Lubricants and Lubrication

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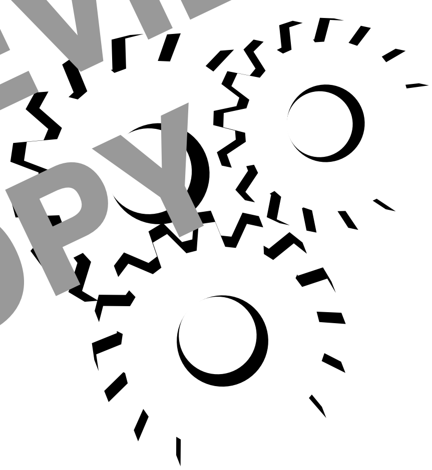
LUBRICANTS AND LUBRICATION

Lesson One

Principles of Lubrication



TPC Training Systems

30201

Lesson

1 Principles of Lubrication

TOPICS

Lubrication
Lubricant Classification
Characteristics of Friction
Why Lubricate Machinery?
Reducing Wear
Dampening Shock
Cooling Action of Lubricants
Corrosion Prevention
Sealing Action of Lubricants
Preventive Maintenance

OBJECTIVES

After studying this lesson, you should be able to…

- Define lubrication and describe the four forms of lubricants.
- Discuss the characteristics of static, kinetic, fluid, and rolling friction.
- Explain how a lubricant reduces wear and dampens shock.
- Discuss the cooling action of lubricants and explain how they prevent corrosion.
- Explain the importance of a lubricant's sealing action and explain how it works.

KEY TECHNICAL TERMS

Lubricant 1.02 a substance that reduces friction by creating a slippery film between two surfaces

Seize 1.20 a condition in which machine parts, because of lack of lubrication, partially fuse together, causing the machine to stop

Dampen 1.36 to absorb or diminish shock or vibration

In the last lesson of the previous course, you read about friction. You saw how it originates, and you saw its effects in terms of different types of wear and surface fatigue. This lesson introduces the topic of lubrication and shows how lubrication counteracts the negative effects of friction.

Proper lubrication is essential to keeping industrial equipment operating. Almost every machine and tool requires lubrication to protect its moving parts and ensure smooth operation. Every maintenance technician should have a strong working knowledge of lubrication principles and procedures.

As you know, every trade or profession has its own special language and vocabulary. The first two lessons of this course present a number of lubrication terms for you to learn.

After you master these terms and ideas, the remainder of this course will involve you in practical skills as they relate to your job. This lesson presents the specifics of bearing and gear lubrication. It also explains why lubricants must be altered in certain ways to meet certain requirements. Finally, the lesson gives you pointers on how lubricants should be handled and stored.

Lubrication

1.01 From the moment you walk through the doors of your plant, you can find all kinds of machinery with moving parts that must be lubricated. Even the hinges on the doors must be oiled or greased. Moving parts of air compressors, machine tools, power presses, and conveyor systems all need lubrication.

1.02 To *lubricate* means to make a surface smooth and slippery. It also means to apply a lubricant. A *lubricant* is any substance that reduces friction by creating a slippery film between two surfaces. This film permits one surface to move easily over the other surface. Some lubricants are made of animal or vegetable fats, while others are of mineral origin. A typical example of a lubricant is the oil in your car's engine. The oil forms a film between the surface of each piston and the cylinder wall.

1.03 As you know, friction is not always a problem. In fact, in many instances, friction is very necessary. For example, it is friction that stops a moving crane or forklift truck when brakes are applied. Friction also transmits power between the belts and pulleys of a drive system.

1.04 Lubrication is required where friction is a problem and must be reduced as much as possible. Unwanted friction causes machine parts to wear out, resulting in costly repairs. Friction force also produces heat and wastes energy. In some instances, the high temperatures caused by friction can even start a fire.

1.05 You may have seen how friction causes wear on the ways of a lathe or other machine parts. It may take a long time for the wear to appear. Retarding the wear on machine parts is one purpose of lubrication.

