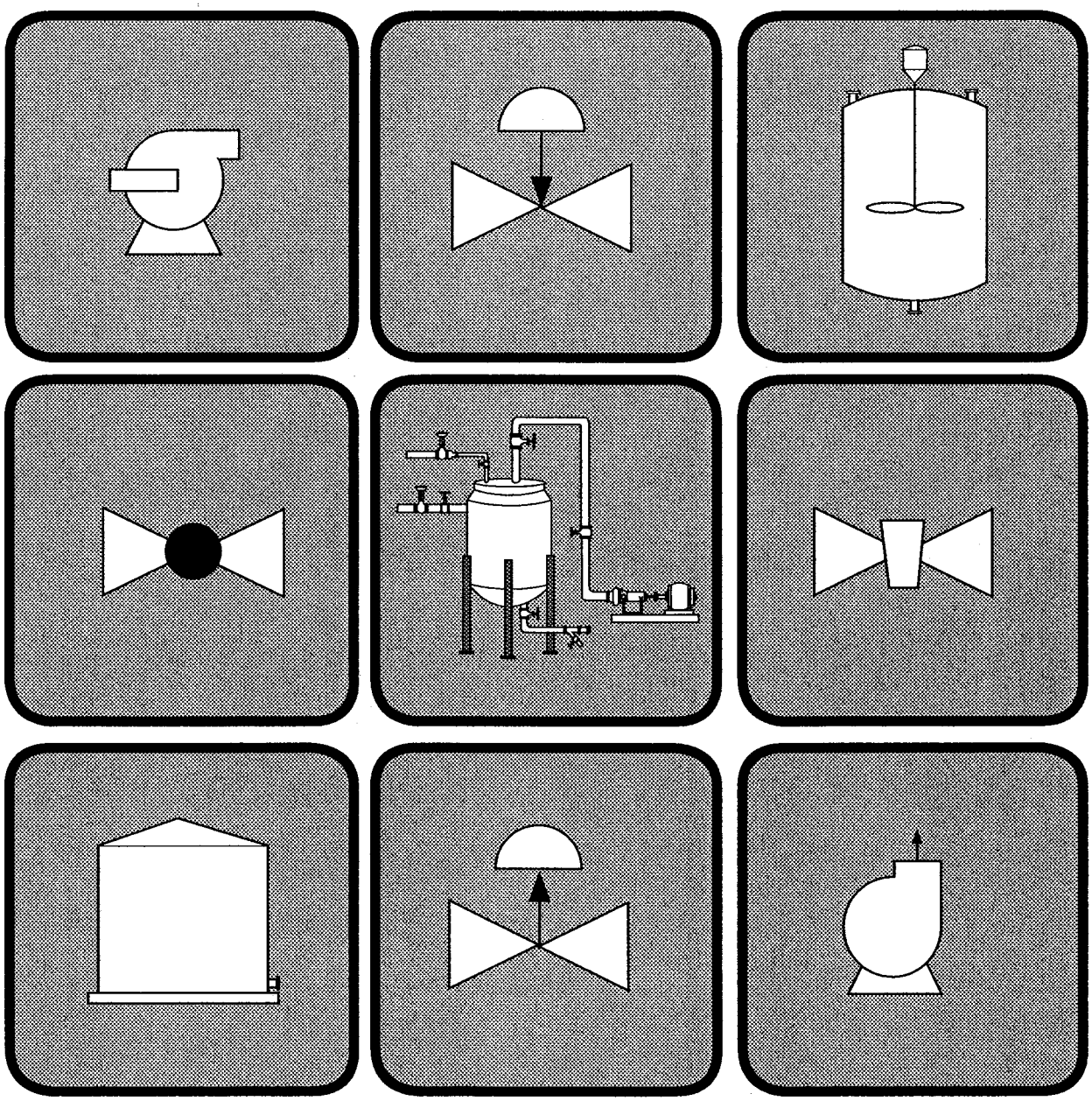
JOB TRAINING SYSTEMS, INC.

READING A P&ID

Course No. 203



HPS Engr Dept

JOB TRAINING SYSTEMS, INC.

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Course No. 203

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NOTE:

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Getting Started

Before you begin...
You should have previous work experience and knowledge of facilities and processes in your work area. Before beginning the course, you should:

1. Be able to identify the process equipment in your work area and describe its function;
2. Be able to identify instrumentation in your work area and describe its function;
3. Be able to locate specific equipment or instrumentation in your work area.

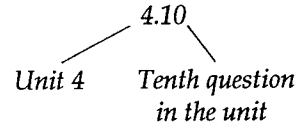
When you finish...
When you successfully complete this course, you will be able to apply the skills you have developed in order to read a P&ID. You should be able to:

1. Identify symbols and function labels commonly found on P&IDs;
2. Describe how system components are related;
3. Trace process stream flow and control loop functions.

Course Design
This is a self-study workbook. You will review units of information and answer questions on each section. At the end of the workbook there are answer sheets. You may choose to finish a section and then check your answers, or you may want to check each answer immediately. If you miss a question, go back and review the material again. Make a note of any questions and discuss them with a person competent in the subject matter. Appendices are included at the back of the workbook for reference. Section 9, Exercises for Review, will allow you to evaluate how well you have learned the material. You should complete both of the exercises before checking you answers.

This is your workbook!
Please mark in it.
Make notes.
Correct any wrong answers using the Answer Sheet.

The answers on the sheets at the end of the workbook have numbers that match the question numbers in each study unit. The answers and questions are numbered as follows:



At the very back of the book is a Demonstration Exercise (yellow sheet). You will use the skills you have developed in the course to read a P&ID for an area of your plant that is familiar to you. In your work area, you will use the P&ID to:

1. Locate equipment and trace process stream flow;
2. Describe instrumentation controls for a process.

Have a person competent in the subject matter accompany you and determine if your responses are correct. A completion statement is included on page one of the Demonstration Exercise so your satisfactory completion can be documented.

1. Introduction

Unit Objectives

Upon completing this unit, you should be able to:

1. Define what a P&ID is;
2. Describe why they are important to the operation of your facility;
3. Give examples of when you might use a P&ID.

What are P&IDs?

P&ID stands for Piping and Instrumentation Diagram. It is a drawing or blueprint of the systems in a section of your plant. A P&ID shows you the components needed to run, monitor, and control specific processes. It was 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).

When you see this arrow, it means that information next to it is especially important.

A P&ID layout includes:

- Equipment;
- Piping that connects the equipment;
- Lines and instruments used to monitor and control the process.

P&IDs often look very complicated because they show so much information. We will break down a typical P&ID into small parts and study each part one at a time. At the end of the course, you will put together what you have learned in order to read a real P&ID.

When you see this check, it means that you are asked to answer a question. ✓

1.1

Choose three things you would expect to see represented on a P&ID by placing a check (✓) in the circle next to each of your choices...

- ○ Piping that connects equipment
- ○ Equipment
- ○ The chemical reactions in a process
- ○ Lines and instrumentation that monitor and control a process
- ○ Procedures

Why are P&IDs important?

P&IDs are important tools for :

- Working safely
- Maintaining a process operation
- Understanding and communicating about a process
- Training

P&IDs must be kept accurate and up-to-date. Any changes made in a process system must be noted on the diagram (not usually the responsibility of an operator). For example, if an additional pump is installed, the change must be noted on a new issue of the P&ID for the system. It is important to keep information recorded on the P&IDs for specific areas consistent with actual plant operations. Your safety and that of your co-workers may depend on it. Also, some processes come under government regulations. P&IDs covering these processes may be needed to document plant operations. (Note that the government , however, does not regulate how P&IDs must be drawn.) If you have any questions or doubts about the accuracy of a P&ID, ask your supervisor before proceeding with a job.

P&IDs must be kept accurate and up-to-date.

1.2

Choose (✓) three reasons that P&IDs are important: ✓

❍ Appearance of the site
❍ Maintenance
❍ Communicating process information
❍ Plant safety

1.3

If you need to look at a P&ID before beginning a job and you think the information on a P&ID does not match the real situation in the plant area, what should you do? Place a ✓ by your choice.

❍ Correct the P&ID.
❍ Put the P&ID back in the file.
❍ Discuss your question with your supervisor.
❍ Go ahead with the work and discuss the question later.

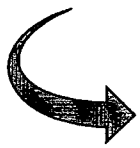
1.4

P&ID stands for...

❍ Piping and instructions diagram
❍ Piping and instrumentation decisions
❍ Plumbing and insulation directions
❍ Piping and instrumentation diagram

Who uses P&IDs?

P&IDs for an area may be important to any person who has responsibility for 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 check 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 employee.

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.

Think about times when you may need to check a P&ID for information in your job.

Note some examples:

_____

_____

_____

_____

_____

As you learn more about the information on P&IDs and how to read them, your list may grow!

You do not need to be an engineer to read a P&ID. Experienced operators should already be familiar with process equipment and functions that are described on the diagrams for their work area. This course will give you the tools needed to understand how this information is recorded on drawings. P&IDs can be a valuable source of information to help you perform your job and increase your self-reliance.

How will being able to read P&IDs help you in your job?

Review ✓

1.5
P&ID stands for _____ and _____ diagram.

1.6
A P&ID shows the different pieces of process_____ in an area and the _____ that connect them.

1.7
A P&ID also shows the instrumentation that monitors a process and how the process is _____.

1.8
P&IDs must be kept _____.

1.9
P&IDs are useful to anyone who is _____ for maintaining the safe and efficient operation of a process _____.

1.10
P&IDs are helpful in planning a job and _____.

1.11
Some of the processes diagrammed on a P&ID may be covered by _____ regulations.

Fill in the blanks with words from the list below. Each word may be used only one time, and one word will not be used.

instrumentation
engineering
accurately
government
equipment
responsible
troubleshooting
controlled
piping
system
lines

2. Information on a Typical P&ID

Unit Objectives

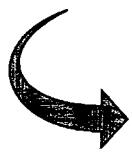
Upon completing this unit, you should be able to identify and describe the written information in the following parts of a P&ID:

1. Title block
2. Main diagram
3. Line schedules
4. Equipment descriptions
5. Notes
6. Zone numbers

What kinds of information are on a P&ID?

P&IDs appear to be very complicated because there is so much information included on them, but you should already be familiar with much that is recorded for your area. In this course, you will learn how that information is generally represented on P&IDs in a standardized way.

This course covers two basic types of information:



- **Written** information such as titles, label tables, and equipment specifications and
- Information represented by **symbols and drawings.**

Much P&ID information is recorded in a standardized way.

Standardized means that certain information is usually represented the same way. This is true much of the time on P&IDs! You should be aware that there may be differences. P&IDs may be hand drawn or produced using a computer. A symbol for a certain type of valve, for example, may look slightly different on diagrams at various sites; or one plant may have a unique way of numbering and labeling instrumentation. This course covers common practices used to produce P&IDs. As always, if you have any questions, ask your supervisor before proceeding.

✓ 2.1

Because information is generally recorded on P&IDs in a standardized way, you can expect the symbol for a pneumatic valve on P&IDs from different sites to look...

○ Different ○ Similar ○ Simple

Figure 1 below shows some of the parts of a P&ID that you may see. In this course, we will look at the parts numbered 1-6 in Figure 1. How P&IDs are drawn will differ, but you can always expect a title block and main diagram. The amount of detail given will vary from site to site. Line schedules, for example, may be placed at the top of the P&ID at some sites instead of near the bottom as shown in our diagram. Some P&IDs will not include a line schedule. **We will be building skills in this course that will help you use the information that is often given.**

The Title Block

Every P&ID has a **Title Block** which is usually located in the bottom right hand corner of the page. In Figure 1 below, the Title Block is area number 1.

Be sure that you have the correct drawing for the area. Using an outdated drawing or a drawing for the wrong area could result in an unsafe act or costly mistake. The Title Block contains the following information that is important for choosing the correct drawing:

- Plant name and location
- Process area covered in the diagram
- Date the P&ID was originally issued and current issue number
- Drawing number

Be sure that you have the correct drawing.

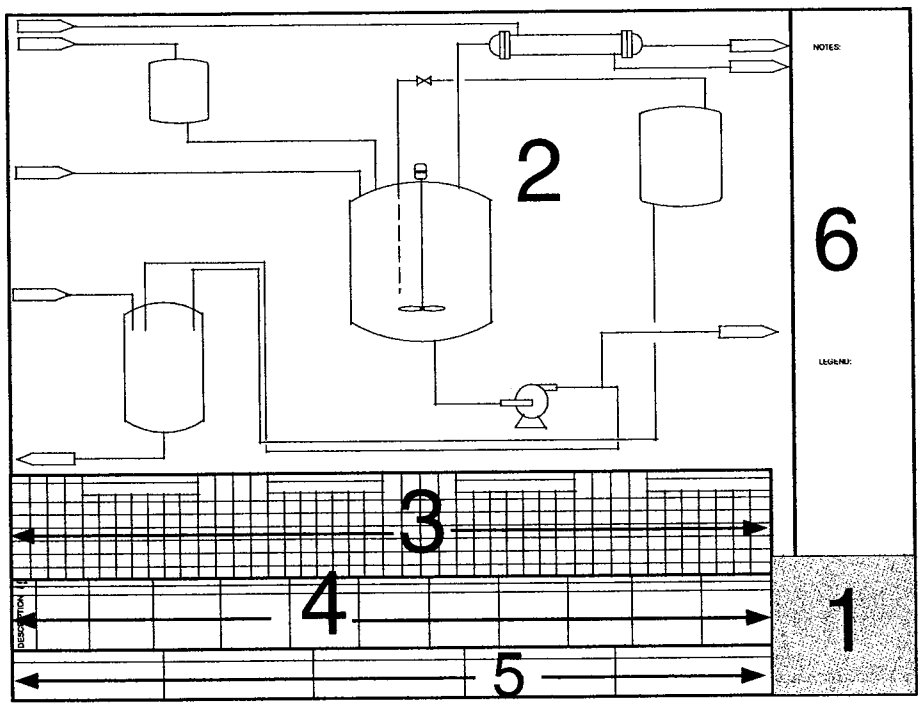


Figure 1

The layout and amount of information on P&IDs will vary by site. Our study example shows:

1. *Title Block*
2. *Main Diagram*
3. *Line Schedules*
4. *Equipment Descriptions*
5. *Issue Descriptions*
6. *Notes*

✓ In **Figure 2** below,

2.2 The name of the company is _____.

2.3 The name of the plant is _____.

2.4 The location of the plant is _____.

2.5 The process described in the diagram is _____

_____.

2.6 The title of the Drawing is _____.

2.7 The current issue number is _____.

2.8 The drawing number is _____.

Always be sure that you have the correct P&ID for the job at hand. Check the title, issue number, and drawing number.

This is generally the information you will need to make sure you have the correct drawing. **Using the wrong drawing could lead to an unsafe act or mistake on the job.** Additional information may be in the Title Block. For example, the Title Block may include the name of the engineering company or group at your company that prepared the diagram and the name of the person who authorized the diagram for construction use.

Title Block

Figure 2 is an enlargement of block number 1 from Figure 1 on the previous page (page 7). This figure shows the kinds of information typically given in the title block of a P&ID.

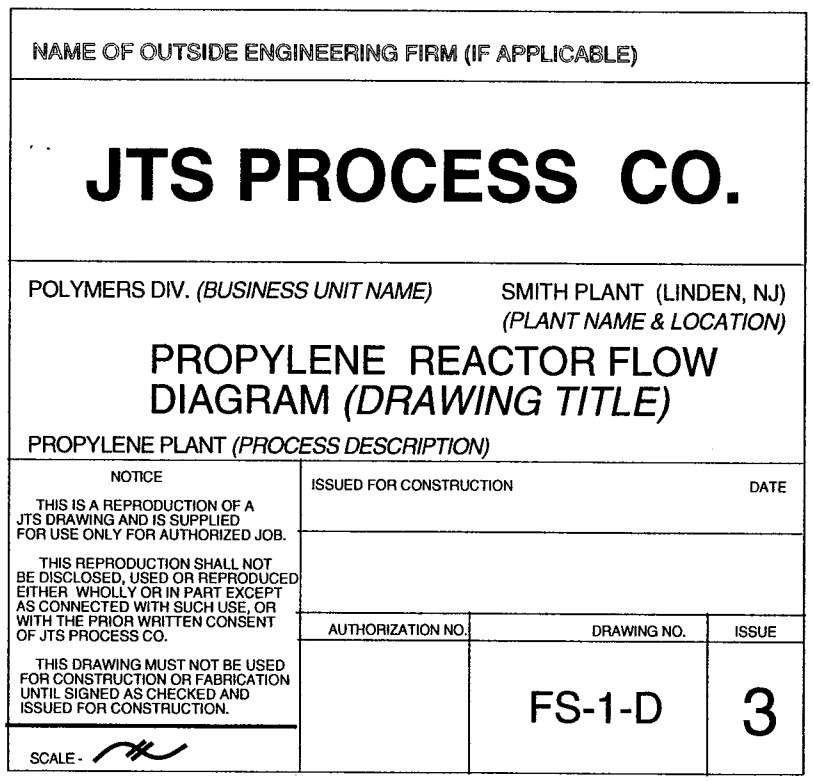
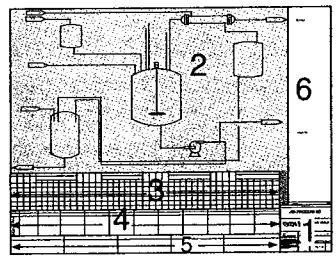


Figure 2

Main Drawing



The largest section of the P&ID is the **Main Drawing**. The Main Drawing contains the information that can be represented by symbols and lines. In Figure 1 (page 7), the Main Drawing is block number 2.

On a real P&ID, you will see symbols and lines in the Main Drawing for:

- Equipment
- Piping connecting pieces of equipment
- Instruments
- Lines connecting instruments
- Instrument control loops

We will look at each of these types of symbols and lines in more detail later in this course. For now, we will use simple squares, circles, and triangles as symbols to show how a P&ID is put together.

Relative Size of Symbols

The **relative size of the symbols** represents the relative size of the actual equipment. For example, in **Figure 3** below, Square A is smaller than Square B on the drawing. In the plant, expect the vessel represented by Square A to be physically smaller than the vessel represented by Square B.

2.9

In Figure 3, which symbol represents the **smallest** vessel in the plant area?

✓

○ Square A ○ Square B ○ Square C

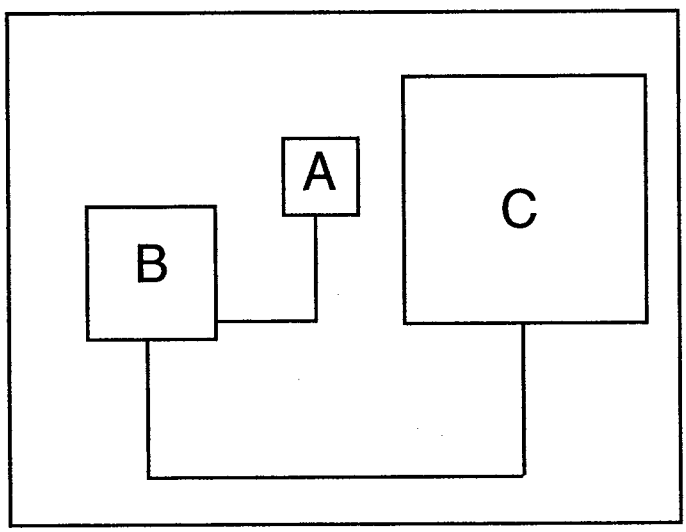


Figure 3

Relative Position of Symbols

Positions on a P&ID are relative, but distances are not in true proportion.

The **relative position of the symbols** also represents the relative position of the actual equipment on the plant. **The word *relative* is important.** Unlike on a road map, you cannot expect the distances on a P&ID to be proportional to the actual distances between equipment on the real plant. But if a pump is located under a vessel on the P&ID, you should expect the real pump to be located somewhere under the real vessel. The P&ID will not tell you how far away it really is, however.

✓

2.10
In Figure 4, where would you expect the piece of equipment represented by the triangle to be located on the real plant?

❍ Above Vessel A ❍ Below Vessel A
❍ Above Vessel B ❍ Below Vessel C

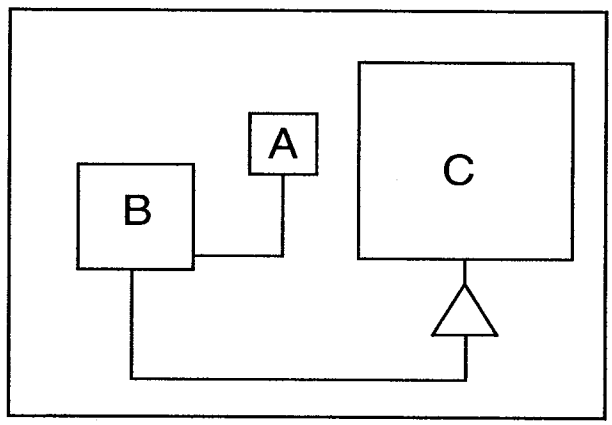


Figure 4

Review ✓

Fill in the blanks with the words below. Use each word only once. There is one extra word.

size
relative
tanks
instrumentation
distance
equipment

2.11
The symbols in the Main Drawing of a P&ID represent pieces of _____ and _____.

2.12
The location of the symbols shows how the different parts of the system are located _____ to each other.

2.13
P&ID symbols also **represent** the relative_____ of a piece of equipment compared to other equipment in the plant area.

2.14
P&IDs do not show the actual _____ between pieces of equipment or instruments.

Connecting Lines

Each of the pipes and instrument lines in a process area will be drawn on a P&ID as a line. Pipes and lines that have a special purpose will be drawn as lines with unique variations for each purpose. We will look at specific types of pipes and lines and how they are identified later in this course.

Real pipes and lines may go in any direction, cross over each other, go through walls, or just end. This is also true on a P&ID.

On a P&ID, **when two lines cross over or make a corner without any break in the drawn line, it means that those two pipes are actually connected in the real plant.** In Figure 5, the arrows labeled 1 point to areas where the pipes are physically connected.

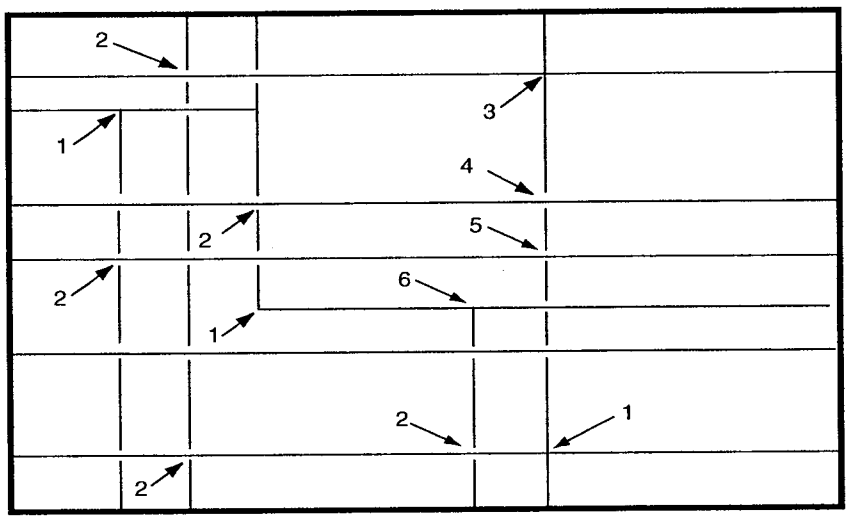


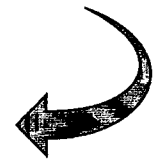
Figure 5

If drawn lines cross over each other but show **a break or gap** at the crossover, these pipes are not connected in the plant. The break in the drawn line may be a simple space, or a small, curved S-shaped or U-shaped symbol on each side of the break to show that the pipes are not physically connected. The arrows numbered 2 in Figure 5 indicate places where drawn lines for pipes cross over each other and **do not physically connect** in the plant.

2.15

For the arrows numbered 3-6 in Figure 5, circle the "Y" (for yes) if the actual lines in the plant are physically connected and the "N" (for no) if the actual lines in the plant are not physically connected.

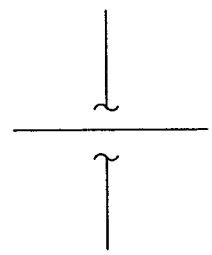
Y	N	Arrow 3	Y	N	Arrow 4
Y	N	Arrow 5	Y	N	Arrow 6



Arrows #1
Physically connected

Arrows #2
Not physically connected

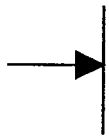
Corners or turns in pipelines on P&IDs do not necessarily represent bends in the real pipelines. Bends are often put in by the person drawing the P&ID to make lines fit in the space available on the drawing. Also, the lines on the drawing do not represent real distances or real location, only relative position (such as a line attached to the bottom of a tank).



