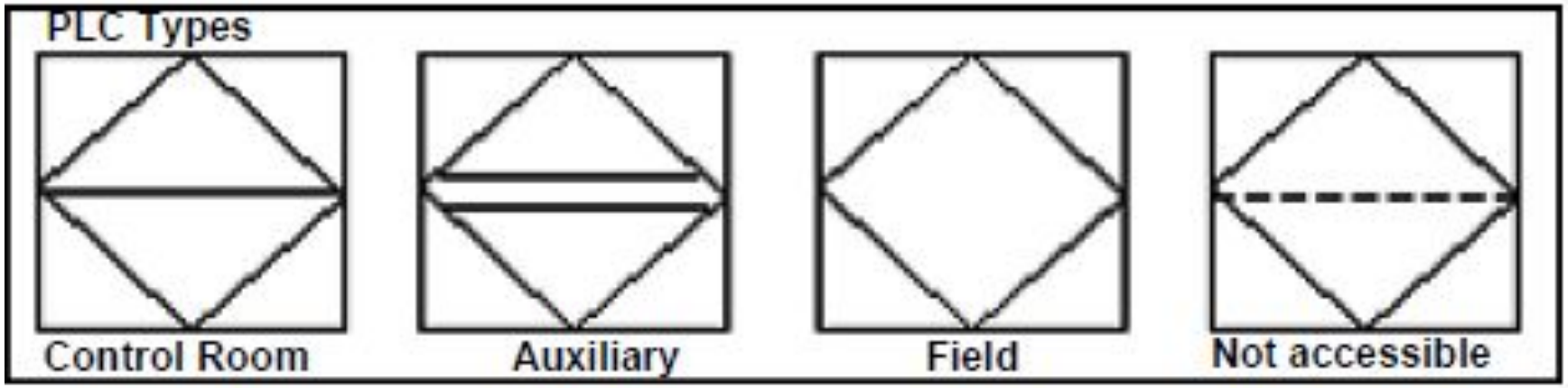


A hexagon represents computer functions, such as those carried out by a controller



Computer Functions (Controllers)

A square with a diamond inside represents PLCs



PLCs

FIGURE 12-7 Legend Example for Instrument Balloon Interpretation

GENERAL INSTRUMENT SYMBOLS - BALLOONS

LOCATION / DESCRIPTION	CONTROL ROOM INSTRUMENTS	LOCALLY MOUNTED INSTRUMENTS	LOCAL BOARD MOUNTED INSTRUMENTS
DISCREET INSTRUMENT			
PURPOSE / DESCRIPTION	DISPLAY	FUNCTION	
COMPUTER SYSTEM (FOX1A)			
PROGRAMMABLE LOGIC CONTROLLER			
DISTRIBUTED CONTROL SYSTEM			
MACHINERY HEALTH MONITORING SYSTEM (HP 10000 COMPUTER)			

NORMALLY INACCESSIBLE OR BEHIND THE PANEL DEVICES OR FUNCTIONS MAY BE DEPICTED BY USING THE SAME SYMBOLS BUT WIH DASHED HORIZONTAL BARS,I.E.

* PANEL DEVICES LOCATED ON DCS CONTROLES

EXAMPLE OF INSTRUMENT BUBBLE ATTRIBUTE

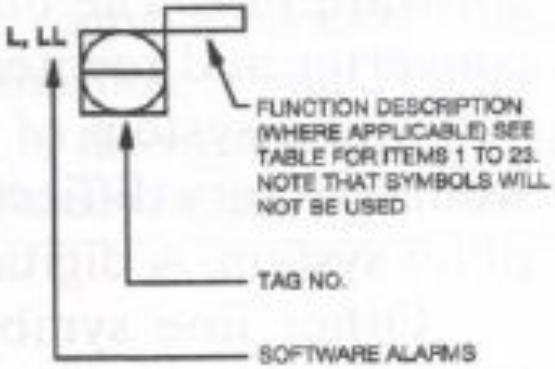


TABLE 12-5 Instrument Balloon Symbols

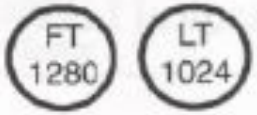
Balloon Variation	*Interpretation*
No lines in balloon 	A field-mounted instrument.
A solid line through it 	A board-mounted instrument
Two parallel lines through it 	Located in an auxiliary location, usually on a control panel located in the processing area
A broken line through it 	Located behind the panel board, or at least is not readily accessible
A box around it 	Digital Control Systems (DCS) or computer interface

