CHAPTER 15

Welding Drafting

Section 15.1
Types of Joints, Welds, and Symbols

Section 15.2
Producing a Welding Drawing

Chapter Objectives

- **Identify** types of joints and welds.
- **Explain** the welding process.
- **Describe** the fusion welding process.
- **Determine** the appropriate joint preparation for a specific weld application.
- **Convert** a drawing for a casting into an appropriate one for a welded part.

Discuss The Photo

Team Players Hernandez and McCollough work as a team by sharing and combining sketches and ideas they initially come up with on their own. ***Have you worked on a creative team? If so, how did the team members work together?***

DRAFTING CAREER Success

Proenza Schouler, *Fashion Designers*

From Concept

According to the fashion press, Proenza Schouler's women's clothes are made for "upscale dressing." But these upscale clothes often have a sporty, edgy, youthful look with features that remind you of the mod look of the sixties, a time when miniskirts and white boots were popular. Lazaro Hernandez and Jack McCollough teamed up in design school and created a label using their mother's maiden names—Proenza and Schouler. These award-winning designers have risen quickly to the top of the fashion design world.

To Reality

One remarkable aspect of Proenza Schouler's success is that their popular clothing lines result from a collaborative process between two people who seem to share a vision and philosophy. Each designer works independently to sketch his ideas before sharing them with the other. Then they inspect each other's sketches and find ways to combine their ideas and create something unique and cool.

Academic Skills and Abilities

- Sketching and drawing
- Drafting
- Collaboration and teamwork
- Textiles, fabric, and clothing
- Business administration

Career Pathways

Degree programs in fashion design are offered at the Associate's and Bachelor's levels at many colleges and design schools. Some fashion designers also pursue a degree in business, marketing, or fashion merchandising, especially those who want to run their own business or retail store. In addition to basic design courses, human anatomy, mathematics, and psychology are also useful.

Go to **glencoe.com** for this book's OLC to learn more about Proenza Schouler.

Frazer Harrison/Getty Images

15.1 Types of Joints, Welds, and Symbols

READING GUIDE

Before You Read

Preview Drafters must understand basic welding principles to be able to incorporate welds in designs. How do you think fusion welding works?

Content Vocabulary

- welding
- groove weld
- fillet weld
- plug weld
- slot weld
- fusion welding
- gas welding
- arc welding
- gas-and-shielded-arc welding
- intermittent weld

Academic Vocabulary

Learning these words while you read this section will also help you in your other subjects and tests.

- combination
- ignition

Graphic Organizer

Use a table like the one below to organize notes about welding.

Types of Welds	Types of Joints	Fusion Welding Methods

Go to **glencoe.com** for this book's OLC for a downloadable version of this graphic organizer.

Academic Standards

English Language Arts

Read texts to acquire new information (NCTE)

Mathematics

Measurement Understand measurable attributes of objects and the units, systems, and processes of measurement (NCTM)

Science

Physical Science Chemical reactions; interactions of energy and matter (NSES)
Science and Technology Abilities of technological design (NSES)

Industry Standards

ADDA Section 13

Welding Drafting (ASME/ANSI B31.1; ASME/ANSI B31.3, ASME/ANSI 31.9)

NCTE *National Council of Teachers of English Language Arts*
NCTM *National Council of Teachers of Mathematics*
NSES *National Science Education Standards*
ADDA *American Design Drafting Association*
ANSI *American National Standards Institute*
ASME *American Society of Mechanical Engineers*

Types of Joint and Welds

What specific facts must you know about the welding process when you draw parts to be welded?

Welding is the process of joining metal parts together using heat (fusion welding) or a **combination** of heat and pressure (resistance welding). It has become a major assembly method in industries that use steel, aluminum, and magnesium to build cars, trucks, airplanes, ships, and buildings. Welded steel parts for industrial use are generally lighter, stronger, and longer lasting than parts made by other methods. See **Figure 15-1A** for a pulley housing made by casting. Compare it with the similar part made by welding (see **Figure 15-1B**).

Welding is not the best method for joining parts that require quick assembly and disassembly. In such cases, bolts or screws, or a combination of fastening methods might be a better choice.

A drafter drawing the parts to be welded works with a design engineer who knows what types of welding to use with different metals. Nevertheless, the drafter must be familiar with the various welding processes as well as their associated drafting symbols.

Reading Check

Identify What are the advantages of welded steel parts?

Industrial processes require a variety of joints and welds, because welding is used for so many different purposes. Various types of joints and welds can be combined in many different ways to achieve the strength and characteristics desired for each application. Complete specifications for a weld must include both the type of joint to be achieved and the type of weld to use.

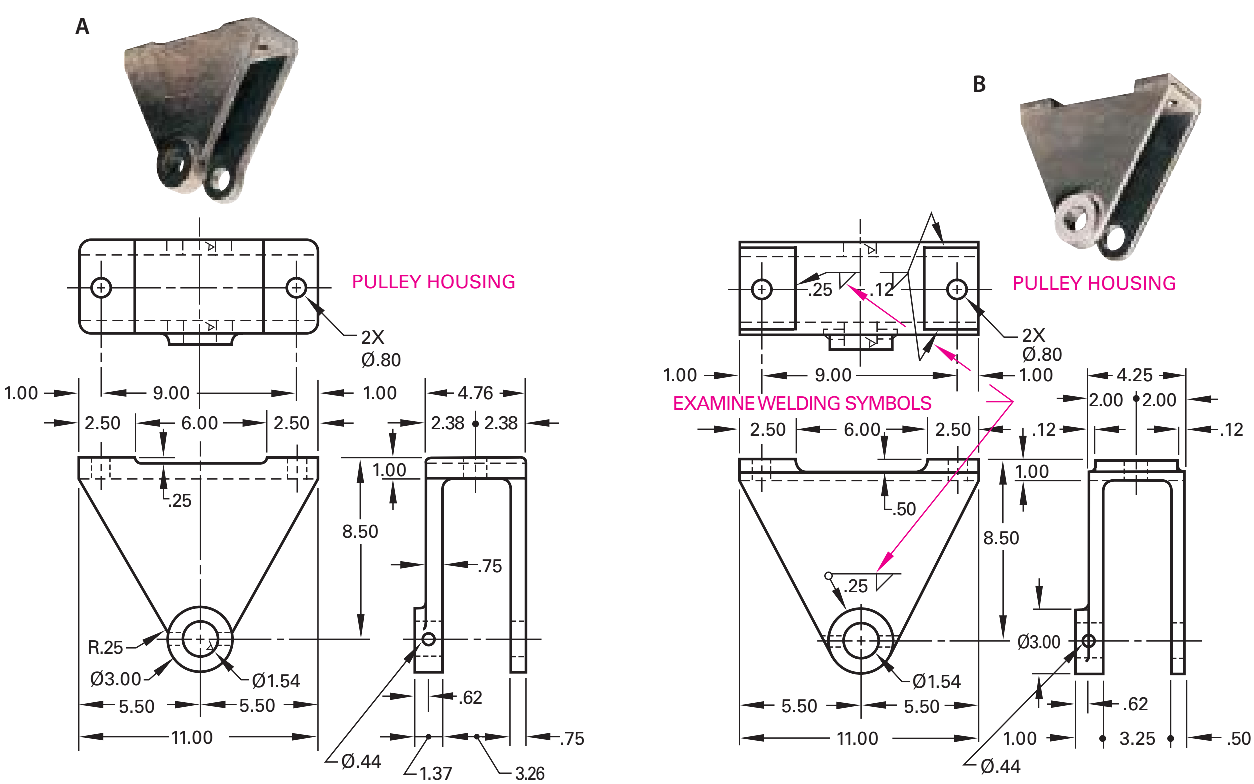


Figure 15-1

Pulley housing made by casting (A) and by welding (B)

Joints

See **Figure 15-2** for an illustration of the five basic joints used in welding:

- butt joints
- corner joints
- T-joints
- lap joints
- edge joints

To decide on the correct joint, the designer must be familiar with the specified materials processes, and the conditions of each.

Welds

The proper weld for a particular job depends on the type of material specified, the tools to be used, and the preparation cost. The following describes some basic welds:

- A **groove weld** is located in a groove or notch in the work material. The grooves are classified according to their shape (see **Figure 15-3**). Although the welds in that figure are applied to a butt joint, they can also be applied to any other joint. Note that the grooves may be single or double.

