Lesson One — Piping Systems

Preface

Piping, piping systems, and the many components that make piping systems function are of interest to craftsmen involved in pipefitting, plumbing, and steamfitting. Although each group is specialized, all are directly concerned with various forms of piping, hose, tubing, and the fittings that connect these components into workable systems.

As you study the lessons in this unit, you will gain important, practical knowledge about the piping systems that are a vital part of your plant operation and essential to the success of its total activity. Skilled maintenance craftsmen perform the important function of preventive maintenance to avoid major trouble, and they are depended on to handle the needed repairs when breakdowns occur.

Every occupation, sport, and profession has its own specialized vocabulary, and so does piping. You will find each new term explained as you progress in this unit.

Piping Systems

1.01 This is about piping systems. The term piping system means a complete network of pipes, valves, and other parts designed to do a specific job in your plant. This lesson introduces you to piping systems, and how to maintain them. Many plant operations are so tied-in to the piping system that a piping or valve breakdown in one part of the plant can bring operations in another section to an almost immediate halt.

1.02 Piping systems are necessary to the successful operation of the modern plant facility. Wherever fluids and gases are used in processing operations, they usually move through pipes. Piping carries fuel oil to heating plants, steam to run steam turbines which power generators and alternators used for generating electricity, and lubricants for a variety of equipment. Piping carries the plant's water supply and removes its liquefied wastes. Hoses supply compressed air to air-powered tools and pneumatic systems, as well as fluids in hydraulic systems.

1.03 The materials moved through piping include acids, paints, oils, chemicals, liquefied gases, pulp, and many others. Because of the variety of materials, the components of piping systems are themselves made of different materials. Pipes and fittings can, for example, be made of brass, stainless steel, plastic, and even glass, as well as lead, cast iron, and steel. All components are furnished in many sizes, to accommodate the requirements of numerous applications.

1.04 A familiar example of a piping system is the network of water pipes in your home. It includes pipes, fittings, valves, and faucets. It is the whole group of components working together for one purpose that makes up a system. The system has a definite purpose, which is to bring water into your home and to distribute it.

1.05 A plant has many piping systems. One provides hot and cold water. Another system helps heat the plant, while still another may be used for air-conditioning. Other systems may supply steam, compressed air, or chemicals to the equipment where they are to be used or processed. Examples are given later in this lesson.

1.06 In piping system maintenance, only the fluid transfer systems are important to you, not the units the piping serves or supplies. For example, where a steam boiler is used to provide steam to an enclosed vat or tank you need only be concerned with the piping.

1.07 But maintenance of the boiler itself or of the vat is not a consideration. For our purposes, it is the piping system used to circulate the steam with which we are concerned. That interest begins where the steam outlet is connected to the boiler, and it continues to the point where the pipe is connected to the vat or tank. The piping, fittings, and valves of the pipeline definitely are very important to you.

1.08 Traps, expansion joints, and other fittings help ensure the effective flow of steam through the lines. You will find many of them as you trace a pipeline through the plant. They are important because they are directly related to the operation of the system. And piping maintenance, of course, is concerned with keeping the systems closed, leakproof, and functioning properly.

Fluids

1.09 As you have learned, piping carries "fluids" from one part of the plant to another. According to the dictionary, a fluid is any substance, like a liquid or a gas, that *flows*. (Air is a good example of a gas.) Some of the fluids carried by piping systems include thick mixtures such as concrete in a semi-fluid state. Although such materials would seem to be more solid than liquid, they do flow, and so are considered to be fluids.

1.10 In addition to carrying liquids such as hydraulic fluids and oils, piping systems carry steam and compressed air, which are considered to be fluids because they flow. Fluids travel through a system at various temperatures, pressures, and speeds.

The exercise on the next page covers the material you have just read. Using the REVEAL KEY as explained in the Trainee's Guide, carefully read and answer the first question and check your answer against the printed one before proceeding to the next question. If the answers do not agree, review the material in the paragraph or figure given in the answer frame.

1-1. A complete network of pipes, valves, and related components make a ________ ________.

1-2. A plant piping system is designed to do a specific ______.

1-3. Name four materials used in making pipes and components.

________ ________

________ ________

1-4. The most important consideration in piping system maintenance is the ________ ________ system.

1-5. Piping maintenance is concerned with keeping the system __________ and functioning properly.

1-6. Piping is designed to carry or transfer ________.

1-7. A fluid is defined as any substance or material that ________.

