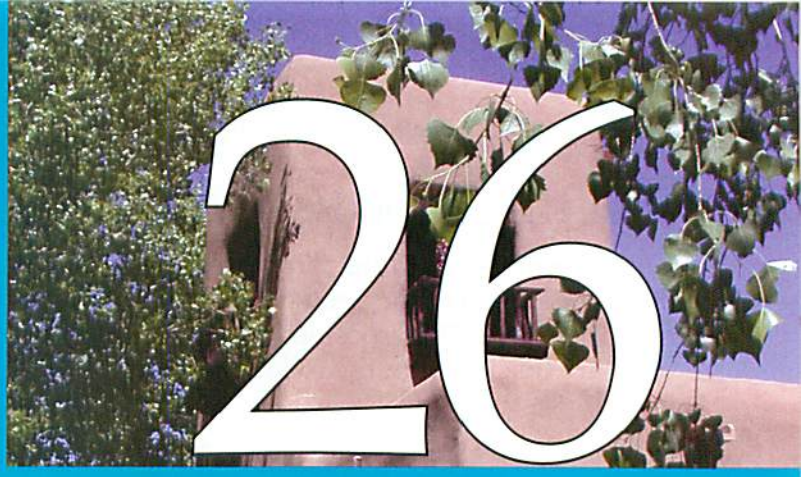
Welding Drafting



Learning Objectives

After studying this chapter, you will be able to:

- List and describe some of the most common welding processes.
- Identify the basic types of welded joints.
- Describe the purpose of weld symbols and identify the different types used on drawings.
- Explain the elements making up a welding symbol and interpret the information provided.

Technical Terms

Arc welding
Brazing
Electron beam welding (EBW)
Flash welding
Gas metal arc welding (GMAW)
Gas tungsten arc welding (GTAW)
Induction welding
Oxyfuel gas welding
Resistance welding
Seam welding
Spot welding
Standard welding symbol
Weld symbols
Welding drawing
Welding symbols

Welding has become one of the principal means of fastening parts together, **Figure 26-1**. Welding can also be used to build up the surface of a part. Advances in technology have brought about the development of welding processes and materials to meet nearly any metal fabricating need. These capabilities have placed a major responsibility on design and drafting departments to adequately specify welds required for a particular structure or machine part.

A ***welding drawing*** is a type of assembly drawing that shows the components of an assembly in position to be welded, rather than as separate parts. Specification of the type(s) of welds to be used on various joints is standard procedure on welding drawings. This chapter discusses common welding processes and standard conventions used to specify welds on drawings.

Welding Processes

Numerous welding processes have been developed to meet the need for joining different types of metals. The processes that are commonly used are discussed in the following sections.

Brazing

Brazing is the process of joining metals by adhesion with a low melting point filler metal. This process does not melt the parent metal. A copper base filler metal is commonly used.

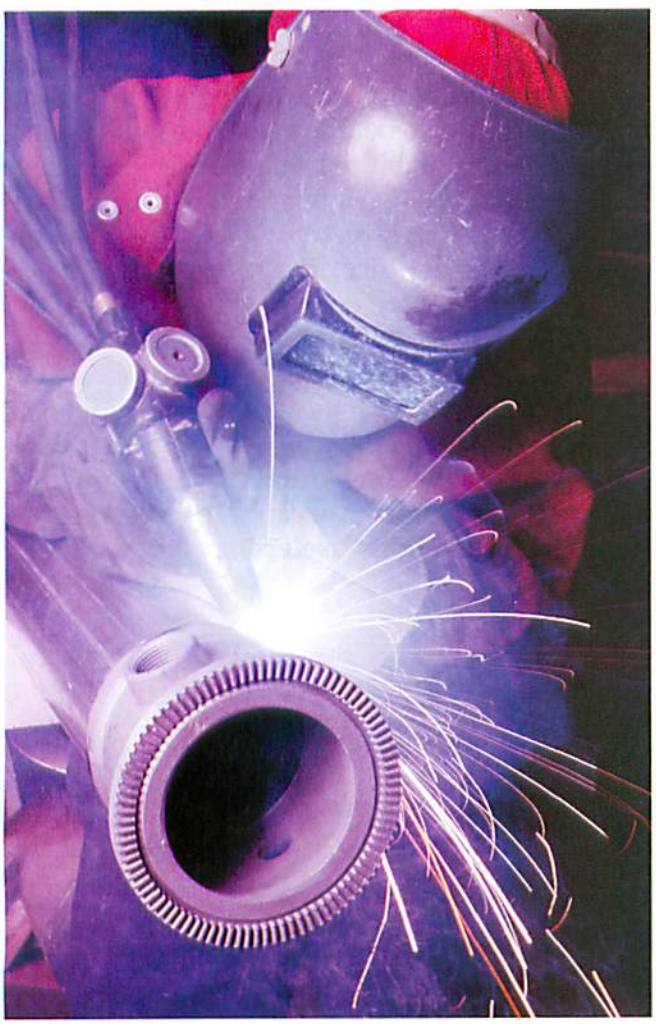


Figure 26-1. Modern industry depends on welding processes for many jobs. A drawing must clearly specify the engineering designer's intent for each weld if the part is to be properly fabricated.

Oxyfuel Gas Welding

Oxyfuel gas welding is a process in which the heat generated by burning gases causes the parent metal to melt and "fuse" into one piece. In some cases, a filler metal is used. The most commonly used oxyfuel gas welding process is *oxyacetylene welding.*

Arc Welding

Arc welding is a process in which heat is produced by an electric arc between a welding electrode and the parent metal. The heat causes the metal to melt and fuse, **Figure 26-2.** Two types of arc welding are gas tungsten arc welding (GTAW) and gas metal arc welding (GMAW).

Figure 26-2. In arc welding, heat is generated by an electric arc between a metal electrode and the parent metal. In some arc welding processes, metal is added to the parent materials being joined. (Lincoln Electric)

Gas tungsten arc welding (GTAW) is also known as *tungsten inert gas (TIG) welding.* It is a gas-shielded arc welding process (a "shield" of gas protects the area being welded). The tungsten electrode maintains an intense heat and a metal filler rod may or may not be added, depending on the requirements of the joint. An inert gas (one that does not chemically combine with the weld) surrounds the weld and produces a clean weld. The gas typically used is a combination of argon and helium.

The primary use of the GTAW welding process is in joining lightweight (less than 1/4" thick) nonferrous metal including aluminum, magnesium, silicon-bronze, copper and nickel alloys, stainless steel, and precious metals. The gas-shielded arc gives an unobstructed view of the slag-free weld.

Gas metal arc welding (GMAW) is also known as *metal inert gas (MIG) welding.* It is a gas-shielded arc welding process similar to GTAW welding. In GMAW welding, the electrode is a filler wire that is fed into the weld automatically, **Figure 26-3**. GMAW is used for welding metals 1/4" thick or thicker.

