Skills for Life!

Jubail Technical Institute
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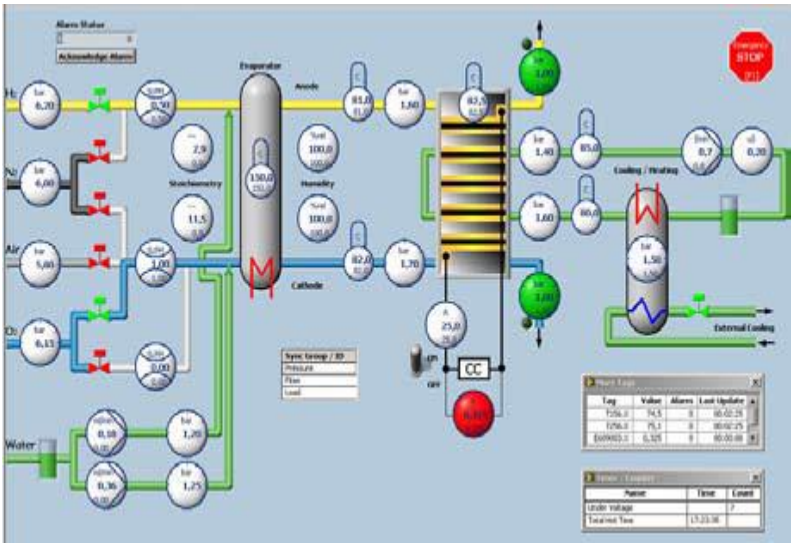
Department of Electrical and Electronics Skills

STUDENT HANDBOOK

Piping and Instrumentation Diagrams Reading

INCT 2432

2020



Prepared by

Industrial Instrumentation & Control Skills Team

Piping & Instrumentation Diagrams

INCT 2432

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DIAGRAMS

INTRODUCTION

Maps are used to help locate things. They can help to find country, a city or a street or roads. They can cover large or smaller areas of land. The smaller the area covered a map, the more detail can be put on the map. Maps can give a lot of useful information if they are used correctly.

Industrial plants are made up of storage tank systems, pipeline systems, electrical systems, sewer systems, flow systems and much more. Each system is made up of many smaller parts. As a technical person, you must know how each part in the system operates and how the different processing, pumping, piping and strong systems are connected and how these equipment work together to form a system and what changes the material goes through at each stage in the process flow. To follow the flow of materials it is important to know how to read a plot plan, a Process Flow diagram and a Piping and Instrument diagram.

Diagram/Drawings: Information that is needed to identify and locate the major work areas of a plant, the flow of a process through the plant, the valves, instruments, piping, end other equipment is found in a type of drawing called a diagram. A diagram is a line drawing that shows the arrangements and relationship of objects. It is used to show the different parts of a piece of equipment, or a system, and how these parts are connected.

The Typical Process Diagrams are:

1. Plot Plan
2. Block Flow Diagram (BFD)
3. Process Flow Diagram (PFD)
4. Piping & Instrumentation Diagram (P&ID)

Plot Plans:

A Plot Plan is a diagram that shows the location of the buildings, roads, fences, work, areas, and major pieces of equipment in the plant. Plot Plans can be made to cover large or small areas of the plant. A Plot Plan will help you to locate any area of the plant, or major piece of equipment, quickly and easily.

Plot Plans are also made to show the work areas and equipment in smaller areas of the plant. Plot Plans that cover smaller areas of the plant can show the location of drains, sewers, fire fighting equipment, fire alarms, storage tanks, and other items. The general plot plan attached shows the common facilities.

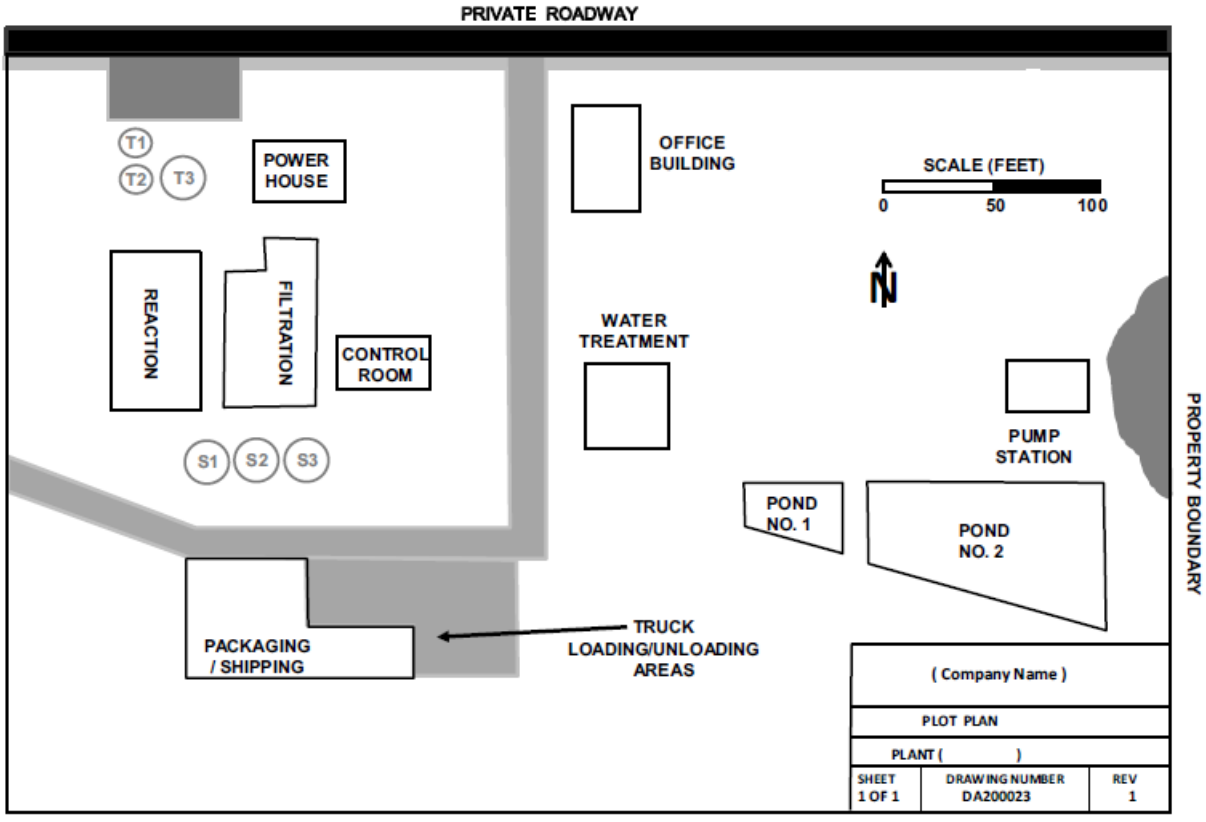


Figure: 1 Plot Plan

Block Flow Diagram (BFD):

Block flow diagram shows only the major units and process flows. The general goal is to provide an overview of the process to build understanding of the entire plant shown in a single drawing. Typically, each unit shown as a rectangle (block). and are Connected by solid lines with the flow direction indicated by arrows. NO special symbols or guidelines are used in developing these drawings. A block flow diagram is a useful tool in both designing a new process and in improving existing processes. In both cases the block flow diagram provides a quick high-level view of the work and may rapidly lead to process points of interest.

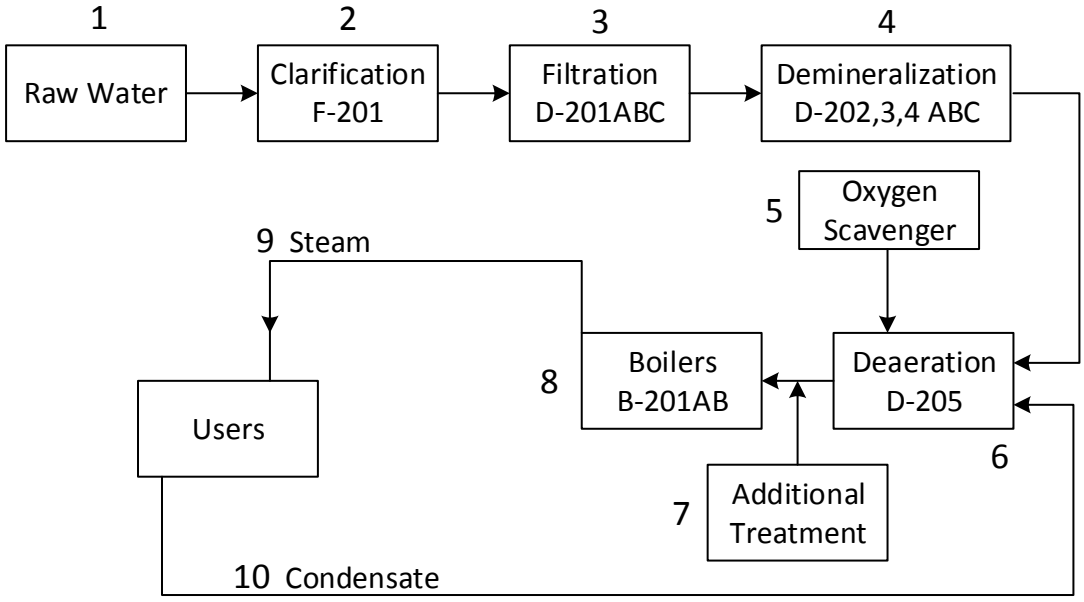


Figure: 2 Block Flow Diagram

This drawing shows all major equipment and process flows. Symbols and identifications (e.g., T-201) are used to represent unit operations and processes. and each stream is designated With a number. The stream properties are given in association with tables, but utility flow rates (e.g.. air. steam, fuel, etc.) are typically not given. In some drawings, a few basic control loops are provided to indicate how process flows and other key variables are maintained at desired values.

Process Flow Diagram (PFD):

The main purpose of the Process Flow Diagram is to show how all the main parts in a process flow system are connected. There are seven (7) major things that all process flow diagrams show. They are:

1) Process Flow and Direction

2) Major Equipment

3) Sequence of Equipment in the Process Flow

4) Material being Processed in the Flow

5) Pressure, Temperatures, and Flow rates

6) Major Control Valves

7) Major Instrument Loops..

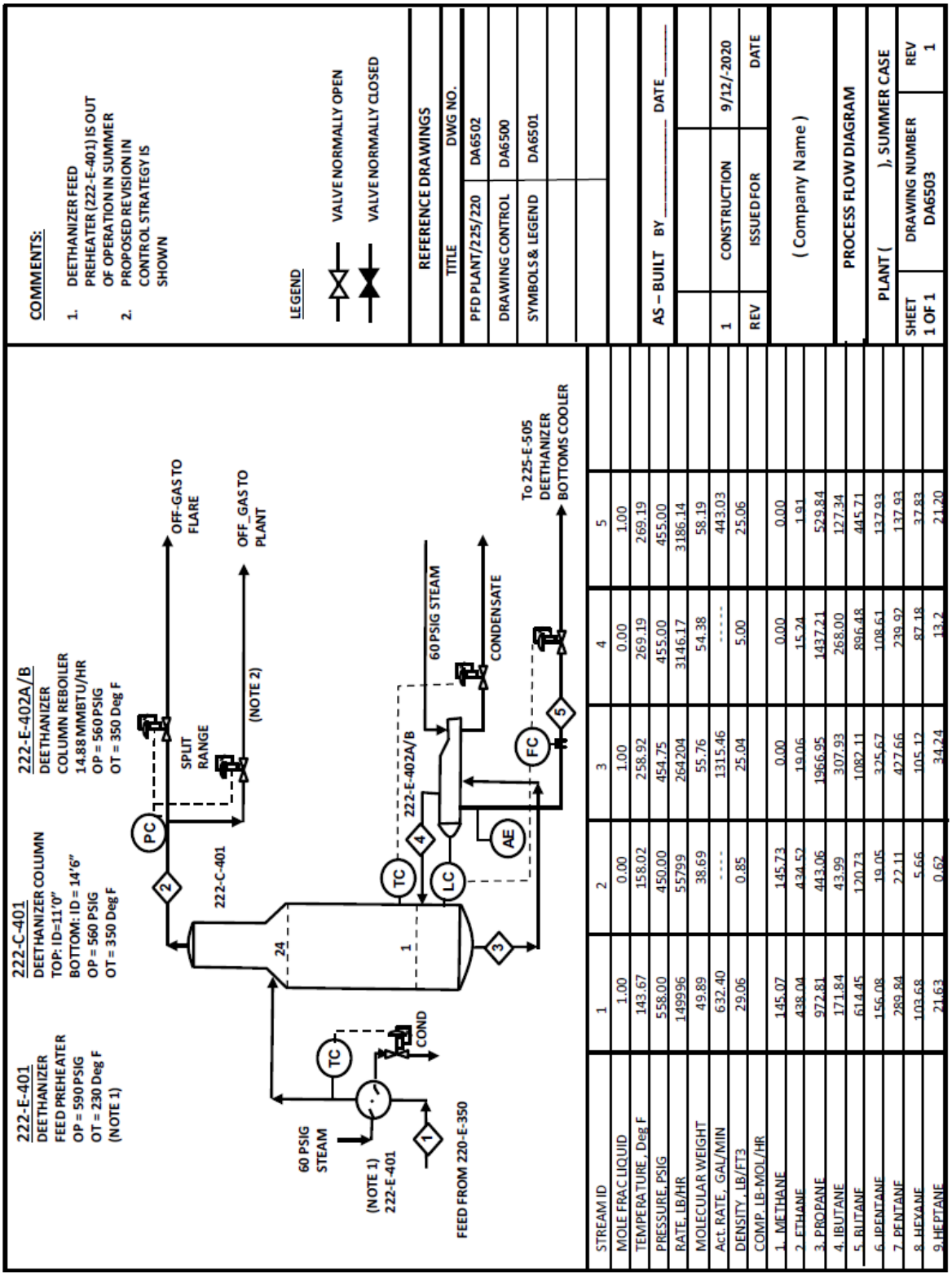


Figure: 3 Process Flow Diagram

Piping and Instrumentation Diagram (P&ID):

P & ID's play an important role in training personnel where it is one of the most important tools that a technician should have. It shows the layout of the components and instruments in plant and their relationship to the operation of that plant. The first thing to be done to understand how to use the P & ID is becoming familiar with the symbols used to represent the various components and instruments. The purpose of this course is to enable students to read a Piping and Instrumentation Diagram and understand the various, basic instrumentation involved.

The symbols used to represent components and instruments on piping and instrumentation diagrams are usually located on a legend. A legend is usually found at the begging of the P&ID and it is simply a list of symbols with their meanings.

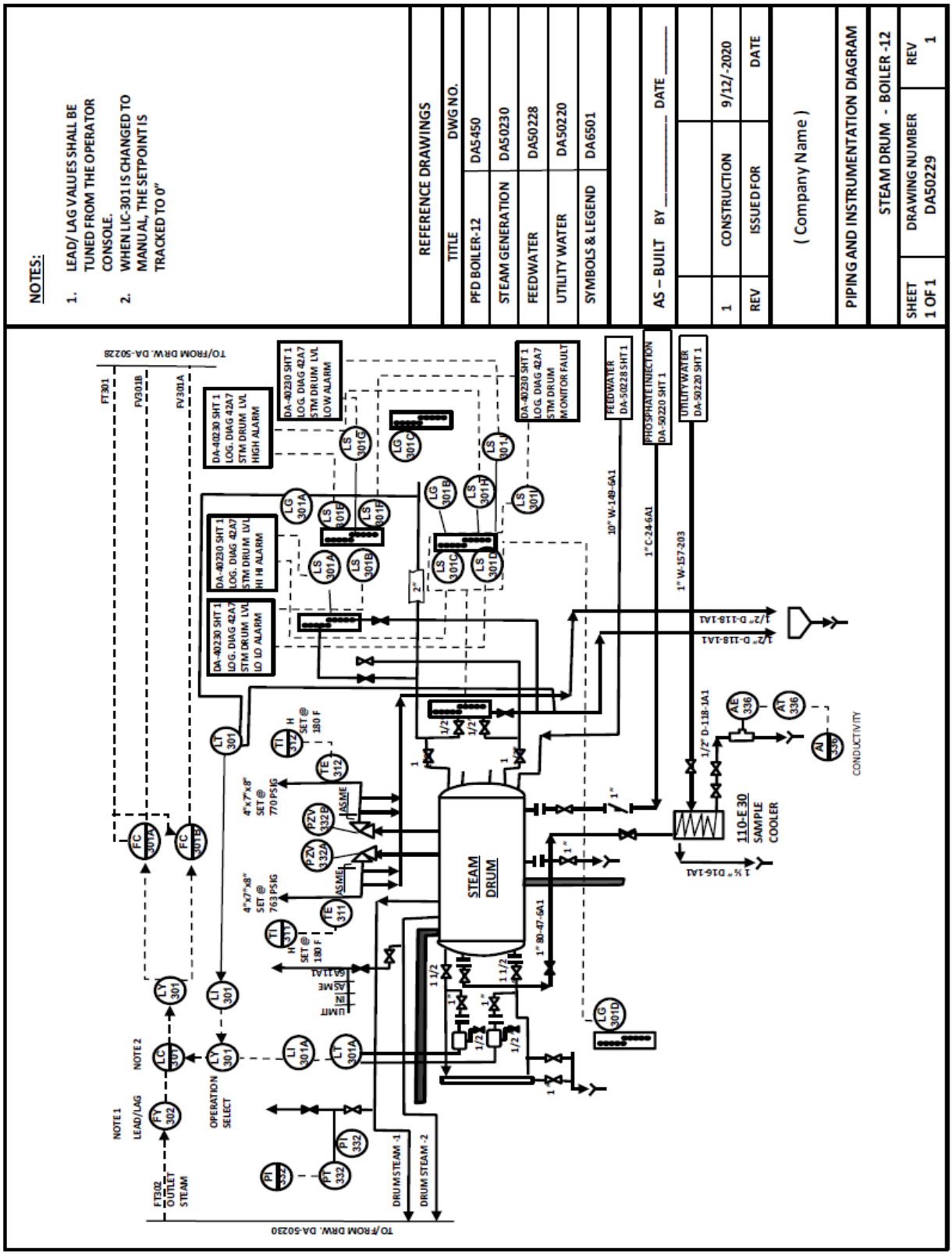


Figure: 3 Piping & Instrumentation Diagram

WHAT'S P&ID?

P&ID stands for Piping and Instrumentation Diagram. It shows the interconnection of process equipment and the instrumentation used to control the process. It's usually made during the design and construction of the plant. A P&ID does not describe the chemical reactions involved or give you procedures. In some plants a P&ID may be known as a Process and Instrumentation Diagram, or as a Process and Control Diagram (P & CD).

P&ID LAYOUT

A P&ID layout includes:

1. Instrumentation and designations
2. Mechanical equipment with names and numbers
3. All valves and their identifications
4. Process piping, sizes and identification
5. Miscellanea - vents, drains, special fittings, sampling lines
6. Permanent start-up and flush lines
7. Flow directions
8. Control inputs and outputs, interlocks
9. Computer control system input
10. Identification of components and subsystems delivered by others

P & IDs might be important to any person who has responsibility of maintaining safe and efficient operation of a process system. The following are some examples of times when an operator, mechanic, or technician may need to refers to a P&ID:

- Planning a job;
- Writing a job safety analysis (JSA)
- Lockout before repair or replacement of a piece of process equipment.
- Troubleshooting if a problem develops
- Emergency preparedness and dealing with emergency situations
- Process hazard reviews
- Training a new employees

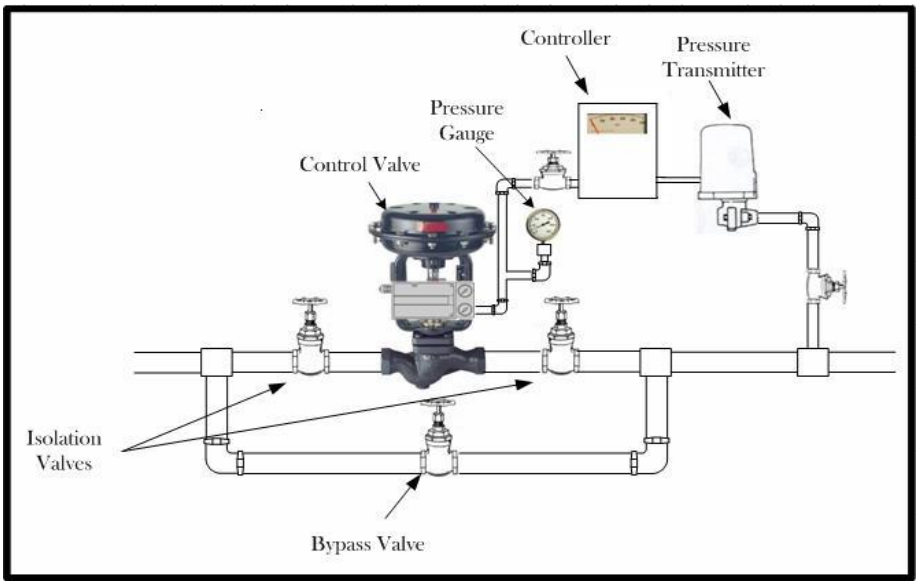
P & IDs are one of many sources of information. In some cases, you will need to check other sources as well as P & IDs to complete a job. For example, to replace an instrument, you might need to check instrument specification sheets for information such as the name of the instrument manufacturer.

On P & IDs, symbols and abbreviations are used to represent equipment and instrumentation to prevent the drawing from becoming too crowded.

Figure 4A shows how a simple control loop set-up appears in the plant.

Figure 4B shows a P & ID compared to the as-built arrangement in Figure 4 A.

Figure-4a



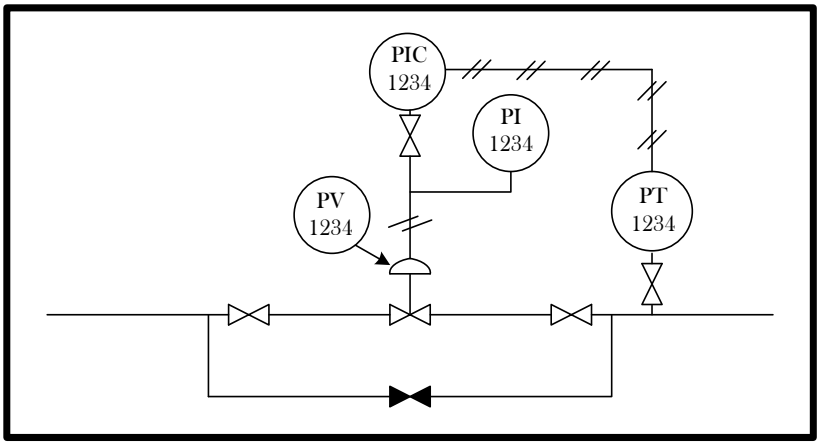


Figure-4b

INSTRUMENTS SYMBOLS

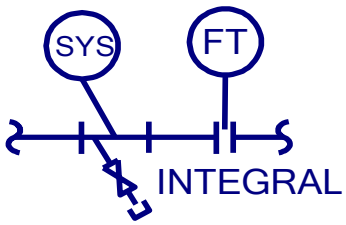
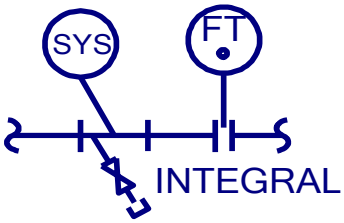
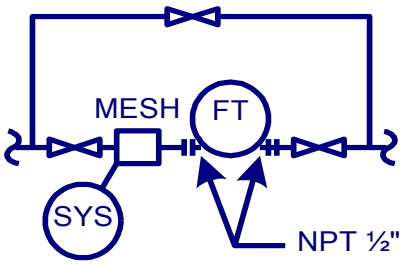
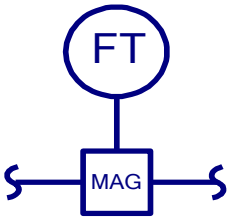
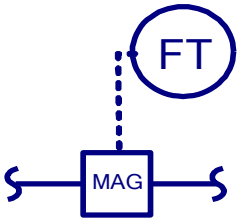
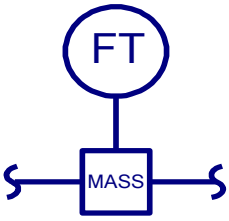
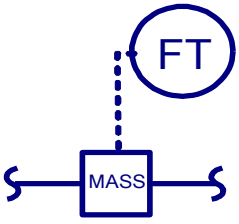
Symbols, such as circles, letters, numbers and lines are used to provide information about the process. Symbols may represent the devices in the system, or identify the function of instruments, or indicate how devices are connected to each other or to the process. On a P & ID, each instrument in the system is represented by a circle called a **balloon** or a **bubble** . Letters. Numbers, and lines drawn inside the balloon give specific information about the type of instrument , its location, and the function it performs.

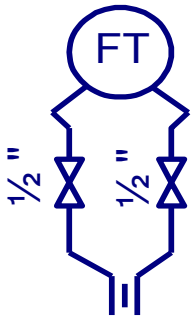
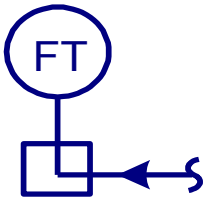
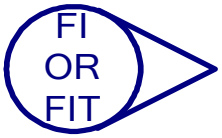
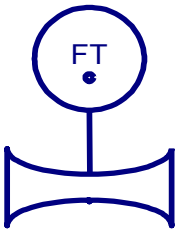
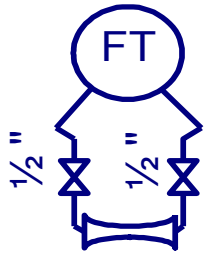
Instrument mounting symbols

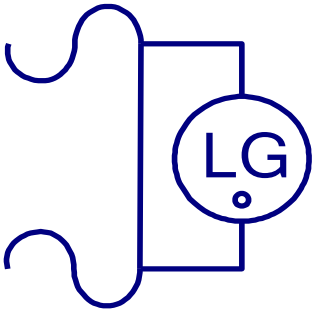
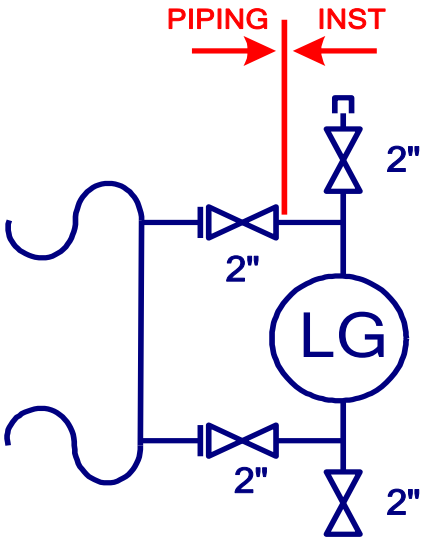
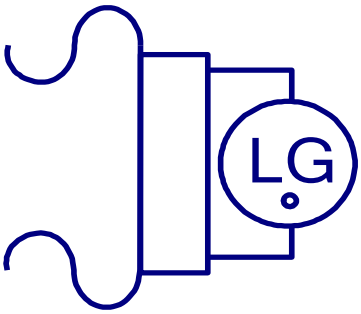
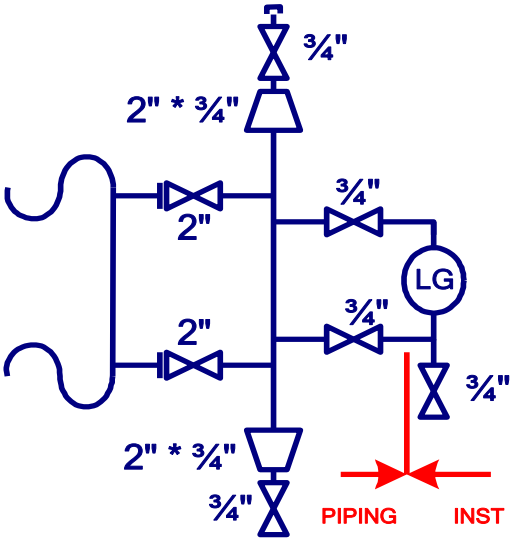
Lines or the absence of lines through the balloons are used to indicate where an instrument is mounted.