1-8. Steam and compressed air ________ considered to be fluids.
(are/are not)

Protecting Steam Lines

1.11 Before looking at more involved networks of pipes, let's first consider one section of a typical system. Figure 1-1 shows a common arrangement of pipes, valves, and fittings in a low-pressure steam line. This part of the system happens to be built around the steam trap (to be defined later). The valves control the flow of steam through the piping. The fittings connect the sections of pipe. In an actual installation, the length of piping between valves is much greater, depending on the application and its requirements.

1.12 The purpose of this section of the steam line is to direct the steam to the trap, which bleeds the hot water out of the system so only the steam is carried through the piping. The hot water collected by the trap is produced when, for any number of reasons, steam in the piping condenses. That is, the steam cools enough so that some of it becomes water again. This water is called "condensate." The trap is so constructed that the water is caught, but the steam remains in the system.

1.13 To trace the steam line, begin at the upper-left corner of Fig. 1-1, where you will see a fitting that connects three pipes. (The dotted lines show where a fourth pipe could be added, if necessary.) This is where the steam and condensate enter this section of the system.

1.14 With the blow-off and globe valves closed, steam passes through the open gate valve and the strainer to the trap. When the blow-off valve is opened, accumulated debris is blown out of the strainer. With the valve closed, the steam continues through the line to the trap.

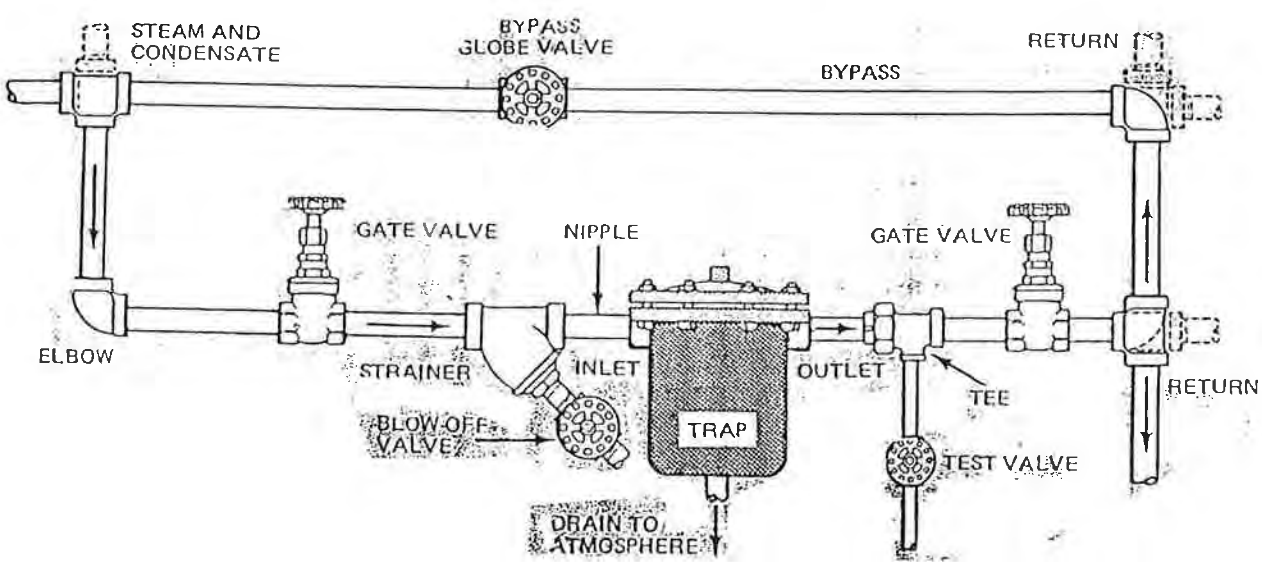
1.15 To permit the pipeline to make a turn, a fitting called an "elbow" is used. Short lengths of pipe known as "nipples" connect the inlet and outlet of the trap to the rest of the system. Condensate left behind in the trap drains to the atmosphere through the bottom outlet of the trap.

1.16 You will note another fitting called a "tee," because it resembles the letter "T." When it is necessary to test the steam for any reason, the gate valve is closed, and the test valve is opened, and the steam passes through the test valve for sampling. When no testing is being done, the steam passes straight through the open gate valve and returns to the steam line.

1.17 When the trap in a functional system similar to that in Fig. 1-1 must be disassembled for inspection or repairs, the globe valve is first opened to let the steam bypass the trap. Then the gate valves are closed to block passage through the trap.