Figure 26-3. In gas metal arc welding (GMAW), a metal filler wire is automatically fed into the weld area. (Lincoln Electric)

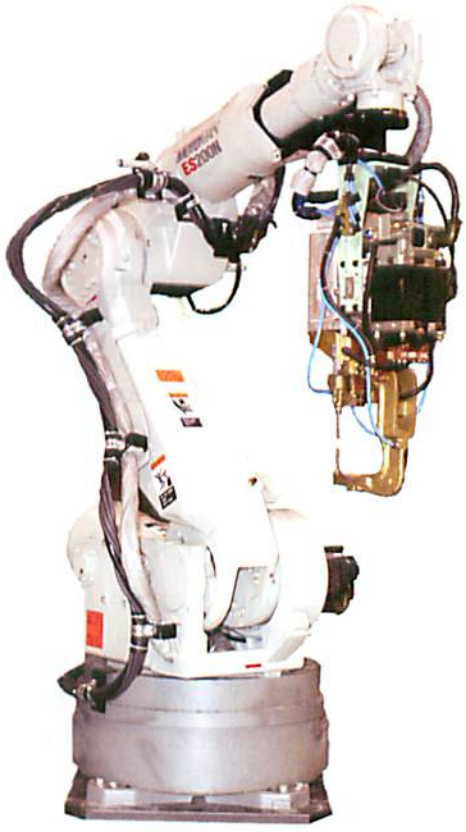


Figure 26-4. A robotic spot welder. Resistance welding is commonly used in fabricating automobile body sections. (Motoman, Inc.)

Resistance Welding

Resistance welding is an effective and economical means of fastening metal parts, **Figure 26-4**. An electric current is the source of heat. Pressure is applied to bring the parts together at the point of weld.

Resistance welding is based on the principle that resistance to current flow causes metal to become hot. Resistance is greatest at the joint between the pieces. Therefore, when the current is properly adjusted, the metal pieces melt and fuse at the joint.

The primary types of resistance welding are spot welding, seam welding, and flash welding. In ***spot welding***, the metal is fluxed only in the

contact spots. In ***seam welding***, or *butt welding*, an entire joint or seam between work parts is welded. In ***flash welding***, the ends of two metal parts are brought together under pressure and welded.

Induction Welding

Induction welding is similar to resistance welding. However, in induction welding the heat generated for the weld is produced by the resistance of the metal parts to the flow of an induced electric current. The welding action may occur with or without pressure.

Electron Beam Welding (EBW)

The source of heat in ***electron beam welding (EBW)*** is a high-intensity beam of electrons focused in a small area at the surface to be welded. This is a special welding process used in applications where greater control is required.

Electron beam welding is done in a vacuum. This practically eliminates contamination of the weld from the atmosphere, **Figure 26-5**. There is minimum distortion of the workpiece because the heat is concentrated in a small area. EBW is used in welding metals such as titanium, beryllium, and zirconium. These metals are common to the aerospace industry and are difficult to weld by other welding processes.

Types of Welded Joints

The welding process lends itself to a variety of joints in fastening metal parts. There are five basic types of joints commonly used. These are the butt joint, corner joint, T-joint, lap joint, and edge joint. These joints, and the welds applicable to each type, are shown in **Figure 26-6**.

Types of Welds

The term "weld" refers to the basic design of the weld itself. Common weld types are shown in **Figure 26-7**. Also shown is the welding symbol representation for each type of weld on the drawing. ***Weld symbols*** (designating the specific type of weld to be performed) and ***welding symbols*** (designating all pertinent information required for welding) are discussed in the sections that follow.

Design selection is basically determined by the thickness of the metals to be joined. The design selection is also determined by the penetration of the weld into the joint for the strength required. The type of metal also has a bearing on the weld design selected.

Weld Symbols

The American Welding Society (AWS) has developed a set of standard symbols for use in specifying types of welds on drawings,

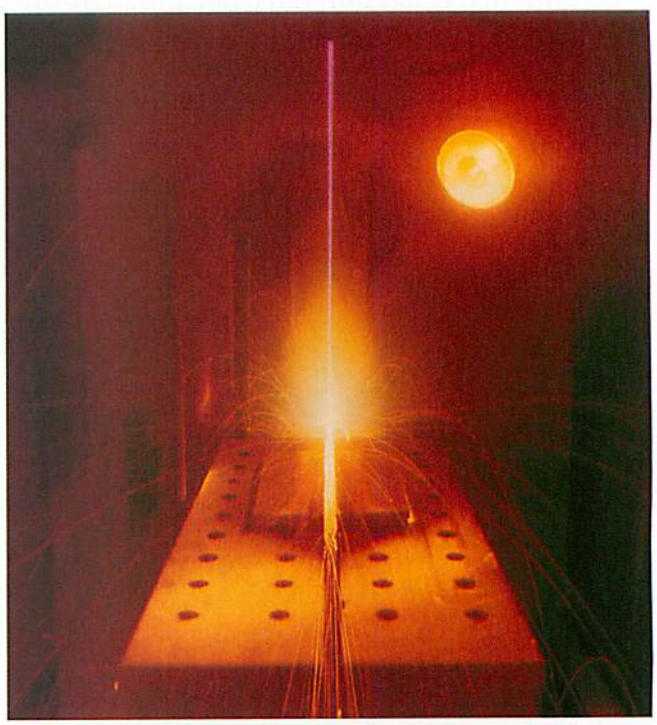


Figure 26-5. An electron beam welder uses a concentrated beam of electrons. The welding is done inside a vacuum chamber. (United Technologies)