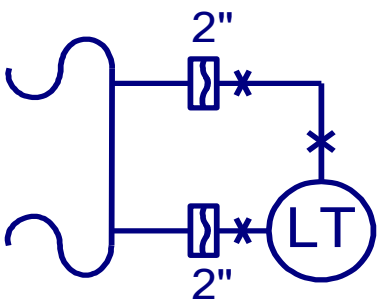
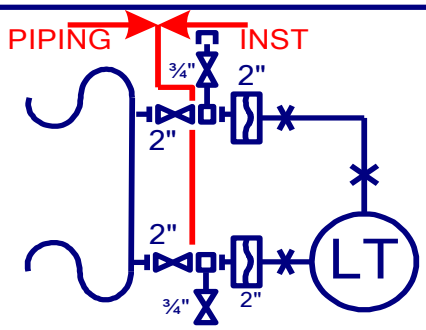
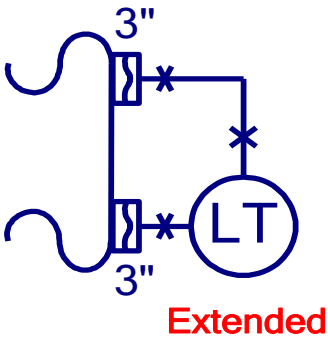
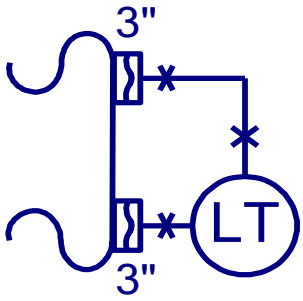
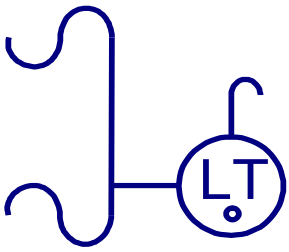
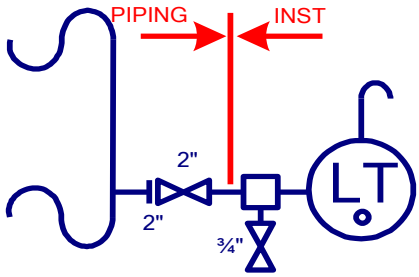
Location / Accessibility	Discrete Instruments	Shared display & Control (DCS)	PLC	Computer function	Discrete Hardware Interlock
Field Mounted I. Field or locally mounted II. Accessible to an operator at device					
Primary location normally accessible to the operator I. Central or main control room II. Front of main panel or console mounted III. Visible on video display IV. Accessible to an operator at device or console					
Primary location normally inaccessible to the operator I. Central or main control room II. rear of panel or cabinet mounted III. Not visible on video display IV. Normally not accessible to an operator at device or console					
Auxiliary location normally accessible to an operator I. Secondary or local control room II. Field or local control panel III. Front of secondary or local panel mounted IV. Visible on video display. V. accessible to an operator at device or console					
Auxiliary location normally inaccessible to an operator I. Secondary or local control room II. Field or local control panel III. Rear of secondary or local panel or cabinet mounted IV. Not visible on video display. V. Not Normally accessible to an operator at device or console					

MISCELLANEOUS INSTRUMENT CONNECTIONS & SYMBOLS

Item	P & ID symbol	Actual Connection Arrangement
Integral orifice without bypass		
Integral orifice with bypass		
Magnetic flow meter with flow transmitter		
Mass flow meter with flow transmitter		

Item	P & ID symbol	Actual Connection Arrangement
Orifice plate with flow transmitter		
Pitot tube,annubaror pitot venture tube with flow transmitter		
Rotameter or Rotameter with flow transmitter		
Turbine or propeller type primary flow element with flow transmitter		
Venture tube or flow nozzle with flow transmitter		

Item	P & ID symbol	Actual Connection Arrangement
Level Gauge (Magnetic)		
Level Gauge (Glass)		

Item	P & ID symbol	Actual Connection Arrangement
Level Transmitter Diaphragm type D/P cell type		
Level Transmitter without isolating valve (Extended diaphragm seal D/P cell type)		
Level Transmitter (Flange mounted D/P cell type)		

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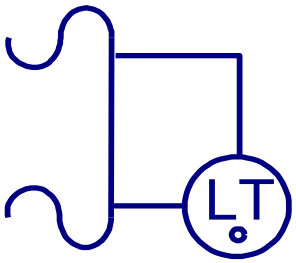
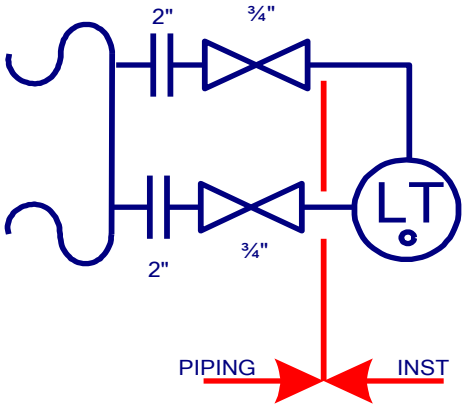
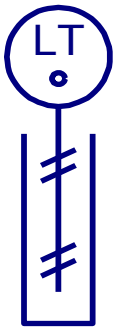
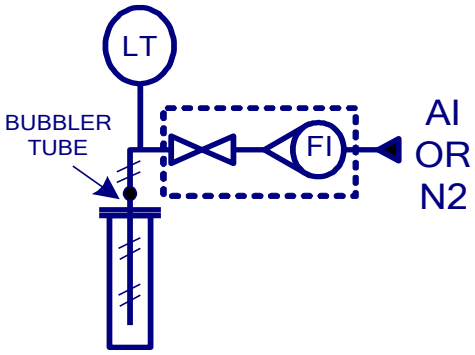
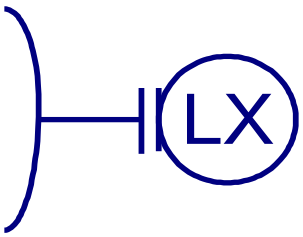
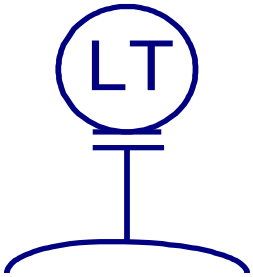
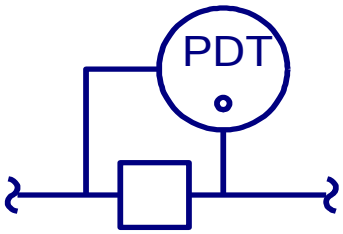
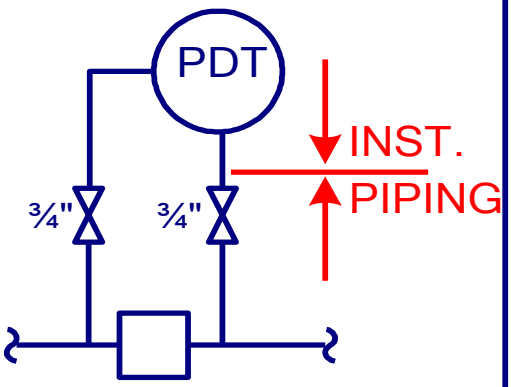
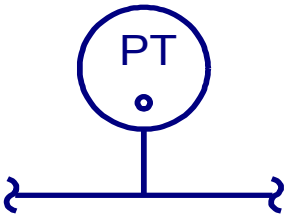
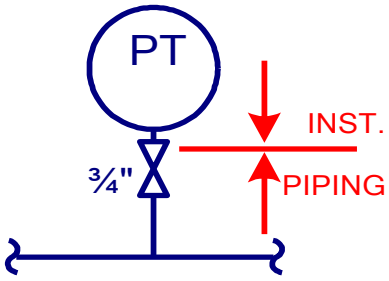
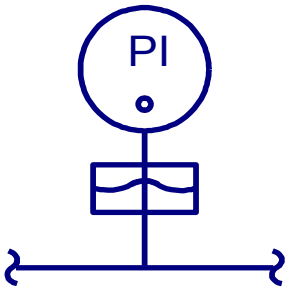
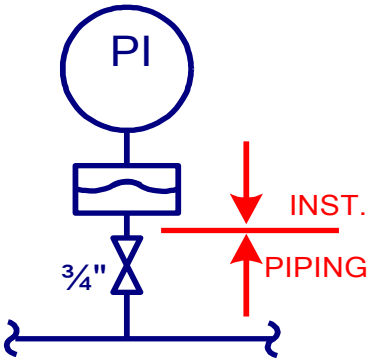
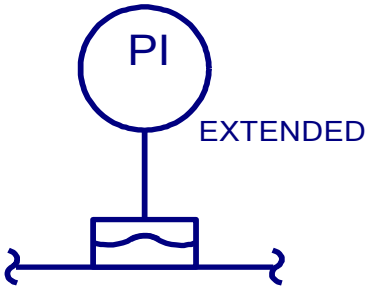
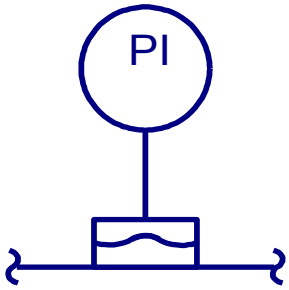
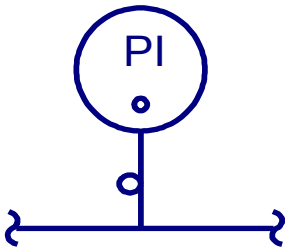
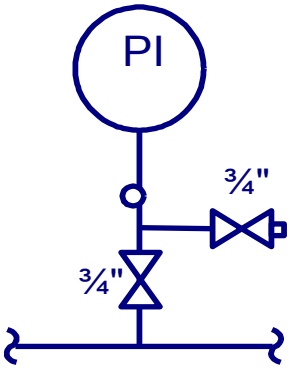
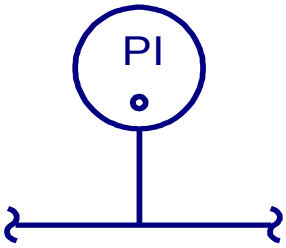
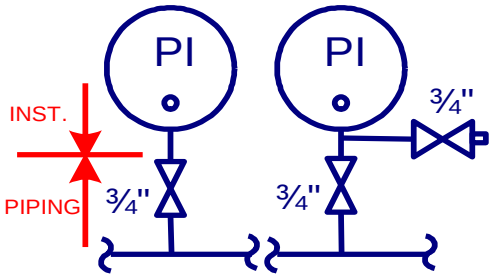
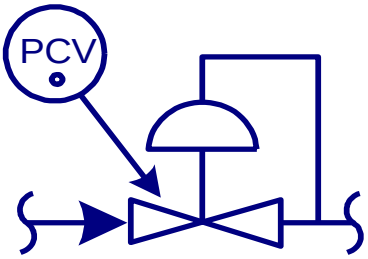
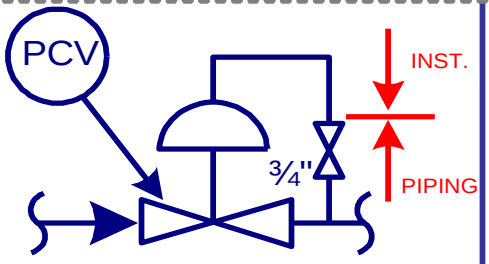
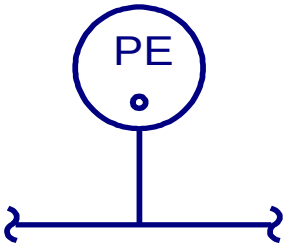
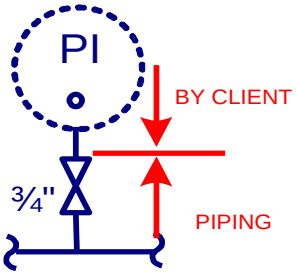
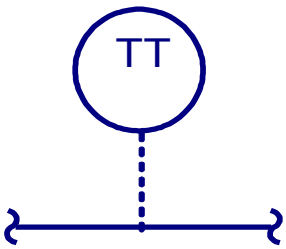
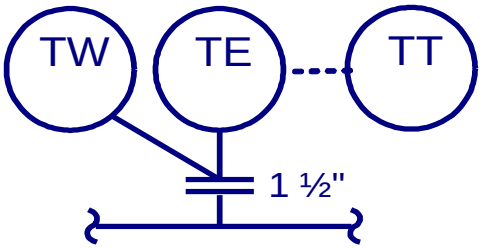
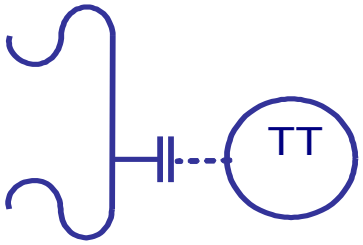
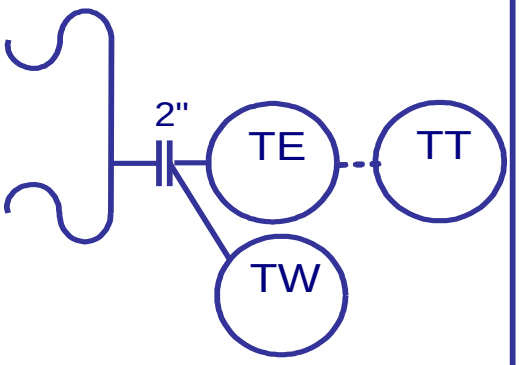
Level Transmitter (D/P)		
Level Transmitter with bubbler		
Radioactive source level transmitter		

Item	P & ID symbol	Actual Connection Arrangement
Capacitance/ Radar/Vibration Level transmitter		
Differential Pressure Transmitter		
Pressure Transmitter		

Item	P & ID symbol	Actual Connection Arrangement
Pressure gauge or pressure transmitter with isolation valve and diaphragm seal		
Pressure gauge or pressure TX without isolation valve with diaphragm seal		
Pressure Indicator (steam)		

Item	P & ID symbol	Actual Connection Arrangement
Pressure Indicator		
Pressure regulator with external pressure tap		
Pressure gauge test connection		
Temperature transmitter in line		

Item	P & ID symbol	Actual Connection Arrangement
Temperature transmitter on vessel		

INSTRUMENT IDENTIFICATION

The letters and numbers written inside an instrument balloon are used to identify the instrument. These letters and numbers, called the **Instrument identification** or **Tag numbers** furnish various types of information about the instrument.

Tag numbers are divided into two sections to provide different types of identification information.

Functional Identification:

It's located in the top part of the balloon. This code is used to identify the measured or initiating variable and the function of the individual instrument.

It normally consists of two, three, or four letters.

The first letter indicates the measured or initiating variable and the remaining letters usually indicate the function performed by the individual instrument. The second letter in the functional identification may act as **modifier** of the first letter. For example, Pressure **(P)** could be modified to indicate differential pressure **(PD).** In such a cases, a third letter would be used to identify the function of the individual instrument. Similarly, the letter used to designate a function may be followed by a modifier. A table listing the meanings of standard identification letters can be found on next page.

The most common process variables and their abbreviations are:

P = Pressure **T** = Temperature **L** = Level **F** = Flow

The most common instrument functions are:

I = Indicator **A** = Alarm **G** = Gauge **T** = Transmitter **R** = Recorder **S** = Switch
C = controller

IDENTIFICATION LETTERS

	First letter		Succeeding letters		
	Measured or initiating variable	**Modifier**	**Readout or passive function**	**Output function**	**Modifier**
A	Analysis		Alarm		
B	Burner, combustion				
C	Conductivity			Control	
D	Density	Differential			
E	Voltage		Sensor (primary element)		
F	Flow rate	Ratio (fraction)			
G	User's choice		Glass, viewing device		
H	Hand				High
I	Current		Indication		
J	Power	Scan			
K	Time	Time rate of change		Control station	
L	Level		Light		Low
M	Moisture				Middle, intermediate
N			User's choice	User's choice	User's choice
O			Orifice, restriction		
P	Pressure		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	

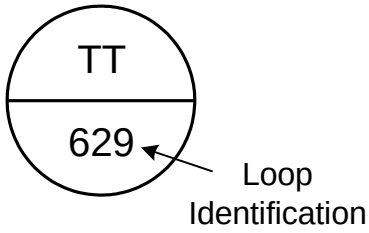
LOOP IDENTIFICATION

It's located in the bottom part of the balloon. As its name implies, this code is used to identify the loop of which instrument is a part.

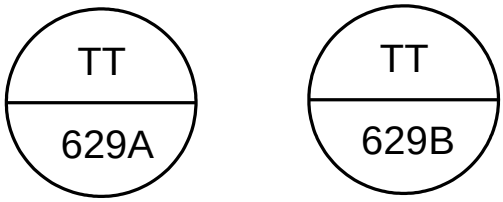
A loop is a combination of one or more interconnected instrument arranged to measure or control a process variable or both.

Each instrument in the loop is identified on an instrumentation diagram using a group of numbers shown in the lower portion of the instrument balloon.

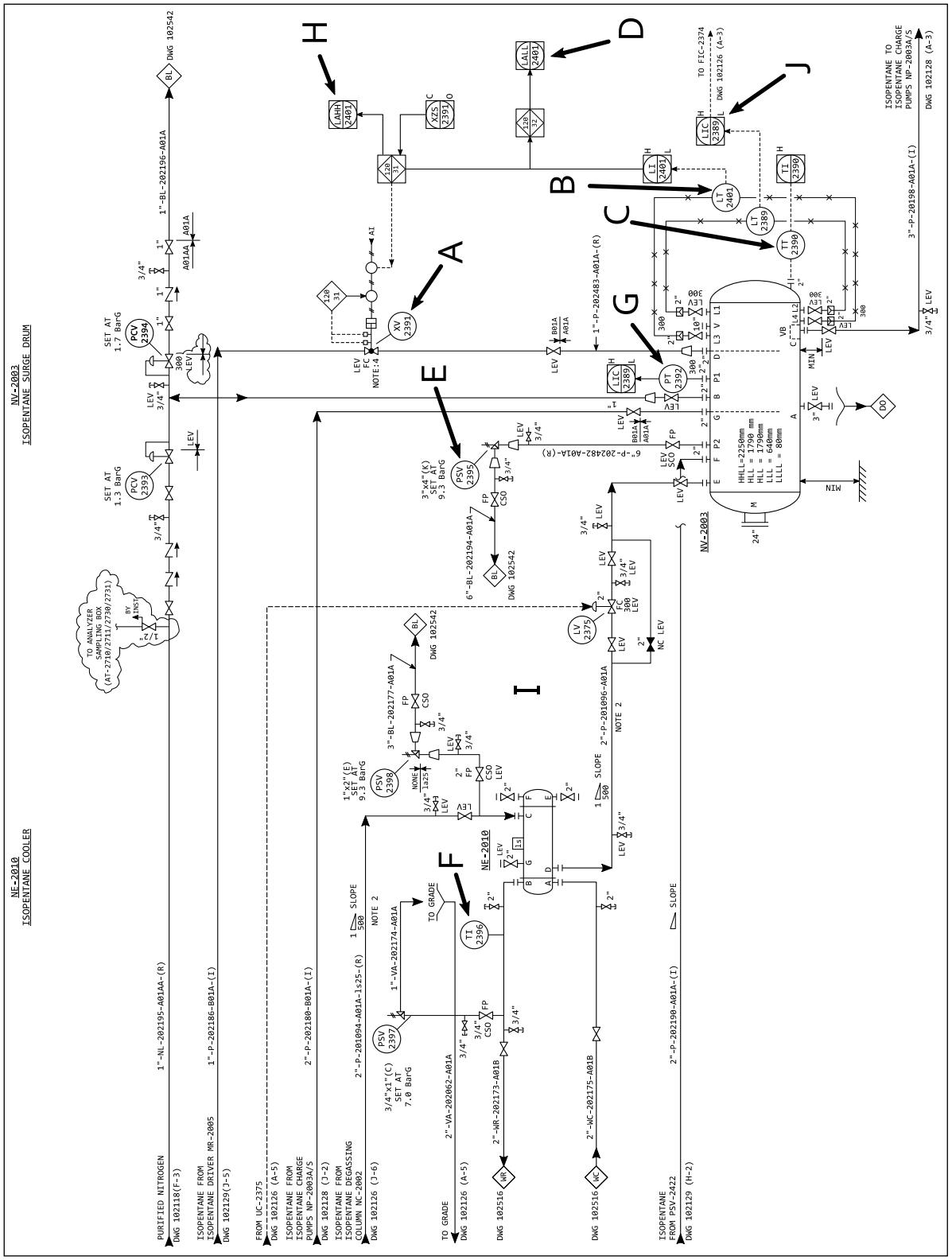
Each loop in a plant is assigned a specific number. All of the instruments in a particular loop will have the same loop identification number regardless of the type of instrument or the function it performs.



Some loops may have two or more instruments performing the sane function. If this is the case a consecutive letter suffix is usually added to the loop identification number for each instrument.

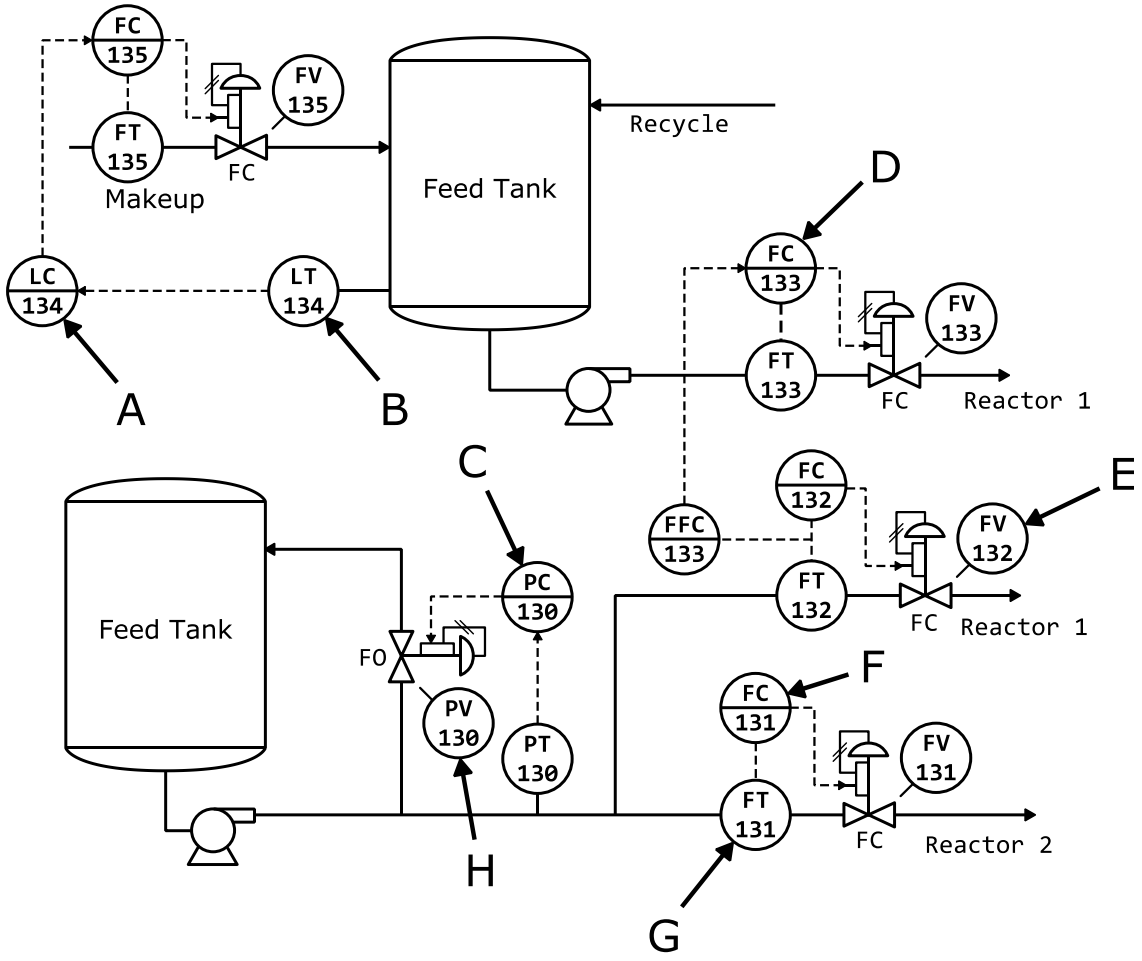


Exercise-1: Interpret each of the following instrument symbols:



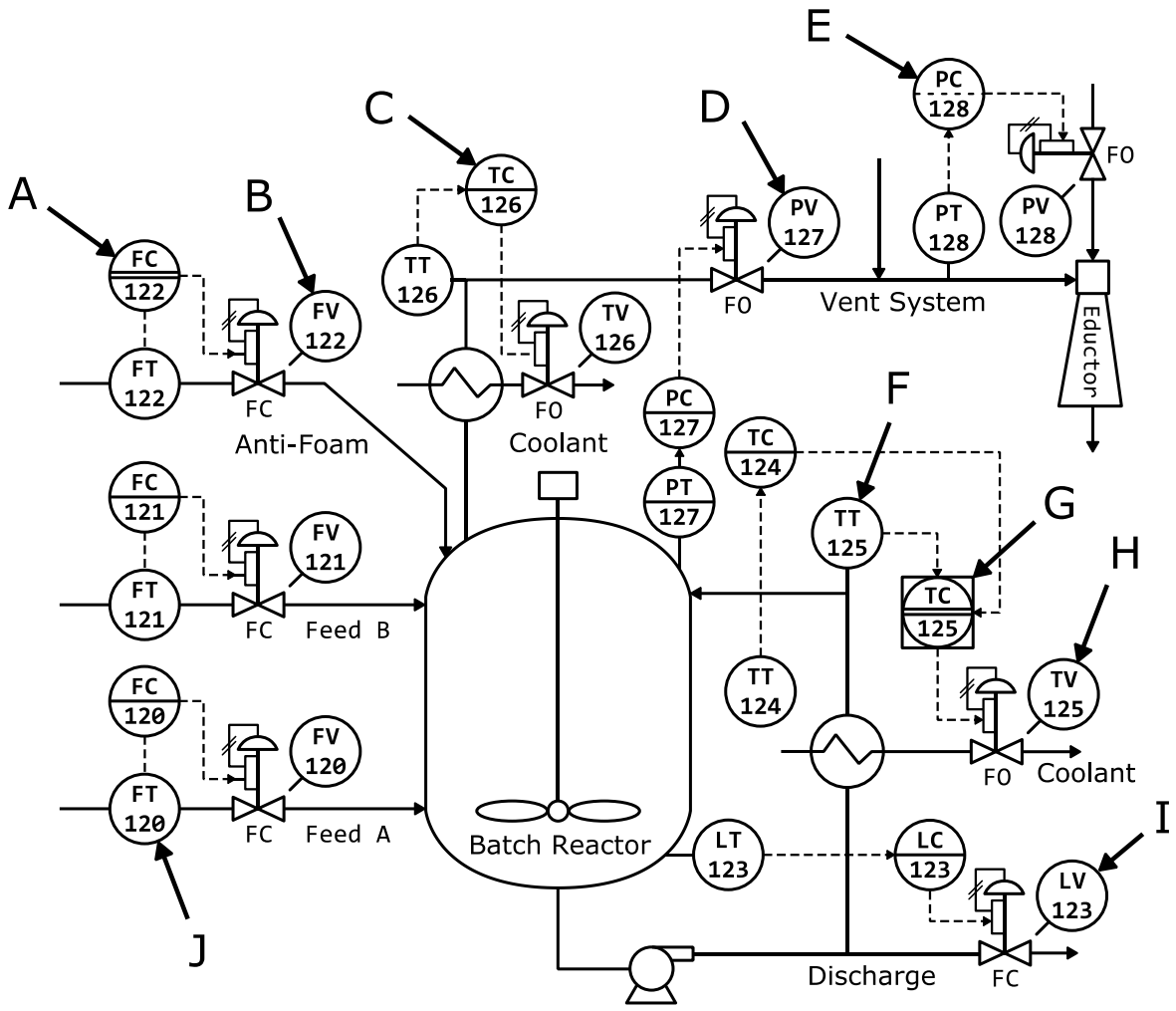
Instrument	Functional Identification	Loop Identification	Location	Description
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				

Exercise-2: Interpret each of the following instrument symbols:



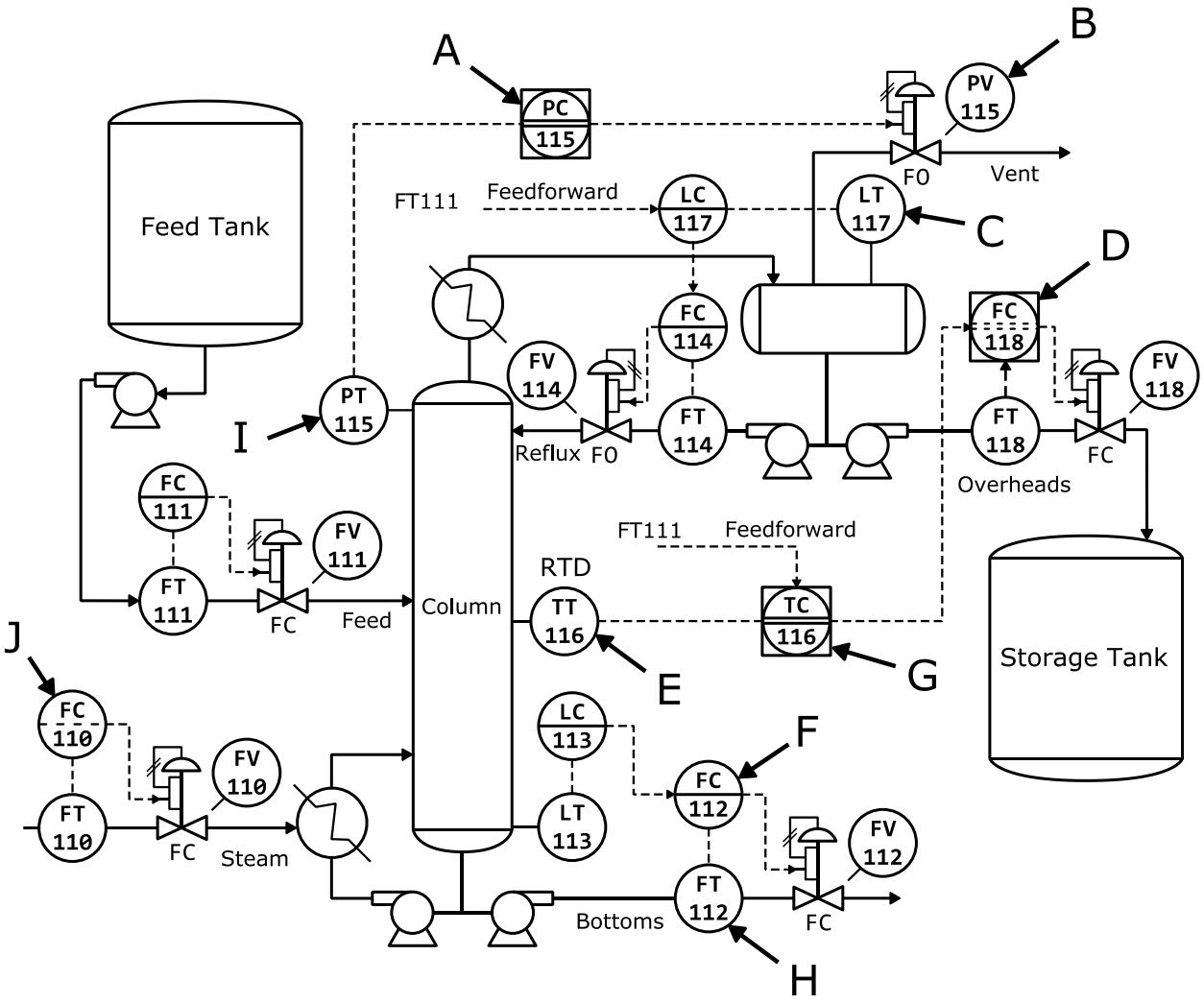
Instrument	Functional Identification	Loop Identification	Location	Description
A				
B				
C				
D				
E				
F				
G				
H				

Exercise-3: Interpret each of the following instrument symbols:



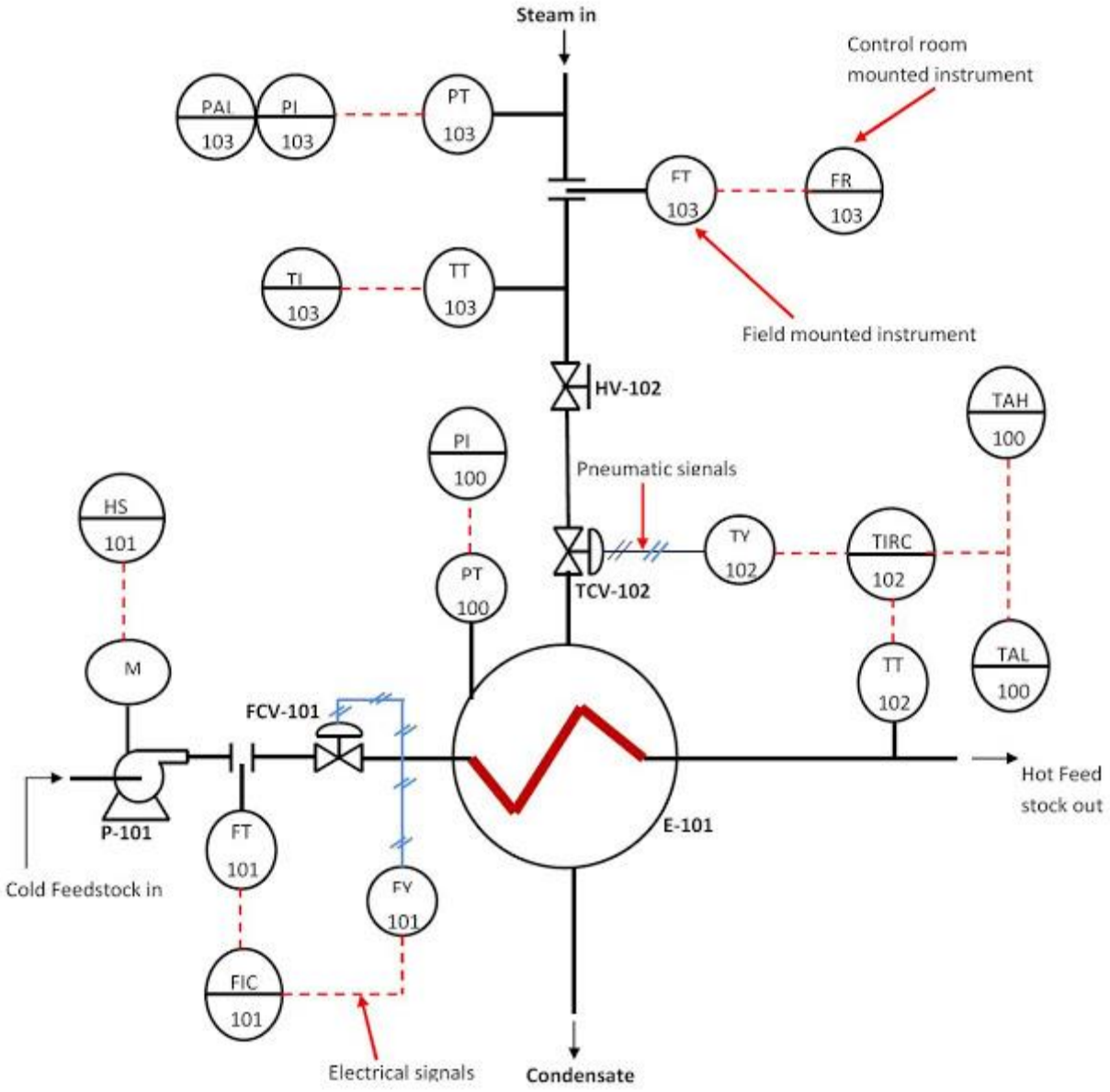
Instrument	Functional Identification	Loop Identification	Location	Description
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				

Exercise-4: Interpret each of the following instrument symbols:



Instrument	Functional Identification	Loop Identification	Location	Description
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				

Exercise-5: Heat Exchanger



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 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 feed stock or change in the inlet temperature of the feed stock. 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.

The Piping and Instrumentation Diagram:

Instruments on the P&ID

The instruments are represented in P&IDs by bubbles . 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

Write down detailed description of P&ID

A. FIC 101: _____

B. FR 103: _____

C. HS 101: _____

D. HV 102: _____

E. PAL 103: _____

F. PI 100: _____

G. PI 103: _____

H. TAH/L 102: _____

I. TI 103: _____

J. TT 102: _____

K. TIRC 102: _____

L. TR 101: _____

LINE SYMBOLS

Instrumentation diagrams contain other symbols in addition balloons, which designate instruments and their functions. In order to read a P & ID you will also need to interpret different kinds of line symbols. These lines may indicate:

- Process piping
- Process connections
- Signals

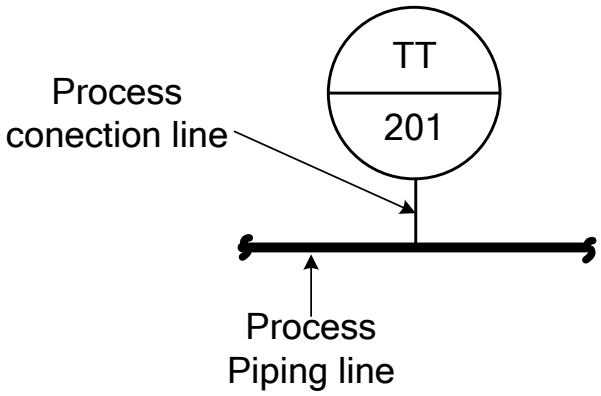
Process Line Symbols:

Process line symbols represent the piping that carries the working fluid.

Process Connection lines:

Fine lines used to represent different types of connections, such as:

- A mechanical link between two parts of an instrument system
- A connection between an instrument and the process
- A connection indicating the supply line to an instrument.



Signal lines:

In industrial processes, it is often necessary to send a signal from one instrument to another instrument. Different types of lines are used on instrumentation diagram s to represent the pathways for different types of signals. The type of line that is used on the diagram will depend on the type of signal transmitted.

No	Symbol	Application
1	(1) IA	• IA may be replaced by PA [plant air], NS [nitrogen], or GS [any gas supply]. • Indicate supply pressure as required, e.g., PA-70 kPa, NS-150 psig, etc.
2	(1) ES	• Instrument electric power supply. • Indicate voltage and type as required, e.g. ES-220 Vac. • ES may be replaced by 24 Vdc, 120 Vac, etc.
3	(1) HS	• Instrument hydraulic power supply. • Indicate pressure as required, e.g., HS-70 psig.
4	(2)	• Undefined signal. • Use for Process Flow Diagrams. • Use for discussions or diagrams where type of signal is not of concern.
5	(2)	• Pneumatic signal, continuously variable or binary.
6	(2)	• Electronic or electrical continuously variable or binary signal. • Functional diagram binary signal.
7	(2)	• Functional diagram continuously variable signal. • Electrical schematic ladder diagram signal and power rails.
8	(2)	• Hydraulic signal.
9	(2)	• Filled thermal element capillary tube. • Filled sensing line between pressure seal and instrument.
10	(2)	• Guided electromagnetic signal. • Guided sonic signal. • Fiber optic cable.
11	(3) a) b)	• Unguided electromagnetic signals, light, radiation, radio, sound, wireless, etc. • Wireless instrumentation signal. • Wireless communication link.
12	(4)	• Communication link and system bus, between devices and functions of a shared display, shared control system. • DCS, PLC, or PC communication link and system bus.
13	(5)	• Communication link or bus connecting two or more independent microprocessor or computer-based systems. • DCS-to-DCS, DCS-to-PLC, PLC-to-PC, DCS-to-Fieldbus, etc. connections.
14	(6)	• Communication link and system bus, between devices and functions of a fieldbus system. • Link from and to "intelligent" devices.
15	(7)	• Communication link between a device and a remote calibration adjustment device or system. • Link from and to "smart" devices.

* The following abbreviations are suggested to denote the types of power supply. These designations may also be applied to purge fluid supplies.

AS - Air Supply
IA - Instrument Air
PA - Plant Air
} Options
ES - Electric Supply
GS - Gas Supply
HS - Hydraulic Supply
NS - Nitrogen Supply
SS - Steam Supply
WS - Water Supply

The supply level may be added to the instrument supply line, e.g., AS-100, a 100 psig air supply; ES-24-DC, a 24-volt direct current power supply.

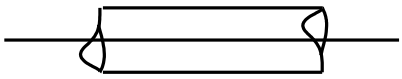
** The pneumatic signal symbol applies to a signal using any gas as the signal medium. If a gas other than air is used, the gas may be identified by a note on the signal symbol or otherwise.

*** Electromagnetic phenomena include heat, radio waves, nuclear radiation and light.

TRACING & INSULATION

Pipes are sometimes covered and/or traced. The Line Schedule and designation number will contain some codes that are used to represent the insulation material and thickness. In addition, some symbol might be used to represent the tracing and insulation type as shown below.

Steam Traced Line



Steam Jacketed Line

Electric Traced Line

NOTE Some Insulation Materials codes are listed below:

CODE	INSULATION TYPE
Et	ELECTRIC TRACED & INSULATED
Ia	ACOUSTIC INSULATION
Ias	ANT-SWEAT INSULATION
Ic	COLD INSULATION
Ica	COLD AND ACOUSTIC INSULATION
Id	DUAL PURPOSE INSULATION
Ih	HOT INSULATION
Iha	HEAT AND ACOUSTIC INSULATION
Is	SAFETY INSULATION (PERSONAL ROTECTION)
St	STEAM TRACED & INSULATED
Isa	SAFETY & ACOUSTIC INSULATION
Iasa	ANTI-SWEAT & ACOUSTIC INSULATION

LINE DESIGNATION

Most of the questions that come up about Line designation include: What is it? Why is it? What does it mean? Who does it? Another question that is often asked "is there a common pipe line designation system? Do engineering companies and clients have different line designation systems? .

These all are good questions and it is important for every technician to know the answers to each one. It is actually safe to say there is no "common pipe line designation system" in use in the process plant engineering and design world.

To properly discuss this subject we need to understand the purpose of the "Line designation" or "Line numbering" as some companies called it. Whether the term "Line number" or the term "Line designation" is used the purpose is still the same.

It is a name for the line, it is for positive identification. It is the same as for you your name is the way to positively identify you. The pipeline identification is necessary through out the project and is used for many purposes by many different people or groups. The line designation is an important aspect of the piping on a project and should only be created and controlled by the piping group for the project, specifically by the piping material engineer for that project.

There are two basic areas that tend to govern line numbering. These are the line number **method** and the line number **elements**.

- **Methods** - There are two basic line designation "methods." ***The first*** method is based on the Purpose or Function of the line. ***The second*** method is based on the line "Size."

- **Elements** - There are many potential line identification elements that may be included in a line designation system. The elements that are most commonly included in a line numbering scheme are: Plant Location, Line Identity, Line Class (Line Specification), Size, Insulation Type (when required) and Heat Tracing Type (when required).

Methods:

The purpose or functional method of line designation is where the line is best defined as a single line having an origin and a terminus consistent with a purpose or function. An example of this might be a pump suction line. It might come from a storage tank, a tower bottom or an accumulator. It travels some distance and then splits and connects to the two pumps designated for that service or function. This is one line, it serves one purpose or function therefore it has only one line number. Another example would be the pump discharge that leaves both of these pumps and join to form the single pipe line that runs to the next piece of equipment. This line also has one purpose or function therefore, it has only one number.

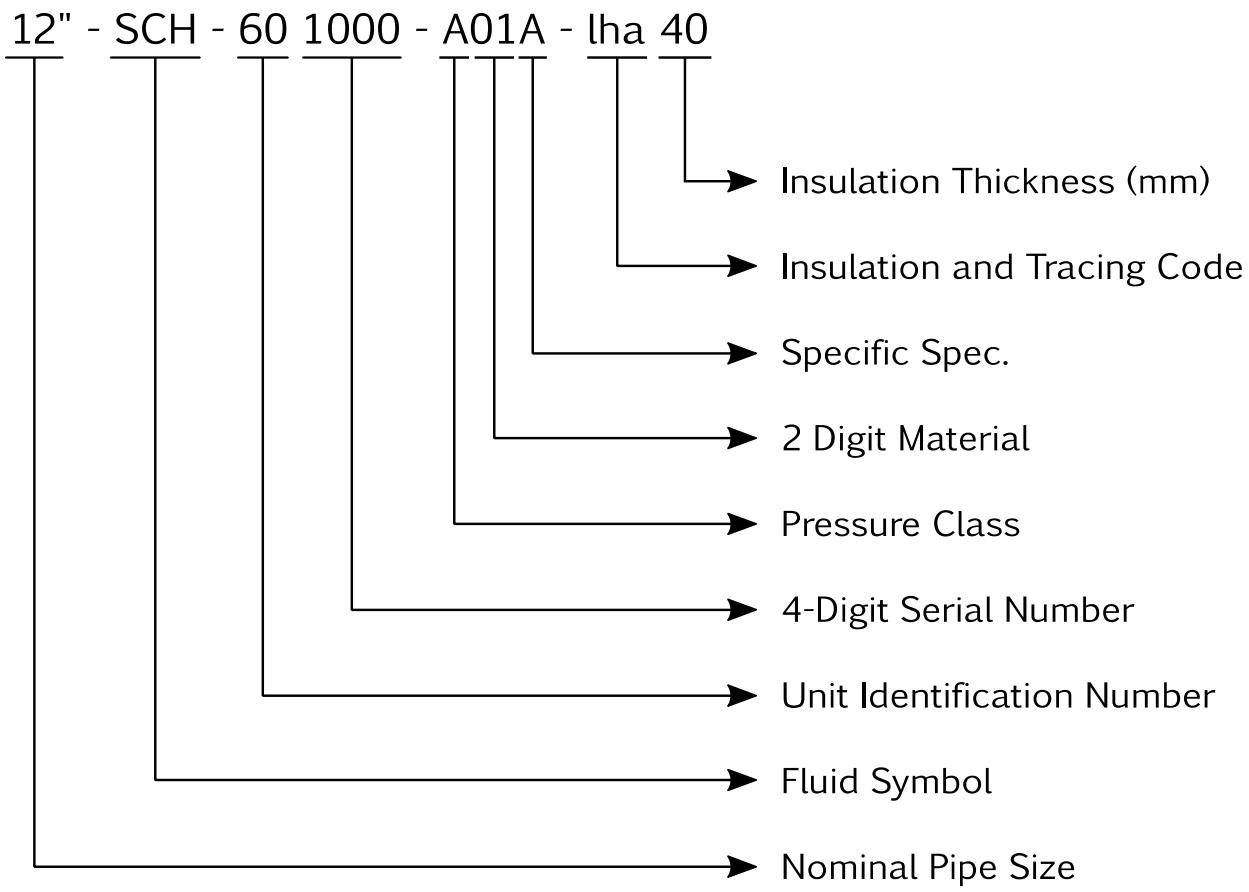
The line size method is where the line number changes whenever and wherever the line size changes. When compared to the first (purpose or function) method, the pump suction line might have five line numbers instead of one. The pump discharge might also have five

or more depending on what happens at the destination end of the line.

One or the other of these two methods becomes the rule for a company, client or project. As we all know, for every rule you will always find exceptions. One exception that is common to both of these rules is the rule of the change of line class or (line specification). The change in line class is most often caused by a change in pressure or material. A line might be the same size from one point to another but includes a pressure control valve that lets the pressure down to a level that allows a lower flange rating and or another material therefore a different line class. Any change in a lines conditions or material causes a mandatory change in the line number no mater which line designation method is being used.

Elements:

The elements of a line number might be arranged and look something like this:



NOTE: Other fluid symbols that could be included in the line identification number are listed on the following page.

Fluid Symbols/Line Service Code

AB	BREATHING AIR
AC	COMBUSTION AIR
AD	DRYING AIR
AFL	AIR FOAM LIQUID
AFW	AIR FOAM SOLUTION
AI	INSTRUMENT AIR
AP	PROCESS AIR
AR	REGENERATION AIR
AT	TRANSFER AIR
AU	UTILITY AIR
BC	COLD BLOW DOWN
BH	HOT BLOW DOWN
BL	LOW PRESSURE BLOW DOWN
BO	BOILER BLOW OFF
CA	CATALYST
CL	CHLORINE
CPS	PHOSPHATE SOLUTION
DA	ACID SEWER

DC	CAUSTIC SEWER
DK	CHEMICAL SEWER
DO	OILY WATER SEWER
DM	DMDS DRAIN
DP	PROCESS SEWER
DPE	PE WATER SEWER
DR	STORM SEWER
DS	SANITARY SEWER
EF	POND EFFLUENT
GF	FUEL GAS
GH	HYDROGEN
GI	INERT GAS(NITROGEN)
GN	NATURAL GAS
HC	HYDROCHLORIC ACID
HS	SULFURIC ACID
IN	INHIBITOR
KC	CAUSTIC
KP	PROCESS CHEMICALS

NL	L.P. PURIFIED NITROGEN
NH	H.P.PURIFIED NITROGEN
NT	TRANSFER NITROGEN
OC	COOLING OIL
OF	FUEL OIL
OH	HYDRAULIC OIL
OL	LUBE OIL AND SEAL OIL
OW	WASH OIL
OX	SLOPE OIL
P	PROCESS PIPING
PC	PROCESS CONDENSATE
PE	PE WASTE WATER
RE	ETHYLENE REFRIGERATION
RP	PROPYLENE REFRIGERATION
SCH	H.P. STEAM CONDENSATE
SCL	L.P.STEAM CONDENSATE
SCM	M.P STEAM CONDENSATE
SC	SUBCOOLED CONDENSATE
SH	H.P.STEAM
SL	L.P.STEAM CONDENSATE
SM	M.P.STEAM

VA	VENT TO ATMOSPHERE
WA	POTABLE WATER
WB	BOILER FEED WATER
WC	COOLING WATER SUPPLY
WD	DRINKING WATER
WF	FIRE WATER
WI	DEMINERALIZED WATER
WJ	JACKET WATER
WL	CHILLED WATER SUPPLY
WM	CHILLED WATER RETURN
WP	PROCESS WATER
WPE	PELLET WATER
WQ	QUENCH WATER
WR	COOLING WATER RETURN
WRC	RECOVERY WATER
WSR	SEA WATER RETURN
WS	WASTE SLUDGE
WSS	SEA WATER SUPPLY
WU	SERVICE WATER
WW	WASTE WATER
WWN	NEUTRALIZED WASTE WATER

In this case, the **"60"** refers to a physical plant unit as defined by the project documents. Other units might be 10, 20, 30, 40 or 11, 12, 13, etc. The **"1000"** represents the line serial number in unit 60. All line serial numbers on this project will be four digits number. Pressure class and material of the pipe as well as some other specifications will be deduced from the line number. Furthermore, line number may contain insulation tracing code and thickness if the line was insulated.

LINE SCHEDULE

Line schedule tells us the following kinds of information about each pipe on the P&ID:

- Pipeline number
- Material flowing through the pipe
- Where the stream flow is coming from and flowing to
- Specifications, size, material of construction, and if insulation or tracing is on the pipe.

The table below shows examples of typical headings and information given for three different pipelines in a line schedule, A P&ID may have many lines; the line schedule listing may cover most of the bottom of the page. In this course, we will learn how to apply the information from the line schedule when reading a P&ID.

LINE NUMBER	PRODUCT	FROM	TO	SPEC	PIPE				
					SIZE	SCH	MAT	INS	TRAC
WTOL-179-3	WET TOLUENE	2-28H1	3"W-179-2	N-1	2"	SO	TF	NO	NO
WWA-179-6	STORM WATER	S-17P3	PROCESS SEWER	A1	1.12"	80	CS	NO	NO
WWA-179-5	WASTE WATER	S-17P3	E/N FACILITY	A1	1.12"	80	CS	NO	NO

NOTE: SPEC = Specification, SCH = Schedule, MAT = Material, INS = Insulation, TRAC = Tracing

Exercise: Referring to the line schedule on the previous page fill the blanks below.

1. The material in pipe number WWA-179-5 is waste water.

   The material in pipe number WWA-179-6 is _____.

2. The size of pipe number WTOL-179-3 is 2 inches.

   The size of pipe number WWA-179-5 is _____.