An S-shaped symbol is sometimes used to show that crossing pipes are not connected.

✓

Direction of Process Flow



Sometimes the flow direction arrow may be at the point where the lines connect.

Tracing flow direction

Into B
Out of B
Into D
Out of D
Into C
Out of C

A P&ID shows the direction a material stream is flowing within a pipe. **The direction of flow is drawn as a solid arrowhead on the line representing the pipe.** Each segment of line (a segment is made each time another line crosses or connects to the line) will usually have a flow direction arrow.

In the drawing below, the direction of flow is into the equipment Symbol B at the top and out of Symbol B at the bottom.

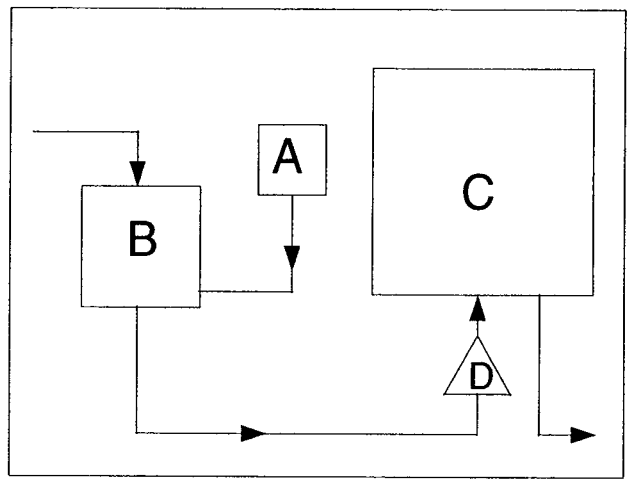


Figure 6

We can trace a process stream's flow from where it begins, through piping, into equipment such as tanks and pumps, through control valves, and out of the system shown on the current P&ID. The drawing may show that the stream leaves the plant, or it may indicate that the flow continues on another diagram. By tracing along the line against the flow, you can locate where the stream enters the current diagram. We will do more stream tracing later in this course.

✓

2.16
In Figure 6 (above), where does the stream flow enter the equipment labeled Symbol C?

O At the top O At the bottom
O At the left side O At the right side

2.17
Where does the stream flow leave Symbol C?

O At the top O At the bottom
O At the left side O At the right side

Line Schedules

Block number 3 on Figure 1 (page 7) is the **Line Schedule**. The Line Schedule tells us the following kinds of information about each pipe on the P&ID:

- Pipe line 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

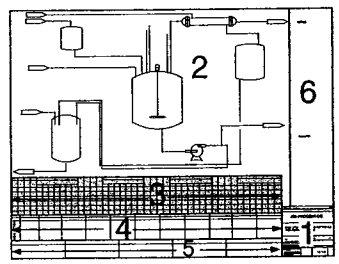


Figure 7 below shows examples of typical headings and information given for three different pipelines in a line schedule. A P&ID may have many lines; the line schedule listing may cover most of the bottom of the page. In this course, we will learn how to apply the information from the line schedule when reading a P&ID.

Example Line Schedule

LINE NUMBER	PRODUCT	FROM	TO	SPEC	PIPE				
					SIZE	SCH	MATL	INS	TRACE
WTOL-179-3	WET TOLUENE	2-28H1	3" W-179-2	N4	2"	80	TF	NO	NO
WWA-179-6	STORM WATER	S-17P3	PROCESS SEWER	A1	1-1/2"	80	CS	NO	NO
WWA-179-5	WASTE WATER	S-17P3	E/N FACILITY	A1	1-1/2"	80	CS	NO	NO

Note: SPEC = specification, SCH = schedule, MATL = material, INS = insulation

Line schedules on real P&IDs will often give more information and contain many more lines than are shown in this example.

Figure 7

2.18
In Figure 7, the **material** in pipe number WWA-179-5 is waste water. The **material** in pipe number WWA-179-6 is _____.

✓

2.19
The **size** of pipe number WTOL-179-3 is 2 inches. The **size** of pipe number WWA-179-5 is ____ inches.

2.20
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 _____.

Line schedule number

Notice that the abbreviation for the material flowing in a pipe is included in the line schedule identification for that pipe. In the sample in Figure 7, "WWA" stands for waste water of some type in line WWA-179-5. **You will want to be familiar with the abbreviations for the materials in your area of the plant.** However, you do not need to memorize the abbreviations for every material in the plant. You can look up this information in tables covered in the next section.

✓ 2.21
In Figure 7, what material is flowing in the pipe labeled

WTOL-179-3? _____

Flowing FROM and TO

The columns named **"FROM" and "TO"** tell us where the material stream starts and ends. Examples of where a product stream may **start** and **go to** are:

- A piece of equipment such as a tank or a pump
- Another line

Stream flows may also end at a vent or drain.

2.22
In Figure 7, the product stream wet toluene is flowing **to**

✓

_____.

2.23
The material in pipe number WWA-179-6 started at _____

2.24
The material storm water is flowing to the _____.

Pipe description

The line schedule gives specific information about the actual piping. Our sample table gives:

- Size or diameter of the pipe
- Schedule (SCH) thickness or relative strength of the pipe - the higher the number, the stronger the pipe
- Material the pipe is made of - such as stainless steel (SS), teflon (TF), or carbon steel (CS)
- If the pipe is insulated or traced and how

2.25
In Figure 7, what is the size of line WWA-179-6?_____inches ✓

2.26
What is line WWA-179-5 made of? _____

2.27
What schedule pipe is used for line WTOL-179-3? _____

2.28
Is line WTOL-179-3 insulated? _____

Other information may be in the line schedule block.

The Line Schedule block on some P&IDs may give additional **information that relates to the process.** This information may include such things as:

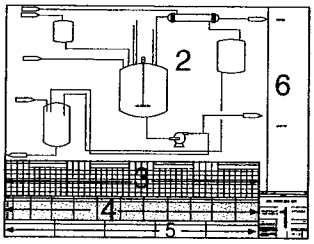
- Pressure at which the stream is flowing
- Temperature of the product in the line
- The product flow in pounds/hour

P&IDs with these kinds of additional **process** information cover the function of equipment and lines as well as how they are physically related.

2.29 ✓
Pressure and temperature of a product in a system line are examples of _____ information.

○ Tracing ○ Equipment ○ Process

Equipment Descriptions



Sometimes a P&ID will give descriptions of the important pieces of equipment shown in the drawing. This information is block number 4 in the example Figure 1 on page 7. P&IDs may have the equipment information in the form of notes at the bottom of the main drawing. Regardless of how or where they are written, the equipment descriptions may include the following kinds of information depending on the type of equipment:

- Unique equipment number - appears on each piece of equipment and on the P&ID equipment symbols
- Capacity
- Size
- Material of construction
- Vendor who makes it if this is important and model number
- Temperature and pressure information
- Horsepower of pumps

The equipment number is shown inside the equipment symbol or very near it if the symbol is relatively small. The number is unique - that is, no other piece of process equipment should have that number in the plant. Specific information about a tank, for example, may also be written on the tank on site.

Use Figure 8 to answer the next questions.

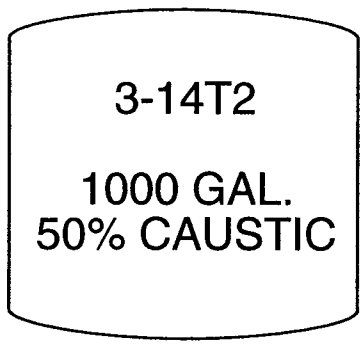


Figure 8

✓ 2.30
How many tanks in the plant will have the number 3-14T2?

○ 5 ○ 3 ○ 4 ○ 1

2.31
To find out information about this tank in the equipment description blocks, you should look for the number_____.

○ 3-14T2 ○ 50 ○ 600 ○ 14T2

Figure 9 below shows two sample P&ID equipment descriptions. The pieces of equipment are a tank and an agitator inside the tank.

CTW 16990 **AGITATOR**	**CTW 16992** **3-14T2**
1750 RPM Motor to be 3/60/440 TEFC .43 HP Mounted on CTW 16992 Serial no. 85/264872	Vertical 5'-6" dia. x 5'9" Work press. 5 PSIG @ 140F Serial no. 85-352 Carbon steel ASTM 516-70 Shell and heads

These are sample equipment descriptions. The amount of information will vary, and some P&IDs may not have equipment descriptions.

Figure 9

Our example plant uses a special label or **CTW number** for some pieces of equipment. If the equipment has a value of more than $1,000.00, it has a CTW number. **Numbering systems will differ from site to site.** Be sure that you understand the numbering system at your site.

Equipment numbering systems will differ from site to site.

We will look at how equipment is labeled in more detail later in this course.

2.32

Using Figure 9, put a "T" beside information that refers to the tank, and put an "A" by the information that refers to the agitator.

✓

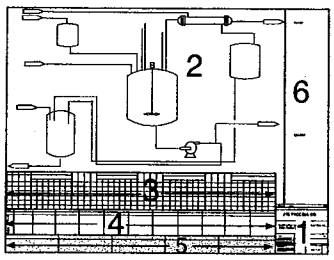
- ○ Serial number 85-352
- ○ 5'6" Dia x 5'9"
- ○ 1750 RPM
- ○ CTW 16992

2.33

Where is the agitator labeled CTW 16990 mounted in the plant?

- ○ On serial No. 85/264872
- ○ On tank 3-14T2
- ○ On Model No. XJC-43
- ○ On tank 16990

Issue Descriptions



The issue number (or revision number) for a P&ID is included in the Title Block (see page 8). Changes may be made during the design and construction of a process; also, additions and changes may be made to the process system throughout the operating life of the plant. **The P&ID for an area is revised and reissued every time a change(s) is (are) made.** The issue descriptions, which are usually along the bottom of the page, (see block 5 on page 7) tell you exactly what changes were made with each new issue number of the P&ID for the area.

✓ 2.34

A P&ID for an area must be changed every time that _____.

- ○ Supervision changes.
- ○ The cost of equipment goes up.
- ○ A change is made in the process equipment.
- ○ It's on the schedule.

Issue Notes

Notes may be made in the main drawing to show where a change has been made in the plant. In this example, a "cloud" has been sketched in to show where the new heat exchanger is. A real P&ID might have several similar pieces of equipment, and the "cloud" or some other indicator makes the new heat exchanger easier to find.

The triangle is used to indicate that the "6" refers to the issue number for recording this change.

The enlarged blocks on the left give the explanation for the changes made in issue #5 and the new issue #6 (the most current issue) of the P&ID for this area of the plant.

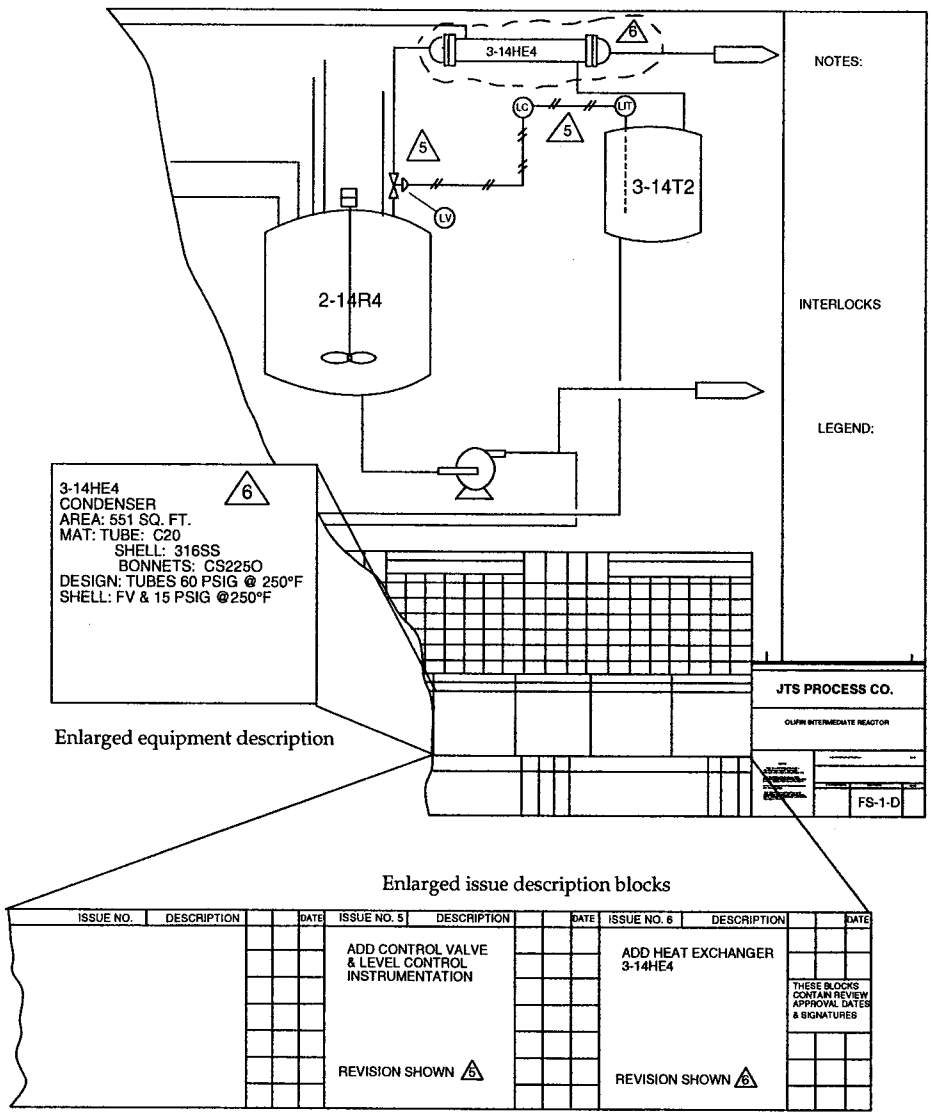
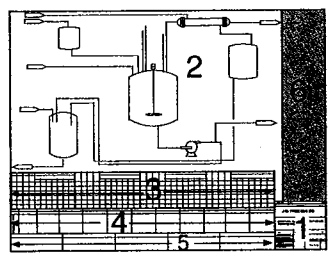


Figure 10

Special symbols and notes may also be in the main drawing to point out where changes were made in the plant. In Figure 10 on the previous page, a triangle is placed with the number of the current issue everywhere there is a difference with the previous P&ID issue for the area. A triangle with the new issue number also appears in the equipment list next to a description of the new heat exchanger as well as in the main drawing next to the heat exchanger's symbol. Some engineers might also put a "cloud" or some other sketch around all of the parts of the system that have been changed with the current issue.

The issue description blocks along the bottom of the drawing summarize the changes that have been made with each issue and give such things as date of work and person approving the change(s).

Notes



In Figure 1 (page 7), block 6 is the area of the drawing where many different kinds of information may be included. While notes may appear in almost any part of the P&ID, they are often along the right side of the drawing. We will look at three examples (the possibilities are many) of additional information that may be written on a P&ID:

- Interlock information
- Special symbol descriptions
- Safety information

The engineer preparing the P&ID may make a note about anything that varies from the usual or is especially important. For this reason, **you should always pay close attention to all noted information.**

2.35

Which statement is true?

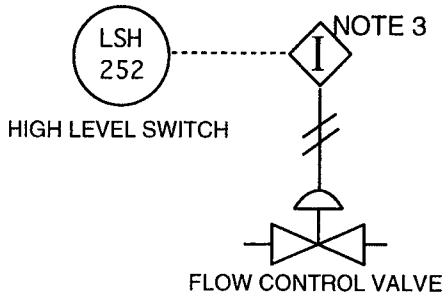
- ○ The notes on P&IDs are extra information that is of interest to engineers but is probably not particularly important to anyone else.

- ○ Notes on P&IDs contain significant information that may be very important to your work. ✓

Notes may be added at any location on the P&ID but are often on the right side. Notes are usually numbered. For example, a note might be made about interlocks because they are so important for safety reasons.

The interlock symbol is diamond shaped and may have an "I" in the center. Below is an example of a note that might appear with this symbol on a P&ID.

Information concerning interlocks may be in a special note on a P&ID.



Example of an interlock note that might appear in the note section.

NOTE 3:
WHEN HIGH LEVEL SWITCH CLOSES, INTERLOCK WILL SEND SIGNAL TO CONTROL VALVE TO STOP FLOW.

Examples of other information that the drawing engineer may give in notes are:

- Enlargement of the detail of a particularly complex control loop
- How a vent is to be made accessible in case of emergency
- Installation information such as - "All pump suction lines will be provided with drain valves on pump side of block valve."

Review ✓

Fill in the blanks with words from the list below. Use each word only once. There is one extra word.

safety
changes
triangle
issue description
square

2.36
The _____ is the section of a P&ID that tells you what revisions or _____ have been made to an area in the plant.

2.37
The changes that have been made on a new issue of a P&ID may be noted with the issue number inside a _____.

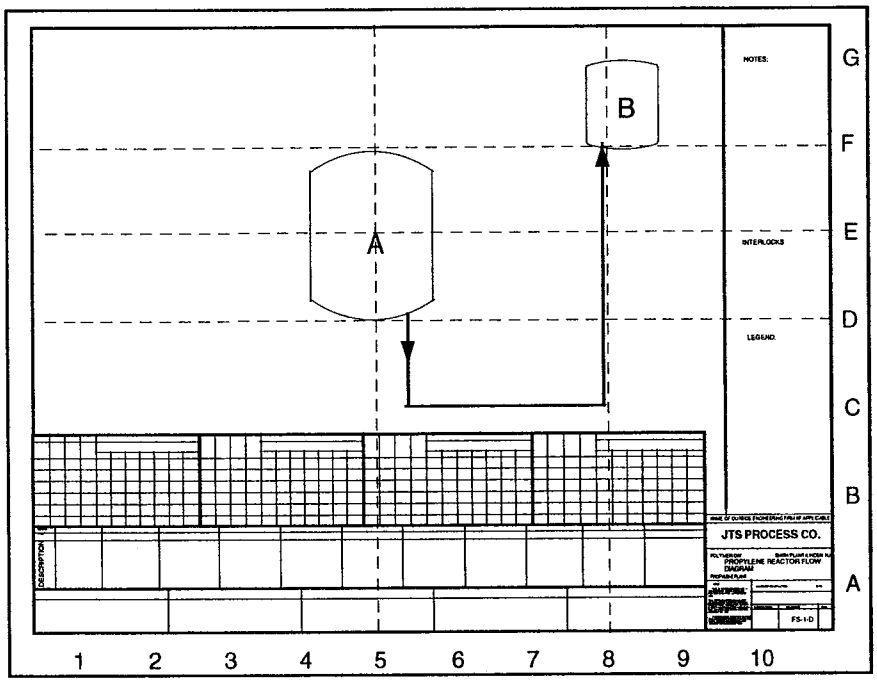
2.38
Information concerning interlocks may be noted on a P&ID because they are very important for _____ reasons.

Zone Numbers

Sometimes, **zone numbers** are used on a P&ID to help locate information on the main drawing. These numbers are very similar to the reference numbers on an ordinary road map. On a P&ID, numbers run from left to right along the bottom of the page, and letters run from the bottom up along the right hand side of the page. To locate a specific spot on the P&ID, draw imaginary lines up from a number and across from a letter. Where the two imaginary lines cross each other is the location of the area you want. The title block, for example, in the figure below is located where lines A and 10 cross.

Some P&IDs have zone numbers to use in locating a specific piece of equipment or where two pipelines join, for example. Other P&IDs will not have zone numbers at all.

Remember, the dotted lines below are not real lines that you will actually see on the P&ID. Do not confuse them with the many pipes and instrument signal lines that **do** appear on a P&ID!



Imaginary lines have been drawn in this example to show you how to use zone numbers for locating a specific area on a P&ID. ***This type of dotted line will not appear on a real P&ID.*** *Dashed lines, however, are used to represent instrument lines. We will cover this type of line symbol in Unit 6.*

Figure 11

2.39 In Figure 11, **Vessel A** is located where lines __ and __ cross. ✓

2.40 Where is the bottom of **Vessel A** located? ____ and ____

2.41 Where does the pipeline enter **Vessel B**? ___ and ___

2.42 Where does the pipeline exit **Vessel A**? ___ and ___

3. The Master Sheet

Unit Objectives

Upon completing this unit, you should be able to use a Master Sheet as a reference for identifying P&ID symbols and labels found in the:

1. Line tables,
2. Instrument symbols and designations tables,
3. Graphic symbols tables.

What is the Master Sheet?

When you complete this course, you will be familiar with many symbols and line designations or identifications; but this course does not try to cover all the possible equipment and line combinations that can appear on P&IDs. However, with the skills taught in this course, you should be able to look at any P&ID and describe the relationship between system components and trace process flow. You can do this using the **Master Sheet (also called Legend Sheet) to look up the symbols and line identifications that you do not know.**

The information given on the Master Sheet for a set of P&IDs will vary from site to site depending on who made the drawings and what processes are involved.

A Master Sheet should come with the set of diagrams for a process area. It is printed on the same kind of paper and with the same kind of ink as the P&IDs, and should be on file with them. This sheet is the key to what symbols and labels mean on the set of P&IDs. How this information is recorded and what is included will vary from site to site. We will look at an example Master that has four parts:

Table I - Line Designations
Table II - Instrument Symbols
Table III - Graphic Symbols
Table IV - Process Equipment Symbols

We will practice skills that will help you to understand and use a typical Master Sheet.

In this course, we will practice the skills needed to use a typical Master as a reference. More complete tables than our examples are included in the appendices of this manual. Use them throughout the course just as you would use the Master Sheet on site if you needed additional information.

✓ 3.1

If you do not know the meaning of a symbol on a P&ID, you should look it up on the:

- ○ Master Sheet
- ○ Procedures manual
- ○ Maintenance procedures
- ○ Safety manual

The line schedule in the previous unit (see pages 13-15) gave us several pieces of important information about each pipeline. The material flowing through a pipe is given on the line schedule and in the line identification number as an abbreviation. In the example line designation we used in the previous unit, "WTOL" stands for wet toluene. **The Line Designations section of the Master Sheet tells you what the abbreviations mean.**

A sample table is given below. Remember, a real table may include many more abbreviations than we show here. See Appendix 1 for a more complete list.

Table I
Line Designations

Part of a typical Line Designations Table

Line designation letters may be the same as instrument designations in some cases.

If the letters are on a line, their meaning can be found on a Line Designation Table. If they are in an instrument symbol, their meaning can be found on an Instrument Designation Table. For example "PV" means pressure vent on a line and pressure valve when it is an instrument symbol.

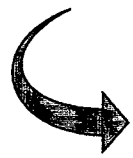
Table I
Line Designations

A	Compressed air (wet)	G	Gasoline
AA	Acetic acid	H	Hydrogen
AC	Acetylene	HA	Hot air
AD	Ammonia drains	HCN	Hydrogen cyanide
AG	Ammonia gas	IA	Instrument air (dry)
ALC	Alcohol	LA	Liquid ammonia
AN	Acrylonitrile	LS	Lime solution
ANH	Anhydrous ammonia	M	Methane
ANS	Ammonia nitrate solution	MA	Methanol
ANV	Ammonia nitrate vapor	MG	Mixed gas and steam
AOT	Aerosol	N	Nitrogen
AQS	Aqua solution	NG	Natural gas
AS	Acid slurry	NTA	Ammonium nitrate
ATV	Atmospheric vent	O	Oxygen
BD	Boiler blow down	OF	Off gas
BG	Burner gas	PGC	Cooled process gas
Bl	Blend	PRG	Process gas
BR	Brine	PV	Pressure vent
C	Condensate	S	Steam
CA	Conditioning agent	SL	Slurry
CAT	Catalyst	SLG	Sludge
CB	Continuous blow off	STG	Stack gas
CF	Chemical feed	SV	Solvent
CLG	Chlorine gas	SH	Sodium hydroxide
CLS	Chlorine solution	SUR	Surfactant
CNG	Converter/converted gas	TOL	Toluene
CS	Chemical sewer	U	Urea
D	Drains	UA	Utility air
EA	Exhaust air	V	Vent
EQ	Equalizer line	VAC	Vacuum
ES	Exhaust steam	VC	Vent cold
F	Filtrate (cold)	VCL	Vinyl chloride
FG	Fuel gas	VG	Vent gas
FLRG	Flare gas	WC	Cooling water supply
FO	Fuel oil	WCR	Cooling water return
FR	Freon	WT	Treated water
FRG	Freon gas	WTOL	Wet toluene
FRL	Freon liquid	WWH	Wash water
FS	Freon solvent		
FSL	Ferrous sulfate		

Be familiar with the designations for your work area.

