

P&ID stands for Piping and Instrumentation Diagram or Drawing. Alternatively, it could also be called Process and Instrumentation Diagram or simply P&I diagram or drawing. P&IDs are also known as Engineering Flow Diagrams or Mechanical Flow Diagrams. P&IDs are often used in the process industry to show the process flow and other installed equipment and instruments. They show the interconnection of process equipment and the instrumentation used to control the process.

The Piping & Instrumentation Diagrams (P&ID) Handbook

Piping and Instrumentation Diagrams play a crucial role in the design and engineering of process plants and piping systems. P&IDs are schematic diagrams that contain engineering and design details of the process plants. It is a pictorial representation of:

- Key Piping and Instrument Details
- Control and Shutdown Schemes
- Safety and regulatory requirements and
- Basic Start-up and Operational Information

A P&ID is a working document that is used by every discipline involved in the design, engineering and construction of process plants. It is used as a Process Plant Layout and Piping Design reference for checking engineering and design documents and drawings associated with a project.

Control System Documentation: Applying Symbols and Identification:

1. P&IDs are also used in material take-off, in generating a “Bill of Materials” for procurement and construction. P&IDs typically contain the following information:
2. All the equipment and their specifications, usually presented in the form of a table
3. All piping and line specifications
4. All piping system components such as fittings, flanges and valves with their specifications
5. All instrumentation and control components
6. Flow directions
7. Information on process variables such as pressure and temperature.
8. Material Specifications
9. Specialty Items such as strainers.
10. Control Input and Output, Interlocks and Alarm System
11. Interconnections References
12. Computer Control System input
13. Identification of Components and Subsystems Delivered To and By Others

P&IDs play very important roles in plant maintenance and modification in that they demonstrate the physical sequence of equipment and system as well as how they all connect. During the Design stage they provide the basis for the development of system control schemes, allowing for further safety and operational investigations like HAZOP (Hazards and Operability Study).

The Piping & Instrumentation Diagrams (P&ID) Handbook

ISA P&ID Symbols:

In the process industry, a standard set of symbols are used to prepare piping and instrumentation diagrams (P&IDs). Most of the P&ID drawings you may come across have instrument symbols based on ISA standard S5.1 (ISA stands for Instrumentation Systems and Automation Society).

Let us start by understanding the ISA standard symbols for developing P&ID drawings

ISA S5.1 defines four general symbols for identifying instruments on a Piping and instrumentation diagram (P&ID). They are:

- (a) Discrete instruments
- (b) Shared control/display
- (c) Computer function
- (d) Programmable logic controllers

These distinct symbols used in P&IDs are grouped into three location categories namely:

- (a) Primary location usually a central control room

- (b) Auxiliary location possibly a local panel in the field or process plant
- (c) Field mounted

The Piping & Instrumentation Diagrams (P&ID) Handbook

On P&ID drawings, individual instruments are indicated by circular symbols or circle. Shared control/display elements are circles surrounded by a square. Computer functions are indicated by a hexagon and programmable logic controller function are shown as a diamond inside a square

Adding a single horizontal bar across any of the four graphical elements indicates the function resides in the primary location category. A double line indicates an auxiliary location, and no line places the device or instrument in the field. Devices located behind a panel-board in some other inaccessible location are shown with a dashed line.

Control System Documentation: Applying Symbols and Identification:

The table below gives a brief description of the four general P&ID symbols used in instrumentation diagrams.

	Central Control Room		Auxiliary Location		Field Mounted Instrument
	Accessible to Operator	Behind the panel or otherwise inaccessible to Operator	Accessible to Operator	Behind the panel or otherwise inaccessible to Operator	
Discrete Instruments					
Shared Hardware Shared Display, Shared Control					
Software Computer Function					
Shared Logic Programmable Logic Control					

See common P&ID symbols used in developing instrumentation diagrams for details on the various symbols used in P&ID drawings

Letter and number combinations appear inside each graphical element and letter combinations are defined by the ISA standard. Numbers are user assigned and schemes vary. while some companies use sequential numbering, others tie the instrument number to the process line number, and still others adopt unique and sometimes unusual numbering systems.

The first letter defines the measured or initiating variables such as Analysis (A), Flow (F), Temperature (T), etc. with succeeding letters defining readout, passive, or output functions such as Indicator (I), Recorder (R), Transmitter (T), and so forth

The table below gives a breakdown of the various letters used in Piping and instrumentation diagrams (P&IDs) and their functions:

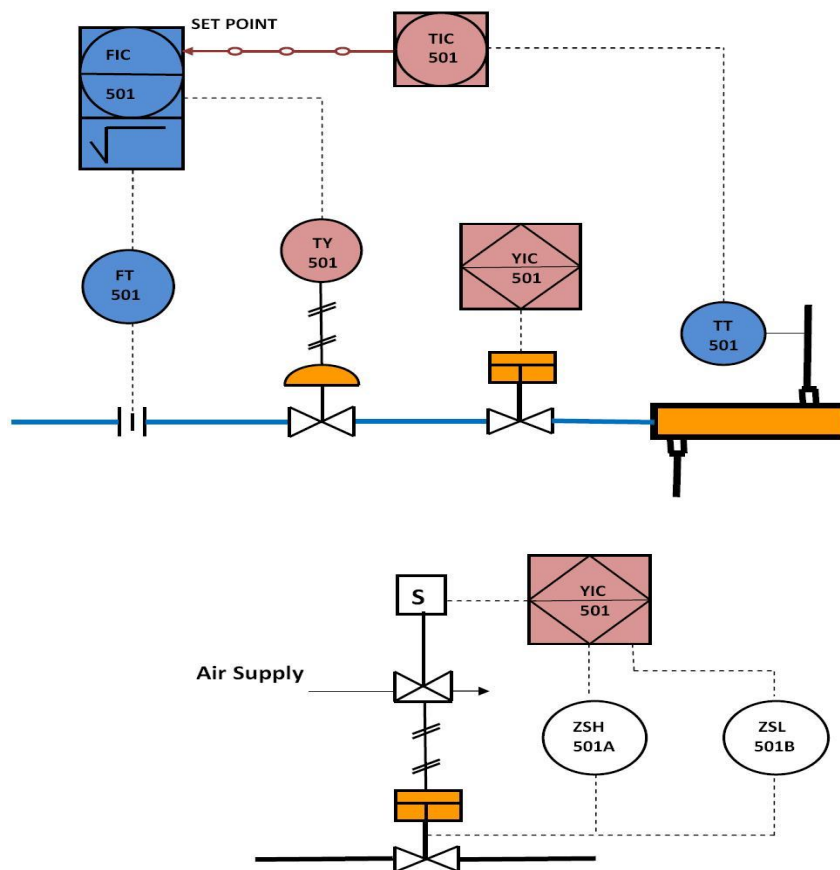
ISA SYMBOLS AND LETTERING

	MEASURED VARIABLE	MODIFIER	READ OUT	DEVICE 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	Electrical Current		Indication		
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	User's choice
O	User's choice		Orifice, restriction		
P	Pressure, vacuum		Pressure, vacuum Point, test connection		
Q	Quantity	Integrate, totalizer			
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	

To understand better how various letter combinations are used in constructing instrument letter abbreviations found on Piping and instrumentation diagram symbols in P&ID drawings, check out:

Let us consider some P&IDs in order to learn how to read and interpret them.

P&ID Drawing 1:



As shown in the P&ID, FT 501 is a field mounted flow transmitter connected via electrical signals (dotted lines) to a flow indicator and controller, FIC 501 located in the control room. Please note that a square root extraction of the input signal is applied as part of the functionality of FIC 501. This is because flow is proportional to the square root of the differential pressure being measured by the flow transmitter. To make flow proportional to differential pressure, the square root has to be extracted.

Control System Documentation: Applying Symbols and Identification:

The output of FIC 501 is an electrical signal to TY 501 (an I/P converter) mounted in the field. The output of TY 501 is a pneumatic signal which acts on the control valve connected to it.

TT 501 and TIC 501 are respectively temperature transmitter and temperature indicator and controller measuring, indicating and controlling temperature. The output of TIC 501 is connected through an internal software or data link (lines with bubbles) to the set point of FIC 501

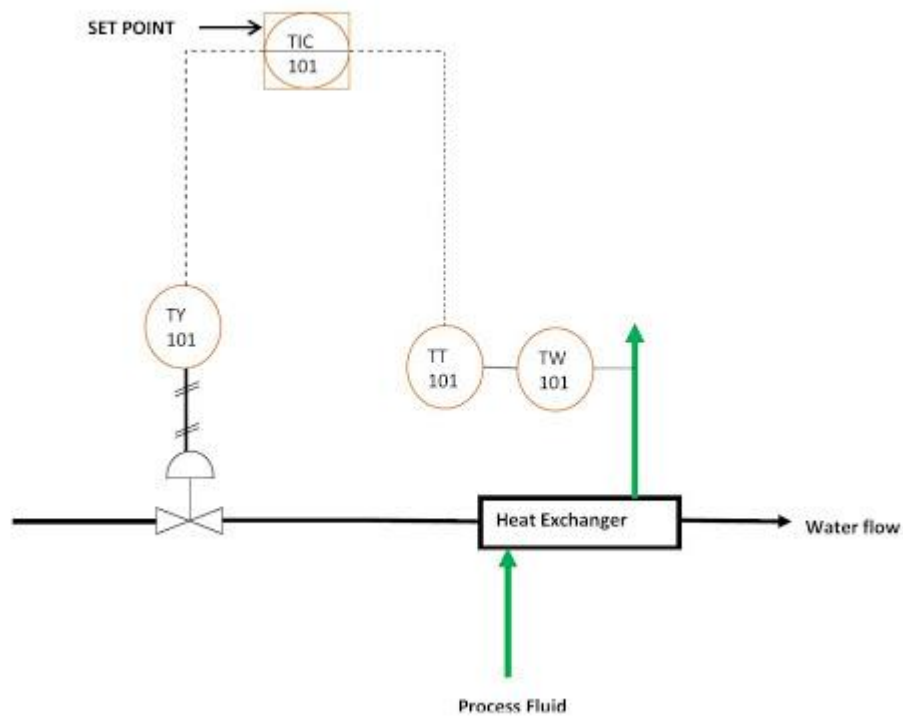
-->

The YIC 501 arrangement is typical of most on/off valves. Here, the YIC is an on/off valve being controlled by a solenoid valve and is fitted with limit switches ZSH and ZSL. ZSH indicates that the valve is open while ZSL indicates that the valve is in closed position or closed. All inputs and outputs are wired to a PLC that's accessible to the operator (diamond in a square with a solid horizontal line).

The Piping & Instrumentation Diagrams (P&ID) Handbook

P&ID Drawing 2:

Simple Temperature Control Loop



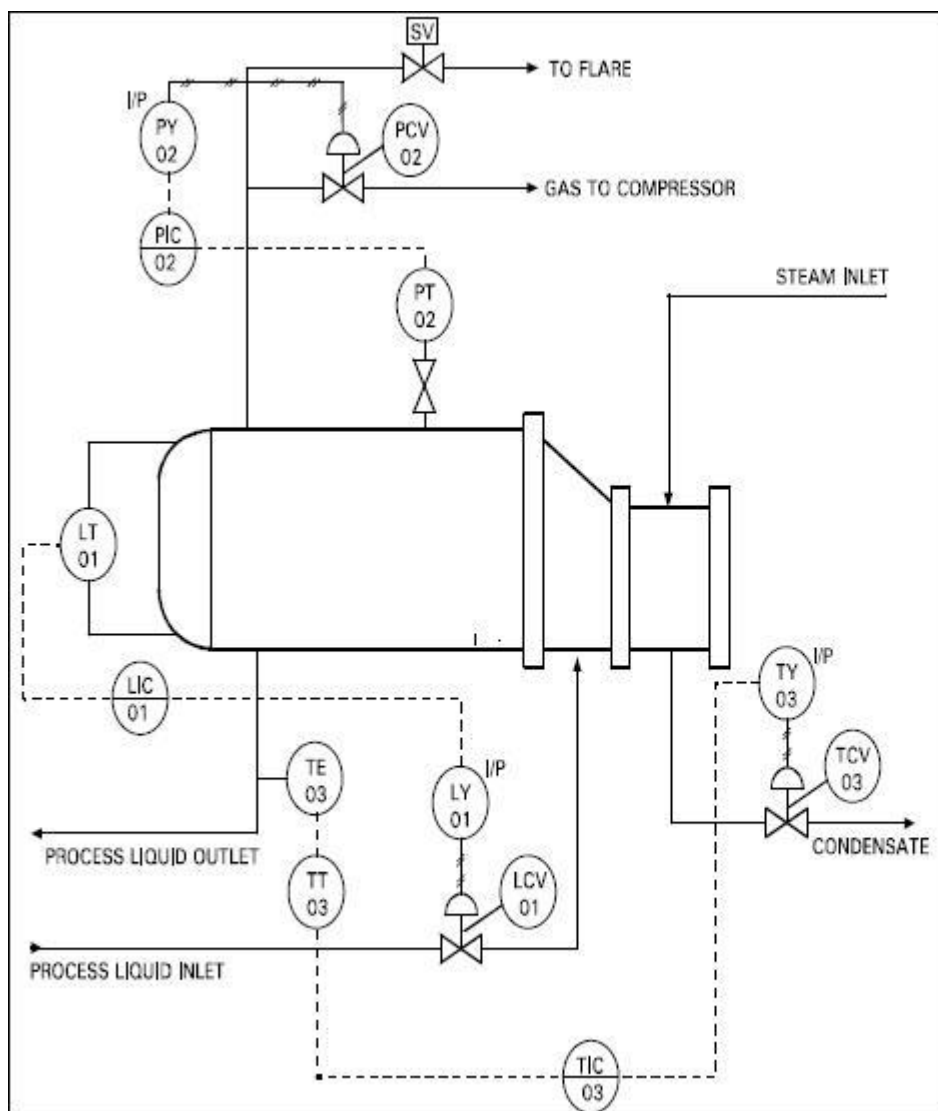
Firstly let us get an idea of the simple process: The above loop controls the temperature of a process fluid (green lines) by passing the fluid and the cooling medium water into a heat exchanger. The process fluid passes through the tube of the exchanger while water passes through the shell.