1.18 Pipe fittings (like elbows) are the parts that connect sections of pipe, sections of hoses, and tubing. Those shown in the figure are threaded fittings. When the system is first set up, the pipe sections are cut to the proper length. The ends of the pipe are then threaded to accommodate the appropriate fit-

Fig. 1-1. Valves and piping in a low-pressure steam line.



ting. (Valves and fittings are covered in later lessons.)

1.19 The system-within-a-system represented by Fig. 1-1 shows one part of a more extensive piping system that carries steam from a boiler to a steam turbine, which generates electricity. The boiler and the turbine themselves are not parts of the piping system. The fittings, valves, and trap are, however, necessary to the operation of the system.

1.20 The piping system section is a good example of the fact that a piping system performs a particular job. The whole purpose of the piping leading to and from the trap is to collect the condensate, which is undesirable. Regardless of how complicated the system may seem to be, it is simply a network of components, which carry a liquid or gas from one point to another. Actually, it is not that the system is more complicated, it is just that it may have many elements in it in order to accomplish its function.

Keeping Fluids Clean and Moving

1.21 The components of piping systems have two purposes: One, to help keep the fluid moving freely and smoothly through the system and, two, to help keep the system and fluids in good condition. The steam trap is one example, and filters are another.

1.22 Your automobile engine has an oil filter to clean the oil running through the engine. Impurities such as pieces of metal and dirt can damage engine components and cause excessive wear. To help prevent that wear, the oil is continuously run through a filter designed to trap and clean out the impurities.

1.23 Because piping systems need similar protection, they include traps, strainers, and filters. Such units are especially important because the fluids carried through a system may be damaging to the piping, valves, and fittings. Steam under pressure, acids, various types of waste products, and paint — all are good examples of such fluids. The filters and strainers keep those fluids free from sludge and sediment to protect both the equipment that the system serves, and the piping system itself.

1.24 Figure 1-2 shows what can happen to a piping system. The sludge and corrosion in the pipe

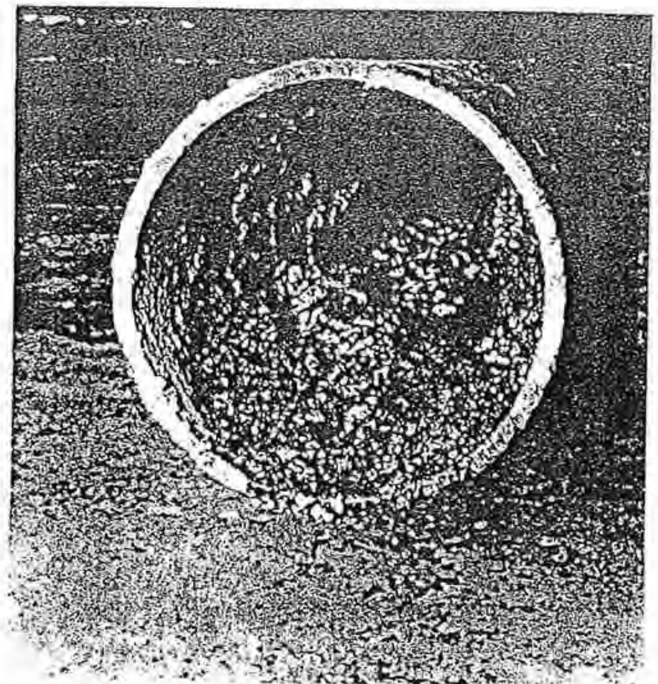


Fig. 1-2. Corrosion and clogging in a water pipe.

shown were produced because impurities in the water that the line carried reacted chemically with the walls of the pipe. This emphasizes the necessity for providing maximum protection in a piping system.

1.25 As an example of the effect of such conditions, consider what happened in this piping system, designed to operate at 80 pounds pressure. Because the sludge and corrosion reduced the inside diameter of the pipe so much, the actual pressure dropped to 35 pounds. As a result, much equipment was not operating properly.

1.26 Originally, the positive-displacement pumps (used to provide the 80 pounds pressure) pumped a given volume of water through the clean pipe. After the clogging took place, the pumps continued to try forcing the same volume of water through the system at 80 pounds pressure, but the pressure had dropped. Obviously, if the pumps continued to run, something else had to be wrong.