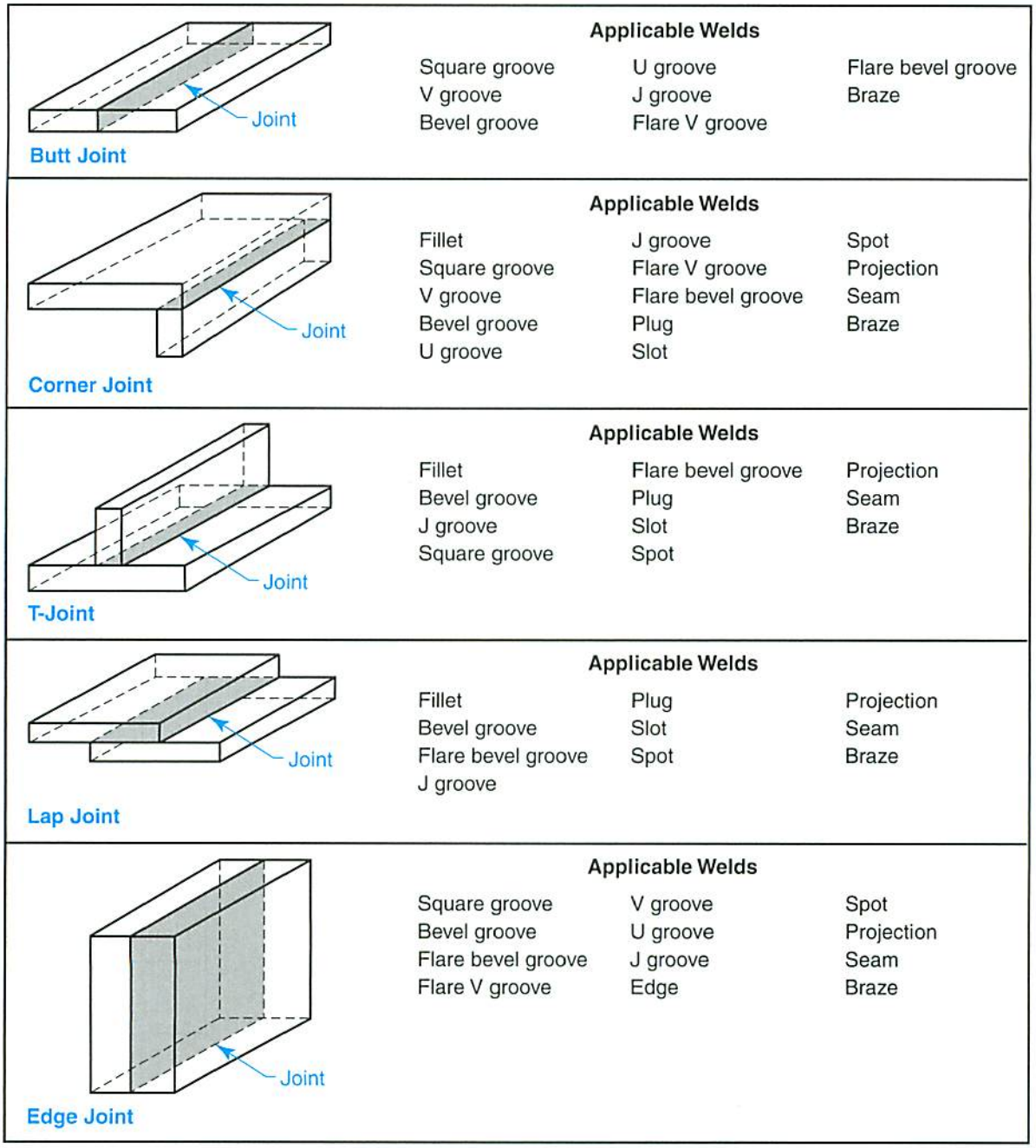


Figure 26-6. The five basic types of joints used in welding. (American Welding Society)

Figure 26-8. Weld symbols should be understood by designers, drafters, welders, and all other personnel in industries using welding processes. Weld symbols should be used only as a part of the welding symbol discussed in the next section.

Standard Welding Symbol

The ***standard welding symbol*** is a composite symbol that carries all pertinent information for a particular weld. A welding symbol indicates the type of weld, the size, the location, and the welding process (if specified), **Figure 26-9.**

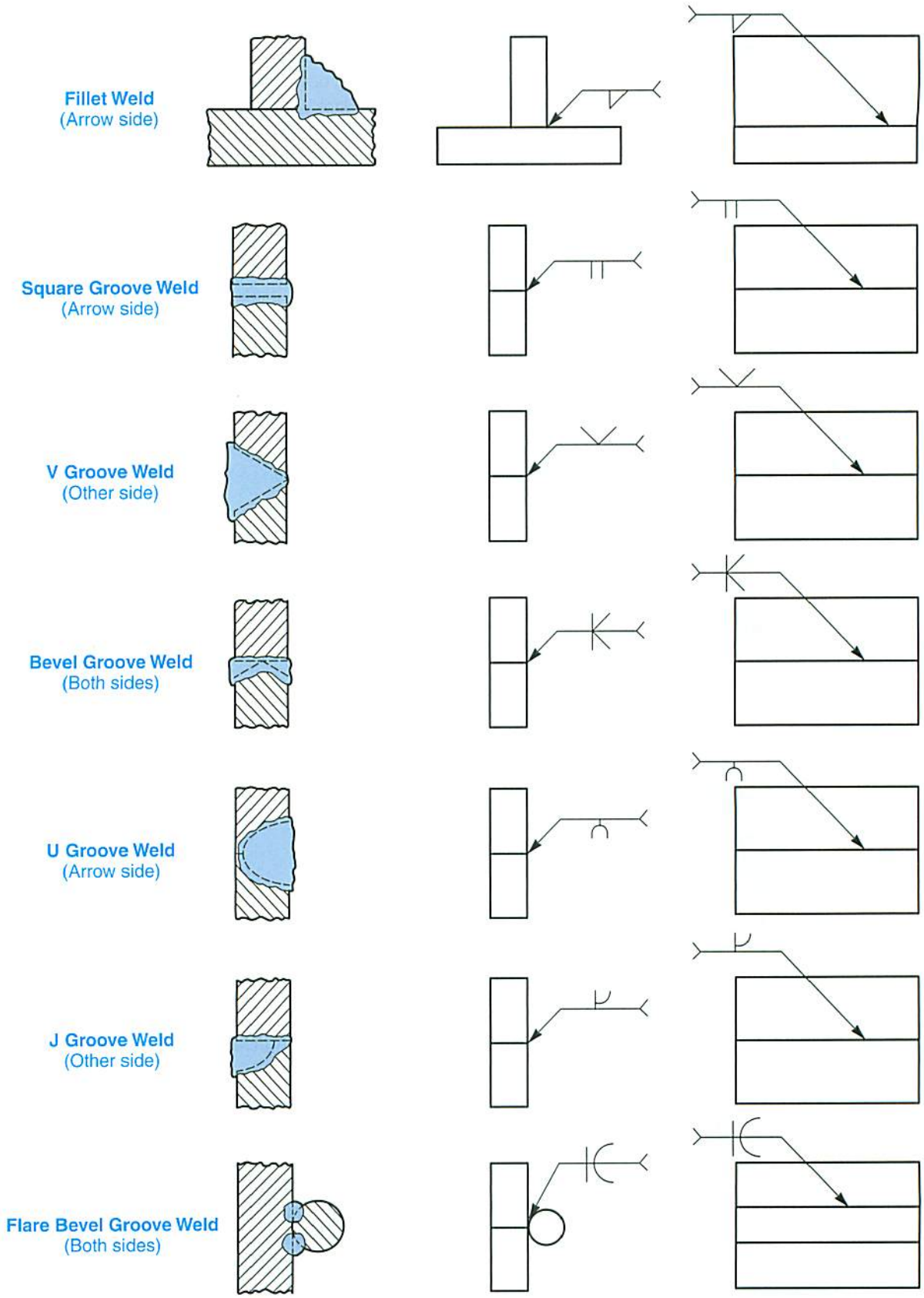


Figure 26-7. Common types of welds. Each type is represented differently on a drawing.

