

CHAPTER 4

MACHINE DRAWING

When you have read and understood this chapter, you should be able to answer the following learning objectives:

- Describe basic machine drawings.
- Describe the types of machine threads.
- Describe gear and helical spring nomenclature.
- Explain the use of finish marks on drawings.

This chapter discusses the common terms, tools, and conventions used in the production of machine drawings.

COMMON TERMS AND SYMBOLS

In learning to read machine drawings, you must first become familiar with the common terms, symbols, and conventions defined and discussed in the following paragraphs.

GENERAL TERMS

The following paragraphs cover the common terms most used in all aspects of machine drawings.

Tolerances

Engineers realize that absolute accuracy is impossible, so they figure how much variation is permissible. This allowance is known as tolerance. It is stated on a drawing as (plus or minus) a certain amount, either by a fraction or decimal. Limits are the maximum and/or minimum values prescribed for a specific dimension, while tolerance represents the total amount by which a specific dimension may vary. Tolerances may be shown on drawings by several different methods; figure 4-1 shows three examples. The unilateral method (view A) is used when variation from the design size is permissible in one direction only. In the bilateral method (view B), the dimension figure shows the plus or minus variation that is acceptable. In the limit dimensioning method (view C), the maximum and minimum measurements are both stated

The surfaces being toleranced have geometrical characteristics such as roundness, or perpendicularity to another surface. Figure 4-2 shows typical geometrical characteristic symbols. A datum is a surface, line, or

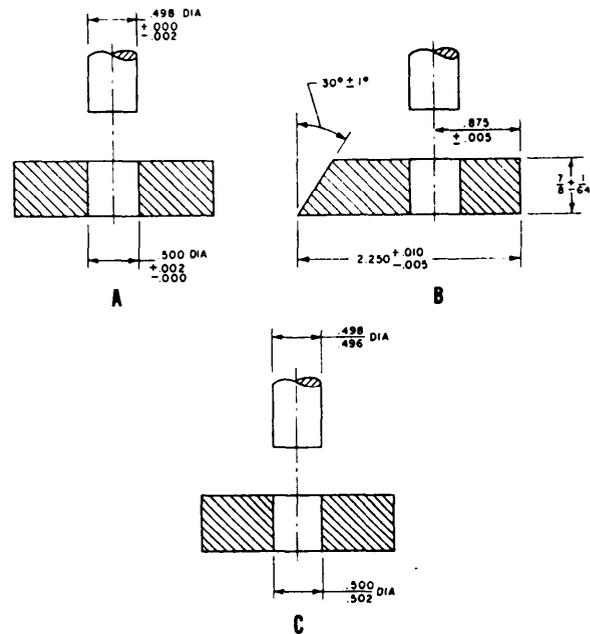


Figure 4-1.—Methods of indicating tolerance.

	FLATNESS & STRAIGHTNESS
	ANGULARITY
	PERPENDICULARITY
	PARALLELISM
	CONCENTRICITY
	TRUE POSITION
	ROUNDNESS
	SYMMETRY
	(MMC) MAXIMUM MATERIAL CONDITION
	(RFS) REGARDLESS OF FEATURE SIZE
	DATUM IDENTIFYING SYMBOL

Figure 4-2.—Geometric characteristic symbols.

point from which a geometric position is to be determined or from which a distance is to be measured. Any letter of the alphabet except I, O, and Q may be used as a datum identifying symbol. A feature control symbol is made of geometric symbols and tolerances. Figure 4-3 shows how a feature control symbol may include datum references.

Fillets and Rounds

Fillets are concave metal corner (inside) surfaces. In a cast, a fillet normally increases the strength of a metal corner because a rounded corner cools more evenly than a sharp corner, thereby reducing the possibility of a break. Rounds or radii are edges or outside corners that have been rounded to prevent chipping and to avoid sharp cutting edges. Figure 4-4 shows fillets and rounds.

Slots and Slides

Slots and slides are used to mate two specially shaped pieces of material and securely hold them together, yet allow them to move or slide. Figure 4-5 shows two types: the tee slot, and the dovetail slot. For examples, a tee slot arrangement is used on a milling machine table, and a dovetail is used on the cross slide assembly of an engine lathe.

Keys, Keyseats, and Keyways

A key is a small wedge or rectangular piece of metal inserted in a slot or groove between a shaft and a hub to prevent slippage. Figure 4-6 shows three types of keys.

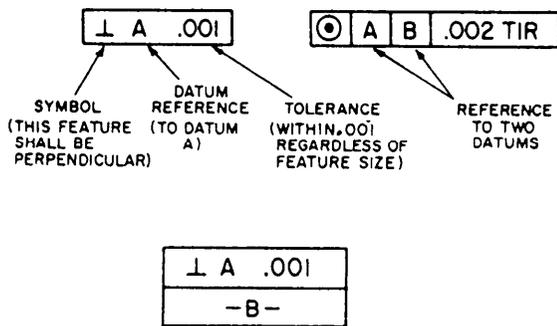


Figure 4-3.—Feature control frame indicating a datum reference.

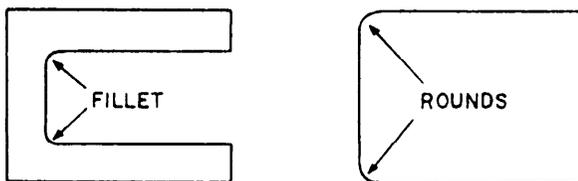


Figure 4-4.—Fillets and rounds

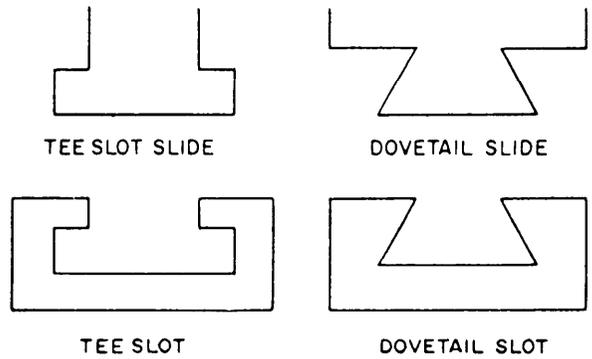


Figure 4-5.—Slots and slides.

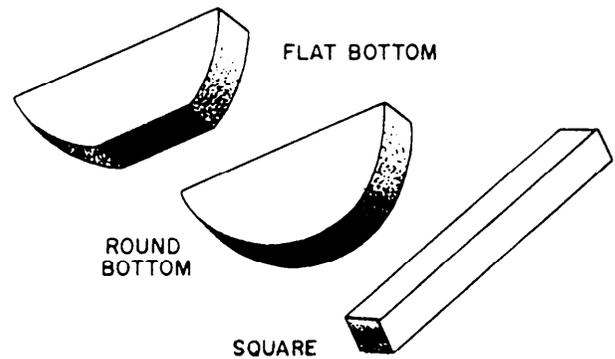


Figure 4-6.—Three types of keys.

Figure 4-7 shows a keyseat and keyway. View A shows a keyseat, which is a slot or groove on the outside of a part into which the key fits. View B shows a keyway, which is a slot or groove within a cylinder, tube, or pipe. A key fitted into a keyseat will slide into the keyway and prevent movement of the parts.

SCREW THREADS

Draftsmen use different methods to show thread on drawings. Figures 4-8 through 4-11 show several of

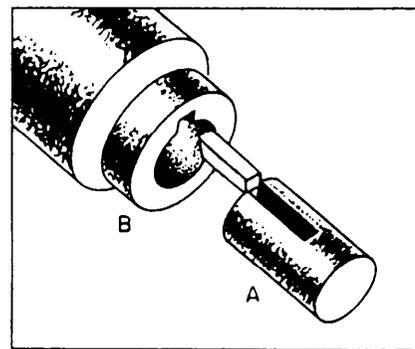


Figure 4-7.—A keyseat and keyway.