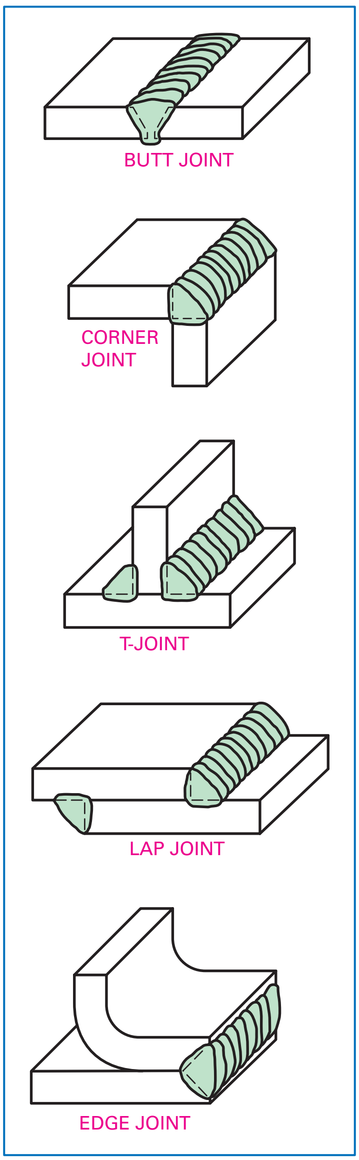


Figure 15-2

Five basic types of welded joints

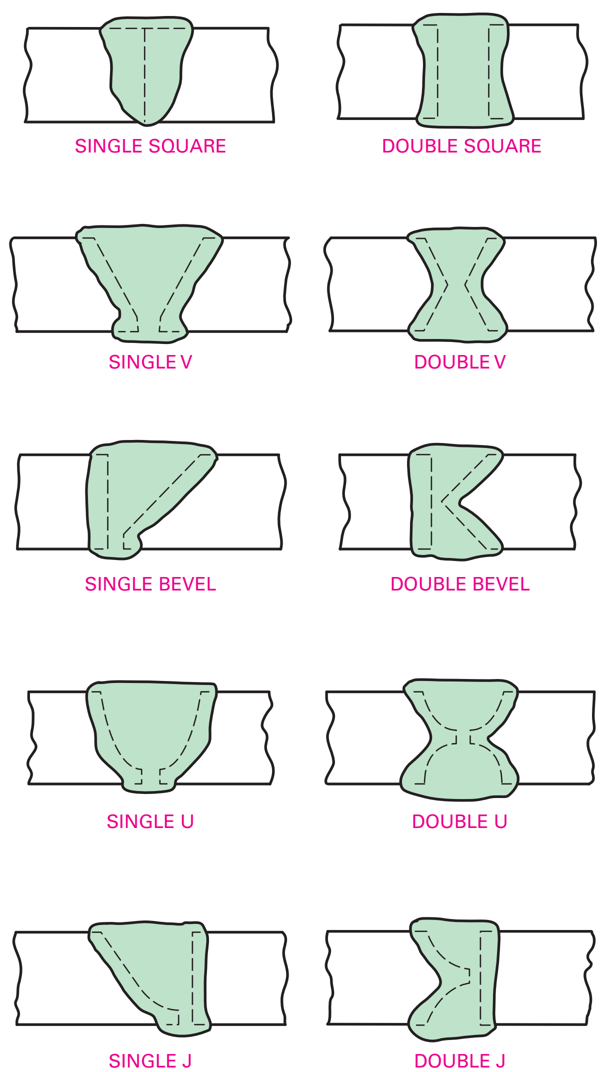


Figure 15-3

Ten basic types of groove welds applied to a butt joint

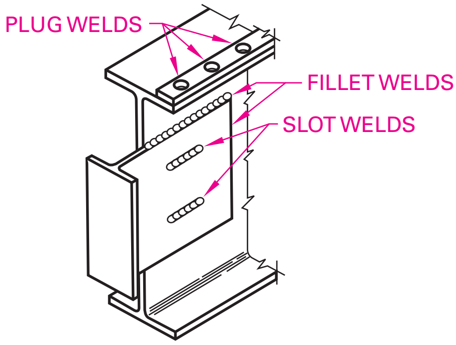


Figure 15-4

Plug, fillet, and slot welds

- Similar to a groove weld, a **fillet weld** rests on top of the joint. See **Figure 15-4** for an example of a fillet weld.
- A **plug weld** fits into a small hole in the work material (see Figure 15-4).
- Similar to a plug weld, a **slot weld** has an opening that is a slot. The weld symbol for slot and plug welds is the same.

Reading Check

Compare and Contrast What are the similarities and differences between a plug weld and a slot weld?

Fusion Welding

Why do you need two elements for fusion welding?

Fusion welding applies heat to create a weld. Fusion welding includes the gas, arc, thermit, and gas-and-shielded-arc processes. Although called by their separate names, soldering and brazing are also forms of fusion welding.

Fusion welding uses a welding filler material in the form of a wire or rod. The welder heats the material with a gas flame or a carbon arc. When the material melts, it fills in a joint and combines with the metal being welded.

A combination of gases is used to create the heat for **gas welding**. This process was developed in 1885, when two gases—oxygen from liquid air and acetylene from calcium carbide—were used. Burning acetylene supported by oxygen produces temperatures of between 5000° and 6500°F (2760° and 3595°C).

In 1881, de Meritens in France first performed a process known as **arc welding**, a form of fusion welding in which an electric arc forms between the work (part to be welded) and an electrode. The arc causes intense heat to develop at the tip of the electrode. This heat melts a spot on the work and on a rod of filler material, fusing the two.

The natural chemical reaction of aluminum with oxygen forms the basis for *thermit welding* in which a mixture, or charge, made of finely granulated aluminum and iron oxide is ignited by a small amount of special **ignition** powder. The charge burns rapidly, producing a very high temperature. This melts the metal, which then flows into molds and fuses mating parts.

Aluminum, magnesium, low-alloy steels, carbon steels, stainless steel, copper, nickel, and titanium are some of the metals that can be welded using **gas-and-shielded-arc welding**. As its name implies, this process combines arc welding and gas welding. Two forms of gas can be used: *tungsten-inert gas (TIG)* and *metallic-inert gas (MIG)*. In TIG welding, the electrode that provides the arc for welding is made of tungsten. Because it provides only the heat, some other material must be used for filler. In MIG welding, the electrode contains a consumable metallic rod, providing both the filler material and the arc for fusion.

Symbols for Fusion Welding

Drafters use special symbols established by the American Welding Society to specify welds on a welding drawing. See **Figure 15-5** for an example of the use of welding symbols used on a machine drawing. In **Figure 15-6**, they are used on a structural drawing.

Refer to **Figure 15-7** on page 531 for a description of the standard welding symbols approved by the American Welding Society. The notes in the illustration explain how to place symbols and data in relation to the reference line. By combining the symbols in Figure 15-7, you can describe any welded joint, from the simplest to the most complex.

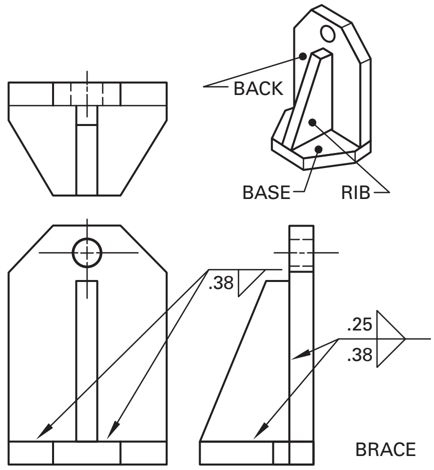


Figure 15-5

The application of welding symbols on a machine part

Reading Check

Contrast What is the primary difference between gas welding and arc welding?

Standard Symbols

The distinction between the terms *weld symbol* and *welding symbol* should be understood. The weld symbol, illustrated in Figure 15-7, indicates the type of weld. The welding symbol is a system for representing a weld on drawings. It includes not only the symbol but also supplementary information and consists of the following elements:

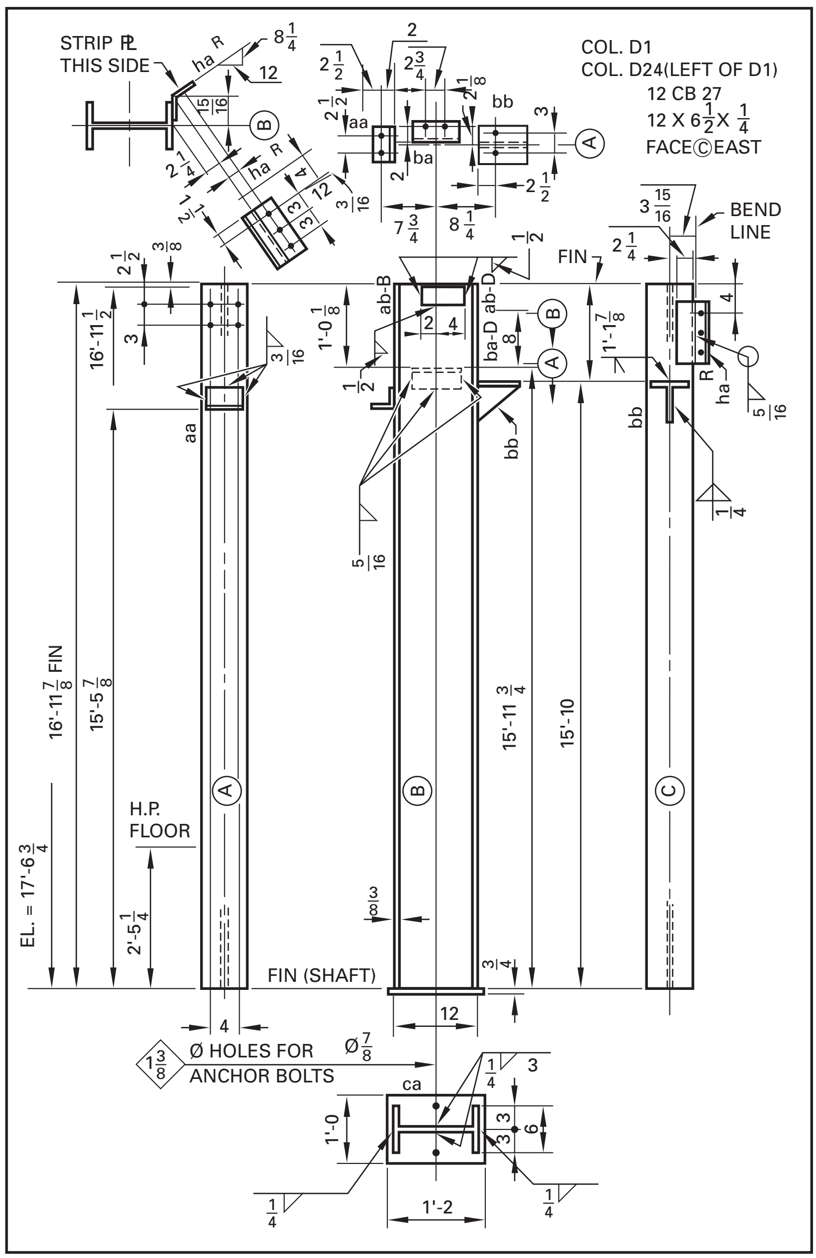


Figure 15-6

The application of welding symbols on a structural drawing

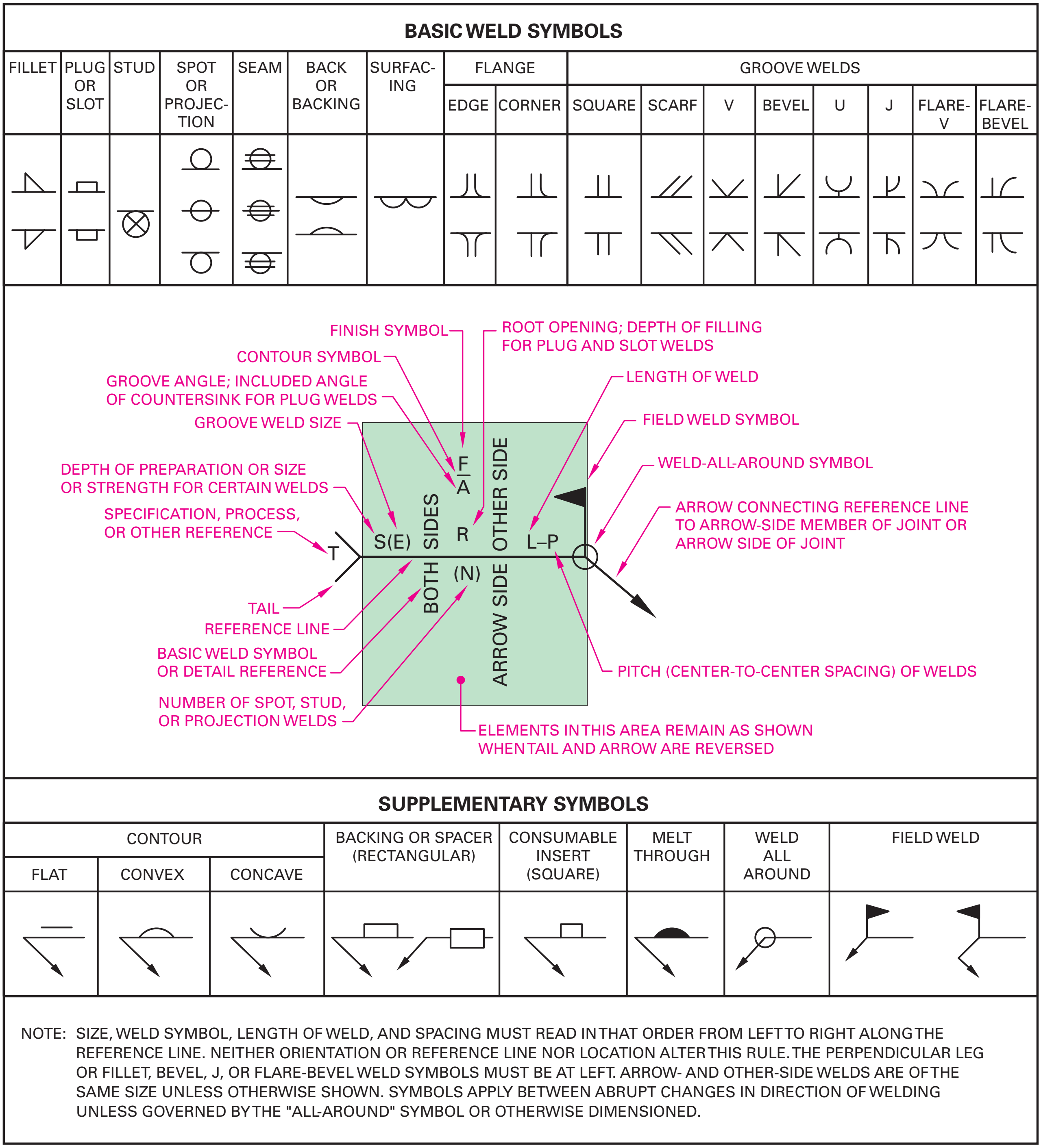


Figure 15-7

Weld symbols

- reference line
- arrow
- basic weld symbol
- dimensions and related data
- supplementary symbols
- finish symbols
- tail
- specifications, process, or other references

Not all elements of a welding symbol need be used. Use only those that are needed to describe the weld clearly and completely.

A welding symbol includes information about not only what type of weld to use but also where on the joint to place the weld. See **Figure 15-8** for five typical groove welds and the symbol for each. The symbol

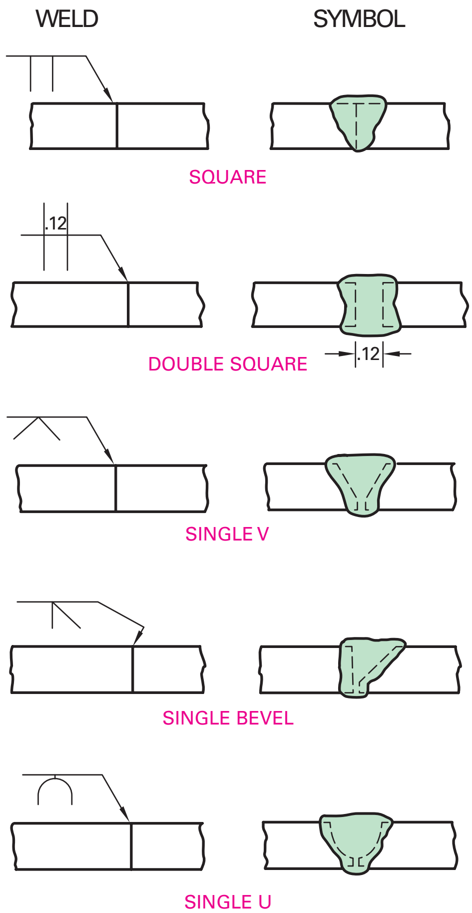


Figure 15-8

Symbols for five typical groove welds

can be drawn on either side of the joint as space permits. *Note:* When drawing a fillet, bevel, or J-grooved weld symbol, place the perpendicular leg of the symbol to the left (see **Figure 15-9**).

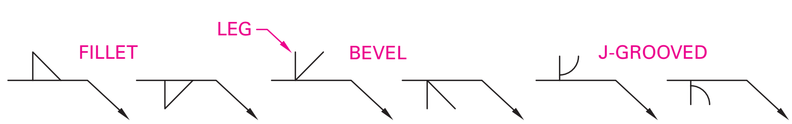
An arrow leads from the symbol's reference line to the joint. The side of the joint to which the arrow points is called the *arrow side*. The opposite side is called the *other side*. If the weld is to be on the arrow side of the joint, draw the type-of-weld part of the symbol below the reference line (see **Figure 15-10A** and **D**). If the weld is to be on the other side, draw the type-of-weld part of the symbol above the reference line (see **Figure 15-10B** and **E**). If the weld is to be on both sides of the joint, draw the type-of-weld part of the symbol both above and below the reference line (**Figure 15-10C**).

When the weld is to be a J-grooved weld, you must place the arrow from the welding symbol correctly to avoid confusion. For example, in **Figure 15-11A**, it is not clear which piece is to be grooved. In **Figure 15-11B**, the arrow has been redrawn to show clearly that the vertical piece is to be grooved as in **Figure 15-11C**. The drawing in **Figure 15-11D** calls for two welds. The symbol below the reference line includes a J-grooved weld on the arrow side. The arrow shows that the horizontal piece is to be grooved. The symbol above the reference line indicates a fillet weld on the other side. The drawing in **Figure 15-11E** shows how the completed welds would look.

In **Figure 15-12A**, the reference dimensions have been included with the welding

Figure 15-9

The perpendicular leg on a weld symbol is always drawn to the left.