In the P&ID, TW is a field mounted temperature sensor located inside a Thermowell (TW). The signal from the sensor is transmitted via a field mounted temperature transmitter TT101 to a temperature indicator and controller TIC 101 located in the control room by electrical signals (shown by dotted lines). Based on the set point in TIC 101, TIC 101 then sends an electrical signal to TY 101 located in the field or plant. TY 101 is an I/P (I to P) converter i.e current to pneumatic signal converter. This is because TY 101 receives an electrical signal from TIC 101 and then converts it to a pneumatic signal which then acts on the control valve shown in the P&ID above. The control valve then opens or closes to increase or decrease water flow into the heater exchanger.

-->

The key to understanding Piping and instrumentation diagrams (P&IDs) is to familiarize yourself with the ISA P&ID symbols for most process plant instruments and equipment and then try to read as many Piping and instrumentation diagrams (P&IDs) you can lay your hands on. In no distant time, you will be amazed at how well you will be able to read and interpret Piping and instrumentation diagrams (P&IDs). If you are still confused about the P&ID above, please go back and read:

In continuation of our lessons on how to read and interpret P&IDs, let us look at the piping and instrumentation diagram below:



The Piping & Instrumentation Diagrams (P&ID) Handbook

At first this P&ID looks complicated, but on closer examination, it is actually a simple P&ID. For easier understanding the P&ID is broken into:

(a) Sensors/Measuring or Sensing elements:

TE 03 is a field mounted thermocouple that senses the change in the outlet temperature of the process liquid and converts the change in temperature to a millivolt signal. The millivolt signal (electric) then goes to TT 03, a temperature transmitter, which then converts the millivolt signal to a standard 4-20mA signal for transmission to TIC 03

LT 01 is a level transmitter which senses and measures changes in the level of the process liquid in the vessel (exchanger). The level measurement is converted into a standard 4-20mA signal for transmission to LIC 01

Control System Documentation: Applying Symbols and Identification:

PT 02 is a pressure transmitter that measures the process pressure in the vessel. This measurement is then converted into a 4-20mA signal for transmission to PIC 02

(b) Controllers/Controlling Elements:

-->

Also in the above P&ID are devices we call controllers. They receive the standard signals from the transmitters/sensing elements (TT 01, PT 02 and (LT 01)

TIC 03 is a control room mounted, Temperature Indicator and Controller. It receives the 4-20mA signal from TT 03 and compares it to a preset temperature set point and then initiates a control action by sending a corresponding electric signal to TCV 03 via TY 03

AutoCAD P&ID 2014 Tutorial

LIC 01 is a control room mounted Level Indicator and Controller. It receives a 4-20mA from LT 01 and compares it to a preset level set point within the controller. Based on this comparison, LIC 01 initiates a control action and sends a corresponding signal to the final control element LCV 01 via LY

Lastly, PIC 02 is a control room mounted, Pressure Indicator and Controller. It gets a 4-20mA signal from PT 02, compares it to a preset pressure set point and initiates a control action by sending a corresponding signal to final control element PCV 02 via PY

The Piping & Instrumentation Diagrams (P&ID) Handbook

(c) Final Control Elements:

TCV 03, is a field mounted Temperature Control Valve which receives its control signal from TIC 03 (located in the control room) to either open or close to drain condensate in order to control the temperature of the process liquid

-->

On TCV 03 is TY 03. TY 03 is an I/P converter which converts the electric signal it receives from TIC 03 to a pneumatic signal.

Similarly, LCV 01 (a level control valve) and PCV 02 (pressure control valve) get signals from LIC 01 and PIC 02 to either open or close, thereby controlling level and pressure respectively.

TY 03, LY 01 and PY 02 are called transducers. They convert electrical signals to pneumatic signals.

Having understood the P&ID above, it is important to note that:

There are three control loops in the P&ID namely temperature control (TE 03-TT 03- TIC 03 –TCV 03), level control (LT 01-LIC 01-LCV 01) and pressure control (PT 02-PIC 02-PCV 02)

The next time you see a P&ID, don't get scared! The complexity of the P&ID is not important rather what is important is the individual control loops that make up the P&ID. Understand the P&ID, you understand the process!

The primary functions of instruments and control components are monitoring, display, recording and control of process variables. Instrument and control symbols consist of an instrument bubble or circle with the instrument abbreviation lettered inside the bubble. The abbreviation completely describes the function of the instrument/control component.

Instruments/control elements can be grouped into different categories based on the process variable that the instrument or the control element is monitoring or controlling. The first letter in the instrument abbreviation indicates the process variable being monitored or controlled. The four common process variables are:

- 1) Flow (F)
- 2) Level (G)
- 3) Pressure (P)
- 4) Temperature (T)

Instruments can also be grouped according to the function they perform. The second letter in the instrument abbreviation commonly indicates the instrument function although sometimes it could be a readout or just a modifier of the first letter (usually the process variable). Again, a third letter could indicate either a device function or a modifier. You can get more information on P&ID symbols and lettering system at the ISA Web site [International Society for Automation](http://www.isa.org)

Instrument Functions in P&IDs

The common functions performed by instruments and control components are:

(a) **Alarms (A):** Alarms are devices responsible for alerting plant operators about an upset condition of the process variable. Alarms typically consist of sound and light outputs that attract the attention of the plant operators. On P&IDs, the alarm function is used to modify basic process variables such as pressure, temperature, level and flow

-->

(b) **Controllers (C):** A controller is a device that receives data from a measurement instrument, compares that data to a programmed set point, and, if necessary, signals a control element to take corrective action. Controllers are responsible for the control of the process variable. A typical controller receives input on the status of the process variable and compares the value with the “set point” and initiates the appropriate action. Actuators and control valves execute the control action. As explained in instrument abbreviations used in P&ID, the controller function is denoted by the letter (C).

(c) **Indicators (I):** An indicator is a human-readable device that displays information about the process. Indicators may be as simple as a pressure or temperature gauge or more complex, such as a digital read-out device. Some indicators simply display the measured variable, while others have control buttons that enable operators to change settings in the field. Indicators located at the process unit are also known as “Gauges”. A Level Gauge (LG) is an indicator used in the measurement of liquid level in process vessels. Again on P&IDs, the indicator function modifies basic instrumentation variables such as Level, flow, temperature and pressure

(d) **Sensors:** Sensors are the first element in a process control loop. They are often called the primary element. Sensors are devices that actually measure the value of the process variable. Examples of sensors are thermocouples and orifice meters used in temperature and flow measurements respectively. Transducers are used in converting the analog measurements into digital values. On P&IDs, sensors are represented by different letter combinations for example FE and TE represent a flow sensor(flow element) and a temperature sensor(temperature element) respectively

(e) **Recorders (R):** A recorder is a device that records the output of a measurement device. Different recorders display the data they collect differently. Some recorders list a set of readings and the times the readings were taken; others create a chart or graph of the readings. Recorders that create charts or graphs are called chart recorders. Their information is very useful in monitoring plant performance and in quality control of the products. On P&IDs, the recorder function is denoted by the letter (R). It signifies an instrument with a recording function

-->

(f) **Transmitters (T):** A transmitter is a device that converts a reading from a sensor or transducer into a standard signal and transmits that signal to a monitor or controller. Transmitter types include:

- 1) Pressure transmitters
- 2) Flow transmitters
- 3) Temperature transmitters
- 4) Level transmitters
- 5) Analytic (O₂ [oxygen], CO [carbon monoxide], and pH) transmitters.

Transmitters are very common and popular in instrumentation system design. This is because, there is often the need to transmit data from sensors in the field to a central control room for monitoring or control purposes. On P&IDs, the transmitter function(T) modifies basic process variables such as pressure, temperature, level and flow. Typically, on a P&ID, you might have PT, TT, FT and LT. These are all transmitters. PT is a pressure transmitter; TT is a temperature transmitter; FT is a flow transmitter; and LT is a level transmitter.

I hope you have learnt something useful on P&IDs from this post. Please continue to:[Instrument Abbreviations used in instrumentation diagrams](#) for more information.

P&IDs play very important roles in plant maintenance and modification in that they demonstrate the physical sequence of equipment and system as well as how they all connect. During the Design stage they provide the basis for the development of system control schemes, allowing for further safety and operational investigations like HAZOP (Hazards and Operability Study).

Piping on a piping and instrumentation diagram(P&ID) is indicated by:

1. Usage: For example, process, drain, nitrogen, blow down, etc.
2. Line Number: The identification number of the line on the plant.
3. Size: Usually in inches.
4. Piping Class: The piping specification, both material and pressure rating
5. The insulation class

The specification is usually given using American standards e.g. American Society of Mechanical Engineers (ASME) or American Petroleum Institute (API). Each installation uses slightly different methods to do this but the end result is the same. A typical example is given below:

3"-P-12007-A11A-H30

Here:

3" - Signifies the line size in inches, i.e the line size here is 3 inches

P - Signifies fluid service

12007 – 12 here Signifies unit or facility number while 007 denotes the serial number

A11A - denotes the piping service class

H - denotes the insulation type

30 - denotes the insulation thickness

If we further break the piping service class A11A down, we see that:

A - denotes the flange rating

11 - denotes the piping material

A - a suffix qualifying the piping material

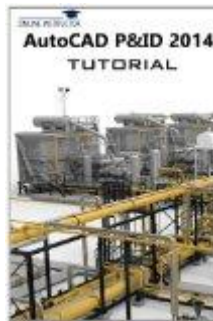
The designation here may be a little different from the ones you may come across but the basic components below will always be part of the piping designation in a piping and instrumentation diagram:

- Usage
- Line number
- Size
- Piping class and
- Insulation class

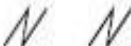
The symbols used in piping and Instrumentation diagrams or drawings are many and varied. I have dealt with some of these symbols before but here I have given a comprehensive list of the common P&ID symbols of process equipment such as valves, flowmeters, piping line connections, and much more. Go through them and familiarize your self with them. However they are by no means exhaustive. Getting to know these common P&ID symbols used in developing instrumentation diagrams will ensure that each time you see a P&ID, no matter how complicated you should be able to identify a symbol or two.

-->

Also know that most piping and instrumentation diagrams will come with their own library of symbols that may be different from the ones listed and pictured here. The first thing you should do with any P&ID is to check the legend section where details of every symbol used on the piping and instrumentation diagram is listed to ensure that you are interpreting the right equipment.