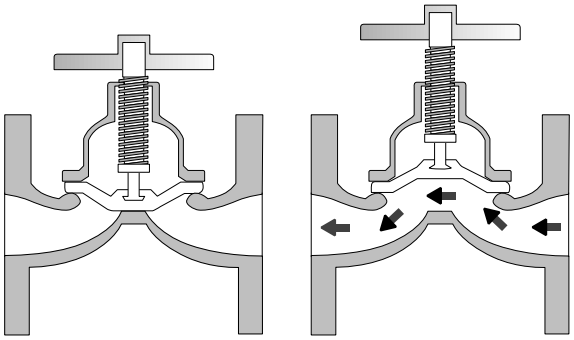
3. The material in pipe number WWA-179-6 is flowing to the process sewer.

   The material in pipe number WWA-179-5 is flowing to the _____ .

CONTROL VALVES SYMBOLS

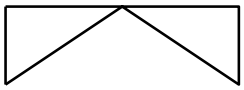
Diaphragm valve:

Diaphragm valve consists of a valve body with two or more ports, a diaphragm, and a saddle or seat upon which the diaphragm closes the valve. The valve is constructed from either plastic or steel.



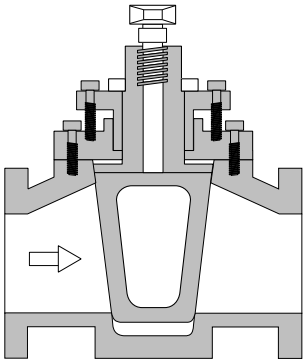
Closed Open

P & ID SYMBOL

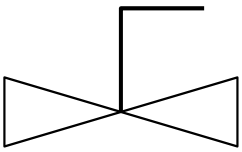


Plug valve:

The plug valve is basically on-off valve based on a plug with a rectangular hole through which the fluid flows. The plug is either tapered or cylinderical and is located in the valve body and can be rotated through a quarter turn to line the hole up with the pipe when open or across the pipe when closed.

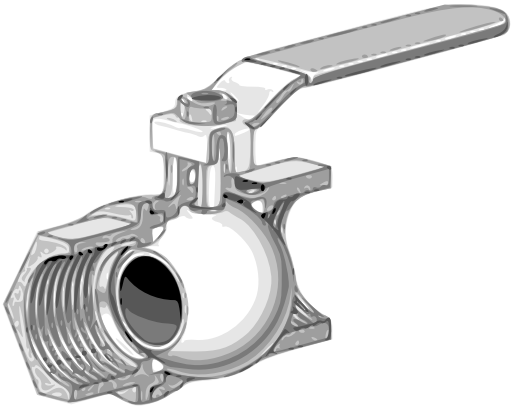


P & ID SYMBOL

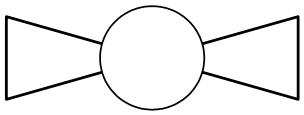


Ball valve:

The ball valve is basically a plug valve with a spherical plug and a round hole.

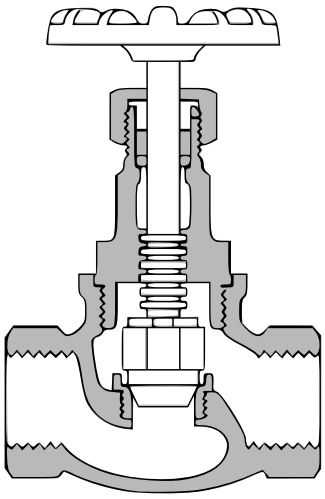


P & ID SYMBOL

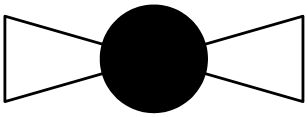


Globe valve:

A Globe valve is a type of valve used for regulating flow in a pipeline, consisting of a movable disk-type element and a stationary ring seat in a generally spherical body.

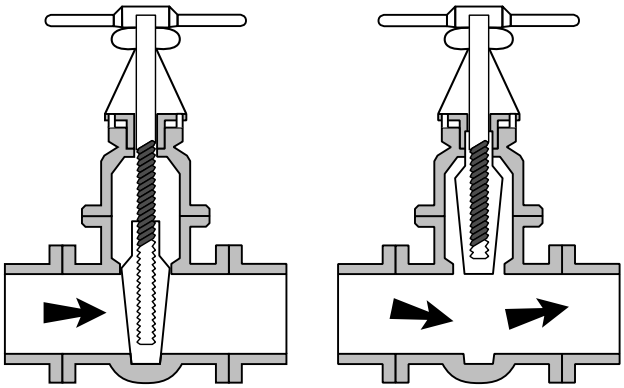


P & ID SYMBOL

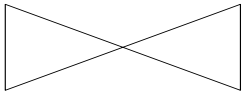


Gate valve:

A Gate Valve, or Sluice Valve, as it is sometimes known, is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid.

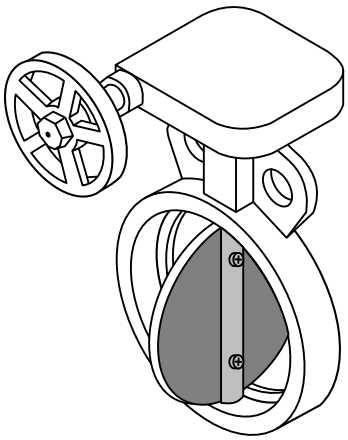


P & ID SYMBOL

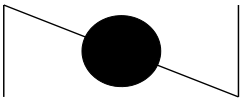


Butterfly valve:

A butterfly valve is from a family of valves called quarter-turn valves. The "butterfly" is a metal disc mounted on a rod. When the valve is closed, the disc is turned so that it completely blocks off the passageway. When the valve is fully open, the disc is rotated a quarter turn so that it allows an almost unrestricted passage of the process fluid.

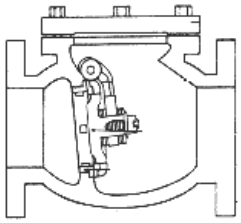


P & ID SYMBOL



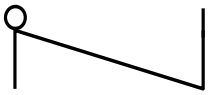
Check valve:

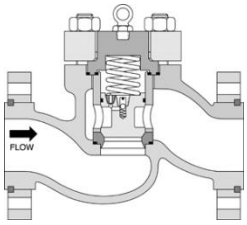
A **check valve**, **clack valve**, **non-return valve** or **one-way valve** is a mechanical device, a valve, which normally allows fluid (liquid or gas) to flow through it in only one direction. Check valves are two-port valves, meaning they have two openings in the body, one for fluid to enter and the other for fluid to leave.



LIFT OR SWING TYPE

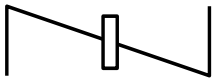
P & ID SYMBOL





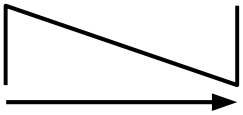
PISTON TYPE

P & ID SYMBOL



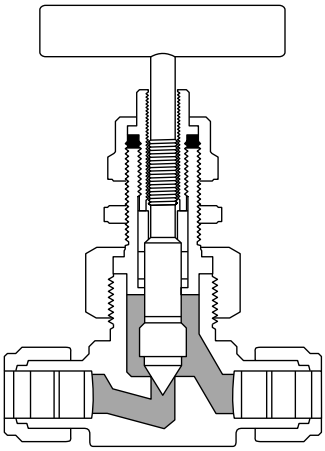
In some P & ID's, the following symbol is used as common symbol for any type of check valves.

P & ID SYMBOL

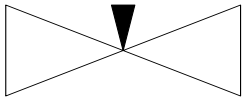


Needle valve:

A **needle valve** is a type of valve having a small orifice and a threaded, needle-like plunger. It allows precise regulation of flow, although it is generally used for, and is capable of, only relatively small flow rates.



P & ID SYMBOL



ACTUATORS SYMBOLS

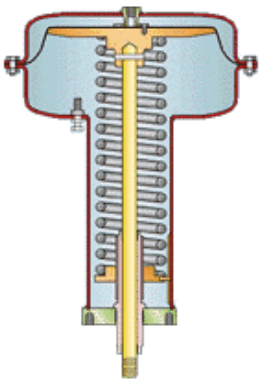
An actuator is a device that controls the operation of a final control element, usually a control valve. It moves the valve stem and plug to the position required by the process conditions.

PNEUMATIC DIAPHRAGM ACTUATOR

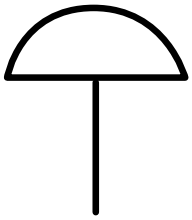
It is controlled by a pneumatic (air) signal.

Diaphragm

Diaphragm Actuator

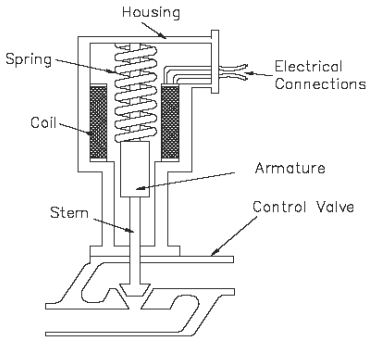


P & ID SYMBOL

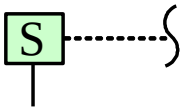


SOLENOID ACTUATOR

Solenoid Actuator



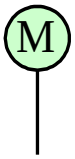
P & ID SYMBOL



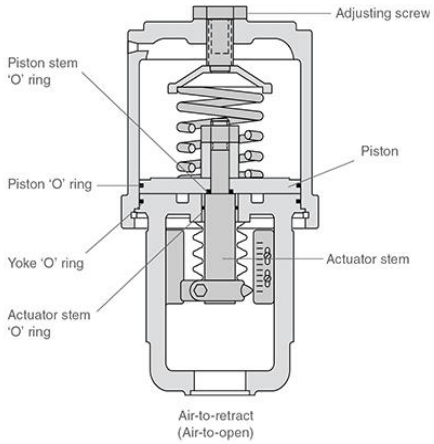
ELECTRICAL MOTOR ACTUATOR

Motor Actuator

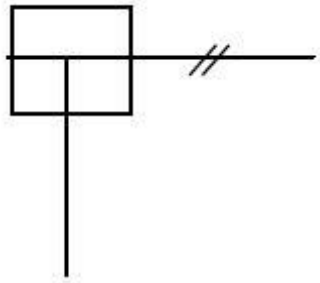
P & ID SYMBOL



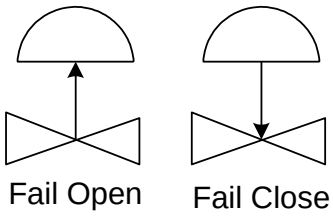
PISTON ACTUATOR



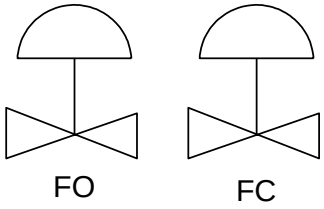
P & ID SYMBOL



The valves below show the use of an arrowhead to show the fail position.



Fail open and fail close positions can be represented also by writing FO and FC below the valves as shown below



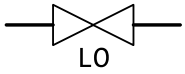
Valve status symbols:

Closed Valve:

Open Valve:

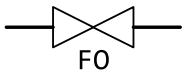
Throttled Valve:

Locked Open Valve:

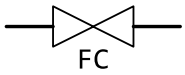


Locked Closed Valve:

Valve Fails Open:



Valve Fails Closed:



Valve Fails As Is:

Exercise 1:

- Match the symbol with the name of the valve.

●Check Valve

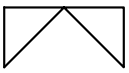
●Globe Valve

●Ball Valve

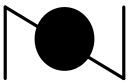
●Butterfly Valve

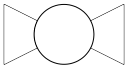
●Gate Valve

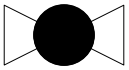
●Diaphragm Valve

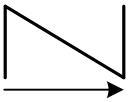
a. 

b. 

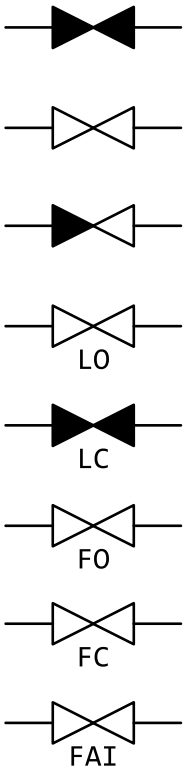
c. 

d. 

e. 

f. 

Exercise 3: Write the name of the symbol in the space provided:



Exercise 4: Draw the following symbols:

1) Globe valve _____

2) Check valve _____

3) Ball valve _____

4) Angle valve _____

5) Open valve _____

6) Closed valve _____

7) Valve fail open _____

8) Valve fail closed _____

9) Throttled valve _____

Valve Actuators symbols:

1) Diaphragm _____

2) Electric motor _____

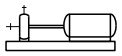
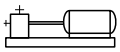
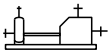
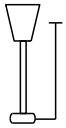
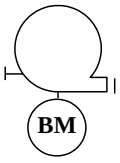
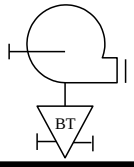
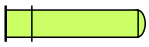
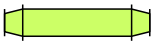
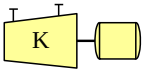
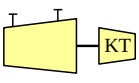
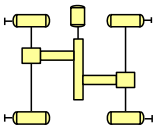
3) Solenoid _____

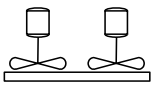
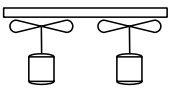
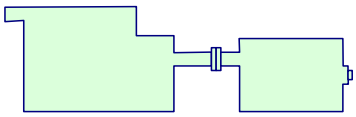
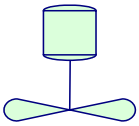
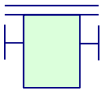
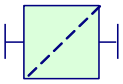
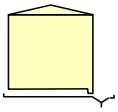
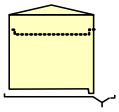
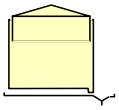
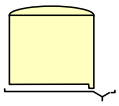
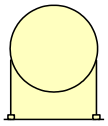
4) Piston _____

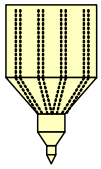
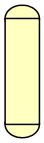
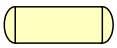
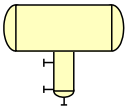
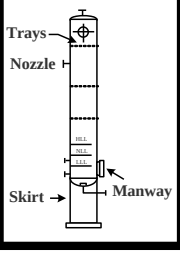
5) Manual _____

EQUIPMENT SYMBOLS

The table below gives example of process equipment symbols. They will often be some of the largest symbols that you see on a P&ID.

EQUIPMENT	1	2	3	4	5
Motor Driven Pumps	Centrifugal	Reciprocating	Inline	Submerged	
					
Turbine Driven Pumps	Centrifugal	Submerged			
					
Blowers	Motor driven	Turbine driven			
					
Exchanger					
					
Compressors	Centrifugal Motor driven	Centrifugal Turbine driven	Reciprocating		
					

EQUIPMENT	1	2	3	4	5
Air coolers	Induced draft 	Forced draft 			
Generator					
Agitator					
Filters					
Tanks	Cone Roof Tank 	Internal floating roof 	External floating roof 	Dome Roof Tank 	Spherical 

EQUIPMENT	1	2	3	4	5
Silo					
Vessels	Vertical	Horizontal	Horizontal with boot		
					
Column					

Exercise 5: Draw the following symbols

1) Motor Driven Pump:

2) Turbine Driven pump:

3) Blower:

4) Exchanger:

5) Compressor:

6) Air cooler

7) Generator:

8) Agitator:

9) Filter:

10) Tank:

11) Silo:

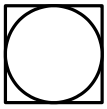
12) Vessel:

13) Column:

Section 2.
DIGITAL CONTROL INTERPRETATION

DIGITAL CONTROL CONCEPTS

Digital control systems provide versatile and efficient process control and data acquisition in many industries.

Shared Display and Shared Controller 

Processes include many variables that must be monitored and controlled. With digital systems, the variables can be checked at a remote location using a shared display. A shared display is a device that allows interface with the process to provide and display measurement and control information from a number of different locations within the process. Often, an entire process can be monitored on one shared display screen.

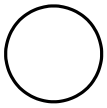
A shared controller, or multifunction controller, is one that controls several process variables simultaneously.

Scanning

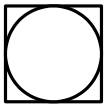
Processes must be continually monitored and controlled. The function of a scanning device is often to ascertain the state or value of many process variables. Being able to scan or sample a number of process variables is essential for multi-process controller. In a typical digital control system, a controller can continuously scan process variables such as flow rate, temperature, and level. Often, scanning is combined with one or more other functions, such as controlling, recording, and alarming. The information gained from scanning can be communicated to the controller so that appropriate control action can be taken to the .recorder which then logs a current record of the value or state of all the process variables and to the alarm function, which will alert operator to any upset in the process variable.

SYMBOLS AND DESIGNATIONS

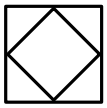
We have seen in previous lectures the symbols used to depict instruction on a diagram and drawings. Several of the symbols which may be seen on a digital instrumentation diagrams are shown below:



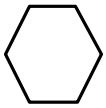
Discrete



Shared display / Control

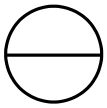


PLC

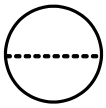


Computer Function

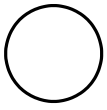
The presence or absence of lines within an instrument symbol provide information about its location within the process system.



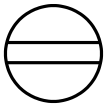
Primary Location



Behind Panel



Field Mounted



Auxiliary Location

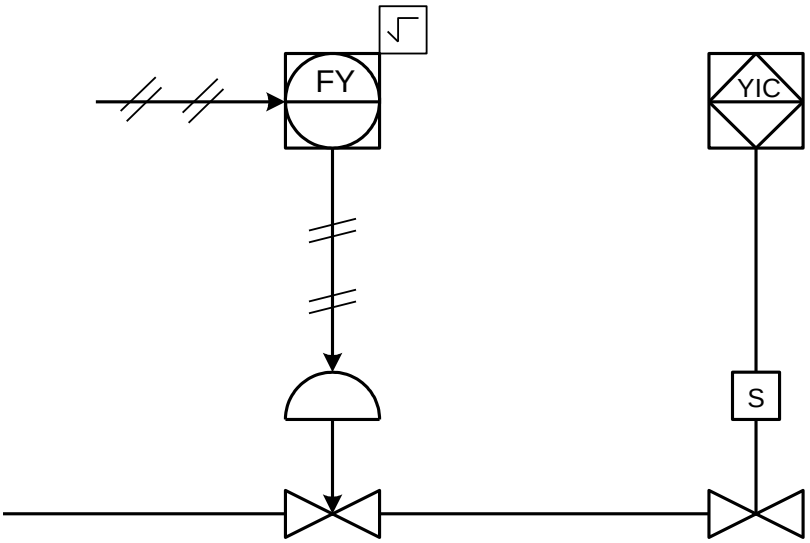
Example:

L = Measured or initiating variable

I = Readout or passive function

C = Output function

Example: Letters associated with digital control.



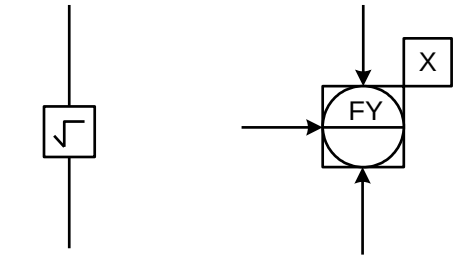
In this process, the letter Y is used to represent the measured variable in one instrument and the output function on another. In instances in which Y is the first letter identifier, Y represents control that is event driven, or might signify

a state. Where Y is the -second letter in this example, it indicates computing function such as the square root extracting.

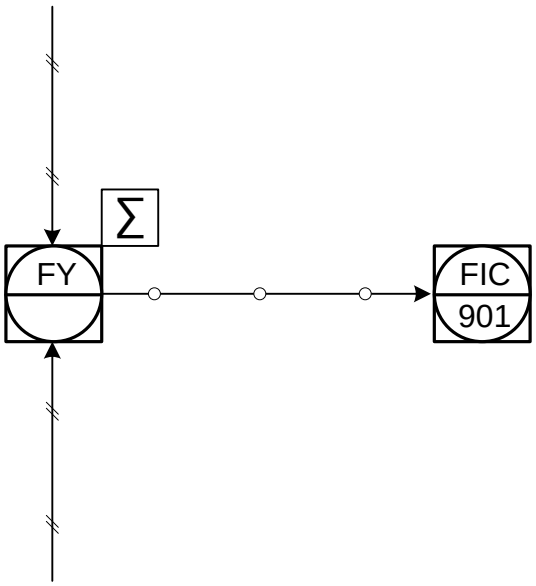
FUNCTION BLOCKS

Function blocks designate the computations and conversions within a loop or an instrument. Function blocks are used in several ways in instrumentation drawings. A function block may be used as a standalone symbol that represents only the functional aspects of a loop. It may also be used as flags, designating a function of a specific component or instrument.

Examples:



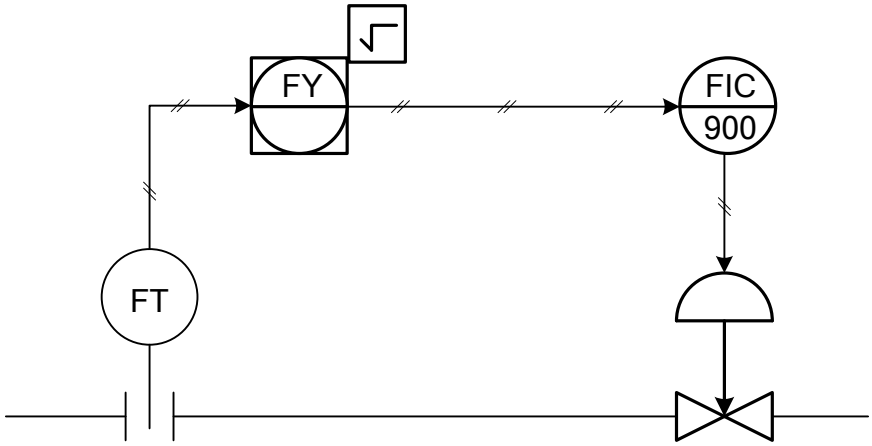
Example 1 (summing):



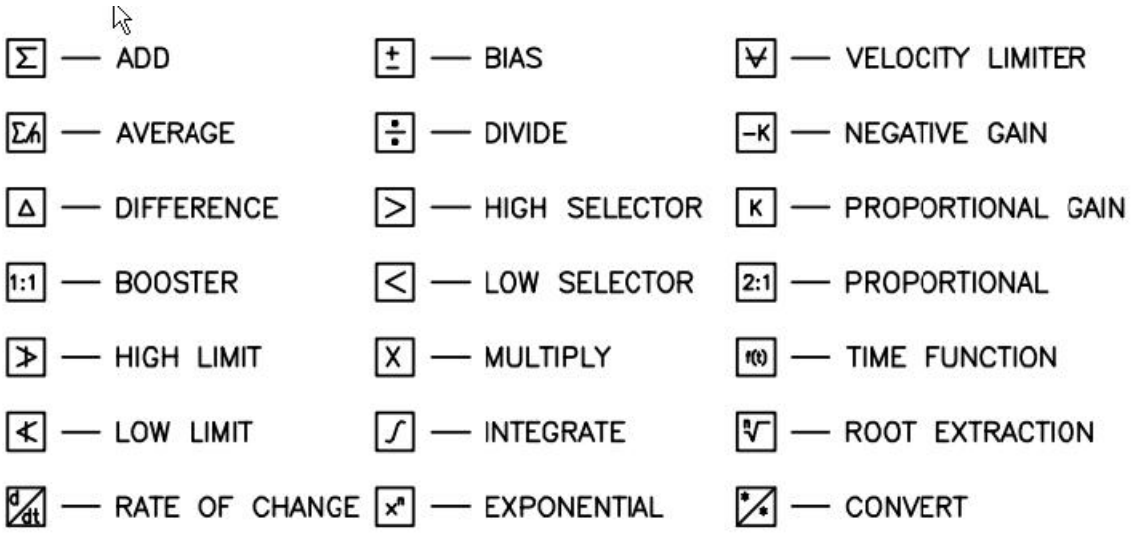
This is the symbol for summing function. This function indicates that the output of the instrument will equal the algebraic sum of the inputs.