TABLE 12-6 Instrument Balloon Symbol Examples

Balloon Variation	*Interpretation*
	FLOW
	Flow Controller
	Flow Element
	Flow Indicator
	Flow Recorder
	Flow Transmitter
	LEVEL
	Level Alarm High (LAH) ("H" for High)
	Level Indicator Controller
	Level Gauge, field mounted
	Level Indicator, field mounted
	Level Recorder, board mounted
	Level Transmitter

PRESSURE	
PAH	Pressure Alarm High (PAH or PHA), panel mounted
PIC 60	Pressure Controller, board mounted
PI	Pressure Indicator, field mounted
PIC 100	Pressure Indicating Controller, board mounted
PR 50	Pressure Recorder, board mounted
PCR 90	Pressure Recording Controller, board mounted
PT 45	Pressure Transmitter, board mounted

TABLE 12-6 *Continued*

TEMPERATURE	
TC	Temperature Controller
TE	Temperature Element
TI	Temperature Indicator
TR	Temperature Recorder
TT	Temperature Transmitter

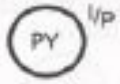
pH Analyzer Transmitter

I/P and P/I Converters convert a current signal to a pneumatic signal so a Distributed Control System (DCS), Programmable Logic Control (PLC), or Personal Computer (PC) can control a valve or actuator; may also convert a pneumatic signal to current so remote pneumatic devices can interface with electronic instruments and computer based monitoring systems.

E/P transducers convert electrical signals to equivalent pneumatic signals and they are commonly used in the field to supply instrument air to field control elements.

Temperature transducer—transducer electronic to pneumatic symbol used to activate a pneumatic positioner on a valve for a temperature loop.

Level transducer—transducer electronic to pneumatic symbol used to activate a pneumatic positioner on a valve for a pressure loop.



Pressure transducer—transducer to pneumatic symbol used to activate a pneumatic positioner on a valve for a pressure loop.

Flow transducer—transducer, isolator and converter; current to voltage.

TABLE 12-7 Pressure

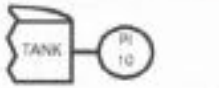
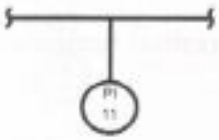
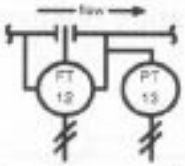
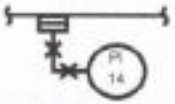
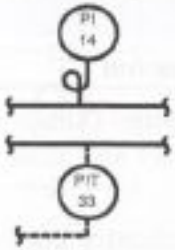
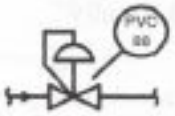
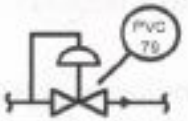
Symbol Variation	*Interpretation*
	A Pressure Indicator directly connected to a tank/vessel
	A Pressure Indicator connected to process piping
	A Pressure Transmitter connected via piping to a low-pressure lead coming off a Flow Transmitter
	A Pressure Indicator connected to a special type of chemical seal to protect the instrument from the process fluid (capillary)
	A Pressure Indicator connected to process piping where a siphon is installed Pressure element, strain-gauge type, connected to pressure indicating transmitter (TAG Strain Gage PE-33)
	Back-pressure regulator, self-contained with handwheel adjustable setpoint
	Pressure-reducing regulator, self-contained
	Backpressure regulator with external pressure tap

TABLE 12-8 Temperature

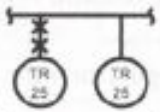
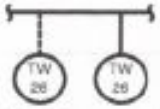
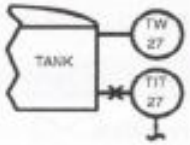
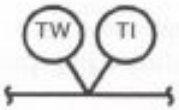
Symbol Variation	*Interpretation*
	A local Temperature Recorder, filled thermal system and thermowell connected to process piping
	A local Temperature Recorder, thermocouple, or RTD and thermowell connected to process piping
	A Temperature Indicating Transmitter and filled thermal system connected to a tank/vessel and thermowell
	A Temperature Transmitter of the thermal radiation type using an optical pyrometer connected to a furnace fire box
	A bimetallic thermometer (Temperature Indicator) inserted in a thermowell in process piping