Do you need to memorize all the abbreviations in the line designations table? No! But you should be familiar with those abbreviations that refer to lines in your work area. If you need to look at a P&ID before beginning a job, for example, and you do not recognize the material code for what is in a line, you should check the table. If you have any questions, ask your supervisor.

Using the sample Table I on page 23, notice how the abbreviations on this master are put together. **There is no absolute standard for defining how line designations will be written.**



- **ANH** is anhydrous ammonia.
- **ANS** is ammonia nitrate solution.
- **ANV** is ammonia nitrate vapor.

But be sure to check carefully. Notice that **AN** is *acrylonitrile* on our sample table. One letter can make a very important difference. Be sure that you know exactly what is in a line before you perform any work on a line. If you are still not sure after looking at the Master, ask your supervisor.

✓ 3.2 The abbreviation_____ stands for conditioning agent.

Using sample Table I of line designations on page 23 or Appendix 1, fill in the blanks.

3.3 _____ stands for liquid ammonia.

3.4 _____ stands for chlorine solution.

3.5 _____ stands for sludge.

3.6 _____ stands for cooling water supply.

3.7 A line designation is 1"-WCR-9. What material is in the line?

_____

3.8 A line designation is 2"-AA-3. What material is in the line?

_____

3.9 Is line 1"-FRL-5 carrying a liquid or a gas?

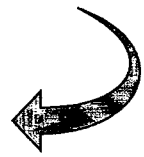
_____

3.10 IA stands for _____ _____.

3.11 PGC stands for _____ _____ _____.

Instrument Designations

Table II on our Master Sheet gives abbreviations for instrument designations. We will look at only a sample of abbreviations. This table is usually divided into sections according to the process variable that the instruments monitor. **A process variable is a physical characteristic of the process that can change.** The process variables that we will look at are:



- Temperature
- Pressure
- Level
- Flow

Other types of instruments that are usually included on the instrument designations table measure variables such as conductivity, specific gravity, weight, speed or frequency, and humidity or moisture.

3.12

_____ are physical characteristics of a process that can change such as temperature, pressure, and flow. ✓

- ○ Records
- ○ Limits
- ○ Process variables
- ○ Degrees

Instrument line designations are made up of:

- A two or three (usually) letter abbreviation
- A number

How are instrument line designation abbreviations used on a P&ID?

The ISA standard S5.1 contains tables and examples for creating letter abbreviations that are used for instruments on P&IDs. Most P&IDs follow this standard to some degree. **The first letter in a label for an instrument line stands for the variable being measured.**

For example, **"P"** is for pressure, **"F"** is for flow, **"L"** is for level, **"T"** is for temperature and **"W"** is for weight.

Some plants may call instrument designations instrument tags.

The second letter or letters stand for the <u>function</u> of the instrument.

First letter = variable

For example, **"V"** is for valve; **"IT"** is for an indicating transmitter.

Second letter(s) = function

In combination then,

Check the Master tables if you are not sure what an abbreviation means.

"PV" is a pressure control valve;
"FIT" is a flow indicating transmitter.

Table II Instrument Designations

The abbreviations below are samples from a typical Instrument Designations table found on a Master Sheet. A more complete table is in Appendix 2.

Designations for Instrument Components

Flow

FAL	Flow alarm low
FAH	Flow alarm high
FE	Flow element
FI	Flow indicator
FIC	Flow indicating controller
FIT	Flow indicating transmitter
FS	Flow switch
FT	Flow transmitter
FV	Flow control valve

Level

LAL	Level alarm low
LAH	Level alarm high
LC	Level controller
LCV	Level control valve self-operated
LE	Level element
LG	Level glass
LI	Level indicator
LIT	Level indicating transmitter
LR	Level recorder
LS	Level switch
LT	Level transmitter
LV	Level control valve
LY	Level interlock solenoid valve, relay or converter

Pressure or Vacuum

PAL	Pressure alarm low
PAH	Pressure alarm high
PC	Pressure controller
PCV	Pressure control valve, self-operated
PDI	Pressure differential indicator
PE	Pressure element
PI	Pressure indicator or manometer
PIT	Pressure indicating transmitter
PSV	Pressure safety relief valve
PSE	Rupture disc, vacuum breaker or emergency vent valve
PT	Pressure transmitter
PV	Pressure control valve

Temperature

TAL	Temperature alarm low
TC	Temperature controller
TE	Temperature element, thermocouple, resistance bulb, or thermopile
TI	Temperature indicator
TIC	Temperature indicating controller
TIS	Temperature indicating switch
TIT	Temperature indicating transmitter
TR	Temperature recorder
TS	Temperature switch
TT	Temperature transmitter
TV	Temperature control valve
TW	Temperature well
TY	Temperature interlock solenoid valve, relay or converter

Miscellaneous

BC	Burner controller
HC	Manual (hand) controller
HV	Manual (hand) control valve
II	Current indicator
ZI	Position indicator
A	Analysis
I	Current
J	Power
K	Time, program, or counting
Q	Quantity
WI	Weight indicator

3.13

✓

Using the table above, draw a line from the abbreviation to the instrument it stands for on a P&ID.

HV	Pressure safety relief valve
PSV	Level interlock solenoid valve
LT	Flow switch
FAL	Manual (hand) control valve
TIC	Temperature indicating controller
LY	Level transmitter
FS	Flow alarm low

Recognizing instruments on a P&ID

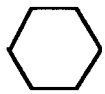
Generally, the letter abbreviation and number identifying an instrument on a P&ID will be written in a circle symbol. The different circle symbols are given on the Master Sheet, often with the instrument designations. **The circle symbol usually represents an instrument and also gives some information about where the instrument component is located in the plant area.** Other symbols may be used for special types of instruments.

Field mounted instrument 

Panel mounted instrument 

Behind panel mounted instrument, normally inaccessible to operator 

Auxiliary mounted instrument, normally accessible to operator 

Computer controlled function 

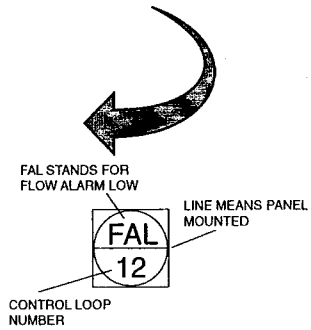
Programmable logic control 

Shared display, shared control 

We will look at numbering systems for instruments again when we cover instrument control loops in Unit 8.

ISA Standard S5.1

The instrument symbols shown are according to ISA standard S5.1, which gives detailed information and examples on the use of instrument symbols.



The instrument designation appears in the symbol. A number for the instrument loop will also be given in the lower half of the symbol.

Appendix 5 gives a more complete table of instrument symbols.

3.14
Place a check in the symbol below that represents an instrument. ✓

3.15
Place a check in the symbol below that represents an instrument located behind a panel in the plant.

Tables III and IV Graphic Symbols

When you look at a P&ID, you see many connecting lines and a wide variety of symbols. We have identified the symbols that contain instrument abbreviations and numbers. The many other symbols and what they stand for are given in the remaining tables on the Master. Our example Master gives the following symbols tables:

Table III	Graphic Symbols (for use on flow diagrams)
Table IV	Equipment Symbols (for process equipment)

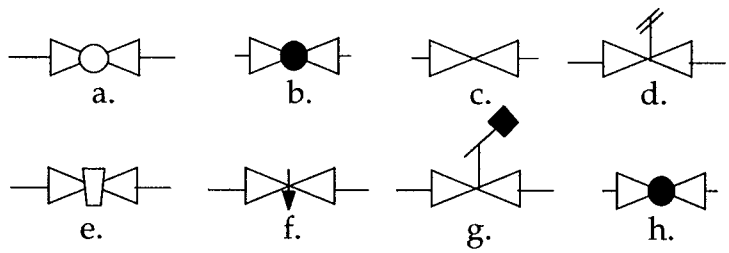
Table III Graphic Symbols for Flow Diagrams

Table III contains most of the smaller symbols you will see on a drawing of a process system. **You should be familiar with the symbols for the equipment in your area.** If you see a symbol you do not know, check the Master. You will notice that many symbols are similar. There are several types of valves, for example. We will look more closely at specific groups of equipment symbols later in the course. For now, **remember that an extra line or slight difference between two symbols can indicate a different type of equipment.**

3.16

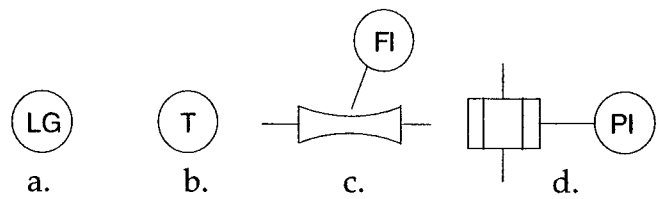
✓ Circle the two symbols below that show **the exact same type** of valve.

Small differences in symbols may mean that they are specific kinds of equipment. Look carefully, and check the Master if you are not sure exactly what kind of equipment is represented.



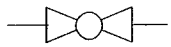
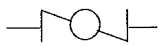
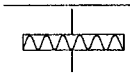
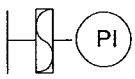
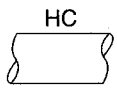
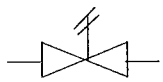
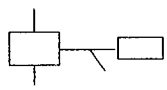
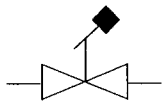
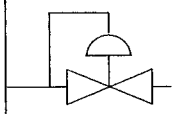
3.17

✓ Using what you know about instrument identification on P&IDs from the previous section, circle the instrument symbol below that represents a special type of **pressure** gage.



Below is a sample of the symbols in Table III. A more complete table is in Appendix 3. Some P&IDs may have differences in how they show specific pieces of equipment depending on who drew them. If you have any questions, ask your supervisor.

Table III
Graphic Symbols for Use on Flow Diagrams

	BURNER		BALL VALVE
	EYEWASH FOUNTAIN		CHECK VALVE (BALL TYPE)
	FLAME ARRESTOR		GATE VALVE (ALSO SYMBOL FOR GENERIC TWO-WAY VALVE)
	FLOW ELEMENT		GLOBE VALVE
	PRESSURE GAUGE WITH CHEMICAL SEAL		NEEDLE VALVE
	INTERLOCK		PLUG OR COCK VALVE
	HEAT CONSERVATION INSULATION		QUICK OPENING VALVE (LEVER TYPE)
	OPEN DRAIN		SAMPLING VALVE WITH LINE INSERT
	RUPTURE DISC		WEIGHT-OPERATED GATE VALVE
	INSTRUMENT SIGNAL		BACK PRESSURE CONTROL VALVE

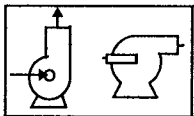
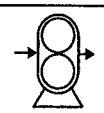
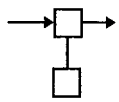
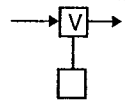
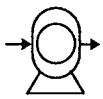
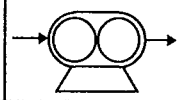
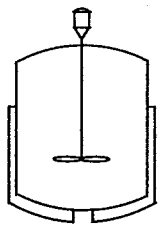
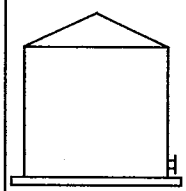
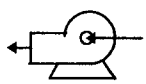
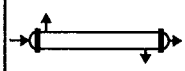
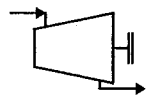
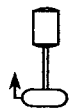
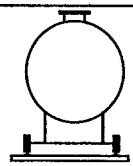
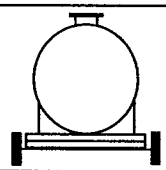
The way specific symbols are drawn may differ from site to site.

Table IV
Equipment Symbols

The table below gives examples of process equipment symbols. They will often be some of the largest symbols that you see on a P&ID. A more complete list of equipment symbols that may appear on Masters is in Appendix 4.

Note:
The reactor shown in Table IV is jacketed.

Table IV
Equipment Symbols (Process)

	CENTRIFUGAL PUMP		ROTARY GEAR PUMP
	RECIPROCATING PUMP		VACUUM PUMP
	CENTRIFUGAL COMPRESSOR		ROTARY COMPRESSOR
	REACTOR		STORAGE TANK
	CENTRIFUGAL FAN		BLOWER
	HEAT EXCHANGER OR COOLER		TURBINE
	AGITATOR		SUMP PUMP
	RAILROAD TANK CAR		TANK TRUCK

Using the diagram below and information given in the previous sections from tables on the sample Master, fill in the blanks.

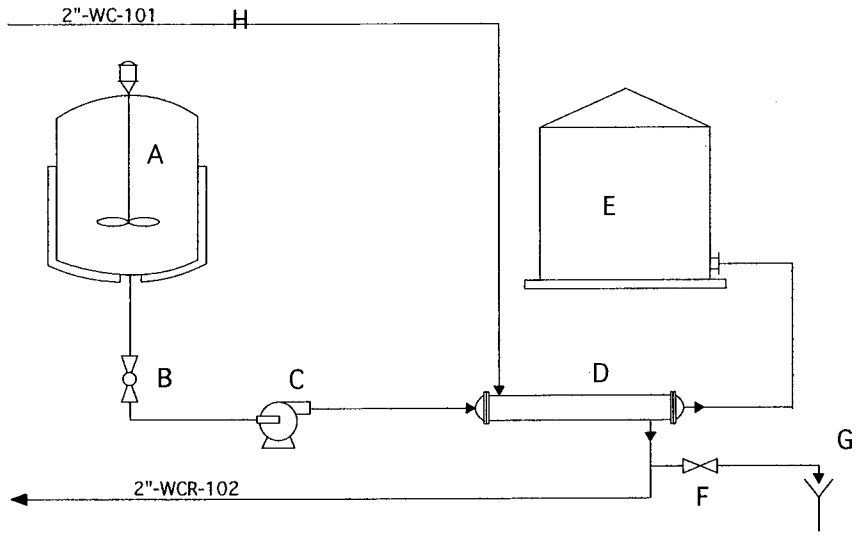


Figure 12

3.18
The equipment piece labeled A is a _____.

Review ✓

3.19
The component marked B is a _____.

3.20
The equipment piece labeled C is a _____.

3.21
The equipment piece labeled D is a _____.

3.22
The vessel labeled E is a _____.

3.23
The component labeled F is a _____.

3.24
The flow from the component labeled F goes to G which is an _____.

3.25
The line labeled I is _____ in size and contains _____.

3.26
The line labeled H is _____ in size and contains _____.

4. SYMBOLS

Unit Objectives

Upon completing this unit, you should be able to:

1. Identify the symbols for selected vessels, compressors, heat exchangers, valves, and pumps.
2. Interpret an example numbering system used for labeling equipment on P&IDs.

SYMBOLS

Vessels

You should now be able to tell what kind of equipment a symbol on a typical P&ID represents by using the Master Sheet. Notice that equipment symbols usually contain an identification number. **At some sites, the identification number will tell you information about the equipment's location** in plant buildings. We will use a numbering system that is used at one plant to develop skills for applying specific systems to interpreting P&IDs. Check to see if your plant has a specific numbering system. Some sites will not have a special numbering system.

We will use our tank example from a previous unit.

Example of a special numbering system

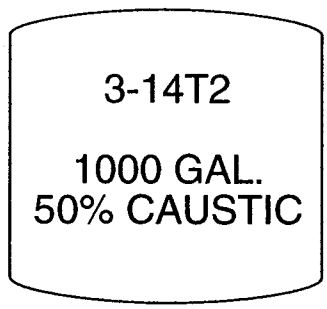


Figure 13

For this tank, the number 3-14T2 on this site means...

Some sites have a special numbering system for labeling equipment. Find out if your site equipment numbers are designed to give specific information about the piece of equipment.

3 - 1 4 T 2

Equipment is on **floor 3.**

Equipment is in **Bay 14** on floor 3.

Equipment is a **tank.**

Equipment is the **second tank** installed on floor 3.

Plant buildings at this site are divided into bay areas. **Bay numbers** will be the same for each floor of a building. The figure below shows a part of a typical floor divided into bays which are 18 feet wide in this plant.

This site has a special numbering system. The position of the numbers gives specific information about the location of the tank in a building.

This system is based on the floors of the buildings divided into bays.

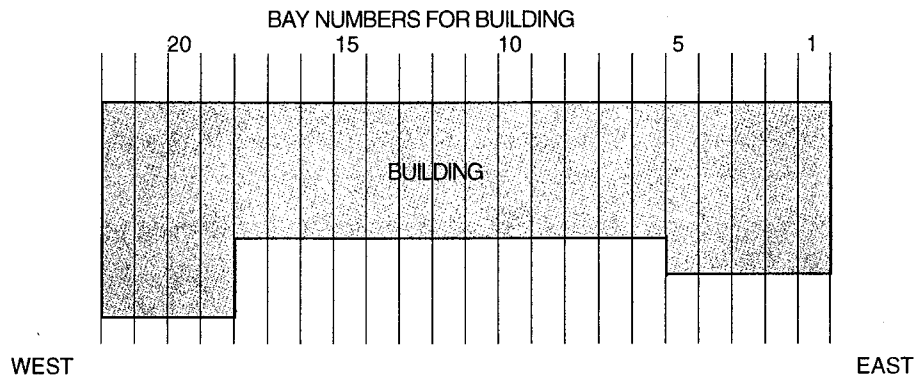


Figure 14

The P&ID may show an additional number that appears on the real tank on the site as well as an identification number. Frequently used **abbreviations** in equipment numbers are:

T or TA	Tank
R	Reactor
H or EX	Heat exchanger
CN	Condenser
P	Pump

Use the equipment number **1-16P2** and the example numbering system from the previous page to answer the following questions.

4.1 ✓
This piece of equipment (1-16P2) is a _____.
O Tank O Compressor O Valve O Pump

4.2
This equipment is located on floor _____.
O 6 O 11 O 2 O 1

4.3
There are at least how many pieces of this type of equipment on this floor?
O 5 O 14 O 2 O 11

4.4
True or False? All P&IDs use the same numbering system for labeling equipment.
O True O False

Size and Shape of Vessels

Vessels come in many sizes and shapes.

Vessels can be any size or shape. Vessels are used to hold or process liquids, gases or solids. Not all vessel symbols look similar to the actual equipment, but many do. Symbols for tanks or reactors, for example, have a shape that reminds you of the real equipment and will usually be the larger symbols on a P&ID. The main drawing shows the relative size of equipment, but the symbols are not drawn to scale. If equipment descriptions are given, they may have more specific information such as actual size or capacity.

Associated Equipment

An important piece of equipment that is often associated with vessels is an **agitator**. The **function of an agitator is to agitate or mix** the material in the vessel. The reactor symbol below includes an agitator. Agitators will have their own identification numbers and may be covered in the equipment descriptions as well. In some cases, the agitator motor may have a separate equipment number.

An agitator is a motor-driven piece of equipment that mixes material inside a vessel.

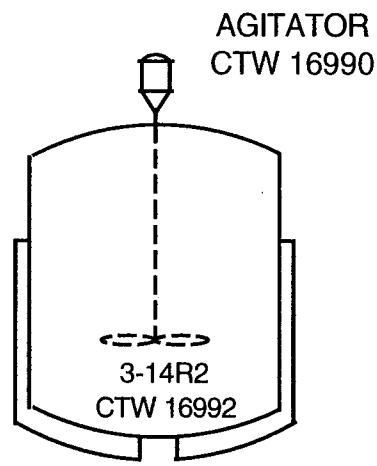


Figure 15

✓ 4.5

The function of an agitator is to...

- O Drain off process liquid
- O Mix process materials
- O Control the process
- O Store the process materials

4.6

Generally, the larger symbols on a P&ID will be...

- O Agitators
- O Vessels
- O Instruments
- O Bays

Nozzles on vessels

The symbol for a vessel will show important pieces of equipment and connections that are attached to the vessel. For example, nozzles on a vessel will be shown on the P&ID vessel symbol near their actual position on the real tank. Most nozzles are round because they connect to pipes. The diameter of each nozzle may be given near its symbol. The figure below shows the top of a reactor from a P&ID.

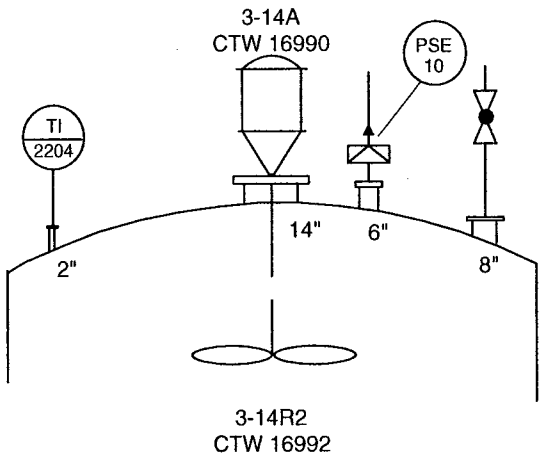


Figure 16

The diameter of a nozzle will be the same as the diameter of the line attached to it.

✓

4.7
How many nozzles are attached to the top of this reactor?

O 4 O 2 O 8 O 3

4.8
What is the diameter of the nozzle at the center of the top of the reactor?

O 2 inches O 6 inches O 14 inches O 8 inches

4.9
What piece of equipment is attached at the nozzle at the center of the reactor's top?

O Pump O Valve O Steam trap O Agitator

4.10
What is the identification number of the agitator?

O CTW O 3-14R2 O 2204 O 3-14A

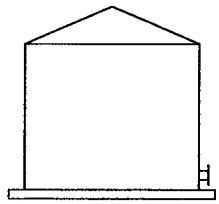
4.11
What is attached to the 6-inch nozzle?

O Rupture disc O Globe valve
O Thermometer O Agitator

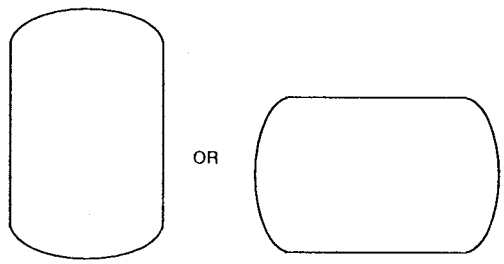
Storage Vessels

This is the symbol for a storage tank from the Master sheet that we are using for this course.

Storage tank



You will see variations of tank symbols on different P&IDs. Some P&IDs use symbols like the ones below for process tanks. The symbols below may be used in both vertical and horizontal positions depending upon the tank's position in the plant.



In addition to the information you can obtain about a vessel from the identification numbers and the equipment descriptions, the P&ID will show you:

- Equipment attached to the tank such as nozzles.
- Where material comes into and out of the tank.
- How material coming into and out of the tank is controlled.
- How the variables (temperature, pressure, level, etc.) for the tank are monitored and controlled.

✓ 4.12

True or False? All symbols on a P&ID must always be shown in the same position.

O True O False

4.13

Material may go into and come out of a storage vessel through a _____.

O Panel O Column O Agitator O Nozzle

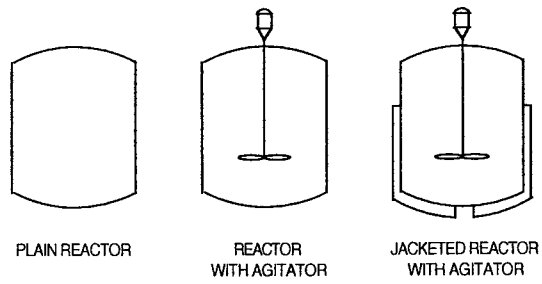
4.14

A storage vessel may contain (select **all** the correct answers)_____.

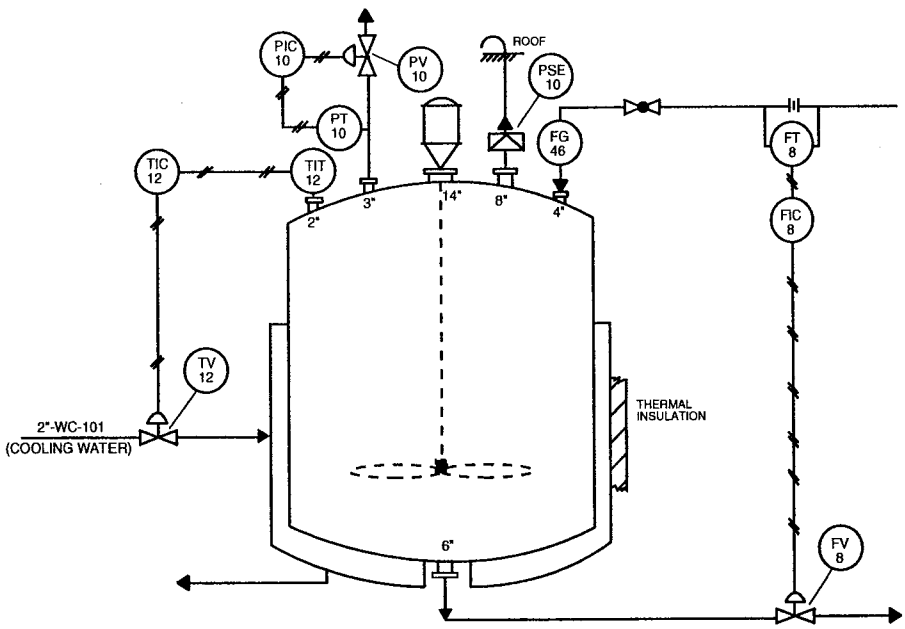
O Liquid O Electricity O Gas O Solid

The symbols below are for reactors.