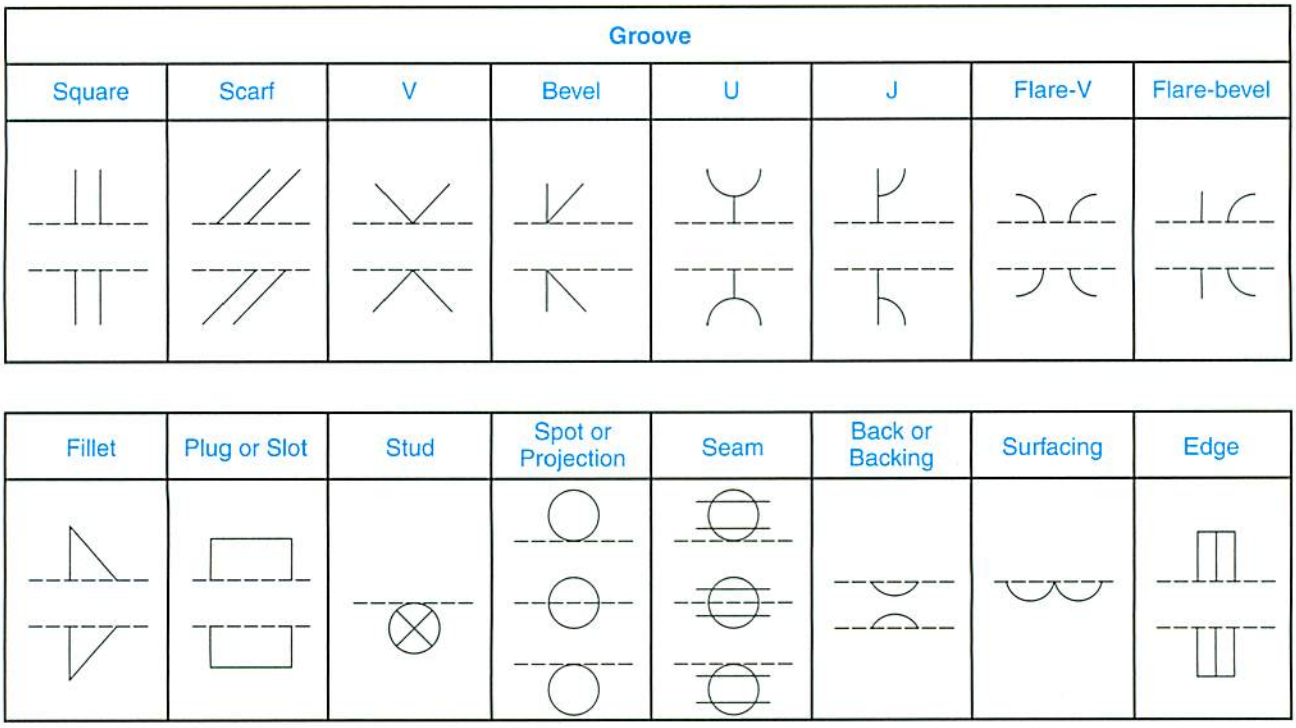


Figure 26-8. Weld symbols specify the type of weld to be performed. (American Welding Society)

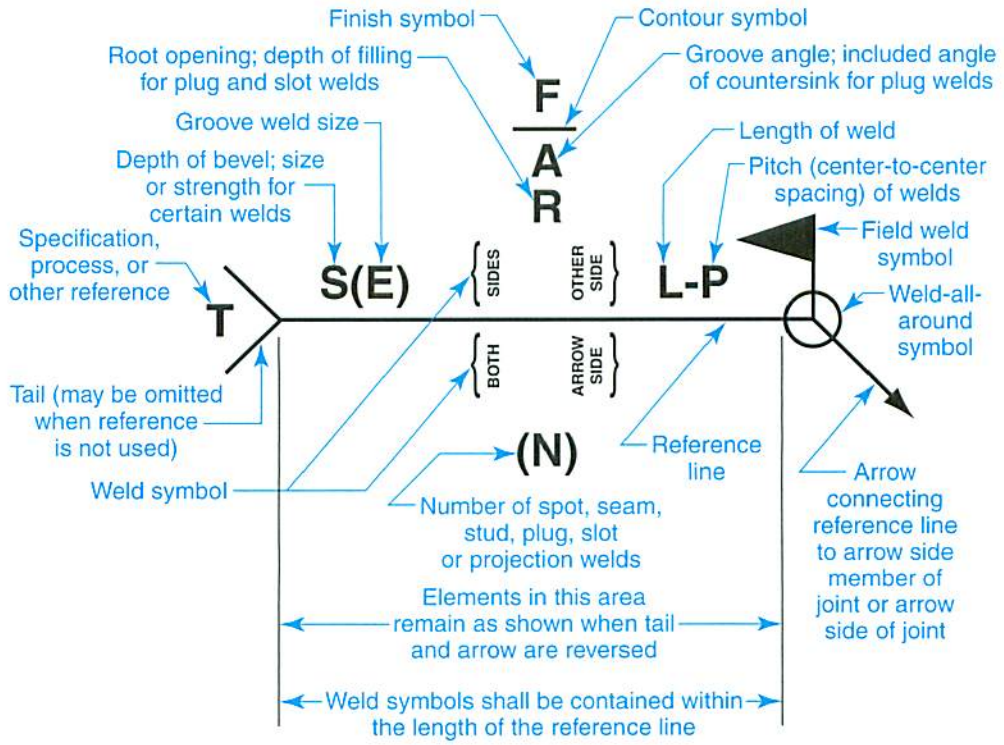


Figure 26-9. The elements of a welding symbol have standard locations that should be followed when drawn. This ensures that anyone who refers to the drawing and who is familiar with the AWS standard can accurately read the drawing.

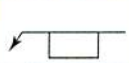
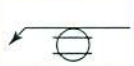
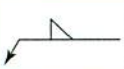
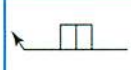
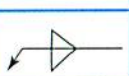
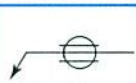
Weld symbols attached to the reference line are shown in an "upright" position when located on the top side ("far side") of the line. Weld symbols are shown in an "upside down" position when located on the lower side ("near side") of the line. The weld symbols are never reversed. For example, the perpendicular leg of the fillet weld symbol and the groove weld symbol is always shown on the left. When no specification, welding process, or other reference is given, the tail section of the symbol may be omitted.

The location of welds with respect to a joint is controlled by the placement of the weld symbol on the reference line of the welding symbol. The location significance of weld symbols is illustrated in **Figure 26-10**. Note that the elements along the reference line of the symbol remain the same when the tail and arrow are reversed. Welds that are to be made on the *arrow side* of the joint are shown by placing the weld symbol on the side of the reference line toward the reader, **Figure 26-11A**. Welds that are to be made on the side opposite the arrow are considered to be on the *other side* of the joint, so the weld symbol is shown on the side of the reference line away from the reader, **Figure 26-11B**.

When the joint is to be welded on both sides, the weld symbol is shown on both sides of the reference line, **Figure 26-11C**. Note in the second example of **Figure 26-11C** that a different weld may be called out for each side of the joint and that a combination of welds may also be specified.

A template for use in preparing symbols on welding drawings is shown in **Figure 26-12**. As with other types of drafting, symbol templates for welding drafting are useful in manual drafting applications. If you are using a CAD system, predrawn welding symbols are typically provided in one of the symbol libraries included with the software.

Weld Symbols and Their Location Significance

Location Significance	Fillet	Plug or Slot	Spot or Projection	Stud	Seam	Back or Backing	Surfacing	Edge
Arrow Side								
Other Side				Not Used			Not Used	
Both Sides		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	
No Arrow Side or Other Side Significance	Not Used	Not Used		Not Used		Not Used	Not Used	Not Used

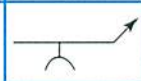
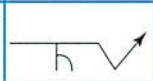
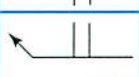
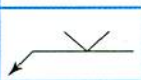
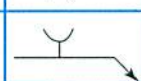
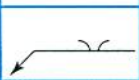
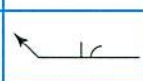
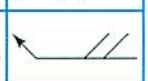
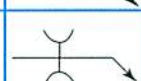
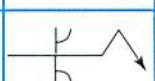
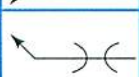
Location Significance	Groove							Scarf for Brazed Joint
	Square	V	Bevel	U	J	Flare V	Flare Bevel	
Arrow Side								
Other Side								
Both Sides								
No Arrow Side or Other Side Significance		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used

Figure 26-10. This chart shows the placement of weld symbols in relation to the reference line and their location significance.