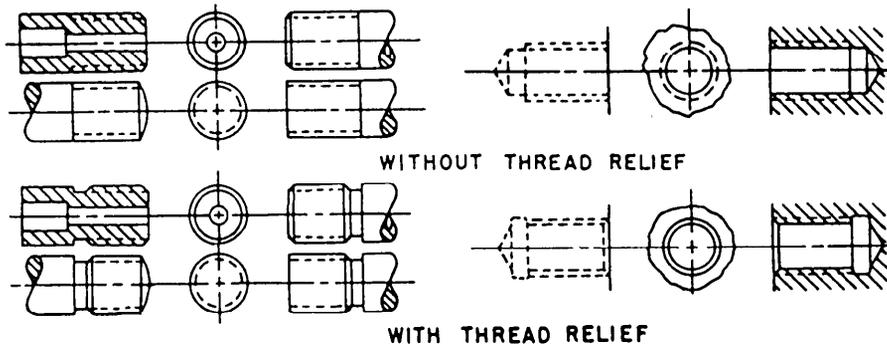


Figure 4-8.—Simplified method of thread representation.

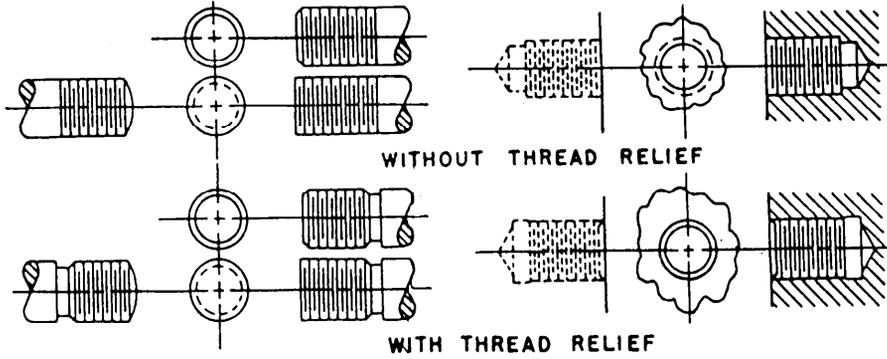


Figure 4-9.—Schematic method of thread representation.

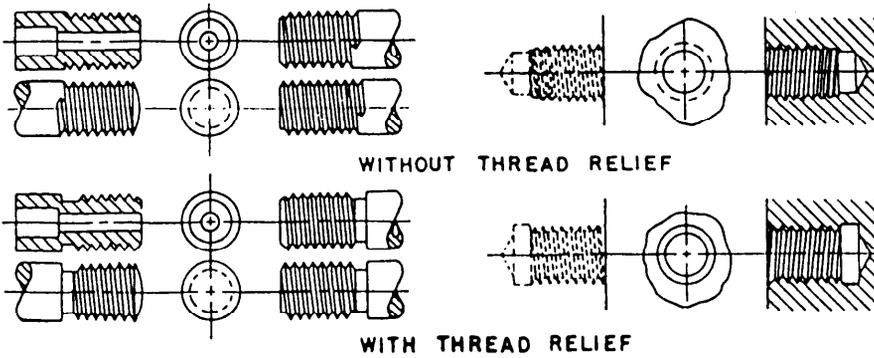


Figure 4-10.—Detailed method of thread representation.

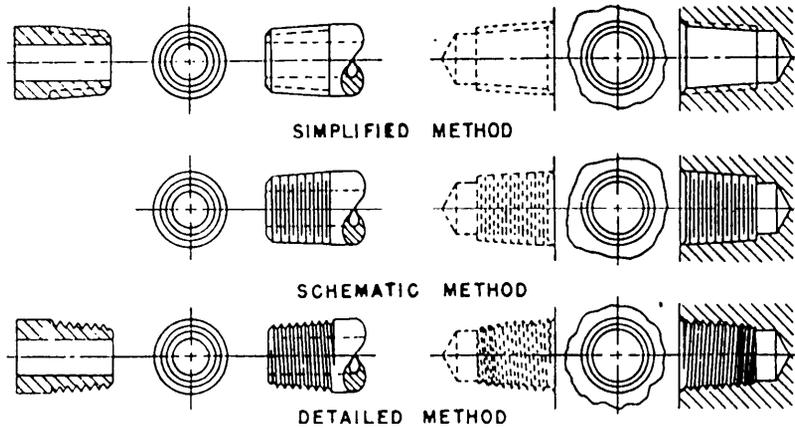


Figure 4-11.—Tapered pipe thread representation.

them. Now look at figure 4-12. The left side shows a thread profile in section and the right side shows a common method of drawing threads. To save time, the draftsman uses symbols that are not drawn to scale. The drawing shows the dimensions of the threaded part but other information may be placed in “notes” almost any place on the drawing but most often in the upper left corner. However, in our example the note is directly above the drawing and shows the thread designator “1/4-20 UNC-2.”

The first number of the note, 1/4, is the nominal size which is the outside diameter. The number after the first dash, 20, means there are 20 threads per inch. The letters UNC identify the thread series as Unified National Coarse. The last number, 2, identifies the class of thread and tolerance, commonly called the fit. If it is a left-hand thread, a dash and the letters LH will follow the class of thread. Threads without the LH are right-hand threads.

Specifications necessary for the manufacture of screws include thread diameter, number of threads per inch, thread series, and class of thread. The two most widely used screw-thread series are (1) Unified or

National Form Threads, which are called National Coarse, or NC, and (2) National Fine, or NF threads. The NF threads have more threads per inch of screw length than the NC.

Classes of threads are distinguished from each other by the amount of tolerance and/or allowance specified. Classes of thread were formerly known as *class of fit*, a term that will probably remain in use for many years. The new term, *class of thread*, was established by the National Bureau of Standards in the *Screw-Thread Standards for Federal Services*, Handbook H-28.

Figure 4-13 shows the terminology used to describe screw threads. Each of the terms is explained in the following list:

HELIX—The curve formed on any cylinder by a straight line in a plane that is wrapped around the cylinder with a forward progression.

EXTERNAL THREAD—A thread on the outside of a member. An example is the thread of a bolt.

INTERNAL THREAD—A thread on the inside of a member. An example is the thread inside a nut.

MAJOR DIAMETER—The largest diameter of an external or internal thread.

AXIS—The center line running lengthwise through a screw.

CREST—The surface of the thread corresponding to the major diameter of an external thread and the minor diameter of an internal thread.

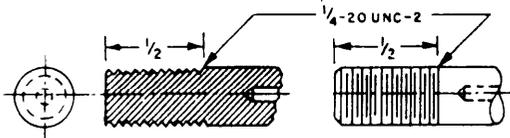


Figure 4-12.—Outside threads.

