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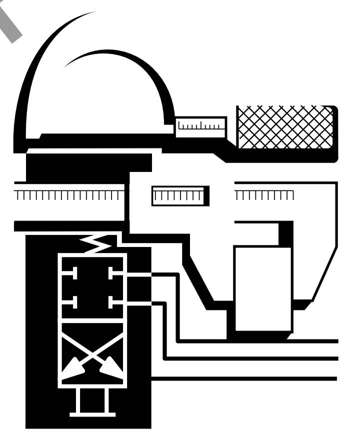
METALS IN THE PLANT

Lesson One

Introduction to Metals



TPC Training Systems

10501

Lesson

1 Introduction to Metals

TOPICS

Metals and Metallurgy
Properties of Metals
Internal Structure of Metals
Important Metals
Casting Metals
Metalworking
Joining Metals

OBJECTIVES

After studying this lesson, you should be able to…

- Name five metals or alloys commonly used in industry.
- Name five mechanical properties of metals.
- Describe the uses of three metal alloys
- Describe the metalworking processes of casting, forming, and machining.

KEY TECHNICAL TERMS

Metallurgy 1.04 study of metals
Malleability 1.05 ability to be shaped by hammering
Ductility 1.05 ability to be stretched into wire
Elasticity 1.05 ability to return to its original shape
Corrosion 1.06 slow, chemical destruction of metal
Conductivity 1.09 ability to carry heat or electricity
Ferromagnetic 1.10 having magnetic properties like iron
Latent 1.16 hidden
Alloy 1.28 mixture of metals
Cupola 1.53 vertical furnace used to melt iron

Metals are the materials most widely used in making industrial equipment, machines, and machine parts. The properties of metals determine their uses. Certain metals are useful because of their hardness. Others are useful because they are soft.

Copper, silver, and aluminum conduct electricity well. Tungsten resists the flow of electricity. Certain steels are used in making springs, because they have high elasticity. That is, they spring back to their original shape when deformed. Lead and tin, once deformed, remain deformed. Gold, silver, and aluminum have an attractive appearance. Zinc and cadmium do not.

Knowing how a metal behaves during metalworking is important when you select the metal for a job. You should understand the basic processes of casting, stamping, and machining so that you can choose the best metal for each process. In this lesson, you will learn about the nature and uses of metals.

Metals and Metallurgy

1.01 Copper, iron, zinc, and aluminum are metals. Hydrogen, carbon, sulfur, and oxygen are not. Metals differ from nonmetals both physically and chemically.

1.02 You can see some of the physical properties of metals easily. For example, they look shiny. Other physical properties are impossible to see. For example, you cannot see that metals are good conductors of heat and electricity.

1.03 Ninety-two chemical elements occur in nature. Eighty-two of these elements are metals. Some metal elements—including iron, aluminum, and magnesium—are abundant in nature. Others—for example, uranium—are rare. Most metals in nature are not found in their pure states. They are found in chemical compounds called *ores*.

1.04 The study of metals is called *metallurgy*, which includes chemical metallurgy and physical metallurgy. *Chemical metallurgy* deals with the separation of metals from their ores and with the mixture of metals to form *alloys*. *Physical metallurgy* is the study of how metals behave during various operations. Physical metallurgy also includes the study of how the atomic structure of a metal affects its mechanical properties.

Properties of Metals

1.05 The physical properties of metals have many names, including strength, malleability, ductility, toughness, and elasticity. A metal's ability to change shape without breaking is called *malleability* or *ductility*. Ductility combined with strength is called *toughness*. The ability of a metal to return to its original shape after being deformed is called *elasticity*.

1.06 Resistance to corrosion is one of the useful chemical properties of a metal. *Corrosion* is a slow chemical process in which the metal combines with oxygen or other materials. For example, iron combines with oxygen to form iron oxide. The iron oxide can then combine with water to form rust. You should consider corrosion in choosing the right metal for a job.

1.07 You should also think about the cost of certain metals compared to others. For example, stainless steel costs too much to use if plain steel will do the job just as well.

1.08 Gold, silver, platinum, bronze, brass, and copper are used mainly for their resistance to corrosion. They are often applied as a thin film over a cheaper metal to improve its appearance or prevent corrosion.

1.09 Two especially useful properties of metals are *electrical conductivity* and *thermal* (heat) *conductivity*. Gold and silver are better conductors than copper or aluminum, but copper and aluminum are generally used instead. They cost far less than gold and silver.

1.10 Some pure metals have magnetic properties. Examples of such metals include iron, nickel, and cobalt. They are called *ferromagnetic metals*. Some alloys have better magnetic properties than pure metals. One example is alnico. *Alnico* is an alloy of aluminum, nickel, and cobalt. It is used as a magnet in many radio speakers, as shown in Fig. 1-1.