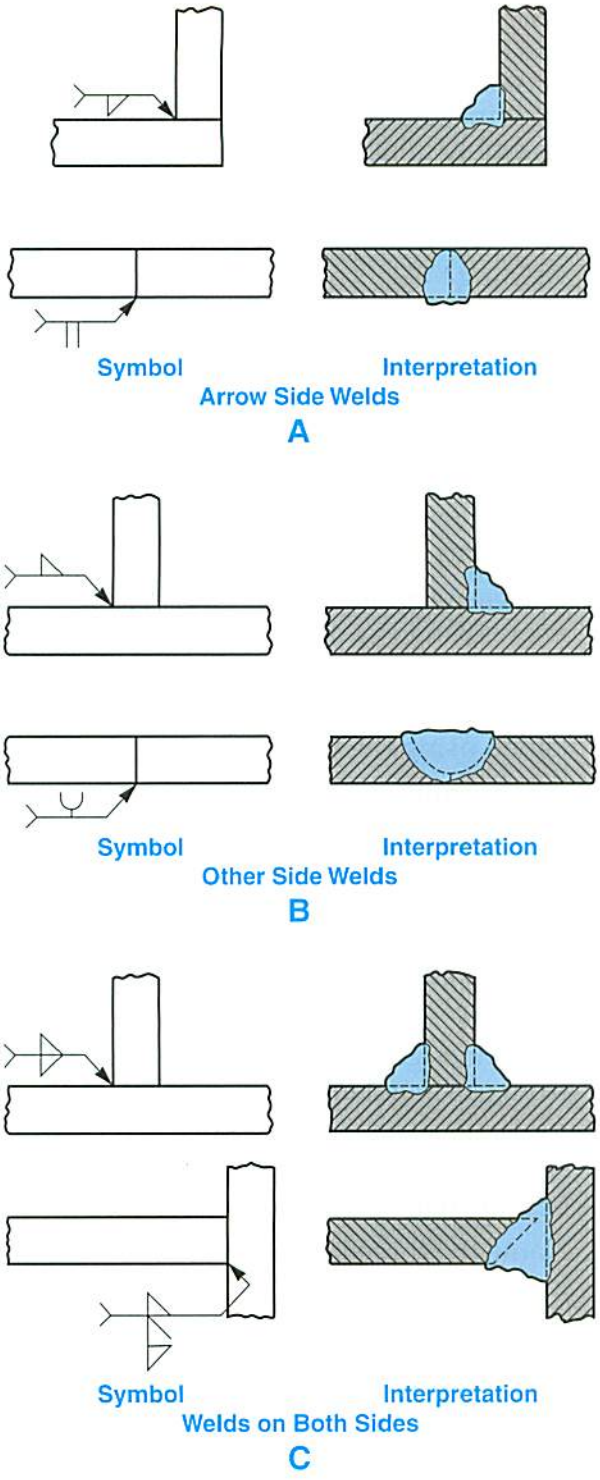


Figure 26-11. The placement of the weld symbol has a specific meaning in locating the weld.

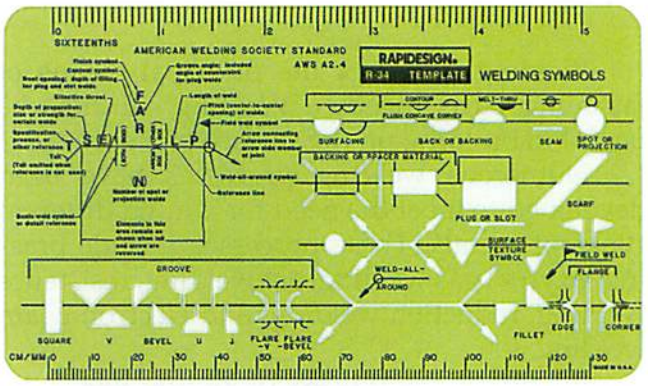


Figure 26-12. Templates speed the application of welding symbols to drawings in manual drafting. (Alvin & Co.)

Supplementary Symbols

Additional information about welds, such as the contour of the weld surface or welds that are to melt through, can be specified by adding the appropriate information or symbol to the welding symbol. Supplementary symbols used with welding symbols are shown in **Figure 26-13.**

For more information on welding symbols, refer to the charts in the Reference Section of this textbook, and to the AWS publication *Standard Symbols for Welding, Brazing, and Nondestructive Examination* (ANSI/AWS A2.4).

Supplementary Symbols			
Weld-All-Around	Field Weld	Melt-Through	Consumable Insert
			(Square)
Backing or Spacer (Rectangular)		Contour	
Backing Spacer		Flush	Convex / Concave

Figure 26-13. Supplementary symbols used with welding symbols on drawings.

Chapter Summary

Welding is one of the principal means of fastening parts together. Welding can also be useful in building up the surface of a part.

Numerous welding processes have been developed to meet the need for joining different types of metals. These processes include brazing, oxyfuel gas welding, arc welding, resistance welding, induction welding, and electron beam welding.

Brazing is the process of joining metals by adhesion with a low melting point filler metal. This process does not melt the parent metal.

Oxyfuel gas welding is a process in which the heat generated by burning gases causes the parent metal to fuse. Gas tungsten arc welding (GTAW) and gas metal arc welding (GMAW) are gas-shielded arc welding processes.

Resistance welding uses an electric current as the source of heat. Three types of resistance welding are common: spot welding, seam welding, and flash welding.

Induction welding is similar to resistance welding. By contrast, the heat is produced by the resistance of the metal parts to the flow of an induced electric current.

Electron beam welding is done in a vacuum. The source of heat is a high-intensity beam of electrons focused on a small area.

There are many types of welded joints used in fastening parts. The five basic types are the butt joint, corner joint, T-joint, lap joint, and edge joint.

Weld symbols specify the type of weld to be made and are used in connection with the standard welding symbol. The standard welding symbol is a composite symbol that completely describes the weld.

Additional Resources

Selected Reading

ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*

AWS A3.0, *Standard Welding Terms and Definitions*

American Welding Society (AWS)
550 N.W. LeJeune Road
Miami, FL 33126
www.aws.org

Review Questions

1. A welding drawing is a type of _____ drawing showing the components of an assembly in position to be welded.
2. What is *brazing*?
3. How does brazing differ from oxyfuel gas welding?
4. What is the most commonly used oxyfuel gas welding process?
5. Arc welding is a process in which heat is produced by an electric arc between a welding _____ and the parent metal.
6. Gas tungsten arc welding (GTAW) is also known as _____ welding.
7. The gas typically used in gas tungsten arc welding is a combination of _____ and _____.
8. Which of the following metals may be joined using the GTAW welding process?
   A. Aluminum
   B. Magnesium
   C. Stainless steel
   D. All of the above.
9. What is gas metal arc welding (GMAW) used for?
10. How does gas tungsten arc welding differ from gas metal arc welding?
11. Resistance welding is based on the principle that resistance to _____ causes metal to become hot.
12. Name the three primary types of resistance welding.
13. How does the induction welding process work?
14. What is the source of heat in electron beam welding?
15. What are the five basic types of joints commonly used in welding?
16. Explain the difference between the terms *weld symbol* and *welding symbol*.
17. Of what significance is the placement of the weld symbol in determining the location of the weld?

