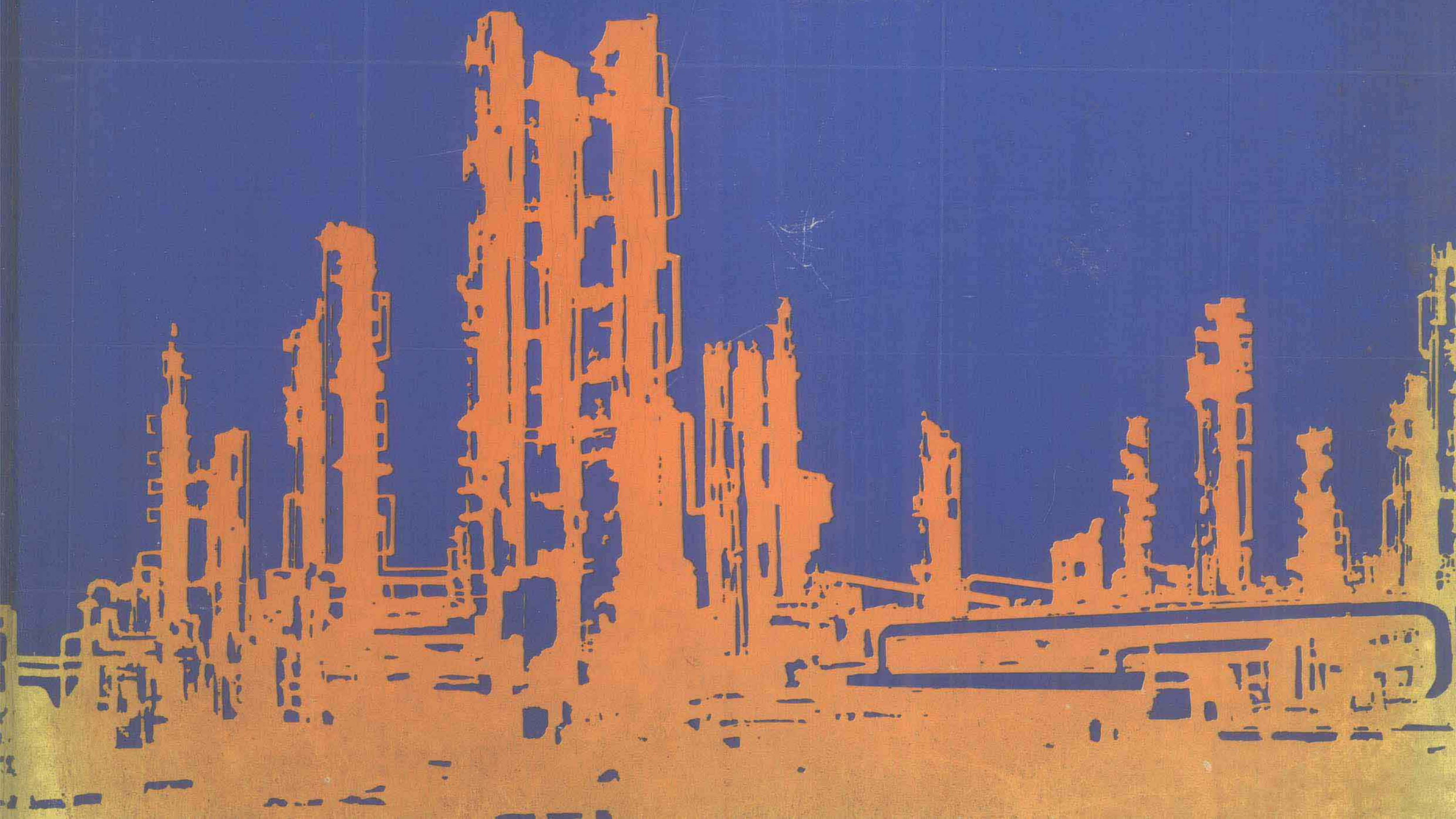
SECOND EDITION

PROCESS PIPING DRAFTING

BY RIP WEAVER



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PREFACE

Many of the diagrams, drawings and specifications in this book will be somewhat familiar to piping draftsmen all over the world. While companies have some vastly different ways of doing the same job, many items in the text are common to several companies.

