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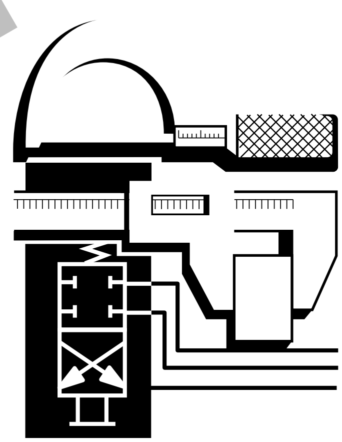
09-1

NONMETALS IN THE PLANT

Lesson One

Introduction to Nonmetals



TPC Training Systems

10601

Lesson

1 Introduction to Nonmetals

TOPICS

Classifying Materials
Properties of Solids
Properties of Liquids
Behavior of Liquids at Rest
Properties of Gases
Behavior of Gases
Fluids in Motion
Mixed States of Matter

OBJECTIVES

After studying this lesson, you should be able to…

- State the definition of a solid, a liquid, a gas, and a plasma.
- Demonstrate how to change a liquid to a solid.
- Demonstrate buoyancy.
- Identify an object less dense than water and an object more dense than water.
- List six possible combinations of matter.

KEY TECHNICAL TERMS

Amorphous 1.14 material having no crystalline structure and no specific melting point

Meniscus 1.16 curved surface of a liquid where it meets a solid surface

Viscosity 1.17 resistance of a liquid to flow

Specific gravity 1.21 density of a material compared to the density of water

Volatile 1.31 able to evaporate rapidly at low temperature

Laminar flow 1.51 flow of liquid or gas in parallel layers

Turbulent flow 1.53 flow of liquid or gas in swirling patterns

Cavitation 1.54 formation of vapor pockets in turbulent-flowing liquid

In order to understand materials, you must understand the basic characteristics of matter. You need to know how matter changes from one form to another. You need to know how matter responds to changes in temperature and pressure.

This lesson explains some of the most basic ideas about matter. It explains things you can see and touch, and things you cannot see or touch. If you can understand matter, you will be better able to use materials in the plant.

This lesson begins with a general explanation of the four states of matter. Then it goes on to describe some of the special characteristics of solids, liquids, gases, and plasmas. Finally, the lesson explains various combinations of materials.

Classifying Materials

1.01 The most important single property of a material is its state of matter—solid, liquid, gas, or plasma. *Solids* generally are rigid objects that keep their size and shape. A block of wood is an example. *Liquids* are water-like materials that flow readily and conform to the shape of their container. Milk in a bottle is an example of a liquid. Most *gases* are invisible vapors. They can expand freely to completely fill a space. Natural gas leaking from a loose fitting is an example of a gas. You cannot see it, but you can smell it quite far from the leak. *Plasmas* are highly charged electrical particles. You will not normally work with plasmas, but you should be familiar with them.

1.02 Another way to explain how solids, liquids, gases, and plasmas differ involves their shape and volume. A solid has a fixed (unchanging) shape and a fixed volume. A liquid has a fixed volume, but its shape can change. Gas and plasma can change both their shape and their volume. Both liquids and gases can flow. For this reason, both are called *fluids*. A fluid is any material that can flow.

1.03 Solids, liquids, gases, and plasmas are *matter*. They have mass, and they occupy space. All matter is made up of tiny particles, called *molecules*. Molecules are always in motion. You cannot see the molecules moving, but their motion is what causes the pressure of a gas. Molecules are constantly striking the walls of a container and bouncing back toward the center. These collisions occur so rapidly and in such large numbers that the effect seems to be a steady, even force over the surface.

1.04 The motion of molecules is also related to temperature. The higher the temperature, the faster the molecules move. The lower the temperature, the slower they move. At a temperature of *absolute zero* (–469°F or –273°C), the molecules have the least possible motion.