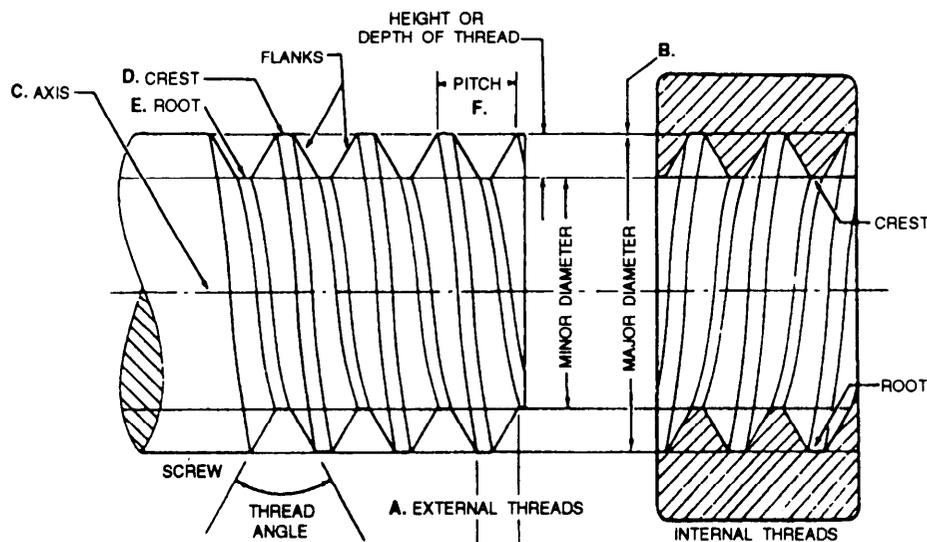


Figure 4-13.—Screw thread terminology.

ROOT—The surface of the thread corresponding to the minor diameter of an external thread and the major diameter of an internal thread

DEPTH—The distance from the root of a thread to the crest, measured perpendicularly to the axis.

PITCH—The distance from a point on a screw thread to a corresponding point on the next thread, measured parallel to the axis.

LEAD—The distance a screw thread advances on one turn, measured parallel to the axis. On a single-thread screw the lead and the pitch are identical; on a double-thread screw the lead is twice the pitch; on a triple-thread screw the lead is three times the pitch

GEARS

When gears are drawn on machine drawings, the draftsman usually draws only enough gear teeth to

identify the necessary dimensions. Figure 4-14 shows gear nomenclature, and the terms in the figure are explained in the following list:

PITCH DIAMETER (PD)—The diameter of the pitch circle (or line), which equals the number of teeth on the gear divided by the diametral pitch

DIAMETRAL PITCH (DP)—The number of teeth to each inch of the pitch diameter or the number of teeth on the gear divided by the pitch diameter. Diametral pitch is usually referred to as simply **PITCH**.

NUMBER OF TEETH (N)—The diametral pitch multiplied by the diameter of the pitch circle ($DP \times PD$).

ADDENDUM CIRCLE (AC)—The circle over the tops of the teeth.

OUTSIDE DIAMETER (OD)—The diameter of the addendum circle.

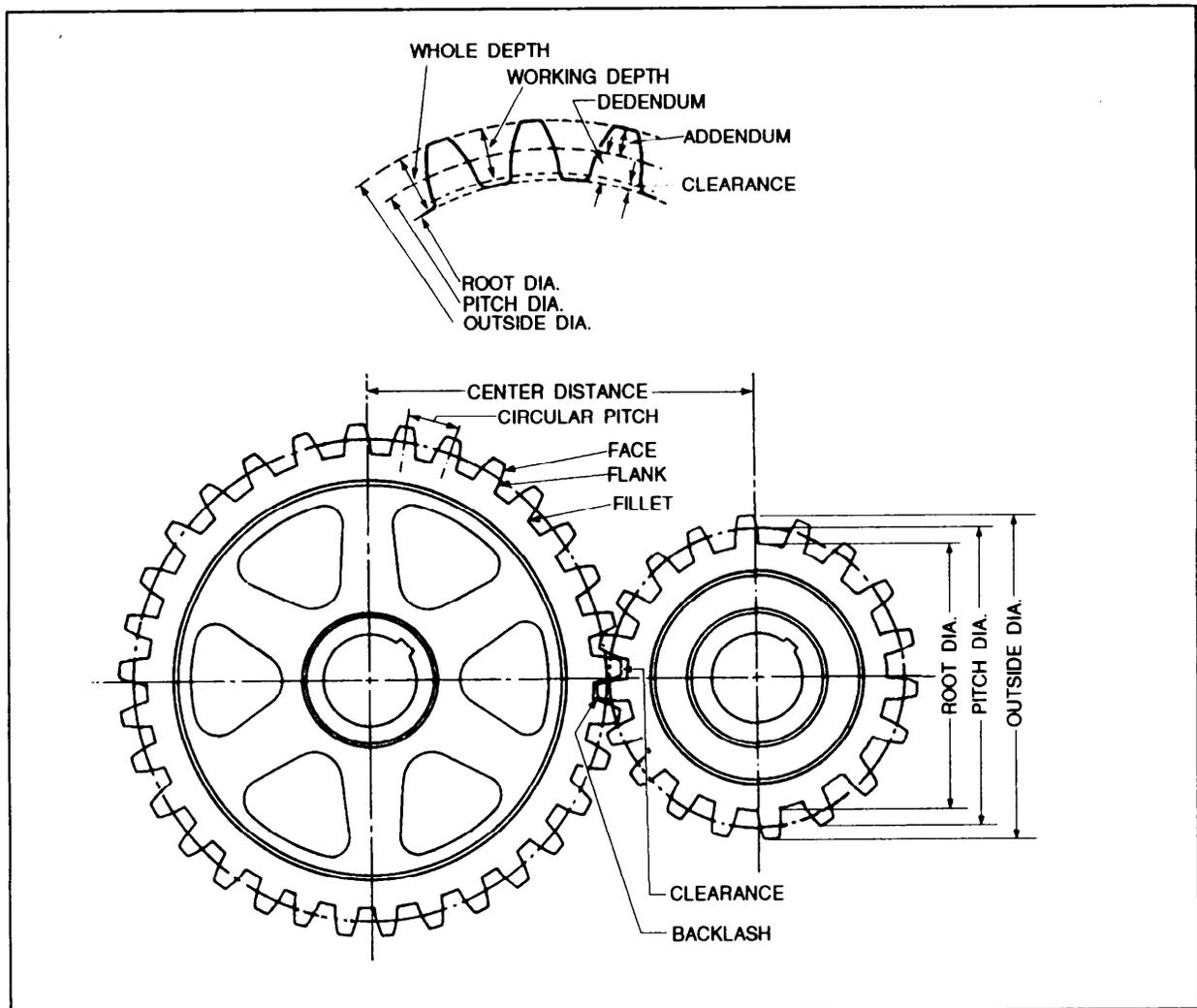


Figure 4-14.—Gear nomenclature.

CIRCULAR PITCH (CP)—The length of the arc of the pitch circle between the centers or corresponding points of adjacent teeth.

ADDENDUM (A)—The height of the tooth above the pitch circle or the radial distance between the pitch circle and the top of the tooth.

DEDENDUM (D)—The length of the portion of the tooth from the pitch circle to the base of the tooth.

CHORDAL PITCH—The distance from center to center of teeth measured along a straight line or chord of the pitch circle.

ROOT DIAMETER (RD)—The diameter of the circle at the root of the teeth.

CLEARANCE (C)—The distance between the bottom of a tooth and the top of a mating tooth.

WHOLE DEPTH (WD)—The distance from the top of the tooth to the bottom, including the clearance.

FACE—The working surface of the tooth over the pitch line.

THICKNESS—The width of the tooth, taken as a chord of the pitch circle.

PITCH CIRCLE—The circle having the pitch diameter.

WORKING DEPTH—The greatest depth to which a tooth of one gear extends into the tooth space of another gear.

RACK TEETH—A rack may be compared to a spur gear that has been straightened out. The linear pitch of the rack teeth must equal the circular pitch of the mating gear.

HELICAL SPRINGS

There are three classifications of helical springs: compression, extension, and torsion. Drawings seldom show a true presentation of the helical shape; instead, they usually show springs with straight lines. Figure 4-15 shows several methods of spring representation including both helical and straight-line drawings. Also, springs are sometimes shown as single-line drawings as in figure 4-16.