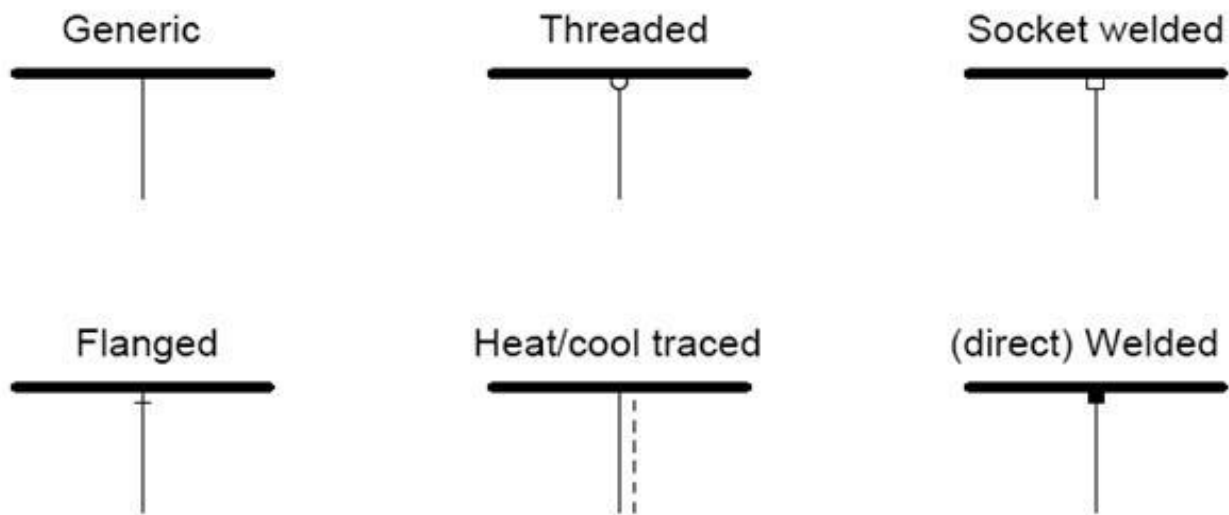


Line Type & Control Signals Symbols Used in P&IDs

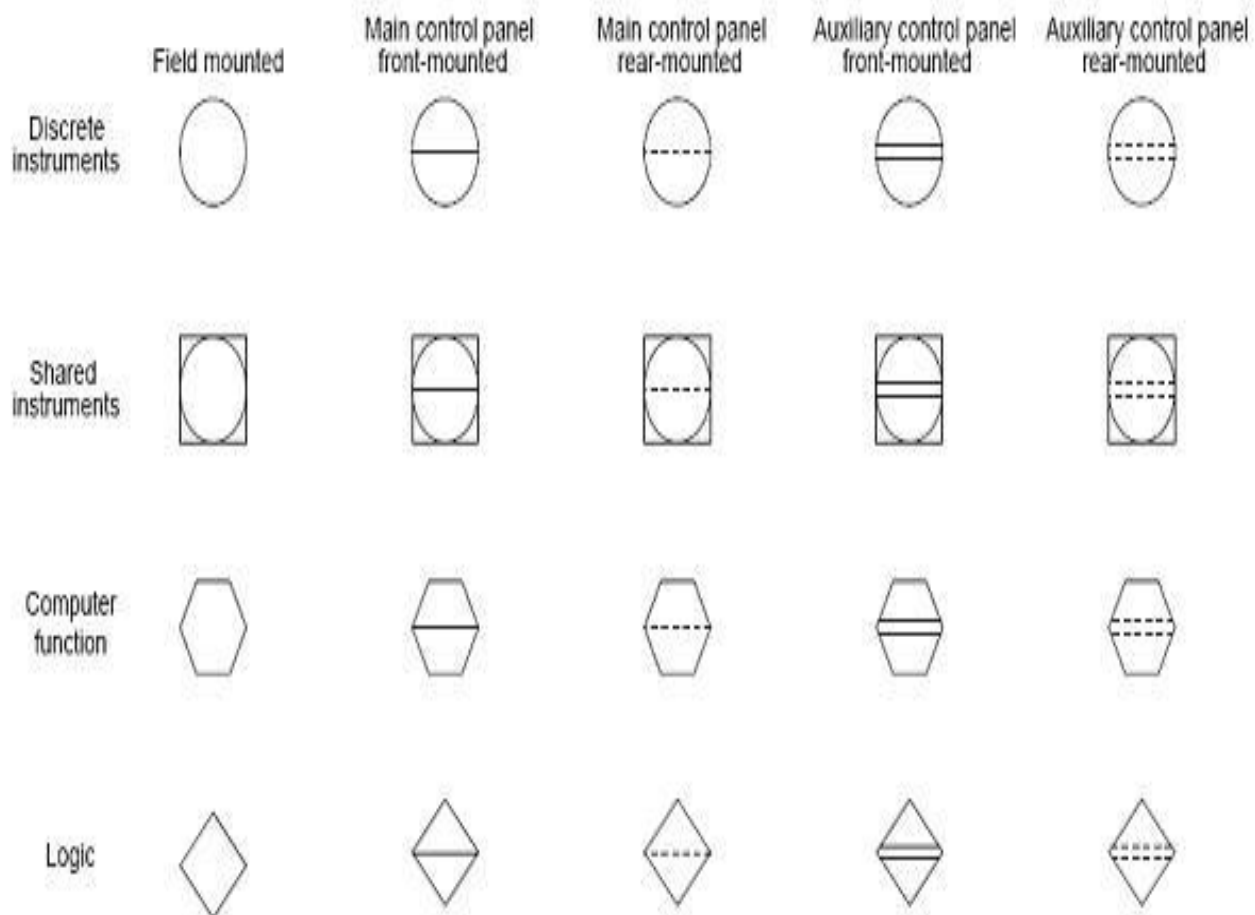
Process flow line 	Instrument supply or process connection (impulse line) 	Waveguide 	Undefined 
Pneumatic signal (continuous) 	Pneumatic signal (discrete -- on/off) 	Capillary tube 	Hydraulic signal 
Electric signal (continuous)  (or) 	Electric signal (discrete -- on/off)  (or) 	Data link (system internal) 	Data link (between systems) 
Mechanical link 	Radio link 	Sonic or other wave 	

Piping Connection Symbols Used in P&IDs

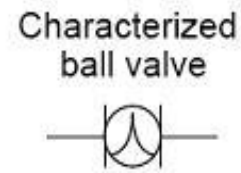
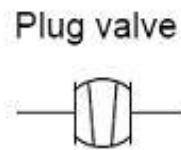
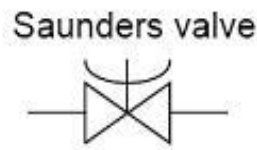
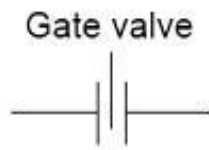
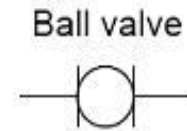
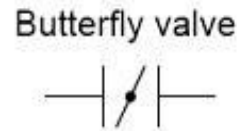
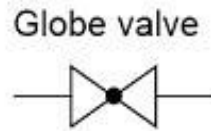
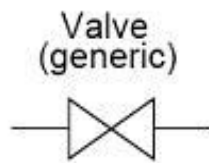
-->



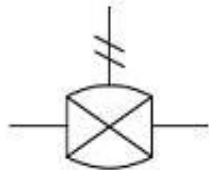
Instrument Short-Hand Symbols or Bubbles Used in P&IDs



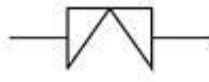
Valves Symbols Used in P&IDs



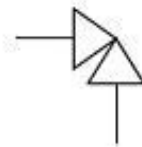
Pneumatic pinch valve



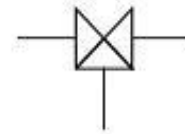
Diaphragm valve



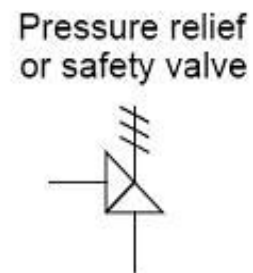
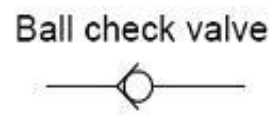
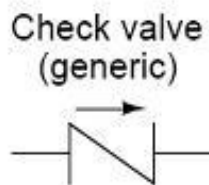
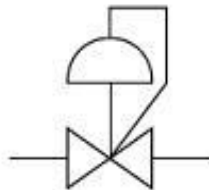
Angle valve



Three-way valve



Pressure regulator

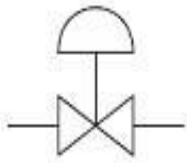


Note that the generic valve symbol is generally used to represent valves in a P&ID. However when we want to be specific as to the kind of valve in question, the specific valve symbol is then used.

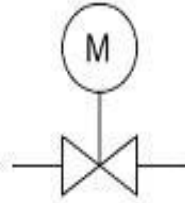
-->

Valve Actuator Types Used in P&IDs:

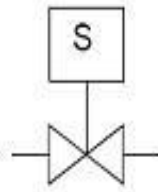
Diaphragm



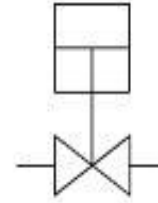
Electric motor



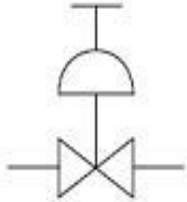
Solenoid



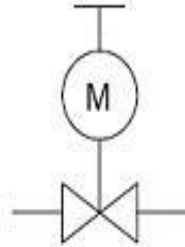
Piston



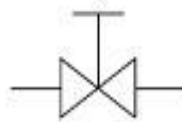
Diaphragm
w/ hand jack



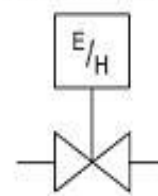
Electric motor
w/ hand jack



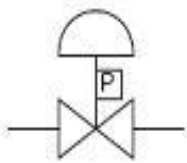
Hand (manual)



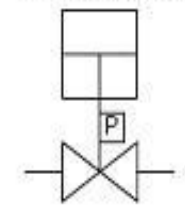
Electro-hydraulic



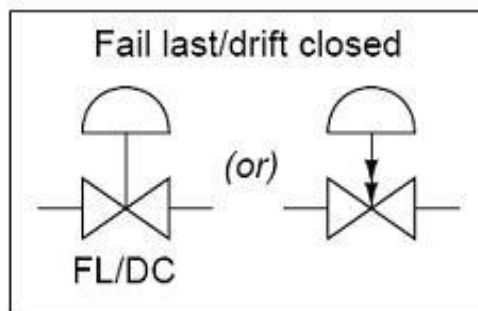
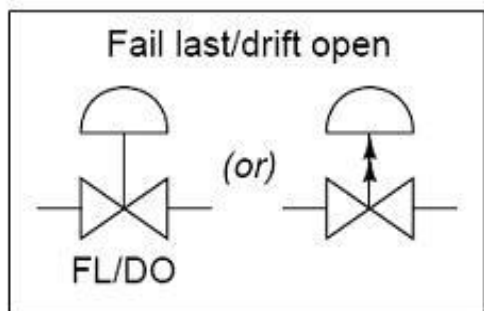
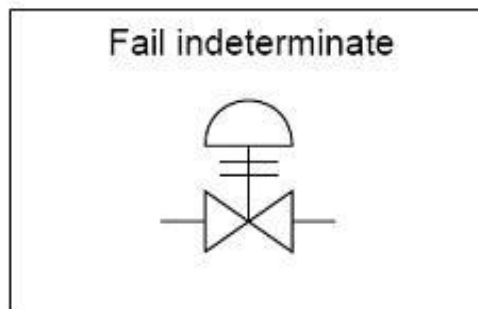
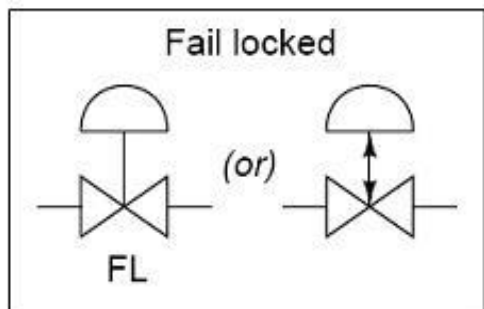
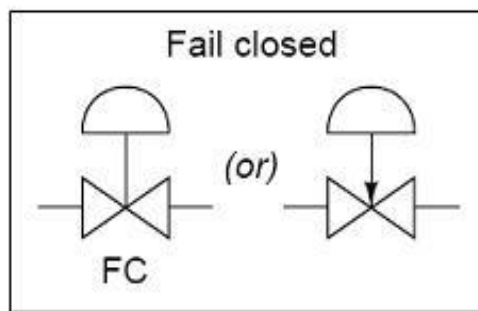
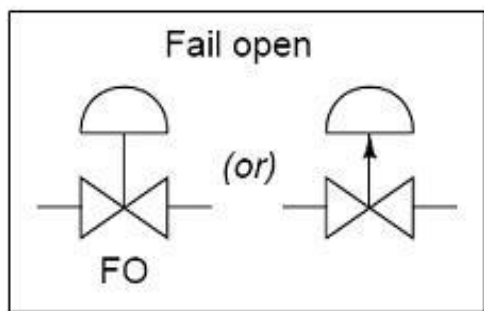
Diaphragm
w/ positioner



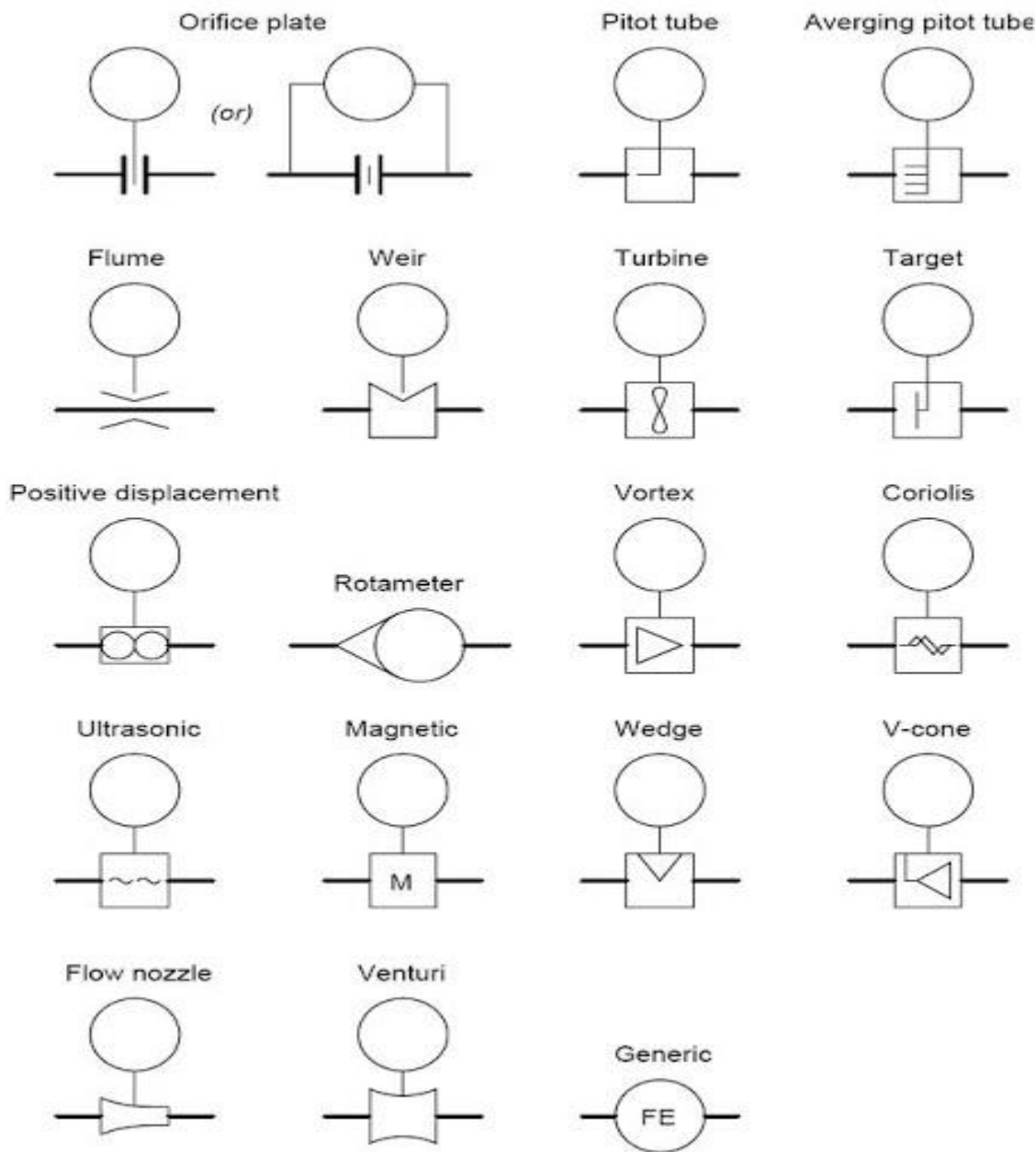
Piston
w/ positioner



Valve Failure Modes Symbols Used in P&IDs:

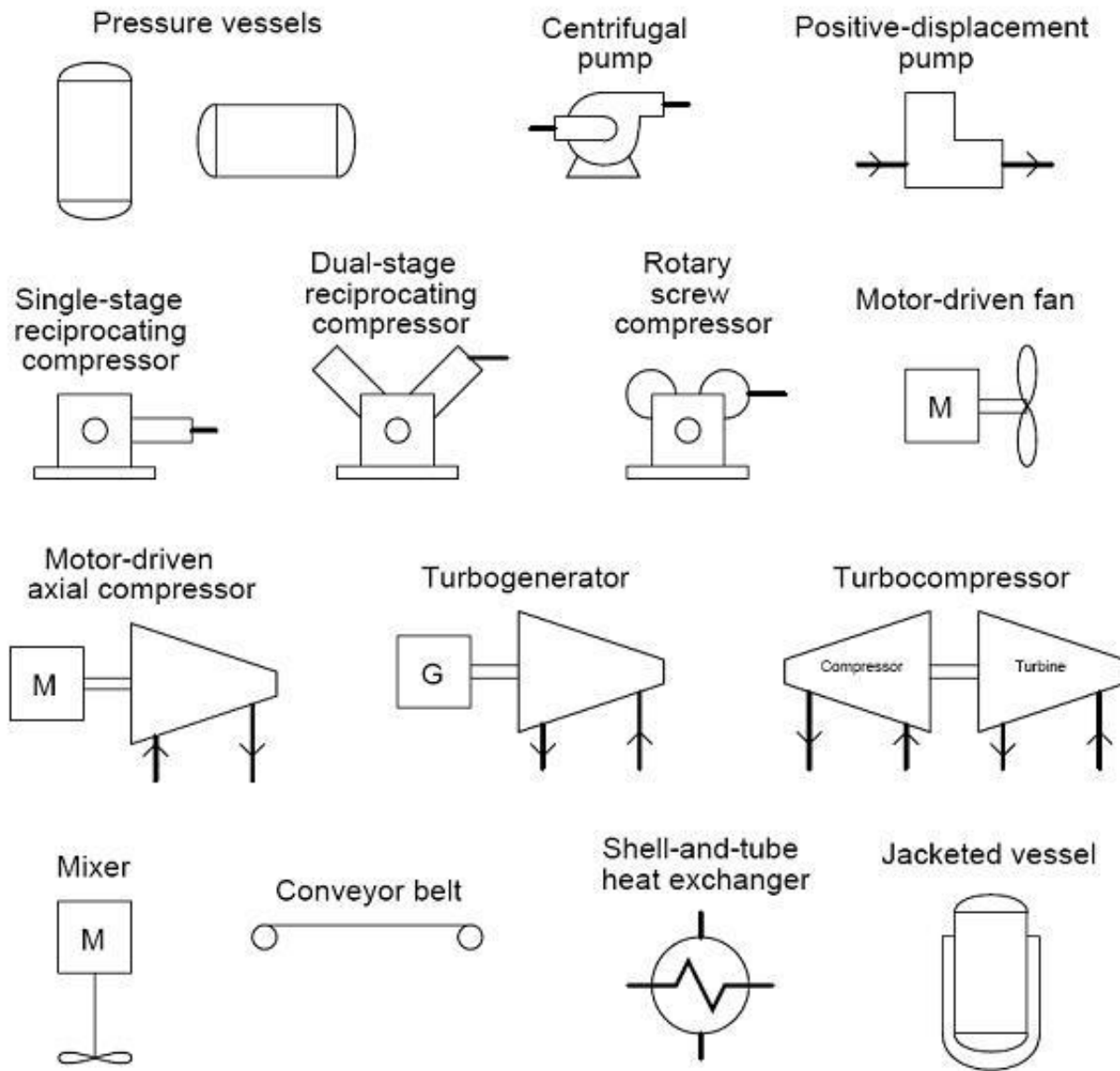


Flow Sensors Symbols Used in P&IDs:



Note that FE is the general symbol for flow sensors in P&IDs. However when we are being specific, then any of the specific symbol for the particular flow sensor/meter can be used

Process Equipment Symbols Used in P&IDs & PFDs (Process Flow Diagrams)



Like I mentioned before every P&ID is unique in its own way. Most of the symbols pictured here, you will see on most P&IDs. However, there could be variations. You must always endeavor to check the legend section of a particular P&ID for any process unit of a plant to get an idea of the library of symbols used to represent various process equipment. This way, there will be no conflict between what you already know and what is being presented

Typically instrument abbreviations used in P&IDs consist of two letters: the first indicating the process variable and the second indicating the instrument/controller function. For example, the instrument abbreviation “PI” denotes a “Pressure Indicator”. Occasionally, a third letter is included in the instrument abbreviation to describe a simultaneous function or a special function. For example: the abbreviation “FRC” represents a “Flow Recorder and Controller” which describes both the recording and control functions and the abbreviation “PAL” denotes a “Pressure Alarm Low” which describes an alarm used in the event of a low pressure condition.

To gain more proficiency in understanding P&IDs and Piping System in Process Plants, please consult the following books for further reading:

- [Piping Design Handbook](#)
- [Piping Systems Manual](#)
- [The Piping & Instrumentation Diagrams \(P&ID\) Handbook](#)
- [Piping Engineering Leadership for Process Plant Projects](#)

The table below contains some of the instrument abbreviations used in conjunction with P&ID symbols in instrumentation diagrams. I have dealt with some of them before but for the purpose of emphasis and completeness let us go through again. The list here is by no means exhaustive but it is a good starting point for beginners to P&IDs:

Instrument Abbreviation	Expansion	Functions Performed
FC	Flow controller	Flow measurement and control
LC	Level controller	Level control
FE	Flow element	Flow sensor
LG	Level gauge	Level measurement
FIC	Flow indicator and controller	Indicating flow as well as controlling flow
LA	Level alarm	Indicating level alarm
FR	Flow recorder	Recording flow
LAH	Level alarm high	Indicating high level
FRC	Flow recorder and controller	Flow recording; controlling flow
LAHH	Level alarm high high	Indicating very high level
FT	Flow transmitter	Transmitting flow signal
LAL	Level alarm low	Indicating low level
FA	Flow alarm	Indicating flow alarm
LI	Level indicator	Level indication
LIC	Level indicator and controller	Indicating level; controlling level
PC	Pressure controller	controlling pressure
TC	Temperature controller	Controlling/regulating temperature
PI	Pressure indicator	Indicating pressure
TI	Temperature indicator	Indicating pressure
PIC	Pressure indicator and controller	Indicating pressure; controlling pressure
TIC	Temperature indicator and controller	Indicating temperature; controlling temperature

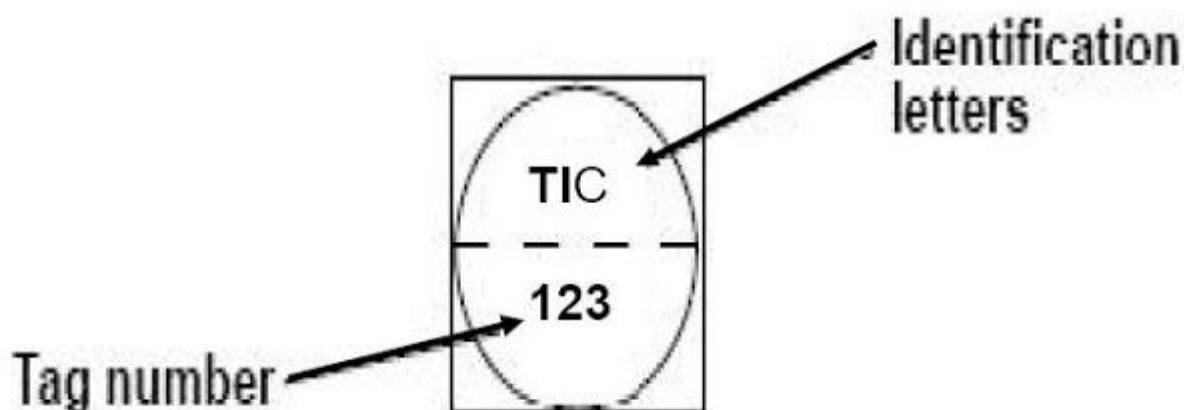
PR	Pressure recorder	Recording pressure
TR	Temperature recorder	Recording temperature
PRC	Pressure recorder and controller	Recording pressure; controlling pressure
TRC	Temperature recorder and controller	Recording temperature; controlling temperature
PSV	Pressure safety valve	Relieving excess pressure in case of high pressure situation
TT	Temperature transmitter	Transmitting measured temperature signals
PT	Pressure transmitter	Transmitting measured pressure signals
TW	Thermowell	Houses temperature sensors
RV	Relief valve	To relieve excess pressure in case of high pressure
TY	Temperature relay/transducer	Converts electrical signals to pneumatic signals
PSH	Pressure switch high	A pressure switch used to indicate high pressure alarm
ZI	Position/limit indicator	Indicates whether a valve is open or close
SDV	Shut down valve	A valve initiating shutdown
ZSC	Position/unit switch closed	Limit switch indicating a valve is closed
ZSO	Position/unit switch open	Limit switch indicating a valve is open
SDY	Shutdown relay	A transducer attached to a shutdown valve
USD	Unit shutdown	Initiate Shut down of a process unit

Below are some common P&ID symbols used with the instrument abbreviations discussed above for developing P&ID drawings

○ LOCALLY MOUNTED INSTRUMENT ◐ BOARD MOUNTED INSTRUMENT	FA FLOW ALARM FE FLOW ELEMENT FI FLOW INDICATOR FR FLOW RECORDER FRC FLOW RECORDING CONTROLLER	USD UNIT SHUT DOWN ZSC V-230 POSITION/ UNIT SWITCH CLOSED SDY V-230 SHUT DOWN VALVE RELAY SDV V-230 SHUT DOWN VALVE ZIO F-250 POSITION/ LIMIT INDICATOR OPEN TY F-250 TEMPERATURE RELAY
PC PRESSURE CONTROLLER PI PRESSURE INDICATOR PR PRESSURE RECORDER PIC PRESSURE INDICATING CONTROLLER PRC PRESSURE RECORDING CONTROLLER PSV PRESSURE SAFETY VALVE RV RELIEF VALVE	TA TEMPERATURE ALARM TI TEMPERATURE INDICATOR TR TEMPERATURE RECORDER TRC TEMPERATURE RECORDING CONTROLLER TW TEMPERATURE WELL	 SPECTACLE BLIND OPEN  SPECTACLE BLIND CLOSED  ORIFICE FLANGES SP PIPING SPECIALITY ITEM
LA LEVEL ALARM LAH LEVEL ALARM HIGH LAL LEVEL ALARM LOW LC LEVEL CONTROLLER LG LEVEL GLASS LI LEVEL INDICATOR LIC LEVEL INDICATING CONTROLLER LRC LEVEL RECORDING CONTROLLER	 GATE VALVE  GLOBE VALVE  CHECK VALVE  CONTROL VALVE  PLUG VALVE  BALL VALVE  BUTTERFLY VALVE	##### INSTRUMENT AIR LINE ---- INSTRUMENT ELECTRICAL ***** INSTRUMENT CAPILLARY TUBING — PIPE

Tag Numbers on P&ID Symbols

Numbers on the P&ID symbols in instrumentation diagrams represent instrument tag numbers. Often these numbers are associated with a particular control loop (e.g., Temperature indicator and controller 123) as shown in the diagram below:



One easy way to learn how to read P&ID drawings and become proficient in it is to look at a lot of Piping and instrumentation diagrams; both simple and complex ones! (please don't get scared). By so doing, you will eventually become good at reading P&IDs. Any good instrumentation textbook should contain one or two sections dedicated to understanding how to interpret and read P&ID drawings.

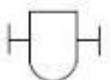
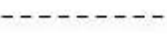
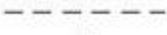
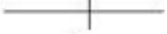
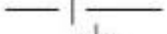
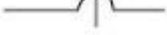
Having understood the importance of a process flow diagram(PFD) from: [What is a Process Flow Diagram \(PFD\)?: The Basics](#), here is a comprehensive list of the common symbols of process equipment used in preparing PFDs and P&IDs. I have dealt with some of these symbols listed here before in [Common P&ID Symbols Used in Developing Instrumentation Diagrams](#) but here again is a comprehensive list of basic and

specialized symbols that you will find useful.