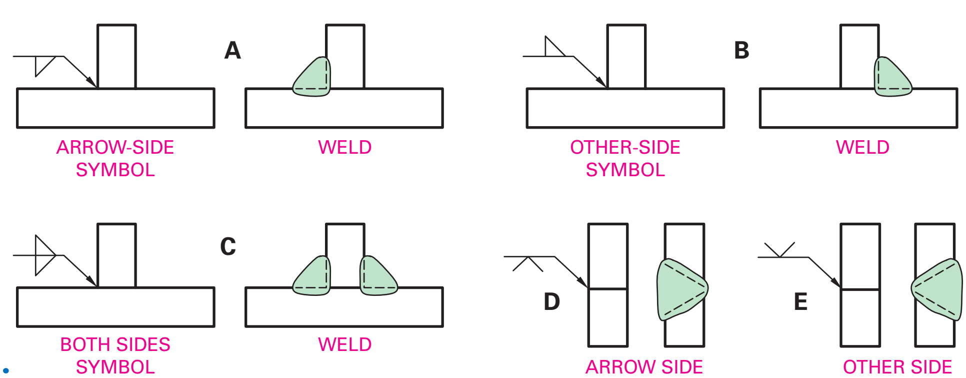


Figure 15-10

Weld symbols show the arrow side, the other side or both sides.

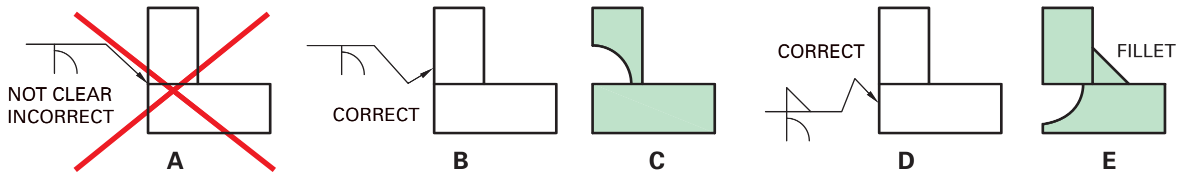


Figure 15-11

Weld symbols for the J-grooved weld

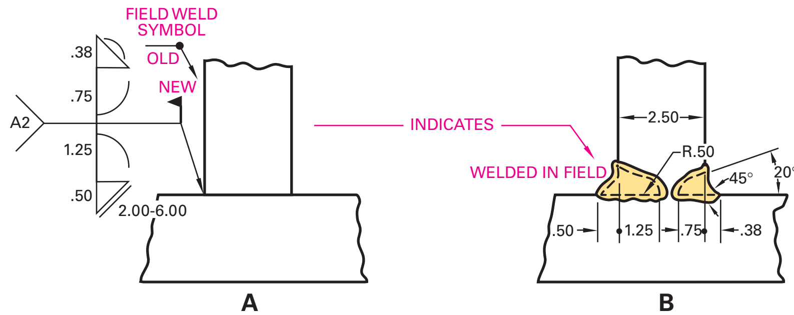


Figure 15-12

Weld symbols and specifications

symbols. The joint in **Figure 15-12B** is made according to the reference specifications in Figure 15-12A. This joint can be described as a double filleted-welded, partially grooved, double-J T-joint with incomplete penetration. The J-groove is of standard proportion. The radius R is .50″ (13 mm), and the included angle is 20°. The penetration is .75″ (19 mm) for the other side and 1.25″ (32 mm) deep for the arrow side. There is a .50″ (13-mm) fillet weld on the arrow side and a continuous .38″ (10-mm) fillet weld on the other side. The fillet on the arrow side is 2.00″ (50 mm) long. The pitch of 6.00″ (150 mm) indicates that it is spaced 6.00″ (150 mm) center-to-center. All fillet welds are standard at 45°.

Supplementary Symbols

Notice the solid black dot on the elbow of the reference line in Figure 15-12A. This dot (or a black flag) is a supplementary symbol for a field weld. Both indicate that the weld is to be made in the field or on the construction site rather than in the shop.

The specification A2 is in the tail of the reference line in Figure 15-12A. This means that the work is to be a metal-arc process that uses a high-grade, covered, mild-steel electrode; the root is to be unchipped and the welds unpeened, but the joint is to be preheated.

Notice the flush contour (outline) symbol over the .50″ (13-mm) fillet weld symbol in Figure 15-12A. This indicates that the contour of this weld is to be flat faced and unfinished. A convex contour symbol is over the .38″ (10-mm) fillet weld on the same reference line. This symbol indicates that this weld is to be finished to a convex contour. Figure 15-7 shows the supplementary welding symbols to be used for finished welding techniques.

Reading Check

Define What does a solid black dot or black flag symbol indicate?

Dimensioning Welds

See **Figure 15-13** for the typical dimensions for a butt joint with a V-grooved weld. Typically, the manufacturer needs to know the required angle of the joint preparation (A), the root opening (R), and the height of reinforcement (C), specified only if a back or backing weld is to be used on the underside of the welded joint. Dimensions for a T-joint with a bevel-grooved weld include the bevel angle (B), the root opening (R), and the height of reinforcement (C) if a weld is to be applied to the underside of the joint (see **Figure 15-14**). See **Figure 15-15** for the U-grooved joint preparation for a butt joint. This joint type is expensive to prepare and is used mainly for

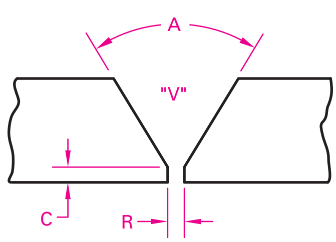


Figure 15-13

Dimensions for a V-grooved weld. A = 60° minimum; C = 0 to .12″; R = .12″ to .25″; stock = .50″ to .75″ thick

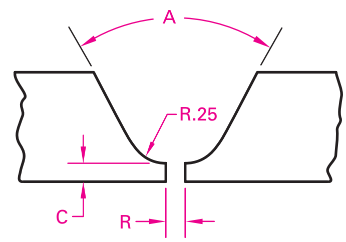


Figure 15-15

Dimensions for a U-grooved weld. A = 45° minimum; C = .06″ to .20″; R = 0 to .56″

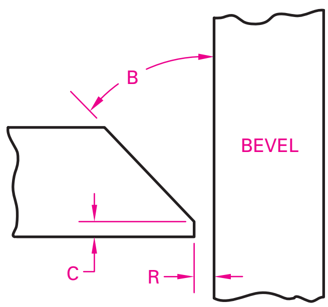


Figure 15-14

Dimensions for a bevel-grooved weld. B = 45° minimum; C = 0 to .12″; R = .12″ to .25″

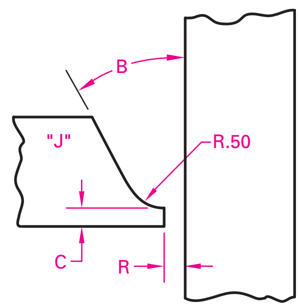


Figure 15-16

Dimensions for a J-grooved weld. B = 25° minimum; C = .06″ to .20″; R = 0 to .56″

joining materials at least 1.00″ thick. In this case, dimension the groove angle (A), the radius (R) at the bottom of the groove, the root opening (R), and the height of reinforcement (C), if applicable. The J-grooved joint preparation is generally used on a T-joint (see **Figure 15-16**). This joint type requires preparation on one part only, as shown, and closely resembles the U-grooved joint. Like the U-grooved joint, it is used when joining materials at least 1.00″ thick.

When the design engineer determines that it is not necessary to run a weld the entire length of the joint the length of the weld is given to the right of the weld symbol (see **Figure 15-17**). A series of two or more short welds along a joint, called an **intermittent weld**, is specified and dimensioned as in **Figure 15-18**. The pitch (center-to-center spacing) of intermittent welds is shown as

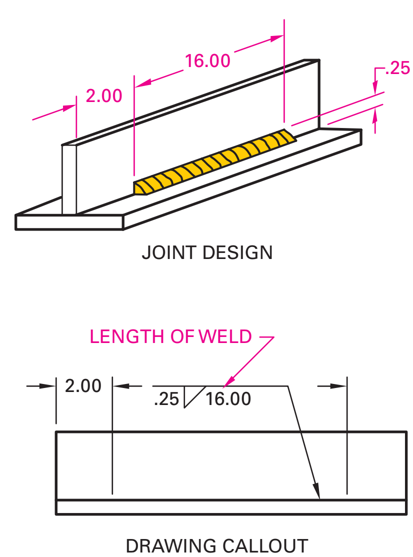


Figure 15-17

Dimensioning the length of a weld

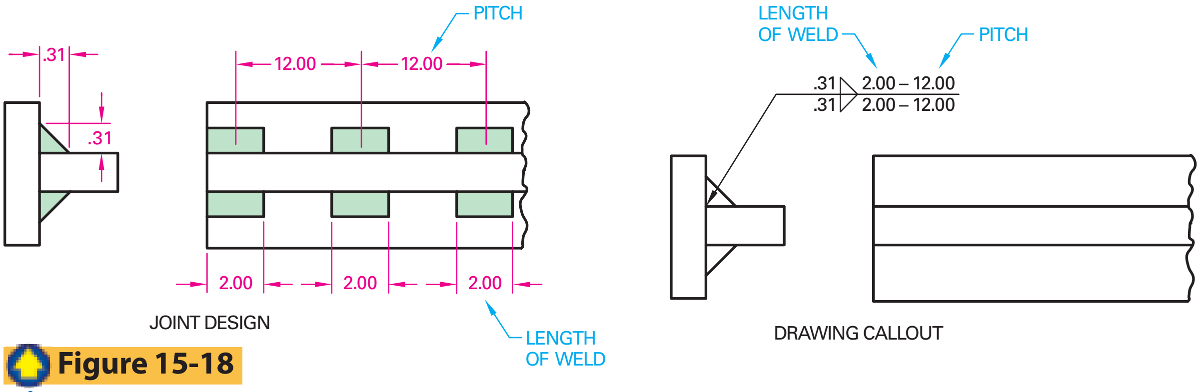


Figure 15-18

Specifying intermittent welds

STEM

Do The Math

Temperature Conversions

Processes such as welding, forging, casting, soldering, and brazing, often involve numerical values for the high temperatures needed in these processes. It is often necessary for drafters, engineers, and welders to work both in degrees Fahrenheit (F) and in degrees Celsius or centigrade (C). Conversion from one system to another can be accomplished using two simple formulas.