1.11 Other useful properties of metals include:

- the ability to give off electrons (electrically charged particles) when heated. This property is important in electronics.
- the ability to reflect light. This property is useful in making mirrors.
- a high melting point. Metals with this property are used as lamp filaments and electrical heating elements.

1.12 Certain metals have unusual characteristics that make them useful in measuring and controlling temperature. For example, when iron and a copper-nickel alloy called *constantan* are joined and heated, they form a thermocouple. A *thermocouple* is a temperature-measuring device made by welding together the ends of two different metal wires. When the welded junction is heated, it produces an electric current.

1.13 Metals also expand at different rates when heated, and contract when cooled. The *bimetallic* (two-metal) *thermostat* makes use of this property. It consists of two strips of different metals, welded together. When heated or cooled, the two metals expand or contract at different rates. As a result the bimetallic strip bends as illustrated in Fig. 1-2. The movement controls a contact which in turn controls a heating or cooling system. The thermostat turns the furnace on or the air conditioner off if the room temperature drops below a preset temperature. It turns the furnace off or the air conditioner on if the room temperature rises above a preset level.

Fig. 1-1. Alnico magnet in a radio speaker

1.14 To see what happens when melting occurs, try the experiment illustrated in Fig. 1-3. Fill a pan with ice cubes or crushed ice. Place a thermometer in the pan. Wait a few minutes for the ice to start melting, and then read the temperature. Write the thermometer reading in this space: _____°.

1.15 Now heat the pan. Read the thermometer again after about half the ice has melted. What is the temperature? _______°. After all the ice has melted, continue heating the pan. Read the thermometer after a few minutes. The thermometer reads _____°.

1.16 A solid and a liquid can exist together at the melting point. Adding heat melts more of the solid, but does not change the temperature. All the solid must melt before the temperature can rise. The heat absorbed during melting is called the *latent heat of fusion* of the solid. *Latent* means *hidden*.

1.17 Latent heat of fusion is defined as the amount of heat required to melt a certain weight of solid, without changing its temperature. All this heat is used in changing the material from a solid to a liquid. When a liquid material freezes, the latent heat of fusion is released.

1.18 The *melting point* of a metal is the temperature at which it changes from a solid to a liquid. Each metal has its own melting point. The melting point of an alloy may be quite different from the melting points of the metals in the alloy.

1.19 You may have noticed in the ice experiment that the temperature of the ice was below 32°F when you started. That is, the temperature was lower than the melting point. The same is true of metals. For example, the melting point of pure iron is 2798°F. Molten iron freezes at this temperature. After freezing, the iron continues to cool to room temperature.

Fig. 1-2. Bimetallic thermostat

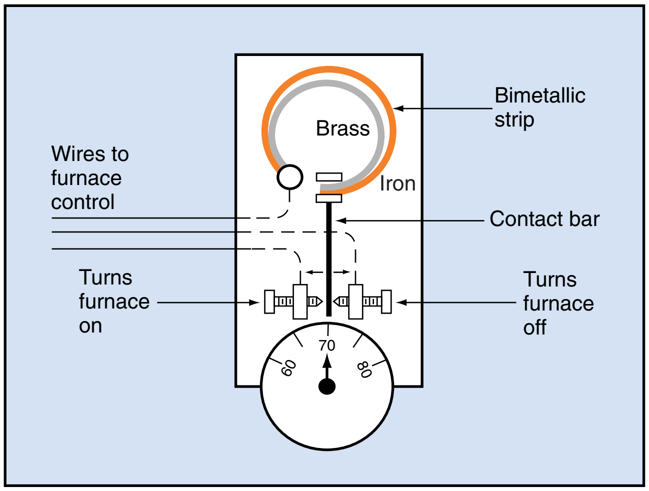
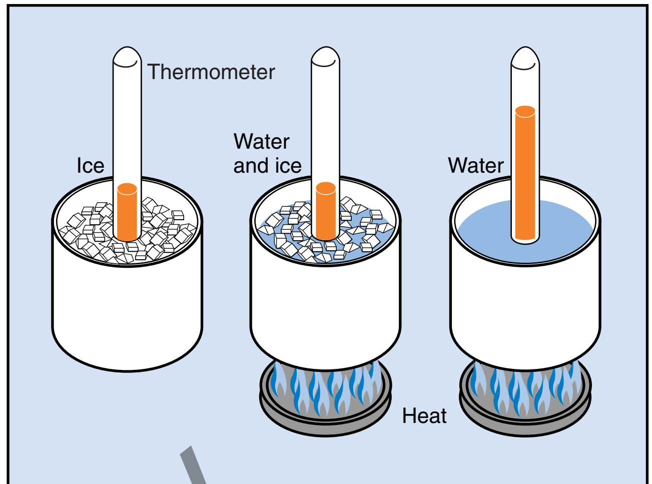


Fig. 1-3. Temperature of melting ice



1.20 Different metals melt at different temperatures. Tungsten has the highest melting point—6170°F. Mercury is liquid at room temperature. Its melting point is –37°F. Table 1-1 lists the melting points of some common metals.