TABLE 12-8 *Continued*

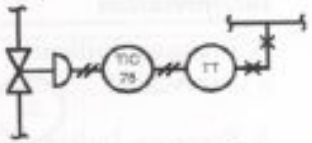
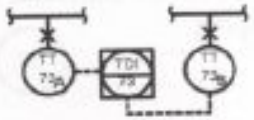
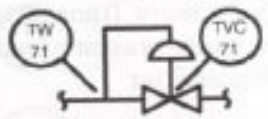
	A temperature indicating controller
	Differential temperature indicator
	Temperature regulator capillary, filled-system type

TABLE 12-9 Level

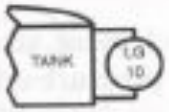
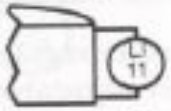
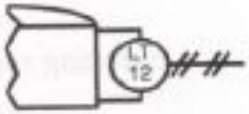
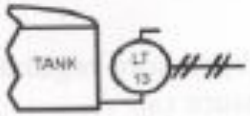
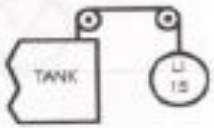
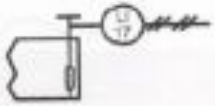
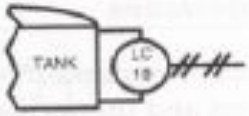
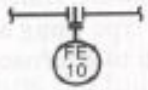
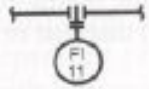
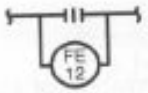
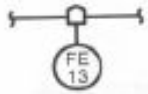
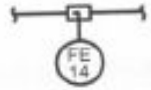
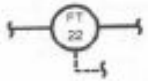
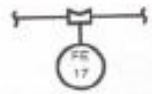
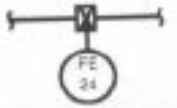
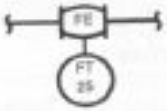
Symbol Variation	*Interpretation*
	Level Gauge (gauge glass) connected to a tank/vessel and read visually
	Level Indicator connected to a tank/vessel and read locally
	Level Transmitter connected to a tank/vesse and read remotely
	Level Transmitter (low side vented) connected to a tank/vessel and read remotely
	Level Indicator (gauge board—float actuated) connected to a tank/vessel and read locally
	Level Recorder/Level Electronic (bubble tube direct connect to final device) connecte to a tank/vessel and read remotely
	Local Controller (piped direct) connected t a tank/vessel and read remotely
	Level regulator with mechanical linkage

TABLE 12-10 Flow

Symbol Variation	*Interpretation*
	Flow Element (orifice plate with flange/ corner taps) installed in piping
	Flow Indicator (orifice plate with flow indicator) installed in piping
	Flow Element (orifice plate with vena contracta radius or pipe taps) installed in piping
	Flow Element (orifice plate in quick change fitting) installed in piping
	Flow Element (pitot tube) installed in piping
	Flow Element (venturi or flow nozzle) installed in piping
	Flow Transmitter installed in piping
	Flow Quantity Indicator
	Flow Element (weir) installed in piping
	Flow Element (flume) installed in piping

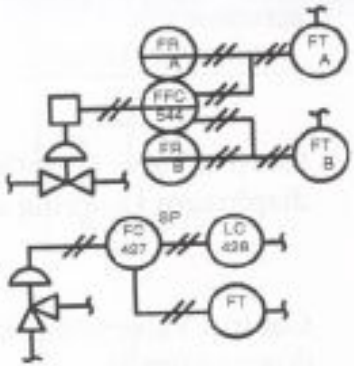


Flow Element (turbine or propeller type primary element) installed in piping



Flow Target (meter) installed in piping

Rotameter (variable area flow indicator) installed in piping



Flow-ratio controller with two pens to record flow

Cascade control

TABLE 12-11 Final Control Elements (Valve Bodies)