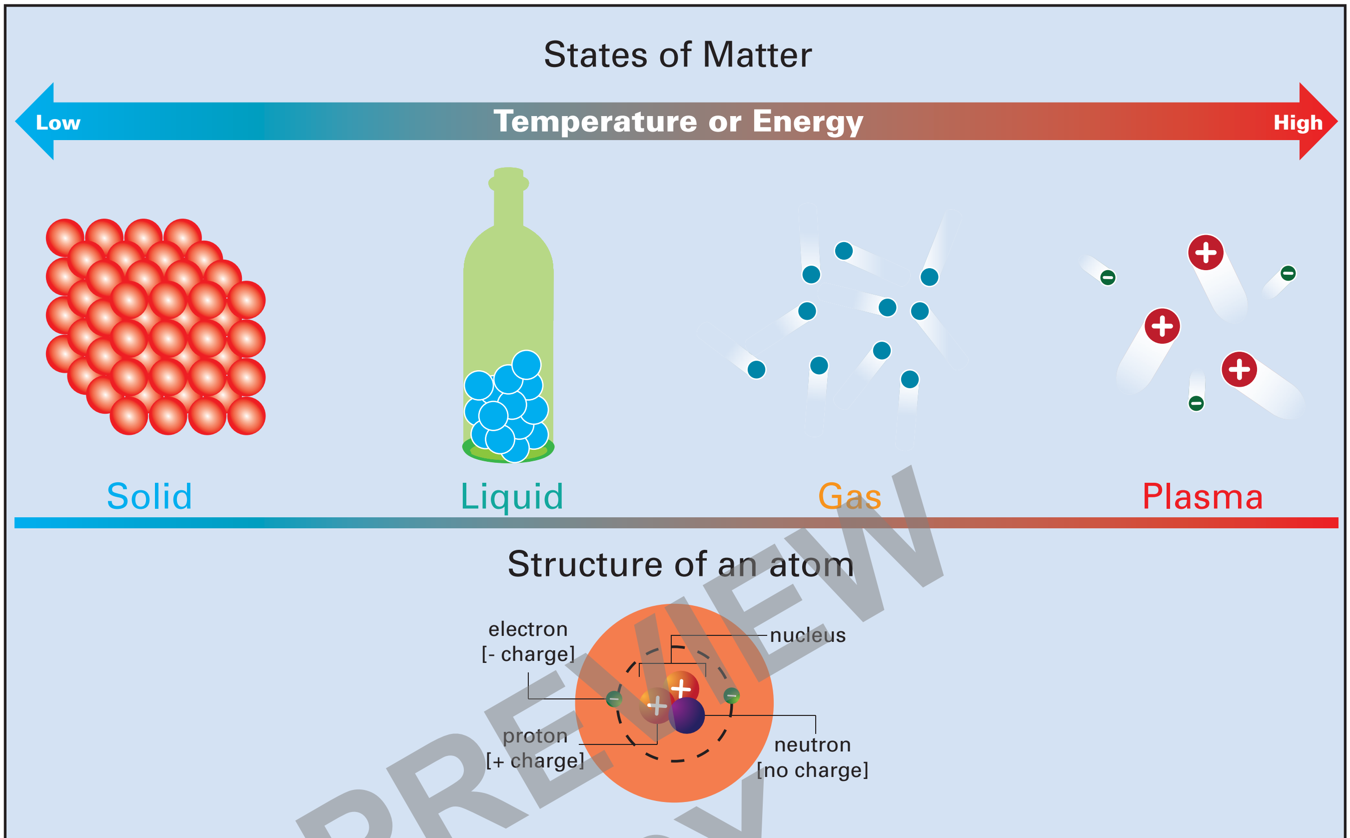
1.05 Some molecules have positive or negative electric charges. These charges produce forces of attraction and repulsion between molecules. Molecules having like charges repel each other, and those having unlike charges attract each other. These forces of attraction and repulsion influence the motion of the molecules and help determine whether the material is a solid, a liquid, or a gas.

1.06 The molecules of a gas fly about until they hit something. But in a liquid, molecules are held together more closely by the forces of attraction. They can still move about, but not as freely. The molecules of most solids fit tightly together, and they only vibrate instead of flying around. As a result, the solid holds its shape, even when it is not in a container. Figure 1-1, on the following page, shows examples of the four states of matter.

1.07 In addition to these electrical forces, all molecules repel each other if they get too close. All molecules attract each other if they are close, but not too close. All these forces, plus the rapid motion of molecules, creates constant chaos among molecules.

1.08 If we could see the molecules, the sight would be very confusing. But we can only see the combined effect of huge numbers of molecules—billions of billions of billions of them. When we see so many, the effects of all their forces and motions

Fig. 1-1. The four states of matter

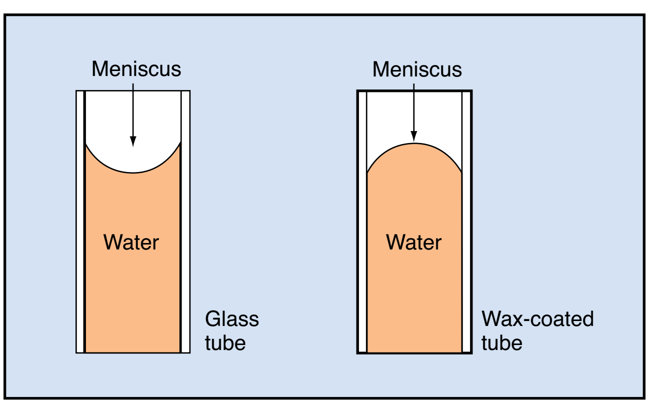


are averaged out. The average looks simple—a solid, a liquid, a gas, or a plasma.

1.09 Materials can change from one state of matter to another, and do so when conditions change. Water is an example of a material that is commonly found in three of the four states of matter—as ice (a solid), as ordinary water (a liquid), and as steam (a gas). The state of water is determined by its temperature and pressure.

1.10 Iron and other metals are most familiar as solids. But they can also be liquid or gas when temperatures are high enough. And, at low enough temperatures, nitrogen, oxygen, and other common gases change into liquids or solids.

Fig. 1-2. Meniscus



Properties of Solids

1.11 Most solids have strong forces of attraction between molecules. These forces hold the molecules closely together in definite geometric patterns. The geometric patterns are called *crystals*.

1.12 Heating a solid to its *melting point* increases the motion of the molecules so much that they break out of their fixed positions. Then the solid changes to a liquid. When cooled, the liquid returns to the solid state.

1.13 Crystalline solids have specific melting points. When you heat the solid, its temperature rises to the melting point, and then stops. The temperature remains constant while the material melts. Then the temperature begins rising again.

1.14 Some solid materials have no crystalline structure and no well-defined melting point. They are called *amorphous* materials. Glass and tar are examples of amorphous solids. When heated, they gradually soften over a range of temperatures until they become liquids. Amorphous materials are also called *noncrystalline solids*.

Properties of Liquids

1.15 An outstanding property of liquid is its ability to flow. A liquid spreads out to fill a container to a certain level forming a *free surface*. The free surface is flat, except where its edges touch the container wall. There it curves slightly upward or downward, depending on whether the liquid "wets" the material of the container.

1.16 For example, water wets glass. Therefore, the surface of water in a glass tube curves upward at the edges. Water does not wet wax. If the tube is coated with wax, the water surface curves downward at the edges, because water does not wet wax. The curved surface is called a *meniscus*. It is shown in Fig. 1-2.