FINISH MARKS

The military standards for finish marks are set forth in ANSI 46.1-1962. Many metal surfaces must be finished with machine tools for various reasons. The acceptable roughness of a surface depends upon how the

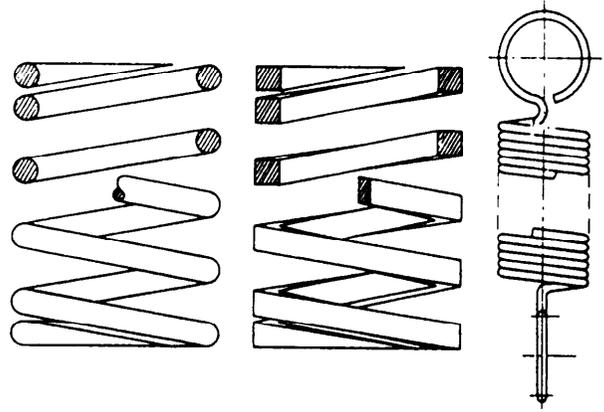


Figure 4-15.—Representation of various types of helical springs.

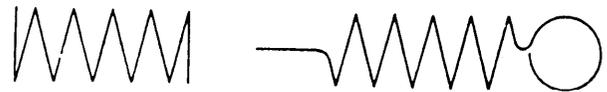


Figure 4-16.—Single line representation of springs

part will be used. Sometimes only certain surfaces of a part need to be finished while others are not. A modified symbol (check mark) with a number or numbers above it is used to show these surfaces and to specify the degree of finish. The proportions of the surface roughness symbol are shown in figure 4-17. On small drawings the symbol is proportionately smaller.

The number in the angle of the check mark, in this case 02, tells the machinist what degree of finish the surface should have. This number is the root-mean-square value of the surface roughness height in millionths of an inch. In other words, it is a measurement of the depth of the scratches made by the machining or abrading process.

Wherever possible, the surface roughness symbol is drawn touching the line representing the surface to

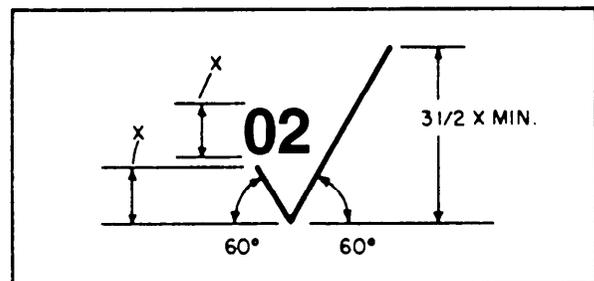


Figure 4-17.—Proportions for a basic finish symbol.

STANDARDS

which it refers. If space is limited, the symbol may be placed on an extension line on that surface or on the tail of a leader with an arrow touching that surface as shown in figure 4-18.

When a part is to be finished to the same roughness all over, a note on the drawing will include the direction "finish all over" along the finish mark and the proper number. An example is FINISH ALL OVER³². When a part is to be finished all over but a few surfaces vary in roughness, the surface roughness symbol number or numbers are applied to the lines representing these surfaces and a note on the drawing will include the surface roughness symbol for the rest of the surfaces. For example, ALL OVER EXCEPT AS NOTED (fig. 4-19).

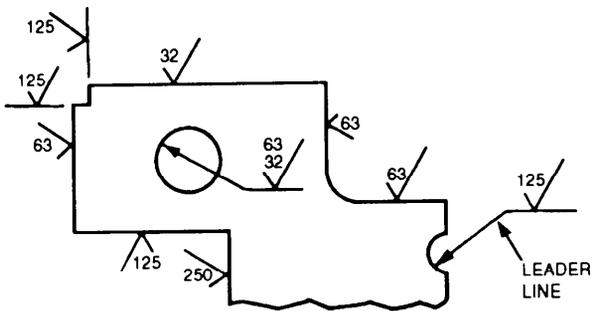


Figure 4-18.—Methods of placing surface roughness symbols.

American industry has adopted a new standard, *Geometrical Dimensioning and Tolerancing*, ANSI Y14.5M-1982. This standard is used in all blueprint production whether the print is drawn by a human hand or by computer-aided drawing (CAD) equipment. It standardizes the production of prints from the simplest hand-made job on site to single or multiple-run items produced in a machine shop with computer-aided manufacturing (CAM) which we explained in chapter 2. DOD is now adopting this standard. For further information, refer to ANSI Y14.5M-1982 and to *Introduction to Geometrical Dimensioning and Tolerancing*, Lowell W. Foster, National Tooling and Machining Association, Fort Washington, MD, 1986.

The following military standards contain most of the information on symbols, conventions, tolerances, and abbreviations used in shop or working drawings:

ANSI Y14.5M-1982	Dimensioning and Tolerancing
MIL-STD-9A	Screw Thread Conventions and Methods of Specifying
ANSI 46.1	Surface Texture
MIL-STD-12,C	Abbreviations for Use On Drawings and In Technical-Type Publications

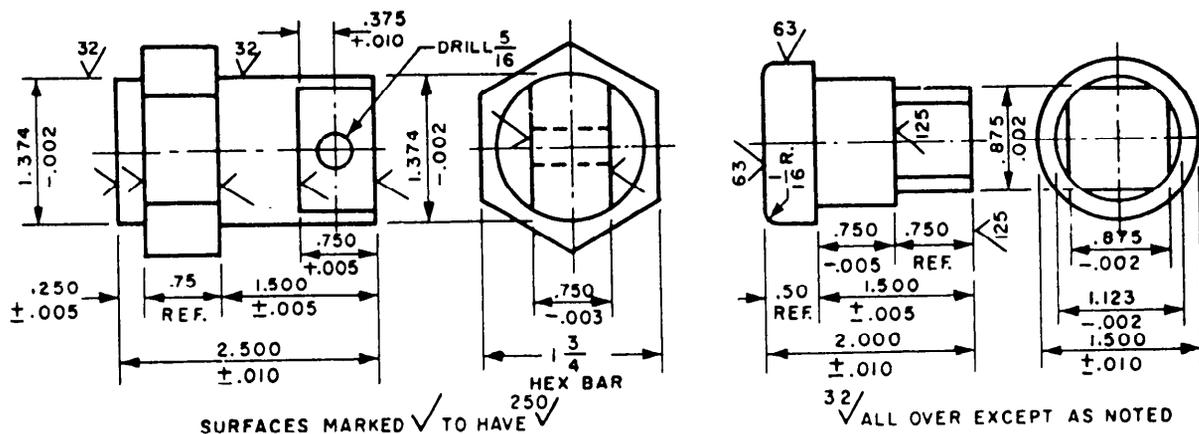


Figure 4-19.—Typical examples of symbol use.

CHAPTER 5

PIPING SYSTEMS

When you have read and understood this chapter, you should be able to answer the following learning objectives:

- Interpret piping blueprints.
- Identify shipboard hydraulic and plumbing blueprints.

PIPING DRAWINGS

Water was at one time the only important fluid that was moved from one point to another in pipes. Today almost every conceivable fluid is handled in pipes during its production, processing, transportation, and use. The age of atomic energy and rocket power has added fluids such as liquid metals, oxygen, and nitrogen to the list of more common fluids such as oil,

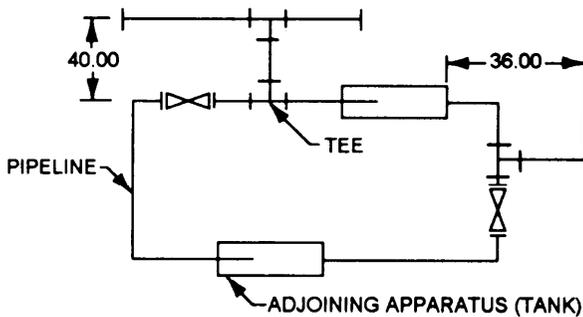


Figure 5-1.—Single-line orthographic pipe drawing.

water, gases, and acids that are being carried in piping systems today. Piping is also used as a structural element in columns and handrails. For these reasons, drafters and engineers should become familiar with pipe drawings.