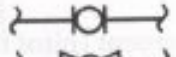
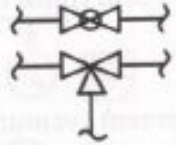
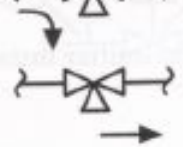
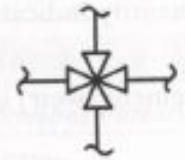
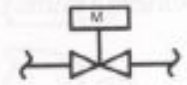
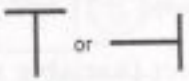
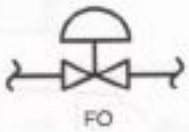
Symbol Variation	*Interpretation*
	General symbol for valve (ON/OFF only)
	General symbol for angle valve NOTE: ISA uses connected triangles.
	General symbol for butterfly valve
	General symbol for globe valve
	Ball (Rotary) Valve
	General symbol for three-way valve NOTE: ISA uses connected triangles.
	3-Way Valve (Fails to Bottom)
	3-Way Valve (Fails Straight)
	General symbol for four-way valve NOTE: ISA uses connected triangles.
	General symbol for diaphragm valve
	General symbol for a motor-operated valve

TABLE 12-12 Actuator Symbols

Symbol Variation	*Interpretation*
	Hand actuator or handwheel
	Diaphragm, spring-opposed, or unspecified actuator
	Control Valve (Fail Open) (straight through diaphragm vs. spring actuator)
	Control Valve (Alternate) (Fails Open) (pu down to open)
	Control Valve (Fail Closed) (straight throug diaphragm vs spring actuator)
	Control Valve (Alternate) (Fails Closed) (push down to open)
	Butterfly Control Valve (Fails Open)

Butterfly Control Valve (Fails Closed)

Butterfly Control Valve (Alternate) (Fails Closed) (push down to open)

Butterfly Control Valve (Alternate) (Fails Open) (push down to close)

Control Valve Actuator with Positioner

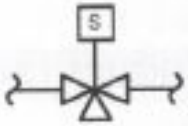
Actuator (Diaphragm vs diaphragm)

Actuator (Piston)

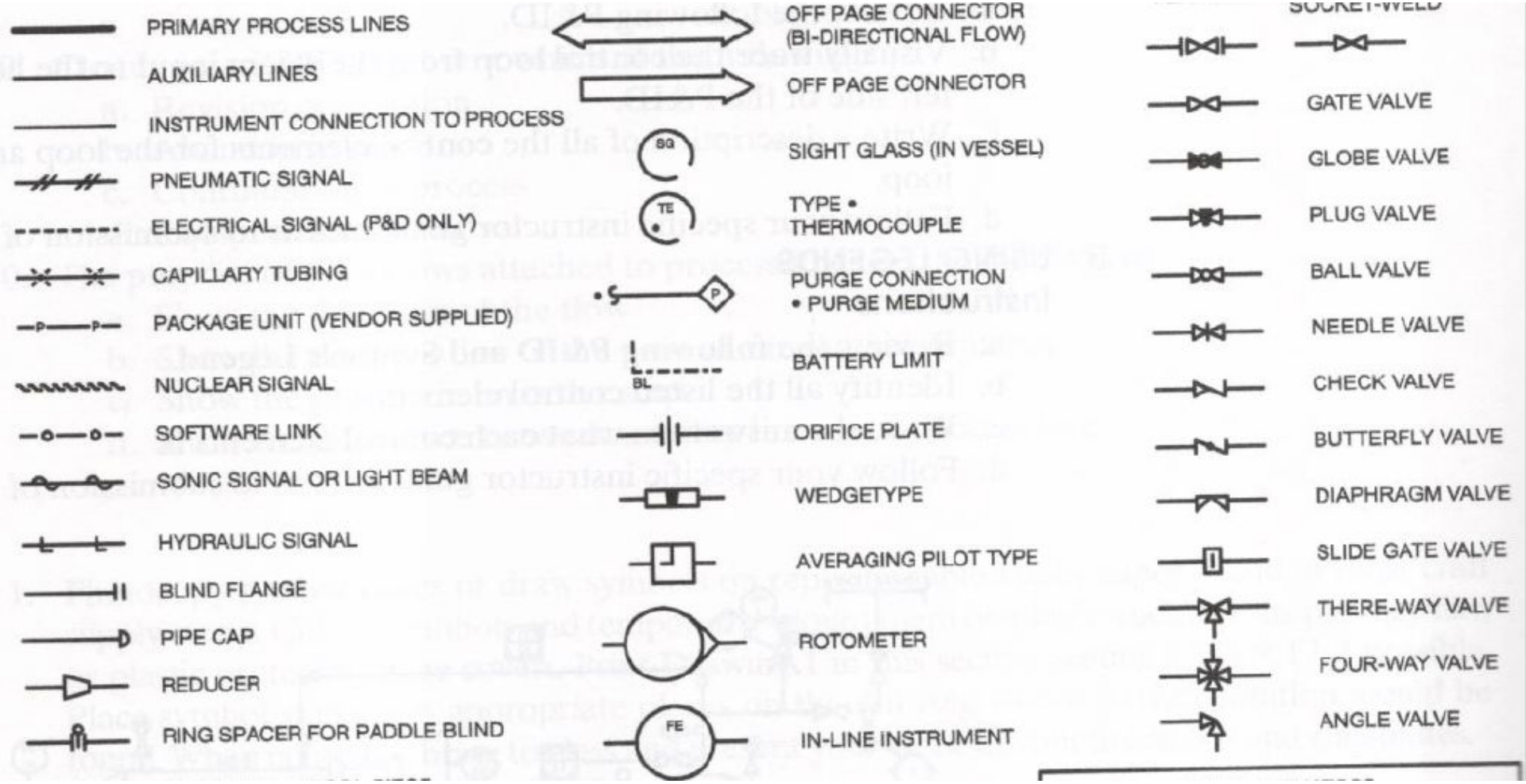
NOTE: ISA draws the piston from side to side on the box.