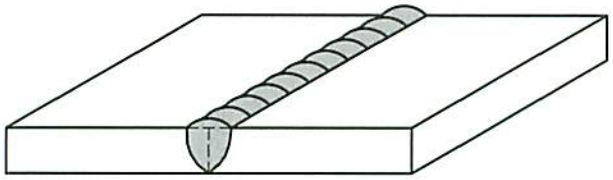
18. When making welding drawings with a CAD system, predrawn welding symbols are typically provided in one of the symbol _____ included with the software.

Problems and Activities

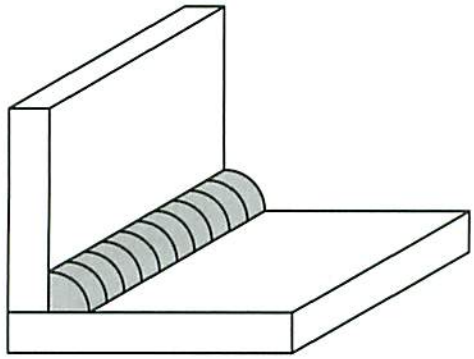
Welding Symbols

For Problems 1–4, draw a view of the part shown and draw the correct welding symbol for the given welded joint.

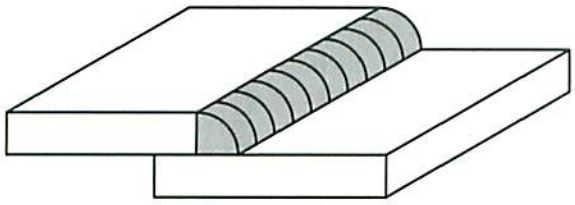
1. Butt Joint



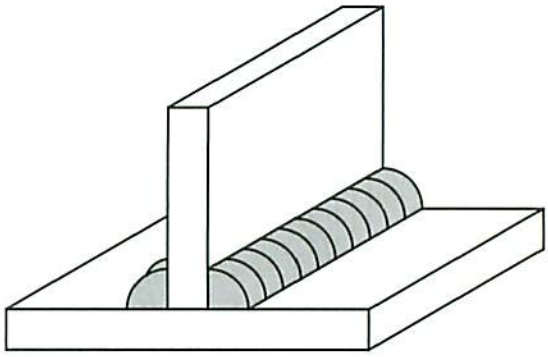
2. Corner Joint



3. Lap Joint



4. T-Joint



Outside Activities

1. Design a piece of furniture requiring welded parts. Make a working drawing of the piece.
2. Design a tool, jig, or fixture requiring welded parts for an item needed at your home, school, or place of work. Make a working drawing and construct a scale model or prototype of the item.

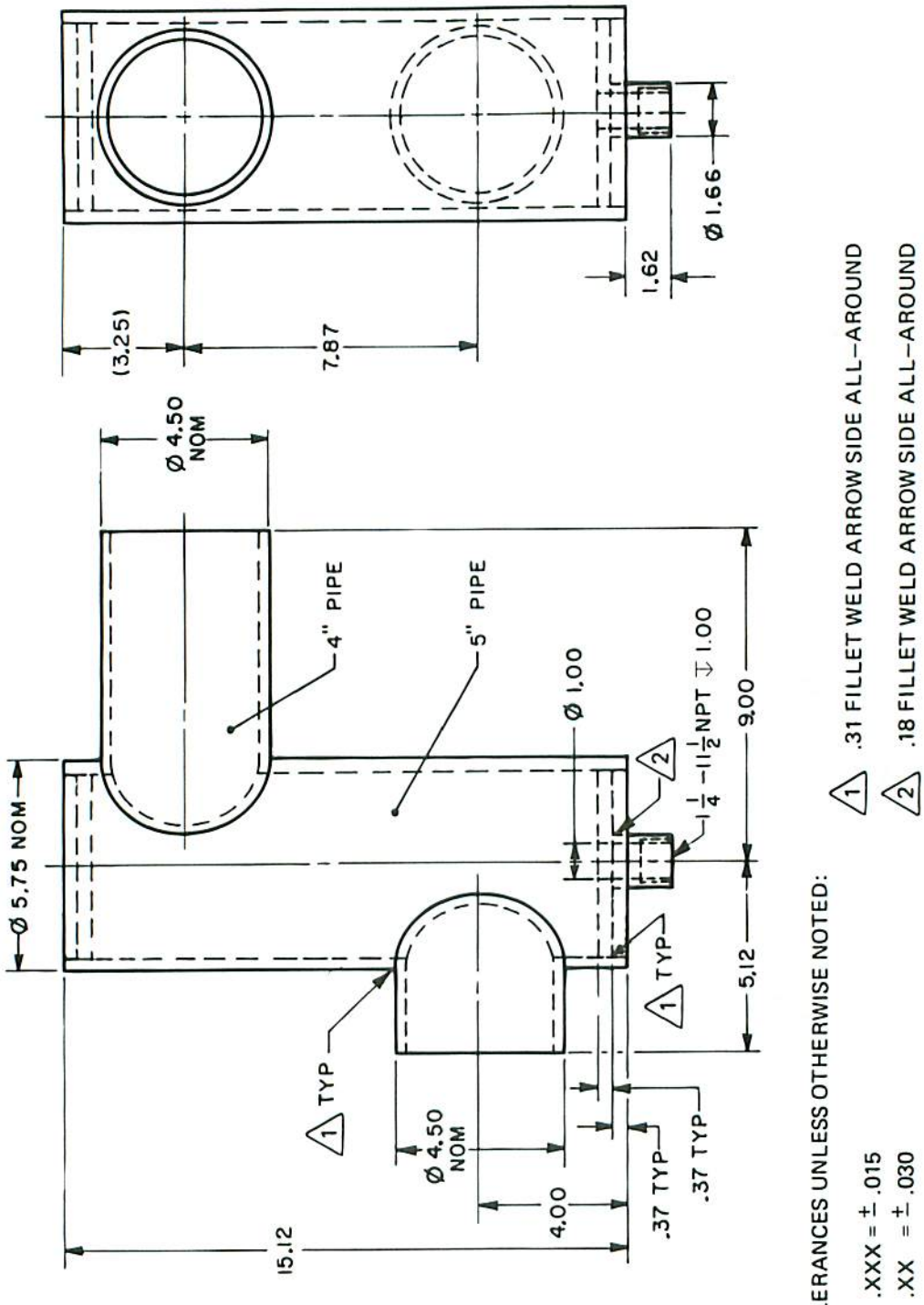
Drawing Problems

Make working drawings, including the specification of welds, for the following problems. Draw the problems as assigned by your instructor. The problems are classified as introductory, intermediate, and advanced. A drawing icon identifies the classification.