1.17 *Viscosity* is the resistance to flow. It is another important property of liquid. Honey and heavy lubricating oils are liquids that flow slowly. They have high viscosity. Water, alcohol, and light machine oil flow easily. These liquids have low viscosity.

1.18 Raising the temperature of a liquid generally lowers its viscosity. This effect is important in an engine oil. The oil is cool and thick when the engine first starts. In cold weather, the oil may be so viscous that it makes the engine hard to start. As the engine warms up to operating temperature, the oil becomes hot and thin. If the viscosity becomes too low, the oil loses some of its lubricating ability.

1.19 To solve this problem, chemists developed engine oils that do not undergo such large changes in viscosity. At low temperatures, they have lower viscosity than other oils. At high temperatures, they have higher viscosity than other oils. These oils are called *multiviscosity oils*, meaning they behave like different oils at different temperatures.

1.20 The density of a liquid is its mass per unit of volume. In the metric system, density is measured in grams per cubic centimeter (g/cm^3) or in kilograms per cubic meter (kg/m^3). In the U.S. standard system of measurement, density is often measured in pounds per cubic foot (lb/ft^3), even though the pound is a unit of weight, not mass. Fresh water has a density of 1 g/cm^3 (62.4 lb/ft^3). Gasoline has a density of 0.67 g/cm^3 (42 lb/ft^3). The density of mercury is 13.6 g/cm^3 (850 lb/ft^3).

1.21 *Specific gravity* is the ratio of the density of a material to the density of water. Materials that are more dense than water have a specific gravity greater than 1. Materials that are less dense than water have a specific gravity less than 1. Table 1-1 lists the specific gravities of several common materials.

Table 1-1. Densities and specific gravities

Material	Density		Specific gravity
	lb/ft^3	g/cm^3	
Nonmetals			
Water (standard)	62.4	1.00	1.00
Ice	56	0.90	0.90
Tar	75	1.20	1.20
Mortar	94	1.50	1.50
Brick	112	1.79	1.79
Plaster of Paris	112	1.79	1.79
Gypsum	150	2.40	2.40
Glass	162	2.59	2.59
Slate	175	2.80	2.80
Portland cement	193	3.09	3.09
Metals			
Water (standard)	62.4	1.00	1.00
Aluminum	165	2.68	2.68
Zinc	440	7.05	7.05
Cast iron	450	7.20	7.20
Tin	459	7.35	7.35
Nickel	537	8.90	8.90
Copper	556	8.96	8.96
Silver	656	10.50	10.50
Mercury	846	13.56	13.56
Gold	1205	19.30	19.30
Gases			
Dry air (standard)	0.075	0.00120	1.000
Hydrogen	0.005	008	0.069
Water vapor	0.047	075	0.623
Nitrogen	0.073	117	0.967
Oxygen	0.083	133	1.105
Carbon dioxide	0.115	184	1.529

Fig. 1-3. Vapor pressure in a boiling liquid

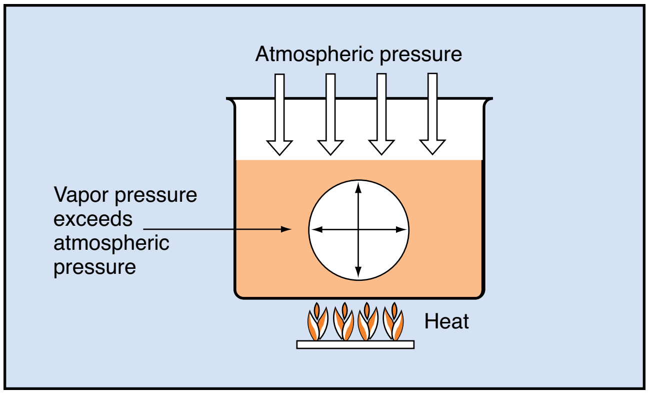
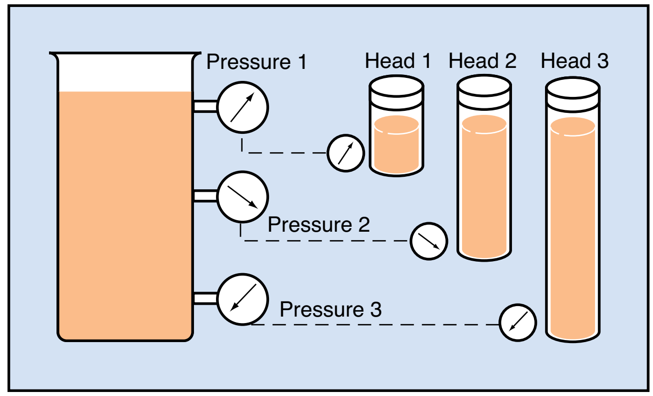


Fig. 1-4. Pressure measured by head



1.22 A material with a specific gravity less than 1 floats in water. If the specific gravity is greater than 1, the material sinks in water. In general, a material floats in a liquid if the specific gravity of the material is less than the specific gravity of the liquid. The material sinks if its specific gravity is greater than the specific gravity of the liquid.

1.23 For example, a block of wood with a specific gravity of 0.8 will float in water (specific gravity = 1.0), but sink in gasoline (specific gravity = 0.67). The specific gravity of the human body is slightly less than 1.0 for most people. That means you will float if you fall into a tank of water. But you will sink if you fall into a tank of gasoline or oil, because your body is too dense compared to the liquid.

1.24 When a liquid is cooled enough, it freezes into a solid. The *freezing point* is the temperature at which a material changes from a liquid to a solid. Water turns to ice at 32°F (0°C). Most liquids shrink when they freeze. But water expands.

1.25 The expansion of freezing water can crack water pipes, an engine-cooling system, and other rigid containers of water. Adding antifreeze lowers the freezing point to avoid such damage.