Convert 8000° Fahrenheit to degrees Celsius.
Convert 2975° Celsius to degrees Fahrenheit.

Math Concept To convert temperatures from degrees Fahrenheit to degrees Celsius, use the formula:

$$C = \frac{5}{9}(F - 32)$$

Academic Standards

Mathematics

Measurement Understand measurable attributes of objects and the units, systems, and processes of measurement (NCTM)

Example: Burning acetylene gas supported by oxygen for gas welding and brazing, temperatures between 5000° and 6500° Fahrenheit can be achieved. These temperatures in Celsius or centigrade are 2760° and 3593°, respectively.

To apply this formula to the lower limit of temperatures for gas welding and brazing, plug in the numbers as follows:

$$C = \frac{5}{9}(5000 - 32)$$

$$C = \frac{5}{9}(4968)$$

$$C = 5 \times \frac{4968}{9}$$

$$C = 2760°$$

To convert temperatures from degrees Celsius to degrees Fahrenheit, use the formula:

$$F = \frac{9}{5}C + 32$$

To convert the lower limit of temperatures for gas welding and brazing from Celsius to Fahrenheit, use the formula as follows:

$$F = 9 \times \frac{2760}{5} + 32$$

$$F = \frac{24{,}840}{5} + 32$$

$$F = 4968 + 32$$

$$F = 5000°$$

For help with this math activity, go to **www.glencoe.com** for this book's OLC and click on Math Handbook.

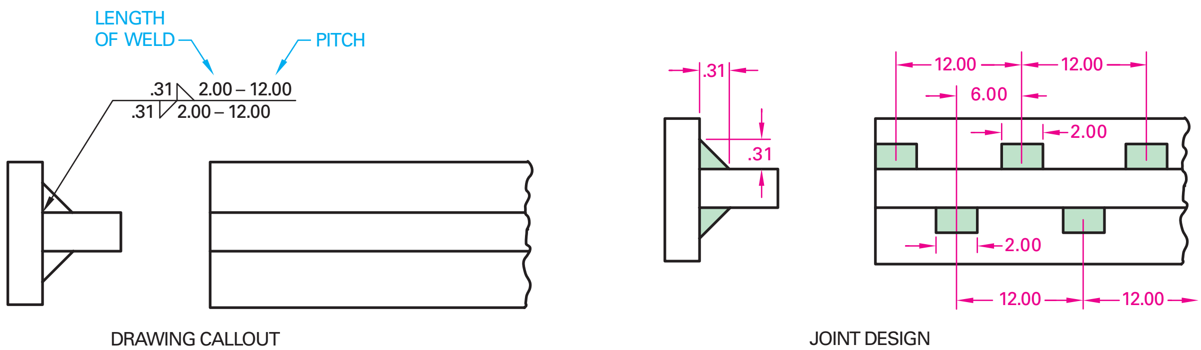


Figure 15-19

Staggered intermittent welds

the distance between centers of increments on one side of the joint. It is shown to the right of the length dimension with a hyphen between the two dimensions. Staggered intermittent welds are shown with the weld symbols staggered (see **Figure 15-19**).

Section 15.1 Assessment
After You Read

Self-Check

1. **List** and describe four different welds.
2. **Explain** the welding process.
3. **Describe** the fusion welding process.
4. **Determine** the appropriate joint preparation for a specific weld application.

Academic Integration

5. **Convert Temperatures** Make the following conversions: 3500°C, 212°C, and 1200°C to Fahrenheit; and 4200°F, 32°F, and 6000°F to Celsius.

Math Concept **Measurement**

Review this chapter's Do the Math activity for the conversion formulas.

Drafting Practice

6. Make a three-view drawing of the lever stand shown in **Figure 15-20**. Determine your own dimensions. Provide a support rib for the upright member. Include dimensions and welding symbols.

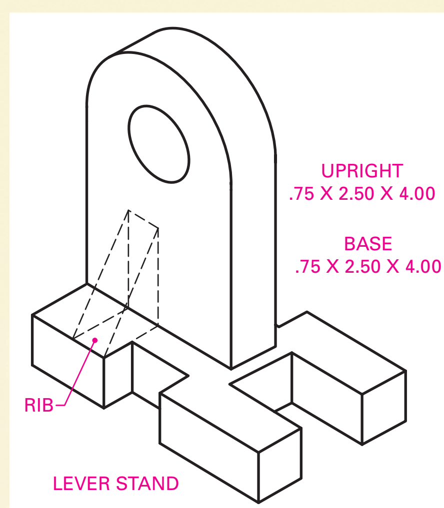


Figure 15-20

Go to **glencoe.com** for this book's OLC for help with this drafting practice.

15.2 Producing a Welding Drawing

READING GUIDE

Before You Read

Connect Now that you have grasped the theory of welding, you will apply the principles you have learned to an actual drawing. What aspect of hands-on work interests you most, and which do you find most challenging?

Content Vocabulary

- weldment

Academic Vocabulary

Learning these words while you read this section will also help you in your other subjects and tests.

- exemplifies
- significantly

Graphic Organizer

Use a chart like the one here to organize notes about steps in creating a welding drawing using board drafting and CAD techniques.

Steps in Creating a Welding Drawing	
Board Drafting	**CAD**
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

Go to **glencoe.com** for this book's OLC for a downloadable version of this graphic organizer.

Academic Standards

English Language Arts

Read texts to acquire new information (NCTE)

Mathematics

Measurement Understand measurable attributes of objects and the units, systems, and processes of measurement (NCTM)

Science

Physical Science Chemical reactions; interactions of energy and matter (NSES)
Science and Technology Abilities of technological design (NSES)

Industry Standards

ADDA Section 13

Welding Drafting (ASME/ANSI B31.1; ASME/ANSI B31.3, ASME/ANSI 31.9)

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Board-Drafting Techniques

What should you consider when preparing a welding drawing, to save a manufacturer "tooling up" time?

You should now be ready to develop a welding drawing with dimensions and symbols. The information given on the completed drawing should be sufficient to manufacture the part. To make this experience more meaningful, the casting of the connecting link (see **Figure 15-21**) will be converted into a **weldment**.

In the conversion process, consider several things:

- When you convert from a casting to a weldment, you can generally reduce the thickness of cast members by 1 material thickness. For example, the ribs on the casting are .38″ thick. Because steel plate is considerably stronger and tougher than cast iron, the thickness of the replacement steel plate can be .25″ thick. This **exemplifies** that careful engineering and good judgment are critical parts of the conversion process.
- In some cases, changing round features on the casting to square, flat, or rectangular parts on the weldment reduces joint preparation. This concept will become evident as you continue to convert the connecting link.
- Because a weldment consists of several individual parts welded together to form an assembly, it is useful to number the parts on the welding drawing and prepare a parts list. This saves the manufacturer considerable time in the "tooling up" process.
- Select appropriate weld joints and joint preparations based on the size of the parts to be joined and strength required. In this case, you can use fillet welds throughout with no special joint preparation.
- A qualified engineer generally determines the size and type of weld to be specified. In this exercise, the engineer has suggested .19″ fillet welds throughout the part.

To create the welding drawing, follow these steps:

1. Consider the changes required or enabled by converting the connecting link from a casting to a weldment.

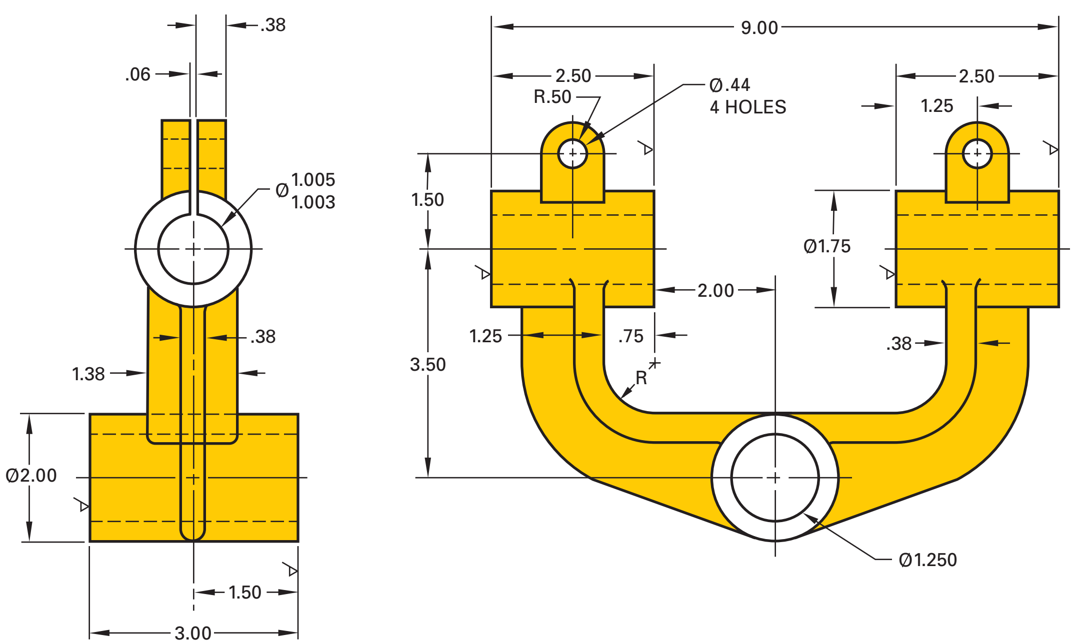


Figure 15-21
Connecting link casting

2. Sketch the necessary views, including dimensions and welding symbols, to determine the appropriate scale and drawing sheet size.
3. Create an instrument drawing of the connecting link, incorporating all changes you determined in step 1.
4. Add the appropriate dimensions and welding symbols.
5. Number the parts on the welding drawing and create a parts list.