1.21 The melting point of an alloy is generally lower than the melting points of the metals in the alloy. For example, *solder* is an alloy of tin and lead. Tin melts at 449°F, and lead melts at 621°F. But solder made of 60% tin and 40% lead melts at 367°F. The melting point of solder varies according to the ratio of lead to tin.

Internal Structure of Metals

1.22 The characteristics of metals depend on the nature of the atoms that make up the metal and how the atoms are arranged. Nothing can be done in refining or manufacturing to change the kind of atoms in a metal. However, the arrangement of the atoms can be controlled by heat treatment or by alloying the metal with other metals.

1.23 Both methods are used to control certain physical properties of a metal and make the metal more useful. For example, bronze (an alloy of copper and tin) is harder than pure copper. An alloy of aluminum with 4% magnesium is much stronger than either aluminum or magnesium alone.

1.24 *Heat treatment* consists of heating a metal to a certain temperature, and then cooling it at a certain rate. You will study heat treatment in another lesson.

1.25 Crystals (also called *grains)* form in molten metal as the metal begins to freeze. The first crystals form in the coolest areas, usually along the edges. As freezing continues, the crystals grow throughout the material. Rapid freezing produces many small crystals. Slow freezing produces crystals of larger size.

1.26 Figure 1-4, on the following page, shows crystals that formed in a small ingot of aluminum as the metal froze. The crystals began forming on the cool sides of the ingot. They grew toward the center as the aluminum froze. You can see the ends of the crystals on the sides of the ingot. The top of the ingot shows how the crystals grew in toward the center.

Table 1-1. Melting points of metals

Metal	Melting point	
	°F	°C
Aluminum	1220	660
Aluminum bronze	1900	1038
Gray cast iron (3.6% carbon)	2150	1175
Copper	1981	1083
Iron	2798	1536
Lead	621	327
Mercury	-37	-38
Nickel	2647	1453
Red brass	1880	1025
Tin	449	232
Tungsten	6170	3410
Yellow brass	1710	930