After reading this post, to gain more proficiency in understanding P&IDs, Process equipment symbols and Piping System in Process Plants, please consult the following books for further reading:

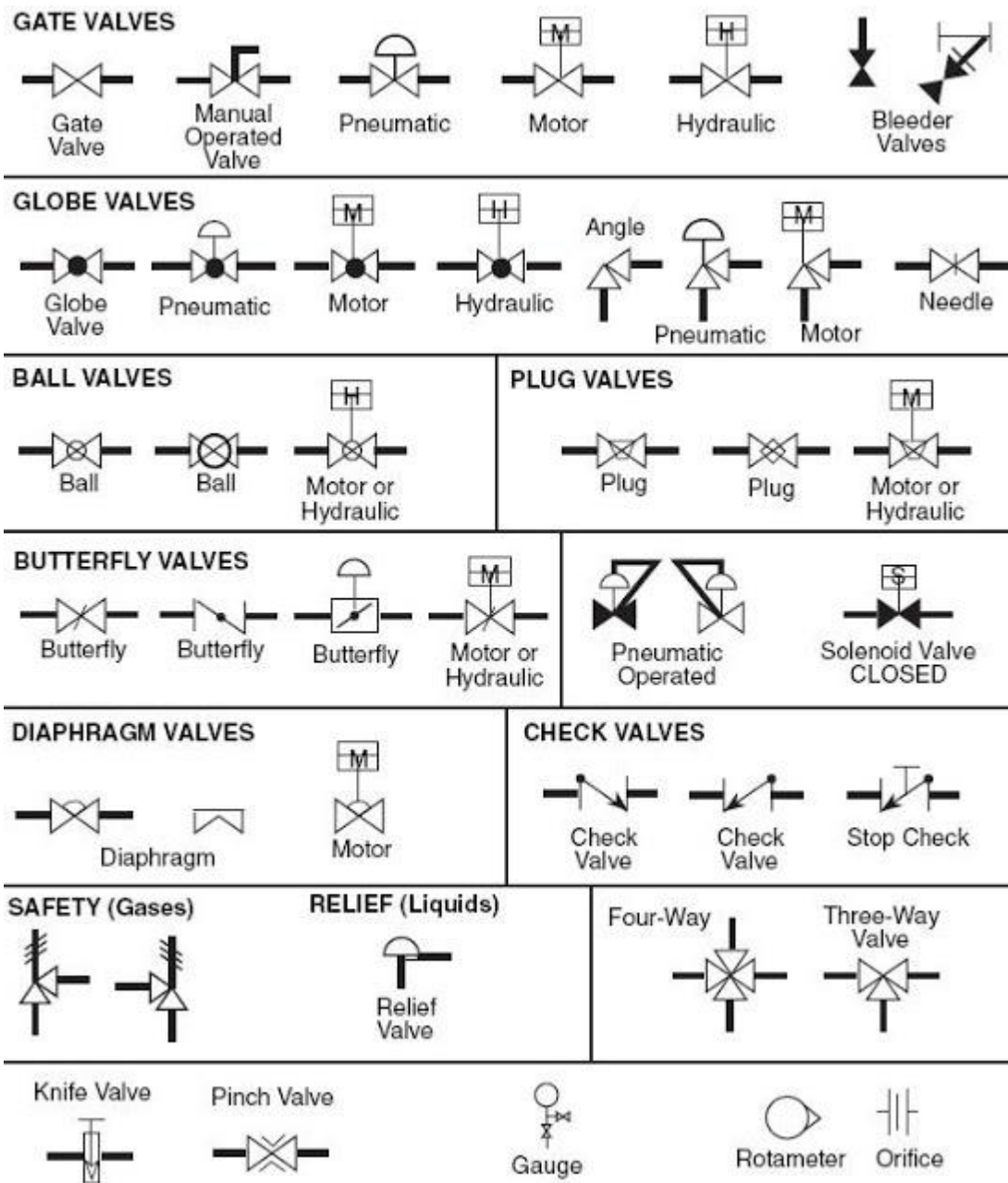
- [Piping Design Handbook](#)
- [Piping Systems Manual](#)
- [The Piping & Instrumentation Diagrams \(P&ID\) Handbook](#)
- [Piping Engineering Leadership for Process Plant Projects](#)

Piping and Miscellaneous Symbols:

	Y-type Strainer		Removable Spool
	Duplex Strainer		Flexible Hose
	Basket Strainer		Expansion Joint
	Detonation Arrestor		Breather
	Flame Arrestor		Vent Cover
	In-Line Silencer		In-Line Mixer
	Steam Trap		Vent Silencer
	Desuperheater		Diverter Valve
	Ejector / Eductor		Rotary Valve
	Exhaust Head		Pulsation Dampener
	Future Equipment		Flange
	Major Process		Electromagnetic, Sonic Optical, Nuclear
	Minor Process		Electric
	Pneumatic		Connecting Line
	Hydraulic		Non-Connecting Line
	Capillary Tubing		Non-Connecting Line
	Mechanical Link		Jacketed or Double Containment
			Software or Data Link

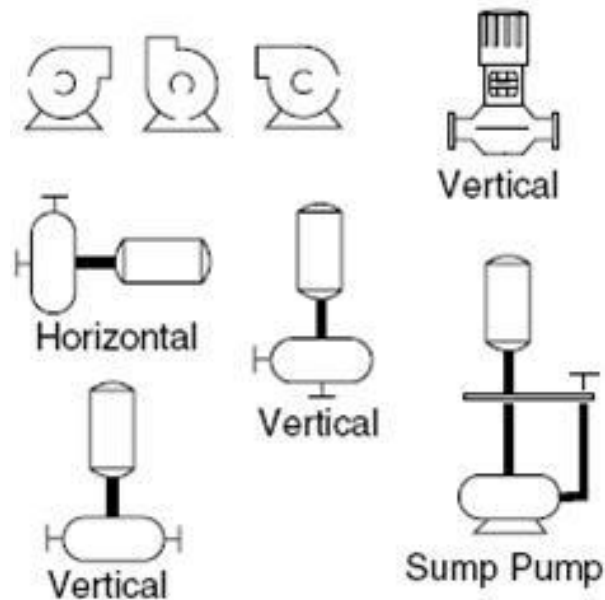
-->

Valve Symbols:

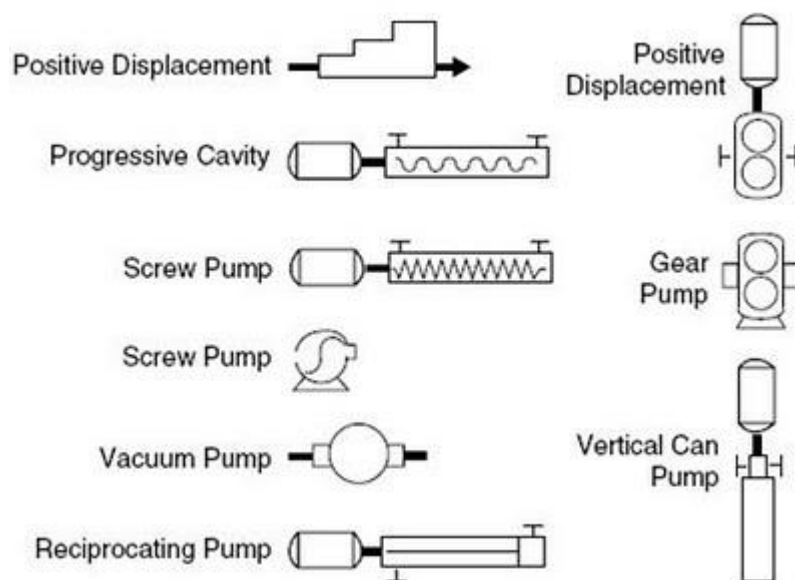


-->

Centrifugal Pump Symbols:

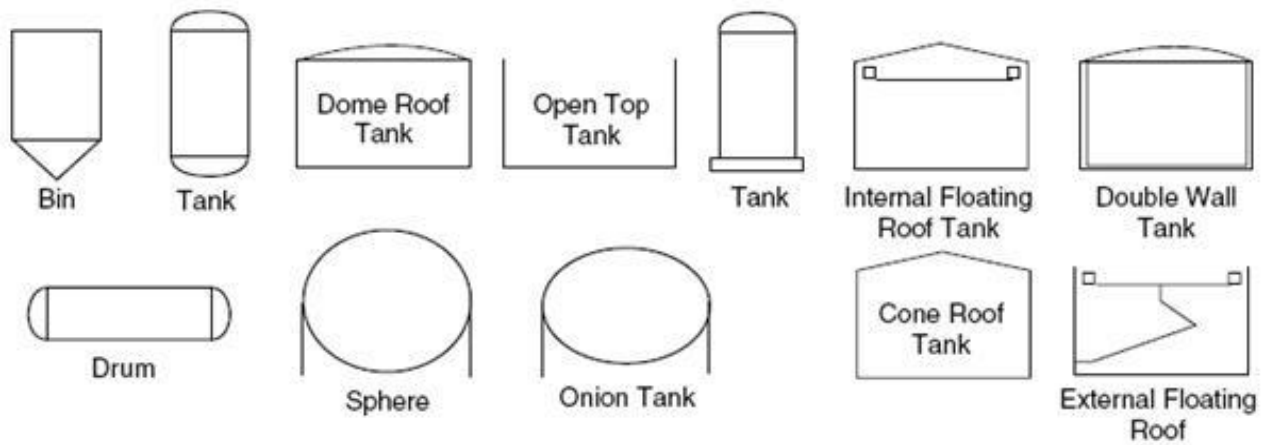


Positive Displacement Pumps Symbols:

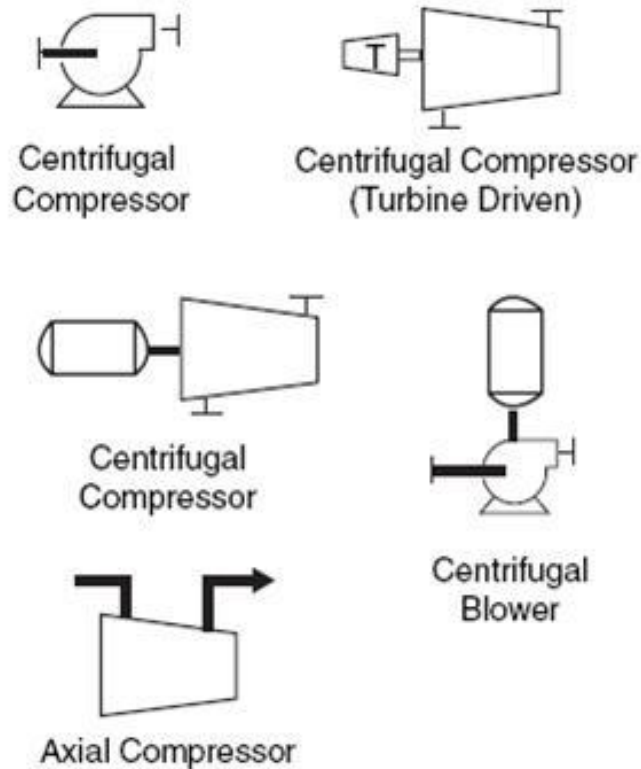


-->

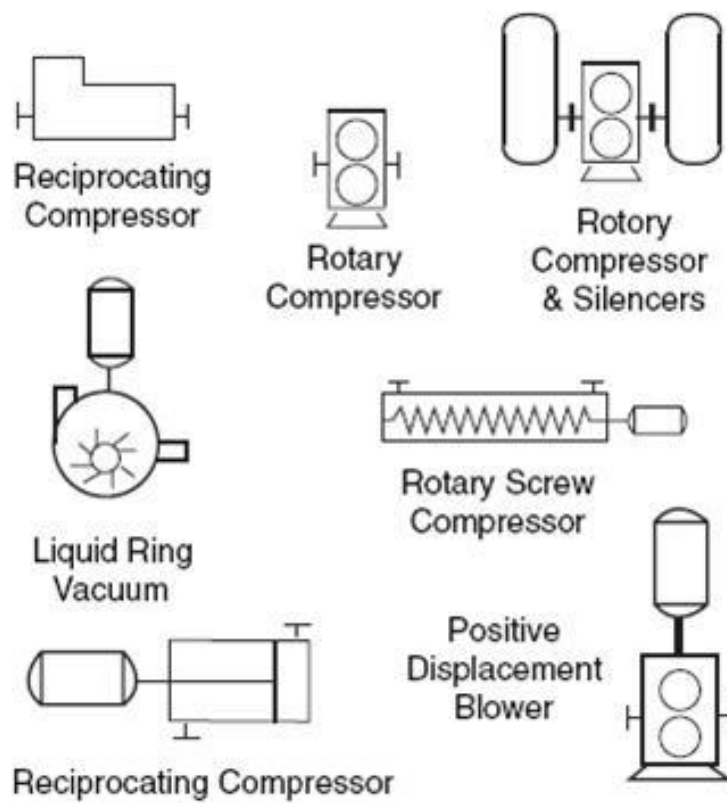
Storage Vessels Symbols:



Centrifugal Compressors Symbols:



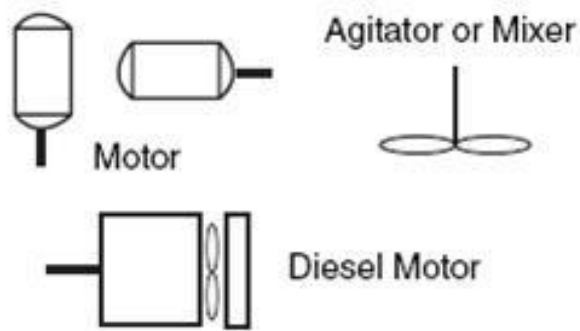
Positive Displacement Compressors Symbols:



In continuation of my piece on process equipment symbols used in developing process flow diagrams and P&IDs, below is an additional list of common symbols used. You may also consult the following books for further reading:

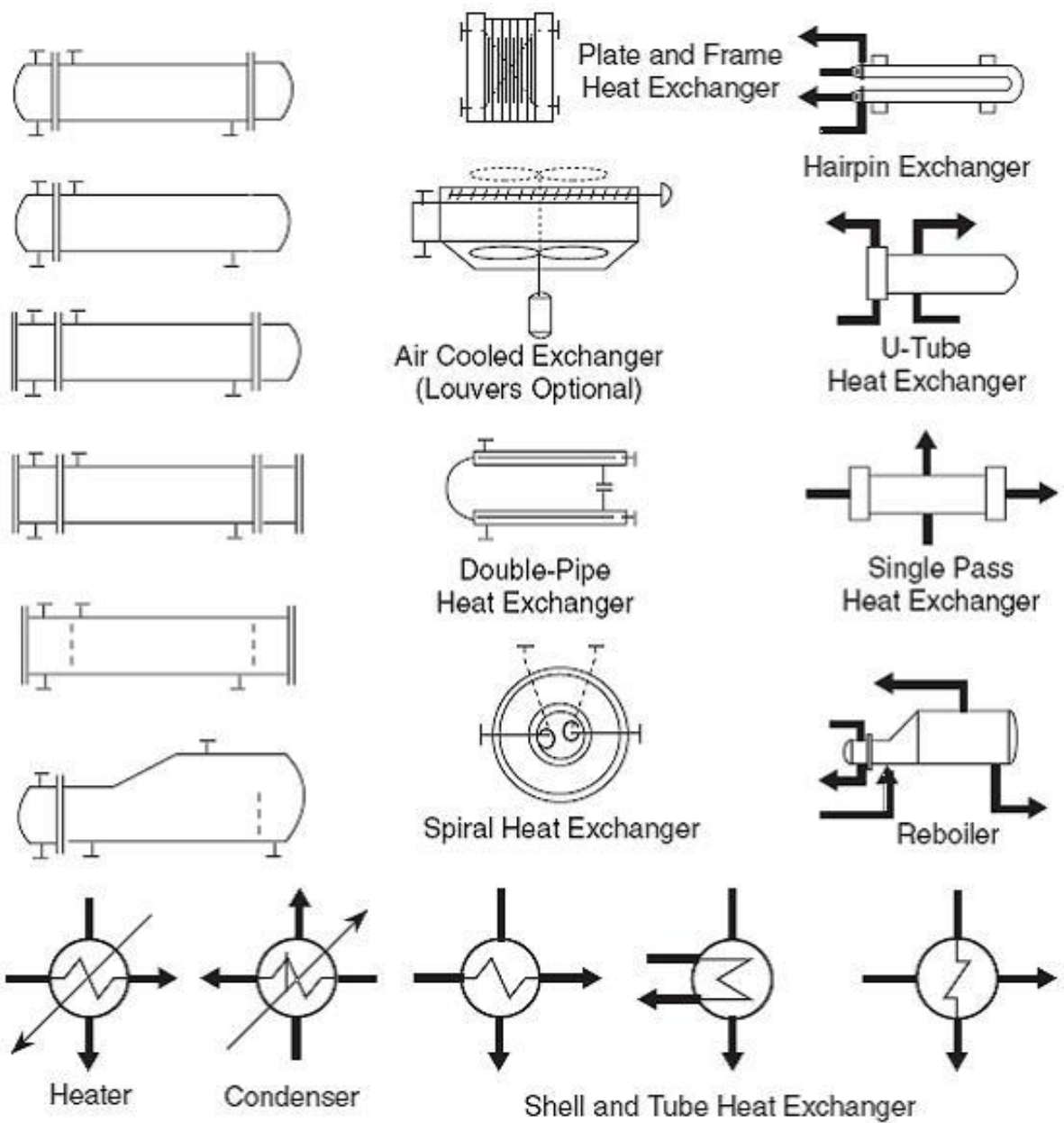
- [Piping Design Handbook](#)
- [Piping Systems Manual](#)
- [The Piping & Instrumentation Diagrams \(P&ID\) Handbook](#)
- [Piping Engineering Leadership for Process Plant Projects](#)

Motors Symbols in PFDs:



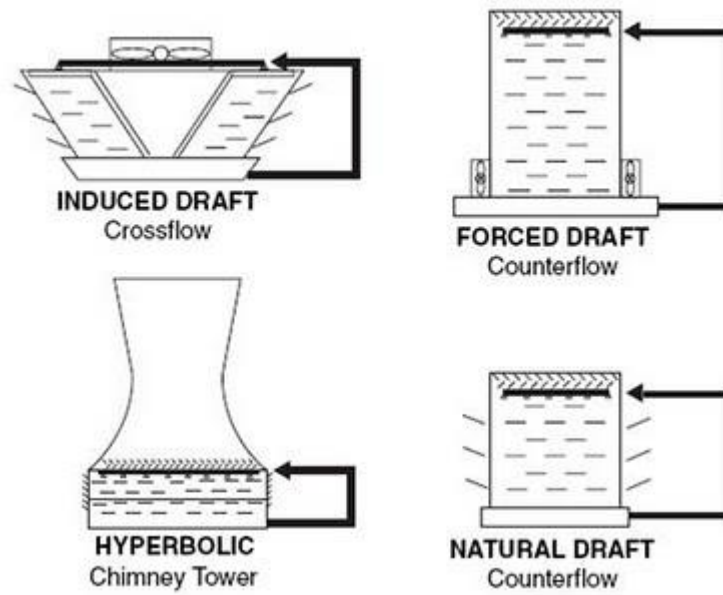
-->

Heat Exchangers Symbols:

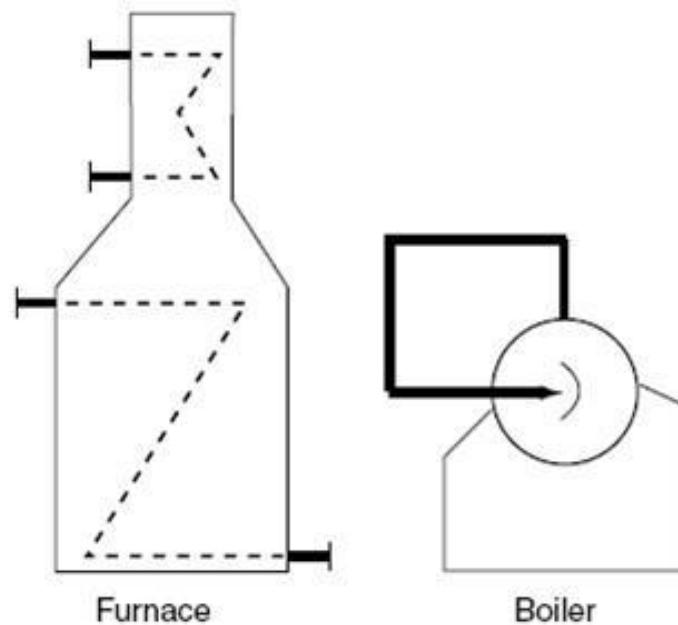


-->

Cooling Towers Symbols:



Furnaces and Boilers Symbols:



-->

Distillation Towers Symbols:

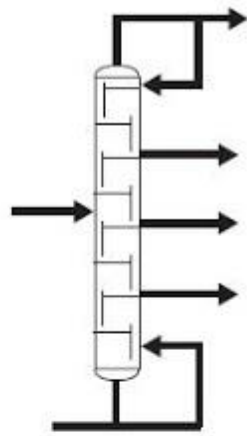
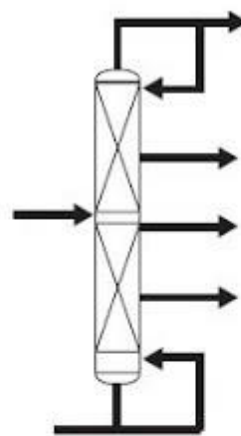
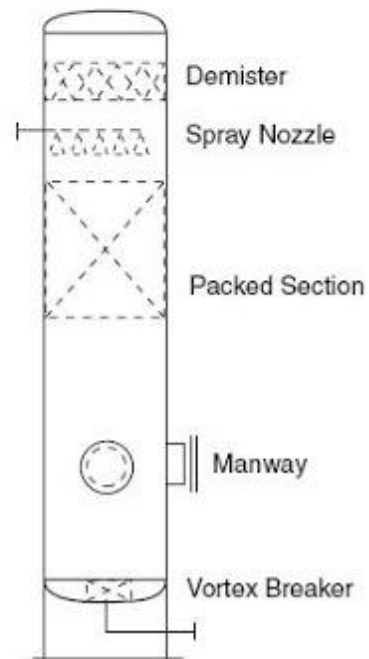
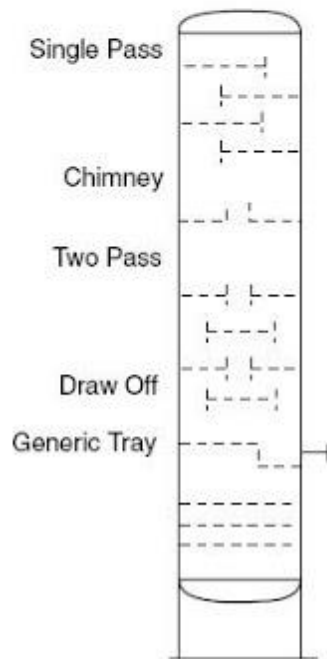


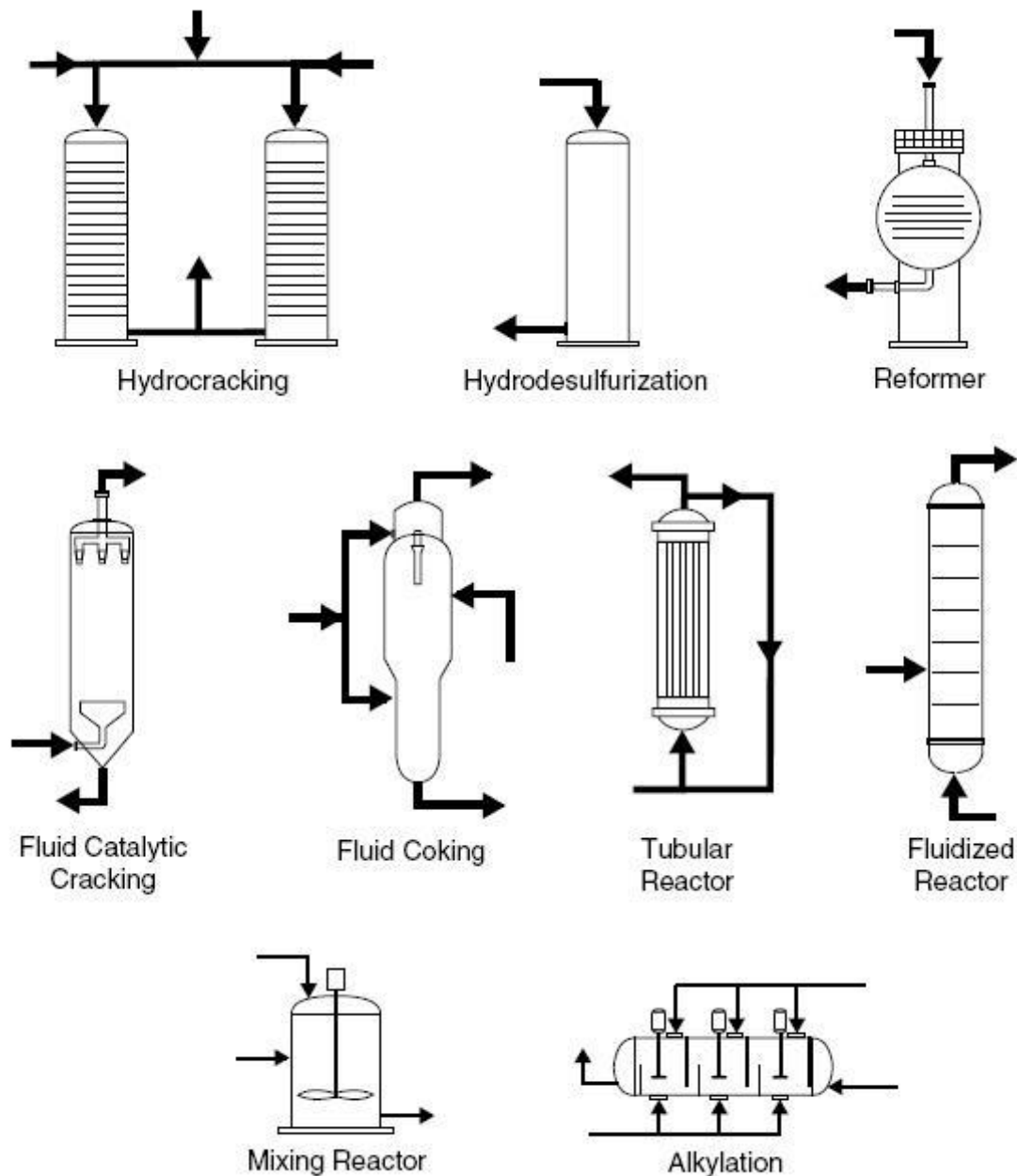
PLATE TOWER
Bubble-cap, Sieve, Valve



PACKED TOWER
Saddle, Ring, Sulzer, Rosette



Reactor Symbols:



For more information on common symbols used for preparing P&IDs and Process flow diagrams (PFD), checkout:

Interpreting P&IDs can often be very challenging especially for beginners. In this piece, I shall be elaborating on some commonly misunderstood terms used in P&IDs to enable the beginner better understand how to interpret the P&ID drawings of their respective plants.

-->

Computing Device

This is a device or function that performs one or more calculations or logic operations, or both, and transmits one or more resultant output signals. A computing device is sometimes called a computing relay.

Converter

A device that receives information in one form of an instrument signal and transmits an output signal in another form is called a converter. An instrument which changes a sensor's output to a standard signal is properly designated as a transmitter, not a converter. Typically, a flow element (FE) may connect to a Flow transmitter (FT), not to a converter (FY). A converter is also referred to as a transducer; however, "transducer" is a completely general term, and its use specifically for signal conversion is not recommended. An I to P (current to pneumatic) converter is a converter we often come across in P&ID drawings.