Example 2 (square root):

 is the symbol for square root extraction

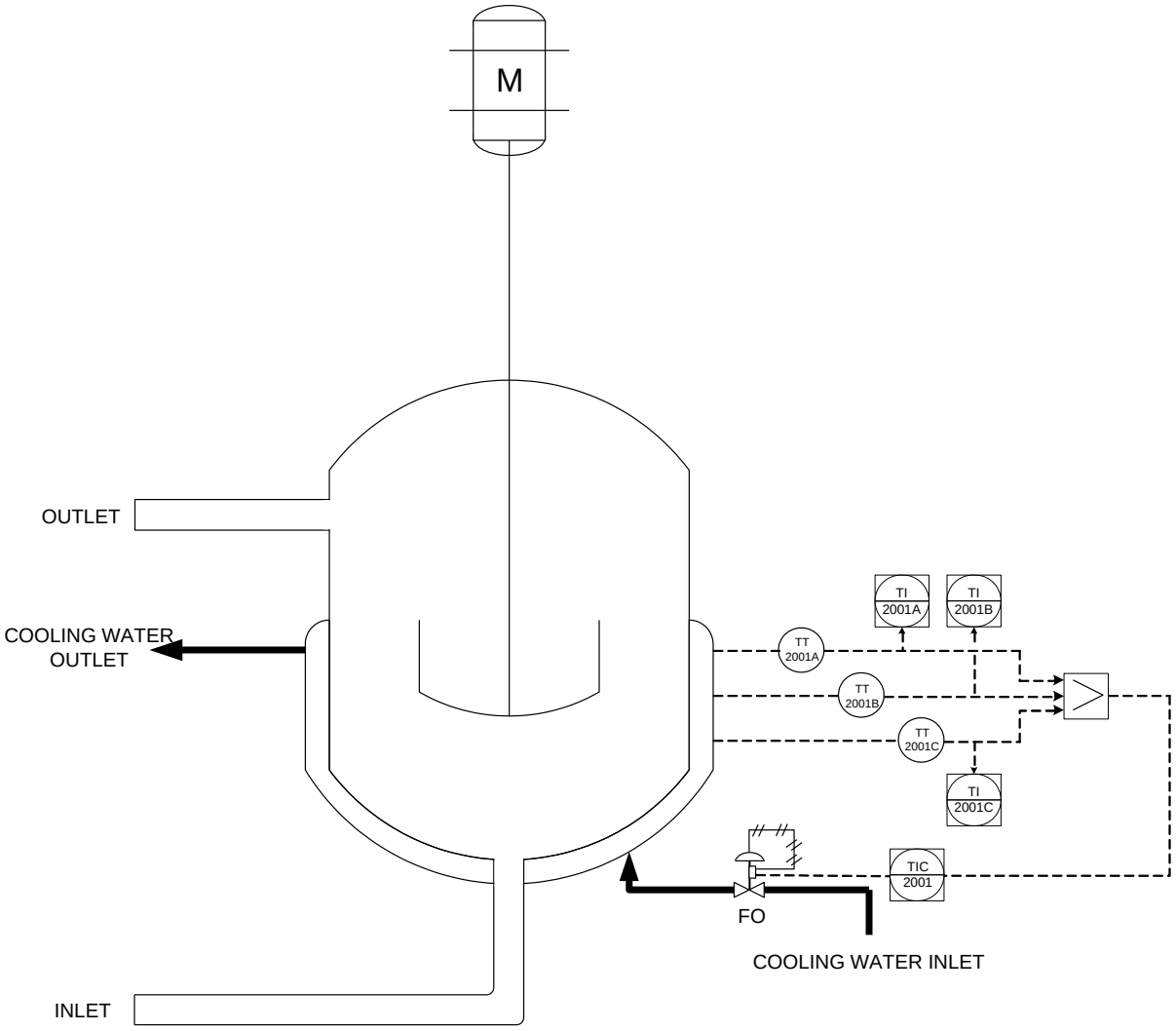


Some of the functions and its symbols are given below:



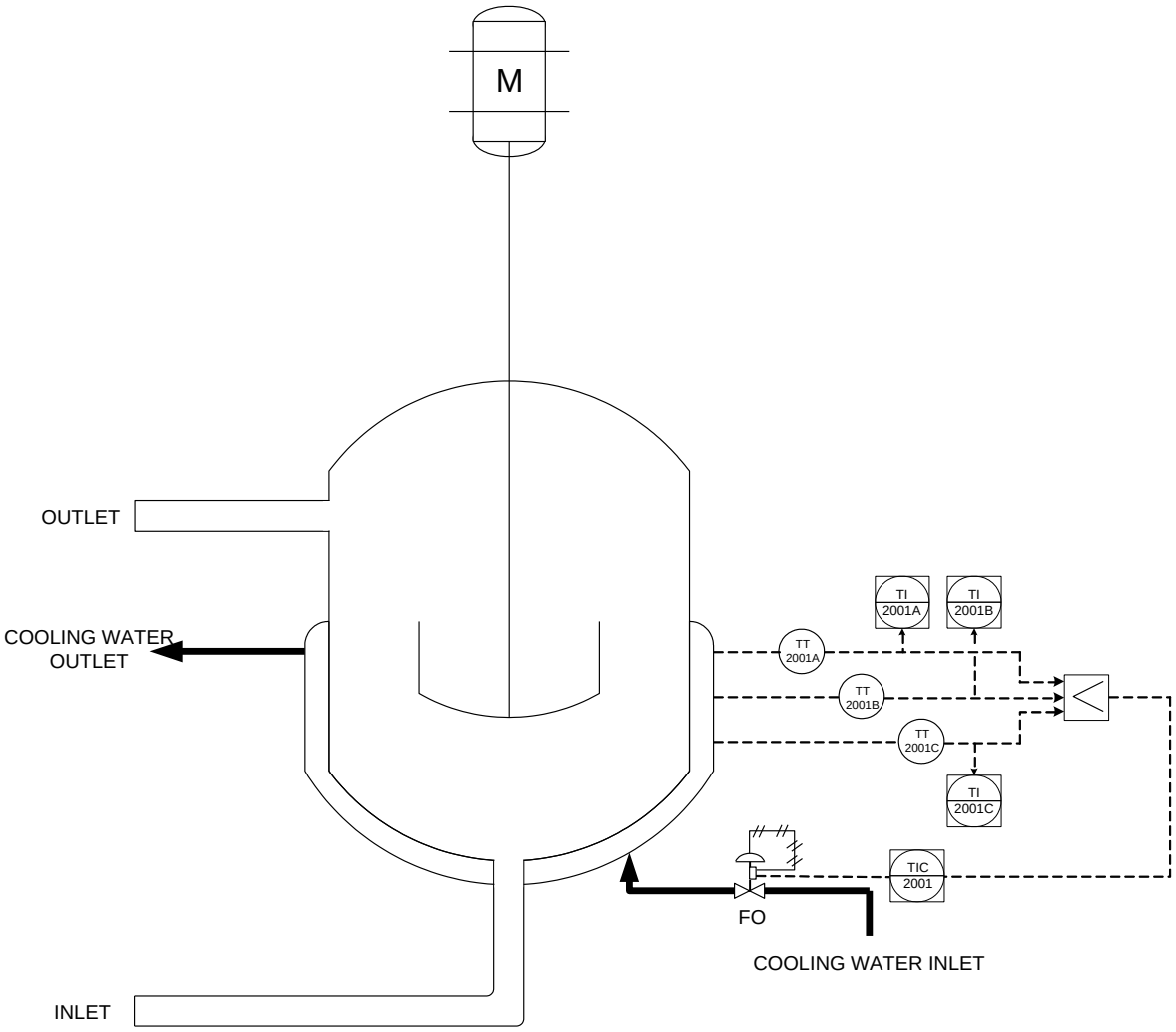
Exercise: Referring to the following drawings fill the tables below:

A-



TX's	RANGE ˚C	PRESENT READING˚C	TIC INPUT (mA)
TT-2001A	0 - 80	40	
TT-2001B	0 - 80	30	
TT-2001C	0 - 80	20	

B-



TX's	RANGE ˚C	PRESENT READING˚C	TIC INPUT (mA)
TT-2001A	0 - 80	40	
TT-2001B	0 - 80	30	
TT-2001C	0 - 80	20	

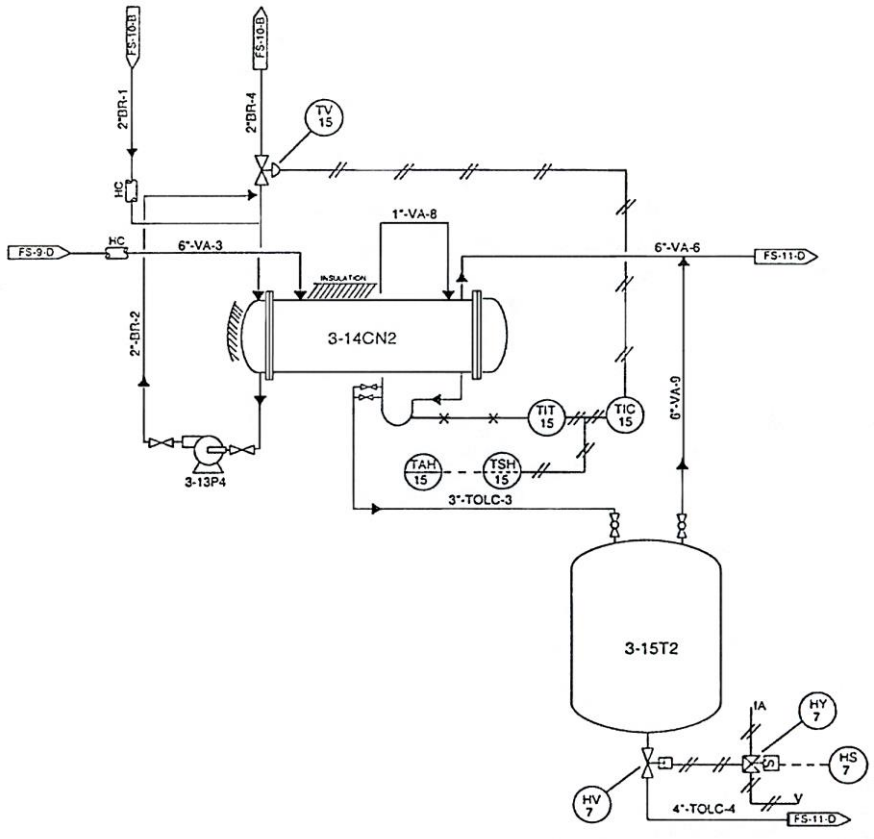
Section 3.
FUNCTIONS OF INSTRUMENTS & TYPES OF P&ID DIAGRAMS

THE FUNCTION OF INSTRUMENTS

The function of an instrument is the work it does, which can usually be:

i.. Sensor
ii.. Transmitter
iii. Controller
iv. Switch
v. Alarm

Some control loops layouts have all the parts given above.



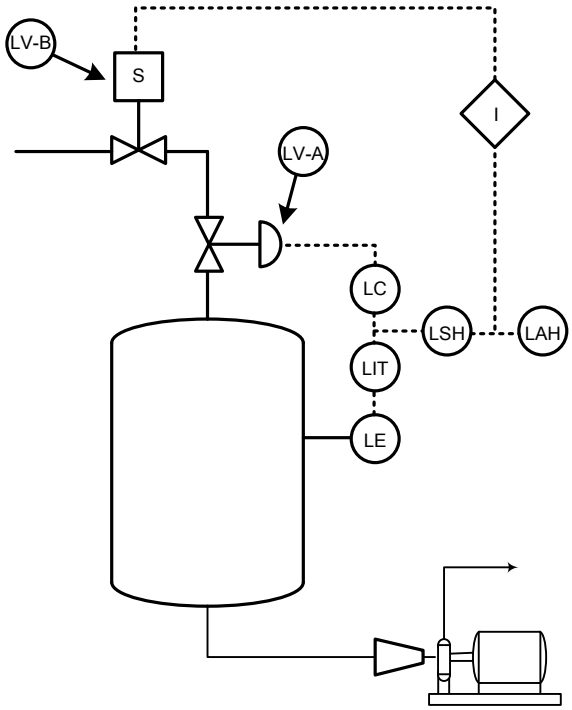
The sensor is the part of the loop that first detects or measures the process variable. The sensor, labeled TE (temperature element) or TI (temperature indicator) on some P&IDs, may be separate or part of a transmitter that will send out information about the variable. In the example above, TIT contains the sensor and transmitter.

Information is sent about the temperature of the toluene in the line to TIC, the controller. In our example, the controller sends information to a pneumatically operated diaphragm valve, TV. This valve physically controls the flow of cooling brine in the line.

For the process covered in this example control loop, we need to be sure that the temperature of the toluene, TOLC, does not go above a certain point. TSH, a switch also connected to TIT, the temperature transmitter. If the temperature of the material in the line exceeds a set point (high), the switch sends a signal to the alarm TAH. The alarm may be visual, such as a red light, or audible, such as a buzzer. The line through the TAH circle shows that the alarm is located on a panel.

INTERLOCKS

Interlocks are very important for the safe operation of a process plant and its function isolate or shut down the system if a dangerous situation occurs. The symbol that is used to represent an interlock is the diamond shape with the letter I in it. Figure below shows control loops with an interlock



Level element senses level inside tank.

Level indicating transmitter sends signal to switch and level controller.

Level controller sends signal to LV-A to control level.

If level is too high, level switch high sends signal to interlock and also sets off alarm warning that level has reached high.

Interlock signals level control valve LV-B to close to prevent overflow-of tank.

Level control valve LV-B is activated by interlock to shut off flow.

P&ID Reading Exercise:

Refer the P&ID1 provided to answer the following questions by choosing the correct answers from the words given in the parenthesis. You may refer to the appendix to identify the symbols or letters.

1. LT-17 is a (level transmitter, light indicator)

2. TE-9 and TE-10 measure the temperature of the (process liquid, low pressure steam, low pressure condensate).

3. Opening LV-17 allows some condensate to (recycle through the turbine, recycle through the tank, stay in the heat exchanger).

4. (Low pressure steam, High pressure steam) enters the turbine at the top of the equipment and (low pressure, high pressure steam) leaves the equipment at the bottom.

5. The steam leaving the turbine is used in the heat exchanger to heat the (process liquid, condensate).

6. We expect the material in the pipe line PRL2 to be (warmer, cooler) than the material in the pipe line PRL1.

7. Before servicing the pump 17-P4, close both (check valves, level elements, globe valves) on the lines entering and leaving the pump.

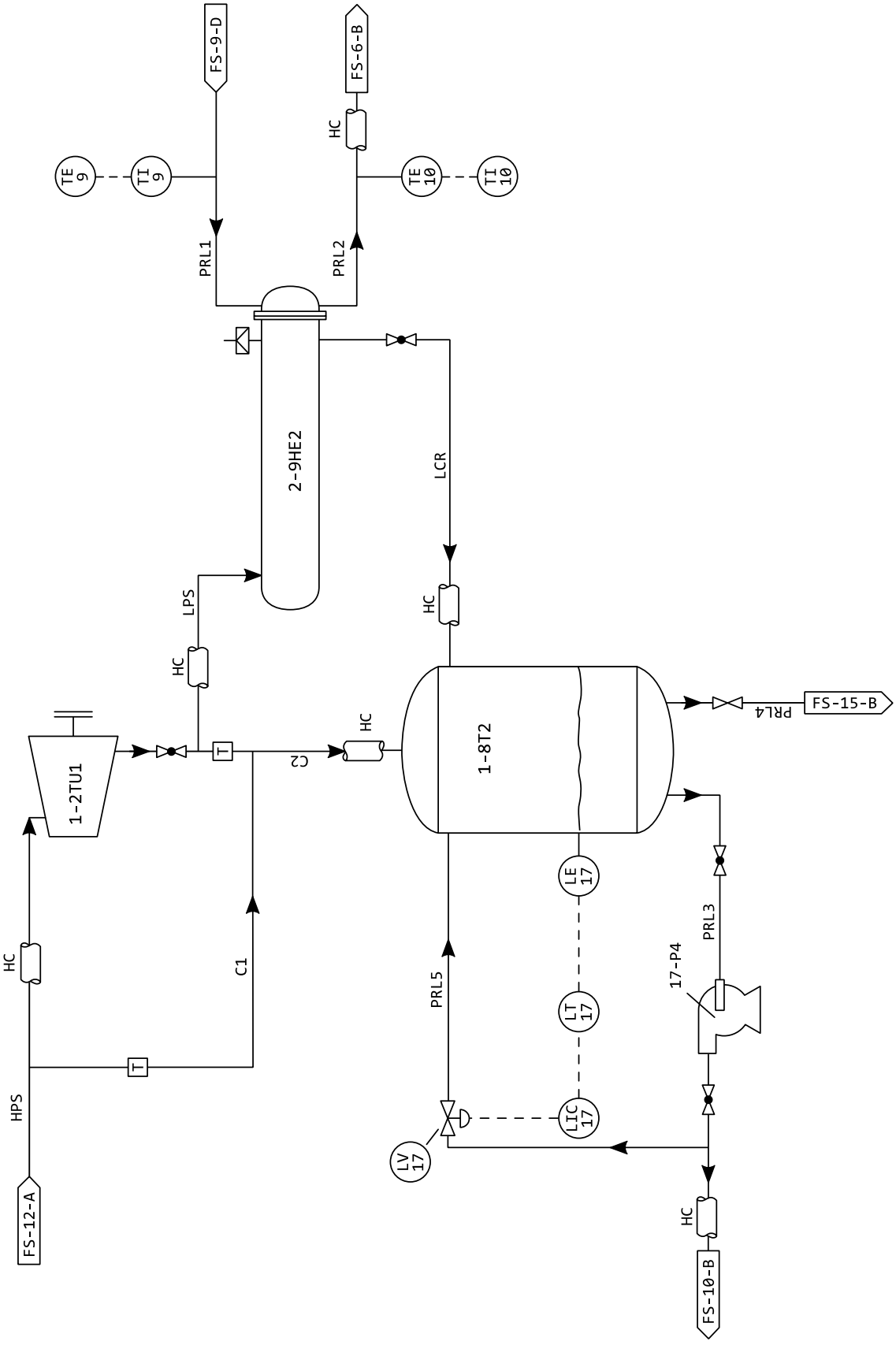
8. The pipes that physically join line C2 are (PRL1, C1, LPS, HPS, PRL3).

9. The material leaving the heat exchanger and going to the tank is (low pressure condensate, low pressure steam, process liquid).

10. The pipe lines LPS and PRL2 are insulated in order to (retain the heat of the material, prevent over heating of the material).

11. The level of the material in the condensate tankj is controlled by _____(pump 17-p4, instrument loop 17).

12. To find out what happened to condensate that leaves the tank, we have to look on p&IDs_____&_____(FS-15-B, FS-10-B,FS-6-B, FS-12-A).


FS-9-D
FS-6-B
HC
TE 9
TI 9
TE 10
TI 10
PRL1
PRL2
2-9HE2
LCR
LPS
HC
HC
HC
1-2TU1
T
C2
1-8T2
PRL4
FS-15-B
LE 17
LT 17
LIC 17
LV 17
PRL5
PRL3
17-P4
C1
T
HC
HPS
FS-12-A
HC
FS-10-B

TYPES OF INSTRUMENTATION DIAGRAMS

There are several types of instrumentation diagrams, each with different purpose and different degree of detail. Simplified instrumentation diagrams are designed to show the points of measurement and control. Conceptual instrumentation diagram designed to emphasize control functions. Detailed instrumentation diagrams describe the specific hardware signals in the control system.

SIMPLIFIED DIAGRAM

Simplified diagrams are usually created during the early stages of system design. Often, the designs are prepared before the specific types of hardware to be used in the system have been selected. Certain types of information that appears on a diagram prepared at later stages, such as hardware specifications and type of input and output signals generated by the components the system, are not noted.

Reading a Simplified Diagram:

Figure.1 is an example of a simplified diagram for a typical distillation process. The balloons in this type of diagram contain abbreviated identification information or identifies. However, the balloons do show the points of measurement control. Although the signal lines are undefined, the path and direction of process flow are indicated, so, it is possible to obtain significant information about the process systems from simplified diagrams. It should be noted the process lines, or piping, on instrumentation diagrams are represented by the solid lines. Instrument lines are represented by finer solid lines.

Reading from left to right starting with the balloon with the letter "F". The use of the identifier F, for flow rate, in an instrument symbol indicates that the fluid flow is being measured. The thick solid line with an arrow extending from the balloon labeled "F" indicates that the process liquid, or process feed, enters the center of the distillation column. Again, reading from left to right another

section of the process is shown. Hot oil enters and exits a heat exchanger. The balloon connected to the supply line is identified as "FC", a flow controller, which indicates that the flow is being controlled at this point.

The symbol for an undefined signal line connects the flow controller to the valve. The process line leading to and from the distillation column show the flow path of the hot oil, pass through the boiler to increase the temperature of the fluid in the column, therefore, we can call this heat exchanger a reboiler.

The balloon labeled LC, indicates that the level of the process fluid in the column is measured and maintained by controlling the rate of fluid flow that is permitted to leave the column. The balloon labeled "A" indicates that the process fluid is analyzed as it leaves the column.

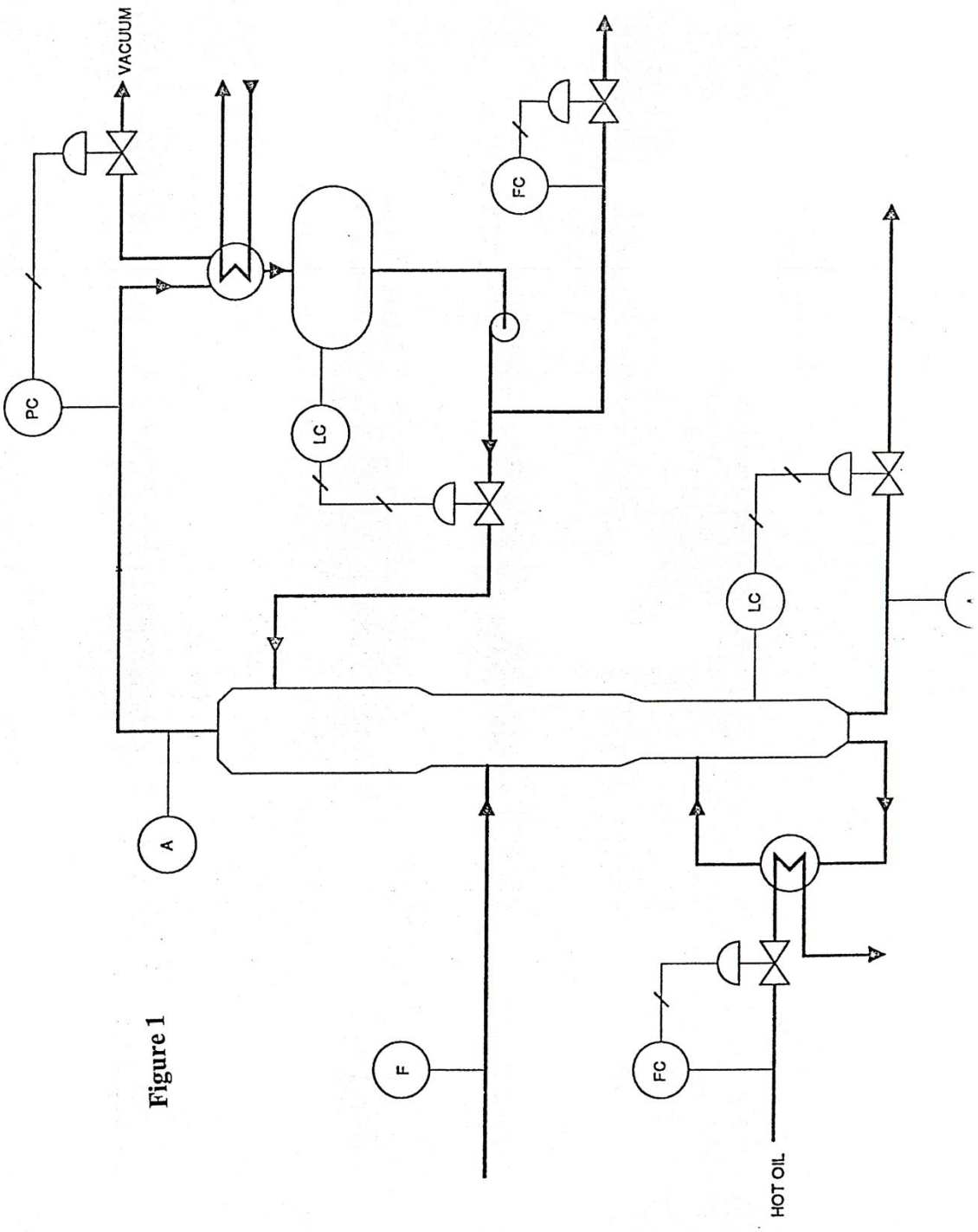


Figure 1

CONCEPTUAL DIAGRAM

Conceptual diagrams (Figure 2) provide significantly more detail on how. the process is controlled. This is evident from the number of additional function symbols provided in this type of diagram. As with simplified diagrams, the symbols for hardware and signal

lines are usually not available in conceptual diagrams. In essence, conceptual_diagrams focus on the functions that control the process. Function symbols designate process control and calculation functions.

Reading Conceptual Diagrams

The hot. oil line to the reboiler is the starting point for this discussion. The symbol for a discreet instrument labeled FT, flow transmitter, indicates that flow is measured at this point. The primary element is an orifice plate. A signal representing the measured variable is sent along an undefined signal line to a square root function. The square root is extracted, and the signal continues to a multiplier function. The linearized signal is then multiplied by a second input to the multiplying function from the differential temperature transmitter, represented by a discrete instrument symbol labeled TDT. The note adjacent to the function block above the flow controller, which is labeled X, shows the algorithm performed by the multiplier function. After the value of the flow rate and the differential temperature are multiplied, a signal representing the product is sent to "a flow controller.

The flow controller also has a second input from another multiplier with two inputs. The first input is from a flow transmitter on the feed line to the column. The transmitter is represented by the symbol for a discrete instrument and labeled FT. The transmitter senses the flow rate through the process line and outputs a corresponding signal. Again, the primary element is an orifice plate. The square root is extracted from this signal and the linearized signal goes to a time function block. At this point, the output signal will equal the input flow value averaged over a period of time. The signal then goes to a multiplier function.

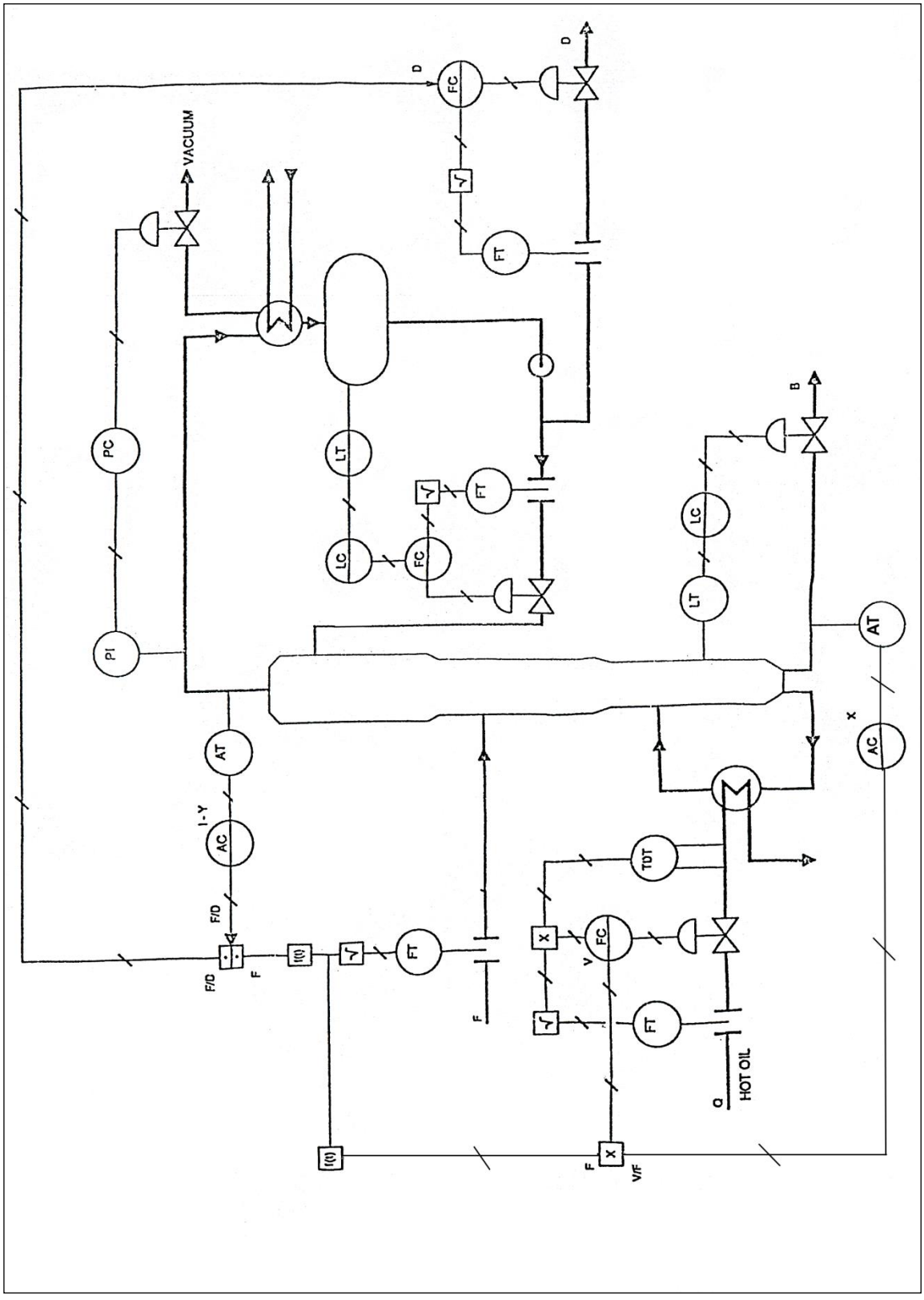
The second input to the multiplier function originates from the analysis transmitter represented by the symbol for a discrete instrument labeled AT in the lower portion of the

diagram. The analysis transmitter is connected to the overhead product line from the column. Its output signal, which represents the analysis of process fluid from the column, is sent to an analysis controller and on to the multiplier function.