Fig. 1-4. Crystals in aluminum

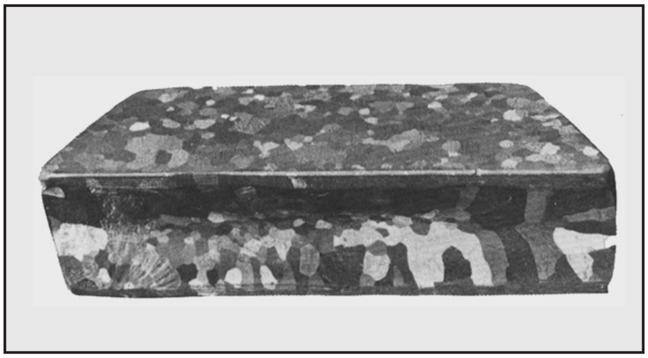


Fig. 1-5. Steel at 2000°F, no grain structure

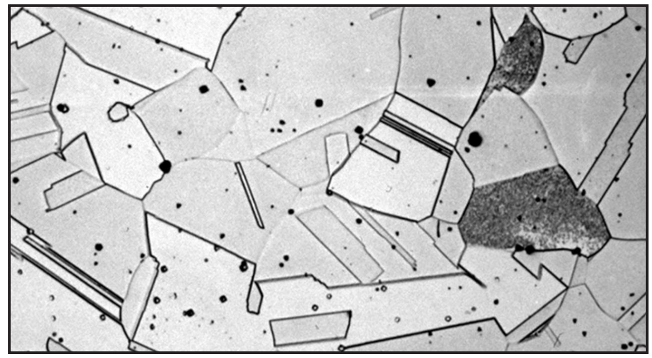


Fig. 1-6. Steel cooled slowly, large grain structure

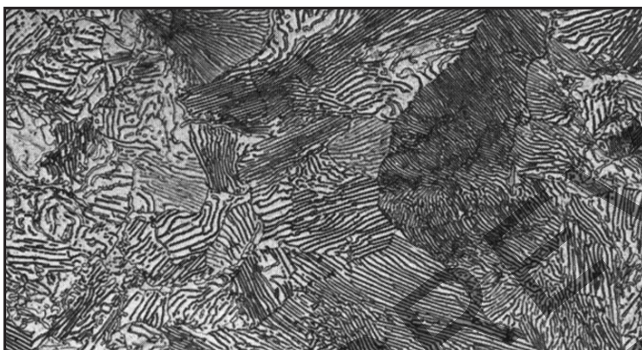
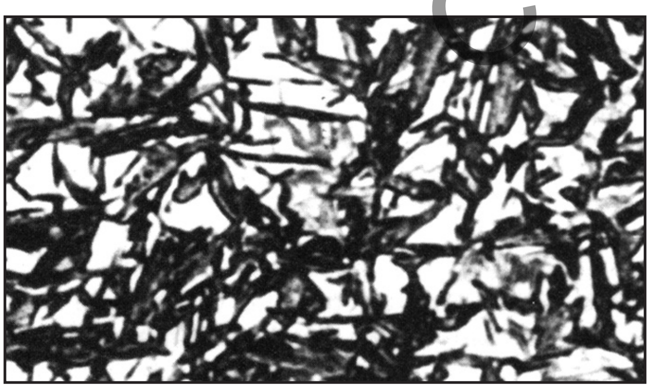


Fig. 1-7. Steel cooled rapidly, fine grain structure

Fig. 1-8. Steel cooled suddenly, no grain structure



1.27 Steel need not be melted to change its crystal structure. It can be heated to about 2000°F, and then cooled. When the hot steel cools to a certain temperature, the crystal structure suddenly changes. Rapid cooling produces small grains. This fine grain structure makes the steel both hard and tough. Figures 1-5 through 1-8 show the effects of cooling rate on crystal structure.

The Programmed Exercises 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. Metals are good conductors of ________ and ________.	1-1. HEAT, ELECTRICITY Ref: 1.02, 1.09
1-2. Most metals found in nature are in the form of chemical compounds called _________.	1-2. ORES Ref: 1.03
1-3. What is the study of metals called?	1-3. METALLURGY Ref: 1.04
1-4. Ductility combined with strength is called ________.	1-4. TOUGHNESS Ref: 1.05
1-5. What term is used to describe the ability of a metal to return to its original shape after being deformed?	1-5. ELASTICITY Ref: 1.05
1-6. A slow chemical process in which a metal combines with oxygen or other materials is called ________.	1-6. CORROSION Ref: 1.06
1-7. The temperature at which a metal changes from a solid to a liquid is called its ________.	1-7. MELTING POINT Ref: 1.18
1-8. The melting point of an alloy is generally ________ than the melting points of the metals in the alloy.	1-8. LOWER Ref: 1.21

Important Metals

1.28 An *alloy* is a mixture of two or more metals. An alloy can have special properties that are lacking in the individual metals. In the following list, write an "E" next to the metals you think are elements, and an "A" next to those you think are alloys. Then check your answers as you study further. Change any incorrect answers.

_____	Iron	_____	Copper
_____	Steel	_____	Babbitt
_____	Brass	_____	Aluminum

1.29 Alloys may contain nonmetal substances. The nonmetals may be impurities, or they may be added on purpose. Alloys that contain iron as the base metal to which other metals or nonmetals are added are called *ferrous alloys*. All common steels and the special steels (including stainless steels) are ferrous alloys.

1.30 Alloys that contain no iron are called *nonferrous alloys*. Examples include brass, bronze, and babbitt. *Brass* is an alloy of copper and zinc. *Bronze* is an alloy of copper and tin. *Babbitt* is an alloy of copper and antimony.

1.31 Most nonferrous metals and alloys can be cast or worked into shape by ordinary metalworking processes. They can also be heat-treated to produce special properties.

1.32 *Aluminum* and *magnesium* and their alloys are used where weight must be kept low. Pure aluminum is not good for structural work. It is usually alloyed with small amounts of silicon, iron, and copper to make it stronger. Aluminum alloys are strong, resist corrosion, and are easy to cut and shape. Pound for pound, aluminum alloys are almost as strong as the best steels.

1.33 Aluminum forms its own protective shield against corrosion. When exposed to air, the outer layer of aluminum combines with oxygen from the air. This forms a thin film of aluminum oxide on the surface. This film keeps oxygen away from the aluminum underneath, preventing further corrosion.

1.34 *Magnesium* is the lightest metal commonly used in industry. It weighs only two-thirds as much as an equal volume of aluminum. Magnesium is alloyed with aluminum, zinc, and manganese to make it strong and tough. Alloys of magnesium and aluminum are widely used in aircraft construction. Flares and fireworks contain magnesium, because the metal burns with a brilliant light when ignited.

1.35 *Copper* is widely used because it is a good conductor of heat and electricity. It is easy to form, and it resists corrosion. It is one of the few metals used more widely as a pure metal than in alloys. The uses of pure copper include electrical wiring and some cooking utensils. Copper is also used to coat other metals by electroplating for better corrosion resistance and heat transfer.