1.26 *Vaporization* is the change of a liquid to a vapor or gas. Heating a liquid in a sealed container allows molecules to escape into the space above the liquid surface. These escaping molecules accumulate and exert *vapor pressure*. Raising the temperature of a liquid increases its vapor pressure, while lowering the temperature decreases it. When molecules are leaving and entering the liquid surface at equal rates, the vapor is said to be *saturated*.

1.27 *Evaporation* is a form of vaporization. During evaporation, molecules with enough energy escape from the surface of a liquid. Evaporation is a cooling process.

1.28 If evaporation is rapid enough, it can cool the remaining liquid enough to freeze it. The rate of evaporation depends mainly on the temperature, the pressure, and the amount of exposed surface area.

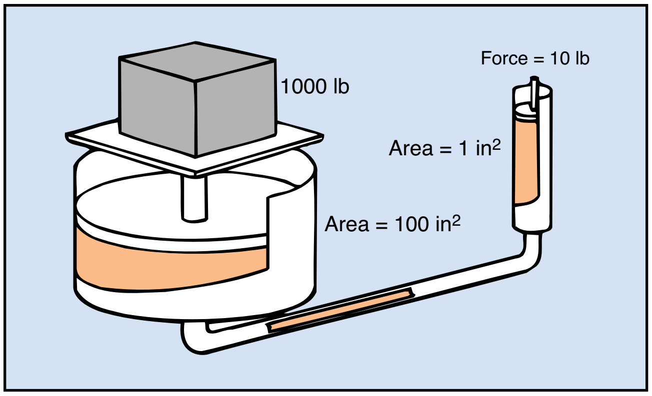
1.29 *Condensation* is the opposite of evaporation. It is a change from vapor to liquid. Condensation occurs when a cold surface is exposed to warmer air. One example is the water that forms on cold pipes on a hot, humid day.

1.30 Boiling *vaporizes* a liquid. The temperature at which a liquid boils is called its *boiling point*. As the temperature of the liquid nears the boiling point, bubbles of vapor begin to form in the liquid and rise to the surface. Boiling begins when the vapor pressure becomes greater than the atmospheric pressure, as shown in Fig. 1-3.

1.31 A *volatile* liquid is one that has a low boiling point. Volatile liquids—gasoline for example—vaporize rapidly at low temperatures. If the liquid is flammable, the vapor is also flammable. A flammable, volatile liquid is dangerous, because it can fill the air with flammable vapor. A flammable liquid that is not volatile is less dangerous.

1.32 Many liquids and their vapors are poisonous or flammable. Some vapor-air mixtures are highly explosive, even at normal room temperatures. To protect yourself and others, always follow all safety recommendations for handling and using any liquid or gas. Your life may depend on it.

Fig. 1-5. Hydraulic lift



WARNING

- **Store all liquids in closed containers.**
- **Do not use or store flammable liquids near a source of flame, heat, or electric spark.**
- **Always provide adequate ventilation.**
- **Use recommended protective equipment.**
- **Always observe safety and health regulations and procedures.**

Behavior of Liquids at Rest

1.33 The pressure at any given point in a liquid equals the depth multiplied by the weight of the liquid per unit value. For example, the pressure of water at a depth of 30 ft is 30 ft × 62.4 lb/ft^3 = 1872 lb/ft^2 = 13 lb/in^2. The pressure in water is the same everywhere at that depth. The total force on the bottom of any tank is the product of the pressure at that depth and the area of the base.

1.34 Pressure can be related to the depth of a liquid. This depth is called *head*. It is the height of a column of liquid that will produce the same pressure. Figure 1-4 shows the head required to produce three different pressures in a tank.

1.35 When you apply an external force to a confined liquid, the pressure at every point in the liquid increases by the amount of the external pressure.

1.36 Figure 1-5 shows how a small external force produces a much larger force. The increase in force occurs because the pressure (force per unit area) is the same on the large piston as on the small piston. The large piston has 100 times the area of the small piston. Therefore, the same pressure produces 100 times as much force on the large piston.

The Programmed Exercises on the following page will tell you how well you understand the material you have just read. Before starting the exercises, remove the Reveal Key from the back of your book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. What are the four states of matter?	1-1. SOLID, LIQUID, GAS, PLASMA Ref: 1.01
1-2. Constant molecular motion causes the ________ in a gas.	1-2. PRESSURE Ref: 1.03
1-3. A ________ material holds its shape even when it is not in a container.	1-3. SOLID Ref: 1.06
1-4. How does the viscosity of a liquid change when its temperature rises?	1-4. DECREASES Ref: 1.18
1-5. The ________ of a material is its mass per unit of volume.	1-5. DENSITY Ref: 1.20
1-6. The process of ________ is the opposite of evaporation.	1-6. CONDENSATION Ref: 1.29
1-7. A liquid with a low boiling point is said to be ________.	1-7. VOLATILE Ref: 1.31
1-8. Head is a measure of ________.	1-8. PRESSURE Ref: 1.34

Properties of Gases

1.37 Gases are measured at a standard temperature and pressure, called *STP*. Standard conditions are necessary, because any change in either temperature or pressure, or both, can change the density or volume of a gas. The standard temperature is 32°F (0°C), and the standard pressure is 1 atmosphere at sea level (14.7 lb/in^2). Industrial gases—oxygen for welding or nitrogen for an inert atmosphere—usually are measured by volume at STP. Occasionally, other temperature and pressure conditions are specified.

1.38 *Density* is mass per unit of volume. The density of a gas is measured in fractions of a pound (weight) per cubic foot (lb/ft^3) or in kilograms (mass) per cubic meter (kg/m^3).