--> **Local**

This is the location of an instrument that is neither in nor on a panel or console, nor is it mounted in a control room. Local instruments are commonly in the vicinity of a primary element or a final control element. The word "field" is often used synonymously with local.

Local **Panel**

This is a panel that is not a central or main panel. Local panels are commonly in the vicinity of plant subsystems or sub-areas. The term "local panel instrument" should not be confused with "local instrument." From my explanation on the word local above, a local instrument implies an instrument in the field.

Monitor

-->

A monitor is a general term for an instrument or instrument system used to measure or sense the status or magnitude of one or more variables for the purpose of deriving useful information. The term monitor is very often unspecific when used in P&ID drawings — sometimes meaning analyzer, indicator, or alarm. Monitor can also be used as a verb

Panel

A panel is a structure that has a group of instruments mounted on it, houses the operator-process interface, and is chosen to have a unique designation. The panel may consist of one or more sections, cubicles, consoles, or desks. Panel is the **Synonym** for board on P&IDs

Panel-mounted

This is the term applied to an instrument that is mounted on a panel or console and is accessible for an operator's normal use. A function that is normally accessible to an operator in a shared-display system is the equivalent of a discrete panel-mounted device.

Pilot **light**

A pilot light indicates which number of normal conditions of a system or device exists. It is unlike an alarm light, which indicates an abnormal condition. The pilot light is also known as a monitor light.

Sensor

A sensor is that part of a loop or instrument that first senses the value of a process variable, and assumes a corresponding, predetermined, and intelligible state or output. The sensor may be separate from or integral with another functional element of a loop. The sensor is also known as a detector or primary element.

Set **point**

The set point is an input variable that sets the desired value of the controlled variable. The set point may be manually set, automatically set, or programmed. Its value is expressed in the same units as the controlled variable.

Shared **controller**

This is a controller, containing pre-programmed algorithms that are usually accessible, configurable, and assignable. It permits a number of process variables to be controlled by a single device.

Shared display This is the operator interface device (usually a video screen) used to display process control information from a number of sources at the command of the operator.

Transducer

Transducer is a general term for a device that receives information in the form of one or more physical quantities, modifies the information and/or its form, if required, and produces a resultant output signal. Depending on the application, the transducer can be a primary element, transmitter, relay, converter or other

device. Because the term "transducer" is not specific, its use for specific applications is not recommended

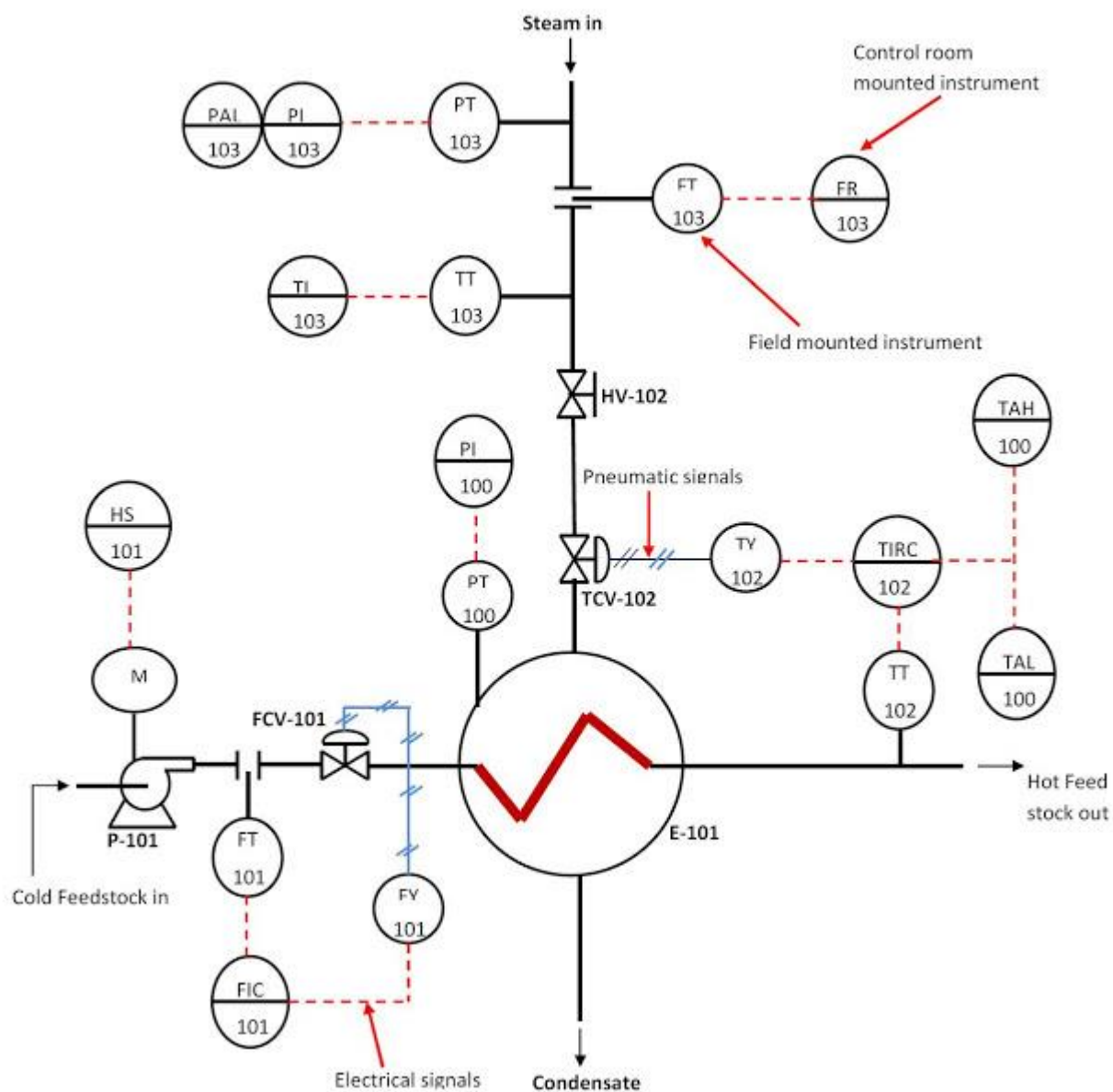
-->

Transmitter

This is a device that senses a process variable through the medium of a sensor and has an output whose steady-state value varies only as a predetermined function of the process variable. The sensor may or may not be integral with the transmitter. A transmitter is often required where the instrument signal needs to be sent to a central control room or transmitted through some distance.

This post will begin a series of tutorials on P&ID to help many people seeking information on the subject to understand more about piping and instrumentation diagrams. Please read on and endeavour to go through all the posts on piping and instrumentation diagrams if you have the time. You will find the links to all my posts on P&IDs at the end of this post. Happy reading.

The Piping & Instrumentation Diagrams (P&ID) Handbook



The P&ID above is that of a typical industrial heat exchanger. You look at the P&ID and you wonder: what is going on? Well the P&ID looks a little complicated if you are new to Piping and instrumentation diagrams. To understand what is actually going on, let us first get to understand what the process whose piping and instrumentation diagrams is depicted above is all about.

-->

The Process

The heat exchanger is a process unit in which steam is used to heat up a liquid material. The material, called feedstock, is pumped at a specific flow rate with pump P-101 into the pipes passing through the heat exchanger chamber (called the tube) where heat is transferred from steam to the material in the pipe. It is usually desired to regulate the temperature of the outlet flow irrespective of the change in the demand (flow rate) of the feedstock or change in the inlet temperature of the feedstock. The regulation of the outlet temperature is achieved by automatic control of the steam flow rate to the heat exchanger (E-101). The P&ID diagram utilizes certain standard symbols to represent the process units, the instrumentation, and the process flow.

AutoCAD P&ID 2014 Tutorial

The Piping and Instrumentation Diagram:

Instruments on the P&ID

Recall that instruments are represented in P&IDs by bubbles defined by ISA standard 5.1. In this P&ID, there are two sets of instrument bubbles used: plain circle bubble and a circle bubble with a solid line across it. As indicated on the P&ID, the plain circle bubbles represent field mounted instruments while circle bubbles with a solid line across represent control room mounted instruments.

Signals on the P&ID

Two kinds of signals are represented on the P&ID. They are:

- Electrical signals
- Pneumatic signals

Electrical signals are represented by the dashed lines with red colour on the P&ID. The pneumatic signals are represented by solid lines with double strip across. They are colored blue on this P&ID

Detailed description of P&ID

FIC 101

Control System Documentation: Applying Symbols and Identification:

Flow Indicator and Controller. This control room mounted instrument controls the flow of cold feedstock entering the tube side of the heat exchanger by accurately positioning a control valve (FCV 101) on the cold feedstock flow path. A Flow transmitter, FT 101, in conjunction with a flow sensor (orifice plate) measures the flow of cold feedstock and sends a corresponding electrical signal to controller, FIC 101, in the control room. The controller then compares the measured flow with its set point and sends an electrical signal to a I/P (current to pneumatic) converter, FY 101, which converts the electrical signal to a corresponding pneumatic signal used to accurately position the control valve FCV 101. Similarly, FT 103 measures the flow of steam into the exchanger using a flow sensor (orifice plate) and sends a corresponding electrical signal to Flow Recorder, FR 103 to indicate the measured flow.

-->

FR 103

Flow Recorder. This control room mounted instrument records the steam flow rate. It measures the steam flow rate in conjunction with a flow transmitter, FT 103 and a flow sensor (orifice plate).

HS 101

Hand Switch, ON/OFF. This hand switch is mounted in the control room. This switch turns on/off cold feedstock pump P-101. When the switch is in the ON condition, the pump is running. When the switch is in the OFF condition, the pump is not running.

HV 102

Hand Valve, OPEN/CLOSED. This valve opens/closes the steam block valve through which steam is routed from the header to the shell side of the heat exchanger.

PAL 103

Pressure Alarm Low,

This alarm fires should the steam header pressure be less than the pressure required for the heat exchanger to work accurately. Note that the alarm module is mounted in the control room.

PI 100

Pressure Indicator, This control room mounted instrument displays the steam pressure at the shell side of the heat exchanger. This pressure measurement is done using pressure transmitter, PT 100.

PI 103

Pressure Indicator, This instrument displays the steam header pressure. Pressure measurement is also done using pressure transmitter, PT 103

TAH/L 102

Temperature Alarm High/Low,

This alarm fires should the temperature of the feedstock at the exchanger outlet goes beyond or falls below stipulated temperatures for high or low temperature of the feedstock coming out of the exchanger.

TI 103

Temperature Indicator

This control room mounted instrument displays the temperature of the steam entering the shell side of the heat exchanger.

TT 102

Temperature transmitter,

This is a field mounted instrument that measures the temperature of the outlet feedstock from the heat exchanger. This measured temperature is converted to electrical signal that is sent to TAH/L 102 for alarming purposes and TIRC 102 for indication, recording and controlling purposes.

TIRC 102

Temperature Indicator, Recorder, and Controller,

This control room mounted instrument controls the temperature of the feedstock at the exchanger outlet by accurately positioning the valve TCV 102 that regulates the steam flow to the exchanger. TT 102 measures the temperature of the feedstock at the exchanger outlet. This measured temperature is sent in the form of electrical signals to TIRC 102. This controller then sends a corresponding electrical signal to an I/P (current to pneumatic) converter, TY 102 which converts the electrical signal to pneumatic signal that is then used to accurately position the temperature control valve, TCV 102. Note also, the electrical signal from TT 102 is also used for alarming purposes (TAH/L 102)

TR 101

Temperature Recorder,

This control room mounted instrument displays the temperature of the feedstock entering the exchanger. This is done by using temperature transmitter TT 101, which measures the temperature of the cold feedstock entering the exchanger in the form of electrical signals and sends it to TR 101.

In continuation of my series on piping and instrumentation diagrams tutorials, we shall look at how to develop and construct a simple piping and instrumentation diagrams (P&ID).

Before we start, I will advise you to go through [Tutorials I](#). If you are completely new to P&ID, I will advise that you go through my various posts on [piping and instrumentation diagrams](#) to ensure that we are on the same page when we use the information provided to develop our P&ID.