Fluor Engineers and Constructors, Inc., a worldwide leader of engineering and constructing industrial complexes, has greatly influenced my thoughts in this book.

However, many items portrayed represent other methods. I have chosen not to represent the methods of any one company but to let the student enter piping drafting with more of a general knowledge.

I do wish to take this opportunity to thank Fluor for its help in getting this book written.

Rip Weaver

INTRODUCTION

This book acquaints the individual with the basic piping fundamentals as used in refinery and petrochemical plant design. After completing this book, along with the class instruction, the student will have the equivalent of about one year's piping drafting experience. With this background he can enter private business, comprehending something of what is expected of him and generally knowing the terms and equipment that make up the refinery or petrochemical installation.

The need for competent piping draftsmen is very high around the world. You can pick up a newspaper in most major cities and see calls for piping draftsmen in the "help wanted" section. This book will help prepare you to fill one of these high paying jobs.

The draftsman's calling card is his ability to do freehand lettering and good linework. Whether filling out an employment application or making a finished drawing, he is automatically judged by his lettering. To be a professional draftsman, you must do professional lettering; so this book will stress lettering and linework throughout.

After completing the book, you should keep it in your files for constant reference. After doing piping drafting a few weeks, you should read the book again because you will probably retain a lot that slipped by you the first time through.

Most of the book deals with welded type piping and fittings, as process piping most commonly uses them. Welded piping is usually specified for sizes 3" and above. Screwed and socketwelded piping is for sizes 2" and below. Chapter 11 assembles reproductions of pertinent pages from manufacturers' catalogs. Illustrations describe valves, flanges and fittings much better than do hundreds of words. Detailed dimensions are also shown on these reproductions.

This book introduces the reader to these items in various chapters. For full details refer to Chapter 11. By combining this information into one chapter, you will have immediate access to it while you are reading this book and also when you are actually working as a piping draftsman.

Piping drafting will challange you. You must display good draftsmanship, accuracy and speed. Every petrochemical unit you help design will have something new. While drawing on flat paper, you must visualize your work in three dimensions. The supervisor may push you beyond your endurance.

But you will find it a very rewarding occupation—for salary and for job satisfaction. One day you may walk down the operating aisle of a huge petrochemical complex and be able to say, "I designed that unit."

Tools and Supplies

Every professional has his own tools. A professional draftsman is no exception. Below are tools you should have for this course and for your drafting job.

1. Trangular 12" architect's scale
2. 10" 30°-60° triangle
3. 8" adjustable triangle
4. Ames lettering guide
5. Compass
6. 2 Mechanical pencils
7. Mechanical pencil pointer
8. Rapidesign #40 circle template
9. Ellipse template
10. Erasing shield
11. Smoley's Combined Tables

The following supplies are also needed for this course.

1. Sandpaper block
2. H, 2H and 3H lead for mechanical pencil
3. Pink pearl eraser
4. Scratch pad
5. #2½ pencil
6. Red and yellow pencils
7. 6 sheets 18" x 24" tracing vellum paper
8. 24 sheets 8½ x 11" tracing vellum paper
9. 1 tablet Ridgeway #1000H isometric paper

CONTENTS

CHAPTER I

EQUIPMENT & TERMS

The student is about to meet a completely new language. The piping draftsman must know the terms of the business. The student has heard some of these; many will be strange. But, even if he has heard the term, does he know what it means? First, the student will investigate some of these new terms. He must learn them well, for a professional knows his business; and this is the language of the professional piping draftsman.

Process Plant Terms

Refinery

A refinery is a plant that takes crude oil as its "feed" or "charge" stock and converts it into the many by-products that people use. Some of these are gasoline, jet fuel, kerosene, butane, propane, fuel oil and asphalt.

Gasoline Plant

The gasoline plant takes natural gas (a vapor) as its charge stock and separates the vapor's heavier products out and reinjects the lighter gas (methane) into a pipeline or perhaps into the gas field it came from. Again gasoline, propane and butane are extracted as products. But, since a gasoline plant starts with a vapor, the heavier hydrocarbons do not exist in its charge stock; so heavier products cannot be made. Asphalt is one of the products that is classified as a heavy hydrocarbon and is not produced in a gasoline plant.