1.39 Some gases have certain uses because of their density compared to the density of air. Hydrogen, for example, is less dense than air by a ratio of about one to 15. For years, hydrogen was used to lift balloons and blimps. Today, helium is used instead. It is less dense than air by a ratio of about one to seven. But unlike hydrogen, helium cannot burn. Therefore, it is safer to use.

1.40 Gases that are heavier than air can settle in low spots and become health or fire hazards. For example, vapors from spilled gasoline creep into low spots because the fumes are about three times as dense as air. To keep these fumes from collecting, always provide plenty of ventilation wherever gasoline is used.

Behavior of Gases

1.41 Gases differ chemically, but they all have similar physical behavior. For example, all gases can be compressed or expanded. If the temperature remains constant, the pressure and volume of a gas are related according to the following formula.

$$\text{Initial conditions} = \text{Final conditions}$$

$$P_1 \times V_1 = P_2 \times V_2$$

1.42 This relationship is called *Boyle's Law*. It states that if the temperature of a confined gas is held constant, the initial pressure (P_1) multiplied by the initial volume (V_1) equals the final pressure (P_2) multiplied by the final volume (V_2). Figure 1-6 shows this relationship for a gas that expands inside a cylinder.

1.43 If a fixed quantity of gas is enclosed in a container having a constant volume, and the temperature increases, the pressure of the gas rises. It is this increase in pressure that causes an aerosol can to explode if you throw it into a fire. This is also the reason why pressurized gases should be stored in cool areas.

1.44 In a container that can change volume—for example, the cylinder in a gasoline engine—pressure and volume vary continually. During the compression stroke, the volume of gas decreases and the pressure and temperature both increase. Then the fuel burns, raising the temperature still more. The increase in temperature produces an increase in pressure, which drives the piston down with great force during the power stroke.

1.45 Some gases can exist in liquid form at room temperature if the pressure is high enough. The industrial gases carbon dioxide, chlorine, ammonia, and propane are stored in liquid form at high pressure in steel cylinders.

1.46 Figure 1-7, on the following page, shows how a gas can be dispensed from a cylinder as a gas or a liquid, depending on the valve position. With the

Fig. 1-6. Boyle's Law

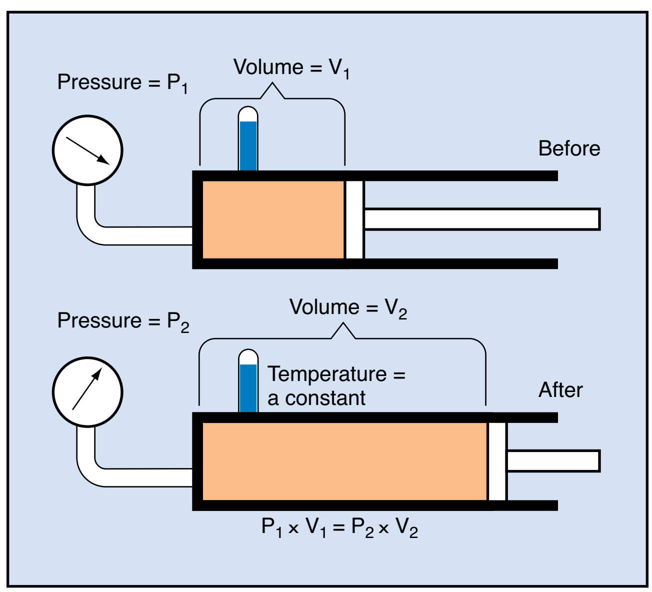


Fig. 1-7. Dispensing gas or liquid

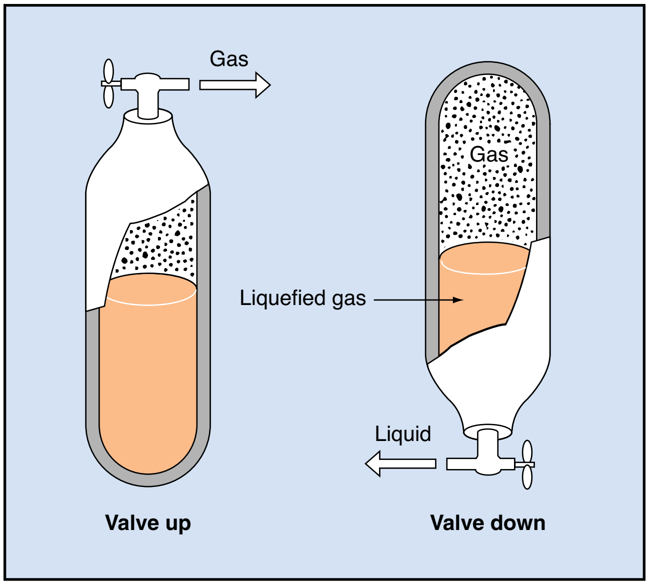
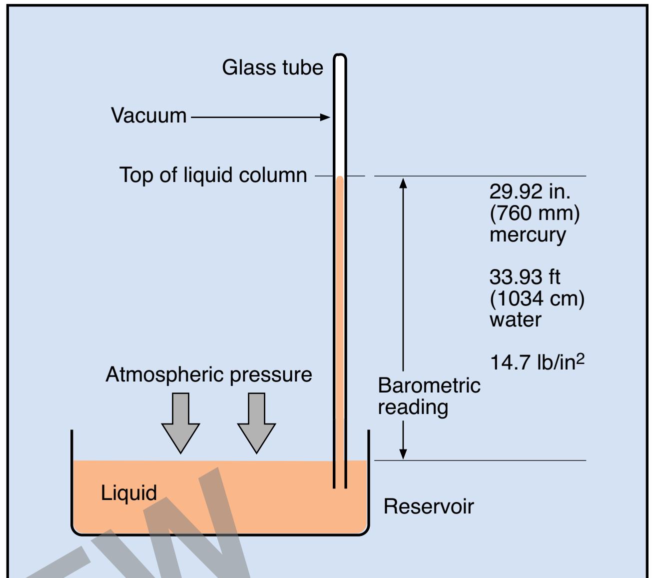