Tutorial Question

The Piping & Instrumentation Diagrams (P&ID) Handbook

Develop the piping and instrumentation diagram (P&ID) of a gas vessel which has natural gas entering it through an inlet header and leaving it through an outlet gas header. The gas vessel will show the following instrumentation:

- (a) An inlet valve that is manually controlled on the gas inlet header
- (b) A pressure transmitter and pressure indicator to indicate inlet gas pressure

- (c) A flow transmitter and flow indicator to measure and indicate inlet flow. Also show instrumentation for high and low flow rates alarms
- (d) A pressure safety valve to relieve excess pressure to a flare system
- (e) A hand valve on the gas outlet header

Control System Documentation: Applying Symbols and Identification:

- (f) A pressure transmitter, a pressure indicator and controller and control valve for monitoring and controlling gas vessel pressure
- (g) An alarm to indicate high vessel pressure
- (h) A check valve on the outlet header
- (i) A pressure transmitter and a pressure indicator on the outlet header to indicate outlet pressure

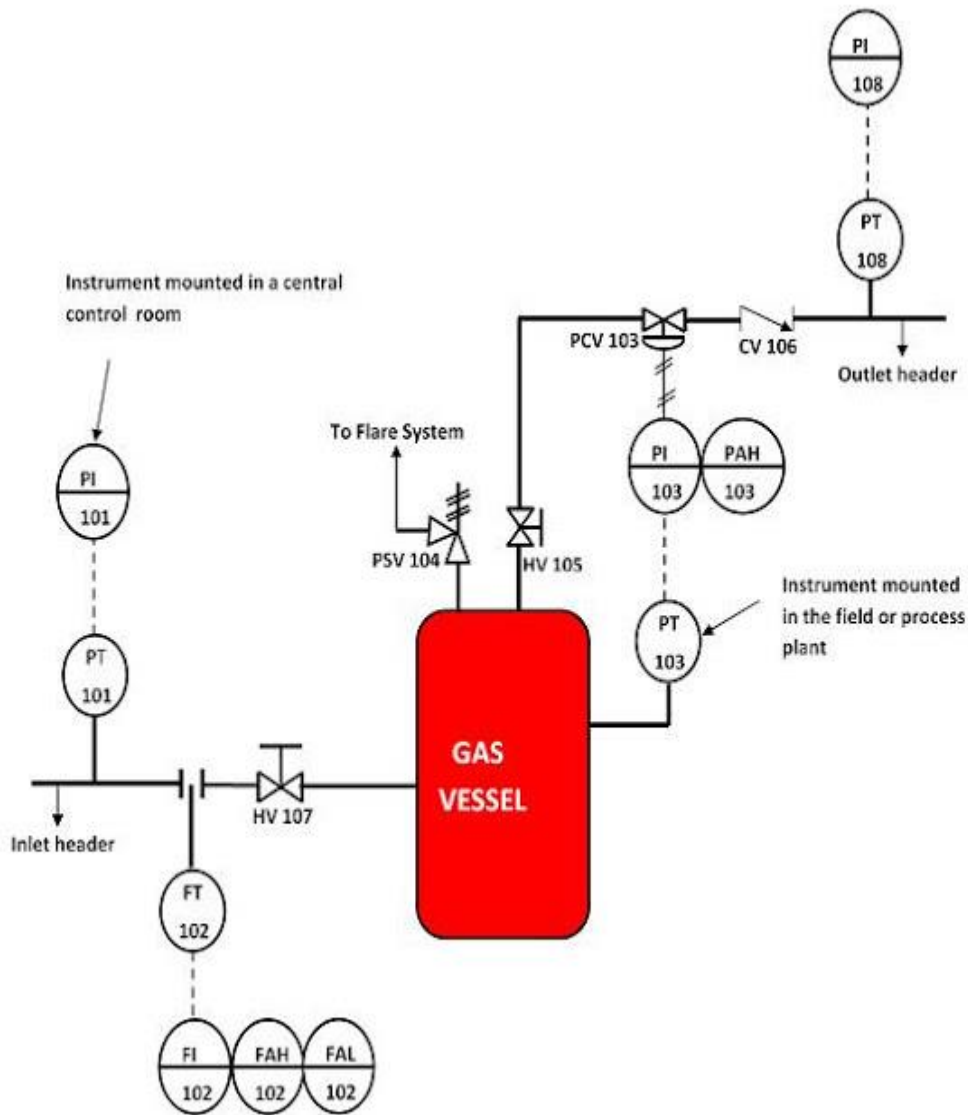
-->

Developing the Piping and instrumentation diagram (P&ID)

To develop this P&ID, the following tips were relied on:

- Know the **symbols for all kinds of valves**
- Know how to represent **various instruments on P&IDs using ISA 5.1 standard**
- Know how to **construct the various abbreviations for instruments on P&IDs**
- Know the **common signals and their representation on P&IDs**

Based on the above tips I have developed the piping and instrumentation diagram (P&ID) below for the gas vessel instrumentation:



<http://instrumenttoolbox.blogspot.com>

The P&ID of the Gas Vessel

Let us now take a detailed look at the piping and instrumentation diagram developed from the information given above. Please note that the tag numbers on the P&ID have been arbitrarily added to give the P&ID an orderly look.

-->

On the developed P&ID, please note that:

- The plain instrument bubble without a solid line across represents a field mounted instrument.
- The instrument bubble with a solid line across represents an instrument that is mounted in a central control room.

Developing the P&ID

(a) we were told the gas vessel instrumentation should have an inlet valve. On the P&ID, inlet valve HV 107 is provided to manually regulate gas flow into the vessel.

-->

(b) A pressure transmitter and a pressure indicator is to be provided to indicate inlet pressure. On the developed piping and instrumentation diagram, PT 101 and PI 101 are provided for this purpose. PT 101 measures the inlet pressure and sends the measured value via electrical signals to the pressure indicator, PI 101

-->

(c) A flow transmitter and a flow indicator are to be provided to measure and indicate flow. Also, instrument for alarming high and low flow rates are to be included. On the developed P&ID, FT 102 measures the flow and FI 102 indicates the flow. Also FAH 102 is a flow alarm switch for indicating high flow rates while FAL 102 is for indicating low flow rates

AutoCAD P&ID 2014 Tutorial

(d) A pressure safety valve is to be provided in the instrumentation to relieve and vent excess pressure to a flare system. On the developed P&ID, PSV 104 is provided to relieve excess pressure and protect the gas vessel.

(e) A manually controlled hand valve is to be provided on the gas vessel outlet header. On the developed P&ID, hand valve, HV 105 is provided.

(f) A pressure transmitter, a pressure indicator and controller and a control valve are to be provided. On the developed P&ID, PT 103 is the pressure transmitter that measures the gas vessel pressure and sends the signal (electrical) to PIC 103, a pressure indicator and controller to indicate the measured pressure and at the same time send a command pneumatic signal depending on its set point to actuate the pressure control valve, PCV 103

(g) Instrumentation for alarm to indicate high vessel pressure is to be provided. On the developed P&ID, pressure alarm switch PAH 103 is used to signal an alarm for high vessel pressure

The Piping & Instrumentation Diagrams (P&ID) Handbook

(h) A check valve on the outlet header is to be provided in the vessel instrumentation. On the developed P&ID, CV 106 is the check valve provided to prevent back flow into the gas vessel

(i) Lastly, a pressure transmitter and pressure indicator is to be provided to measure and indicate gas outlet pressure. On the developed P&ID, PT 108 and PI 108 are performing this function.

If after going through this piece you still have some difficulty, I will advise you go through all the introductory posts on [piping and instrumentation diagrams](#) before coming back to study Tutorials II

In continuation of my series on piping and instrumentation diagram tutorials, we shall continue with the development of P&IDs when given some information about a process or control system. Let us take a look at the tutorial question below:

-->

Tutorial Question:

It is desirable to have a small control system to control liquid flow and consequently level in an open tank. The description of the control system is as follows:

-->

(a) A flow control valve will be used to regulate flow. This flow control will be based on flow measurement in an orifice meter

The Piping & Instrumentation Diagrams (P&ID) Handbook

(b) We want to automatically adjust the setpoint of the flow controller with the aid of a level control loop. As level is being measured, the set point of the flow control valve is adjusted automatically. If the level goes up, the set point of the flow control valve should be lowered and vice versa

(c) The Orifice meter should have a secondary device to transmit a 4 – 20mA signal to the control room. The secondary device should be able to indicate flow rate locally at the Orifice meter.

(d) The secondary device on the Orifice meter is required to send this 4 - 20mA electronic signal to a controller in a central control room. The flow rate should be indicated on this controller

(e) The control room will send a 4 – 20mA signal from the controller to the control valve. At the control valve, we will use an I/P converter to provide pneumatic signal to control our valve. The flow control loop will have a loop number 100.

Control System Documentation: Applying Symbols and Identification:

(f) The level of the tank will be measured using a transmitter, with local indication on the transmitter.

(g) We also want to send a 4 – 20mA level signal to a level controller in the control room. This controller will display the level of the tank in the control room.

(h) The level control instrumentation in the tank will make provision for activating high and low level alarms seen in the control room whenever the level goes too high or too low

(i) The tank should have a local sight glass or gauge for indicating level locally for plant operators

AutoCAD P&ID 2014 Tutorial

(j) The level controller will also send the level signal via wire to the flow controller in the control room, where the setpoint for the flow control valve will be adjusted. The level control loop will have the loop number 101

From the information provided above, develop the piping and instrumentation diagram (P&ID) for this control system.

-->

Developing the Piping and instrumentation diagram.

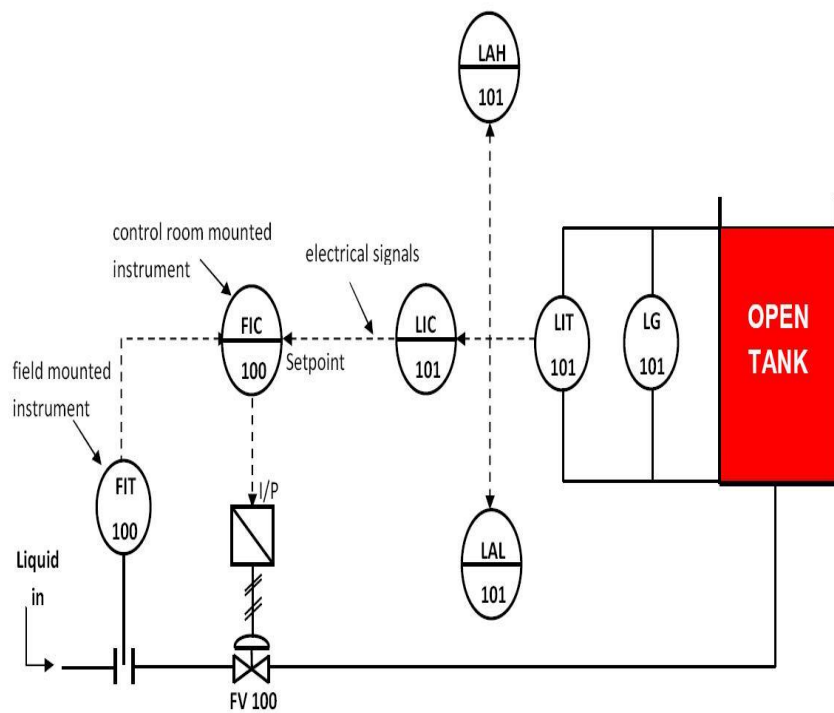
To develop the P&ID from the information given above, you need to be familiar with most of the symbols used for representing flow and level since we are basically dealing with only flow and level control here. You also need to be familiar with the various instruments and control functions encountered in most instrumentation systems. You also need to refresh your mind about the various abbreviations used in denoting instruments and control functions in piping and instrumentation diagrams. To get useful facts about all I have just mentioned, Please go through:

Common P&ID Symbols used in Developing Instrumentation Diagrams

Basic Functions of Instruments in a P&ID

Instrument Abbreviations Used in Instrumentation Diagrams

Below is the piping and instrumentation diagram I have developed from the all the information provided above in our tutorial question:



<http://instrumenttoolbox.blogspot.com>

Let us now examine the information we used to develop the piping and instrumentation diagram above in detail:

(a) A flow control valve is required to regulate flow. On the developed P&ID, FV 100 is the control valve provided to regulate flow

(b) The setpoint of the flow controller is to be adjusted by a level control loop. In the P&ID above, LIT 101 and LIC 101 make up the level control loop that helps to adjust the setpoint of the flow controller FIC 100

The Piping & Instrumentation Diagrams (P&ID) Handbook

(c) The Orifice meter is required to have a secondary device that can transmit a 4 – 20mA signal to the control room and should also indicate flow locally in the plant. In the above P&ID, the Orifice meter is shown to have ,FIT 100, which is a flow indicator and transmitter. The indicator indicates flow locally in the plant and the transmitter transmits the required 4 – 20mA signal to the control room.

-->

(d) The secondary device on the Orifice meter (in this case, FIT 100) is required to send a 4 – 20mA electronic signal to a controller in the control room. In the piping and instrumentation diagram I have developed above, FIT 100 is sending a 4 – 20mA signal to flow indicator and controller, FIC 100, located in the control room. The controller has an indicator function to indicate flow in the control room.

-->

(e) The flow controller in the control room is required to send a 4 – 20mA signal down to the flow control valve. On the flow control valve, an I/P (current to pneumatic converter) will then provide the pneumatic signal required to actuate the control valve. In the P&ID developed, the 4 – 20 mA signal sent to the I/P converter from FIC 100, is converted into pneumatic signal that is used to control the flow control valve, FV 100.

(f) For level measurement, it is required that the open tank should have a transmitter with a local indication function. In the piping and instrumentation diagrams that I have developed above, LIT 101 is a level indicator and transmitter that is measuring the level of the tank and indicating it locally in the plant. The transmitter helps to transmit the measured level signal to the control room.

(g) A 4 – 20mA level signal is required to be sent to a level controller in the control room. In the P&ID above, LIT 101 is sending the required 4 – 20mA level signal to level controller and indicator , LIC 101. Note that because it is required that level should be displayed in the control room, LIC 101 has an indicator function.

(h) The level instrumentation is required to have alarms for high and low levels in the tank. In our P&ID, the level signal from LIT 101 is used for indicating high and low level alarms respectively via LAH 101 (level alarm high) and LAL 101 (level alarm low).

(i) A level gauge or sight glass is required for rough level indication. This is provided by LG 101 in the above P&ID

(j) The level controller LIC 101 is required to send a level signal via wire to our flow controller, FIC 100 so as to adjust the setpoint of this controller. In the P&ID above, LIC 101 is sending the measured level signal to FIC 100. This signal is being used to adjust the setpoint of the flow controller FIC 100. If the level in the tank becomes too high, the setpoint of FIC 100 is automatically reduced and if it becomes too low, it is increased.

Control System Documentation: Applying Symbols and Identification:

Hope you have found this tutorial useful. Please note that on the P&ID developed, there are arrows on the electrical signals indicating the direction where they are being sent to. On actual piping and instrumentation diagrams, this is not often the case. I have done this for the purpose of learning and driving home my point. Also note that the piping and instrumentation diagram is rather simplistic. This is done to facilitate understanding of the basic concepts involved in understanding piping and instrumentation diagrams.