Figure 15-22 shows the finished welding drawing. Notice that by converting the round features on the casting to square features on the weldment, you are able to reduce joint preparation and fitting time **significantly**. This process greatly reduces the cost to manufacture the part. Notice also that all parts except Part No. 5 are stock materials that need only be cut to length, placed in position, and welded. Therefore, relatively little special cutting and fitting are required.

Reading Check

Explain Why can the thickness of steel plate be less than that of cast iron for the same part?

CAD Techniques

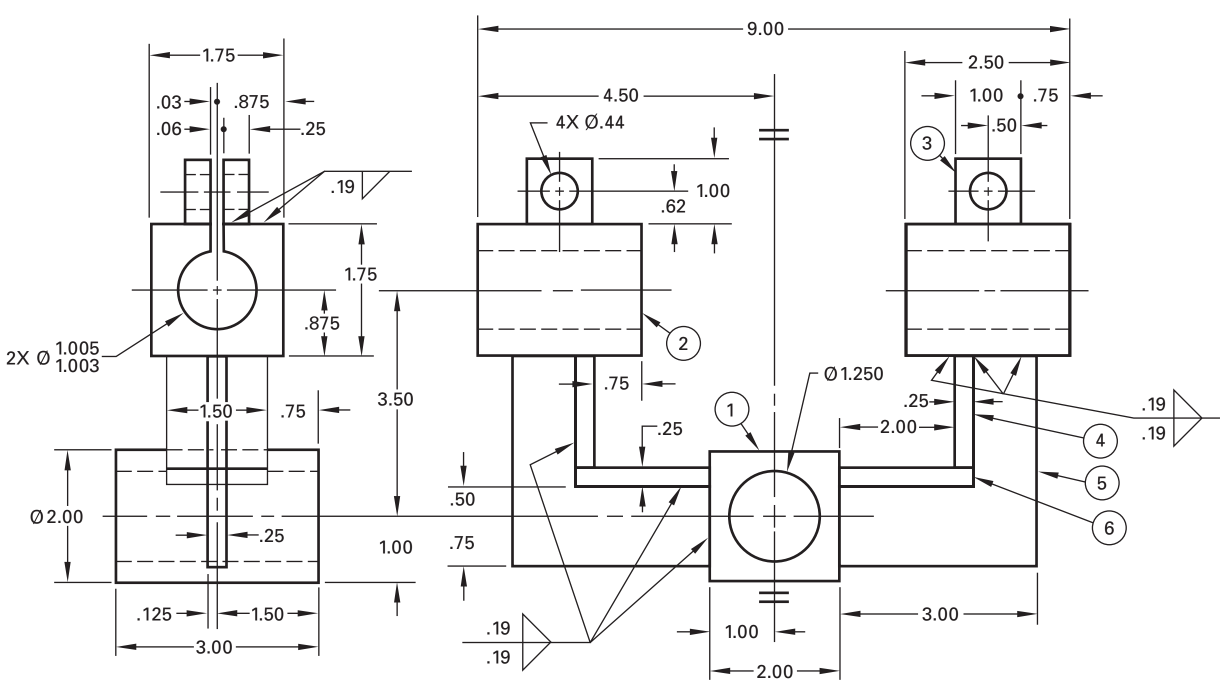
How can you use a symbol library in creating a welding drawing?

The procedure for creating a welding drawing using CAD is similar to that for creating any other CAD drawing. (You must, of course, apply the welding theory discussed in this chapter). The feature that sets the CAD techniques apart from board drafting techniques is the use of symbol libraries for the welding symbols. As in other drafting applications, using a library for welding symbols greatly reduces the time and effort required to create a welding drawing.

Figure 15-22

Welding drawing of the connecting link from Figure 15-21

QTY	ITEM	MATL	DESCRIPTION	PT NO.
1	SHAFT	STL	☐ 2.00 X 3.00	1
2	SHAFT	STL	☐.75 X 2.50	2
4	SUPPORT	STL	.25 X 1.00 X 1.00	3
2	RIB	STL	.25 X 1.50 X 1.88	4
2	RIB	STL	.25 X 3.00 X 3.38	5
2	RIB	STL	.25 X 1.50 X 2.00	6



As with other symbols, those for welds are available from a number of sources: third-party symbol libraries and standard symbol libraries preloaded on CAD systems. Both vary in cost, and some third-party libraries are even free.

To use symbols that come on most versions of AutoCAD (see **Figure 15-23**), open the DesignCenter and navigate to AutoCAD's Samples folder and then to the DesignCenter folder. The welding symbols consist of blocks in the Welding.dwg file. Pick the + next to Welding.dwg. Pick Blocks to display the welding symbols. To use one of the symbols in your drawing, just pick it and drag it into the current drawing.

A typical drawing task a drafter encounters might be to convert the plan for a casting into one for a weldment. Figure 15-21 shows a drawing of a casting for a connecting link. To convert this into a welding drawing, follow these steps:

1. Study the bulleted list of considerations for converting a casting into a weldment that appears earlier in the chapter. Then follow these steps:
2. Consider the changes required or enabled by converting the connecting link from a casting to a weldment.
3. Determine the appropriate drawing sheet size and the scale at which you will print the finished drawing.

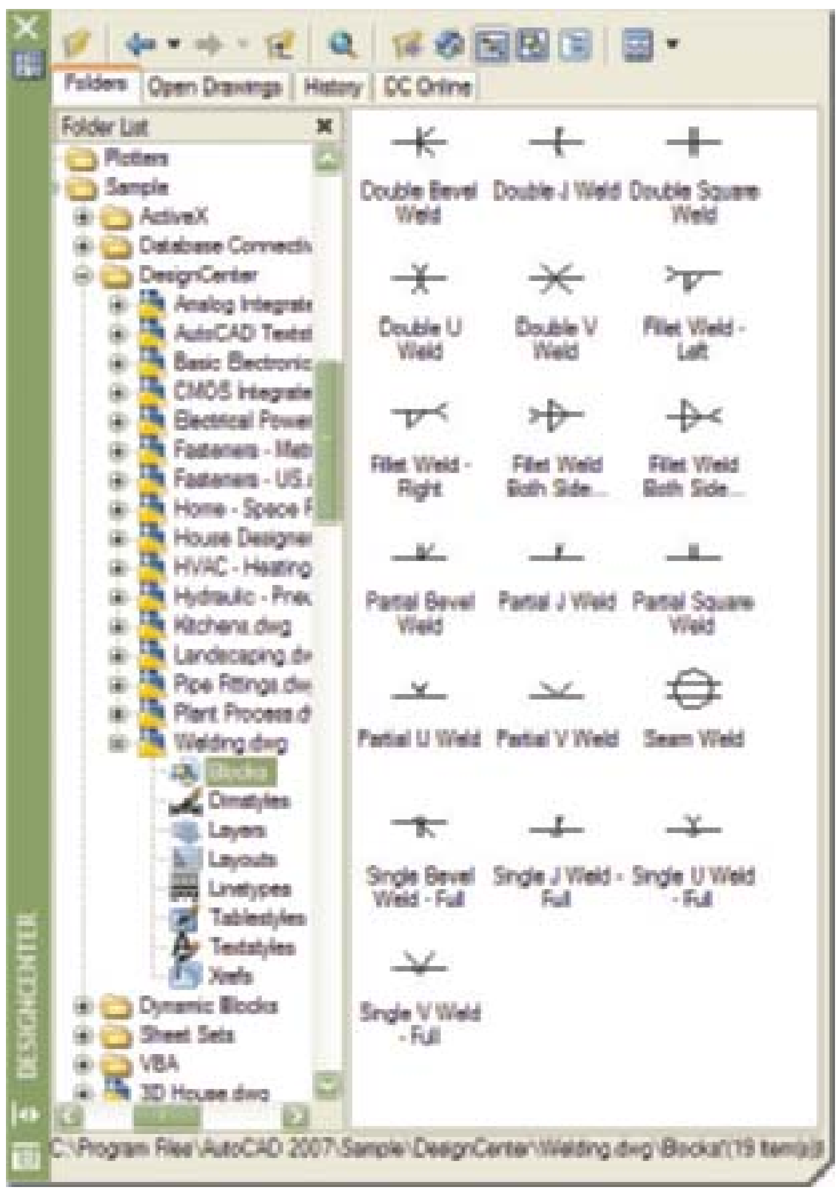


Figure 15-23

Open DesignCenter to use the symbols in AutoCAD's welding symbol library.