1.27 Why did the choking up of the pipe lower the effective pressure? The answer was a familiar one: Friction. The reduction of the I.D. increased the friction between the fluid and the lining or inside wall of the pipe. It is a basic principle applying to all fluids flowing through pipes, that pressure is affected by friction. In other words, the greater the friction, the greater the loss of pressure.

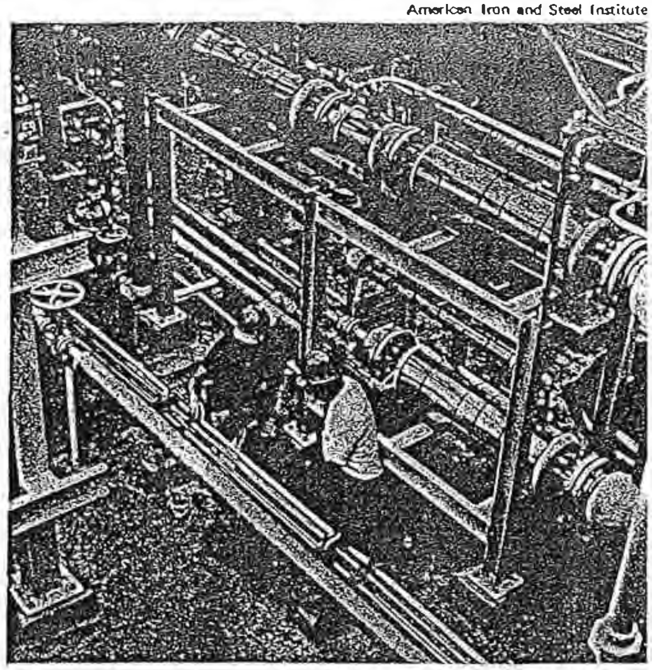


Fig. 1-3. *Routine inspection of a section of a specialized piping application.*

1.28 It is also a rule that if the speed of the fluid is doubled, the friction is increased by four times what it was before. *Or, you can say that ordinarily, the amount of friction increase is the square of the velocity.* If the speed or velocity is three times greater than it was, the amount of friction is nine times greater. If the velocity increases five times, the friction increases 25 times, and so on.

1.29 The water had to run faster, in our example, to move through the pipe. Because the speed of the water pushed by the pumps had to increase up to four times what it was when the piping was clean, the friction increased to 16 times what it was before. The friction loss was the reason that only 35 pounds of pressure reached the far end of the piping system. The equipment designed to operate at 80 pounds pressure couldn't work on the 35 pounds pressure being supplied.

1.30 Why couldn't the pumps be slowed down so that the water could pass more slowly through the system to avoid the effect of increased friction? The answer is that when *pump speed is reduced, lower pressure results.* Besides, if pumps run at other than the speed they are designed for, they do not operate as efficiently.

1.31 The only practical solutions to the problem in our example were either to replace the piping, or to clean the system. It was decided to clean it. This particular installation had three miles of such piping. As you can see, a cleaning job of this kind was a major operation, and a real challenge. It was complicated by the fact that it had to be done with a minimum disruption of normal plant activity.

Piping System Maintenance

1.32 Well-designed piping systems have various features to minimize maintenance and wear-and-tear. One such protective feature is the blow-off valve which you saw in the steam line in Fig. 1-1. The valve can be opened to blow out any foreign material in the line.

1.33 Piping systems may also be equipped with clean-out plugs, inserted in the line at intervals. A clean-out plug is a thick, threaded, round unit screwed into the side of the pipe. With the plug removed, you have access to the inside of the pipe and can clean it out for some distance on each side of the plug. Before that is done, of course, pressure is cut off from the system, or at least from that section of the system which is being cleaned. This is done by either shutting down the system or using valves and auxiliary piping to bypass that section of the line.

1.34 The piping in Fig. 1-2 could have been cleaned by either running chemical solvents through the lines or using mechanical clean-out devices. The solvents dissolve the sludge and corrosion, thus freeing the line so that it can once again supply the needed 80 pounds of pressure. The clean-out devices do the same job mechanically. One type of clean-out device has steel scrapers which clean the sludge out as the tool is drawn through the section of pipe. Rubber squeegee discs at the end of the tool wipe the material out of the pipe after it has been freed by the scrapers.

1.35 Routine preventive maintenance would have detected the problem long before it reached the stage it did. Figure 1-3 shows a two-man team checking a section of piping and tubing. Such inspections at suitable intervals are one of the best means of preventing trouble before it occurs. If you look closely at the illustration, you will note a wide variety of pipes, valves, and fittings. All of them are necessary parts of the total system that, in this case, is in a plant converting salt water into fresh water. Because of salt water's corrosive effects, much of the piping and tubing that you see in the picture is made of stainless steel.