1.36 Four types of copper are commonly available in industry.

- *Electrolytic cake copper* is used for electrical conductors because of its high conductivity.
- *Deoxidized copper* has exceptional workability and good welding properties. It also has high electrical conductivity.
- *Fire-refined copper* is rolled into thin sheets and used for cold-forming copper parts. Arsenic is added as an alloying element.
- *Tough-pitch copper* is fire-refined copper with 0.03 to 0.05% oxygen added to make the metal easier to cast and to increase its strength.

1.37 Copper alloys have characteristics that other metals and alloys do not have. For example, brass is easy to cold-form. It also has good corrosion resistance, and it can be electroplated with nickel or chromium to improve its appearance. As the percentage of zinc increases in brass, the alloy becomes more yellow and less red in color.

1.38 *Brasses* are easy to cast. The three major groups of casting brasses are red brass, semi-red brass, and yellow brass. *Red casting brass* (2 to 8% zinc) contains tin as a hardener and lead to improve its machinability. It is used for valves in high-pressure lines. *Semi-red casting brass* contains 8 to 17% zinc.

Yellow casting brass contains more than 17% zinc, plus about 2% total of aluminum, manganese, silicon, nickel, and iron. It is used for plumbing fixtures, machine parts, and ornamental castings. *Manganese brass* is used for casting marine fittings, because it resists corrosion. It also is stronger, tougher, and harder than other casting brasses.

1.39 *Manganese bronze* is 5% manganese and 95% copper. It is rolled into sheets, plates, and strips.

1.40 *Aluminum bronze* is strong and hard, and it resists fatigue and shock. These properties make aluminum bronze useful for gears, bearings, and pump parts. It contains from 4 to 14% aluminum, plus iron and tin. If aluminum bronze contains 89% copper, it is used for casting. With 88% copper content, it is used for forging.

1.41 *Beryllium-copper* alloys are made into strips, rods, wire, sheets, and tubing. These shapes in turn are used in making springs, electrical contacts, bearings, bushings, gears, valves, spring shims, and washers. Beryllium-copper is nonmagnetic and nonsparking. Therefore, the alloy is used in making safety tools for use in explosive atmospheres.

1.42 Beryllium-copper is strong, and it conducts heat and electricity well. The alloy is made with more than 1.5% beryllium to achieve its greatest strength and hardness. With less than 0.75% beryllium, the alloy has its greatest electrical and thermal conductivity.

1.43 *Nickel* is alloyed with cast iron, steel, and copper. An alloy with 70% nickel and 30% copper is called *monel*. Monel is strong and resists corrosion. It is cast to make hinges, doorknobs, and other ornamental hardware.

1.44 Another useful alloy of nickel is called *nichrome*. Nichrome contains 80% nickel and 20% chromium. It has a high electrical resistance, and is used for heating elements in toasters, soldering irons, portable heaters, and dryers. *Elinvar*, another nickel alloy, is made into springs for watches, electrical meter movements, and other precision instruments.

1.45 *Lead* in its pure form is soft and heavy. It is so soft that it can be scratched easily with a fingernail. However, lead resists corrosion in water, many chemicals, and air. The main uses of lead and lead alloys are in storage batteries, solder, covering for underground electrical cable, roof flashing, pipes, and bearings. Lead is alloyed with tin, antimony, zinc, copper, and iron.

1.46 *Tin* is a soft, silver-white metal. It resists corrosion caused by many chemicals and foods. Everyone is familiar with the "tin can." Actually, the tin can is made of sheet steel that is coated with tin.

1.47 *Tin solder* contains 95% tin and 5% antimony. It is used in sealing containers that come into contact with food.

1.48 *Tin foil* also contains 95% tin and 5% zinc. It was once widely used for wrapping food. Aluminum foil has replaced tin foil as a metal food wrap. *Pewter* is an alloy containing 92% tin and 8% antimony or copper. Its main use today is in making vases, bowls, and other ornamental objects.

1.49 *Cadmium* is found only in small amounts in nature, usually with zinc deposits. Cadmium is similar to zinc in many ways. It has good corrosion resistance, and it adheres well to other metals. Its most important use is for plating iron and steel to prevent rusting.

WARNING

The fumes from cadmium and its compounds, including solutions of its compounds, are extremely poisonous. Even small amounts can cause death.

1.50 The most common cause of cadmium poisoning is breathing its fumes or the fumes of its compounds. One source of cadmium fumes is the process of *silver brazing*. Cadmium fumes irritate the lungs, causing the lungs to fill up with liquid. When enough liquid builds up, the lungs can no longer supply the blood with enough oxygen. Death soon follows. Wherever there is a likelihood of cadmium fumes, all workers must wear protective masks and the area must be well ventilated.