The multiplier then sends an output feed rate, based on the column feed rate as well as the overhead and the bottoms product analysis, to the flow controller. The flow controller outputs signals based on the values of these two multiplier functions to operate a valve that controls the flow rate of hot oil through the system.

The analysis of the overhead product, along with the forward flow of the overhead from the accumulator, is also part of the temperature control calculation. As is evident the rate of hot oil flow through the system is determined by several variables and functions.

Figure 2



DETAILED DIAGRAM

Detailed diagrams (Figure 3) are prepared only after the specific hardware for the system has been selected. At that stage in the development of the process control system, the instrumentation symbols used on the diagram actually illustrate the control system including such details as how discrete and shared display/control instruments control the process. Detailed diagrams also include specific symbols for equipment, functions, signal lines, and system links.

Reading a detailed diagram:

The starting point for this discussion is the entry of hot oil into the system. As hot oil flows through the supply line, it passes through an orifice in Loop 900. An instrument balloon representing a flow transmitter (FT -900) is connected to the orifice. The flow

transmitter sends an electrical output signal to the square root extractor (FY -900A) also located in Loop 900, The letter A after the loop number indicates that there is more than one computing function in the loop, The use of this symbol also indicates that this is a software function in a shared controller that is not accessible to the operator. The function designation flag attached to the symbol indicates that the computing function is square root extraction.

The output from the square root extractor (FY -900A) is a data link to a second flow computing function (FY-900B). Similarly, this function is not accessible to the operator. The function designation flag identifies it as a multiplier. There is a second input to this function, an electrical signal from a discrete field-mounted differential transmitter, labeled TDT -920, in Loop 920. This transmitter has an input from each of two temperature sensors. A note adjacent to the symbol identifies RTDs as the devices providing inputs to the differential temperature transmitter.

The output from the differential transmitter is sent to computing function FY -900B. As this is a multiplying function, the product of its inputs is sent by data link to the set point of FIC-900. FIC-900 is a flow-indicating controller in Loop 900. Its symbol indicates that it is part of a shared display/shared control. The center line in the symbol indicates that there is operator interface at a primary location. The note (FAHL) adjacent to the symbol identifies

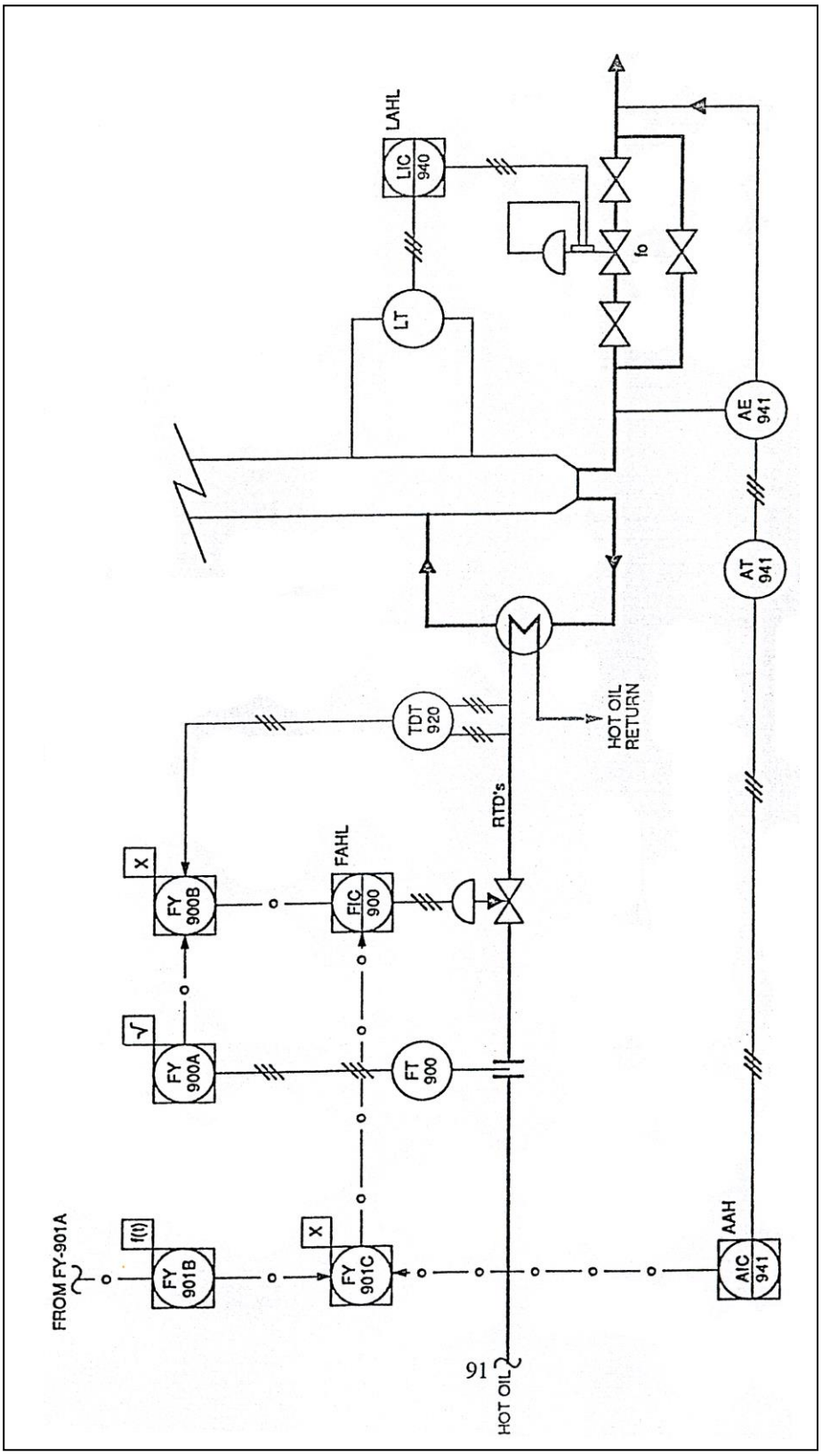
a flow rate alarm that actuates at high and low conditions. This device ensures that the alarm is activated whenever the flow rate of hot oil to the reboiler deviates from the established limits.

The flow-indicating controller, FIC-900, receives a second input from flow multiplier function FY-901c. Multiplier FY-901C also receives input signals from two sources. One input to multiplier FY-901C originates at a field-mounted analysis sensor (AE-941) in Loop 941. AE-941 sends an electrical signal to an analysis transmitter (AT-941), which is also field-mounted. The analysis transmitter (AT -941) sends an electrical signal from the field to the control room. This can be discerned by the signal line symbol connecting AT -941 to AIC-941. The symbol for AIC-941 indicates that it has a shared display/shared control function that is accessible. The note (AAH) adjacent to the symbol indicates that the analysis controller has a high limit alarm.

The signal from the analysis controller is received by multiplier function 901C. In addition, another input to this multiplier function is from the flow-computing function FY -901 B. This is a time-function that is not accessible to the operator. The note above FY -90IB (From FY-901A) indicates the source of the flow signal to FY-901C. Multiplier function FY-901C multiplies the inputs from FY -901 Band AIC-941 and transmits the information via a data link to FIC-900. the flow-indicating controller in Loop 900. The controller sends an electrical signal based on its two inputs to a final control element which, in this application, is a control valve. The valve is more fully described as an electrically actuated two-way control valve that will fail closed in case of signal or power failure.

In order to fully understand the operation of a control system it may be necessary to consult all three types of diagrams: simplified diagrams conceptual diagrams, and detailed diagrams. Each type of diagram provides a different level of information about process systems and how they function. All three types of diagrams also have important information about the system and the drawings themselves which can be found in the information blocks generally located at the bottom of the sheet. Safe practice and common sense dictate that some time be spent reviewing the instrumentation diagrams before beginning any work on a process system. Also remember that it is essential to follow the safety procedures established by your facility and by the equipment manufacturers when working with any process system components.

Figure 3


LAHL
LIC 940
LT
fo
AE 941
AT 941
TDT 920
HOT OIL RETURN
RTD's
FAHL
FIC 900
FY 900B
FY 900A
FT 900
FROM FY-901A
FY 901B
FY 901C
AAH
AIC 941
91
HOT OIL

Section 4.
INSTRUMENT LOOP DIAGRAM

INSTRUMENT LOOP DIAGRAM

A loop diagram is a diagram of an individual loop that forms part of a process system. Loop diagrams are used to provide more detailed information about process loops. The information on a loop diagram may be used in the design, construction, maintenance and operation of a loop.

Some types of information will be shown on both instrumentation diagram and the loop diagram. This information usually includes the information provided by the instrument balloons and signal line symbols. Other types of information, specific to the loop, will only be shown on the loop diagram.

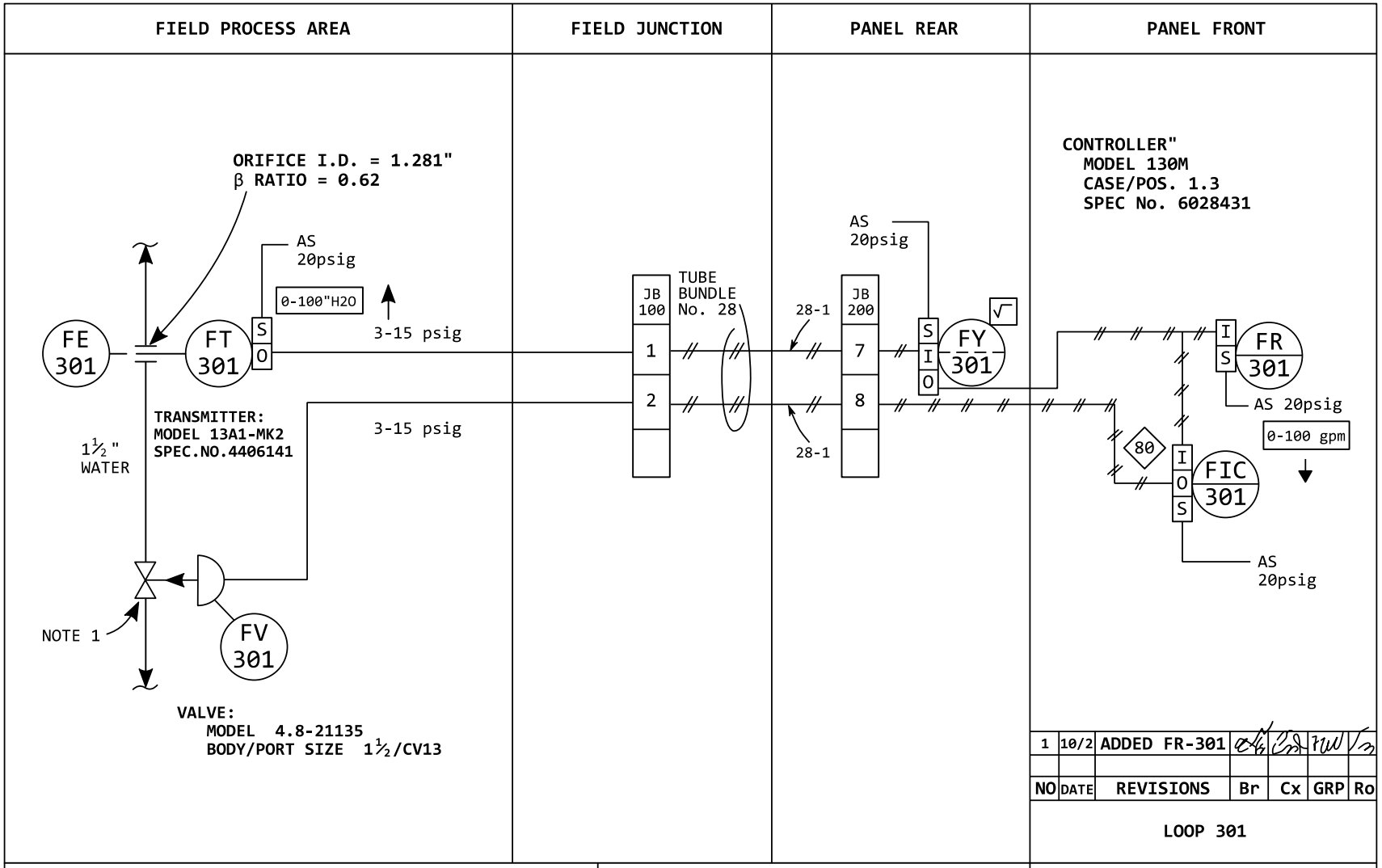
In order to find the loop diagram for a particular loop, the loop should first be located and identified on the instrumentation diagram. The loop number, process variable, and type of signal used in the loop can be determined from the information provided on the instrumentation diagram. The required loop diagram can be then found looking for a diagram with the appropriate loop number and title. This information is shown in the title block of the loop diagram. Your facility's document control file system may require different procedures for locating loop diagrams.

Revision information is usually shown near the title block on the loop diagram. This information should be checked to ensure that the diagram is up-to-date.

Loop diagrams are usually divided into sections. The sections can be used to help identity the locations of the instruments in the loop. Example:

FIELD PROCESS AREA	FIELD JUNCTION	PANEL REAR	PANEL FRONT

- **Field Process Area** - shows the location of field-mounted instruments.
- **Field Junction** - shows the locations of junction boxes. This section usually does not contain instruments.
- **Panel Rear -** shows the location of instruments that are mounted behind the board.
- **Panel Front -** shows the location of panel mounted instruments.


FIELD PROCESS AREA
FIELD JUNCTION
PANEL REAR
PANEL FRONT
ORIFICE I.D. = 1.281"
β RATIO = 0.62
AS
20psig
0-100"H2O
3-15 psig
FE
301
FT
301
S
O
TRANSMITTER:
MODEL 13A1-MK2
SPEC.NO.4406141
1½"
WATER
3-15 psig
NOTE 1
FV
301
VALVE:
MODEL 4.8-21135
BODY/PORT SIZE 1½/CV13
JB
100
TUBE
BUNDLE
No. 28
1
2
28-1
28-1
JB
200
7
8
AS
20psig
S
I
O
FY
301
√
CONTROLLER"
MODEL 130M
CASE/POS. 1.3
SPEC No. 6028431
I
S
FR
301
AS 20psig
0-100 gpm
80
I
O
S
FIC
301
AS
20psig
1 10/2 ADDED FR-301
NO DATE REVISIONS Br Cx GRP Ro
LOOP 301
NOTES:
1. FV-301 FULLY CLOSED AT 3 psig AND FULLY OPEN AT 15 psig.
2. ALL TUBING IS POLYPROPYLENE - ¼"O.D.
REFERENCE DRAWINGS:
P&ID 2150-7D SHEET 1 OF 1
INSTRUMENT INSTALLATION DETAILS 424-1
CONTROL BOARD SPECIFICATION 100-34
MIXING SYSTEM #1
INDUSTRIAL PROCESS CORP.
DRAWN BY DATE 7/10/11
REVIEWED BY DATE 12/2/12
APPROVED BY DATE 10/3/12
JOB NO DRAWING NO
B-3.14 2150.70-1

INSTRUMENT PORT CONNECTION

An instrument port is the connection point between an instrument and a supply of signal line. Knowing where these connections are located can help you to trace problems that may develop in the process loop.

Instrument port connections are represented by symbols on loop diagrams. The symbols are used to identify the number and types of ports for instruments in the loop.

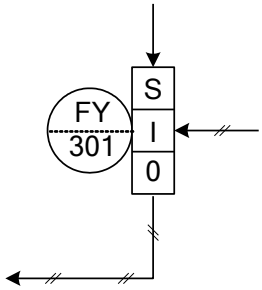
The symbols for an instrument port connection in a pneumatic loop is a rectangle, drawn vertically and attached to the instrument balloon. The rectangle is divided into squares. Each of the squares represents a separate connection.

"Poor instrument port connections can also cause problems in the signal line.

"Other symbols may be used to represent port connections in different types of loops".

Letters shown inside the squares are use to indicate the type of connection. The identification letters that are used usually designated by the instrument manufacturer or the facility. Typical identification letters include:

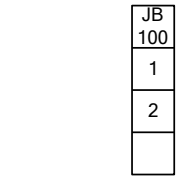
- S - supply
- I-input, and
- O- output

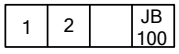


JUNCTION BOXES

Junction boxes are used to provide central connection points for signal lines. Junction boxes are usually located in the field or at the rear of the panel.

The symbol for a junction box in a pneumatic loop symbol differs slightly .It is also a rectangle, divided into squares. In this case, however, the symbol is not attached to an instrument balloon.





The top or right square of the symbol contains the letters JB, for junction box, and an identification 100 number. The other squares contain numbers that are used to identify each of the connections in the junction box. Facility-designated numbers are usually used.

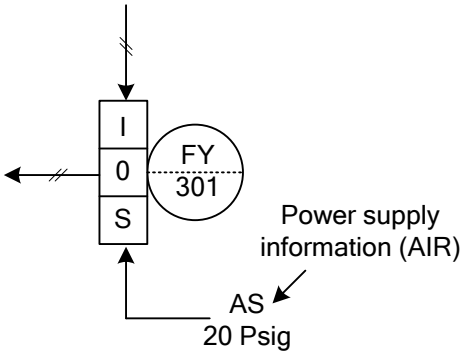
The number of squares shown in the rectangle will depend on the number of connections available at the junction box. In some cases, a square will not contain a number, indicating that that particular junction box connection has not been used.

This symbol can also be used to represent pneumatic manifold, bulkhead, or other types of connections.

When doing maintenance, troubleshooting, or installation work, knowledge of instrument port connections and other connections is very important. Information on the loop diagrams about these connection points can tell you such things as where signal lines should be connected. This might help you identify leaks or poor connections in the system.

POWER SOURCES

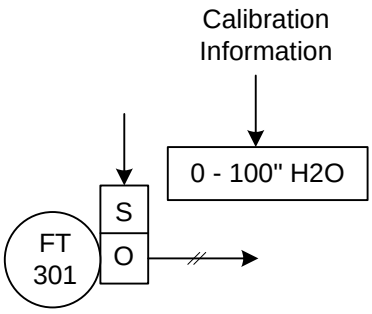
A loop diagram may provide information about the power source for the loop. An air supply is represented on the loop diagram by AS followed by the value of the air supply pressure. The symbol for the power source is connected by a leader line to the symbol for the appropriate instrument supply port. Knowing which instruments have their own air supplies can be helpful in trapshooting air supply problems in a pneumatic loop.



CALIBRATION INFORMATION

Loop diagrams often provide information about the calibration values of instruments in the loop, calibration values of an instrument specify the range of values of the variable over which the instrument is calibrated.

The symbol for calibration information is usually a horizontal rectangle located near the instrument symbol. The calibration values are written inside the rectangle.

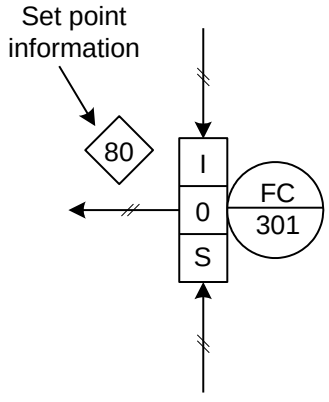


SET POINT

The set point of an instrument is the value of the input variable which sets the desired value of the controlled variable.

The symbol for a set point is a diamond. The value of the set point is indicated inside the diamond. The value of the set point inside the diamond may include the units, such as °F, gpm or psi.

On loop diagrams, set point symbols are located near .the instruments to which they refer.

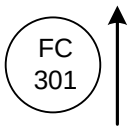


CONTROLLER ACTION

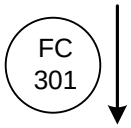
The controller action symbol indicates how controllers and other instruments respond to changes in signals.

The symbol for controller action is a vertical arrow located near the instrument. The arrow may point up or down.

- An arrow pointing up indicates that the value of the output signal of the instrument increases as the value of the input increases. This is called "direct acting."



- An arrow pointing down indicates that the value of the output signal of the instrument decreases as the value of the input increases. This is called "reverse acting."

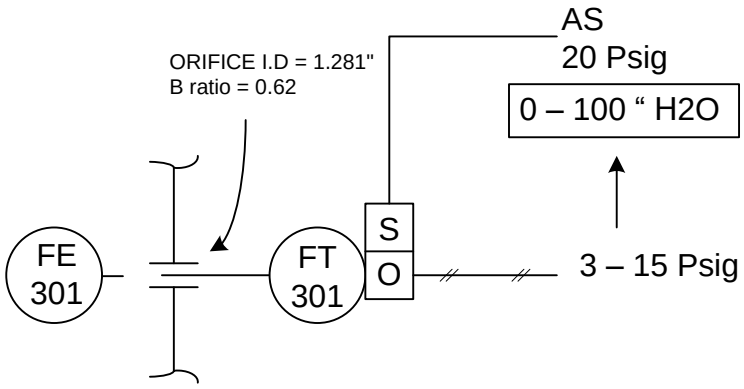


Controller action symbols are useful when analyzing show an instrument is designed to respond to changes in input. You may see controller action symbols for instruments such as controllers, transmitters, and valves.

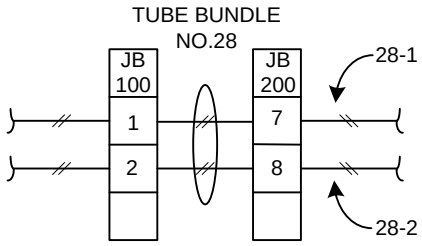
PNEUMATIC LOOP DIAGRAM

A pneumatic loop diagram should be read starting from one end or the other, not from the middle. It is usually advisable to start in the field process area. The primary element in the loop provides a good starting point.

In the pneumatic loop shown, primary element was an orifice. The orifice creates a differential pressure proportional to flow rate. This signal is sent to a transmitter. The transmitter has an air supply of 20 psig and is calibrated to sense a signal with a range of 0-100 inches of water. A note indicates that the output signal from the transmitter is in the range of 3-15 psi. The arrow pointing up, next to the transmitter, indicates that the output signal increases as the input increases. The signal line leaving the output port of the transmitter indicates that the signal is pneumatic.

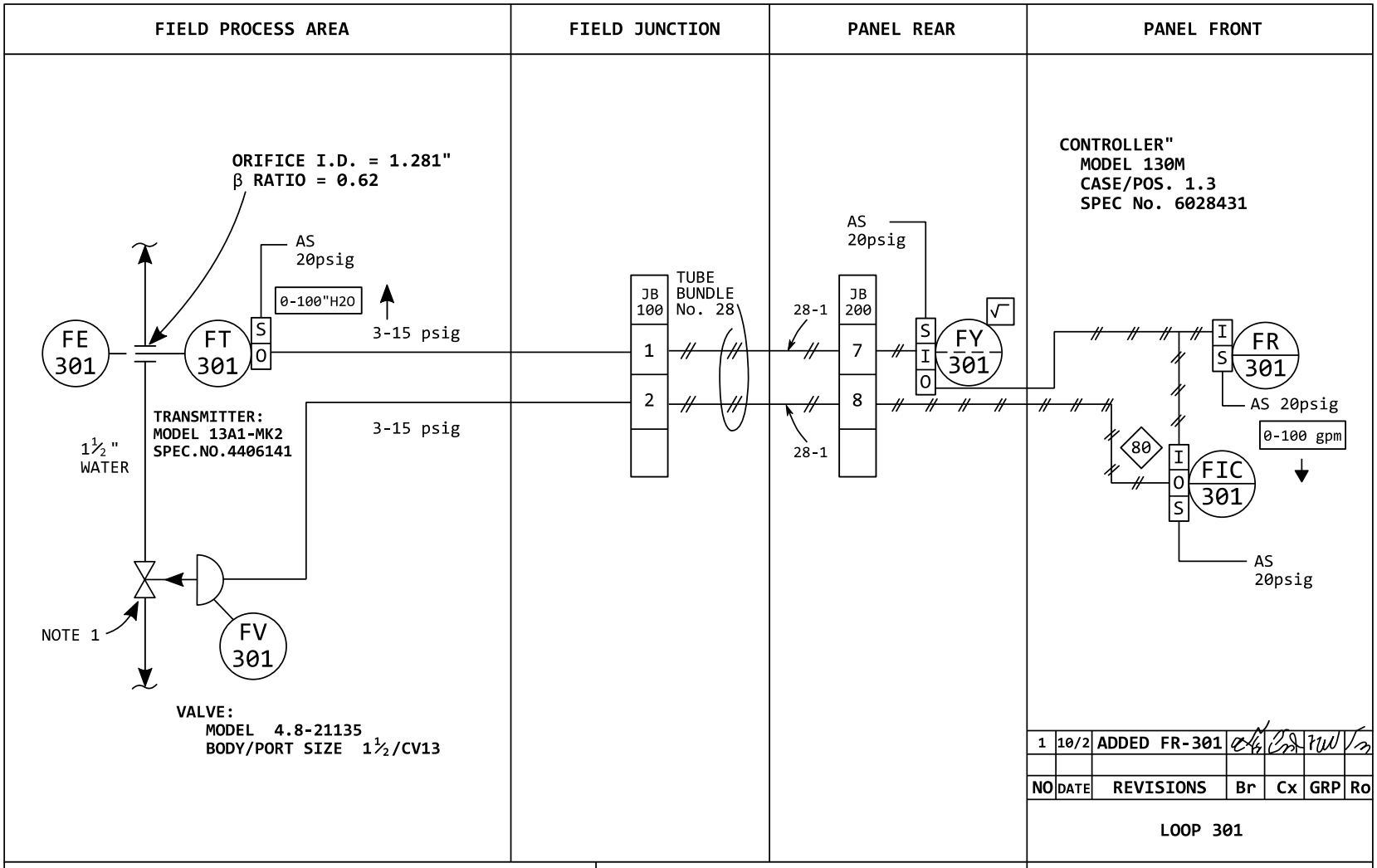


From the transmitter, the signal passes through a junction box in the field junction area and through a second junction box in the panel rear. The numbers shown on the junction box symbols enable the connections to be located in the junction boxes themselves. A line identification



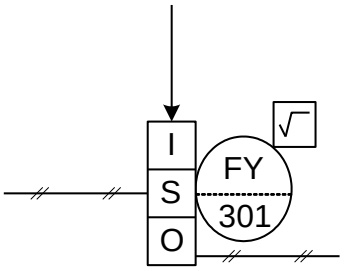
"28-1" means bundle 28 tube 1

Note gives the number of the line and of the bundle of which it forms a part.