Reactor Vessels



Reactors are vessels designed to contain processes that cause chemical change in one or more substances. The symbol for a simple reactor looks like a tank. Reactors are usually made of special materials that can withstand the pressure and temperature of the chemical reaction. Reactors on P&IDs will often have numerous pieces of additional equipment associated with them for monitoring and controlling the process reaction.



*This drawing shows a condensation reactor. In addition to an agitator and several nozzles, **instrument control loops** monitor pressure, flow, and temperature; an **insulated jacket** is around the vessel.*

Nozzles are often drawn on equipment pieces, and their size is given as shown in Figure 17. If no size is shown, the nozzle generally is the same size as the pipe attached to it.

Figure 17

✓

Fill in the blanks with a word from the list below. One word is not needed.

TV-12
Roof
Open drain
TIT-12

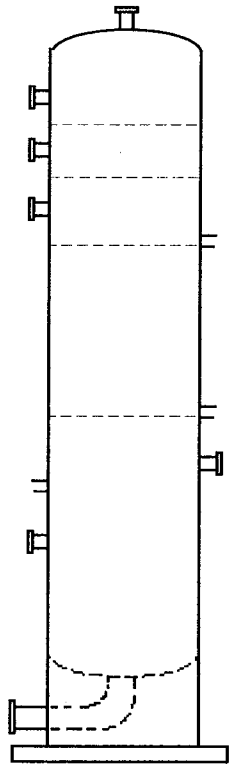
4.15
The temperature transmitter is labeled _____.

4.16
_____ controls the flow of cooling water into the jacket.

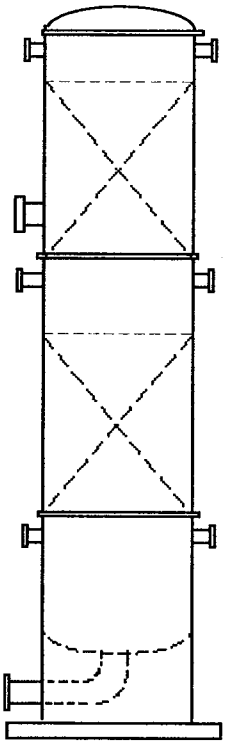
4.17
Too high pressure will vent off to the _____.

Distillation Columns

Distillation columns are another type of vessel commonly found in chemical plants. The symbols for different types of distillation columns show parts that represent trays and columns with packing. Two example symbols are shown below.



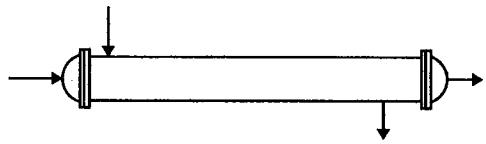
TRAY COLUMN



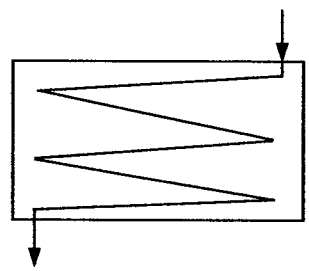
PACKED COLUMN

Heat Exchangers

Heat exchangers are frequently used in process systems. This equipment is used to heat or cool a material. Heat exchangers may be connected to vessels, for example. The symbols below are for two common types of heat exchangers.



HEAT EXCHANGER
OR
COOLER



BOX TYPE CONDENSER
OR
COOLER

4.18

Draw lines connecting the names of the equipment pieces with their symbols.

Process tank

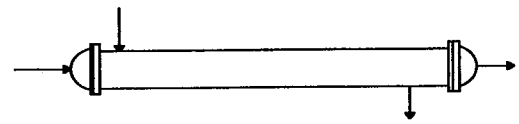
Heat exchanger

Reactor

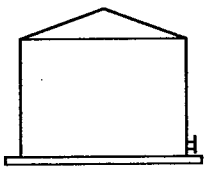
Distillation column

Storage tank

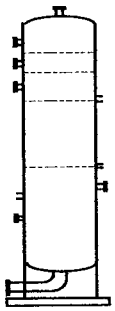
a.



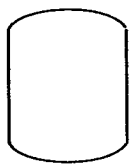
b.



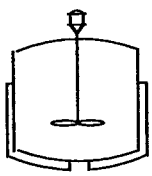
c.



d.



e.



4.19

All of the symbols above are examples of what kind of equipment?

○ Lines ○ Vessels ○ Instruments ○ Columns

4.20

The identification number of a vessel symbol may tell you where the actual vessel is_____ at some sites.

○ Located ○ Manufactured ○ Processed

4.21

A _____ is a type of vessel used to heat or cool material.

○ Storage tank ○ Reactor
○ Heat exchanger ○ Vertical tank

You have completed approximately half of the course. Record any notes or questions you may have.

For example:

Does your site have a special numbering system for equipment?

What are the symbols for the equipment in the area of the site where you work?

What materials flow through the pipelines in your area?

Where can you find the P&IDs for your work area?

Valves

Valves are the equipment in the plant that control the flow of material between other pieces of equipment such as tanks and heat exchangers. Valves are always attached to at least one pipe and usually to two, one at each side. There are many different types of valves. Valve symbols often, but not always, use small triangles.

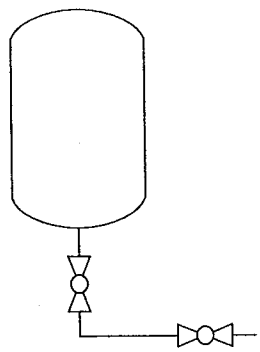
We will look at the following types of valves:

Ball	Globe
Check	Diaphragm
Plug or cock	Back pressure control
Solenoid	

Valve identification numbers

On a P&ID, **if a valve is part of an instrument control loop, the valve will be identified in a circle** the same way instruments are. Because the valve symbols are small, the circle is drawn outside of the symbol and attached to the symbol with a line. Valves that are not part of instrument loops are very common on P&IDs and are not usually numbered. Sometimes manually operated valves are identified by a circle containing a number and the letter "V" or "HV".

Valve symbols may be drawn in any position on a line.



Two ball valves in different positions are shown on the line at the bottom of a tank.

Figure 18

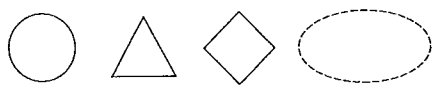
4.22 ✓

Valves _____ the flow of material in a system.

○ Monitor ○ Measure ○ Control ○ Cool

4.23

Valves that are part of control loops are usually identified by numbers shown inside a __



a. b. c. d.

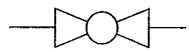
4.24

Is it important if a valve symbol is upside down on a drawing?

○ Yes ○ No

Ball valve

A ball valve is typically used in either the full open or full closed position and not used for partial flow.



BALL VALVE

Globe valve

A globe valve will regulate flow or ensure complete shut off of flow through a pipeline.

GLOBE VALVE

Check valve

A check valve is used to keep a liquid or gas from flowing in the wrong direction in a pipe.

BALL TYPE LIFT OR SWING TYPE PISTON TYPE

Diaphragm valve

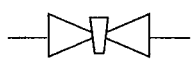
A diaphragm valve has a special seal of flexible material to control flow and prevent valve stem leaks.

DIAPHRAGM VALVE (GATE SERVICE) (SAUNDERS PAT.)

DIAPHRAGM VALVE (GLOBE SERVICE) (SAUNDERS PAT.)

Plug valve

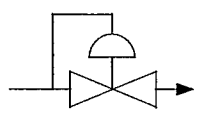
To control flow through a plug valve, the plug must be turned.



PLUG VALVE

Back pressure valve

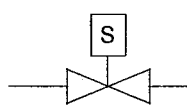
An automatic back pressure control valve maintains constant pressure upstream of the valve.



AUTOMATIC
BACK PRESSURE CONTROL VALVE

Solenoid valve

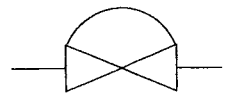
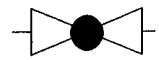
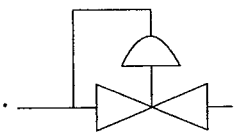
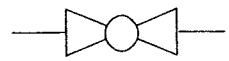
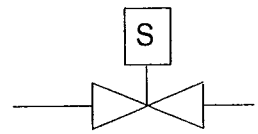
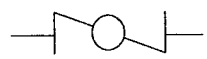
A solenoid valve will open and close when an electrical signal is sent to it.



SOLENOID ACTUATED VALVE

4.25 ✓

Match the symbol with the name of the valve.

Ball valve	a.	
Check valve	b.	
Plug valve	c.	
Solenoid valve	d.	
Globe valve	e.	
Diaphragm valve	f.	
Back pressure valve	g.	

4.26 ✓

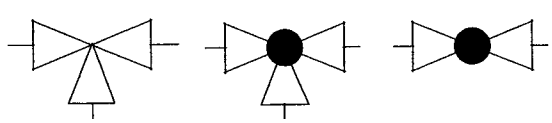
Valves regulate the flow of what kinds of materials? (Check all that are correct.)

O Electricity O Liquids O Gases

4.27

Which of the symbols below would you expect to be a **three-way globe valve?**

a. b. c.



4.28

A valve will be attached to at least one _____.

O Pipe O Electric line

O Exchanger O Transmitter

How are valves controlled?

Every valve must be controlled by some means. The control will be either manual or automatic. On a P&ID, **a manual valve** is usually drawn simply as the valve symbol for its type. For example, the symbols for a globe valve and a gate valve below indicate that these are manual valves, since no actuator is shown.

Manual valves

Also commonly used a the symbol for a generic two-way valve.

Globe valve

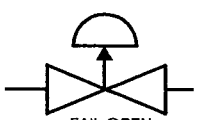
Gate valve

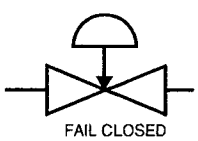
An actuator controls the operation of a valve.

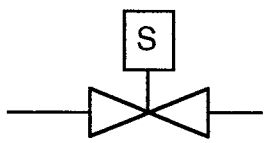
Most symbols for automatically controlled valves will usually show the actuator as a square. One exception is the pneumatically operated diaphragm valve; it has a half circle on top of the valve stem. **An actuator is the part that controls the valve.** The symbols below are for **automatic valves**. Notice that the square (represents the actuator) above the valve also tells you something about how the actuator operates. Valves with actuators often have the notation "FO" for fail open and "FC" for fail closed next to them to show their fail position. An arrowhead on the valve stem may also be used to show the fail position.

Actuator symbols for valves

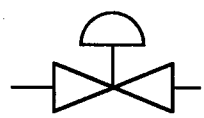
The valves below show the use of an arrowhead to show the fail position.



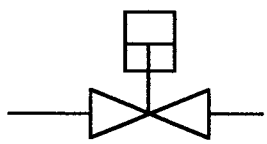




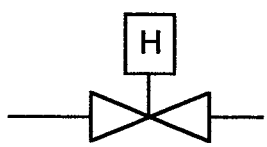
Solenoid actuated valve
The valve will open and close when an electric signal is sent to the actuator.



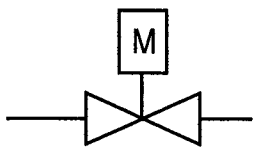
Pneumatic diaphragm valve
A diaphragm controlled by a pneumatic (air) signal actuates the valve.



Piston actuated valve
The valve is controlled by a pneumatic (air) signal.



Hydraulic piston actuated valve
The controlling signal is carried by hydraulic fluid instead of air.



Electric motor actuated valve
The valve is controlled by an electric motor.

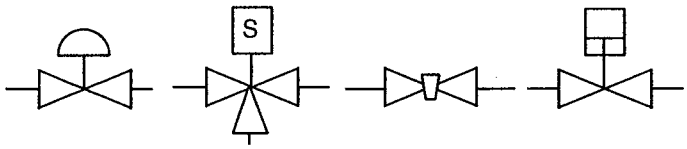
✓ **Review**

4.29
Every valve, no matter what type, must be _____ by some means.
○ Controlled ○ Gated ○ Sealed ○ Automated

4.30
If a valve is controlled by an actuator, it is what kind of valve?
○ Manual ○ Electric ○ Automatic ○ Vacuum

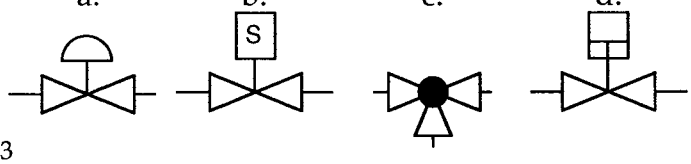
4.31
Circle the symbol below that represents a manual valve.

a. b. c. d.



4.32
Circle the symbol below that represents an automatic valve controlled by an electric signal.

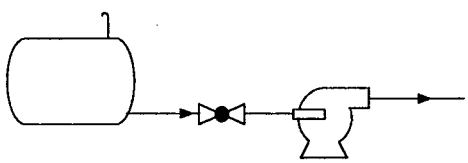
a. b. c. d.



4.33
The square on the symbol for an automatic valve represents the ...
○ Actuator ○ Means of servicing
○ Type of fluid ○ Equipment number

4.34
True or false? All triangles on a P&ID represent valves. (Hint: How did we represent changes that had been made between issues of a P&ID on the main drawing?)
○ True ○ False

4.35
In the figure below, material is flowing from _____ to _____.

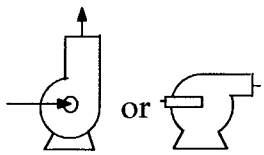


○ Left to right
○ Right to left

Pumps and Compressors

Pumps and compressors are types of equipment that use energy to move material from one place to another. **Pumps move liquids.** The **equipment used to move a gas is commonly called a compressor** or blower. Unlike the symbols for valves, the symbols for pumps and compressors may be very different.

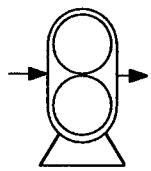
We will look at three different types of pumps.



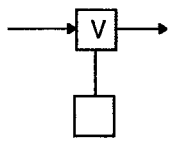
Centrifugal pump
Centrifugal pumps are very common because they have a relatively low cost and require low maintenance. The basic shape of this symbol suggests the impeller of an actual centrifugal pump.

Pumps

Pumps use energy to move liquids.



Rotary, gear, or positive displacement pump
The symbol for this pump suggests the two gears that are important parts in this pump.



Vacuum pump
This pump is used to create a vacuum (sub-atmospheric pressure) on its inlet side.

Tracing flow through pumps

Remember that arrows indicate the direction of flow in piping shown on P&IDs. By using the direction arrows you should be able to tell where material enters and exits a pump. The figure below shows material entering at the suction point and exiting at the discharge point of a centrifugal pump.

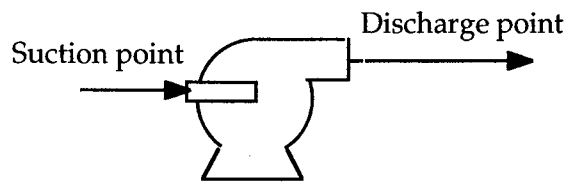
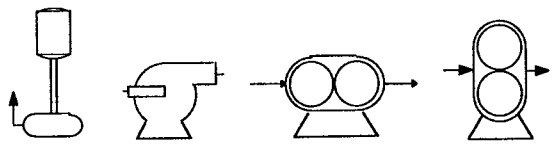


Figure 19

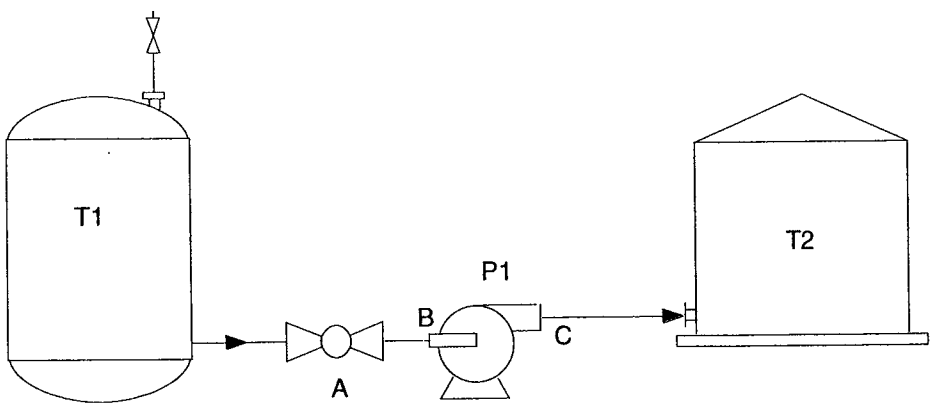
4.36
A liquid must to be moved through a line from one tank to another tank. What piece of equipment should be used? ✓
○ Compressor ○ Agitator ○ Exchanger ○ Pump

4.37
What piece of equipment is used to move a gas through a line?
○ Compressor ○ Agitator ○ Exchanger ○ Pump

4.38
Which symbol below represents a rotary gear pump?



Use the diagram below to answer the next questions.



4.39
A liquid is moving through pump ___. The liquid enters the pump at point _____ and leaves the pump at point _____. ✓

4.40
The equipment labeled "A" is a _____.
○ Centrifuge ○ Ball valve ○ Interlock valve ○ Gage

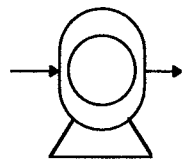
4.41
A liquid is being moved from tank _____ to tank _____.

4.42
How many nozzles are shown on the top of tank T1?
○ 4 ○ 2 ○ 1 ○ None

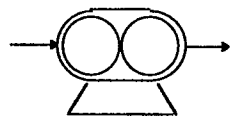
Compressors

The equipment used to move a gas is called a compressor or blower. The name comes from the way the equipment compresses the gas to a higher pressure. You will notice that some compressor symbols are similar to pump symbols. This is because they work in a similar way. We will look at three examples.

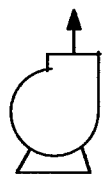
Compressors use energy to move gases.



Centrifugal compressor



Rotary compressor



Blower

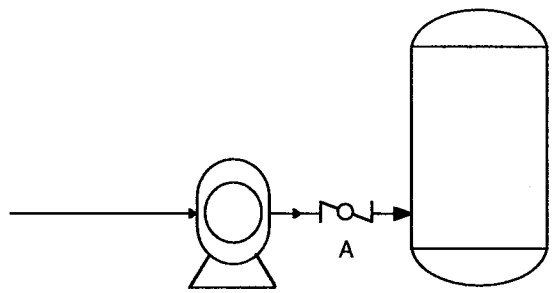
Tracing flow through compressors

You can trace the direction of flow for compressors the same way you do for pumps. In the drawing below, what is the direction of flow through the compressor?

4.43

✓ ○ Left to right

○ Right to left



4.44

What kind of compressor is represented?

○ Discharge ○ Centrifugal ○ Rotary ○ Blower

4.45

What kind of equipment is labeled "A"?

○ Motor ○ Gate valve ○ Check valve ○ Blower

Pump and compressor identification numbers

Pumps and compressors are important pieces of equipment that may require service or replacement. Pumps and compressors may be **identified by a number** similar to those used for other pieces of equipment such as tanks and reactors. In the figure below, a centrifugal pump is identified using the same example numbering system we used in a previous section.

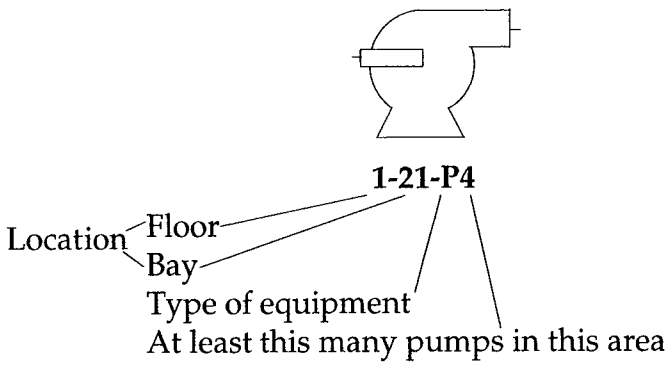


Figure 20

Important information about pumps and compressors may also be given in the equipment descriptions on a P&ID. Use the identification number to find the information you need for a specific piece of equipment.

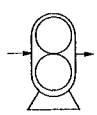
4.46
You need to find out the capacity of a pump shown on a P&ID. Where might you find this information?

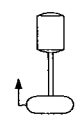
✓

O Title block O Line schedule
O Zone numbers O Equipment descriptions

4.47
For the pump in the figure above, what number do you look for in the equipment descriptions to find out specific information about the pump?

O 21-C4 O 1-21-P4 O 2-12-C4 O P4


2-8-P1


3-12-P1

4.48
What kind of equipment does the symbol 2-8-P1 represent?

O Diaphragm valve O Back pressure valve
O Diaphragm pump O Positive displacement pump

4.49
What kind of equipment does symbol 3-12-P1 represent?

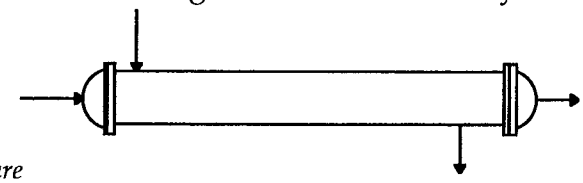
O Sump pump O Vacuum pump O Reciprocating pump

Heat Exchangers

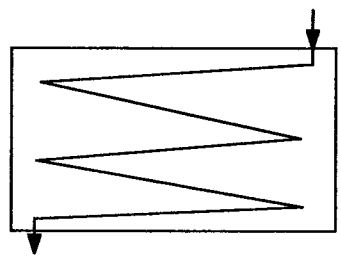
A heat exchanger is a piece of equipment used to heat or cool a material. There are many different types. Heat exchangers that are designed to cool materials are sometimes called coolers or condensers. Heat exchangers that heat materials may be called vaporizers or heaters. We will look at two symbols for heat exchangers that are commonly found on P&IDs.

Condensers or coolers are used to cool material.

Heaters or vaporizers are used to heat material.



Condenser/ heat exchanger
Tube bundle



Condenser/heat exchanger
Cubical

Tracing material flow through a heat exchanger

The P&ID will show you where the material to be heated or cooled flows into and out of a heat exchanger and where the heat transfer medium flows into and out of the heat exchanger. If the function of the equipment is to cool the material, expect the material coming out to be cooler than when it went in. If the function of the equipment is to heat the material, expect the material to be warmer coming out than when it went in.

You may find additional information about specific heat exchangers on a P&ID in the equipment descriptions.

✓ 4.50
What is one kind of instrumentation that you would expect to find closely associated with all heat exchangers?

- O Steam generators
- O Density indicators
- O Level recorders
- O Temperature indicators

4.51
The function of a heat exchanger is to _____ .

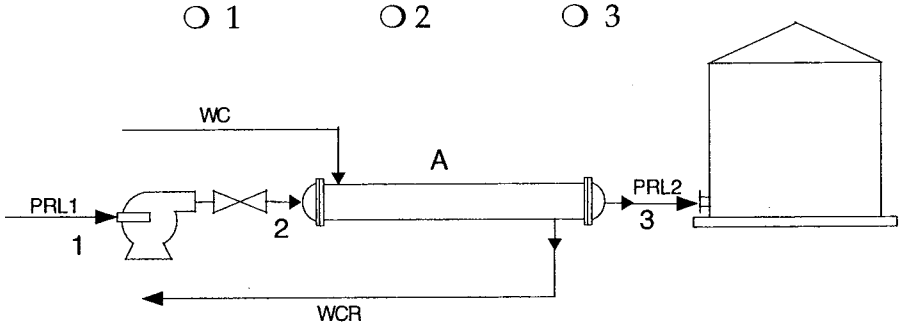
- O Monitor pressure exchange
- O Heat or cool material
- O Raise or lower pressure of material
- O Record or regulate temperature

We will look more closely at monitoring and controlling variables associated with equipment such as heat exchangers when we cover instrument control loops later in this course.

4.52 ✓ Review

In the figure below, symbol A is a condenser. The process liquid, PRL, should be cooler at which point on the line?