1.51 *Cobalt* is used in making magnets, tool alloys, and alloys for use at high temperature.

Fig. 1-9. A mold prepared for casting

Cobalt alloyed with tungsten and steel produces tool steels that can cut steel and other metals at high speed.

1.52 Cobalt is a silver-white, hard, magnetic metal. It looks much like nickel and iron. Pure cobalt is rarely used. One of the few uses of pure cobalt is the radioactive cobalt-60 used in medical treatment.

Casting Metals

1.53 Metals and alloys used for casting are melted in furnaces in foundries. For example, iron is melted in a vertical furnace called a *cupola*. The molten metal is then cast by pouring it into a mold. The mold can withstand high temperatures without breaking or melting. The metal may be cast into a block called an *ingot*, which can then be formed into other more useful shapes. The molten metal may also be cast directly into a useful shape. For example, automobile engine blocks are cast from molten iron or aluminum.

1.54 Alloys with low melting points are often die-cast. In *die-casting*, the molten metal is forced into a

Fig. 1-10. Pouring a mold

Fig. 1-11. Finished castings

steel mold under high pressure. The alloy freezes rapidly in the mold. As a result, the mold can be reused quickly.

1.55 *Sand casting* is the most common casting process. A pattern of the object is first made from wood, plastic, or metal. Patterns are usually made oversize to allow for casting shrinkage. A special mixture of sand, clay, and other materials is then packed around the pattern to form the mold. Figure 1-9 shows a mold prepared for casting.

1.56 The pattern is then removed, and the hollow space is filled with molten metal, as shown in Fig. 1-10. After the metal becomes solid and cool enough, the mold is broken away and the casting removed.

1.57 Finishing the casting includes blasting with grit or steel shot to remove sand and scale. The surface of the casting remains rough. It may undergo further work before it is finished. Automobile engine blocks, rear axle housings, transmission housings, brake drums, plumbing parts, and the bases and housings of machine tools are examples of castings. Figure 1-11 shows finished castings.

Metalworking

1.58 Many metal products are not cast. Examples include steel rails, beams, angle-iron, sheets, plates, wire, nails, and screws. These products and others are formed by forcing metal into the desired shape with large machines capable of exerting great forces. Rods and wires are formed either by *drawing* (pulling) or by *extruding* (pushing) the metal through a die.

1.59 Sheet metal is shaped in dies to make home appliances, automobile bodies, electrical boxes, and other products. Name some structures in your plant that are made from sheet metal.

1. ______________________________

2. ______________________________

3. ______________________________

1.60 Figure 1-12 shows an electrical box stamped from sheet metal. Simple shapes are formed in one operation with one set of dies. More complex shapes may require two, three, or more operations.

Fig. 1-12. Stamped electrical box

1.61 *Machining* is an important metalworking operation. A strong machine forces a cutting tool through the metal to cut part of it away. Common machining operations include drilling, reaming, grinding, shaping, and cutting. These operations are all performed by machine tools. Figures 1-13 and 1-14, on the following page, show machining operations.

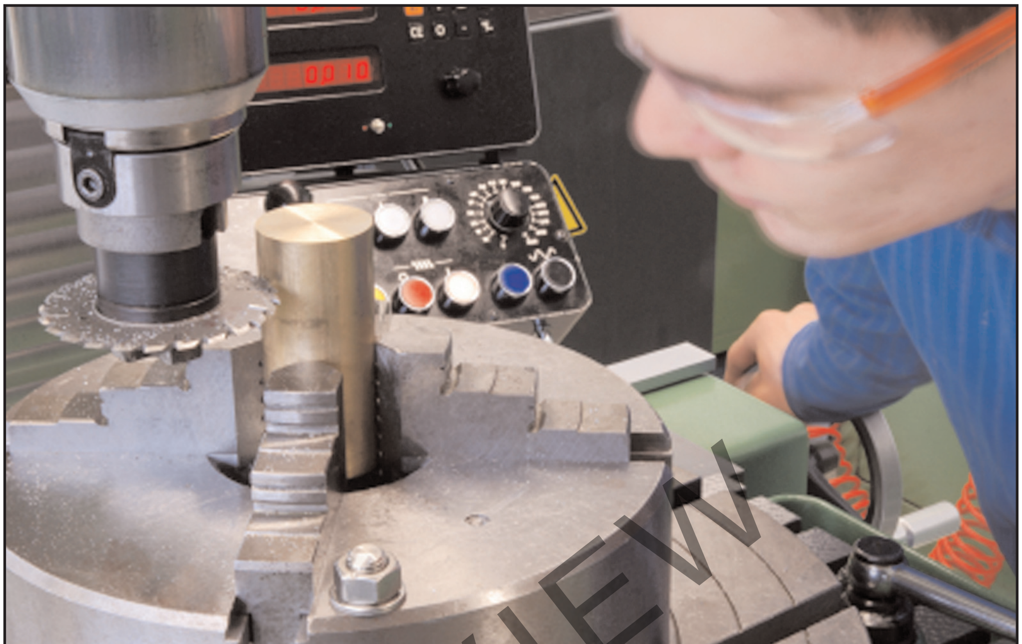
1.62 The speed and ease with which a metal can be cut on a machine tool is called its *machinability*. Hard steel alloys do not machine as easily as softer metals. The design of a product and how it will be used determines the metal and machining operations required.