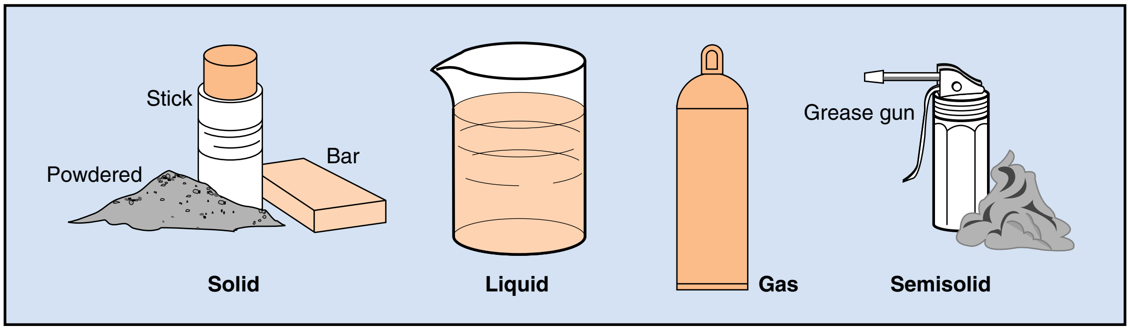
1.06 Friction can destroy bearings if they are not lubricated properly. Both the bearings and shafts can become overheated. High temperature can cause the shaft to expand and the bearings to seize, seriously damaging the equipment. Engineers, designers, and manufacturers are constantly seeking ways to reduce friction between contacting surfaces. Reducing friction reduces wear on the equipment and decreases the energy needed to run it.

Lubricant Classification

1.07 You will come across several different ways of classifying lubricants. Some systems are based on the ways the lubricants can be used, other systems are based on the origins of the lubricants. These systems are covered in later lessons. The one you will read about now is based on the physical form of the lubricant.

1.08 Basically, matter exists in three main forms or physical states: solid, liquid, and gas. Any sample of

Fig. 1-1. Physical forms of lubricants



matter can be changed from one of these physical states to any other physical state if the temperature and pressure conditions are right. This means that any lubricant can exist as a solid, a liquid, or a gas, if certain temperatures and pressures prevail.

1.09 As a result, a classification based on the physical state of a material is meaningless, unless you specify the temperature and pressure conditions you are talking about. In the following discussion, you can assume that the form of the material is the form it has at normal room temperature of 65 to 75°F (approximately 18 to 24°C) and normal atmospheric pressure.

1.10 **Liquid lubricants.** Lubricants that are liquid at room temperature have all the usual properties of a liquid. They occupy a definite volume of space that cannot be changed unless you add more lubricant or take some away. They pour from one container to another. They take the shape of the container into which they are poured, and they can be pumped from place to place. All oils are liquid lubricants.

1.11 **Semisolid lubricants.** Semisolid is not a true physical state of matter, but rather a hybrid between two states—solid and liquid. A semisolid becomes more like a liquid when the temperature rises, and more like a solid when the temperature falls. It can be pumped from place to place, but with greater difficulty than oils. Grease is an example of a semisolid lubricant. You can identify a semisolid by the way it maintains its shape for awhile, but slowly oozes into the shape of its container.

1.12 **Solid lubricants.** A solid is any substance that maintains its shape under normal conditions. Solid lubricants often take the form of powders or granules. Some are made up of extremely fine flakes. They are useful in places where ultra-low temperatures would freeze ordinary liquid lubricants (oils). They are also used in applications where high temperatures would cause ordinary oils to burn up.

1.13 **Gases.** While it may seem strange that a gas could be used as a lubricant, remember that one of the main purposes of a lubricant is to separate moving loaded surfaces. Gases are used under conditions that would make the use of ordinary oils undesirable or impractical, such as high or low temperatures. Mainly, they are used in applications requiring highly accurate separation of moving surfaces. Figure 1-1 shows examples of each of the four physical forms of lubricant.

1.14 The form of a lubricant determines its mode of application. Lubricants are applied in a number of different ways, even by spreading them with your fingers in some cases. Equipment for applying liquid lubricants ranges from thumb-operated oil cans to complex, nearly automatic systems built into the equipment itself. Such systems are not really fully automatic because someone still must see to it that oil levels are maintained in the reservoirs.

Characteristics of Friction

1.15 The primary purpose of a lubricant is to reduce friction. Lubrication is merely a means of separating moving surfaces by providing a film for the surfaces to travel on. To help you understand how this is done, recall some of the basics of friction that were covered in the previous course in this series.