O 1 O 2 O 3



(Equipment Description)
Condenser A
Area: 551 sq. ft.
Mat'l: Tube - C-20
Shell - 316ss
Bonnets - cs
Design: Tubes - 60 psig @250 degrees F
Shell - FV & 15 psig @ 250 degrees F

This is the kind of information you might see about a condenser when equipment descriptions are used.

4.53 ✓

At which point does the process liquid enter the condenser?

O 1 O 2 O 3

4.54

At which point does the process material leave the condenser?

O 1 O 2 O 3

4.55

Looking at the equipment description for condenser A, what process variable in addition to temperature is often associated with heat exchangers?

O Tubes O Density O Viscosity O Pressure

4.56

The tubes in condenser A are designed to function at pressure no higher than what when the temperature is 250 degrees F?

O 250 psig O 15 psig O 60 psig O 551 psig

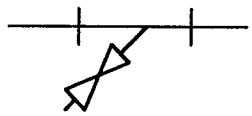
4.57

What is the material of construction for the shell of condenser A?

O Stainless steel O Carbon steel O Aluminum

Other Symbols

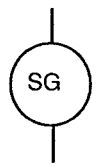
In this course, we cannot cover all the types of symbols that you may come across in reading P&IDs. We have looked at examples of the larger kinds of equipment. **Fittings** are smaller pieces of equipment in a piping system that you will see often. Examples of fittings commonly found on piping are strainers, sight glasses, and pipe size reducers.



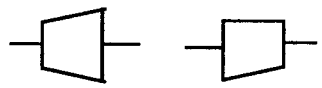
Strainer
Y type with valve

Fittings

Fittings are smaller pieces of equipment that you will see often on P&IDs.



Sight glass

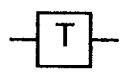


Reducer

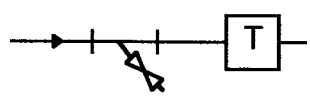
Concentric Eccentric

Steam traps

Steam traps are often associated with heat exchangers or heating coils. A steam trap allows condensate to be released while keeping the steam pressure up. A strainer may be installed in the line in front of the trap to keep dirt, rust, or scale from clogging the trap.



Steam trap



Steam trap with strainer

4.58

A type of fitting used to keep steam pressure up while releasing condensate is a...

- ○ Thermometer
- ○ Solenoid
- ○ Steam trap
- ○ Drain

5. Instruments

Unit Objectives

Upon completing this unit, you should be able to:

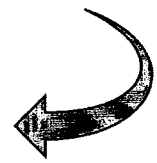
1. Explain why instruments and control loops are important for the safe operation of a plant.
2. Identify the symbols for selected instruments.
3. Describe how instruments in control loops are related and named on a P&ID.

Why are instruments and control loops important?

In order to maintain plant operations within safe limits, control loops monitor the process variables in a system. Remember that a variable is a physical characteristic of a process that can change. The P&ID for an area will show the lines, instruments, and equipment that monitor and control each process.

Maintaining safe operation is extremely important. Control loops are needed to:

- Keep process variables within safe operating limits.
- Detect potentially dangerous situations as they develop.
- Provide a way of initiating alarms and shutting down a process if required.



Control loops also help ensure that a product meets specified quality standards and cost objectives.

5.1

Instruments monitor the _____ of a process. ✓

○ Loops ○ Development ○ Variables ○ Design

5.2

Choose all the reasons why instrument control loops are important to plant operations.

- ○ Initiate alarms if a dangerous condition develops
- ○ Needed to stay within cost limits
- ○ Allow for improved plant housekeeping
- ○ Keep process variables within safe limits
- ○ Help meet quality specifications

Instrument Identification

ISA Standard S5.1 gives guidance on instrument identification which many companies follow when drawing P&IDs.

On a P&ID, instrument identification is usually given in a circle. Identification of controlling elements (valves) in a control loop will also be given in a circle. **All instruments and control elements in a specific control loop will generally have the same number.** Note that identification methods may differ from site to site. For example, the symbols for computer controlled devices may not be the same at every site. Ask your supervisor if you have questions about a specific P&ID and check the Master Sheet. The figure below shows a pressure control loop.

The pressure control loop on the right has an identification "12-230" labeling each part of the loop.

IF PV-12-230 is closed, material going into the tank will be diverted away from the tank after leaving the pump. Pressure in the tank would then decrease.

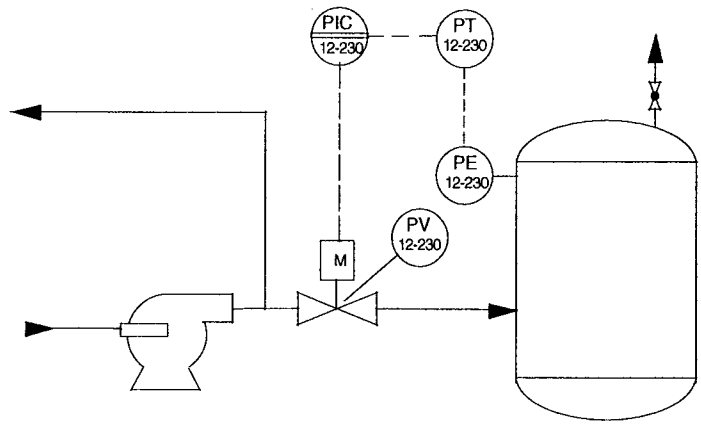
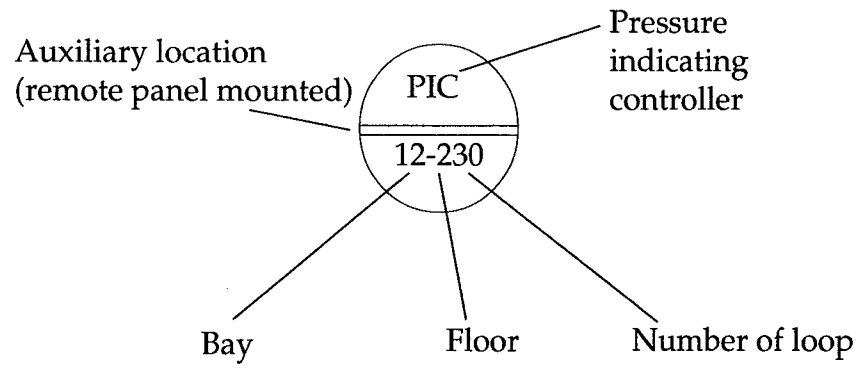


Figure 21

What does the instrument symbol tell us?

The identification circle gives us a great deal of information. As with equipment numbers, the identification number may indicate where the control loop begins, for example, if a special numbering system is used.

This example shows the same numbering system we used for equipment. Sites often have their own unique numbering systems. Check to see if numbers at your site carry special information.



We looked at the meaning of the type of circle and how the letter label for the instrument is put together in our unit on using the Master sheet. (See page 26-27.) In the example above, the **double line through the circle** means that this instrument is mounted away from the equipment it is monitoring or in a "remote" location, perhaps in a control room. **The first letter tells us the variable being measured. "PIC"** tells us that the instrument is a pressure indicating controller, monitoring, indicating and controlling the **pressure** of a material in the tank in Figure 21.

If you need help with the questions in this unit, use the following appendices at the back of this workbook for your Master:

Appendix 2: Instrument Designations
Appendix 3: Graphic Symbols for Flow Diagrams

5.3
All instruments and controlling elements in a control loop will have the same _____ on a P&ID. ✓

○ Number ○ Design ○ Actuators ○ Function

5.4
Draw a line from the instrument designations below to the **variables** they monitor or control.

PI	a. Temperature
LAH	b. Level
TIC	c. Weight
FCV	d. Pressure
WSL	e. Flow

Identifying Instrument Function

The letters after the first letter in the identification for an instrument tell us its **function.** The action or work performed by a device is its function. In the example on the opposite page, PIC, "IC" means that it is an indicating controller. Likewise, if the label is PRC, the instrument is a recording controller for the pressure inside the tank.

There are many possible combinations of instruments on P&IDs. Designations for controllers, transmitters, switches, and alarms are common, but there are many others. The letter designations are often relatively easy to figure out, but some may not be obvious.

Check the Master sheet if you are not sure what an instrument designation means.

5.5
Draw a line from the instrument designations to the correct instrument names. ✓

PI	a. Level alarm high
LAH	b. Temperature indicating controller
TIC	c. Flow control valve (self-operated)
FCV	d. Pressure indicating device
WSL	e. Weight switch low
AS	f. Manual control valve
HV	g. Analysis switch

Use the Appendix 2 if you need help.

6. Line Designations

Unit Objectives

Upon completing this unit, you should be able to:

1. Identify piping on a P&ID.
2. Give specific information about a pipeline including material in the line, size of the pipe, line number, and whether or not the line is insulated or traced.
3. Identify pneumatic, electric, and hydraulic instrumentation signal lines.

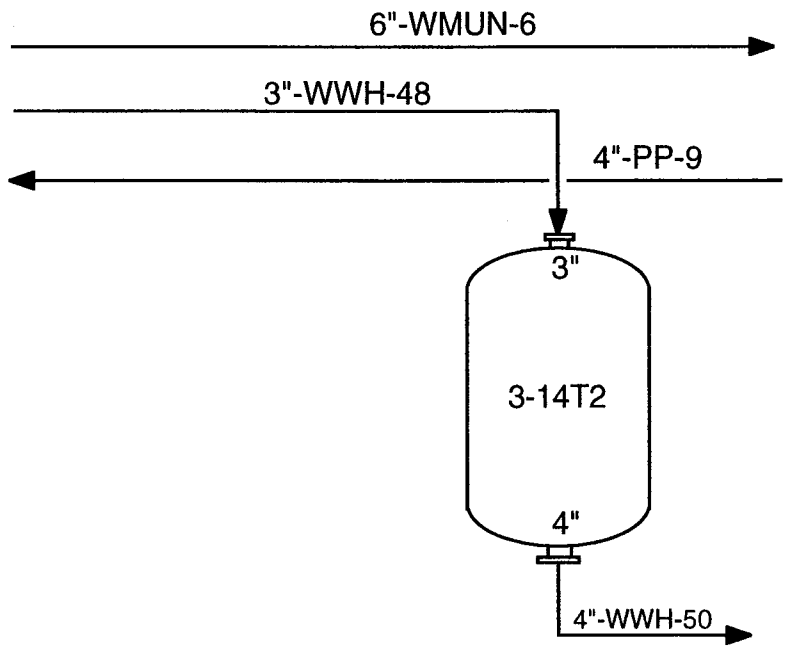
Piping

We have looked at the symbols and designations for equipment and instruments. On a P&ID, symbols will be connected with numerous drawn lines that represent piping and instrument lines. In the overview of what information is given in the main diagram, we covered:

- Lines that were physically connected and physically not connected.
- Arrows that show flow direction.

Review what we have learned in previous units about pipelines. See pages 11-15.

We saw that specific information about each pipe may be given in the Line Schedule. Some information will also be included in the main diagram to identify each pipeline. Pipelines are drawn as a solid line on a P&ID. The figure below shows several pipelines, including one that feeds into the top of a tank.



Notice that the nozzles have the same diameter as the pipes going into them. 6"-WMUN-6 and 4"-PP-9 are not connected to any other lines or equipment in the drawing.

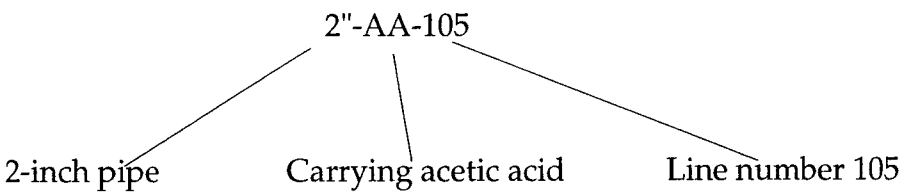
Figure 22

The line designation on a P&ID will include:

- Size of the pipe;
- Letters that stand for the material in the pipe;
- An identifying number, usually associated with the pipe's point of origin, where it begins.

In this example:

Example line label



Use the Figure 22 on the opposite page to answer the following questions. Remember that you can find the abbreviations for materials on the Master. (See Appendix 1.)

6.1
What is the size of the pipe carrying WMUN?

✓

O 6 inches O 3-1/4 inches
O 4 inches O 1/2 inch

6.2
What is the size of the nozzle connecting the pipe WWH-48 to the tank?

O 3 inches O 3-1/2 inches
O 6 inches O 1/2 inch

6.3
What material is flowing through the 3-inch pipe?

O Nitric acid O Warm water
O Wash water O Solvent

6.4
What is the line number of the pipe carrying material that is leaving the tank?

O 48 O 50 O 148 O 4

6.5
As far as you can tell from this section of P&ID, are line numbers 6 and 9 connected in the plant?

O Yes O No

Tracing and insulation

Pipes are sometimes covered and/or traced. The Line Schedule information block will tell you if this is the case. Also, a code may appear with the line designation for a pipe on the P&ID. A "C" indicates that the pipe is covered. Another possible note is "C-OP" which means covered for operator protection.

"ET&C" means that the pipe is electrically traced and covered. A traced line is generally insulated as well. A real-life example would be a pipe carrying material that must be maintained at a certain temperature. The material may be heated with an electrical coil, a steam jacket, or an oil jacket.

6.6

✓ A traced line will generally be _____.

○ 2 inches in diameter ○ Designated ○ Insulated

Instrument Lines

We will look at four ways that instrument lines may be represented on a P&ID.

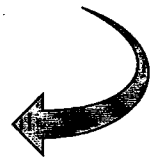
Pneumatic or air signals

Electrical signal leads

Capillary tubing

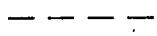
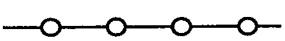
Software or data link

In general, only one signal line will be shown on a P&ID to represent how instruments are connected even though there may be more than one physically connecting line in the real plant. Remember that there are many variations in how P&IDs are drawn.



We saw earlier in this course, equipment symbols on a P&ID show us how the real equipment is located relative to other pieces of equipment. This is less true with instrumentation. **The connecting lines for control loops show us what the functional logic or path of information flow is,** but may tell us nothing about distances. Keep in mind that the type of circle does give us some information about location. For example, the circle with a dotted line through it means "mounted behind a panel."

6.7
Match the type of line with the correct name.

Electrical	a.	
Pneumatic	b.	
Software or data link	c.	
Capillary	d.	

7. Tracing Process Flow

Unit Objectives

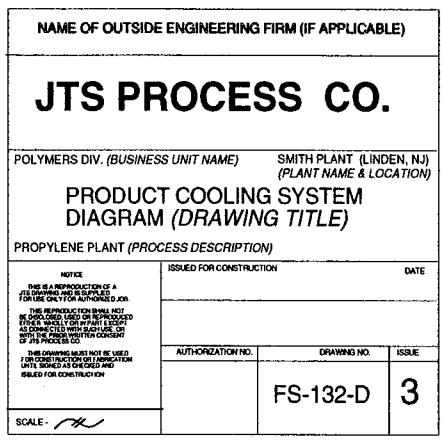
Upon completing this unit, you should be able to trace the flow of a process stream:

1. Into a P&ID by identifying the number of the P&ID showing the stream before it entered the area covered by the current P&ID;
2. Through pipes and equipment such as tanks and heat exchangers in the current plant area;
3. Out of the P&ID by identifying the number of the P&ID where the process stream continues if relevant.

Identifying where a process stream begins

Until now, our study examples have been presented using only one P&ID at a time. Chemical processes will generally require more than one P&ID, perhaps several, to diagram an entire process. You will need to know how to find the correct P&IDs for the work at hand. Remember that each P&ID carries an identifying number as well as an area name and issue number in the Title Block in the lower right hand corner.

Check the Title Block to be sure you have the P&ID that you need. Look at the site name, issue number, and process area covered.


NAME OF OUTSIDE ENGINEERING FIRM (IF APPLICABLE)

JTS PROCESS CO.

POLYMERS DIV. *(BUSINESS UNIT NAME)* SMITH PLANT (LINDEN, NJ) *(PLANT NAME & LOCATION)*

PRODUCT COOLING SYSTEM DIAGRAM *(DRAWING TITLE)*

PROPYLENE PLANT *(PROCESS DESCRIPTION)*

NOTICE

ISSUED FOR CONSTRUCTION DATE

AUTHORIZATION NO. | DRAWING NO. | ISSUE

FS-132-D | 3

SCALE -

Figure 23

✓ 7.1

In the example above, the drawing number is...

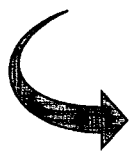
○ FS-132 ○ 132 ○ FS-132-D ○ FS-312

7.2

The process system covered in this P&ID is the...

○ Product Cooling System ○ Product Reactor Flow

○ Product Storage System ○ Product Condensers



Where a process stream begins may be shown on the P&ID you are reading, but it is more likely that it begins in another area of the plant. If you must trace a material back to where it begins, you may need to refer to at least one other (perhaps several) P&IDs. How do you know which diagrams to check?

Find the beginning of a process line.

In the diagram below, **begin tracing the process stream back from where it enters the tank against the flow direction of the arrows** to the edge of the P&ID page. Begin at the marker arrow labeled 1. (Remember, these marker arrows and numbers are for our study and would not appear on a real P&ID.) Each process line will have a tag or label at the point where it enters the P&ID. See arrow #2. The identifying tag or number may be in a sausage shaped or rectangular box with an arrow point or be simply written on the line. (How P&IDs are drawn varies!) This identifying tag carries the number of the P&ID from which the current process stream came. The tag may also include the number of a piece of equipment where the material stream began.

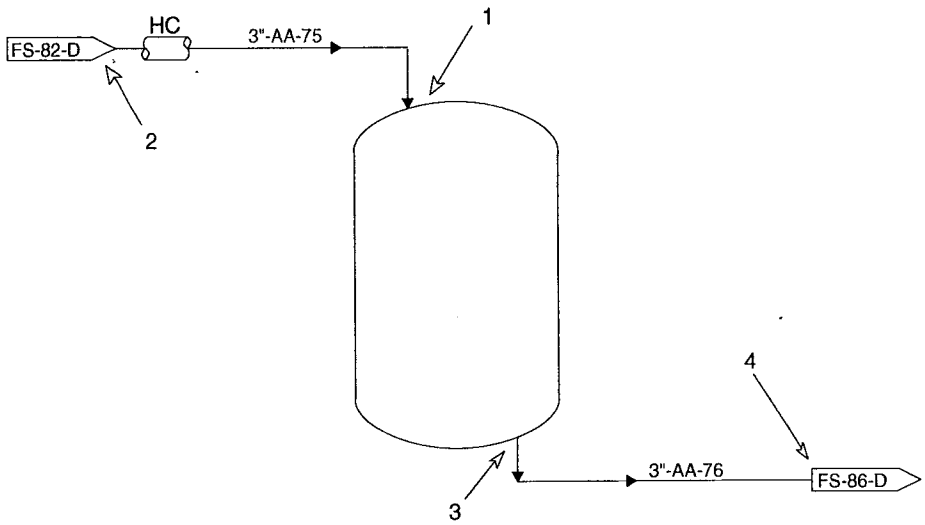
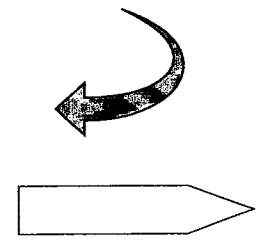


Figure 24



The pointed end of this tag indicates flow direction. In this case from left to right.

Pipeline 3"-AA-75 comes to the current P&ID from P&ID number FS-82-D. Process flow continues on P&ID number FS-86-D.

Follow a process line to another P&ID.

Beginning at arrow #3, **trace the process material's path in the direction of the flow arrows.** If the material stream does not end at a piece of equipment on the current P&ID, it will continue to an edge of the drawing. The line ends with a tag giving the number of the P&ID where you can continue to trace the material stream. See arrow #4. You may also see the number of the piece of equipment to which the material is going on some P&IDs.

Notice that the entering line is insulated, and the identifying label for the line is shown near the entry point.

The example above shows only two pipelines. **On a real P&ID, you will usually see many different process and instrumentation lines.** The process lines may enter and leave the P&ID at any point around the outside edge of the diagram.

Tracing a Process Stream

Use the diagram below to trace the process stream, VA-3 (VA stands for a vapor; see Appendix 1 for other examples). Notice where:

- VA-3 enters this P&ID from P&ID FS-9-D.
- It flows through condenser 3-14CN2.
- It exits the condenser as two new material streams, VA-6 and TOLC-3.
- One new material stream, VA-6, leaves the current P&ID and continues on FS-11-D.
- The other new stream, TOLC-3 (contaminated toluene), goes into receiving tank 3-15T2.
- A new stream, TOLC-4, leaves the tank and continues on FS-11-D.

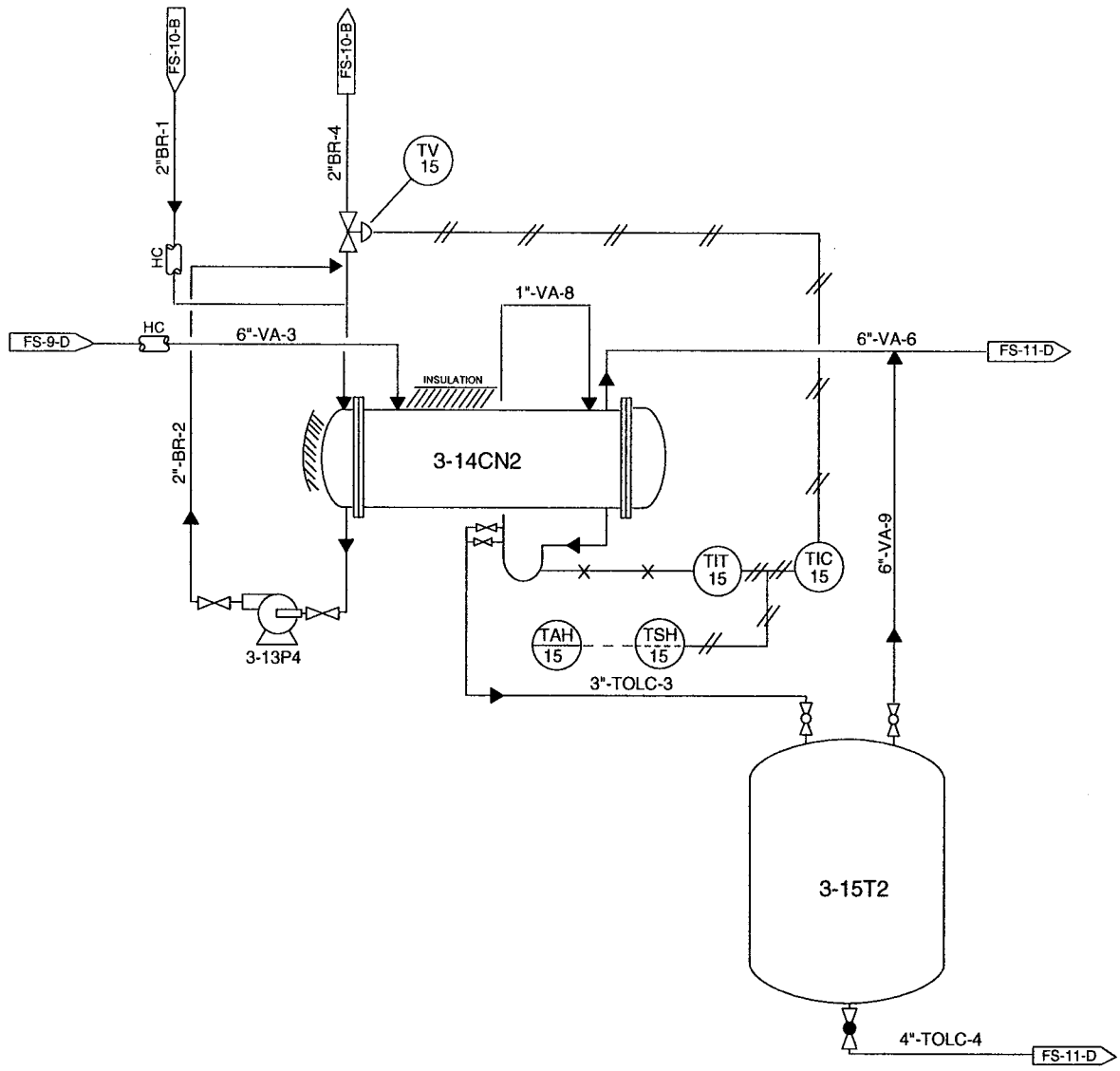


Figure 25

✓ Review

Use the diagram on the opposite page to answer these questions.

7.3
Where would you look to find out what happens to the stream, TOLC-4, after leaving the area shown on the current P&ID?