Joining Metals

1.63 Buildings, large machinery, piping and conveying systems, and other structures are too large to be produced in one piece. They are built from parts that can be handled, transported, and then joined together by riveting, bolting, welding, soldering, or brazing. Figure 1-15, on page 15, shows steel pipe sections being welded into a continuous pipe.

1.64 *Welding* consists of joining two or more pieces of metal by a heat source. Electric current

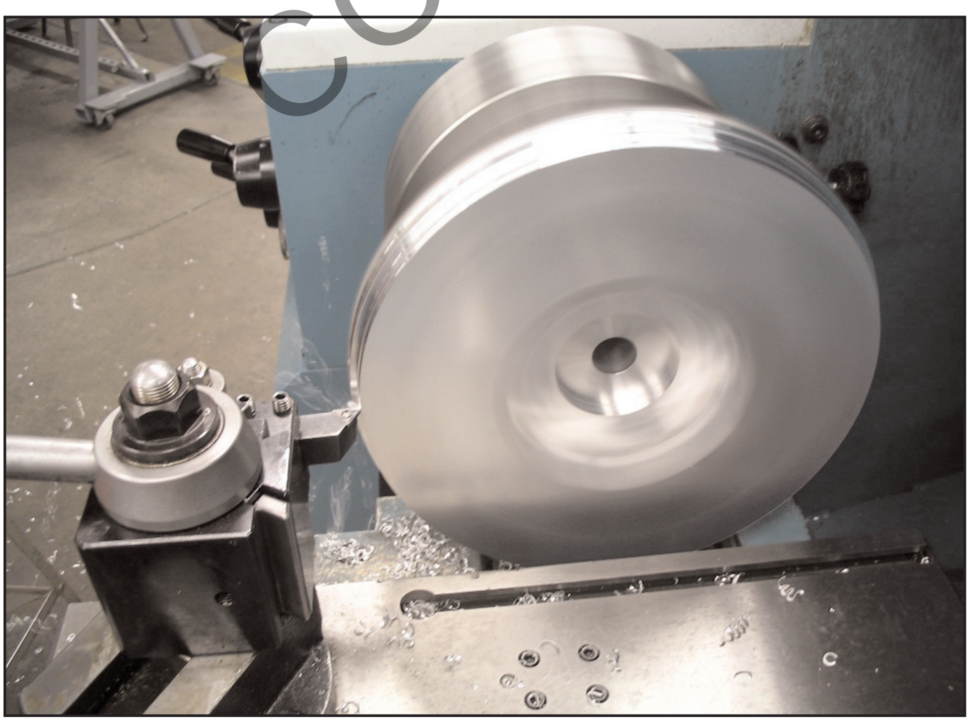
Fig. 1-13. Machining on a milling machine



and gas flames are the most common methods of heat for welding. During the process, heat melts the metals at the joint. As the metal begins to cool, it fuses into one piece.

1.65 An ideal weld is one where the properties at the joint are identical to the properties of the metals joined. Sometimes the joint is stronger than the parts joined, because it is thicker.

Fig. 1-14. Machining on a lathe



1.66 *Arc welding* uses an electric arc to heat the metal being joined. Metal called *filler metal* may be added during welding. It comes from a *welding rod*. The welding rod serves as one of the electrodes in forming the electric arc.

1.67 *Gas welding* is one of the oldest welding methods. In this process, a gas burns in oxygen to heat the joint. The gas may be acetylene, hydrogen, or natural or manufactured gas. The welder usually feeds a filler metal into the joint to make the weld.

1.68 *Brazing* is a joining process in which metal parts are heated but not melted. The parts are joined by a nonferrous metal or alloy filler. The filler has a melting point of 800°F or higher, but lower than the melting points of the pieces being joined. As the pieces are heated, the filler metal melts and wets the surfaces to be joined. The filler metal flows into the joint by capillary action. The strength of a properly brazed joint is greater than the strength of the filler metal.