1-9. The flow of steam or other fluids is controlled by ________.

1-10. When steam cools, the resulting water is called ________.

1-11. The fitting normally used to allow a pipeline to make a turn is called an ________.

1-12. Sections or lengths of pipe are connected with pipe ________.

1-13. Name the two basic purposes of pipe system components.

____

____

1-14. Pressure loss of fluids in pipes is affected by ________.

1-15. As friction increases in a piping system the output pressure ________ *(increases/decreases)*

1-16. Piping can be cleaned out either mechanically or with ________ or ________.

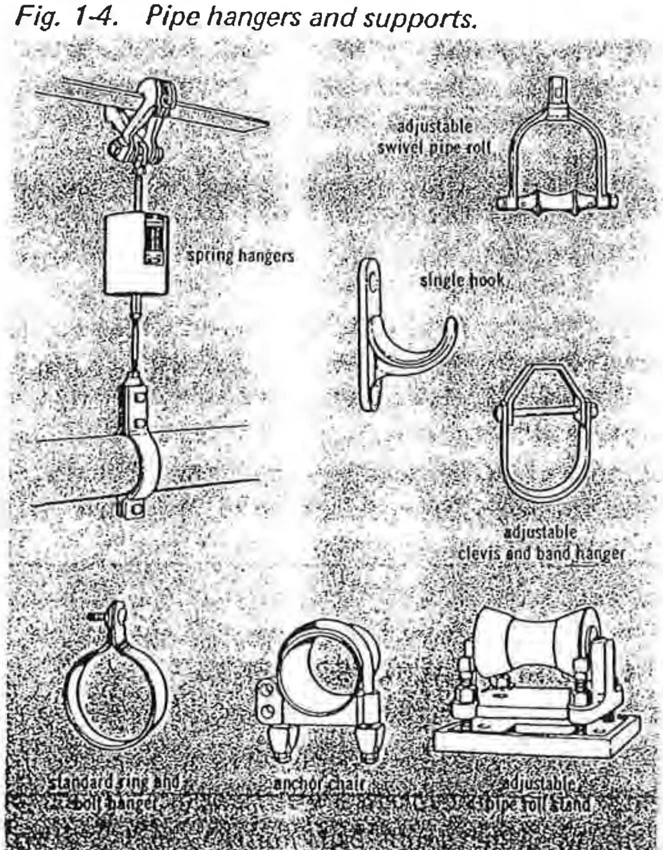
Valves and Fittings

1.36 Piping systems have many components, all related to the single function of moving fluids from one point to another for a particular purpose. The ways in which such components are designed and installed depend on the fluids themselves, the pressures and the temperatures to be expected in the system.

1.37 Remember that the purpose of the steam trap shown in Fig. 1-1 was to collect condensed hot water while keeping the steam in the system. Other components include devices to regulate pressure. Some are protective devices such as valves that automatically open to vent fluid out of the pipe when the pressure in the lines gets too high. In lines carrying liquids you will often see relief valves, preset to open at a given pressure. When they open, liquid flows through the valve and specially provided piping to relieve the excessive pressure in the main pipeline. Protective devices are designed to operate automatically.

1.38 The gate valves and globe valves that you saw earlier are operated by hand, as a rule. That is an important difference between protective valves, or safety valves, and control valves. You will also find pressure gages that show what the pressure in the pipeline is. Many lines include temperature indicators as well.

Fig. 1-4. Pipe hangers and supports.



1.39 To keep fluids clean and free from impurities, piping systems use many types of filters and strainers. Common types include oil bath filters or fine-mesh screens. Oil baths and water sprayers, for example, can be used to remove dust and dirt particles from compressed air lines. If such particles are not removed, they can cause damage and excessive wear to air-driven tools and motors.

1.40 Even a small particle of dirt in a high-pressure air system can be very destructive when it passes through an air turbine. You have probably seen buildings being cleaned by sandblasting. On a smaller scale, dust particles will sandblast air-powered equipment. This is why they must be removed from the line. Filters and strainers in a pipeline carrying liquids help prevent the condition illustrated in Fig. 1-2.