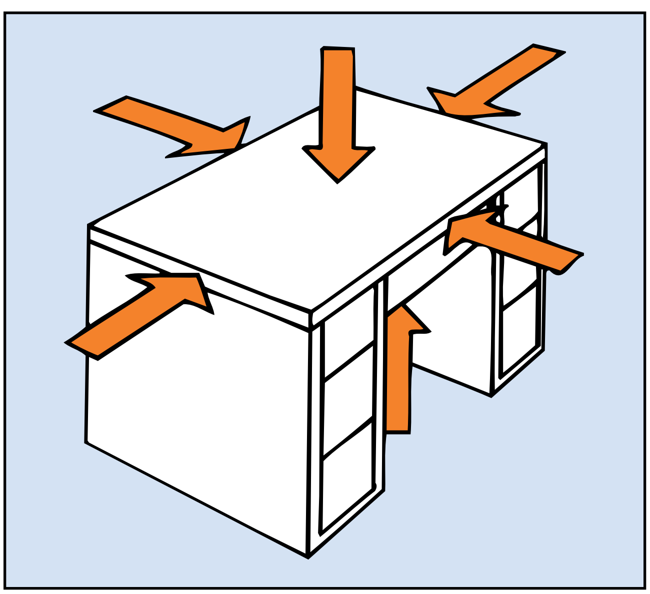
Fig. 1-8. Barometer



valve up, the gas above the liquid flows out through the valve. With the valve down, the liquified gas flows out through the valve.

1.47 *Air* is the most common gas. It is mainly a mixture of oxygen and nitrogen. Air has weight and exerts pressure (force per unit area) on all surfaces it touches. At sea level and 59°F (15°C), atmospheric pressure averages 14.7 lb/in^2 Atmospheric pressure is measured with a *barometer*, as shown in Fig. 1-8. The air pressure forces a liquid (usually mercury) up into a tube that has a vacuum at the top. The height of the liquid in the tube rises and falls with changing air pressure. The average height of the column at sea level is 29.92 in. (760 mm) of mercury.

Fig. 1-9. Balanced forces from air pressure



1.48 Air pressure is usually balanced by other pressures. As a result, the large forces exerted by the atmosphere often are overlooked. For example, the pressure on the top of a 30 × 60 in. desk top produces a force of more than 13 tons, as shown by the following calculation.

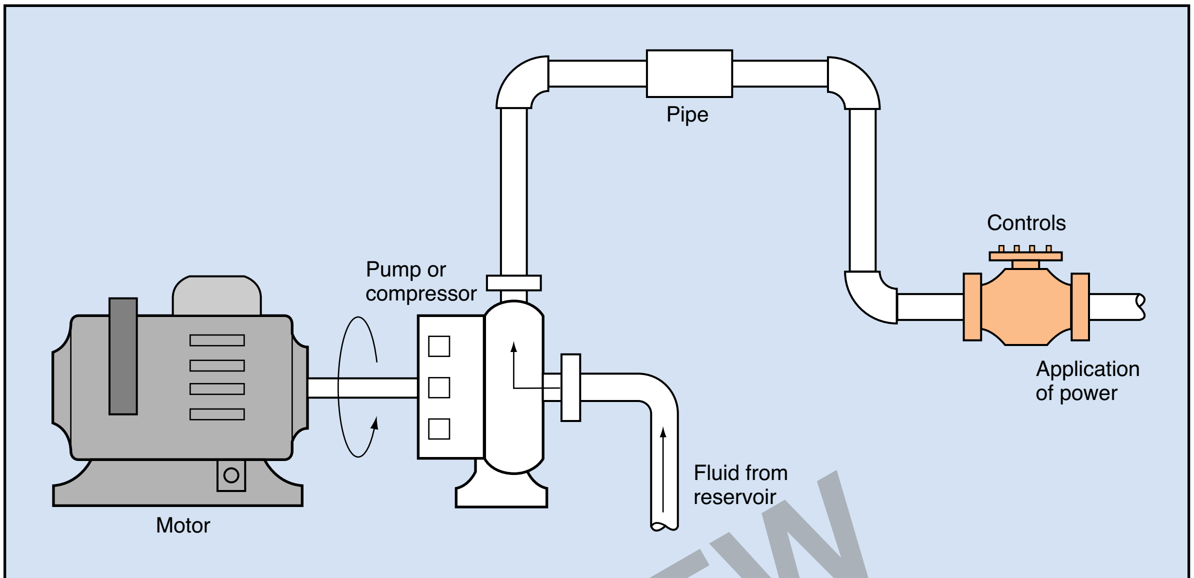
$$30 \text{ in.} \times 60 \text{ in.} \times 14.7 \text{ lb/in}^2 = 26{,}460 \text{ lb}$$

$$= 13.23 \text{ tons}$$

This force is balanced by an equal force upward from under the desk, because the same air pressure acts on the underside of the desk. The same kind of equality acts on the sides of the desk, as shown in Fig. 1-9.

1.49 Pumping the air out of a sealed container removes this balancing pressure. If the force from the outside air pressure becomes greater than the container walls can resist, the container collapses. Therefore, containers that have the air pumped out to create a vacuum must be made of strong materials in special shapes to resist the forces caused by the surrounding air.

Fig. 1-10. Fluid power system



Fluids in Motion

1.50 In a hydraulic or pneumatic power system, a liquid or gas transmits the power. Figure 1-10 shows the basic parts of a fluid-power system. In a hydraulic system, a pump forces a liquid through the transmission line. A pneumatic system uses air or another gas put in motion by a compressor.