Fig. 1-15. Welding steel pipe

1-9. A mixture of two or more metals is called a(n) _________.	1-9. ALLOY Ref: 1.28
1-10. What metals are combined to make brass?	1-10. COPPER, ZINC Ref: 1.30
1-11. The lightest metal commonly used in industry is _________.	1-11. MAGNESIUM Ref: 1.34
1-12. What metal's fumes are extremely poisonous?	1-12. CADMIUM Ref: 1.50
1-13. What is the most common casting process?	1-13. SAND CASTING Ref: 1.55
1-14. Rods and wires are formed either by drawing or by extruding the metal through a(n) _________.	1-14. DIE Ref: 1.58
1-15. The speed and ease with which a metal can be cut on a machine tool is called its _________.	1-15. MACHINABILITY Ref: 1.62
1-16. The process by which two or more pieces of metal are joined by heat is called _________.	1-16. WELDING Ref: 1.64

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

1-1. Iron and aluminum are

- ☐ a. alloys
- ☐ b. compounds
- ☐ c. elements
- ☐ d. nonmetals

1-2. Which of the following is *not* a property of metals?

- ☐ a. Heat of fusion
- ☐ b. Machinability
- ☐ c. Malleability
- ☐ d. Metallurgy

1-3. Elasticity is a metal's ability to

- ☐ a. change shape without breaking
- ☐ b. combine with other metals easily to form alloys
- ☐ c. resist corrosion from air, moisture, and chemicals
- ☐ d. return to its original shape after being deformed

1-4. Iron, nickel, and cobalt are said to be

- ☐ a. corrosion resistant
- ☐ b. ferromagnetic
- ☐ c. heat resistant
- ☐ d. nonmagnetic

1-5. A metal changes from a solid to a liquid at its ______ point.

- ☐ a. bending
- ☐ b. elasticity
- ☐ c. melting
- ☐ d. tensile

1-6. When heated steel is cooled rapidly, the grains that form are

- ☐ a. demagnetized
- ☐ b. large
- ☐ c. magnetized
- ☐ d. small

1-7. What term is used to describe a mixture of two or more metals?

- ☐ a. Alloy
- ☐ b. Compound
- ☐ c. Ferromagnetic metal
- ☐ d. Nonferrous metal

1-8. An alloy of copper and zinc is called

- ☐ a. brass
- ☐ b. bronze
- ☐ c. stainless copper
- ☐ d. zinc oxide

1-9. Forcing molten metal into a steel mold under high pressure is called

- ☐ a. die-casting
- ☐ b. quenching
- ☐ c. soaking
- ☐ d. tempering

1-10. The speed and ease with which a metal can be cut on a machine tool is called its

- ☐ a. ductility
- ☐ b. elasticity
- ☐ c. machinability
- ☐ d. malleability

SUMMARY

This lesson provides a general overview of metals. Most chemical elements are metals. The study of these elements is called metallurgy.

Different metals have different properties. These differences are the basis for selecting the best metal for a specific job in the plant. You have read about strength, elasticity, and other properties. Now you should try to learn about these properties in the specific metals you will be using.

Industrial workers use alloys more often than pure metals. The combinations of metals in alloys are almost endless. These combinations provide metals having many different properties. As a maintenance specialist, you will be able to choose the alloy that provides the best combination of properties for a specific job.

Metals must be shaped in order to do their jobs. You should understand casting, machining, and welding in order to know how to shape the metals you will be using.

The remaining lessons in this course explain more about the most important metals and how you can use them.

Answers to Self-Check Quiz

1-1. c. Elements. Ref: 1.03

1-2. d. Metallurgy. Ref: 1.04

1-3. d. Return to its original shape after being deformed. Ref: 1.05

1-4. b. Ferromagnetic. Ref: 1.10

1-5. c. Melting. Ref: 1.14

1-6. d. Small. Ref: 1.27

1-7. a. Alloy. Ref: 1.28

1-8. a. Brass. Ref: 1.30

1-9. a. Die-casting. Ref: 1.54

1-10. c. Machinability. Ref: 1.62

Contributions from the following sources are appreciated:

Figure 1-1.	TPC Brandt and Associates
Figure 1-4.	TPC Brandt and Associates
Figure 1-5.	Buehler Ltd.
Figure 1-6.	Buehler Ltd.
Figure 1-7.	Buehler Ltd.
Figure 1-8.	Buehler Ltd.
Figure 1-9.	Naylor Aluminum Foundry, Inc.
Figure 1-10.	Naylor Aluminum Foundry, Inc.
Figure 1-11.	Naylor Aluminum Foundry, Inc.
Figure 1-12.	Hubbell (RACO)
Figure 1-13.	TPC Brandt and Associates
Figure 1-14.	WC Lathe
Figure 1-15.	Westinghouse Electric Corp.