Hydrocarbon

The hydrocarbon compound contains hydrogen and carbon. Hydrocarbon compounds are numerous and form the basis for petroleum products.

They exist mostly as vapors and liquids but may also be solid. In general, piping systems in refineries and gasoline plants transport hydrocarbons or utilities.

Chemical Plant

The chemical plant takes semirefined products from refineries and gasoline plants and—by running them through their units, sometimes blending in other products—converts them into certain chemicals which may be sold as a finished consumer product. One such product widely demanded today is plastic. Chemical plants make many ingredients in modern medicines.

Tank Farm

The tank farm is the area that contains the huge storage tanks of the refinery and gasoline or chemical plants. The tanks are usually isolated from the main processing units in case of fire. They may be 200' or more in diameter and will contain the plant's charge stock for several days. The tanks also will store the plant's products, until the shipment goes to the consumer.

Process Plant Utilities

Utility

The utility is a refinery's service portion. While a home has water, gas and electricity, a refinery or other plant has many more, some of which are below.

Steam. Steam services many plant items. Heat generates steam in fired boilers or heaters, which will make many different steam pressures and temperatures. They apply heat and convert condensate (a pure water) to steam (a vapor). The steam then goes to the different plant units in the piping systems which use the steam.

Many students think they have seen steam, but they haven't. They cannot acutally see steam; it is invisible. What they have seen is the condensate condensing out of the steam. That is where the term "condensate" comes from.

Condensate. As the energy in steam is used, the steam turns to condensate. Another piping system collects this condensate, which is returned under a low pressure to a collection point and is pumped through the boiler tubing and converted to steam again. So the condensate is in a constant cycle from steam to condensate to steam.

Fuel Oil. Fuel oil is another utility that refineries make and partially consume. It is also sold as a product to heat homes and fire furnaces in private business.

Instrument Air. A utility that operates the plant instruments is instrument air. A piping system distributes this air, which has been compressed and dried to remove all its moisture, as the moisture would harm the instruments.

Utility Air. Utility air drives air motors and blows air on objects to clean them, such as some barbers blow cut hair off customers with air hoses.

Cooling Water. Cooling water cools various streams in a plant. The water starts at a cooling tower and is pumped through a piping system to exchangers, which exchange heat. It comes out hotter—much like water from a hot water heater in a home. This water then returns to the cooling tower, which cools the water, and then is ready for more circulation into the unit. Like the steam and condensate system above, this is a constantly circulating system.

Drains. An underground utility collects drains from funnels or catch basins and, in a separate piping system, transports them to a disposal point. Since no pressure is in this drain piping, the pipes must slope to cause flow. This slope is usually 1 foot per 100 feet of line or greater.

It can be very difficult to design drain systems. Since they run underground, they must miss all other underground items. As an example, a $25 million installation will use about 20,000 yards of concrete, most of which will be underground as foundations for the process equipment. The drainage system must twist and turn to miss all the foundations.

Most plants also have more than one drain system. They may have an oily water sewer, a storm water sewer and an acid sewer. The oily water sewer handles the oily drips and drains. The storm water sewer collects surface runoff from rains. The acid sewer collects acid drains and drips. There may be many other types of separate drain systems.

Flare System. The flare system transports vapors (via a piping system) to a flare stack which is very tall and has a flame burning at the top. This system burns waste gases and also collects and burns relief valve discharges. At night the flare stack usually stands out–sending flames high into the air. This is waste gas burning. If it did not burn, it would pollute the air.

These are some basic terms and piping systems you should learn completely. And you will be exposed to many more–beginning with the definition of piping.

Piping and Pipe Sizes

Piping transports a vapor or liquid and some solids. A familiar piping system is the gas and water pipes in a home. These are sized to flow sufficient products into the home. Most are ½" and ¾" and are usually screwed fittings because the pressures and temperatures are very low. Piping systems for refineries usually are 1"-24" with some special systems measuring several feet in diameter. A person could easily walk in some. Pressures and temperatures are very high, so these pipes and fittings are welded and not screwed.