- ○ P&ID number FS-11-D
- ○ The procedures manual
- ○ P&ID number FS-19-D
- ○ Title Block

7.4
Information about the pipeline, TOLC-3, might also be found on a real P&ID in the...

- ○ Title Block
- ○ Line schedule
- ○ Issue number
- ○ Equipment descriptions

7.5
The material stream, VA-3, comes from...

- ○ A reactor
- ○ P&ID number FS-11-D
- ○ P&ID number FS-9-D
- ○ The line schedule

7.6
Where would you look to find out what happens to the stream, VA-6?

- ○ Procedures manual
- ○ P&ID number FS-9-D
- ○ 14CN2
- ○ P&ID number FS-11-D

7.7
The equipment labeled 3-14CN2 is...

- ○ Restricted
- ○ Insulated
- ○ Empty
- ○ Centrifugal compressor

7.8
The line connecting TV -15 and TIC -15 is a...

- ○ Electric line
- ○ Pneumatic line
- ○ Pipeline
- ○ Backup line

7.9
True or false? The lines VA-6 and VA-9 are connected in the actual plant.

- ○ True
- ○ False

8. Controlling Process Operations

Unit Objectives

Upon completing this unit, you should be able to:

1. Identify instruments that belong to the same control loop on a P&ID.
2. Describe how a process variable is measured and controlled by reading a P&ID for the process.

Why are control loops important?

Instrument control loops are needed for the safe and efficient operation of a process.

Instruments perform these functions:

- **Monitor process variables**
- **Inform the operator what is happening in a process**
- **Allow control of a process**

In Unit 5, we saw that instrument identification on a P&ID will generally be given in a circle. Tables on the Master sheet give the meaning of the abbreviations commonly used for the different types of instruments. **Instruments in the same control loop will all have the same identification number.** Different types of lines across the circle give us information about the location of each device. An instrument in a control loop may actually be located a considerable distance away from where a variable is measured even though it is shown on the same P&ID.

The instrument control loop below is from the P&ID example in the previous unit.

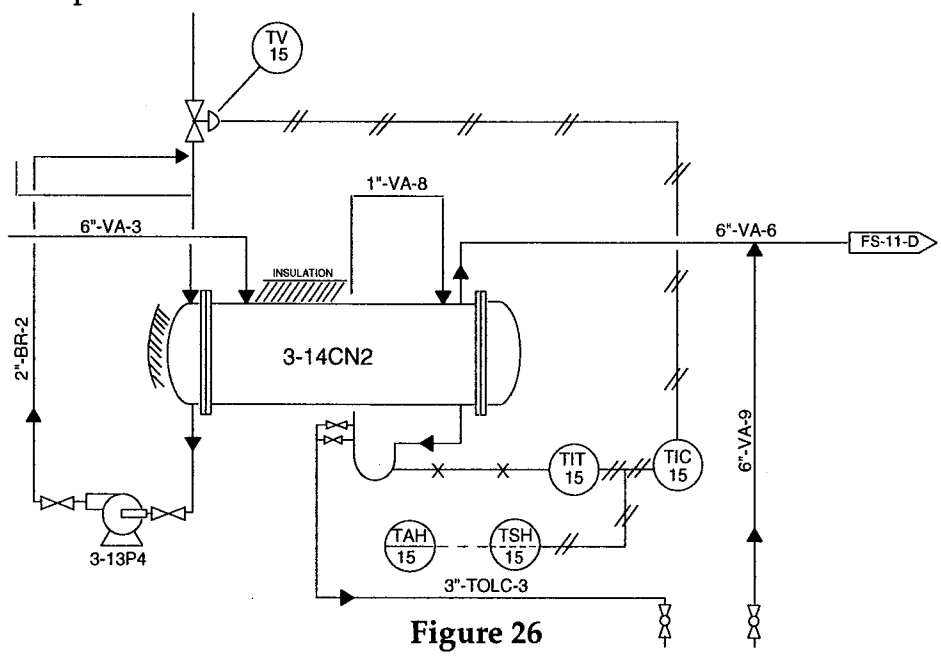


Figure 26

You may want to use the table in Appendix 2 as a reference to answer the following questions. In the control loop shown in Figure 26, on page 64, ...

✓ *Use the diagram on the opposite page to answer these questions.*

8.1
The variable being monitored is...
○ Pressure ○ Flow ○ Temperature ○ Electricity

8.2
The instrument TIT is a...
○ Temperature indicating transmitter
○ Temperature indicator
○ Temperature indicating timer
○ Temperature test

8.3
The instruments TAH and TSH are connected by what kind of line?
○ Capillary tube ○ Computer signal
○ Pneumatic signal ○ Electric signal

8.4
The instrument TSH is mounted... (Hint: see page 27)
○ Behind a panel ○ Locally
○ On a computer ○ On a panel

8.5
The instrument TAH is mounted...
○ Behind a panel ○ On a control panel
○ On a computer ○ Over 3"-TOLC-3

8.6
What connects the instrument TIT to the line containing toluene?
○ Computer signal ○ Capillary tubing
○ Copper tube ○ Electric signal

Functions of Instruments in a Control Loop

We will look at the functional parts of a typical control loop:

- Sensor
- Transmitter
- Controller
- Switch
- Alarm

The function of an instrument is the work it does. Some control loops may not have all of the parts listed above.

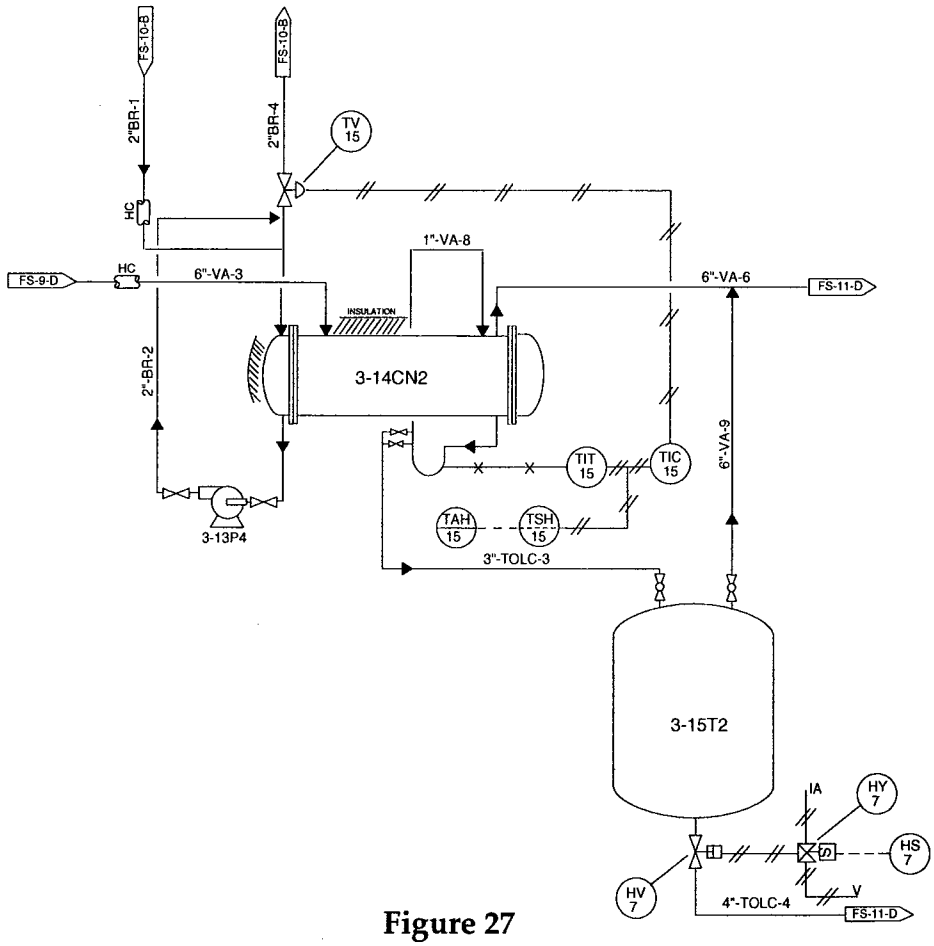


Figure 27

Sensor

Transmitter

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.

Controller

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.

Switch

Alarm

For the process covered in our 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,** is 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 or bell. The line through the TAH circle shows that the alarm is located on a panel.

A P&ID will not generally give information about specific instrumentation. If you need more detailed information to perform a job, check sources such as specification or data sheets or ask your supervisor. Also, P&IDs will usually use only one signal line to connect two instruments even though they may actually be connected by more than one line.

Remember that the degree of detail given on different P&IDs can vary. Control loops generally show only the functional logic of how information about a variable flows from one instrument to the next.

8.7
The flow rate of stream TOLC-4 can be controlled by the:
O TV 15 O ball valve O Tank T-2 O Piston-operated valve

✓

Use the diagram on the opposite page when needed to answer these questions.

8.8
In control loop 7, the switch HS is actuated .....
O By computer O By hand O By air O By Solenoids

8.9
Control loops on P&IDs show ...
O The real distance a signal must travel between instruments
O How to take temperature readings
O The functional logic of how the control loop works
O How to replace an electrical instrument

8.10
In control loop 15, the transmitter, TIT, sends a signal to...(choose all the correct answers)
O The condenser, 3-14CN2
O The alarm, TAH
O The switch, TSH
O The controller, TIC

8.11
The valve, TV, changes the temperature of the toluene stream, TOLC-3, by controlling the...
O Brine leaving the condenser
O Toluene leaving the condenser
O The amount of insulation on the condenser
O Vapor leaving the condenser

8.12
Opening the valve, TV, allows more brine that has been heated during the condensation process to leave the system. More of what material stream is then pulled into the condenser...?
O Brine, BR-2
O Vapor, VA-3
O Toluene, TOLC-4
O Cooling brine, BR-1

Interlocks

The symbol for an interlock is a diamond.

Interlocks are very important to the safe operation of a process system. **The function of an interlock is to isolate or shut down the system if a dangerous situation develops.** One or more interlocks may be connected to a control loop. P&IDs may show switches that activate interlocks controlling flow, temperature, or pressure. Switches connected to interlocks sometimes may be manually operated. Such things as auxiliary electrical relays and other components of electric interlock systems, however, may not be shown on a typical P&ID.

Example of a control loop with an interlock

In an electrical control loop the electrical current signal to a pneumatic valve actuator is usually converted to a pneumatic signal at the valve. The I/P (current/pneumatic) converter is usually not shown on the P&ID.

Level element senses level inside tank.

Level indicating transmitter sends signal to switch and level controller.

Level controller sends signal to LV-15A 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-15B to close to prevent overflow of tank.

Level control valve LV-15B is activated by interlock to shut off flow.

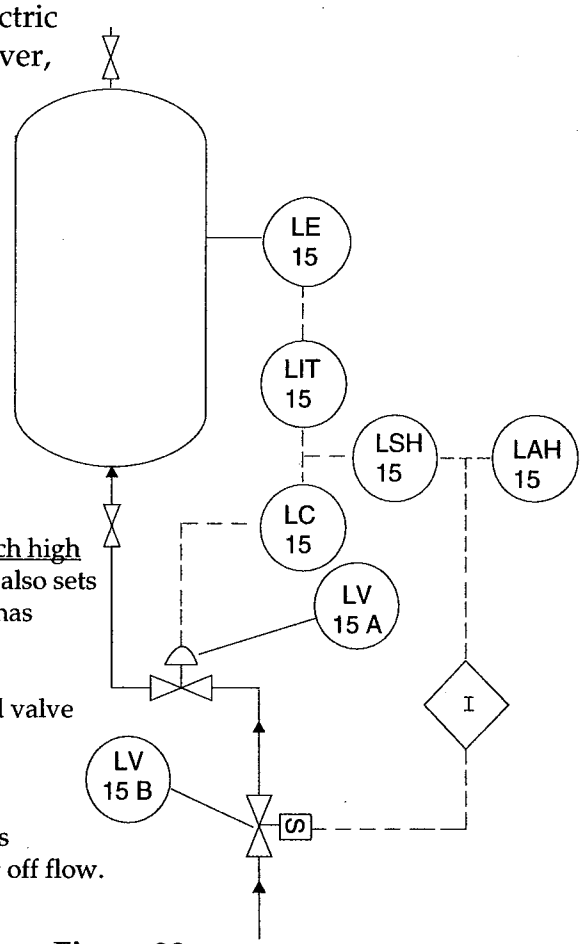


Figure 28

✓

Use the diagram above to answer these questions.

8.13

What is the identifying number for this control loop?

○ 5 ○ 15 ○ 25 ○ Unknown

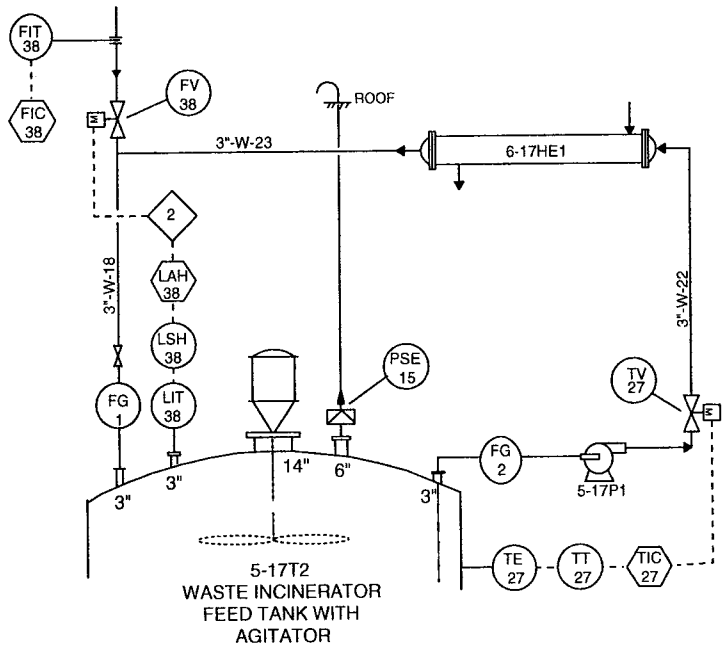
8.14

Which part of the control loop has the function of shutting off flow to the tank when the high level is reached?

○ Solenoid valve ○ Level element
○ Flow controller ○ Level high alarm

✓ **Review**

The diagram below shows the top of a tank and some of the instrumentation attached to it. You may use the tables in the appendices to answer the following questions.



8.15
What is the function of the instrument PSE-15?

- ○ To control pressure in the line
- ○ To allow venting of excessive pressure in the tank
- ○ To activate an alarm
- ○ To record pressure readings

8.16
Which "instrument" is actually a computer program that duplicates the action of a controller?

○ TE-27 ○ TIC-27 ○ TT-27 ○ TV-27

8.17
Why does the level control valve in the control loop 38 have a label that begins with "F"?

- ○ The valve is foreign.
- ○ It measures when the tank is full.
- ○ It controls flow of the waste stream into the tank.

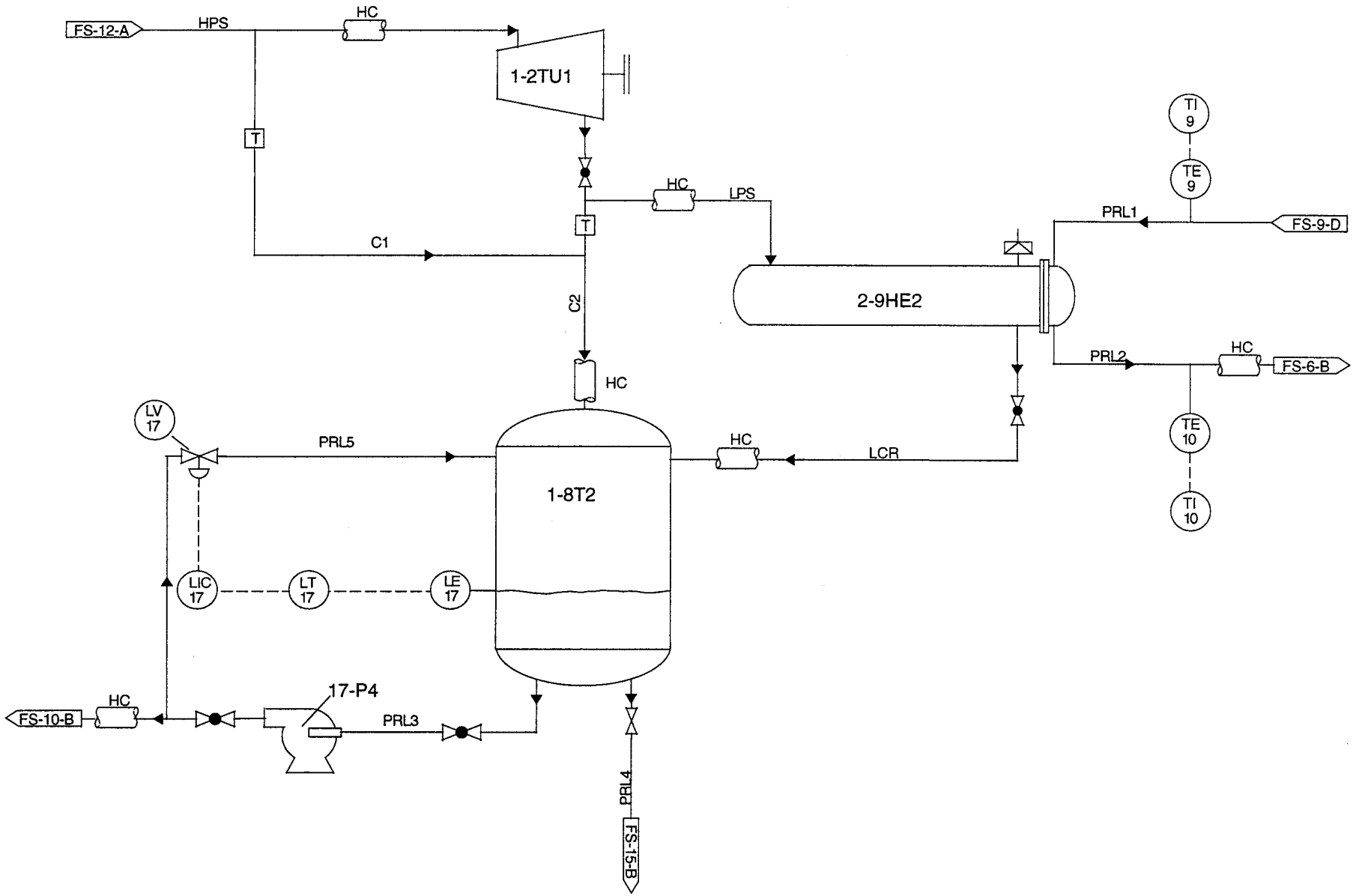
8.18
What is the instrument FG on the line W-18?

○ Flow glass ○ Full gauge ○ Fault indicator ○ Filling gauge

8.19
True or false? This tank is insulated.

○ True ○ False

REDUCING TURBINE AND CONDENSATE COLLECTION EXERCISE



Questions for Review/Reducing Turbine and Condensate Collection

1. The P&ID above shows three large pieces of equipment. Place the letter of the symbol from the right column next to the correct word(s) in the left column. You may use a symbol more than once.

___2-9HE2

___Condensate tank

___1-2TU1

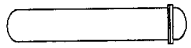
___1-8T2

___Turbine

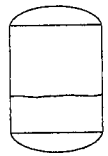
___Heat exchanger

a.

b.



c.



2. Numerous smaller symbols appear on this P&ID. Place the letter of the symbol next to its name.

___Insulated line

___Globe valve

___Centrifugal pump

___Gate valve

___Steam trap

___Rupture disc

___Pneumatic valve

___Pneumatic line

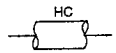
a.

b.

c.

d.

e.



f.

g.

h.

In questions 3-15, choose the correct answers for the blanks from the words in parentheses and circle it.

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

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

5. You would expect the material in the pipeline PRL2 to be _____ (warmer, cooler) than the material in the pipeline PRL1.

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

7. The pipelines LPS and PRL2 are insulated in order to _____ (retain heat of the material, prevent overheating of the material).

8. The level of material in the condensate tank is controlled by _____ (pump 17-P4, instrument loop 17).

9. If you wanted to find out what happens to condensate that leaves the tank, you would look on P&IDs numbered _____ and _____ (FS-6-B, FS-10-B, FS-6-B, FS-12-A, FS-15-B).

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

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

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

13. Steam _____ (can, cannot) be recycled through the turbine.

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

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

Questions for Review/Reactor Exercise

Use the large pull-out drawing of a reactor system (the drawing is the same on both sides to make it easier to answer the questions) for this exercise. For the purpose of this review, the labels CH1 and CH2 stand for two different chemicals that go into a controlled reaction. CH1 and CH2 are imaginary labels and do not occur on real-life P&IDs.

1. Place the letter of the symbols in the right column next to the correct name or label in the left column. You may use a symbol more than once.

____ 3-12RE1

____ Flow element

____ Tank Truck from the CH1 Company

____ 2-9T4

____ Flexible metal hose

____ Nozzle

____ Interlock

____ Flow totalizer switch

____ Hand-operated valve

____ Electric signal line

____ 2-15HE2

____ Pneumatic valve

____ Heat exchanger

____ Holding Tank

____ Reactor

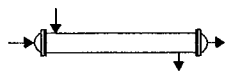
____ Analysis indicating transmitter

a. 

b. 

c. 

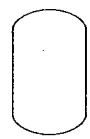
d. 

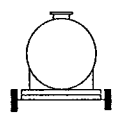
e. 

f. 

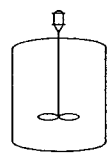
g. 

h. 

i. 

j. 

k. 

l. 

m.

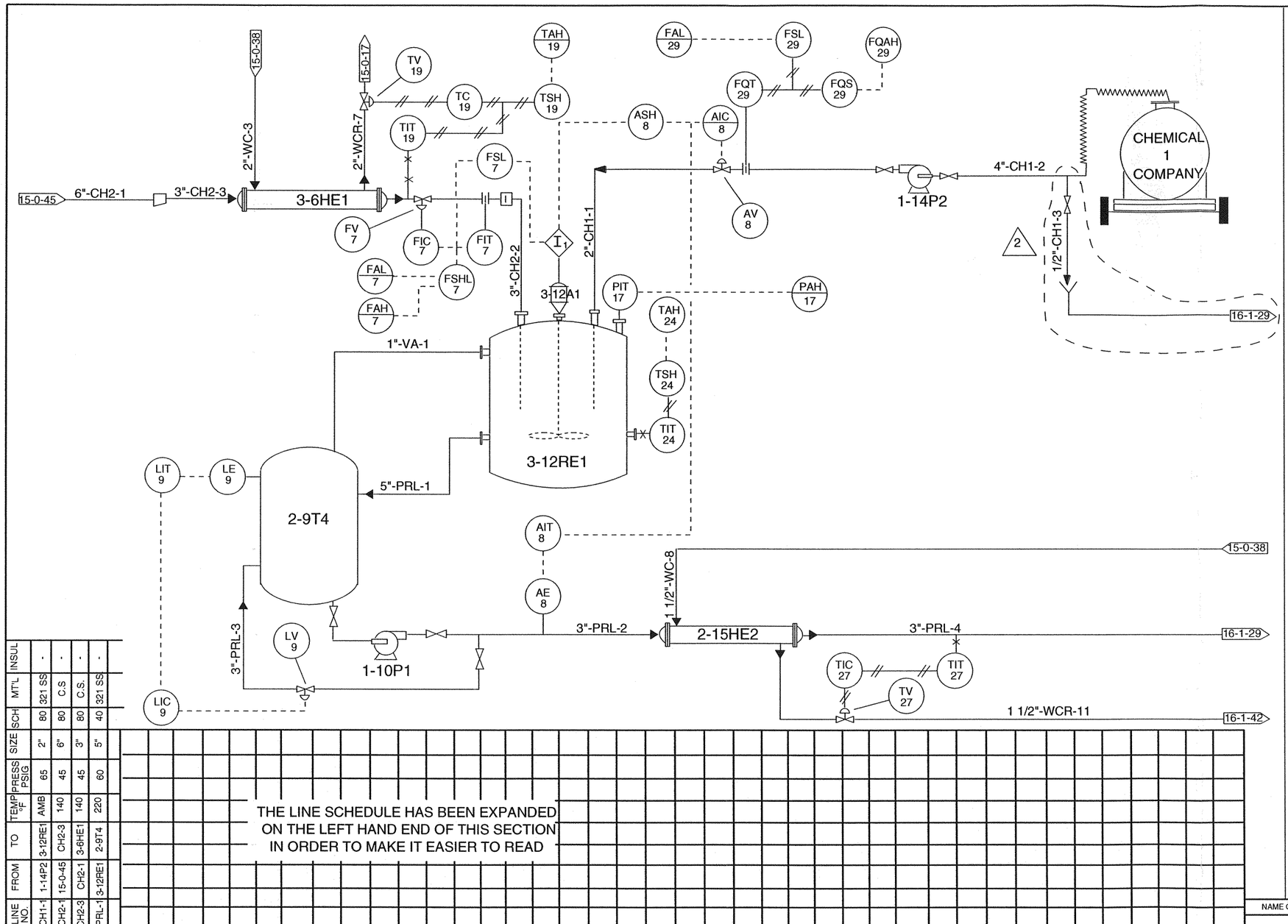
Circle the correct word(s) to fill in the blank in the following questions. **(Some blanks may have more than one correct answer. Circle <u>all</u> correct answers for each question!)**

2. CH1 comes into this P&ID from _____ (another reactor, a tank truck, 15-0-45, 16-1-29).

3. The interlock will be activated by the _____ (1-14P2, agitator, low flow of CH2, FSHL-7).

4. Flow of CH2 that is being added to the reaction is controlled by _____ (FV-7, analysis of the product, flow of CH1, improper function of the agitator).