Pipe Hangers and Supports

1.41 Piping must be supported to keep the line straight and to prevent sagging. A rigid pipe that sags excessively will strain its connecting fittings, which will probably cause leakage. A pipeline may be designed to run at a slight angle and will be supported at suitable intervals.

1.42 To some extent, rigid piping is self-supporting because it has a certain amount of mechanical strength. Yet, in a long run, rigid piping must be supported and fastened to the floor, walls, ceiling, or pillars. Figure 1-4 shows a number of common types of pipe hangers and supports. Spring hangers help absorb vibration. The roll types permit the pipe to move as it grows or shrinks in length because of temperature variations.

1.43 Routine preventive maintenance includes checking to be sure that hangers and supports remain properly fastened. Such inspections are especially important in pipelines affected by vibration caused by the activity of the fluids being carried, or by machinery to which the pipes are attached.

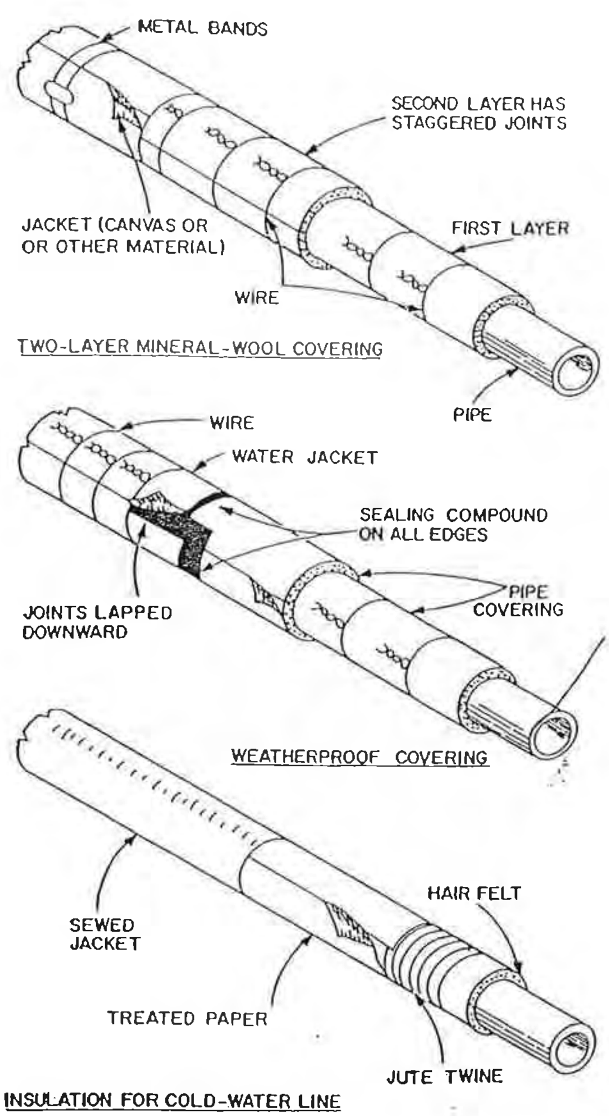


Fig. 1-5. Common pipe insulations.

Temperature Effects

1.44 Nearly all materials, and metals in particular, expand as the temperature increases and contract or become smaller in size as the temperature decreases. To allow for this expansion and contraction in piping systems, expansion joints must be included in the line between sections of rigid pipe. As those sections expand or contract, the expansion joint compresses or expands accordingly. This eliminates strain on the pipes.

1.45 All materials do not expand or contract at the same rate. In applications where pipes and fittings are not made of the same materials, each pipe and fitting will expand or contract at a different rate. Difficulties result if provision for expansion is not made.

1.46 A familiar example of this kind of difficulty is a glass bottle filled with water, capped, and then left out to freeze. It happens that water expands as it freezes, and glass contracts. The result? If the cap does not give way, the bottle breaks.

1.47 Or a large building may be heated by circulating hot water, and air-conditioned by circulating chilled water, through the same pipes. During the winter, the pipes will expand because of the heat, but they will contract in the summer when the air-conditioning system is used. This can strain the pipe fittings. Most connections have seals or caulking to make them tight. Strains can squeeze the caulking from the joints and cause leakage. Proper maintenance includes recognizing such possibilities and preventing them wherever possible.