4. Start a new drawing file and create the two-view drawing of the connecting link, incorporating all of the changes you determined in step 1.
5. Add the appropriate dimensions.
6. Open a welding symbol library. Drag the appropriate symbols from the symbol library into the connecting link drawing. Size and place the symbols as necessary.
7. Create the parts list. If the blocks in the symbol library you are using have embedded attributes, you may be able to use the attributes to create the parts list automatically. See Chapter 11 for more information about using blocks and attributes.

CAD TIP

Custom Welding Symbols

If you do not have access to a welding symbol library, it may be worth your time to create one. Welding symbols are neither difficult nor time consuming to create. You can draw them once, add custom attributes that will make your parts list easier to create, and save the file for use in this and other drawings.

Section 15.2 Assessment
After You Read

Self-Check

1. **Explain** how to convert a drawing for a casting into an appropriate drawing for a welded part.

Academic Integration
English Language Arts

2. The topic sentence of a paragraph sometimes appears at the beginning. Sometimes it appears in the middle or at the end, and sometimes it is not directly stated, but must be inferred. Take notes from one of the sections by identifying and writing down the key words and phrases from the topic sentence of each paragraph.

Drafting Practice

3. Prepare a drawing of each girder section shown in **Figure 15-24** and place the symbols for welding in appropriate locations with dimensioning.

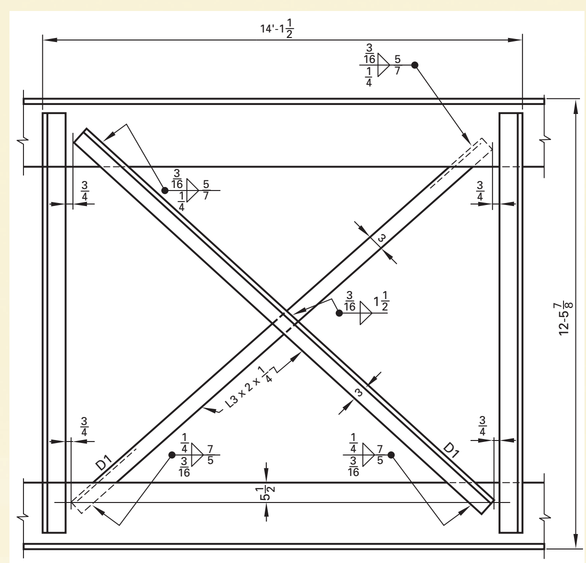


Figure 15-24

Go to **glencoe.com** for this book's OLC for help with this drafting practice.

CHAPTER 15

Review and Assessment

Chapter Summary

Section 15.1

- Because welding is a major assembly method in industry, drafters must be actively aware of all aspects of welding when they make welding drawings.
- Fusion welding applies heat to form a weld whereas resistance welding combines heat and pressure to form the weld.

Section 15.2

- Information given on a finished welding drawing must be complete, so that the part involved can be accurately and efficiently manufactured.
- Welding symbols are available in libraries for use in CAD systems.

Review Content Vocabulary and Academic Vocabulary

1. Use each of these content and academic vocabulary words in a sentence or drawing.

Content Vocabulary

- welding (p. 527)
- groove weld (p. 528)
- fillet weld (p. 529)
- plug weld (p. 529)
- slot weld (p. 529)
- fusion welding (p. 529)
- gas welding (p. 529)
- arc welding (p. 529)
- gas-and-shielded-arc welding (p. 529)
- intermittent weld (p. 534)
- weldment (p. 538)

Academic Vocabulary

- combination (p. 527)
- ignition (p. 529)
- exemplifies (p. 538)
- significantly (p. 539)

Review Key Concepts

2. **Identify** the various types of joints and welds.
3. **Explain** the welding process.
4. **Describe** the fusion welding process.
5. **Determine** the appropriate joint preparation for a specific weld application.
6. **Explain** how to convert a drawing for a casting into an appropriate one for a welded part.

STEM Science

7. Science of Welding

As you read in this chapter, welding fuses using high temperatures. How does this happen scientifically? Choose one of the four types of fusion welding discussed in this chapter and research the scientific process that occurs during the welding. For example, what causes the increase in temperature? What happens to cause the metal parts to join together? After conducting research, create a poster that illustrates the chemical, electrical, or combined chemical-electrical process that creates your chosen weld.

21st Century Skills

8. Leadership and Responsibility

You and a friend recently started working for a large corporation. It does random drug testing, and your friend, but not you, has been selected for testing. Your friend says he has a bad back and is taking pain pills for it. He wants you to take the drug test for him. The company is so big, he says, no one will ever know. What is your response, and why?

STEM Mathematics

9. Calculating Volume

Imagine you are in charge of finding storage facilities for your company's surplus inventory. The inventory is stored on pallets and has a total volume of 2,690 cubic feet. You find a storage site with an area that fits your needs. If the floor measures 23 feet by 13 feet, how high would the ceiling have to be to accommodate your inventory?

Math Concept Geometry: Volume

The column of a three-dimensional geometric figure is measured in cubic units. You can memorize the formulas for finding the volumes of various figures, or you can look them up in a math glossary. To find the volume of a rectangular solid, multiply length by width and height.

Standardized Test Practice

Prep For ACT

True/False Questions

Directions Read the following statements and determine whether each statement is true or false.

10. Fusion welding uses heat and pressure to create a weld.

T

F

11. Another word for *inert* is active.

T

F

TEST-TAKING TIP

Look for key words in test directions and questions such as *choose, describe, explain, compare, identify, similar, except, not,* and *but.*

SkillsUSA Win Competitive Events

12. Personal Qualities in the Workplace

Organizations such as SkillsUSA offer a variety of architectural, career, and drafting competitions. Completing activities such as the one below will help you prepare for these events.

Activity In a group of two or three, arrange to interview a local employer about personal qualities required to be a successful employee today. Brainstorm with your group to prepare questions before the interview, and analyze the responses afterward. Then prepare a media presentation to instruct other groups about your findings.

Go to **glencoe.com** for this book's OLC for more information about competitive events.

Chapter 15 Problems

Drafting Problems

The drafting problems in this chapter are designed to be completed using board-drafting or CAD techniques.

1. Prepare a drawing of each girder section shown in **Figure 15-25** and place the symbols for welding in appropriate locations with dimensioning.

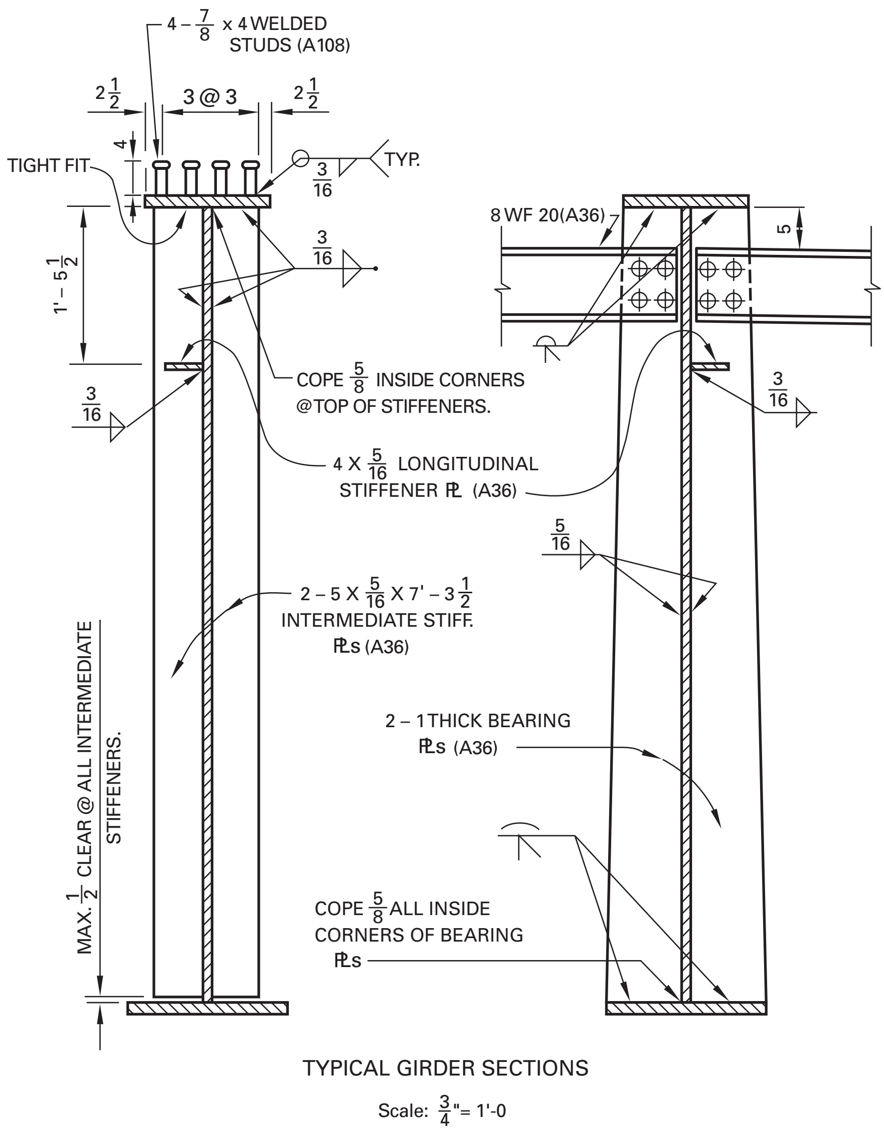


Figure 15-25

2. Develop a three-view drawing of the bearing support shown in **Figure 15-26**. Include appropriate welding symbols to assemble the five parts that form the bearing support.