Pipe sizes are calculated to flow a certain product at a set quantity at its pressure and temperature. The higher the pressure, the more pipe thickness required. As the system's temperature rises, it not only affects the thickness, but hot objects expand, and expanding pipe creates a force which must be considered.

Pipes are constructed of many materials–most commonly of carbon steel. They may also be of stainless steel, chrome steel, vitrified clay, cast iron, plastic, glass and many other materials.

Process Plant Equipment

It's important to remember the names and functions of equipment to which the piping draftsman will have to connect.

Vessel

A vessel is only a large diameter pipe which may have internals. Some are installed horizontally, like those at a service station. Most vessels there are underground to store regular and premium gasoline. Many are vertical and vary in size and shape. The tall ones, which have "fractionating trays" inside, are *fractionating towers*. They are 100' or more high.

Reactors are vertical vessels or spheres which contain a catalyst. A chemical reaction occurs in this vessel, changing the molecular structure of the fluid going through it.

No chemical change occurs in fractionating towers which separate the various compounds. The separation results from the different boiling points of the different products. The lighter the product, the lower the boiling point. The desired "cut," or product separation, is drawn off generally as a vapor from the top of the fractionating tower. This vapor is then cooled, usually by cooling water, and condensed to a liquid which the overhead accumulator (see below) then retains. The main point to remember is that the fractionating tower "fractionates," or separates, products. No chemical change occurs just like no chemical change occurs when cream is separated from whole milk. In a "reactor" a chemical change, or reaction, *does* occur.

Overhead accumulator is sometimes called "reflux accumulator." This is a horizontal vessel which collects the overhead product from a fractionating tower. It usually operates one-half full of liquid. These vessels usually have little, if any, internals.

Storage Tanks

Storage tanks still fall under the "vessel" category but are not in the process areas. They usually appear as bunches and are called a "tank farm." The tanks run more than 200' in diameter and are 40 to 60' high. They store the crude oil until the process units are ready for it, store all the various products until they are sold or the plant consumes them and also store "rerun" products, which have come from one unit and are held for further refinement in another.

These tanks have many types. Most are flat bottomed with a conical top. Some have a floating top which floats on top of the stored liquid. These tanks are used when the stored liquid has a high evaporation loss.

Most "light ends" products are stored under pressure so they won't evaporate. Some are propane and butane, which are stored in "bullets" or long horizontal vessels. Some of these lighter products are stored in "spheres," which legs support.

Exchangers

The "heat exchanger" gets its name from exchanging heat from one stream to another. Many methods accomplish this. A common exchanger is the car radiator. This heat exchange comes from water radiating heat through the metal of the radiator. Another common exchanger is the home hot water heater. This exchanges heat from the heating medium to the water. In most applications in process units, this exchange occurs between two process streams so that heat is not wasted. Heat is energy, and wasted energy costs money.

Exchangers also differ in size and shape. Most are the "shell and tube" type installed horizontally. Another is the "fin-fan" or air cooler type, which blows air over exposed tubes to cool the fluid, much like the car radiator works. While the car radiator is vertical, the "fin-fan" is usually horizontal. The "double pipe" exchanger is another type. It has pipe inside a larger pipe, transferring heat from one stream to the other stream. In an exchanger the two streams *never* mix. They exchange their heat through a pipe or "tube" just as the car radiator exchanges heat through the radiator. The water doesn't actually contact the air, or a leak would result, losing the water.

Pumps

Pumps increase the pressure of a *liquid* and cause circulation. The heart, for example, is a pump. The liquid comes to the pump at a low pressure and is discharged at a higher pressure, causing circulation.

Many different pumps exist. The most common is the "centrifugal," which uses a high speed impeller and centrifugal force to increase the pressure. A "reciprocating" pump's parts reciprocate and increase the pressure much like a car's pistons, which go back and forth. This type is often called a "positive displacement" pump.