Piping Insulation

1.48 Piping is frequently covered by layers of insulation, as you have seen in your travels through the plant. Pipe insulation amounts to wrapping the pipe in a blanket of insulating material. The thickness of the blanket of insulation depends on the application. It is a natural law that heat passes from a hot or warm surface to a cold or colder one. Insulation helps prevent hot fluid from cooling as it passes through the system. And if the piping is carrying a cold fluid, insulation helps keep the fluid cold. For example, steam pipes are insulated to help keep the heat in the pipes. If a steam pipe were not insulated, lower temperatures would cause the steam to condense. Also, by keeping the heat in, steam lines do not add heat to areas they pass through.

1.49 Materials used for insulation vary, and they are selected according to the requirements of the application. Typical insulating materials include polystyrene foam, fiberglass, hair-felt, and mineral wool. As shown in Fig. 1-5, insulating layers are applied to pipe in several ways. An outer wrapping may be used to protect the insulating material against the effects of water, chemicals, and mold, or other damaging conditions.

1.50 Condensation is a common problem when a pipe carries a cold fluid. The difference in temperature between the cold pipe and the warmer room

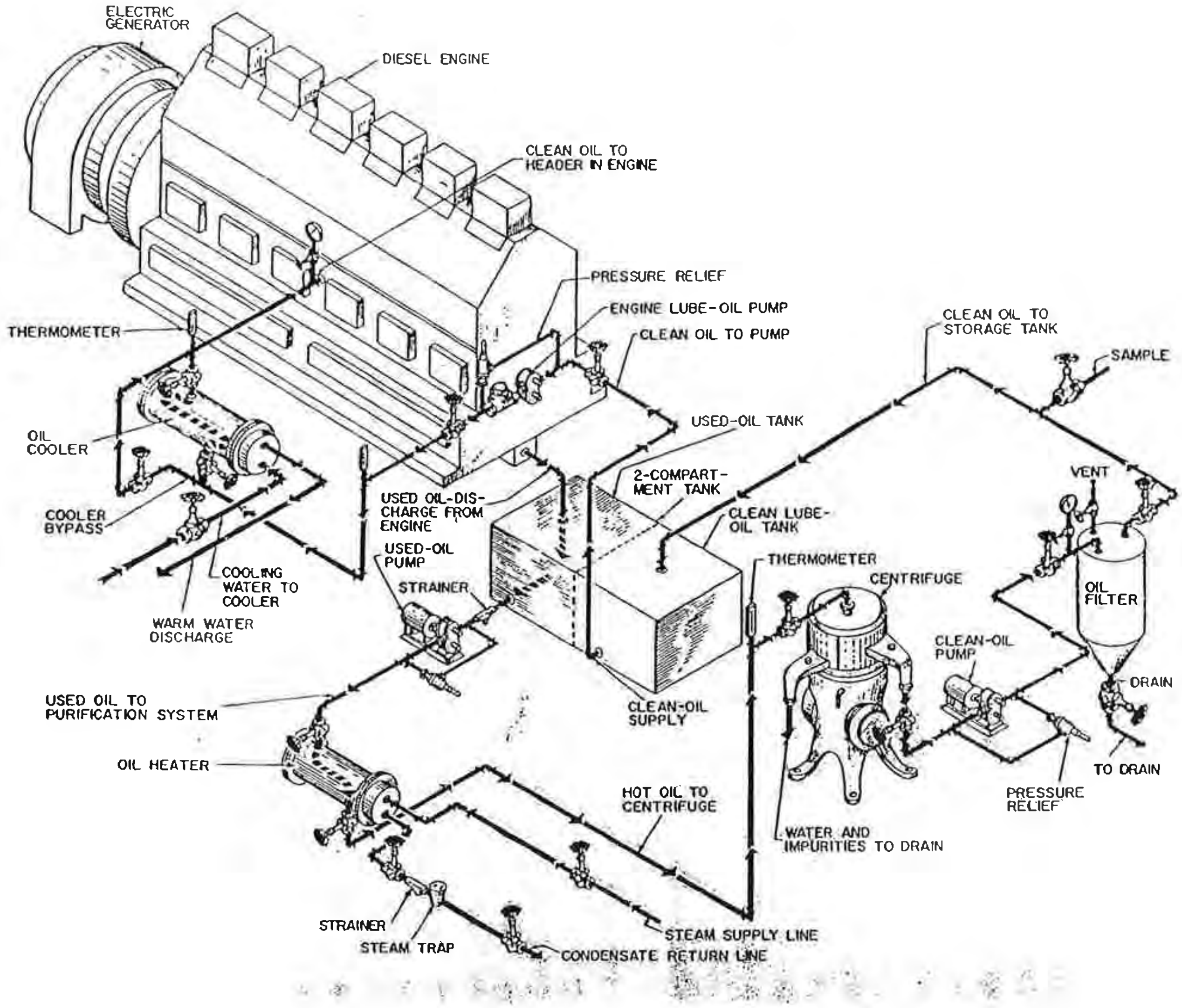


Fig. 1-6. Piping network used in the lubrication-oil purification system of a diesel engine.

air causes water droplets to form on the pipe. The condensation then drips from the pipe. This is the reason why drip pans are commonly installed underneath uninsulated pipes in office areas where circulating cold water is used in the air-conditioning system.