Piping drawings show the size and location of pipes, fittings, and valves. A set of symbols has been developed to identify these features on drawings. We will show and explain the symbols later in this chapter.

Two methods of projection used in pipe drawings are orthographic and isometric (pictorial). Chapter 3 has a general description of these methods and the following paragraphs explain their use in pipe drawings.

ORTHOGRAPHIC PIPE DRAWINGS

Single- and double-line orthographic pipe drawings (fig. 5-1 and 5-2) are recommended for showing single pipes either straight or bent in one plane only. This method also may be used for more complicated piping systems.

ISOMETRIC (PICTORIAL) PIPE DRAWINGS

Pictorial projection is used for all pipes bent in more than one plane, and for assembly and layout work. The finished drawing is easier to understand in the pictorial format.

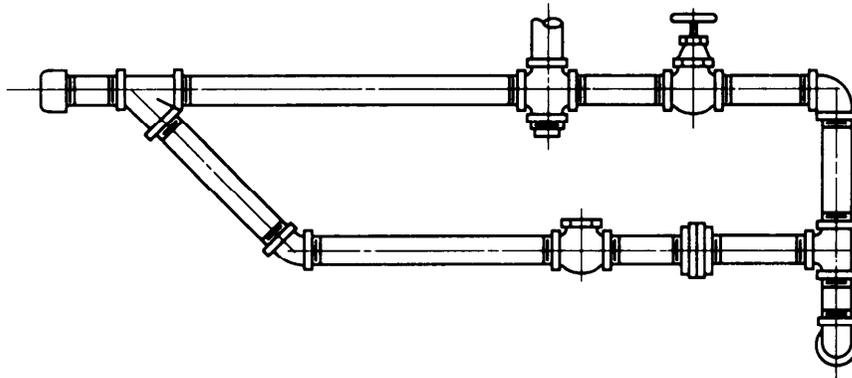


Figure 5-2.—Double-line orthographic pipe drawing.

Draftsmen use single-line drawings to show the arrangement of pipes and fittings. Figure 5-3 is a single-line (isometric) pictorial drawing of figure 5-1. The center line of the pipe is drawn as a thick line to which the valve symbols are added.

Single-line drawings take less time and show all information required to lay out and produce a piping system.

Double-line pipe drawings (fig. 5-4) require more time to draw and therefore are not recommended for production drawings. Figure 5-4 is an example of a

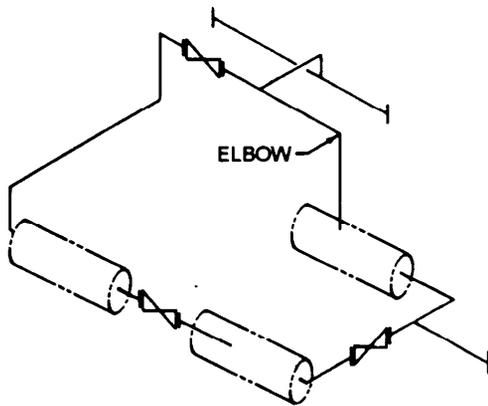


Figure 5-3.—Single-line pictorial piping drawing of figure 5-1.

double-line pictorial pipe drawing. They are generally used for catalogs and similar applications where visual appearance is more important than drawing time.

CROSSINGS

The crossing of pipes without connections is normally shown without interrupting the line representing the hidden line (fig. 5-5, view A). But when there is a need to show that one pipe must pass behind another, the line representing the pipe farthest from the viewer will be shown with a break, or interruption, where the other pipe passes in front of it, as shown in figure 5-5, view B.

CONNECTIONS

Permanent connections, whether made by welding or other processes such as gluing or soldering, should be shown on the drawing by a heavy dot (fig. 5-6). The draftsman normally will use a general note or specification to describe the type of connection.

Detachable connections are shown by a single thick line (figs. 5-6 and 5-7). The specification, a general note, or bill of material will list the types of connections such as flanges, unions, or couplings and whether the fittings are flanged or threaded.

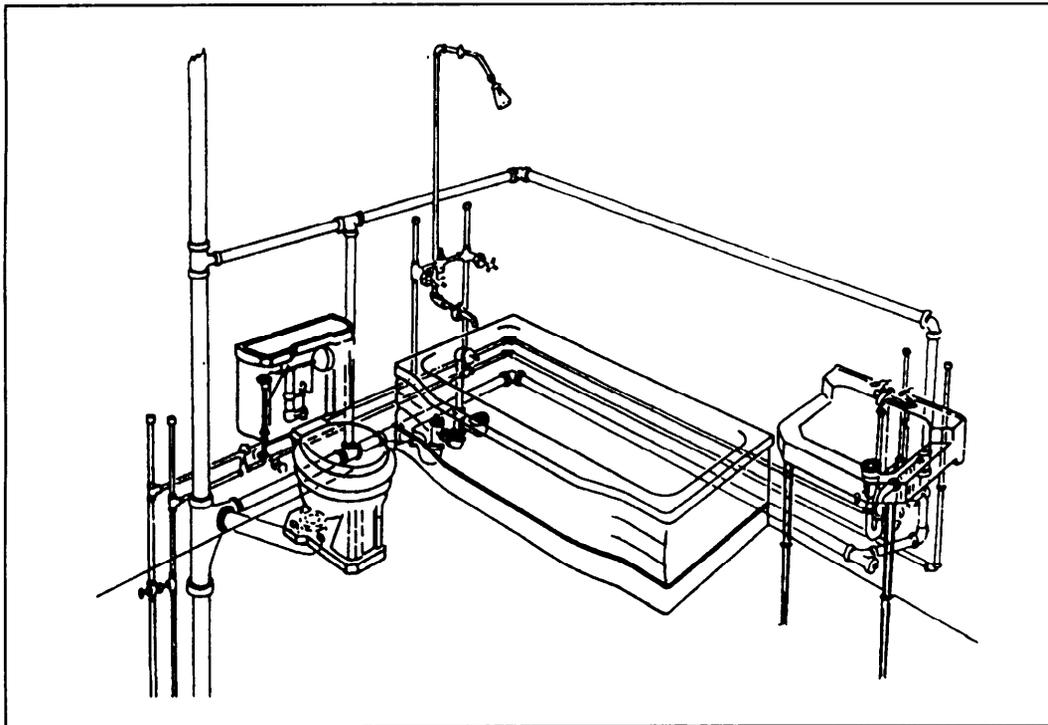


Figure 5-4.—Double-line pictorial piping drawing.

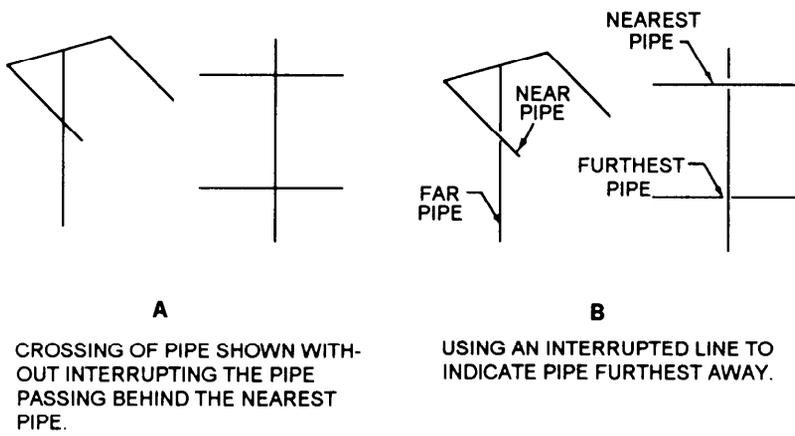


Figure 5-5.—Crossing of pipes.