5. The function of 3-6HE1 is to _____ (heat CH2, cool CH2, heat CH1, cool CH1).



2 ALL CH1 LEFT IN UNLOADING HOSE MUST BE DRAINED INTO THE ENVIRONMENTAL COLLECTION SUMP

I1 INTERLOCK SHUTS DOWN AGITATOR IF LOW FLOW OR HIGH PH OCCURS.

LINE NO.	FROM	TO	TEMP °F	PRESS PSIG	SIZE	SCH	MT'L	INSUL
CH1-1	1-14P2	3-12RE1	AMB	65	2"	80	321 SS	-
CH2-1	15-0-45	CH2-3	140	45	6"	80	C.S	-
CH2-3	CH2-1	3-6HE1	140	45	3"	80	C.S.	-
PRL-1	3-12RE1	2-9T4	220	60	5"	40	321 SS	-

THE LINE SCHEDULE HAS BEEN EXPANDED ON THE LEFT HAND END OF THIS SECTION IN ORDER TO MAKE IT EASIER TO READ

ITEM NO. (CTW NO.,)	CTW 16992	CTW 17545	CTW 17546	CTW 16991	CTW 16992	CTW 18500	CTW 18501			
EQUIPMENT IDENTIFICATION NO.	2-9T4	3-6HE1	2-15HE2	3-12RE1	3-12A1	1-10P1	1-14P2			
DESCRIPTION	SISTERVILLE TANK WORKS VETRICAL 5'6" DIA.X5'9"S.S WORK PRESS. 80 PSIG@280°F TO BE STRESS RELIEVED SERIAL NO. 72-344 CARBON STEEL ASTM 516-70 SHELL AND HEADS	CH2 HEAT EXCHANGER SIZE: 25,000 BTU/HR MT'L: TUBE SIDE C.S SHELL SIDE: CS BONNET: 316 SS SHELL AND HEADS.	PRL HEAT EXCHANGER SIZE: 35,000 BTU/HR MT'L: TUBE SIDE 321SS SHELL SIDE: CS BONNET: 321 SS	PRL REACTOR BRADFORD CORP. 6'-6" DIA.X8'-6". WORK PRESS. 80 PSIG @220°F SERIAL NO. 85-352 321 SS SHELL & HEADS	LIGHTNING MODEL NO. XJC-43 FOR 2,000 GAL. TANK WETTED PARTS TO BE SS MOTOR 3/60/440 TEFC 1.2HP SERIAL NO. 43/27458 MOUNTED ON 3-12RE1	DURIRION CO. DURCON MARK II 2X1-20A CENTRIFUGAL PUMP DESIGN: 100 GPM MATERIAL 316 SS MOTOR: 15 HP 3/60/460	DURIRION CO DURCON MARK II 2X1-10A CENTRIFUGAL PUMP DESIGN: 50 GPM MATERIAL 316 SS MOTOR: 5 HP 3/60/460.			

ISSUE 2	DESCRIPTION	ISSUE 1	DESCRIPTION
2	ADDED VALVE AND DRAIN LINE TO ENVIRONMENTAL SUMP INDICATES REVISION DATE: 11/8/93		APPROVED FOR CONSTRUCTION

NAME OF OUTSIDE ENGINEERING FIRM (IF APPLICABLE)

JTS PROCESS CO.

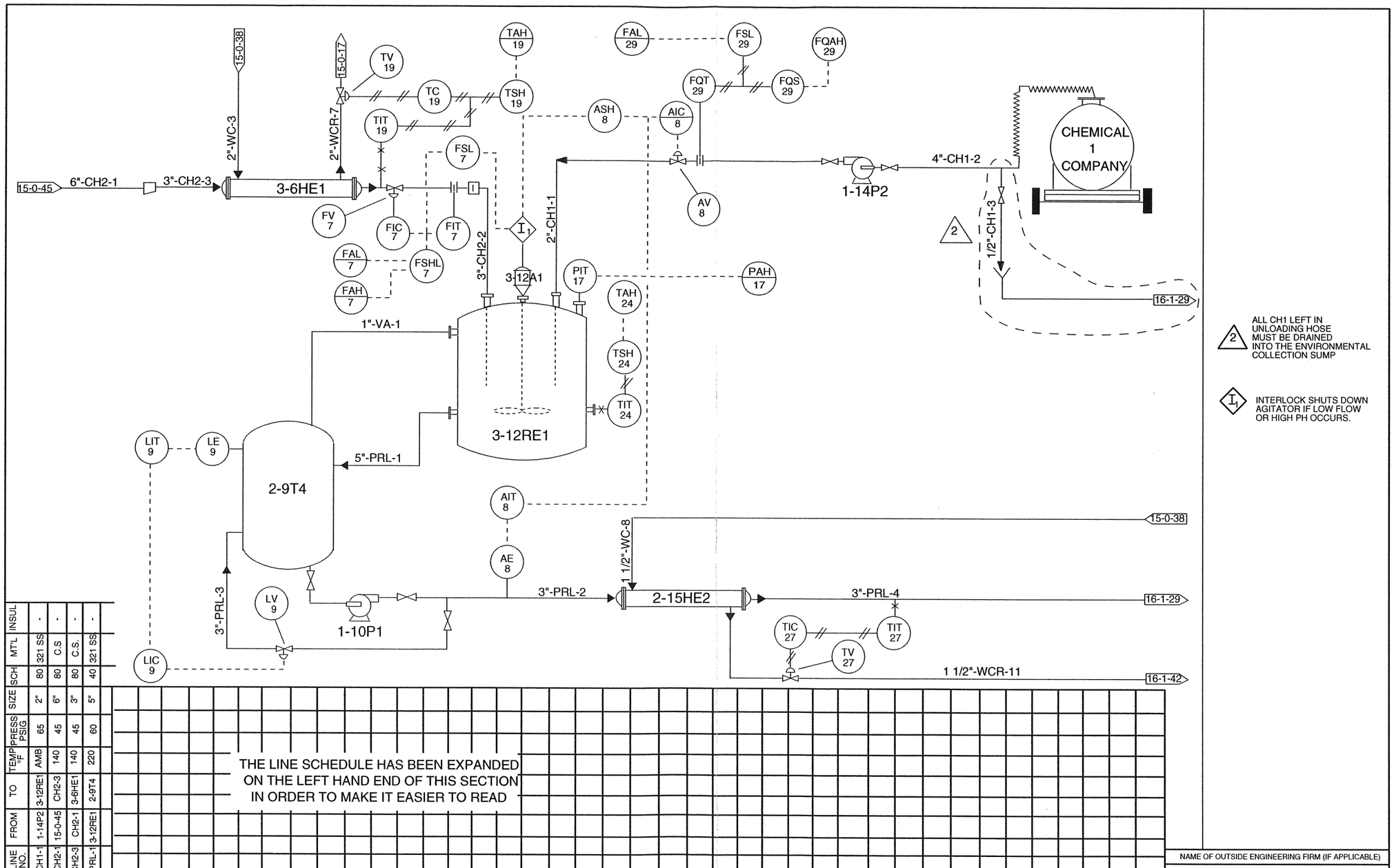
YOUR BUSINESS UNIT — ACME PLANT

PRL1 REACTOR

ISSUED FOR CONSTRUCTION — DATE

AUTHORIZATION NO.	DRAWING NO.	ISSUE NO.
	FS-5-D	2

SCALE:



2 ALL CH1 LEFT IN UNLOADING HOSE MUST BE DRAINED INTO THE ENVIRONMENTAL COLLECTION SUMP

I_1 INTERLOCK SHUTS DOWN AGITATOR IF LOW FLOW OR HIGH PH OCCURS.

LINE NO.	FROM	TO	TEMP °F	PRESS PSIG	SIZE	SCH	MT'L	INSUL
CH1-1	1-14P2	3-12RE1	AMB	65	2"	80	321 SS	-
CH2-1	15-0-45	CH2-3	140	45	6"	80	C.S	-
CH2-3	CH2-1	3-6HE1	140	45	3"	80	C.S.	-
PRL-1	3-12RE1	2-9T4	220	60	5"	40	321 SS	-

THE LINE SCHEDULE HAS BEEN EXPANDED ON THE LEFT HAND END OF THIS SECTION IN ORDER TO MAKE IT EASIER TO READ

ITEM NO. (CTW NO.,)	CTW 16992	CTW 17545	CTW 17546	CTW 16991	CTW 16992	CTW 18500	CTW 18501
EQUIPMENT IDENTIFICATION NO.	2-9T4	3-6HE1	2-15HE2	3-12RE1	3-12A1	1-10P1	1-14P2
DESCRIPTION	SISTERVILLE TANK WORKS VETRICAL 5'6" DIA.X5'9"S.S WORK PRESS. 80 PSIG@280°F TO BE STRESS RELIEVED SERIAL NO. 72-344 CARBON STEEL ASTM 516-70 SHELL AND HEADS	CH2 HEAT EXCHANGER SIZE: 25,000 BTU/HR MT'L: TUBE SIDE C.S SHELL SIDE: CS BONNET: 316 SS SHELL AND HEADS.	PRL HEAT EXCHANGER SIZE: 35,000 BTU/HR MT'L: TUBE SIDE 321SS SHELL SIDE: CS BONNET: 321 SS	PRL REACTOR BRADFORD CORP. 6'-6" DIA.X8'-6". WORK PRESS. 80 PSIG @220°F SERIAL NO. 85-352 321 SS SHELL & HEADS	LIGHTNING MODEL NO. XJC-43 FOR 2,000 GAL. TANK WETTED PARTS TO BE SS MOTOR 3/60/440 TEFC 1.2HP SERIAL NO. 43/27458 MOUNTED ON 3-12RE1	DURIRION CO. DURCON MARK II 2X1-20A CENTRIFUGAL PUMP DESIGN: 100 GPM MATERIAL 316 SS MOTOR: 15 HP 3/60/460	DURIRION CO DURCON MARK II 2X1-10A CENTRIFUGAL PUMP DESIGN: 50 GPM MATERIAL 316 SS MOTOR: 5 HP 3/60/460.

ISSUE 2	DESCRIPTION	ISSUE 1	DESCRIPTION
2	ADDED VALVE AND DRAIN LINE TO ENVIRONMENTAL SUMP INDICATES REVISION DATE: 11/8/93		APPROVED FOR CONSTRUCTION

NAME OF OUTSIDE ENGINEERING FIRM (IF APPLICABLE)

JTS PROCESS CO.

YOUR BUSINESS UNIT — ACME PLANT

PRL1 REACTOR

SCALE: ~

ISSUED FOR CONSTRUCTION	DATE

AUTHORIZATION NO.	DRAWING NO.	ISSUE NO.
	FS-5-D	2

Reactor Exercise Continued...

6. If the temperature of the material in 3"-CH2-2 is too high, _____ (TV-19, FC-8, TV-27, LV-9) is opened more to allow additional cooling water to flow into the exchanger.

7. 1-10-P1 increases the pressure in line _____ (4"-CH-1, 3"-CH2-1, 3"-PRL-2).

8. The function of LV-9 is to _____ (maintain desired level of PRL in the tank, allow vapor to leave the tank).

9. If the temperature of the reaction becomes too high, an alarm will go off _____ (at the reactor, on a computer control panel, near the tank car, TAH-19).

10. If analysis of the process liquid indicates that PRL did not meet specifications, _____ (TV-27, FV-7, AV-8, 1-10P1, PAH-17) changes the flow of _____ (CH2, CH1, PRL, PRL-3) into the reactor.

11. If PRL-4 is too warm, _____ (TV-17, TV-27, 1-10P1, AE-8) opens more to allow increased cooling flow through _____ (3-6HE1, 2-9T4, 3-12RE1, 2-15HE2).

12. If the interlock is activated, a signal is sent to _____ (FAL-29, 3-12A1, AIC-8, FIT-7, FIC-7, 3-12RE1).

13. The title of this P&ID is _____ (JTS Process Co., Engineering Drawing/Reactor, PRL-1 Reactor); this diagram covers a process occurring at the _____ (Acme Plant, Engineering Firm, coordinate FS-5-D).

14. Specific information about line 5"-PRL-1 can be found in the _____ (Title Block, Line Schedule, Issue Descriptions).

15. Line 2"-CH1-1 is made of _____ (carbon steel, copper, stainless steel) and carries the material _____ (cooling water, CH1, CH2, PRL) at a pressure of _____ (60 psig, 65 psig, 45 psig).

16. Any excess liquid left in the tank truck hose after unloading is completed must go to _____ (the reactor, the holding tank, the environmental collection sump, the sewer drain).

17. The change in the process system that was made with this issue was _____ (addition of an environmental collection sump, a new source of CH1, addition of line 1/2"-CH1-3 and drain, additional CH1).

18. The serial number of the holding tank is _____ (2-9T4, T4, 72-344, FS-5-D).

19. The diameter of the nozzle where CH1 enters the reactor is _____ (4 inches, 3 inches, 5 inches, 2 inches).

20. To locate the changes made on the main diagram of issue 2 of P&ID number FS-5-D, look for _____ (a "cloud-like sketch around specific areas on the P&ID, an arrow with FS-5-D, a triangle with a 2 in it, two changes).

21. The material CH2 enters the heat exchanger at approximately _____ degrees Fahrenheit (45, 220, 140, 65).

22. During the reaction, the material _____ (PRL, cooling water, vapor) is allowed to recycle between the holding tank and the reactor.

23. 3-12RE1 has a working pressure of ____ (45, 80, 65) psig and a shell made of _____ (stainless steel, carbon steel).

24. Trace the flow of PRL from where it is created to where it leaves the current P&ID by arranging the following pieces of equipment in the proper order. Place a "1" next to where PRL is created, "2" where it goes next, and so on....

___2-15HE2	___3-6HE1	___16-1-29	___TV 27	___2-9T4
___3-12RE1	___16-1-42	___1-10P1	___1-14P2	___15-0-45

Appendix 1
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	Acrylamide
AMS	Acrylamide sulfate
AN	Acrylonitrile
ANC	Ammonium nitrate condensate
ANH	Anhydrous ammonia
ANL	Aniline
ANS	Ammonia nitrate solution
ANV	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
BG	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
CLS	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
ETG	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	Glycerine
GN	Guanidine nitrate
GNAS	Guanidine nitrate-ammonia solution
GNSS	Guanidine nitrate-synthesis solution
GS	Gypsum slurry
____	Glycol, ethylene (see BRS & BRR)
H	Hydrgen
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
HP	Hydroperoxide
HPS	High pressure steam
HPV	High pressure vent
HS	Hydrogen sulfide
HSC	Hydrogen sulfate
HSO	Hydrogen sulfate
HTS	High temperature salt
HTSS	High pressure supply
HYF	Hyflo filteraid
IA	Instrument air or dry air
IG	Inert gas
IN	Inhibitor
IPA	Iso-propyl alcohol
IPN	Isopropylnaphthalene
ISB	Isobutylene
ISP	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	Methylchloride
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
PRWL	Process water liquor
PSL	Precoat slurry
PT	Petroleum
PV	Pressure vent
PY	Propylene
QSL	Quenched slurry
RFG	Reformed gas
RG	Raw gas
RNG	Regeneration gas
RPG	Reform plant product gas
S	Steam
SA	Sulfuric acid (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
USC	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
WCR	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
WW	Well water
WWA	Waste water
WWH	Wash water
X	Xylene
ZS	Zinc solution

Appendix 2
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.

Analysis

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 C))

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

Level

LA	Level alarm
LAL	Level alarm low
LAH	Level alarm high
LC	Level controller
LCV	Level control valve self-operated
LG	Level glass (gauge glass)
LI	Level indicator
LIC	Level indicating controller
LLL	Level light low
LLH	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
LY	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, PSH=high, PSHL = high & low)
PSV	Pressure safety relief valve
PSE	Rupture disc or vacuum breaker or emergency vent valve
PT	Pressure transmitter (blind)
PIT	Pressure indicating transmitter
PY	Pressure solenoid valve, relay or converter

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
DY	Density solenoid valve, relay or converter

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

Temperature

TA	Temperature alarm
TAH	Temperature alarm high
TAL	Temperature alarm low
TCV	Temperature control valve self-operated
TE	Temperature element, thermocouple, resistance bulb, or thermopile
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

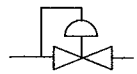
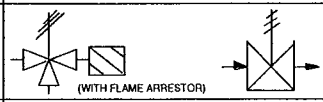
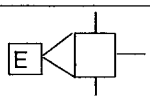
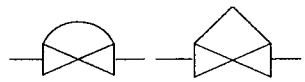
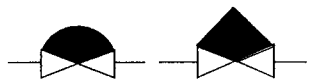
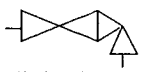
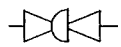
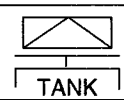
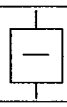
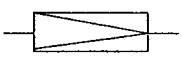
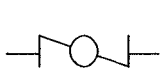
Process Variables

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 (by users choice of letter "M")
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

Appendix 3
Graphic Symbols for Flow Diagrams

VALVE SYMBOLS

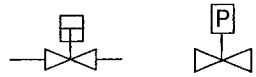
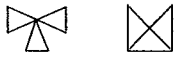
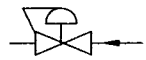
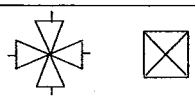
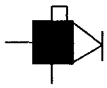
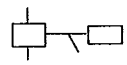
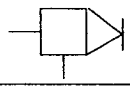
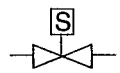
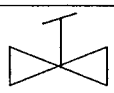
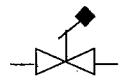
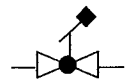
IN SOME CASES, ALTERNATE SYMBOLS ARE SHOWN, SINCE ACTUAL SYMBOLS USED MAY VARY BY PLANT SITE OR ACCORDING TO THE SOURCE OR DATE OF THE ORIGINAL DRAWING.

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 3
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 3
Graphic Symbols for Flow Diagrams

MISCELLANEOUS SYMBOLS

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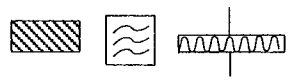
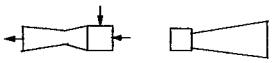
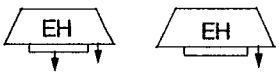
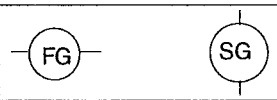
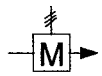
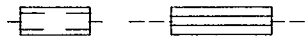
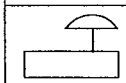
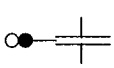
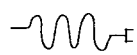
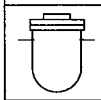
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	ATMOSPHERIC VENT		FLAME ARRESTOR
	SLIP BLIND (CLOSED LINE)		FLARE
	SPECTACLE BLIND		FLEX CONNECTOR
	BURNER		HOSE CONNECTION
	CAP		SANITARY CONNECTOR e.g. "TRICLOVER"
	DRAIN		QUICK CONNECT
	DRINKING FOUNTAIIN		FLOW ELEMENT OR ORIFICE
	EJECTOR		ORIFICE PLATE IN QUICK-CHANGE 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 VANES
	EYE WASH FOUNTAIN		ARMORED HOSE (FLEXIBLE)
	FIGURE EIGHT		FLEX HOSE
	FILTER		METAL HOSE (FLEXIBLE)

Appendix 3
Graphic Symbols for Flow Diagrams

MISCELLANEOUS SYMBOLS

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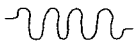
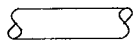
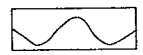
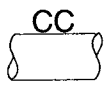
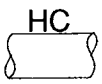
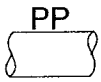
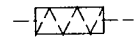
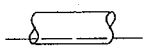
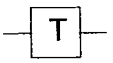
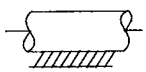
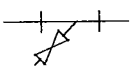
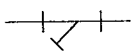
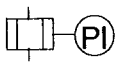
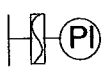
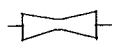
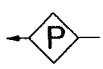
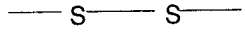
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	PLASTIC HOSE		ROTAMETER
	RUBBER HOSE		RUPTURE DISC
	INSULATION		SAMPLE CONNECTION
	ANTISWEAT INSULATION		SEAL DIAPHRAGM
	COLD CONSERVATION INSULATION		SEPARATOR
	HEAT CONSERVATION INSULATION		SHOWER HEAD
	PERSONNEL PROTECTION INSULATION		STATIC MIXER
	INSULATION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

Appendix 4
Equipment Symbols

EQUIPMENT SYMBOLS

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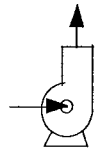
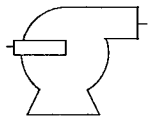

CENTRIFUGAL PUMP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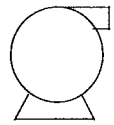
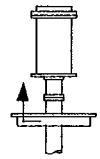
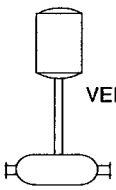
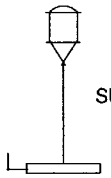
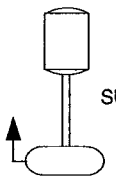
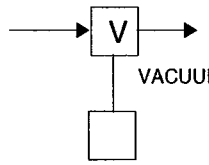