1.16 Take the simplest case of a flat-sided object moving over a flat surface, as shown in Fig. 1-2. If you move Block A across Block B, you feel a consid-

Fig. 1-2. Dry surfaces in contact

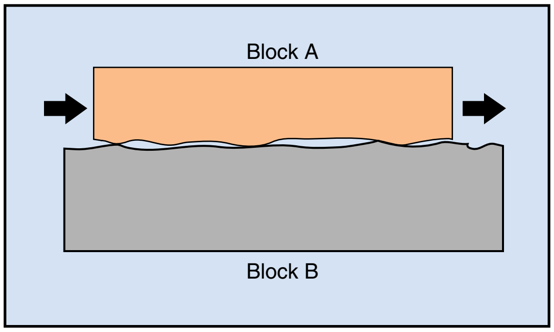
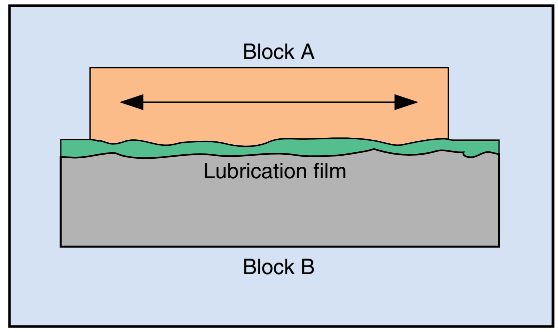


Fig. 1-3. Lubricated surfaces separated by oil film



erable amount of resistance to the effort you apply. That resistance is *friction*. You can think of friction as a resisting force that acts between two surfaces to make it difficult to roll or slide them over each other.

1.17 You recall that *static friction* is the force that must be overcome to start one surface sliding over another. To get Block A to begin to move over Block B, for example, you must first exert a force equal to the maximum static friction between their surfaces. Static friction could be called the friction of bodies at rest.

1.18 Once an object is moving, things become a little easier. The force required to keep an object moving is always less than the static friction force. The force of resistance acting when one surface slides over another is called *kinetic sliding friction*. In other words, this is the friction of motion.

1.19 If Blocks A and B are left standing for some time without a layer of lubrication between them, the static friction force between their surfaces tends to get a little greater. This is because the tiny peaks and ridges that actually touch each other tend to sag and flatten a little, allowing a greater total area of contact.

1.20 If the normal force between Blocks A and B increases greatly, as it does when parts expand due to high temperatures, the starting effort required may be so great that it is almost impossible to get one surface to slide over the other. The surfaces have partially fused together, and the parts have *seized.* This condition occurs where there has been no lubrication.

1.21 But what happens when you apply a lubricant? Figure 1-3 shows the result. Oil is drawn between the two blocks and produces a film between them. When the film is spread evenly across the areas where Blocks A and B are allowed to slide, the blocks remain separated and continually slide on the liquid film. Neither block ever contacts the other.

1.22 When a perfect film is developed and the blocks are fully separated by it, then the laws of *fluid friction* take over. As in the case of friction between solid bodies, fluid friction results from the cohesion of molecules. Anytime you cause one sheet of fluid molecules to move with respect to another sheet of molecules, you disrupt the forces between them. This causes a resisting force.

1.23 Fluid friction can be illustrated in the action of a boat going through the water. The water molecules in contact with the surface of the boat hull tend to adhere to the hull. Therefore, that layer of molecules travels at the boat's speed. Other layers of water molecules nearby are drawn along by the motion. But the layers travel at slower and slower speeds the farther they are from the boat.

1.24 The forces of attraction among all these layers of water molecules tend to retard the motion of the boat. The same effect occurs in a bearing. The friction caused by metal-to-metal contact is eliminated when a film of lubricant is applied. That friction, however, is replaced by another friction, fluid friction, because the metal surfaces are moving through the liquid oil. Fortunately, fluid friction force is usually much smaller than kinetic sliding friction force.

1.25 Another type of kinetic friction that must be mentioned is *rolling friction*, as shown in Fig. 1-4. The rolling action is different from sliding action (Fig. 1-2) because only a small part of the roller is actually touching the surface on which it is rolling.