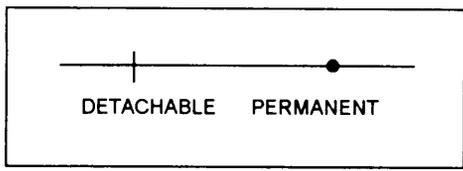


Figure 5-6.—Pipe connection.

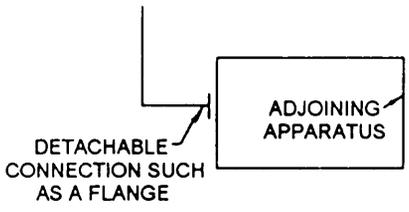


Figure 5-7.—Adjoining apparatus.

FITTINGS

If standard symbols for fittings like tees, elbows, crossings, and so forth are not shown on a drawing, they are represented by a continuous line. The circular symbol for a tee or elbow may be used when it is necessary to show the piping coming toward or moving away from the viewer. Figure 5-8, views A and B, show circular symbols for a connection with and without flanges.

Symbols and Markings

MIL-STD-17B, part I, lists mechanical symbols used on piping prints other than those for aeronautical, aerospacecraft, and spacecraft, which are listed in MIL-STD-17B, part II. Figure 5-9 shows common symbols from MIL-STD-17B, part I. Note that the symbols may show types of connections

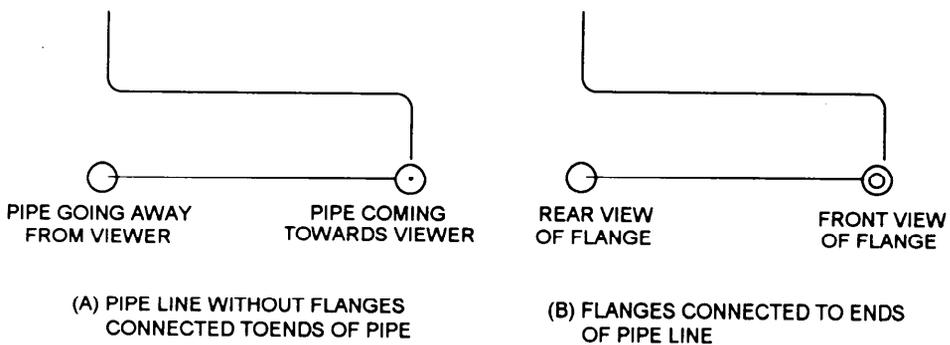


Figure 5-8.—Indicating ends of pipe and fittings.

PIPE FITTINGS, TYPES OF CONNECTIONS					
SCREWED ENDS		CAP		STOP COCK, PLUG OR CYLINDER VALVE, 3 WAY, 3 PORT	
FLANGED ENDS		COUPLING		STOP COCK, PLUG OR CYLINDER VALVE, 4 WAY, 4 PORT	
BELL-AND-SPIGOT ENDS		PLUG		RELIEF, REGULATING, AND SAFETY VALVES	
WELDED AND BRAZED ENDS		REDUCER, CONCENTRIC		VALVE	
SOLDERED ENDS		UNION, FLANGED		SYMBOL	
ELBOWS		UNION, SCREWED		GENERAL SYMBOL	
FITTING		EXPANSION JOINT, BELLOWS		ANGLE, RELIEF	
SYMBOL		EXPANSION JOINT, SLIDING		BACK PRESSURE	
ELBOW, 90 DEGREES		VALVES, TYPES OF CONNECTIONS.			
ELBOW, 45 DEGREES		SCREWED ENDS			
ELBOW, OTHER THAN 90 OR 45 DEGREES, SPECIFY ANGLE		FLANGED ENDS			
ELBOW, LONG RADIUS		BELL-AND-SPIGOT ENDS			
ELBOW, REDUCING		WELDED AND BRAZED ENDS			
ELBOW, SIDE OUTLET, OUTLET DOWN		SOLDERED ENDS			
ELBOW, SIDE OUTLET, OUTLET UP		STOP VALVES			
ELBOW, TURNED DOWN		VALVE		SYMBOL	
ELBOW, TURNED UP		GENERAL SYMBOL			
ELBOW, UNION		ANGLE			
TEES		GATE			
FITTING		GATE, ANGLE			
SYMBOL		GLOBE			
TEE		GLOBE, AIR OPERATED, SPRING CLOSING			
TEE, DOUBLE SWEEP		GLOBE, DECK OPERATED			
TEE, OUTLET DOWN		GLOBE, HYDRAULICALLY OPERATED			
TEE, OUTLET UP		STOP COCK, PLUG OR CYLINDER VALVE, 2 WAY		CHECK VALVES	
TEE, SINGLE SWEEP, OR PLAIN T-Y		STOP COCK, PLUG OR CYLINDER VALVE, 3 WAY, 2 PORT		VALVE	
OTHER PIPE FITTINGS					
FITTING					
SYMBOL					
BUSHING		GENERAL SYMBOL			
		CHECK, LIFT			
		CHECK, SWING			
		GLOBE, STOP CHECK			

Figure 5-9.—Symbols used in engineering plans and diagrams.

OTHER VALVES		BUCKET TRAP	VACUUM-PRESSURE	
VALVE	SYMBOL	FLOAT TRAP	THERMOMETER	
AUTOMATIC, OPERATED BY GOVERNOR		P TRAP	THERMOMETER, DISTANT READING, BARE BULB TYPE	
DIAPHRAGM		RUNNING TRAP	THERMOMETER, DISTANT READING, SEPARATE SOCKET TYPE	
FAUCET		TRAP	AIR CHAMBER	
FLOAT OPERATED		POWER AND HEATING PLANT EQUIPMENT		
LOCK AND SHIELD		UNIT	BULKHEAD JOINT, EXPANSION	
MANIFOLD		AIR EJECTOR	BULKHEAD JOINT, FIXED	
PUMP GOVERNOR		BLOWER	METER, DISPLACEMENT TYPE (OTHER THAN ELECTRICAL)	
SOLENOID CONTROL		BLOWER, SOOT	ORIFICE	
THERMOSTATICALLY CONTROLLED		BOILER, STEAM GENERATOR (WITH ECONOMIZER)	SEA CHEST, DISCHARGE	
STRAINERS		ENGINE, STEAM	SEA CHEST, SUCTION	
TYPE	SYMBOL	EVAPORATOR, SINGLE EFFECT	REFRIGERATION EQUIPMENT	
BOX STRAINER		PUMP, RECIPROCATING	UNIT	SYMBOL
DUPLEX OIL FILTER		PUMP, ROTARY AND SCREW	COIL, PIPE	
DUPLEX STRAINER		TURBINE, STEAM	COMPRESSOR (ALL TYPES)	
STRAINER		GAGES, THERMOMETERS, AND MISCELLANEOUS		CONDENSER, EVAPORATIVE
Y STRAINER		TYPE	SYMBOL	CONDENSING UNIT, AIR COOLED
TRAPS		LIQUID LEVEL	SYMBOL	CONDENSING UNIT, WATER COOLED
TYPE	SYMBOL	PRESSURE	SYMBOL	COOLER, BRINE
AIR ELIMINATOR		VACUUM	SYMBOL	SWITCH, CUT-OUT, HIGH PRESSURE
BOILER RETURN TRAP				SWITCH, CUT-OUT, LOW PRESSURE
				VALVE, EVAPORATOR PRESSURE REGULATING SNAP-ACTION VALVE
				VALVE, EXPANSION, AUTOMATIC
				VALVE, EXPANSION, MANUALLY OPERATED
				VALVE, EXPANSION, THERMOSTATIC

Figure 5-9.—Symbols used in engineering plans and diagram—Continued.