FIELD PROCESS AREA
FIELD JUNCTION
PANEL REAR
PANEL FRONT
ORIFICE I.D. = 1.281"
β RATIO = 0.62
AS
20psig
0-100"H2O
3-15 psig
FE
301
FT
301
S
O
TRANSMITTER:
MODEL 13A1-MK2
SPEC.NO.4406141
1½"
WATER
3-15 psig
NOTE 1
FV
301
VALVE:
MODEL 4.8-21135
BODY/PORT SIZE 1½/CV13
JB
100
TUBE
BUNDLE
No. 28
1
2
28-1
28-1
JB
200
7
8
AS
20psig
S
I
O
FY
301
√
CONTROLLER"
MODEL 130M
CASE/POS. 1.3
SPEC No. 6028431
I
S
FR
301
AS 20psig
0-100 gpm
80
I
O
S
FIC
301
AS
20psig
1 10/2 ADDED FR-301
NO DATE REVISIONS Br Cx GRP Ro
LOOP 301
NOTES:
1. FV-301 FULLY CLOSED AT 3 psig AND FULLY OPEN AT 15 psig.
2. ALL TUBING IS POLYPROPYLENE - ¼"O.D.
REFERENCE DRAWINGS:
P&ID 2150-7D SHEET 1 OF 1
INSTRUMENT INSTALLATION DETAILS 424-1
CONTROL BOARD SPECIFICATION 100-34
MIXING SYSTEM #1
INDUSTRIAL PROCESS CORP.
DRAWN BY DATE 7/10/11
REVIEWED BY DATE 12/2/12
APPROVED BY DATE 10/3/12
JOB NO DRAWING NO
B-3.14 2150.70-1

The loop diagram in the program showed that the signal was then passed through a square root extracting relay. This has the effect of converting the signal from the transmitter into a linear signal that is then sent to the recorder and controller. If a pneumatic loop does not contain such a square root extractor, then the recorded signal is nonlinear and, special square root paper must be used in interpreting it.

After the relay, there is a branch in the signal line. Whenever branching occurs, each branch should be followed in turn until the branch either terminates or rejoins the main line.

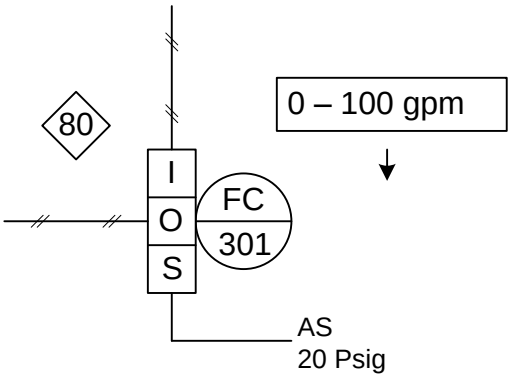


The signal line is now proportional to the flow rate in the loop

In this pneumatic loop, one branch leads to the input port of the recorder. In this case, the recorder will give a linear plot of the flow taking place in the loop.

The other branch leads to the controller. The information in the horizontal rectangle indicates that the controller is calibrated for a range of 0-100 gallons per minute.

The diamond symbol shows a set point of 80 gallons per minute. With the controller action arrow pointing down, the reader knows that the controller responds to increased input with decreased output. The controller has an air supply of 20 psig.

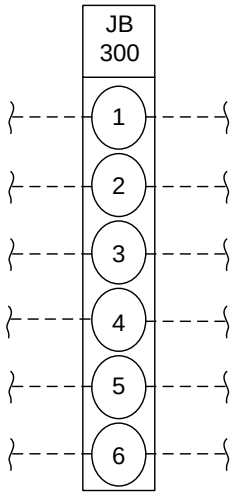


'28-2" means bundle 28, tube 2

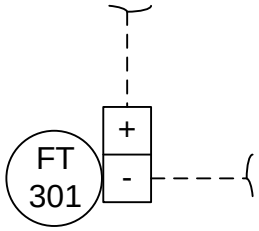
ELECTRONIC LOOP DIAGRAMS

Many of the symbols used on electronic 109P diagrams are the same as those used on pneumatic loop diagrams. Some components, however, are represented by different symbols on electronic loop diagrams.

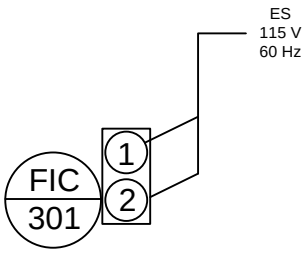
- **Junction boxes** - In electronic loop diagrams, junction box connections are represented by circles instead of squares.



- **Connection points** -In electronic loops, the connection points are terminals rather than ports. In some cases, plus and minus signals are used to indicate the polarity of the terminals.

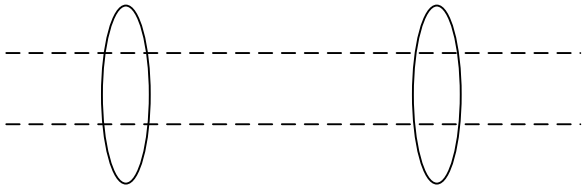


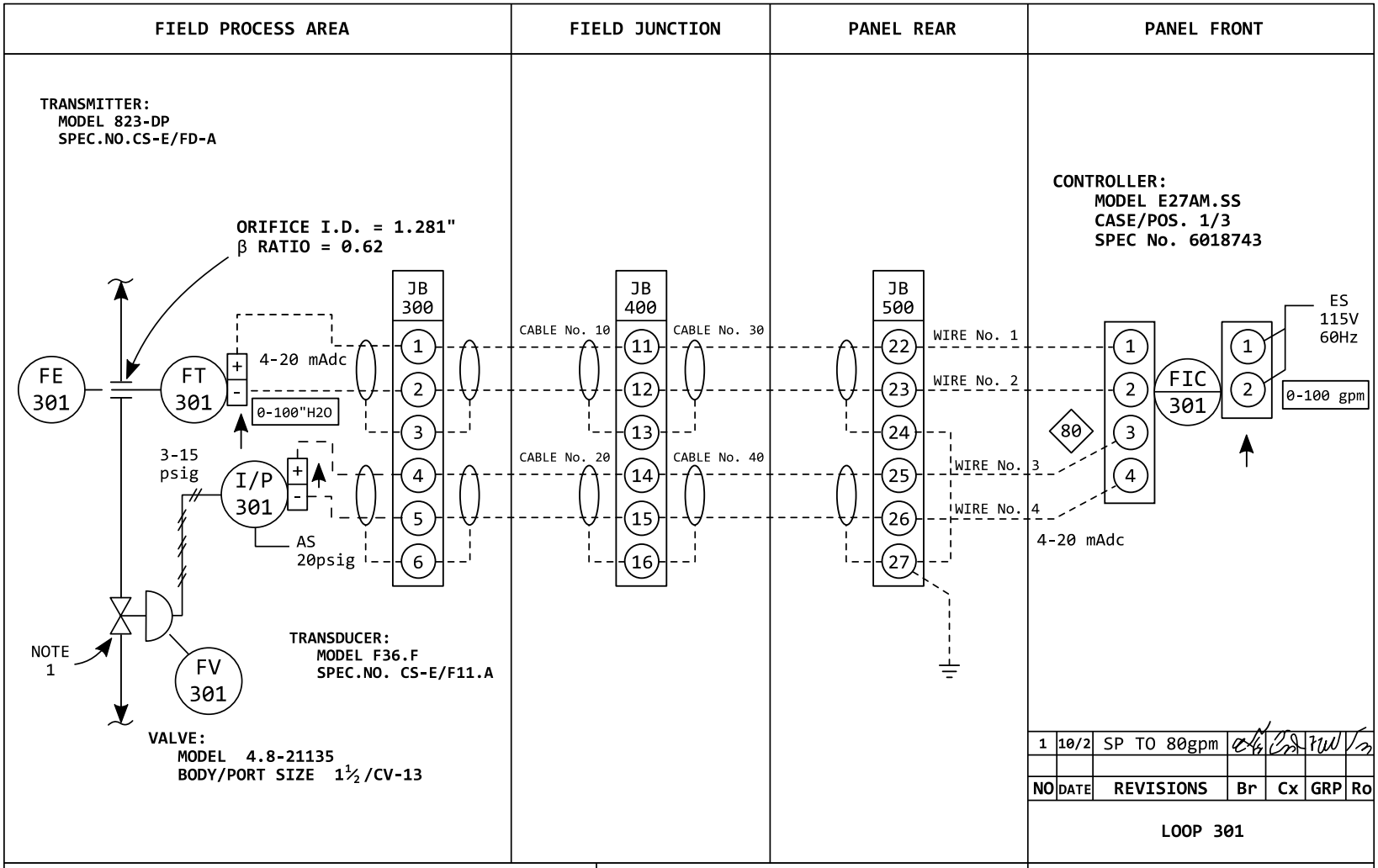
Power source -The electrical power source is represented by the letters ES, followed by the voltage of the supply. If the supply is AC, the frequency is also, shown.



- **Signal lines-** -An electrical signal line, is represented by a dashed line.

- **Shield** - A circle surrounding the symbol for 'an electronic signal line or lines indicates that the line(s) is shielded. Shielding reduces electrical interference with the signal.




FIELD PROCESS AREA
FIELD JUNCTION
PANEL REAR
PANEL FRONT
TRANSMITTER:
MODEL 823-DP
SPEC.NO.CS-E/FD-A
ORIFICE I.D. = 1.281"
β RATIO = 0.62
FE 301
FT 301
4-20 mAdc
0-100"H2O
3-15 psig
I/P 301
AS 20psig
FV 301
NOTE 1
VALVE:
MODEL 4.8-21135
BODY/PORT SIZE 1½/CV-13
TRANSDUCER:
MODEL F36.F
SPEC.NO. CS-E/F11.A
JB 300
JB 400
JB 500
CABLE No. 10
CABLE No. 30
CABLE No. 20
CABLE No. 40
WIRE No. 1
WIRE No. 2
WIRE No. 3
WIRE No. 4
CONTROLLER:
MODEL E27AM.SS
CASE/POS. 1/3
SPEC No. 6018743
FIC 301
80
4-20 mAdc
ES 115V 60Hz
0-100 gpm
1 10/2 SP TO 80gpm
NO DATE REVISIONS Br Cx GRP Ro
LOOP 301
NOTES:
1. FV-301 FULLY OPEN AT 3 psig AND FULLY CLOSED AT 15 psig
2. ALL CABLES ARE 18g. SHIELDED
REFERENCE DRAWINGS:
P&ID 2150-79
INSTRUMENT INSTALLATION DETAILS 423-1
CONTROL BOARD SPECIFICATION 100-33
MIXING SYSTEM #1
INDUSTRIAL PROCESS CORP.
DRAWN BY DATE 7/10/11
REVIEWED BY DATE 12/2/12
APPROVED BY DATE 10/3/12
JOB NO
DRAWING NO

READING AN ELECTRONIC LOOP DIAGRAM

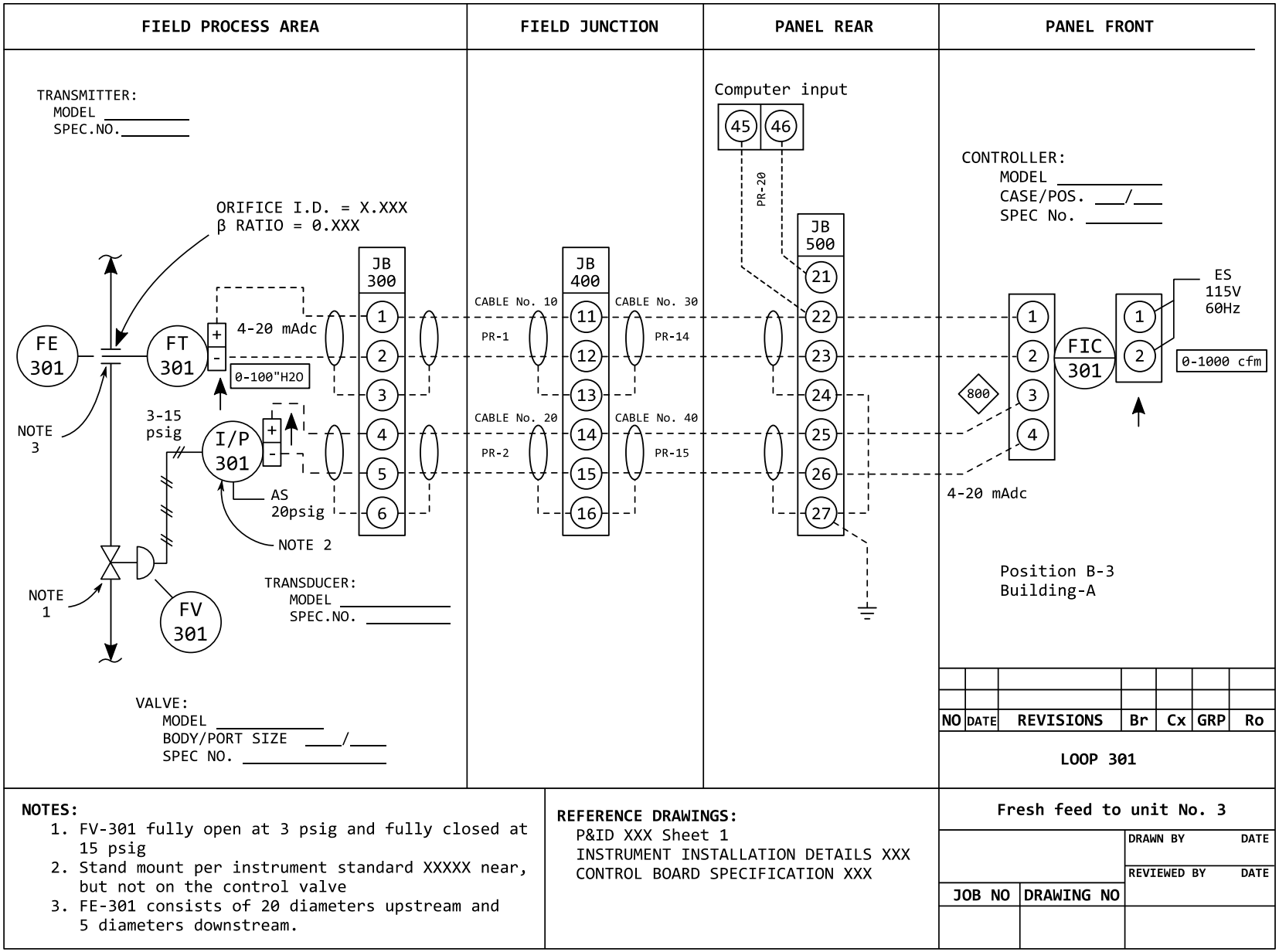
In the electronic loop diagram shown here, the loop is performing a similar function to that performed by the pneumatic loop discussed in the previous segment. The major difference is that, in this case, most of the signals and instruments are electronic.

The sensing element (FE-30I) is an orifice, as before. The transmitter has electric terminals and sends an electric current of 4-20 mA DC along a shielded cable.
The signal passes through three junction boxes (JB300, JB400, and JB500) to the input terminals of) the flow indicating controller (FIC-30I). The cable and wire identification numbers are indicated along the path of the signal.
The controller has a power supply of 110 V and 60 Hz. This is the only power supply for the loop.
The controller has the same calibration information, and set point as the controller shown in the pneumatic loop, but the control action is direct.

A cable connected to the output terminals of the controller takes .the signal back to JB500, and then to the field process area.

In the field process area, the electronic signal -enters an I/P transducer. This changes the electronic signal, designated by I, to a pneumatic signal, designated by P. The transducer has its own air supply that enables it to send air signals to the flow valve actuator. Air-operated valves are often used because of their simplicity. It is quite common to find a change to pneumatic control at the control valve in an electronic loop.

The loop is then completed in the same way as the pneumatic loop.


FIELD PROCESS AREA
FIELD JUNCTION
PANEL REAR
PANEL FRONT
TRANSMITTER:
MODEL
SPEC.NO.
ORIFICE I.D. = X.XXX
β RATIO = 0.XXX
FE 301
FT 301
4-20 mAdc
0-100"H2O
JB 300
JB 400
JB 500
CABLE No. 10
CABLE No. 30
PR-1
PR-14
CABLE No. 20
CABLE No. 40
PR-2
PR-15
PR-20
Computer input
45
46
21
22
23
24
25
26
27
11
12
13
14
15
16
1
2
3
4
5
6
NOTE 3
3-15 psig
I/P 301
AS 20psig
NOTE 2
NOTE 1
FV 301
TRANSDUCER:
MODEL
SPEC.NO.
VALVE:
MODEL
BODY/PORT SIZE ___/___
SPEC NO.
CONTROLLER:
MODEL
CASE/POS. ___/___
SPEC No.
ES
115V
60Hz
FIC 301
0-1000 cfm
800
4-20 mAdc
Position B-3
Building-A
NO
DATE
REVISIONS
Br
Cx
GRP
Ro
LOOP 301
NOTES:
1. FV-301 fully open at 3 psig and fully closed at 15 psig
2. Stand mount per instrument standard XXXXX near, but not on the control valve
3. FE-301 consists of 20 diameters upstream and 5 diameters downstream.
REFERENCE DRAWINGS:
P&ID XXX Sheet 1
INSTRUMENT INSTALLATION DETAILS XXX
CONTROL BOARD SPECIFICATION XXX
Fresh feed to unit No. 3
DRAWN BY
DATE
REVIEWED BY
DATE
JOB NO
DRAWING NO

Exercise: Use the instrument loop diagrams shown on the previous page to answer the following:

1. Is this a pneumatic loop diagram or electronic?

_____

2. What does 

represent?

_____

3. What is the control action of the controller FIC 301 (Direct or Reverse?).

_____

4. Does the signal line shielded? (Yes/No).

_____

5. What is the purpose of shielding the signal line?

_____

6. What is the range of the controller output signal?

_____

7. Can the signal actuate the control valve?

_____

8. What is I/P 301?

_____

9. What does AS 20 psig mean?

_____

10. Is the control valve air-to-close or air-to-open valve?

_____

11. What is the action of the flow transmitter?

_____

12. What is the name of the flow element used here?

_____

13. What is the position of the control valve at 15 psig?

_____

14. If the pneumatic signal to the valve failed, what would be the fail position of the valve?

_____

15. What is the set point of the controller?

_____

Section 5.
APPENDIX

Instrument Designations

Instrument designations may vary by plant site. This appendix gives examples of designations based on ISA S5.1 which is used at many plants. Designations starting with letters C, D, G, M, N, and O are the users choice. For this course we have chosen to designate specific names to some of these letters. Always check the site Master Sheet for designations that apply at specific sites.

AA	Analysis alarm
AAL	Analysis alarm low
AAH	Analysis alarm high
AV	Analysis control valve
AE	Analysis element
AI	Analysis indicator
AIC	Analysis indicating controller
AR	Analysis recorder
ARC	Analysis recording controller
AS	Analysis switch (ASL=low, ASH=high)
AT	Analysis transmitter
AIT	Analysis indicating transmitter
AP	Analysis test sample point
AY	Analysis solenoid valve, relay or converter

Conductivity (by users choice of letter O)

CAL	Conductivity alarm low
CAH	Conductivity alarm high
CE	Conductivity element
CI	Conductivity indicator
CIC	Conductivity indicating controller
CR	Conductivity recorder
CRC	Conductivity record controller
CS	Conductivity switch
CT	Conductivity transmitter
CV	Conductivity control valve
CY	Conductivity solenoid valve, relay or converter

Flow

FAL	Flow alarm low
FAH	Flow alarm high
FE	Flow element (orifice, nozzle, etc.)
FFIC	Flow ratio indicating controller
FFRC	Flow ratio recording controller
FG	Flow glass
FI	Flow indicator
FIC	Flow indicating controller
FIS	Flow indicating switch
FIT	Flow indicating transmitter
FO	Flow restriction orifice
FR	Flow recorder
FRC	Flow recording controller
FS	Flow switch (FSL=low, FSH=high, FSHL = high & low)
FQI	Flow totalizing indicator
FQIC	Flow totalizing indicating controller
FQS	Flow totalizer switch
FQT	Flow totalizer transmitter
FQSH	Flow pressure switch
FV or FCV	Flow control valve
FX	Flow strainer and vent
FY	Flow solenoid valve, relay or converter
LA	Level alarm
LAL	Level alarm low
LAH	Level alarm high
LC	Level controller
LC	Level control valve self-operated
LGG	Level glass (gauge glass)
LI	Level indicator
LIC	Level indicating controller
LLL	Level light low
LL	Level light high
LR	Level recorder
LRC	Level recording controller
LS	Level switch
LSL	Level switch low
LSH	Level switch high
LT	Level transmitter
LIT	Level indicating transmitter
LSR	Level solenoid valve, relay or converter

Moisture or Humidity (by users choice of M)

MAL	Humidity alarm low
MAH	Humidity alarm high
MC	Humidity controller
ME	Humidity element
MI	Humidity indicator
MIC	Humidity indicating controller
MR	Humidity recorder
MRC	Humidity recording controller
MS	Humidity switch
MT	Humidity transmitter
MV	Humidity control valve
MY	Humidity solenoid valve, relay or converter

Pressure or Vacuum

P	Pressure test point
PA	Pressure alarm
PAL	Pressure alarm low
PAH	Pressure alarm high"
PCV	Pressure control valve self-operated »
PV	Pressure control valve
PDI	Pressure differential indicator
PDIC	Pressure differential indicating controller
PDIT	Pressure differential indicating transmitter
DPC	Differential pressure control
PDR	Pressure differential recorder
PI	Pressure indicating gauge or manometer
PIC	Pressure indicating controller
P	Pressure test point
PQIT	Pressure differential indicator
PR	Pressure recorder
PRC	Pressure recording controller
PS	Pressure switch (PSL=low,

Instrument Designations Continued

Specific Gravity or Density (by users choice of letter D)
DAL Density alarm low
DAH Density alarm high
DE Density element
DI Density indicator
DIT Density indicating transmitter
DR Density recorder
DRC Density recording controller
DS Density switch
DT Density transmitter
DV Density control valve

Speed or Frequency
SA Speed alarm
SAL Speed Alarm Low
SAH Speed Alarm High
SC Speed controller
SV Sample valve
SI Speed indicator
SIC Speed indicating controller
SR Speed Recorder
SRC Speed Recording Controller
ST Speed Transmitter
SY Speed Solenoid Valve, relay or converter
DY Density solenoid valve, relay or converter

TA Temperature alarm
TAH Temperature alarm high
TAL Temperature alarm low
TCV Temperature control valve self-operated
TE Temperature element
TI Temperature indicator
TIC Temperature indicating controller
TIS Temperature indicating switch
TIT Temperature indicating transmitter
TR Temperature recorder
TRC Temperature recording controller
TS Temperature switch (TSL=low, TSH=high, TSHL = high & low)
TT Temperature transmitter
TV Temperature control valve
TW Temperature well
TY Temperature solenoid valve, relay or converter

Time. Program, or Counting
KIC Program indicating controller
KV Interlocked control valve
KI Clock
KR Time or operation recorder
KRC Program recording controller
KS Time switch or timer
KQ Operation counter
KY Program solenoid valve, relay or converter

Weight or Force
WA Weight alarm
WAL Weight alarm low
WAH Weight alarm high
WE Weight element
WI Weight indicator (balance, ordinary scale, etc.)
WIC Weight indicating controller (feeder, etc.)
WICS Weight indicating control switch

Weight or Force continued...
WQ Weight totalizer
WQS Weight totalizer switch
WQSH Weight pressure switch
WR Weight recorder (conveyor, scale, etc.)
WRC Weight recording controller
WSH Weight switch high
WSL Weight switch low
WSHL Weight switch high & low
WT Weight transmitter (blind)
WV Weight control valve
WX Weight totalizer
WY Weight solenoid valve, relay or converter

Miscellaneous
Alarm Alarm annunciators
BA Gas burner alarm (no flame)
BC Burner controller
BV Burner control valve
BY Burner solenoid valve
FO Restriction orifice
HC Manual controller
HIC Manual indicating controller
HS Manual switch
HV hand valve
II Current indicator
IT Current transmitter
JV Power control valve
PSV Relief valve, safety valve
PSE Rupture disc or vacuum breaker
ZI position indicator

Process Variables
A Analysis
B Burner
C Conductivity (by users choice of letter "C")
D Specific gravity or density (by users choice of letter "D")
E Voltage or voltmeter
F Flow
G User's choice
H Manual or hand
I Current ammeter
J Power
K Time, timing schedule, program, or counting
L Level (liquid or solid)
M Moisture or humidity
N User's choice
O User's choice
P Pressure
Q Quantity
R Radioactivity
S Speed, frequency
T Temperature
U Multivariable
V Vibration, mechanical analysis
W Weight or force
X Unclassified
Y Event
Z Position

Line Designations

Line designations may vary by plant site. This appendix gives examples of line designations similar to those uses at many plants. Check the site Master Sheet for designations that apply at specific sites

A Compressed air (wet)
AA Acetic acid
AC Acetylene
ACA Acrylic acid
ACC Ammonia CO2 condensate
ACG Ammonia CO2 gas
ACN Acetonitrile
ACS Ammonia carbonate solution
AD Ammonia drains
AFG Ammonia foul gas
AG Ammonia gas
ACH Acetone cyanohydrin
AGR Ammonia gas relief
AHG Ammonia hot gas
ALC Alcohol
ALQ Ammonia liquid
AM Amine solution
AMA Ammonium acrylate
AMD Acryl amide
AMS Acryl amide sulfate
AN Acrylonitrile
ANC Ammonium nitrate condensate
ANH Anhydrous ammonia
ANL Aniline
ANS Ammonia nitrate solution
AK'V Ammonia nitrate vapor
ANVP Acrylonitrile vapor
ANW Acrylonitrile weak
ANVW Acrylonitrile & water vapor
AOT Aerosol
AP Ammonium phosphate
AQ Aqua ammonia
ADS or AQS Aqua solution
AS Acid slurry
ATV Atmospheric vent
AV Ammonia gas vapors (anhyd)
ANOG Acrylonitrile off-gas
ANWOG Acrylonitrile water off-gas
ANWV Acrylonitrile & water vapor
AMDW Acrylamide weak
___ Acid, weak (see WA)

B Butadine
BD Boiler blow down
BFG Blast furnace gas
EG Burner gas
BL Blend
BT Butane
BTM Bottoms
BR Brine (glycol)
BRS Brine supply
BRR Brine return
BFS Boiler feedwater, suction
BFD Boiler feedwater, discharge
BTS Benzo thiazole solution
BN Beta napthol
BZE Benzene & benzol