Actuator (Double-acting Piston)

NOTE: ISA draws the piston from side to side on the box.



Three-way Solenoid Valve


PRIMARY PROCESS LINES
AUXILIARY LINES
INSTRUMENT CONNECTION TO PROCESS
PNEUMATIC SIGNAL
ELECTRICAL SIGNAL (P&D ONLY)
CAPILLARY TUBING
PACKAGE UNIT (VENDOR SUPPLIED)
NUCLEAR SIGNAL
SOFTWARE LINK
SONIC SIGNAL OR LIGHT BEAM
HYDRAULIC SIGNAL
BLIND FLANGE
PIPE CAP
REDUCER
RING SPACER FOR PADDLE BLIND
OFF PAGE CONNECTOR (BI-DIRECTIONAL FLOW)
OFF PAGE CONNECTOR
SG
SIGHT GLASS (IN VESSEL)
TE
TYPE •
THERMOCOUPLE
P
PURGE CONNECTION
• PURGE MEDIUM
BL
BATTERY LIMIT
ORIFICE PLATE
WEDGETYPE
AVERAGING PILOT TYPE
ROTOMETER
FE
IN-LINE INSTRUMENT
SOCKET-WELD
GATE VALVE
GLOBE VALVE
PLUG VALVE
BALL VALVE
NEEDLE VALVE
CHECK VALVE
BUTTERFLY VALVE
DIAPHRAGM VALVE
SLIDE GATE VALVE
THERE-WAY VALVE
FOUR-WAY VALVE
ANGLE VALVE

REMOVABLE SPOOL PIECE

SPECIFICATION BREAK

SPECTACLE BLIND
(NORMALLY OPERATING POSITION)

FLEXIBLE HOSE

PROCESS DRAIN TO SEWER

RAINWATER DRAIN

VORTEX BREAKER

"T" & "Y" STRAINER

EXPANSION JOINT

STEAM TRAP
•• - TYPE NUMBER

INSTRUMENT CHEMICAL SEAL

VENTURI OR FLOW NOZZLE

VORTEX METER

FLAME ARRESTER

STEAM TRACED INSTRUMENT
INCLUDING IMPULSE LINES

SIGHT FLOW INDICATOR

RELIEF VALVE

TURBINE METER

DIAPHRAGM
CONTROL VALVE;
FO - FAIL OPEN
FC - FAIL CLOSED
FIP - FAIL IN PLACE

MISCELLANEOUS

INTERLOCK TO
ELECTRICAL CIRCUIT

LOGIC FUNCTION (AND,
NAND, OR, NOR, ETC)

PURGE

CONTROL LOOP
SELECTOR SWITCH

DIAPHRAGM SEAL

INDICATOR LIGHT
(GREEN) COLOR ABB:
B, G, R, W, Y

INTEGRALLY MOUNTED
GAGE GLASS ON
SIGHT GLASS

VALVE ACTUATORS

PNEUMATIC SPRING
DIAPHRAGM

PISTON OPERATED

ACTUATORS WITH
HANDWHEEL

MOTOR OPERATED

SOLENOID

SOLENOID WITH RESET

MANUAL HAND JACK

ROTARY MOTOR
ACTUATOR

ELECTRO - HYDRAULIC
ACTUATOR