Compressors

Compressors increase the pressure of a *vapor.* They also come as "reciprocating" and "centrifugal." Familiar compressors are the air compressors in a service station or a simple air pump that inflates a bicycle tire. Unlike liquids, vapors will compress. Car tires have compressed air. An inflated ballon must have compressed air.

Fired Heaters

Fired heaters are huge and are in most refineries, gasoline plants and chemical plants. They may be vertical like a hot water heater, or may be horizontal. They contain pipes, or "tubes."

A "vertical" heater is cylindrical and its diameter may be as much as 20'. The tubes or pipes will run vertically. Burners, firing fuel gas or fuel oil will be on the heater's bottom. Its bottom is usually 6'-7' from the ground.

The "horizontal" heater is shaped like a box and is often called a "box" heater. Its tubes run horizontally. The burners may be on the heater's bottom, ends or sides.

Vertical heaters generally operate for smaller duties, while the larger horizontal heaters carry out heavy duty services.

The heaters have two main sections–radient and convection. The radient section is the large part of the heater, where tubes receive heat radiating from the burners. The convection section of the heater is directly above the radient section and just below the stack. The inlet to heaters is usually in this convection section. The convection section of fired heaters often generates steam.

Boiler

The boiler is another fired heater. It takes a condensate and, by applying intense heat, converts it to steam. Fired heaters–instead of boilers–heat hydrocarbons. Boilers generate steam. Fired heaters may generate comparatively little steam in their convection section, but they mainly heat hydrocarbons.

Boilers and fired heaters have stacks. The stack is the large diameter pipe that carries off hot waste gases. The temperature of these gases in the stack runs from 700° F to 1000° F or more.

Valve Types and Uses

Valves

Valves stop or open and regulate flow. Some valves are huge and some are very small.

Gate valve is the most common type that plants use. It is usually manually operated and is designed for open or shut operation. It's not recommended for throttling.

Globe valve is for throttling. Good examples of globe valves are the faucets on a washbasin which throttle or adjust the flow to suit a person's needs.

Relief valve or *safety valve* is an automatic valve that opens when the pressure reaches "set pressure" on the relief valve. Without relief valves the plants could explode during periods of very high pressure. These valves have a spring that holds them shut. The spring holds until a set pressure is obtained; and, when the pressure is more than the set pressure, the spring "gives" and allows the fluid to escape, thereby relieving the pressure. As the pressure reduces, the spring closes and shuts off the flow.

Control Valve is usually an automatic valve built with a "globe valve" body and controls flow in a piping system. This valve opens, closes or throttles on a signal from an instrument. No manual operation is required, although some manual control valves are available. An example of an automatic control valve is the "Big Joe" type pressure regulating valve that controls a home's gas pressure. The gas line near the meter shows this "control valve." Control valves in a car, for instance, control water flow in the car heater.

Plug valve has a plug that rotates when turned and either lets flow pass through a hole in the plug or turns so that no flow is possible. This valve may be used for on-off service or for throttling. It has a more positive shutoff than the gate valve.

Ball valve uses a ball with a hole in it instead of a wedge-shaped plug, and the rotating ball opens or closes the flow. It also may be used for throttling. Ball valves are comparatively new and are gaining wide acceptance.

Check valve "checks" flow. It lets flow go one way and will not let it reverse. When you have a check valve in a line (or pipe), you have made a one-way street. The flow can only go one way. Many check valves are available. The common ones are *swing check,* in which a flapper lifts up to permit flow; the *piston check,* which has a piston in it that lifts to flow; the *ball check,* which has a ball in it which lifts; and the *butterfly check,* which has two vanes like a butterfly has wings. These "wings" fold back to permit flow but will close to stop backflow.

Plants are now using possibly a hundred other valves, but this book can't cover all of them. The student will be exposed to them as he gains actual experience. He should remember that these valves come in all sizes–from very small to sizes a person could walk through for special applications. The most common valving size is ½" through 24".

Valves are expensive; their total cost is approximately 20-25% of the piping system in most plants. Like pipe, they are manufactured to all material specifications. The most common one is carbon steel.

Piping Terms

Flanges

Flanges make a bolted joint. This book will show later that most valves have flanged ends and must have a companion or matching flange attached. A gasket is then inserted between them, and the bolts are tightened to form a flanged joint.