1.51 When several buildings are heated or air-conditioned from a central source, the piping is often underground and insulated. The insulation is further protected with some kind of wrapping. The insulation prevents cooling fluids from absorbing ground heat and prevents warm air from becoming cool, depending on the season of the year.

1.52 Insulation also protects piping against possible rusting and corrosion caused by exposure to water and chemicals in the soil. For additional protection, the outer sheathing is usually covered with a layer of a waterproofing or cement-like material called "mastic."

Typical Piping Systems

1.53 Figure 1-6 shows a piping system used to purify the lubrication oil of a large diesel engine. Although it seems more complicated than the system used in your automobile engine, the principle is exactly the same. That is, dirty oil is cleaned for recirculation to the engine.

1.54 This is how the system works. The used oil drains out of the engine into a used-oil tank. Part or all of the used oil is pumped to a heater, which raises the oil temperature to 180°F (the temperature level considered best for cleaning impurities from oil). The now-heated dirty oil then goes to a centrifuge, a unit which spins the oil around to separate it from water and solid impurities heavier than the oil itself. Next, the partially cleaned oil passes through a filter, which removes smaller impurities. From the filter, the oil is pumped to the clean-oil tank for reuse. On its way back to the engine, the now-clean oil goes through a cooling unit to bring its temperature down to the proper level for use in the engine.

1.55 This type of system is quite common. Note that it has elements that carry oil, and others that carry steam. System components include valves, fittings, and gages.

1.56 As you trace the line, you will find reference to nearly every term covered so far in Lesson One. This is an actual working system, a piping system that is typical of those you will work with.

Maintenance Considerations

1.57 The maintenance of piping systems involves more than making repairs when a breakdown in the system occurs. It is true that accidents can happen, and do, and that unexpected component failures can take place at any time without warning. The real secret of successful maintenance of a piping system lies in knowing what parts it is made of, and where the various parts of the system are located. Preventive maintenance is the key to keeping any piping network operating smoothly and efficiently. By knowing the system, and making routine, scheduled inspections, you will find that your job is much easier and far more satisfying. You will be heading trouble off before it happens.

1.58 The major problems in piping systems are caused by leakage and corrosion. One may cause the other. The nature of the materials being carried has an influence, of course, but you will usually find that the system has been designed to provide maximum precautions, including ample safety margins for excessive pressures and dangerous fluid leakage.

1.59 The following list includes the points with which you, as a maintenance craftsman whose responsibility is the maintenance of piping systems, will be concerned.

1. Checking for corrosion and leakage.
2. Checking to be sure that valves are in working order.
3. Repacking valves, maintaining and replacing gaskets (covered in a later lesson).
4. Checking insulation and possibly installing it as needed.
5. Installing new sections of piping, tubing and hose (covered in a later lesson).
6. Installing, inspecting, and replacing fittings as needed.
7. Checking hangers and pipe supports.
8. Cleaning piping as required.
9. Extending existing systems as needed.
10. Reporting anything of an unusual nature.

In short, it will be up to you to help make certain that the vital pipelines you're concerned with will continue to function smoothly and well. Yours can be one of the most critically important jobs in the whole plant. And that's only one of its advantages. You will also have the personal satisfaction which comes from knowing your job, and doing it well.

1-17. Relief or safety valves are designed to open ______________.

1-18. To keep a pipeline in position and prevent sagging, pipe __________ and __________ are used.

1-19. Spring hangers in piping systems help absorb ______________ .

1-20. To compensate for temperature-caused expansion and contraction of piping, __________ __________ are used.

1-21. What is used to help keep the fluids carried in piping systems hot or cold?

____

1-22. Heat passes from a ________ surface to a __________ surface.

1-23. The key to keeping a piping system operating properly is __________ maintenance

1-24. The major problems in piping systems are caused by __________ and __________