The given problems include customary inch and metric drawings. Use one sheet for each problem. If you are drawing the problems manually, use one of the layout sheet formats given in the Reference Section. If you are using a CAD system, create layers and set up drawing aids as needed. Use an A-size sheet and draw a title block or use a template. Save each problem as a drawing file and save your work frequently.

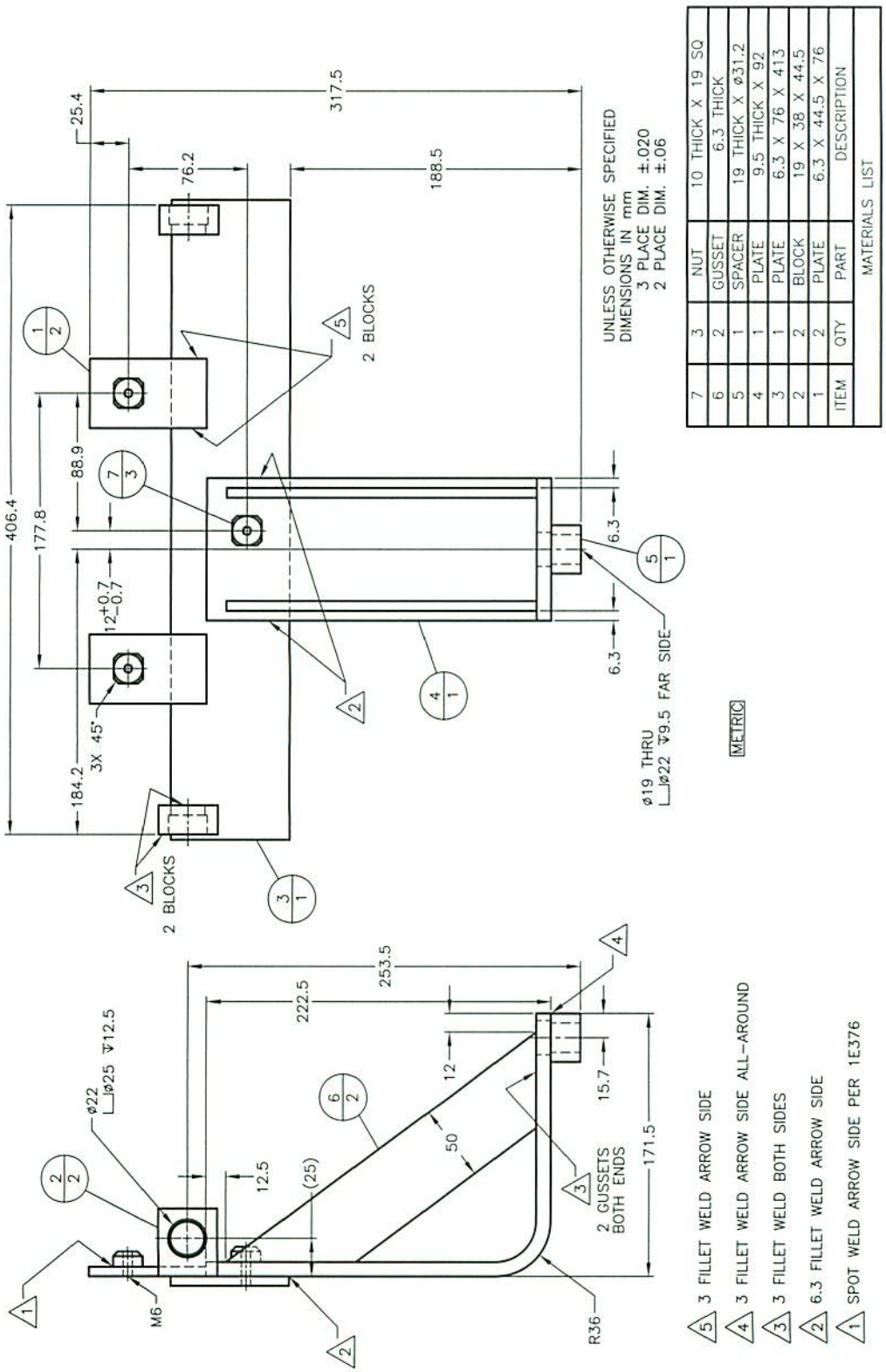
Introductory

1. Liquid Sump Assembly



Intermediate

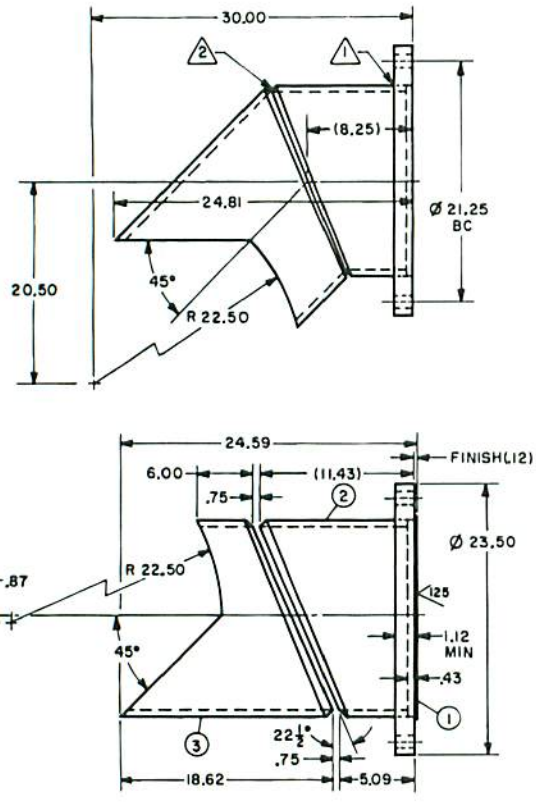
2. Bracket Assembly

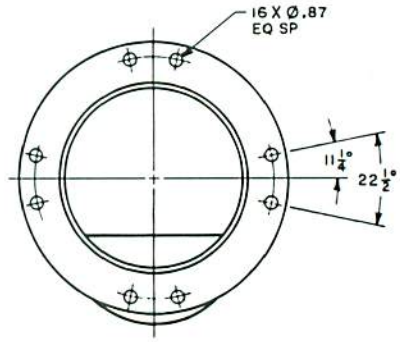


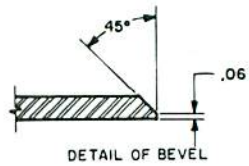
ITEM	QTY	PART	DESCRIPTION
MATERIALS LIST			
7	3	NUT	10 THICK X 19 SQ
6	2	GUSSET	6.3 THICK
5	1	SPACER	19 THICK X ø31.2
4	1	PLATE	9.5 THICK X 92
3	1	PLATE	6.3 X 76 X 413
2	2	BLOCK	19 X 38 X 44.5
1	2	PLATE	6.3 X 44.5 X 76