1.51 In piping systems, the fluid flow is either laminar or turbulent, as shown in Fig. 1-11. In *laminar flow*, the fluid moves in layers parallel to the pipe. Fluid near the surface of the pipe moves slower than fluid near the center of the pipe, due to friction.

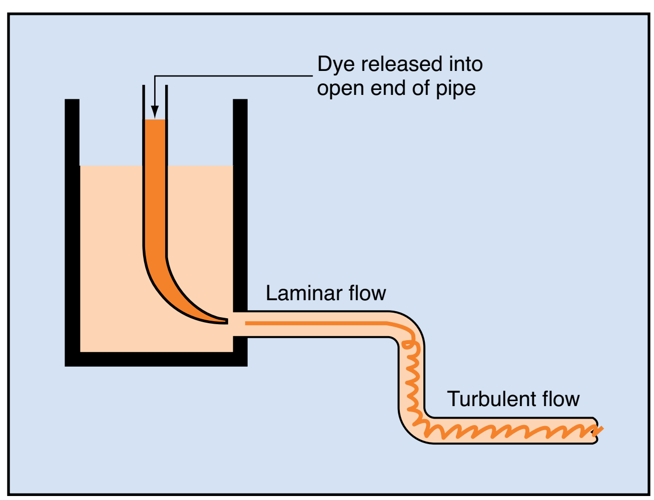
1.52 A disadvantage of laminar flow is that constrictions, obstructions, or sudden changes in direction can change the way the fluid flows. When laying out a piping system, engineers try to avoid such interruptions so that laminar flow is maintained through as much of the piping as possible.

1.53 In *turbulent flow*, the fluid swirls in tiny currents as it flows. Turbulence occurs when fluid is forced through sudden changes in pipe diameter or direction, or around obstacles. Rough or irregularly formed fluid passages also cause turbulence.

1.54 Turbulent flow is undesirable for several reasons. It wastes power, and it causes heat and excessive wear in the piping and equipment. It can also produce tiny pockets of vapor in hydraulic lines or equipment. The formation of vapor pockets is called *cavitation*. Cavitation can make a hydraulic system less responsive, and can damage metal surfaces, making the system useless.

1.55 When a liquid is at rest, the pressure is the same at all points at the same depth. This is not true for liquids in motion. Friction causes a gradual drop in pressure along the pipe in the direction of flow. The pressure drop is proportional to the rate of flow of the liquid. The largest pressure drops in a system are due to constrictions and turns in the pipe.

Fig. 1-11. Laminar and turbulent flow



1.56 There is also a drop in pressure as a fluid is forced to flow through a constriction in a pipe, called a venturi. The fluid speeds up as it goes through the narrower passage, and the pressure decreases as shown by the gauges in Fig. 1-12.

Mixed States of Matter

1.57 Many materials used in industry are mixtures of two or more substances in different states of matter. The six most common combinations are listed below:

- gas and gas
- liquid and liquid
- gas and liquid
- liquid and solid
- gas and solid
- solid and solid.

1.58 In a mixture of two or more gases, each gas exerts pressure as though it were the only gas present. This effect is called the *law of partial pressures*. The sum of the partial pressures equals the total pressure.

1.59 Gases can dissolve in liquids. But the solubility decreases as the temperature rises. The solubility is usually zero at the boiling point of the liquid.

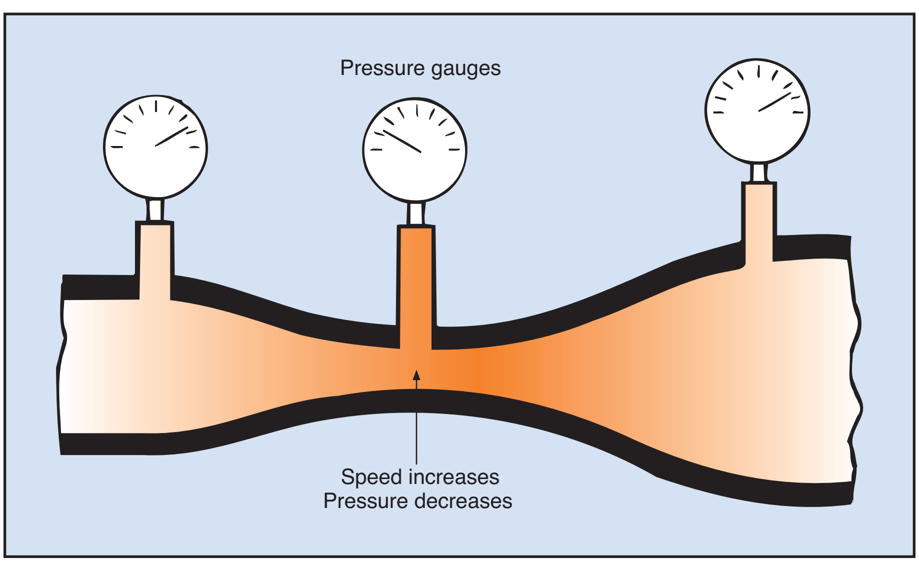
1.60 You can use the relationship between temperature and solubility to solve certain kinds of problems. For example, oxygen in water can cause corrosion. One way to remove dissolved oxygen from water is to boil the water.

1.61 The containers that hold gases under pressure are made of solid materials. This might make it seem that gases and solids do not mix. However, there are many examples of a gas dissolving in a solid. In addition, a solid can be dispersed in a gas. For example, dust is a solid dispersed in air. Activated carbon is an example of a solid that absorbs certain gases. It does this so well that it is used in filters.