C Condensate (steam)
CA Conditioning agent
CAT Catalyst
CB Continuous blow-off (boilers)
CBL Carbon black
CBS Carbamate solution
CCO Clean cylinder oil
CCS Carbonated cyanamid slurry
CCSL Calcium carbonate slurry
CDG Carbon dioxide gas
CDL Carbon dioxide liquid
CF Chemical feed
CFL Flashed condensate
CG Coal gas
CL Chlorine liquid
CLG Chlorine gas
CIS Chlorine solution
CNG Converter or converted gas
CO Carbon monoxide
COG Coke oven gas
COT Coal tar
CS Chemical sewer
CSF Carbonated solution filtrate
-----_ Caustic solution (see NAOH)
CU Copper sulphate
CUS Copper solution
CWR Cooling water (return)
CWS Cooling water (supply)
-----_ Condensate, deaerated (see DEC)
CY Cyanide
CYCH Cyclohexanol
CYG Cyanide gas
CYS Cyanide slurry

D Drains
DCO Dirty cylinder oil
DCS Docusate
DEC Deaerated condensate
DIPN Disopropylnaphthalene
DML Dicyandiamide mother liquor
DL Drain liquor
DO Diesel oil
DSL Dicyandiamide slurry
DSO Dicyandiamide solution
DY Dicyandiamide

E Ethane
EA Exhaust air
EQ Equalizer line
ES Exhaust steam
ET Ethylene
ETC Ethylene glycol (or see BRS and BRR)
EX Engine exhaust
F Filtrate (cold)
FA Formic acid
FG or FLG Fuel gas
FL Fluorine
FLRG Flare gas
FO Fuel oil

Line Designations Continued

FR Freon
FRG Freon gas
FRL Freon liquid
FS Freon solvent
FSL Ferrous sulfate
FSP Ferrous phosphate
FW Fire water
G Gasoline
GL Glycerin
GN Guanidine nitrate
GNA Guanidine nitrate-ammonia solution
S Guanidine nitrate-synthesis solution Gypsum slurry
GNSS Glycol, ethylene (see BRS & BRR)
H Hydrogen
HA Hot air
HCL Hydrochloric acid
HCN Hydrogen cyanide
HCS High pressure cond. Supply
HCR High pressure cond. return
HCN Hydrogen cyanide
HE Helium
HF Hot filtrate
HI Hydrogen impure
HM Hydrogen gas mixed
HN Hydrogen-nitrogen mixed
HO Hot oil
HOC Hydrogen and oxygen condensates Hydroperoxide
HP High pressure steam
HPS High pressure vent
HPV Hydrogen sulfide
HS Hydrogen sulfate
HSC Hydrogen sulfate
HSO High temperature salt
HTS High pressure supply
HYF Hyflo filteraid
IA Instrument air or dry air
IG Inert gas
IN Inhibitor
IPA Iso-propyl alcohol Isopropylnaphthalene
IPN Isobutylene
ISB Isoprene
K Kerosene
KA Kathene
KS Caustic solution
L Liquor
LA Liquid ammonia
LAN Lactonitrile
LCR Low pressure condensate return
LD Let down lines
LN Lime nitrate
LS Lime solution
LPS Low pressure steam
LPV Low pressure vent
LSO Lean solvent
M Methane
MA Methanol
MAA Maleic anhydride
MD Melamine dust
MCR Medium pressure cond. return
MCS Medium pressure cond. supply
ME Methylclodde
MEA Monoethanolamine
MEAL Monoethanolamine lean
MEAR Monoethanolamine rich
MEL Melamine crystals
MG Mixed gas & steam
ML Mother liquor
MSL Melamine-blend slurry
MPS Medium pressure steam
MUA Muriatic acid
MX Monex
N Nitrogen
NAG Nitric acid vapor or gas
NAL Nitric acid liquid (HNO3)
NAOH Caustic solution
NAP Napthalene
NAS Nitroguanidine acid slurry
NE Neon
NG Natural gas
NI Cryogenic nitrogen
NML Nitroguanidine mother liquor
NNS Nitroguanidine nitration syrup
NOG Nitric oxide gas
NS Nitroguanidine solution
NTA Ammonium nitrate
O Oxygen
OC Oily condensate
OD Oily drains
OF Off gas
OG Oil gas
OI Oxygen impure
OIL Oil
OL Oleum
CO Cold oil
HO Hot oil
RO Refrigerated oil
P Purge lines
PA Primary air
PAAC Pam-acrylic acid copolymer
PAMD Polacrylamide
PBS Potasium bisulfite
PBSA Potasiul bisulfate
PCS Potassium carbonate solution
PDG Producer gas
PG Petroleum gas
PGC Cooled process gas
PGH Hot process gas
PW Potable water (drinking water)
PH Phosphate solution
PHA Phosphoric acid
PHL Phenol
PP Propane
PPS Potassium persulfate
PRA Process air
PRG Process gas
PRL Process liquid

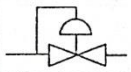
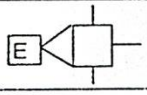
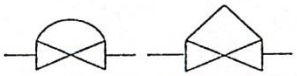
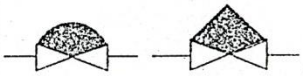
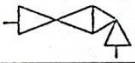
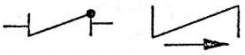
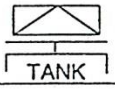
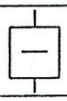
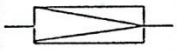
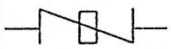
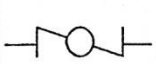
Line Designations Continued

PRS	Process solid
PRW	Process water liquor
PSL	Precoat slurry
PT	Petroleum
PV	Pressure vent
PY	Propylene
QSL	Quenched slurry
RFC	Reformed gas
RG	Raw gas
RNG	Regeneration gas
RPG	Reform plant product gas
S	Steam
SA	Sulfuric add (H2SO4)
SC	Sodium carbonate
SCA	Sodium acrylate
SEQ	Sequestrene
SFC	Copper sulfate
SG	Suction gas
SH	Sodium hydroxide
SL	Slurry
SLG	Sludge
SOG	Sour gas
SOH	Sodium hypochlorite
SS	Sanitary sewer
SSA	Spent sulfuric acid
SSO	Sodium sulfate
STA	Starting air
---	Steam low pressure (see LPS)
---	Steam medium pressure (see MPS)
---	Steam high pressure (see HPS)
STG	Stack gas
STS	Storm sewer
SU	Sulfite
SUD	Sulfur dioxide
SUR	Surfactant
SUT	Sulfur trioxide
SV	Solvent
SWG	Sweet gas
S	Sulfur (molten)
T	Tar
TG	Tail gas
TOL	Toluene
TOLC	Toluene-contaminated
TRID	Tridecanol
U	Urea
UA	Utility air (plant air)
US	Urea solution
USE	Urea carbamate solution
V	Vent
VA	Vapors
VAC	Vacuum
VC	Vent cold
VCL	Vinyl chloride
VG	Vent gas
VH	Vent hot
W	Waste
WC	Cooling water
VVCR	Cooling water return (or see CWR)
WCHS	Chilled water supply
WA	Acid, weak
WC	City water
WCOA	Coagulated water
WCOA	Coagulated water
WCR	City water return
WDE	Demineralized water
WDDE	Deaerated demineralized water
----	Fire water (see FW)
WH	Hot water
WHY	Heavy water
WJ	Jacket water
WLI	Lime water
WLQ	Waste liquor
WM	Mineral water
WMU	Make-up water
WMUN	Municipal water
---	Potable water (see PW)
WOI	Oily water
WOX	Oxidized water
WPR	Process water
WPBF	Process boiler feed water
WQ	Quench water
WR	River water
WS	Salt water
WSA	Sanitary water
WSE	Settled water
WSI	Silt or silty water
WSL	Washed slurry
WSO	Sooty water
WSU	Sulfur water
WT	Treated water
WTOL	Wet toluene
WVW	Well water
WWA	Waste water
WWH	Wash water
X	Xylene
ZS	Zinc solution

Appendix
Graphic Symbols for Flow Diagrams

VALVE SYMBOLS

IN SOME CASES, ALTERNATE SYMBOLS ARE SHOWN, SINCE ACTUAL SYMBOLS USED MAY VARY BY PLANT SITE OR ACCORDING TO THE SOURCE OR DATE OF THE ORIGINAL DRAWING.

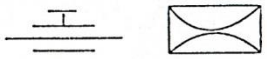
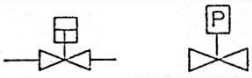
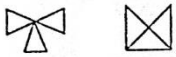
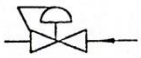
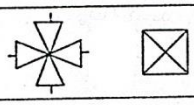
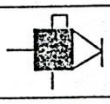
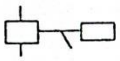
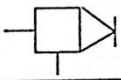
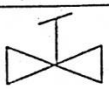
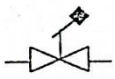
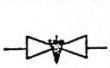
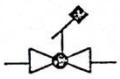
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	ANGLE VALVE (HIGH PRESSURE TYPE)		BACK PRESSURE CONTROL VALVE (SELF OPERATED)
	ANGLE VALVE (LOW PRESSURE TYPE)		CONSERVATION VENT VACUUM & PRESS. RELIEF
	ANGLE VALVE		DIAPHRAGM VALVE PNEUMATIC OPERATED
	AIR CYLINDER OPERATED VALVE		DIAPHRAGM VALVE PNEUMATIC OPERATED WITH HANDWHEEL
	BLOCK VALVE-NEEDLE TYPE 3 WAY (ELEC. OPERATED)		DIAPHRAGM VALVE (SAUNDERS PAT.) (GATE SERVICE)
	BALL VALVE		DIAPHRAGM VALVE (SAUNDERS PAT.) (GLOBE SERVICE)
	BLOW OFF OR BLOW DOWN VALVE (TANDEM VALVE)		ECCENTRIC ROTARY DISC VALVE
	BUTTERFLY VALVE OR DAMPER		ELECTRIC MOTOR OPERATED VALVE
	CHECK VALVE (LIFT OR SWING)		EMERGENCY VENT VALVE WITH TRAY & DRAIN LINE
	CHECK VALVE (EXCESS FLOW TYPE)		EXCESS FLOW VALVE
	CHECK VALVE (HP BLOCK TYPE ECD DESIGN)		EXPANSION VALVE
	CHECK VALVE (PISTON OPERATED)		FLUSH VALVE
	CHECK VALVE (BALL TYPE)		FOOT VALVE

Appendix

Graphic Symbols for Flow Diagrams

VALVE SYMBOLS

IN SOME CASES, ALTERNATE SYMBOLS ARE SHOWN, SINCE ACTUAL SYMBOLS USED MAY VARY BY PLANT SITE OR ACCORDING TO THE SOURCE OR DATE OF THE ORIGINAL DRAWING.

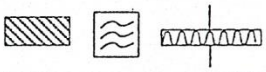
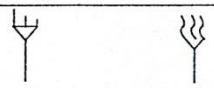
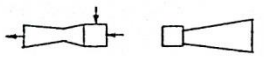
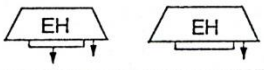
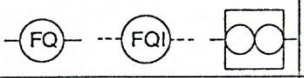
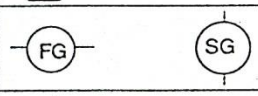
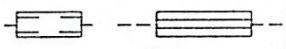
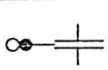
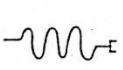
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	FUSIBLE LINK (FIRE VALVE)		PINCH VALVE
	GATE VALVE (ALSO SYMBOL FOR GENERIC TWO-WAY VALVE)		PISTON OPERATED VALVE
	GATE VALVE (JACKETED)		PLUG OR COCK VALVE
	GENERIC THREE WAY VALVE		PRESSURE REDUCING VALVE (SELF OPERATED)
	GENERIC FOUR WAY VALVE		QUENCH VALVE
	GLOBE VALVE		QUICK OPENING VALVE (LEVER OPERATED)
	GLOBE VALVE (3 WAY)		RELIEF VALVE
	5200# H.P. VALVE (NEEDLE TYPE)		SAMPLING VALVE WITH LINE INSERT
	5200# H.P. VALVE (DISC TYPE)		SOLENOID VALVE
	HYDRAULIC CYLINDER OPERATED VALVE		SOLENOIC VALVE (THREE WAY)
	INTERNAL TANK VALVE		STOP CHECK VALVE
	LINE BLIND VALVE (HAMER TYPE)		WEIGHT-OPERATED VALVE (GATE)
	NEEDLE VALVE		WEIGHT-OPERATED VALVE (GLOBE)

Appendix

Graphic Symbols for Flow Diagrams

MISCELLANEOUS SYMBOLS

IN SOME CASES, ALTERNATE SYMBOLS ARE SHOWN, SINCE ACTUAL SYMBOLS USED MAY VARY BY PLANT SITE OR ACCORDING TO THE SOURCE OR DATE OF THE ORIGINAL DRAWING.

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	ATMOSPHERIC VENT		FLAME ARRESTOR
	SLIP BLIND (CLOSED LINE)		FLARE
	SPECTACLE BLIND		FLEX CONNECTOR
	BURNER		HOSE CONNECTION
	CAP		SANITARY CONNECTOR e.g. "TRICLOVER"
	DRAIN		QUICK CONNECT
	DRINKING FOUNTAIIN		FLOW ELEMENT OR ORIFICE
	EJECTOR		ORIFICE PLATE IN QUICK-CHANGE FITTING
	EXHAUST HEAD		FLOW TOTALIZER DISPLACEMENT METER
	EXPANSION JOINT (COMMERCIAL BELLOWS TYPE)		MASS FLOW METER
	EXPANSION JOINT (COMMERCIAL SLIDE TYPE)		FLOW GLASS OR SIGHT GLASS
	EXPANSION JOINT (SPECIAL DESIGN ECD BELLOWS TYPE)		MAGNETIC FLOW METER
	EXPANSION JOINT (SPECIAL DESIGN ECD SLIDE TYPE)		FLOW STRAIGHTENING VAN
	EYE WASH FOUNTAIN		ARMORED HOSE (FLEXIBLE
	FIGURE EIGHT		FLEX HOSE
	FILTER		METAL HOSE (FLEXIBLE)

Appendix

Graphic Symbols for Flow Diagrams

MISCELLANEOUS SYMBOLS

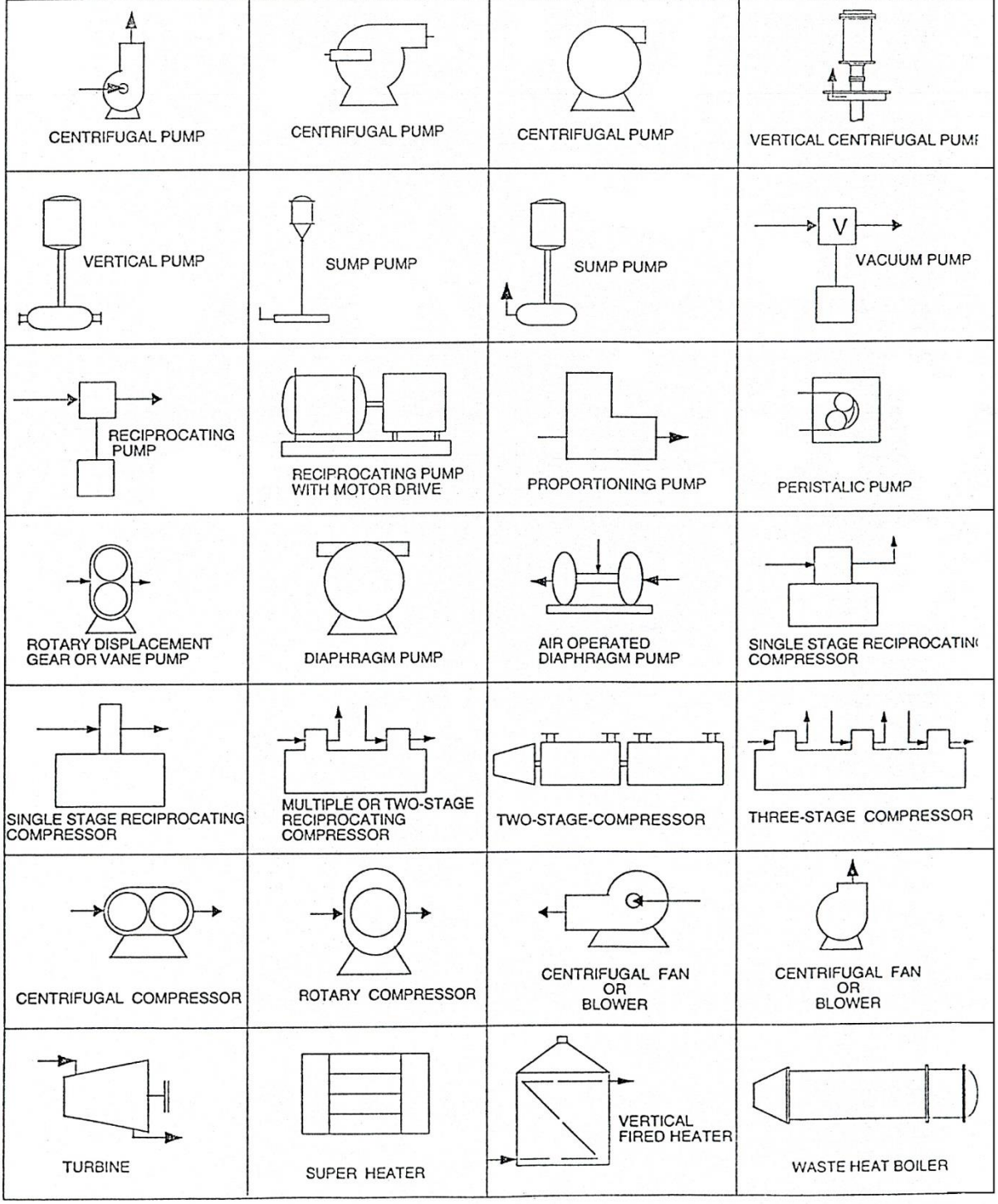
IN SOME CASES, ALTERNATE SYMBOLS ARE SHOWN, SINCE ACTUAL SYMBOLS USED MAY VARY BY PLANT SITE OR ACCORDING TO THE SOURCE OR DATE OF THE ORIGINAL DRAWING.

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	PLASTIC HOSE	FI	ROTAMETER
	RUBBER HOSE		RUPTURE DISC
	INSULATION	S	SAMPLE CONNECTION
AS	ANTISWEAT INSULATION		SEAL DIAPHRAGM
CC	COLD CONSERVATION INSULATION	S	SEPARATOR
HC	HEAT CONSERVATION INSULATION		SHOWER HEAD
PP	PERSONNEL PROTECTION INSULATION		STATIC MIXER
(X)	INSULATION (S) STEAM TRACED X= (E) ELECTRIC TRACED	T	STEAM TRAP
	CHANNEL TRACED & INSULATED PIPE	S	STRAINER BASKET TYPE
LG	LEVEL GAUGE		STRAINER Y TYPE WITH VALVE
	PITOT TUBE		STRAINER Y TYPE WITH PLUG
PI	PRESSURE GAUGE WITH LINE INSERT TYPE SEAL		TURBINE METER
PI	PRESSURE GAUGE WITH CHEMICAL SEAL		VENTURI OR FLOW TUBE
P	PURGE OR FLUSH DEVICE		VORTEX METER
	REDUCER (CONCENTRIC)	S S	STEAM OR HEAT TRACED PROCESS LINE
	REDUCER (ECCENTRIC)	E E	ELECTRICAL TRACING

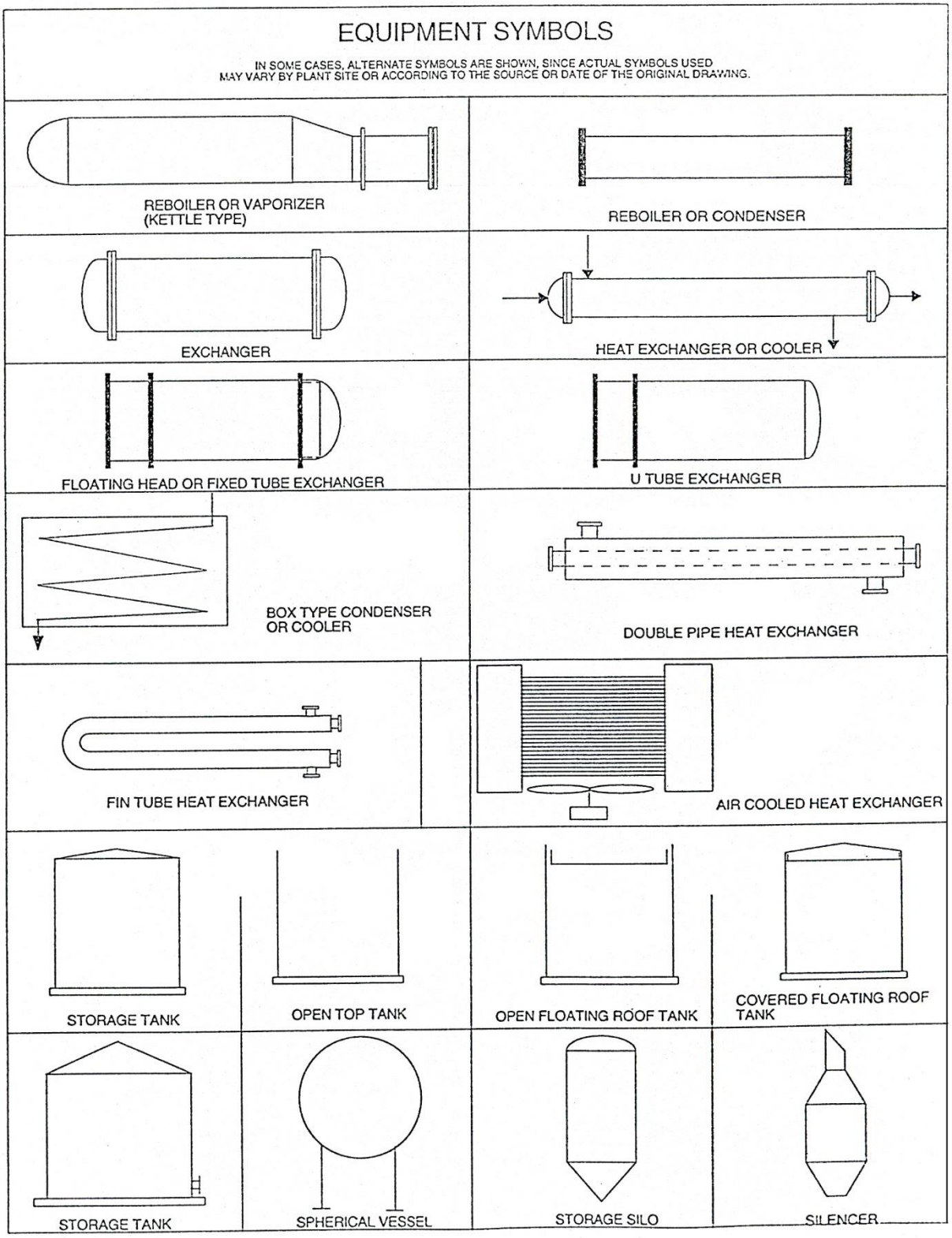
Appendix
Equipment Symbols

EQUIPMENT SYMBOLS

IN SOME CASES, ALTERNATE SYMBOLS ARE SHOWN, SINCE ACTUAL SYMBOLS USED MAY VARY BY PLANT SITE OR ACCORDING TO THE SOURCE OR DATE OF THE ORIGINAL DRAWING.

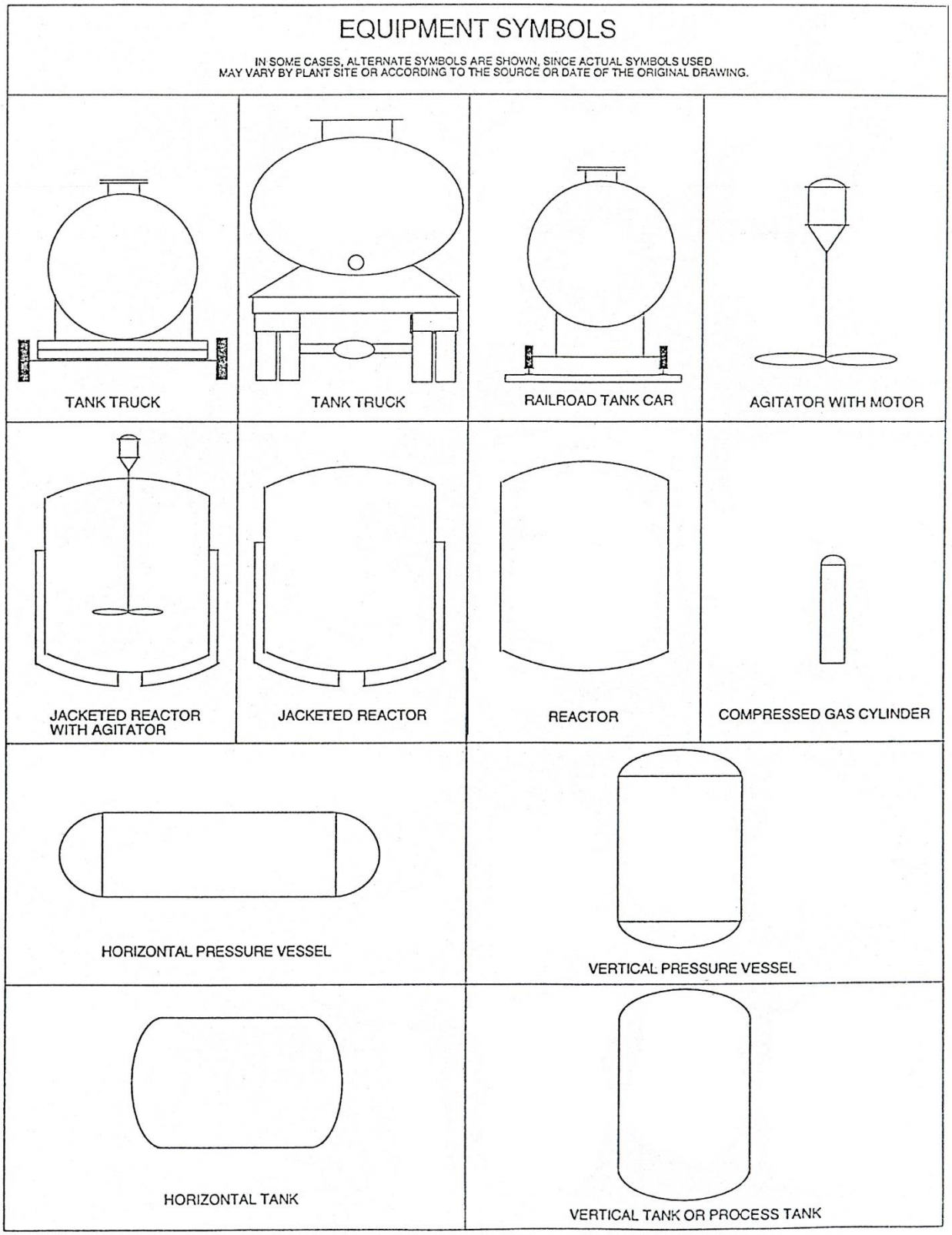


Appendix 4
Equipment Symbols



Appendix

Equipment Symbols



Appendix

Equipment Symbols