Fittings

Fittings are many and varied. Some are elbows, tees, reducers, reducing ells and caps.

Instruments

Instruments tell the operator what is happening inside a vessel or pipe. A *pressure gage* tells him the pressure like an oil gage on a car tells the oil pressure in its piping system. A *gage glass* connected to a vessel tells the operator what the vessel's liquid level is. A *level indicator* tells him what the level is from a remote location. A car's gas gage is a level indicator because it is not hooked to the tank but is remotely located on the dashboard. Gage glasses on large coffee urns in restaurants show how much coffee is in the urns by the level in the gage glass itself.

Temperature indicators tell the fluid temperature in the pipe or vessel. They can be remotely located like a car's "temperature indicator." They also can be connected directly to the pipe or vessel.

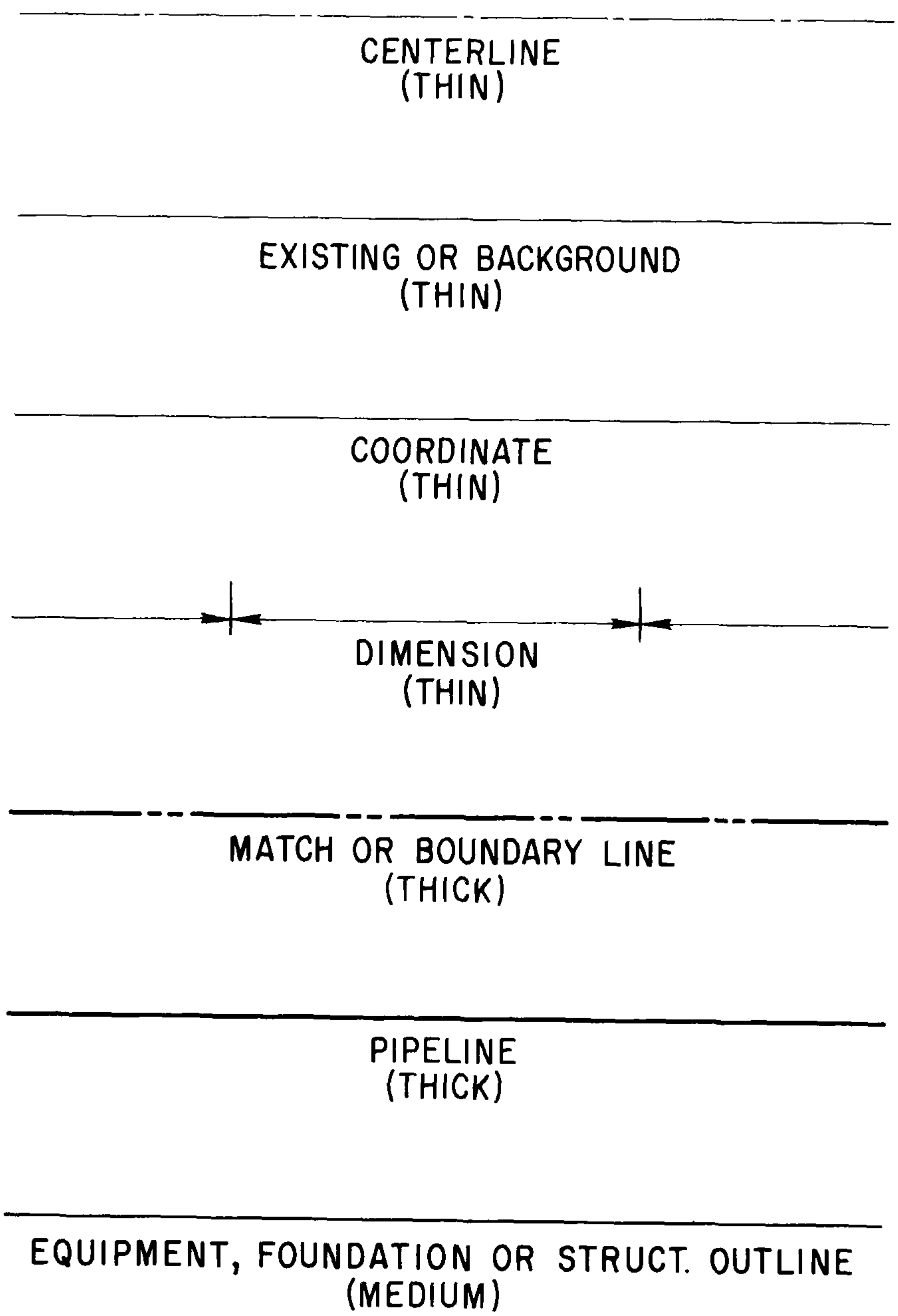
This book will cover other instruments later.