1.62 When two or more liquids are put in the same container, their behavior depends on whether their molecules attract or repel each other. If the liquids do not mix with each other, they form two layers. The combination of water and oil is a familiar example. Two or more liquids whose molecules are attracted to each other can mix to form a single, uniform solution. Examples include kerosene mixed with gasoline, and water mixed with alcohol.

1.63 Even after being mixed, two insoluble liquids will separate again. Special additives, called *emulsifiers*, can be added to keep the liquids from separating. The mixture is then called an *emulsion*. Certain hand lotions, medicines, and oil-water cutting solutions are emulsions.

Fig. 1-12. Fluid flow through a constriction



1.64 Certain solids dissolve in certain liquids. Ordinary salt, for example, dissolves in water, but not in gasoline. When a liquid has absorbed all the solids it can, the solution is said to be at its *saturation point*. If more solid material is added to the liquid, it remains in a solid state because it cannot dissolve in the solution. In general, increasing the temperature of the solution increases the amount of solid that can be dissolved.

1.65 Combining two or more solids is often like mixing sand and gravel. Each solid material retains its own characteristics and can be separated from the mixture. But in metal alloys, two or more metals are mixed while they are in their molten state. These mixtures are more difficult to separate. Steel, brass, bronze, and solder are alloys made from molten metals.

1-9. Industrial gases are measured at a standard temperature of ________ and a standard pressure of ________.	1-9. 32°F (0°C); 1 ATMOSPHERE (14.7 lb/in^2) Ref: 1.37
1-10. $P_1 \times V_1 = P_2 \times V_2$ only when ________.	1-10. TEMPERATURE IS CONSTANT Ref: 1.41
1-11. What happens if a fixed quantity of gas is enclosed in a container having a constant volume, and the temperature rises?	1-11. PRESSURE INCREASES Ref: 1.43
1-12. What is the most common gas?	1-12. AIR Ref: 1.47
1-13. In piping systems, the fluid flow is either ________ or ________.	1-13. LAMINAR, TURBULENT Ref: 1.51
1-14. The formation of vapor pockets in a hydraulic line is called ________.	1-14. CAVITATION Ref: 1.54
1-15. In a mixture of gases, the total pressure equals the sum of the ________ pressures.	1-15. PARTIAL Ref: 1.58
1-16. What can be added to two insoluble liquids to keep them from separating?	1-16. EMULSIFIERS Ref: 1.63

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. A substance with a fixed volume but a changeable shape is called a

- ☐ a. gas
- ☐ b. liquid
- ☐ c. plasma
- ☐ d. solid

1-2. The curved surface where a liquid meets the wall of a container is called a

- ☐ a. free surface
- ☐ b. meniscus
- ☐ c. multiviscosity
- ☐ d. specific gravity

1-3. Density is measured in

- ☐ a. ft^3/lb
- ☐ b. kg/m^3
- ☐ c. lb/in^2
- ☐ d. pounds

1-4. A material floats in water if its specific gravity is

- ☐ a. 0
- ☐ b. less than 1
- ☐ c. 1
- ☐ d. more than 1

1-5. During evaporation, the temperatures of a liquid

- ☐ a. decreases
- ☐ b. increases
- ☐ c. stays the same
- ☐ d. varies

1-6. A volatile liquid

- ☐ a. burns
- ☐ b. evaporates rapidly
- ☐ c. explodes
- ☐ d. forms a dangerous vapor

1-7. STP means ______ for industrial gases.

- ☐ a. 0°F, 14.7 lb/in^2
- ☐ b. 0°C, 1.0 lb/in^2
- ☐ c. 32°C, 1.0 lb/in^2
- ☐ d. 32°F, 14.7 lb/in^2

1-8. The gas in a sealed container expands from a volume of 10 m^3 to 15 m^3. Its temperature remains constant. What happens to its pressure?

- ☐ a. Decreases
- ☐ b. Doubles
- ☐ c. Increases
- ☐ d. Stays constant

1-9. When fluid flows through a constriction, its pressure

- ☐ a. decreases
- ☐ b. increases
- ☐ c. stays constant
- ☐ d. stops

1-10. Increasing the temperature of a solution increases its ability to ______ solids.

- ☐ a. condense
- ☐ b. dissolve
- ☐ c. emulsify
- ☐ d. saturate

SUMMARY

As a maintenance specialist, you will be exposed to and required to work with a variety of nonmetal materials. Each material has its own properties and characteristics that make it useful in some applications and useless in others. The better you understand these properties, the better you will be able to work with the materials in your day-to-day jobs.

This lesson covered the most basic forms of all materials—solids, liquids, gases, and plasmas—the four states of matter. Solids are rigid materials that keep both their size and their shape. Liquids can change their shape, but not their volume.

Gases and plasmas can change both their shape and their volume to fit any container perfectly. Solids, liquids, gases, and plasmas can change from one state to another if the temperature changes.

Always be careful when working with liquids and other gases. Many will ignite when exposed to sparks or to an open flame. Also, poisonous gases can easily escape into the surrounding atmosphere if there is the slightest leak in the container. Some gases can collect in pockets if they are much lighter or much heavier than the surrounding air.

Answers to Self-Check Quiz

1-1. b. Liquid. Ref: 1.02

1-2. b. Meniscus. Ref: 1.16

1-3. b. Kg/m^3. Ref: 1.20

1-4. b. Less than one. Ref: 1.22

1-5. a. Decreases. Ref: 1.27

1-6. b. Evaporates rapidly. Ref: 1.31

1-7. d. 32°F, 14.7 lb/in^2. Ref: 1.37

1-8. a. Decreases. Ref: 1.41

1-9. a. Decreases. Ref: 1.56

1-10. b. Dissolve. Ref: 1.64