Fig. 1-4. Rolling friction is low because of small contact area

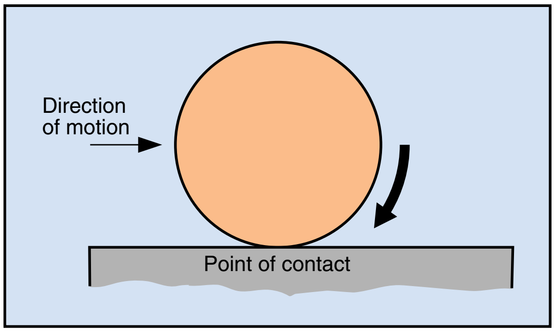


Fig. 1-5. Deformation of a surface by a rolling object

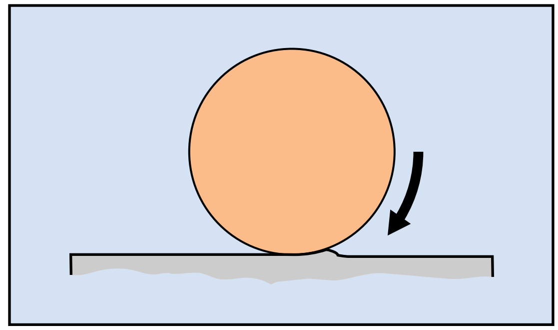
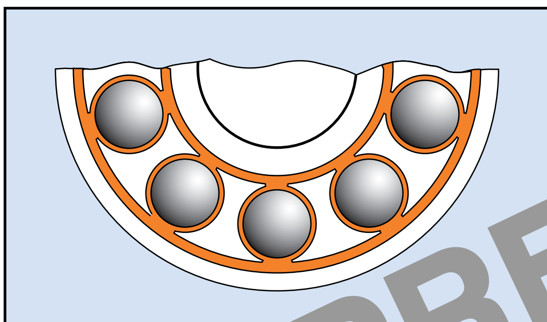


Fig. 1-6. An oil film completely surrounds each ball in a lubricated ball bearing



1.26 As a roller, ball, or wheel moves across a firm surface, the surface is deformed a little by the extra load it has to bear. This deformation moves ahead of the roller like a wave, as shown in Fig. 1-5. The wave is microscopic in size and cannot be seen with the naked eye. Nevertheless, it does cause some resistance to rolling, which is called rolling friction.

1.27 Rolling friction is much slighter than sliding friction. When roller bearings or ball bearings are installed on a shaft, the total rotating friction is much less than if the shaft were rotating in plain journal bearings. Rolling friction can be reduced still more by adding a lubricant.

Table 1-1. The six basic purposes of lubrication

1. To reduce friction	5. To prevent corrosion
2. To reduce wear	6. To seal out dirt and other contaminants
3. To help dampen shock	
4. To cool moving elements	

1.28 When oil is applied to a ball bearing, for example, each ball is completely coated with a film of lubricant. As shown in Fig. 1-6, the film separates the ball from the metal surfaces it had been touching. Now, as the ball rolls along, it produces a small shock wave in the fluid oil instead of in the solid bearing surfaces. Since deforming a liquid causes less resistance than deforming a solid, the total friction has been reduced still more by the oil.

1.29 Because considerable fluid movement occurs in a lubricated ball or roller bearing, fluid friction is an important part of the total friction. Oil is churned and moved about in many directions. As a result, internal friction within the oil itself can become rather large, and the oil can begin to heat up.

Why Lubricate Machinery?

1.30 As you can see, you never really get rid of friction when you lubricate machinery. You can reduce it a great deal, however. The reduction of friction to tolerable levels is the single most important reason for lubrication. However, there are other reasons as well.

1.31 Table 1-1 lists six reasons for lubricating machines. You have examined the first reason, to reduce friction, in some detail. Now consider each of the other five reasons.

Reducing Wear

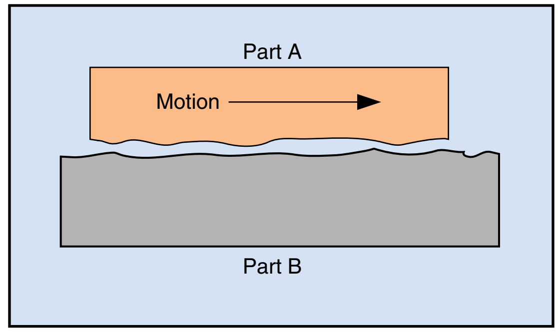
1.32 The wearing down of machine parts is caused by friction. If you reduce friction through lubrication, you also reduce wear. To review how wear occurs, take a look at Fig. 1-7. This drawing shows a closeup view of two surfaces in contact with each other.

1.33 You will recall reading that no surface is completely smooth. It always has numerous microscopic peaks and valleys in it, no matter how much you polish it. When one surface moves over another, the high points of one surface tend to interlock with the low points of the other. In time, the high points break off both surfaces, and new points begin to take the stress.

1.34 As more and more peaks and ridges break off and leave the surface, the surface gradually wears away. How fast this wear occurs depends on the roughness of the surfaces, how hard they are, and how fast the surfaces are moving. When a film of lubricant is introduced between the surfaces, the peaks and valleys are separated from each other, and the wearing down process is stopped almost completely.

1.35 The thickness of the lubricant film is important. If the film is thick enough, the two surfaces will never actually contact each other, and little, if any, wear will occur. If the film is not quite thick enough to separate the two pieces, then some of the high points will break off. In many industrial applications, the film is not thick enough to separate the moving parts completely. This is one reason why even lubricated parts do eventually wear out.