Fluid

Most students may think of fluid as a liquid, but it can also be a vapor. Fluid means something that will flow—something not solid. Piping directs fluid flow.

LINEWORK EXERCISE

Linework is important to the professional draftsman—a simple but often overlooked truth. In the piping field, he draws piping as the thick line. If he were doing electrical drafting, he would want electrical to stand out; so he would draw it heavy. All lines must be dark enough to print on a reproduction machine but not so soft as to smear.



LETTERING EXERCISE

The lettering is a professional draftsman's calling card. The student should strive for perfection in his lettering. This requires constant practice. Throughout this course he should practice lettering. At least once a week, turn in a lettering sheet as duplicated below. As soon as his lettering is very good, the instructor will tell him that he may stop turning in the sheet. All lettering must be in capitals. Lower case lettering is not commonly used for piping drawings.

ALL LETTERING WILL BE UPPER CASE EITHER SLANT OR VERTICAL.

ALL LETTERING ON DRAWINGS SHALL BE APPROXIMATELY 1/8" HIGH WITH THE FOLLOWING EXCEPTIONS:

USE 1/4" HIGH LETTERING FOR VIEW TITLES AND UNDERLINE.
USE APPROXIMATELY 3/16" HIGH LETTERING FOR TITLE BLOCKS. THIS MAY VARY ACCORDING TO NUMBER OF LINES REQUIRED AND SPACE AVAILABLE.

LIGHT GUIDE LINES MAY BE USED, HOWEVER GUIDE LINES MUST BE LIGHT ENOUGH NOT TO PRINT.

PRACTICE:

VERTICAL A B C D E F G H I J K L M N O P Q R S T U V W
X Y Z 1 2 3 4 5 6 7 8 9 0

SLANT *A B C D E F G H I J K L M N O P Q R S T U V W*
X Y Z 1 2 3 4 5 6 7 8 9 0

CHAPTER 2

BASIC PIPING DATA

Many students have never seen pipe like the process plants use. The pipe is dimensionally set by the ANSI (American National Standards Institute) code. Wall thickness varies with the "schedule" number, but the *outside* diameter remains constant for the various sizes. As the thickness changes, the inside diameter changes. A schedule number and "standard weight" and "extra strong" list pipe and fittings. Several schedule numbers are available. This book deals with standard weight and extra strong. In table 2-1 the (–) thickness does not match a schedule number.

An example of pipe is in Figure 2-1.

Several methods of manufacturing pipe exist. The most common method makes "seamless," where the pipe is smooth with no seam or joint on the longitudinal axis. "Welded" pipe has a weld lengthwise. This may be "buttwelded" or "ERW" (electric resistance welded) or may be "spiral welded," which has a weld spiraling around the pipe.

Pipe is manufactured in "random length," which is ± 20'-0", and in "double random length," which is ± 40'-0". Unless double random is specified, the draftsmen will get single random lengths.

Pipe is single line and double line on piping drawings. Most companies have converted to single line piping drawings because they take less manhours to draw. Single line piping uses the heavy line for the pipe's center line. Whether single or double line, the OD (outside diameter) is always drawn to scale. For pipe sizes 1½" and below, this would be very difficult; so in both cases these are single line. (See Figures 2-2a and 2-2b.)

Fittings are welded, screwed and socketwelded. The student will find many other types as he learns the business.

The elbow makes turns. It is commonly called an ell and mainly makes 90° and 45° turns. The 90° elbow comes in "long radius" and "short radius." The 45° elbow comes only in long radius. A