NOTE: WHERE LINE SYMBOLS ON ANY ONE DRAWING
ARE DUPLICATES OF ANOTHER SERVICE LETTER
SYMBOLS MAY BE ADDED.

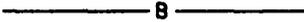
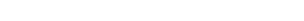
DIRECTION OF FLOW	
AIR CONDITIONING	
BRINE RETURN	
BRINE SUPPLY	
CIRCULATING CHILLED OR HOT-WATER FLOW	
CIRCULATING CHILLED OR HOT-WATER RETURN	
CONDENSER WATER FLOW	
CONDENSER WATER RETURN	
DRAIN	
HUMIDIFICATION LINE	
MAKE-UP WATER	
REFRIGERANT DISCHARGE	
REFRIGERANT LIQUID	
REFRIGERANT SUCTION	
HEATING	
AIR-RELIEF LINE	
BOILER BLOW OFF	
COMPRESSED AIR	
CONDENSATE OR VACUUM PUMP DISCHARGE	
FEEDWATER PUMP DISCHARGE	
FUEL-OIL FLOW	
FUEL-OIL RETURN	
FUEL-OIL TANK VENT	
HIGH-PRESSURE RETURN	
HIGH-PRESSURE STEAM	
HOT-WATER HEATING RETURN	
HOT-WATER HEATING SUPPLY	

Figure 5-10.—Pipe line symbols.

(screwed, flanged, welded, and so forth) as well as fittings, valves, gauges, and items of equipment. When an item is not covered in the standards, the responsible activity designs a suitable symbol and explains it in a note.

Figure 5-10 shows some of the common piping symbols used in piping prints. When a print shows more than one piping system of the same kind, additional letters are added to the symbols to differentiate between the systems.

MIL-STD-101C established the color code used to identify piping carrying hazardous fluids. It applies to all piping installations in naval industrial plants and shore stations where color coding is used. While all valve wheels on hazardous fluid piping must be color coded, the piping itself is optional. The following

colors are painted on valve wheels and pipe lines carrying hazardous fluids:

- Yellow — Flammable materials
- Brown — Toxic and poisonous materials
- Blue — Anesthetics and harmful materials
- Green — Oxidizing materials
- Gray — Physically dangerous materials
- Red — Fire protection materials

Fluid lines in aircraft are marked according to MIL-STD-1247C, *Markings, Functions, and Designations of Hoses, Piping, and Tube Lines for Aircraft, Missiles, and Space Systems*. Figure 5-11 lists the types of aircraft fluid lines with the color code and symbol for each type. Aircraft fluid lines are also

FUNCTION	COLOR	SYMBOL
Fuel	Red	◆
Rocket Oxidizer	Green, Gray	☾
Rocket Fuel	Red, Gray	◆☾
Water Injection	Red, Gray, Red	∇
Lubrication	Yellow	⋮
Hydraulic	Blue, Yellow	●
Solvent	Blue, Brown	≡
Pneumatic	Orange, Blue	X
Instrument air	Orange, Gray	∞
Coolant	Blue	∞
Breathing Oxygen	Green	■
Air Conditioning	Brown, Gray	⋯
Monopropellant	Yellow, Orange	T
Fire Protection	Brown	◆
Deicing	Gray	▲
Rocket Catalyst	Yellow, Green	≡
Compressed gas	Orange	▱
Electrical Conduit	Brown, Orange	↘
Inerting	Orange, Green	++

Figure 5-11.—Aircraft fluid line color code and symbols.

marked with an arrow to show direction of flow and hazard marking, as you will see later in this chapter. The following paragraphs contain markings for the four general classes of hazards, and figure 5-12 shows examples of the hazards in each class.

FLAM — This marking identifies all materials ordinarily known as flammable or combustible.

TOXIC — This marking identifies materials that are extremely hazardous to life or health.

AAHM — This marking identifies anesthetics and harmful materials. These include all materials that produce anesthetic vapors. They also include those that do not normally produce dangerous fumes or vapors, but are hazardous to life and property.

PHDAN — This marking identifies a line that carries material that is not dangerous in itself, but is asphyxiating in confined areas. These materials are generally handled in a dangerous physical state of pressure or temperature.

SHIPBOARD PIPING PRINTS

There are various types of shipboard piping systems. Figure 5-13 shows a section of a piping diagram for a heavy cruiser. Note that the drawing

uses the standard symbols shown in figure 5-9, and that it includes a symbol list. Some small piping diagrams do not include a symbol list; therefore, you must be familiar with the standard symbols to interpret these diagrams.

Standard symbols are generally not used in drawings of shipboard piping systems found in operation and maintenance manuals. Each fitting in those systems may be drawn in detail (pictorially), as shown in figure 5-14, or a block diagram arrangement (fig. 5-15) may be used.