Fig. 1-7. Uneven surfaces in motion



The Programmed Exercises on the next 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. To make a surface smooth and slippery is to ________ it.	1-1. LUBRICATE Ref: 1.02
1-2. Lubrication reduces wear by reducing ________.	1-2. FRICTION Ref: 1.04, 1.05
1-3. Friction can destroy a bearing, because the shaft and the bearing expand and then ________ when overheated.	1-3. SEIZE Ref: 1.06
1-4. If a lubricant is defined as a solid, it means that it is a solid at ________ temperature.	1-4. ROOM Ref: 1.09
1-5. At room temperature, the physical form of grease is midway between a(n) ________ and a(n)________.	1-5. SOLID; LIQUID Ref: 1.11
1-6. The force that you must overcome to start one surface sliding over another is called ________.	1-6. STATIC FRICTION Ref: 1.17
1-7. Lubricating oil reduces friction by providing a film that keeps two surfaces ________.	1-7. APART or SEPARATED Ref: 1.21
1-8. The forces of attraction among layers of molecules in a liquid cause a resistance known as ________ friction.	1-8. FLUID Ref: 1.22 TO 1.24

Dampening Shock

1.36 Another reason for lubrication is to help *dampen* shock. That is, a lubricant can help to absorb the metal-to-metal impacts that often occur in mechanical motion. Machines then run more quietly and last longer.

1.37 A lubricant can dampen shock in either of two ways. First, it can convert mechanical impact into fluid motion. One familiar example of this is found in an automobile shock absorber. The shock absorber is a cylinder containing hydraulic fluid, with a movable piston inside. The piston moves up and down in response to the car wheel, as the wheel moves up and down over bumps in the road.

1.38 As the car moves rapidly along a rough road, its wheels are continually thrown upward and downward as they pass over the bumps. If these shocks were transmitted directly to the car, it would mean a very rough ride. But as the piston in the shock absorber moves inside its cylinder, the fluid moves from one side of the piston to the other through a small hole. In this way, the mechanical motion of the piston (and the car's entire suspension system) is slowed down by the retarding effect of fluid friction.

1.39 The second way a lubricant dampens shock is by making use of its ability to distribute pressure. A practical example of this property is found in gear lubrication. Lubricant is squeezed by the gear teeth as they mesh together. The squeezing action forces the lubricant to squirt out between clearance points in the meshed teeth.

1.40 Refer to Fig. 1-8. According to logic, if the left-hand gear in Fig. 1-8 is the driving gear, the pressure on the lubricant should be much greater at point A than at Point B. Since fluids quickly equalize any pressure differences, however, the excessive pressure is instantly drawn from A and added to B. This reduces the shock at Point A.

1.41 Trapped air within the lubricant also helps dampen shock by compressing under impact. Either way, the lubricant helps to form a shock-absorbing cushion. Well-lubricated gears operate more quietly than improperly lubricated ones, and are subject to less shock damage. This makes the job of maintaining oil levels in gear boxes an essential one.

Cooling Action of Lubricants

1.42 The heat generated by friction can cause all sorts of problems in machinery. Increased heat causes materials to expand. Some materials expand at faster rates than others, but even a low rate of expansion can cause problems if the temperature rise is great enough.

1.43 An inch of steel, for example, expands at the rate of about 0.000006 in. (6 millionths of an inch) for every degree Fahrenheit that its temperature is raised. This means that a 2 in. steel axle shaft will expand 0.006 in. in diameter if its temperature is increased by 500°F. That does not sound like very much, but when parts are machined to very close tolerances, 0.006 in. could be enough to cause the part to seize.

1.44 The problem of heat expansion is even more acute in internal combustion engines, because the enormous heat of combustion is added to the heat of friction. In the engine of a truck, for example, the cylinder walls may routinely reach temperatures up to 200°F or more. The pistons would soon seize in their cylinders if there were no way to cool them.

1.45 By itself, a lubricant does not have much cooling action. What it does, primarily, is prevent excessive friction so that less heat will be generated. But lubricants also carry away some heat from the points where it is generated to cooler areas, where it is then dispelled into the air.