Intermediate

3. Discharge Connector Assembly







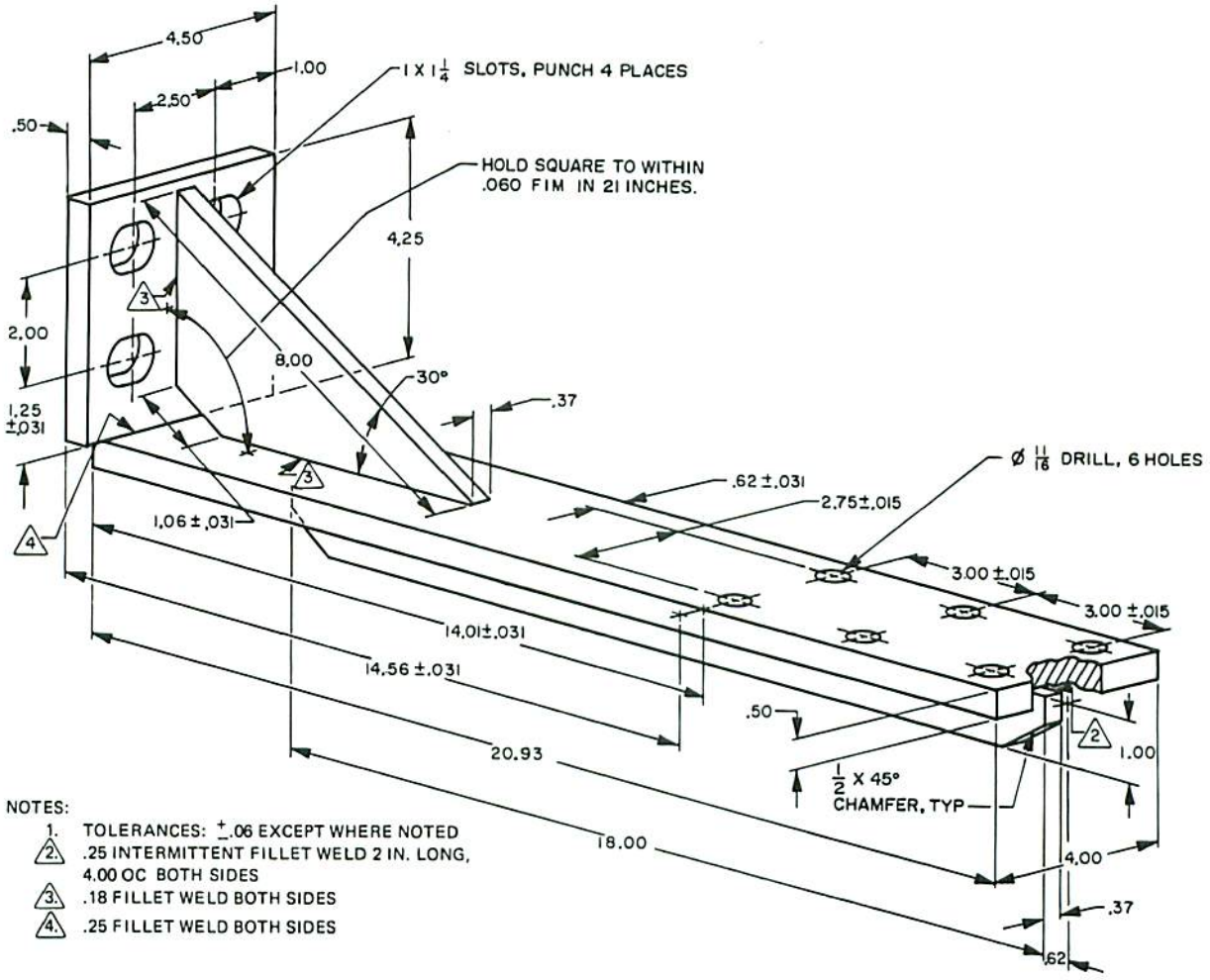
2 FILLET WELD, CONVEX CONTOUR
1 .31 FILLET WELD ARROW SIDE ALL-AROUND

ITEM	QTY	NAME
3	1	PIPE 16" (CUT FROM ITEM 2)
2	1	PIPE 16"
1	1	FLANGE 23½ O.D.

LIST OF MATERIALS

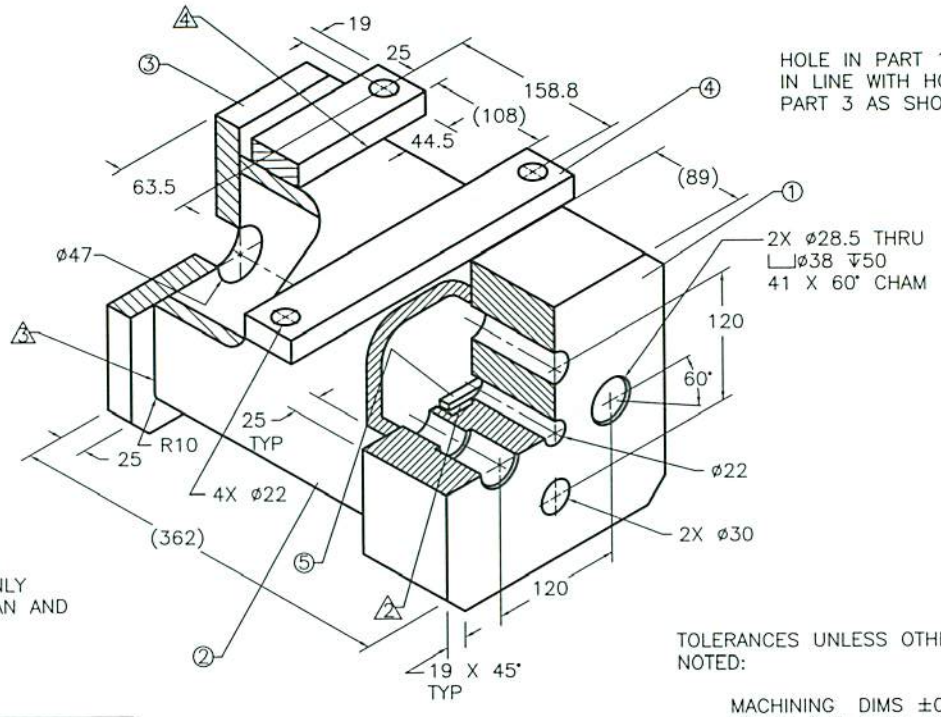
Intermediate

4. Rear Engine Mount



Advanced

5. Lubricator Tank Base



THIS SIDE ONLY—WELD
PART 5 TO PART 1 BEFORE
WELDING PART 1 TO PART 2

4 6 FILLET WELD BOTH SIDES
3 9 FILLET WELD ALL-AROUND,
ARROW SIDE ONLY, BOTH ENDS
2 5 FILLET WELD ARROW SIDE ONLY
1 INSIDE OF TANK MUST BE CLEAN AND
FREE OF ANY RUST OR SCALE

TOLERANCES UNLESS OTHERWISE
NOTED:

MACHINING DIMS ±0.30
TORCH CUT DIMS ±1.50

METRIC

QTY	PART	NAME
1	5	9.5 X 9.5 X 38 LG. STEEL STOCK
2	4	LUB. MTG. BRK'T 22 X 50 X 305
1	3	LUB. BOTTOM 235 SQ
1	2	LUB. TUBE 185 SQ WALL 16 THK
1	1	LUB. TOP 235 SQ

MATERIALS LIST