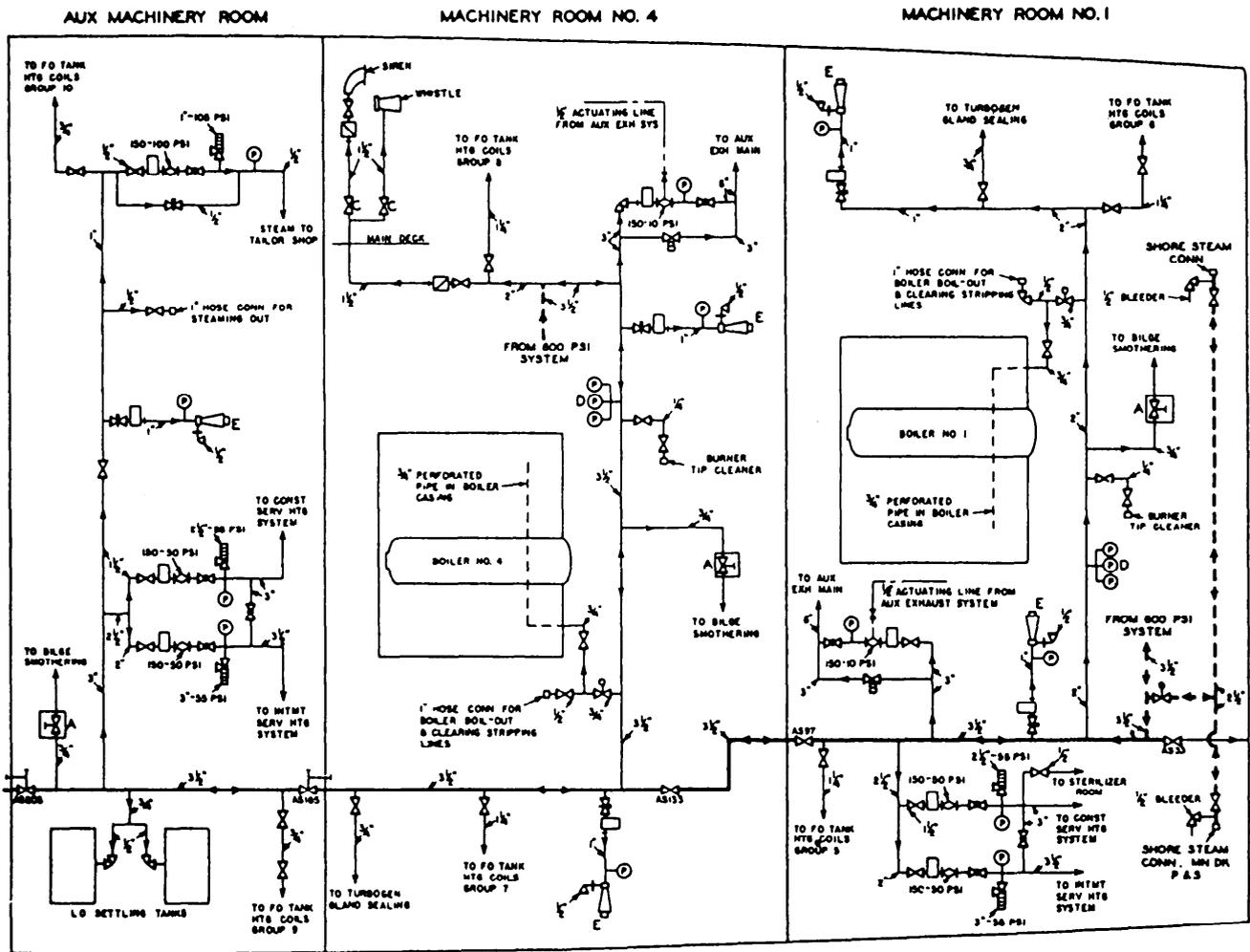
HYDRAULIC PRINTS

The Navy has increased its use of hydraulic systems, tools, and machines in recent years. Hydraulic systems are used on aircraft and aboard ship to activate weapons, navigational equipment, and remote controls of numerous mechanical devices. Shore stations use hydraulically operated maintenance and repair shop equipment. Hydraulic systems are also used in construction, automotive, and weight-handling equipment. Basic hydraulic principles are discussed in the basic training course *Fluid Power*, NAVEDTRA 12064.

To help you distinguish one hydraulic line from another, the draftsman designates each line according

FLUID	HAZARD
Air (under pressure)	PHDAN
Alcohol	FLAM
Carbon dioxide	PHDAN
FREON	PHDAN
Gaseous oxygen	PHDAN
Liquid nitrogen	PHDAN
LPG (liquid petroleum gas)	FLAM
Nitrogen gas	PHDAN
Oils and greases	FLAM
JP-5	FLAM
Trichloroethylene	AAHM

Figure 5-12.—Hazards associated with various fluids.



SYMBOLS

- | | | | |
|-------|------------------------------|--|----------------------------------------------|
| — | 150 PSI STEAM MAIN | | NEEDLE VALVE |
| - - - | STEAM SUPPLY TO MAIN | | REDUCING VALVE |
| | GLOBE STOP VALVE | | RELIEF VALVE |
| | ANGLE STOP VALVE | | PRESSURE GAGE |
| | GLOBE STOP VALVE LOCKED OPEN | | STRAINER |
| | GLOBE STOP VALVE LOCKED SHUT | | SEPARATOR |
| | ANGLE STOP VALVE LOCKED OPEN | | STEAM JET SILENCER FOR SEA CHEST BLOWING OUT |
| | ANGLE STOP CHECK VALVE | | |
| | GATE VALVE | | |

VALVES A ARE ENCLOSED IN A METAL SHIELD & OPERATE FROM ESCAPE TRUNK
 VALVES B OPERATED FROM THE TURBINE OPERATING PLATFORM
 VALVES C ARE LOCATED IN UPTAKE ENCLOSURE AND ARE OPERABLE FROM PASSAGEWAY.
 GAGES D LOCATED ONE EACH ON BOILER GAGEBOARD, OR GAGEBOARD IN CENTRAL CONTROL STATION, & ON SECONDARY CONTROL BOARD IN MACHY ROOM NO 1
 SILENCERS E ARE PROVIDED WITH A 2" HOSE CONN WITH A 1/8" Ø HOLE IN CAP.

Figure 5-13.—A section of an auxiliary steam system piping diagram.

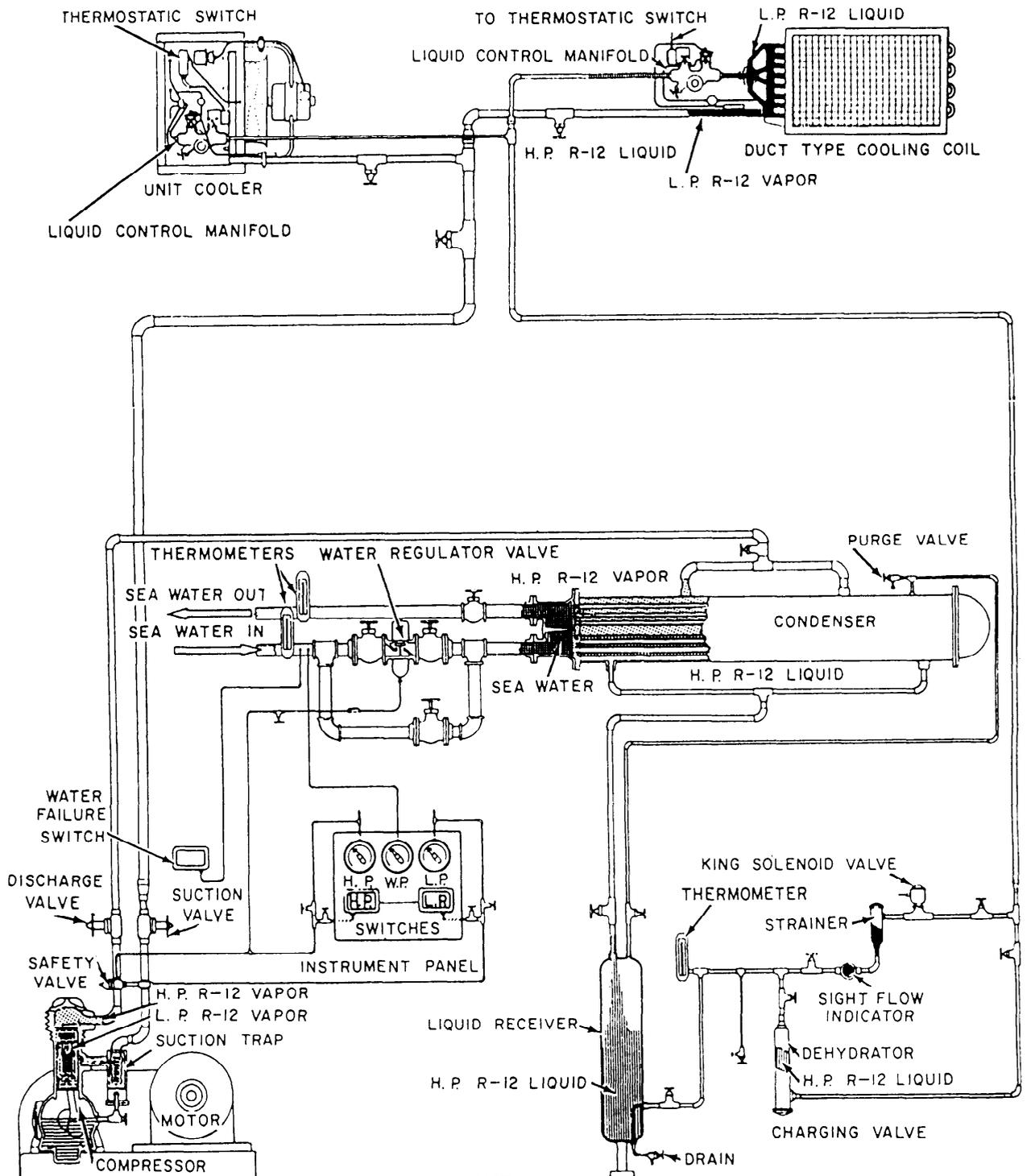


Figure 5-14.—Shipboard refrigerant circulating air-conditioning system.