Fig. 1-8. Dampening shock in a pair of gears

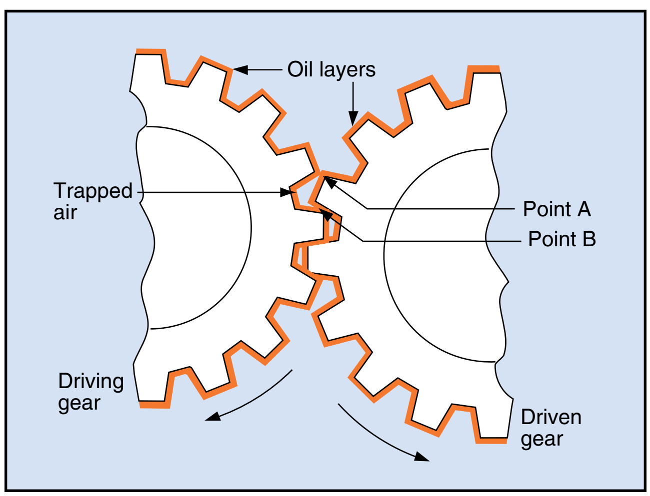
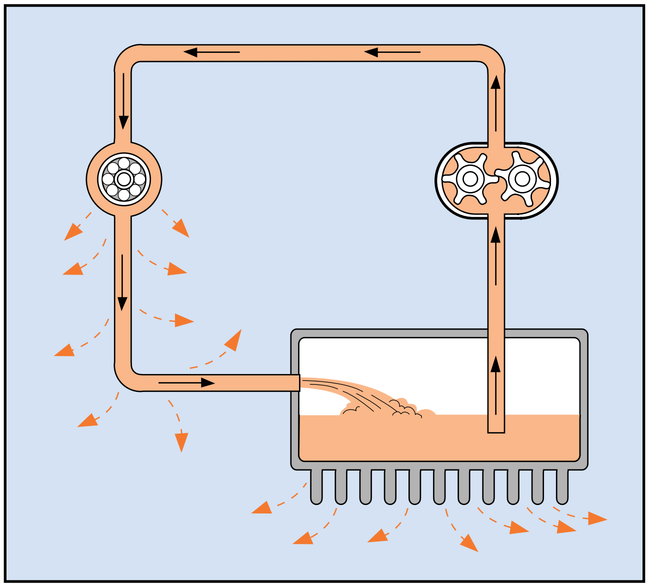


Fig. 1-9. Pressurized lubrication system, with oil cooler

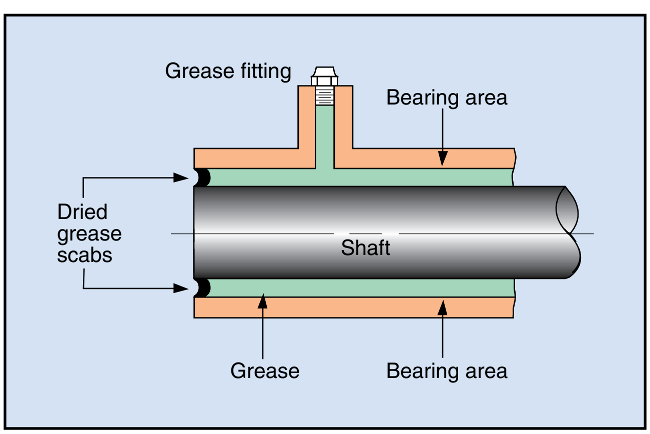


1.46 Oil does not have much capacity for carrying heat away. Water is much more efficient as a cooling element. Water, however, is not a good lubricant. In machines it is usually better to sacrifice some cooling effect in order to get better lubrication.

1.47 As you know, heat energy is measured in Btu and calories. A quart of oil circulating through a bearing can carry away only a few Btu of heat, but there is some helpful cooling effect.

1.48 In many systems, hot oil circulates through an oil cooler. The oil cooler may simply have metal fins to radiate heat into the air, although some coolers have an active cooling device, such as a fan or even mechanical refrigeration. Figure 1-9 shows the heat flow in a pressurized lubrication system.

Fig. 1-10. Grease-packed journal bearing showing self-sealing action



Corrosion Prevention

1.49 Another useful function of lubricants is to prevent or retard rust and corrosion. A lubricant does this when it forms a protective film on metallic machine parts. The film blocks the direct contact of metal with oxygen in the air, so that the metal cannot oxidize.

1.50 The lubricant chosen for a particular application may contain additives designed to prevent or neutralize the corrosive effects of materials present in the application. For example, if acid is a problem, a lubricant with an acid neutralizer should be used.

1.51 How much corrosion protection you need depends on the application. If the equipment is operated indoors where the humidity is low and few corrosive materials are present, corrosion is not going to be a significant problem. In that case, the degree of protection required from the lubricant is not great.

1.52 If equipment is used outdoors in high humidity, you need a thick, oily film of lubricant on the rubbing or turning surfaces. The film will protect vital machine parts from rusting by preventing their contact with moisture and oxygen in the air.