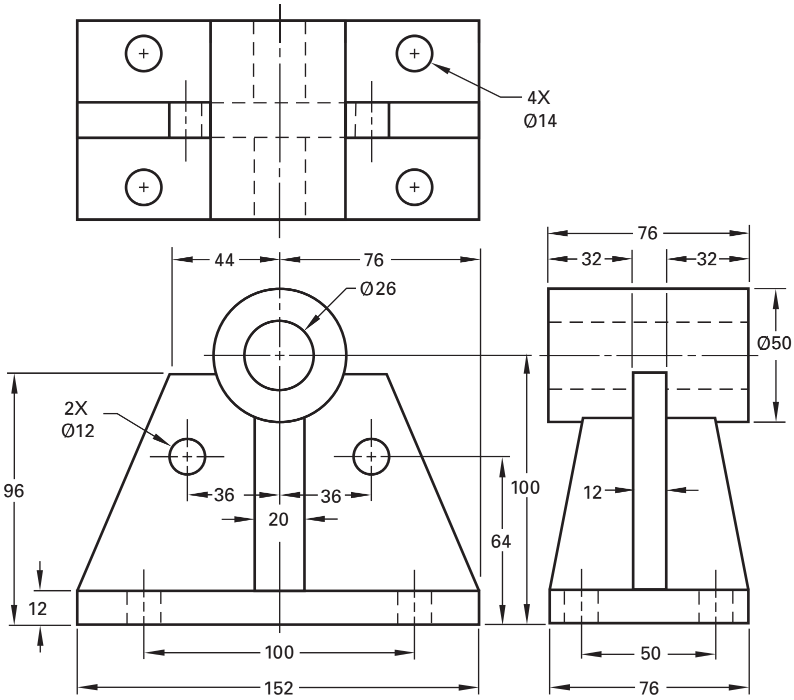


Figure 15-26

3. Prepare three views of the double-bearing swivel support shown in **Figure 15-27**. Dimension in millimeters. Prepare a parts list.

METRIC

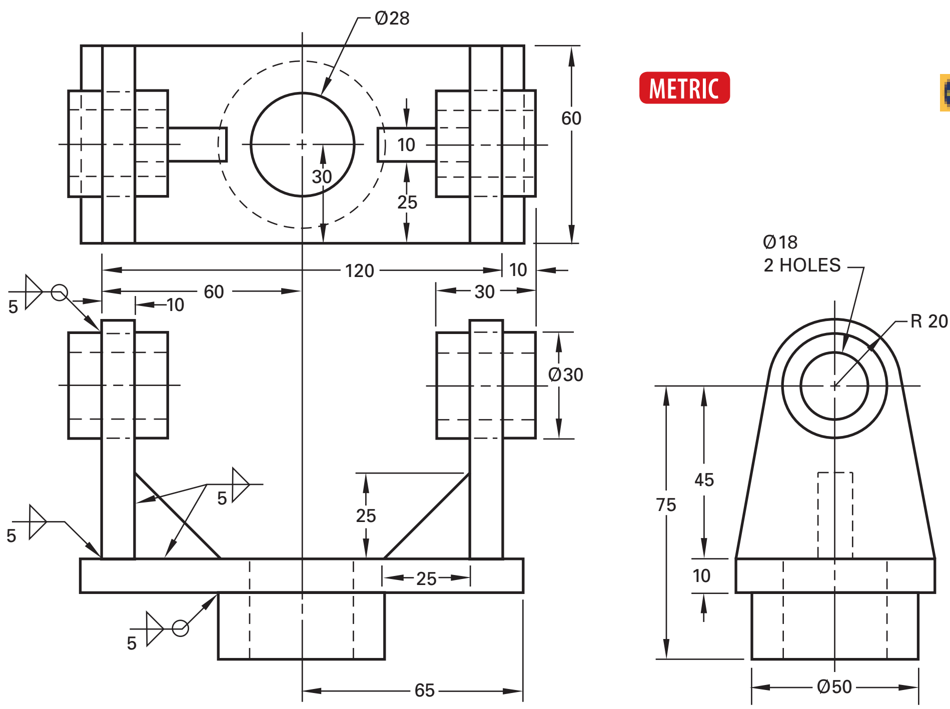


Figure 15-27

15 Problems

4. Convert the casting drawing for the pin link shown in **Figure 15-28** into a weldment drawing. Scale 1:1 on an A-size sheet. Call for .19″ welds and use .25″-thick flat stock to connect the two ends.

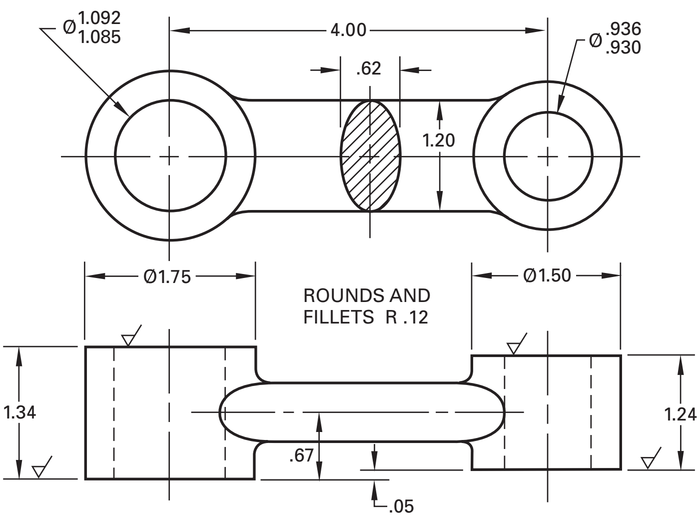


Figure 15-28

5. The shaft support shown in **Figure 15-29** has been cast in gray iron. This is a rather costly method for producing the part. The engineering division of your company has decided to convert the part from a casting to a weldment as a cost-saving measure. On an A-size sheet, make a welding drawing of the shaft support by converting the casting to a weldment. The thickness of the base plate can be reduced to .25″ thick, because steel is tougher and stronger than gray iron. Call for .19″ welds.

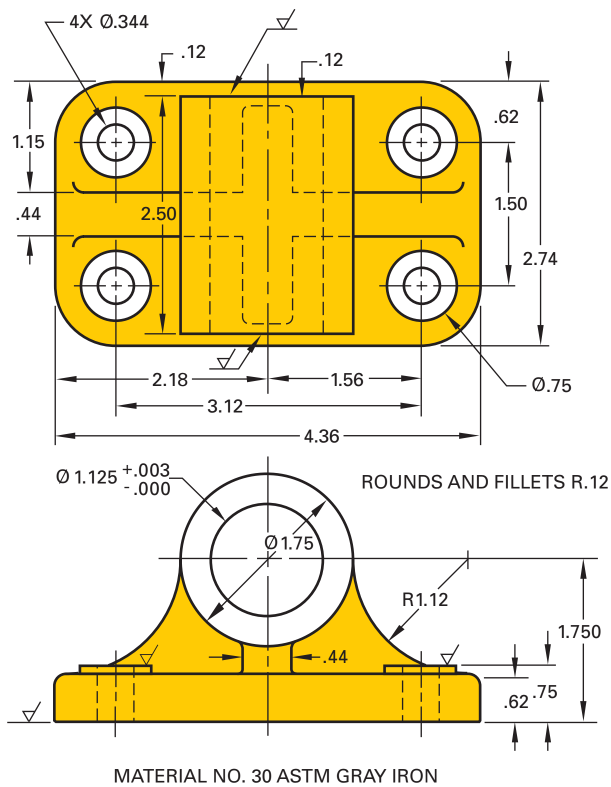


Figure 15-29

Design Problems

Design problems have been prepared to challenge individual students or teams of students. In these problems, you are to apply skills learned mainly in this chapter but also in other chapters throughout the text. They are designed to be completed using board drafting, CAD, or a combination of the two. Be creative and have fun!

Challenge Your Creativity

1. Design a stand to support a 1.25″-diameter by 6′-6″ flagpole. It is to be fastened to the floor with No. 14 flathead wood screws. The design should include steel tubing and plate with welded joints. Develop design sketches and working drawings with dimensions and welding symbols.
2. Design a park bench to be made from at least two different materials. The base should be steel tubing or angle with welded joints. The seat should be wood planks or fiberglass planks. Develop design sketches and working drawings with dimensions and welding symbols.

Teamwork

3. Design a ladder rack for a pickup truck. The design should include square or rectangular steel tubing with welded joints. Each team member should develop sketches of his or her design. Select the best ideas from each to finalize the team design. Prepare a final set of working drawings with dimensions and welding symbols.
4. Design a weightlifting bench that will accommodate at least 500 pounds of free weights. The design should include steel tubing with welded joints. Consider in the design an adjustable inclined bench and an attachment for leg lifts. Each team member should develop sketches of his or her design. Prepare a final set of working drawings with dimensions and welding symbols.