CENTRIFUGAL PUMP


VERTICAL CENTRIFUGAL PUMP

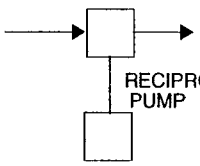

VERTICAL PUMP

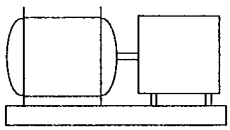

SUMP PUMP

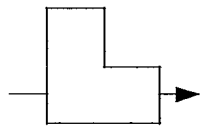

SUMP PUMP

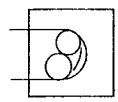


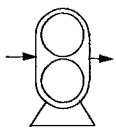
VACUUM PUMP

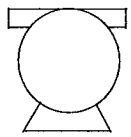

RECIPROCATING PUMP

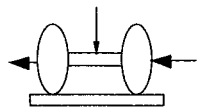

RECIPROCATING PUMP WITH MOTOR DRIVE

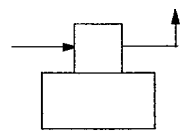

PROPORTIONING PUMP

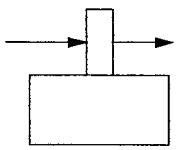

PERISTALIC PUMP

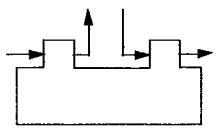

ROTARY DISPLACEMENT GEAR OR VANE PUMP

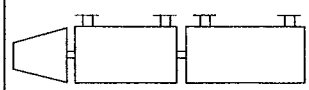

DIAPHRAGM PUMP

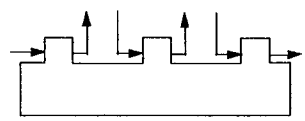

AIR OPERATED DIAPHRAGM PUMP

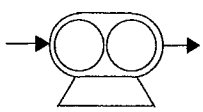

SINGLE STAGE RECIPROCATING COMPRESSOR

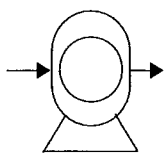

SINGLE STAGE RECIPROCATING COMPRESSOR

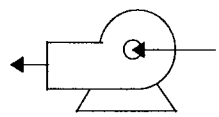

MULTIPLE OR TWO-STAGE RECIPROCATING COMPRESSOR

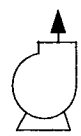

TWO-STAGE-COMPRESSOR

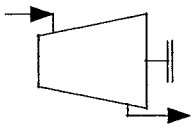

THREE-STAGE COMPRESSOR

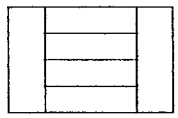

CENTRIFUGAL COMPRESSOR

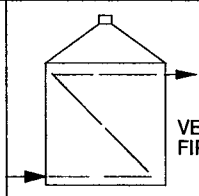

ROTARY COMPRESSOR

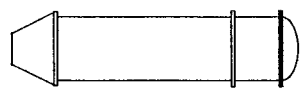

CENTRIFUGAL FAN OR BLOWER


CENTRIFUGAL FAN OR BLOWER

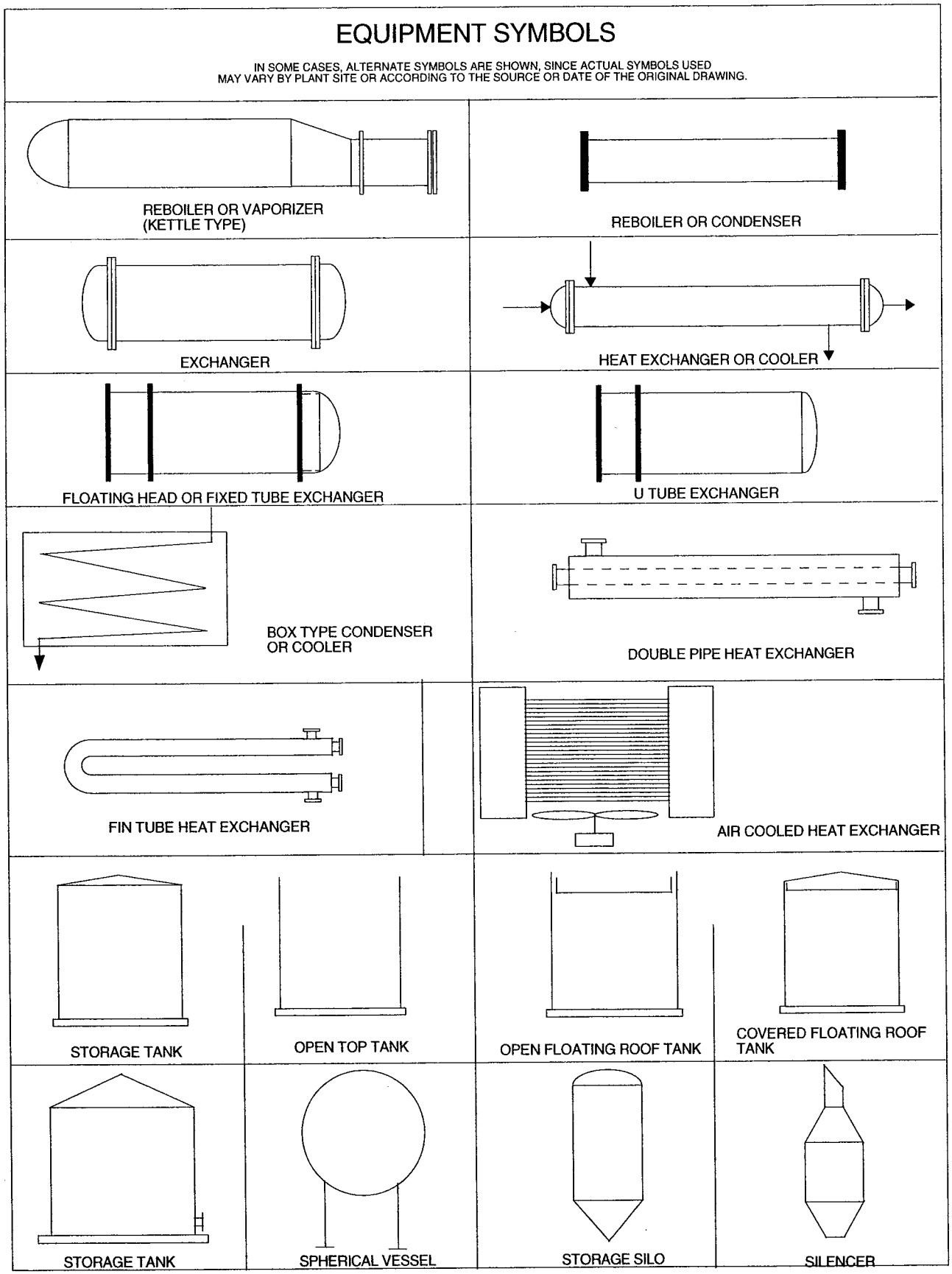

TURBINE


SUPER HEATER


VERTICAL FIRED HEATER


WASTE HEAT BOILER

Appendix 4
Equipment Symbols



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EQUIPMENT SYMBOLS

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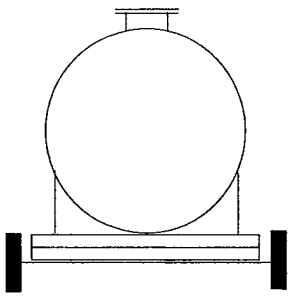
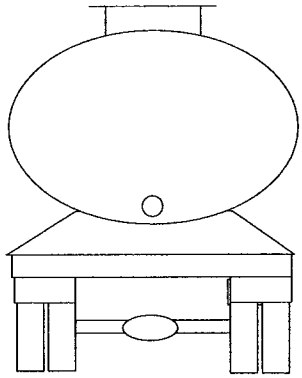
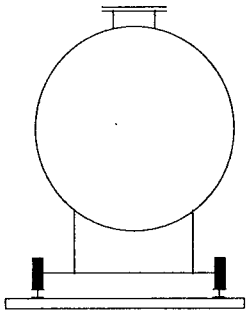


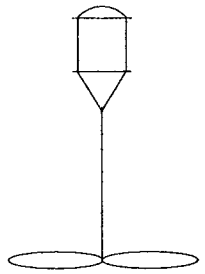
TANK TRUCK



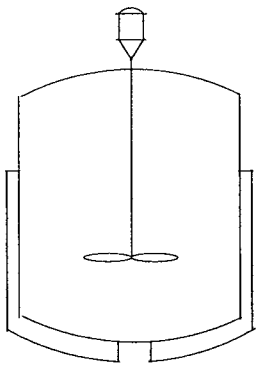
TANK TRUCK



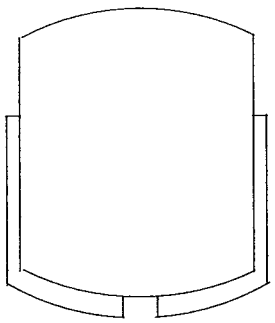
RAILROAD TANK CAR



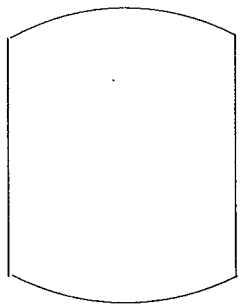
AGITATOR WITH MOTOR



JACKETED REACTOR WITH AGITATOR



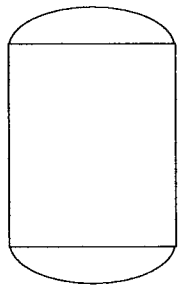
JACKETED REACTOR



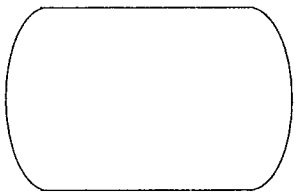
REACTOR

COMPRESSED GAS CYLINDER

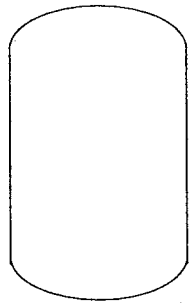
HORIZONTAL PRESSURE VESSEL



VERTICAL PRESSURE VESSEL



HORIZONTAL TANK



VERTICAL TANK OR PROCESS TANK

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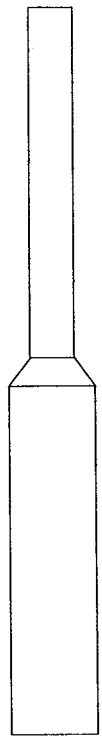
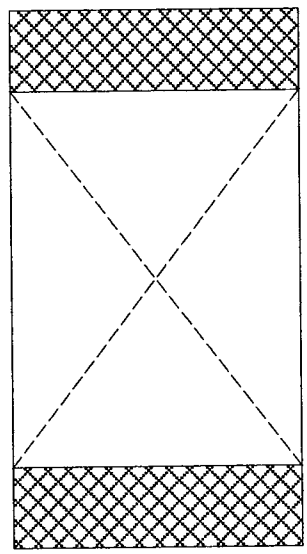
EQUIPMENT SYMBOLS

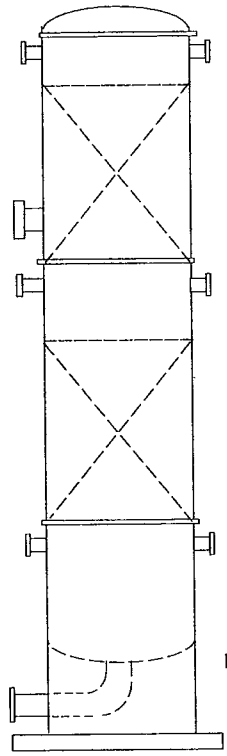
IN SOME CASES, ALTERNATE SYMBOLS ARE SHOWN, SINCE ACTUAL SYMBOLS USED MAY VARY BY PLANT SITE OR ACCORDING TO THE SOURCE OR DATE OF THE ORIGINAL DRAWING.



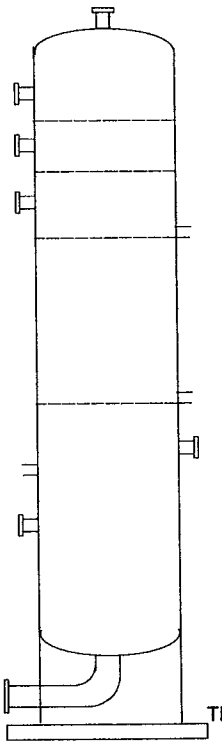
SCRUBBER



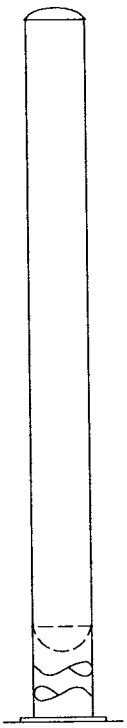
SCRUBBER



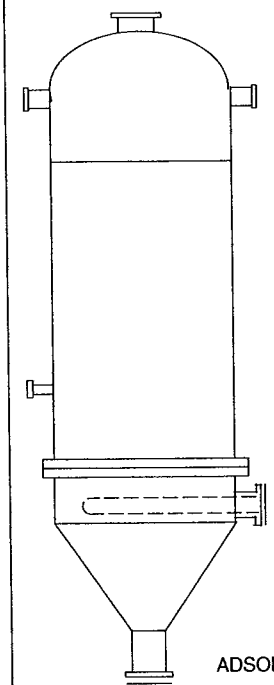
PACKED COLUMN



TRAY COLUMN
OR
DISTILLATION COLUMN



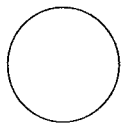
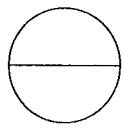
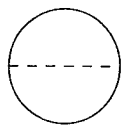
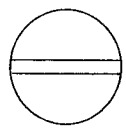
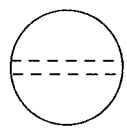
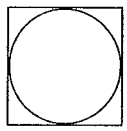
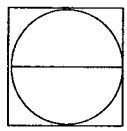
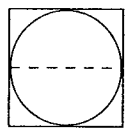
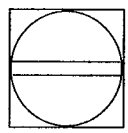
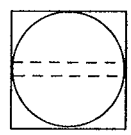
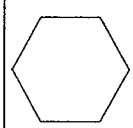
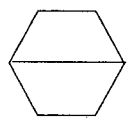
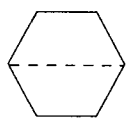
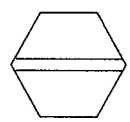
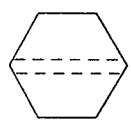
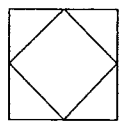
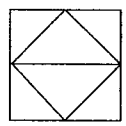
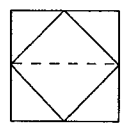
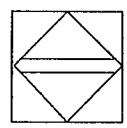
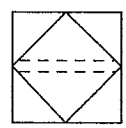
VERTICAL COLUMN



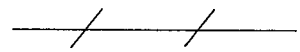
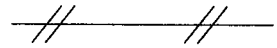
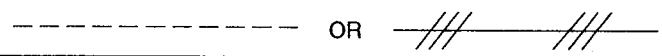
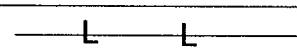
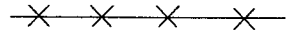
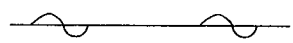
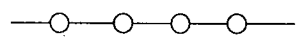
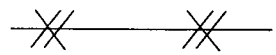
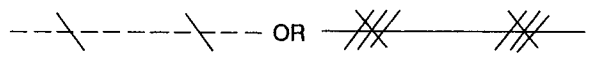
ADSORBER

Appendix 5
Instrument and Instrument Line Symbols

INSTRUMENT OR INSTRUMENT FUNCTION SYMBOLS
(SYMBOLS FROM ISA S5.1, SECTION 6.3)

	FIELD MOUNTED	PRIMARY LOCATION ACCESSIBLE TO OPERATOR	PRIMARY LOCATION INACCESSIBLE OR BEHIND PANEL	AUXILIARY LOCATION ACCESSIBLE TO OPERATOR	AUXILIARY LOCATION INACCESSIBLE OR BEHIND PANEL
DISCRETE INSTRUMENT					
SHARED DISPLAY, SHARED CONTROL (USUALLY A VIDEO SHOWING INFORMATION FROM A NUMBER OF SOURCES AND A NUMBER OF PROCESS VARIABLES CONTROLLED BY A SINGLE DEVICE)					
COMPUTER FUNCTION (PERFORMS ONE OR MORE CALCULATIONS OR LOGIC FUNCTIONS AND TRANSMITS ONE OR MORE OUTPUT SIGNALS)					
PROGRAMMABLE LOGIC CONTROL (CONTROLLER WITH MULTIPLE INPUTS AND OUTPUTS, THAT CONTAINS AN ALTERABLE PROGRAM)					

INSTRUMENT LINE SYMBOLS
(SYMBOLS FROM ISA S5.1, SECTION 6.2)

INSTRUMENT CONNECTION TO PROCESS	
UNDEFINED SIGNAL	
PNEUMATIC SIGNAL	
ELECTRIC SIGNAL	 OR
HYDRAULIC SIGNAL	
CAPILLARY TUBE	
ELECTROMAGNETIC OR SONIC SIGNAL (GUIDED)	
ELECTROMAGNETIC OR SONIC SIGNAL (NOT GUIDED)	
INTERNAL SYSTEM LINK (SOFTWARE OR DATA LINK)	
MECHANICAL LINK	
PNEUMATIC BINARY SIGNAL	
ELECTRIC BINARY SIGNAL	 OR

Answer Sheets
Reading Piping and Instrumentation Diagrams

Unit 1 - Introduction

1.1 Piping that connects equipment
Equipment
Lines and instrumentation that monitor and control a process

1.2 Communicating process information
Maintenance
Plant safety

1.3 Discuss your question with your supervisor.

1.4 Piping and instrumentation diagram

1.5 piping (or process) and instrumentation diagram

1.6 equipment
lines

1.7 controlled

1.8 accurately

1.9 responsible
system

1.10 troubleshooting

1.11 government

Unit 2 - Information on a Typical P&ID

2.1 Similar

2.2 JTS Process Co.

2.3 Smith plant

2.4 Linden, N.J.

2.5 Propylene Plant

2.6 Propylene Reactor Flow

2.7 3

2.8 FS-1-D

2.9 Square A

2.10 Below Vessel C

2.11 equipment and instrumentation

2.12 relative

2.13 size

2.14 distance

2.15 Y Arrow 3, N Arrow 4, N Arrow 5, Y Arrow 6

2.16 At the bottom

2.17 At the bottom

2.18 storm water

2.19 1-1/2 inches

2.20 E/N facility

2.21 wet toluene

2.22 W-179-2

2.23 S-17P3

2.24 process sewer

2.25 1-1/2 inches

2.26 CS (carbon steel)

2.27 80

2.28 No

2.29 process

2.30 1

2.31 3-14T2

2.32 T Serial number 85-352
A 1750 RPM
T 5'6" Dia. x 5'9"
T CTW 16992

2.33 On tank 3-14T2

2.34 A change is made in the process equipment.

2.35 Notes on P&IDs contain significant information that may be very important to your work.

2.36 issue description
changes

2.37 triangle

2.38 safety

2.39 E and 5

2.40 D and 5

2.41 F and 8

2.42 D and 5

Unit 2 - Information on a Typical P&ID continued...

3.1 Master Sheet

3.2 CA

3.3 LA

3.4 CLS

3.5 SLG

3.6 WC

3.7 cooling water

3.8 acetic acid

3.9 liquid (freon liquid)

3.10 instrument air (dry)

3.11 cooled process gas

3.12 Process variables

3.13

HV	Manual control valve
PSV	Pressure safety relief valve
LT	Level transmitter
FAL	Flow alarm low
TIC	Temperature indicating controller
LY	Level interlock solenoid valve
FS	Flow switch

3.14 d.

3.15 d.

3.16 b. and h.

3.17 d.

3.18 reactor

3.19 ball valve

3.20 centrifugal pump

3.21 heat exchanger

3.22 storage tank

3.23 gate valve

3.24 open drain

3.25 2 inches cooling water

3.26 2 inches cooling water

Unit 3 - The Master Sheet

4.1 Pump

4.2 floor 1

4.3 2

4.4 False

4.5 Mix process materials

4.6 Vessels

4.7 4

4.8 14 inches

4.9 Agitator

4.10 3-14A

4.11 Rupture disc

4.12 False

4.13 Nozzle

4.14 Liquid, Gas, Solid

4.15 TIT-12

4.16 TV-12

4.17 roof

4.18

Process tank	d.
Heat exchanger	a.
Reactor	e.
Distillation column	c.
Storage tank	b.

4.19 Vessels

4.20 Located

4.21 Heat exchanger

4.22 Control

4.23 a.

4.24 No

4.25

Ball valve	e.
Check valve	g.
Plug valve	a.
Solenoid valve	f.
Globe valve	c.
Diaphragm valve	b.
Back pressure valve	d.

Unit 4 - Symbols Continued...

4.26 Liquids, gases

4.27 b.

4.28 Pipe

4.29 Controlled

4.30 Automatic

4.31 c.

4.32 b.

4.33 Actuator

4.34 False

4.35 Left to right

4.36 Pump

4.37 Compressor

4.38 d.

4.39 A liquid is moving through pump P1. The liquid enters the pump at point B and leaves the pump at point C.

4.40 Ball valve

4.41 tank T1 to tank T2

4.42 1

4.43 Left to right

4.44 Centrifugal

4.45 Check valve

4.46 Equipment descriptions

4.47 1-21-P4

4.48 Positive displacement pump

4.49 Sump pump

4.50 Temperature indicators

4.51 Heat or cool material

4.52 3

4.53 2

4.54 3

4.55 Pressure

4.56 60 psig

4.57 ss (stainless steel)

4.58 steam trap

Unit 5 - Instruments

5.1 Variables

5.2 Initiate alarms if a dangerous condition develops
Needed to stay within cost limits
Keep process variables within safe limits
Help meet quality specifications

5.3 Number

5.4

PI	d.
LAH	b.
TIC	a.
FCV	e.
WSL	c.

5.5

PI	d.
LAH	a.
TIC	b.
FCV	c.
WSL	e.
AS	g.
HV	f.

Unit 6 - Line Designations

6.1 6 inches

6.2 3 inches

6.3 Wash water

6.4 50

6.5 No

6.6 insulated

6.7

Electrical	b.
Pneumatic	a.
Software or data linked	d.
Capillary	c.

Unit 7 - Tracing Process Flow

7.1 FS-132-D

7.2 Product Cooling System

7.3 P&ID number FS-11-D

7.4 Line schedule

7.5 P&ID number FS-9-D

7.6 P&ID number FS-11-D

7.7 Insulated

7.8 Pneumatic line

7.9 True

Unit 8 - Controlling Process Operations

8.1 Temperature

8.2 Temperature indicating transmitter

8.3 Electric signal

8.4 Behind a panel

8.5 On a control panel

8.6 Capillary tubing

8.7 The piston-operated valve

8.8 By hand

8.9 The functional logic of how the control loop works

8.10 The switch, TSH
The controller, TIC

8.11 Brine leaving the condenser

8.12 Cooling brine, BR-1

8.13 15

8.14 Solenoid valve

8.15 To allow venting of excessive pressure in the tank

8.16 TIC-27

8.17 It controls flow of the waste stream into the tank.

8.18 Flow glass

8.19 False

Unit 9 - Reducing Turbine and Condensate Collection Exercise

1. 2-9HE2 b.
Condensate tank c.
1-2TU1 a.
1-8T2 c.
Turbine a.
Heat exchanger b.

2. Insulated line e.
Globe valve h.
Centrifugal pump f.
Gate valve g.
Steam trap d.
Rupture disk c.
Pneumatic valve a.
Pneumatic line b.

3. high pressure steam
low pressure steam

4. process liquid

5. warmer

6. low pressure condensate

7. retain heat of the material

8. instrument loop 17

9. FS-15-B and FS-10-B

10. level transmitter

11. process liquid

12. recycle through the tank

13. cannot

14. globe valves

15. LPS and C1

1. 3-12RE1 — l.
   Flow element — h.
   Tank truck from CH1 — j.
   2-9T4 — i.
   Flexible metal hose — b.
   Nozzle — d.
   Interlock — a.
   Flow totalizer switch — c.
   Hand-operated valve — k.
   Electric signal line — m.
   2-15HE2 — e.
   Pneumatic valve — f.
   Heat exchanger — e.
   Holding tank — i.
   Reactor — l.
   Analysis indicating transmitter — g.

2. a tank truck

3. low flow of CH2

4. FV-7

5. cool CH2

6. TV-19

7. 3"-PRL-2

8. maintain desired level of PRL in the tank

9. at the reactor

10. AV-8
    CH1

11. TV-27
    2-15HE2

12. 3-12A1

13. PRL-1 Reactor
    Acme Plant

14. Line Schedule

15. stainless steel
    CH1
    65 psig

16. the environmental collection sump

17. addition of line 1/2"-CH1-3 and drain

18. 72-344

19. 2 inches

20. a "cloud-like sketch around specific areas on the P&ID
    a triangle with a "2" in it

21. 140 degrees Fahrenheit

22. vapor

23. 80 psig
    stainless steel

24.
1	3-12RE1	where PRL is created
2	2-9T4	
3	1-10P1	
4	2-15HE2	
5	16-1-29	the P&ID number to continue on...

JOB TRAINING SYSTEMS, INC.

READING A P&ID
Demonstration Exercise

Course No. 203

Completion Statement

_____ _____ _____ _____

Trainee's Name Social Security Number

An employee of _____

Company and Plant Name

has successfully demonstrated the ability to read and use Piping & Instrumentation Diagrams

_____

Trainee's Signature

_____ _____

Evaluator's Signature Date

Note: See Getting Started on page one of this workbook for information on how to use this exercise.

Satisfactory

1. Explain the title block information.
   - a. Where is the title block?
   - b. Is the current P&ID the right one for the work area?
   - c. What is the issue or revision number?

2. Demonstrate the ability to find and interpret general information on the P&ID.
   - a. What changes were made with the current issue?
   - b. Identify the items changed on the main drawing with this issue number.
   - c. Identify the equipment symbols for the major pieces of equipment on the drawing.
   - d. Find line schedule information* for three process lines.
   - e. Locate and interpret any special notes given on the P&ID.

3. Using the Master sheet for the current P&ID, identify:
   - a. If the right Master Sheet is being used for the current P&ID.
   - b. The meaning of three line designations on the P&ID.
   - c. The meaning of three instrument designations on the P&ID.

4. Using the current P&ID:
   - a. With the Master sheet if needed, identify approximately ten symbols including equipment, instruments and other symbols.
   - b. Locate the equipment descriptions* for the major equipment pieces
   - c. Trace a process stream from the point it enters the P&ID to where it no longer exists (mixes in a reactor, for example) or leaves the current P&ID. Identify all graphic symbols and their function along the line. Explain the function of instruments in control loops along the line.
   - d. Trace a process stream from the point where it exits a piece of equipment to where it leaves the current drawing. Explain how to continue tracing the line.

5. Select a process line and ask the trainee to use the P&ID for the area to walk through the work area and identify all components on the line, describe direction of flow, and identify where the material in the line leaves the work area or no longer exists.

When all tasks have been satisfactorily demonstrated, fill in Completion Statement on the reverse side.

* If this information is not present on the P&ID, show trainee how to obtain it.