Sealing Action of Lubricants

1.53 Lubricants serve as seals in machines in two ways. First, a lubricant can seal itself into the place where it is needed. You need to depend on a lubricant staying in place in an application and not running out. Second, a lubricant can also seal out dirt and other contaminants from the contact areas.

1.54 Both of these functions are shown in Fig. 1-10. Grease provides the best example of a lubricant that can seal dirt out and seal itself in. As you can see in the diagram, most of the grease has no contact with the air. It remains soft and pliable, and provides good lubricating action inside the bearing.

1.55 However, a very small amount of grease at the end of the shaft is exposed to the air. It oxidizes just a bit and becomes a little stiffer than the rest of the

Table 1-2. Common lubrication terms

Additives—substances or chemicals added to oil or grease to get a particular result. An additive may be used, for example, to neutralize the effect of an acid that may be present in a given application.

Crude oil—the term given to oil as it comes out of the ground.

Fluid friction—the kind of friction that exists within liquids.

Friction—the resistance of an object to being moved across or over another object or surface.

Friction of motion—another name for kinetic friction.

Friction of rest—another name for static friction.

Kinetic friction—the force required to keep an object moving once it has been put into motion from a standing start.

Linear motion—straight line motion.

Lubricate—to make smooth or slippery.

Preventive maintenance—the practice of regular attention to equipment maintenance, at scheduled intervals of time. Can prevent trouble before it happens.

Rolling friction—the friction resulting when one part is rolled across or over another.

Rotary motion—circular motion, as with a wheel.

Sliding friction—the friction resulting when one part moves across or over another in a straight line.

Solid friction—the friction or resistance to motion that exists between two unlubricated surfaces.

Static friction—the force that resists moving an object from a standing position.

grease. The result is a very thin skin or "scab" that forms on the exposed grease. This scab seals the grease in place and keeps dirt from entering the bearing.

1.56 Even if the scab does not remain in place, dirt and other contaminants are kept out of the bearing by a kind of flushing action. Fluid friction within the grease can warm it up and thin it somewhat as the shaft turns in the bearing. Also, pressures build up because of the weight of the shaft and its rotating motion. This combination of factors often leads to a little of the grease oozing out at the end of the shaft.

1.57 The rate of oozing out of the grease is usually planned for by the equipment manufacturer. That is why a certain type of grease is specified. But this grease must be replaced at regular intervals to keep the bearings properly lubricated. The time interval is also often specified by the manufacturer. If you wait too long, the bearings can run dry.

1.58 When the grease works its way out of the contact area, it acts as a cleansing agent. Any dirt, rust, or foreign material that gets into the contact area is flushed out by the moving grease. A positive pressure in the bearing keeps the grease moving in only one direction. The dirt cannot return.

1.59 Figure 1-10 also shows why clean lubricants and lubricating equipment are necessary. In the illustration, you can see that there is only one way in which dirt or other foreign matter can get into the contacting surface areas once the unit has been assembled. That way is through the grease fitting. If dirt is present at that point and the fitting is not cleaned before new grease is put in, then dirt particles enter with the fresh grease.

1.60 Once inside the bearing area, the dirt particles act like an abrasive, causing the shaft to begin grinding away at the bearing surface. In time, the grinding action opens up the clearance space between the shaft and bearing. The close fit originally designed into the equipment no longer exists.

1.61 Because it is now somewhat loose in the bearing, the shaft begins to wear down the bearing more rapidly. Vibration may also result, which can have damaging effects elsewhere in the equipment. The additional clearance makes lubrication ineffective, because it simply flows out through the enlarged opening. This causes a further increase in both friction and wear. The result is a probable breakdown.

Preventive Maintenance

1.62 The six functions of lubrication covered in this lesson are vital to keeping a plant in operation. You will probably find that your plant has a regular schedule to provide lubrication for all critical equipment. This is part of what is known as a *preventive maintenance program*. This and other lubrication terms used in this lesson are reviewed in Table 1-2 on the previous page.

1.63 Not too many years ago, it was not unusual to let equipment run until it broke down. Only then was the maintenance department called in to remedy the situation and repair the damage. The feeling was that it was cheaper to purchase replacement parts than to employ persons full-time to tour the plant with oil cans and grease guns.

1.64 Today's high-rate production schedules and processing requirements have changed that way of thinking. It makes much more sense to take steps to prevent machine and equipment failures before they occur. This can be done by setting up a system of regular inspection and scheduled maintenance in order to catch signs of trouble before they become major problems. A key part of such a preventive maintenance program is regular lubrication. Lesson Two will show you how certain properties enable lubricants to perform the six functions covered in this lesson.

1-9. One important reason for lubrication is to help ________ shock.	1-9. DAMPEN Ref: 1.36
1-10. A lubricant absorbs shocks by changing mechanical impacts into fluid ________.	1-10. MOTION Ref: 1.37
1-11. Gear oil dampens shock by equalizing ________ differences between the gear teeth.	1-11. PRESSURE Ref: 1.40
1-12. The primary way that an oil can cool moving parts is by reducing ________.	1-12. FRICTION Ref: 1.45
1-13. Which has a higher capacity for transporting heat energy, oil or water?	1-13. WATER Ref: 1.46
1-14. When a film of lubricant prevents a metal surface from coming in contact with the air, the metal will be slow to ________.	1-14. RUST, CORRODE, or OXIDIZE Ref: 1.49
1-15. Grease is an example of a lubricant that tends to form its own ________.	1-15. SEAL Ref: 1.54
1-16. About the only way that dirt and grit can enter into a greased bearing is through the ________.	1-16. GREASE FITTING Ref: 1.59

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

1-1. Lubricants are available as liquids,

- ☐ a. gases, and semisolids
- ☐ b. gases, solids, and semisolids
- ☐ c. semiliquids, semigases, and semisolids
- ☐ d. solids, and semisolids

1-2. The main purpose for lubrication is

- ☐ a. cooling moving parts
- ☐ b. decreasing repair costs
- ☐ c. preventing rust
- ☐ d. reducing friction

1-3. The resistance that must be overcome when starting one part in motion across another is called _______ friction.

- ☐ a. kinetic
- ☐ b. rolling
- ☐ c. solid
- ☐ d. static

1-4. A lubricant helps prevent wear in machinery, because it

- ☐ a. always has special additives
- ☐ b. is always in liquid form when it does the job
- ☐ c. prevents vibrations
- ☐ d. separates the moving surfaces

1-5. One way lubricants dampen mechanical shock is by _______ pressure.

- ☐ a. distributing
- ☐ b. eliminating
- ☐ c. liquefying under
- ☐ d. solidifying under

1-6. The cooling effects of a lubricant result mainly from its ability to

- ☐ a. carry away large quantities of heat
- ☐ b. cleanse away layers of corrosion
- ☐ c. evaporate from surfaces in contact
- ☐ d. reduce friction

1-7. Corrosion can be prevented if bare metal parts are shielded from

- ☐ a. heat
- ☐ b. oxygen
- ☐ c. paint
- ☐ d. shock

1-8. Additives in oil can help prevent corrosion by

- ☐ a. making the oil less transparent
- ☐ b. neutralizing acids in the application
- ☐ c. taking heat away
- ☐ d. thickening the oil

1-9. Bearing grease resists bearing contamination by

- ☐ a. creating a negative pressure
- ☐ b. preventing shock
- ☐ c. sealing itself
- ☐ d. slowing motion

1-10. When dirt enters a supply of bearing grease, it can eventually cause

- ☐ a. abrasive wear in the bearing
- ☐ b. excessive expansion of the grease
- ☐ c. excessive thickening of the grease
- ☐ d. rust to form on the bearing liner

SUMMARY

The gears, shafts, spindles, cylinders, bearings, and sliding supports that make production and plant operation possible must all be lubricated properly. The main purpose of lubrication is to reduce friction. Friction wastes energy and creates unwanted heat. Friction can be classified as either static or kinetic friction. Kinetic friction may be sliding, fluid, or rolling friction.

Fluid friction is the resistance a solid body meets when traveling through a liquid or a gas. When a film of lubricant is applied between two sliding or rolling surfaces, the friction of solid-on-solid is replaced by fluid friction. Overcoming sliding friction consumes the greatest amount of power and produces the most heat. Overcoming rolling friction requires less power and produces less heat. Overcoming fluid friction uses the least power, and produces the smallest amount of heat.

Five additional reasons for lubricating machine parts are to reduce wear, prevent corrosion, dampen shock, cool the moving parts, and seal out contaminants. Most of these other reasons are also related to friction.

Answers to Self-Check Quiz

1-1. b. Gases, solids, and semisolids. Ref: 1.08, 1.11

1-2. d. Reducing friction. Ref: 1.15

1-3. d. Static. Ref: 1.17

1-4. d. Separates the moving surfaces. Ref: 1.34

1-5. a. Distributing. Ref: 1.39

1-6. d. Reduce friction. Ref: 1.45

1-7. b. Oxygen. Ref: 1.49

1-8. b. Neutralizing acids in the application. Ref: 1.50

1-9. c. Sealing itself. Ref: 1.54

1-10. a. Abrasive wear in the bearing. Ref: 1.59, 1.60