CHAPTER 6

Weld Joints and Weld Types

Objectives

After studying this chapter, you will be able to:
- Identify different types of welds used with various joints.
- Read and draw common welding symbols.
- Discuss advantages and disadvantages of different weld joints.
- List factors involved with joint design.

Joint Types

The American Welding Society defines a joint as "the manner in which materials fit together." As shown in Figure 6-1, there are five basic types of weld joints:
- Butt joint.
- T-joint.
- Lap joint.
- Corner joint.
- Edge joint.

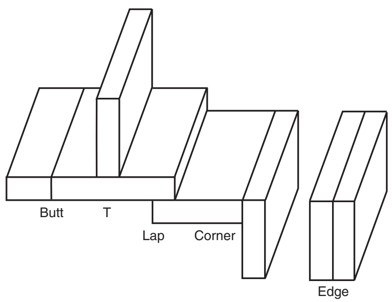

Figure 6-1. The five basic types of joints used in welding.

Joint Preparation

Weld joints may be initially prepared in a number of ways. These include:
- Shearing.
- Casting.
- Forging.
- Machining.
- Stamping.
- Filing.
- Routing.
- Oxyacetylene cutting (thermal cutting process).
- Plasma arc cutting (thermal cutting process).
- Grinding.

Final preparation of the joint prior to welding will be covered in the chapters that detail the welding of specific materials.

Weld Types

There are various types of welds that can be made in each of the basic joints. They include:

Butt joint, Figure 6-2.
- Square-groove butt weld.
- Bevel-groove butt weld.
- V-groove butt weld.
- J-groove butt weld.
- U-groove butt weld.
- Flare-V-groove butt weld.
- Flare-bevel-groove butt weld.

T-joint, Figure 6-3.
- Fillet weld.
- Plug weld.
- Slot weld.
- Bevel-groove weld.
- J-groove weld.
- Flare-bevel-groove weld.
- Melt-through weld.

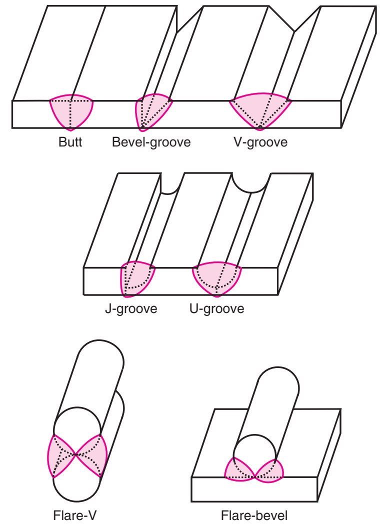

Figure 6-2. Types of welds that may be made with a basic butt joint.

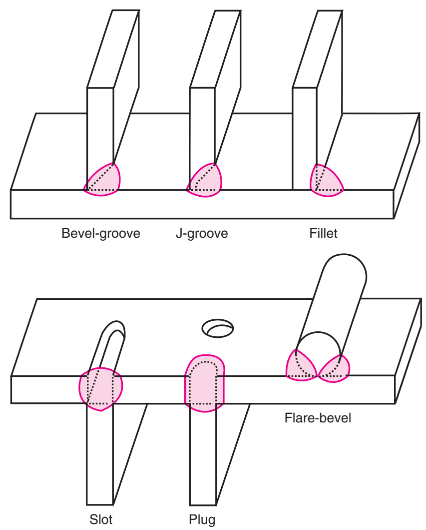

Figure 6-3. Types of welds that may be made with a basic T-joint.

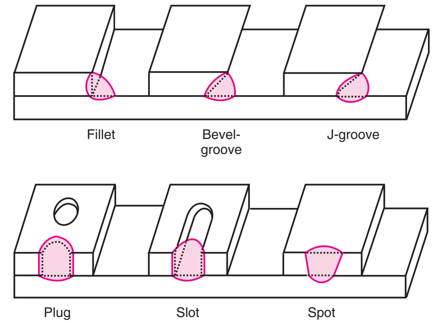

Figure 6-4. Types of welds that may be made with a basic lap joint.

Lap joint, Figure 6-4.
- Fillet weld.
- Plug weld.
- Slot weld.
- Spot weld.
- Bevel-groove weld.
- J-groove weld.
- Flare-bevel-groove weld.

Corner joint, Figure 6-5.
- Fillet weld.
- Spot weld.
- Square-groove weld or butt weld.
- V-groove weld.
- Bevel-groove weld.
- U-groove weld.
- J-groove weld.
- Flare-V-groove weld.
- Edge weld.
- Corner-flange weld.

Edge joint, Figure 6-6.
- Square-groove weld or butt weld.
- Bevel-groove weld.
- V-groove weld.
- J-groove weld.
- U-groove weld.
- Edge-flange weld.
- Corner-flange weld.

Double Welds

In some cases, a weld cannot be made from only one side of the joint. When a weld must be made from both sides, it is known as a ***double weld***. Figure 6-7 shows common applications of double welds in basic joint designs.

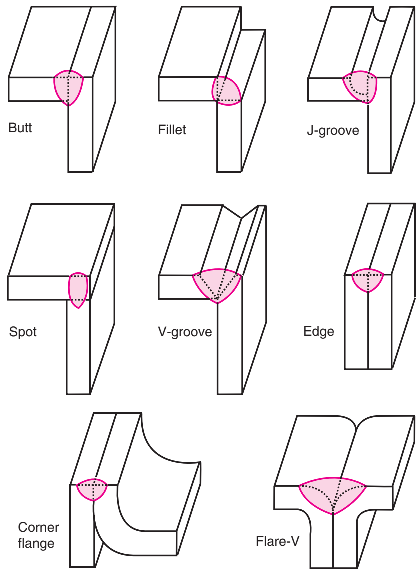

Figure 6-5. Types of welds that may be made with a basic corner joint.

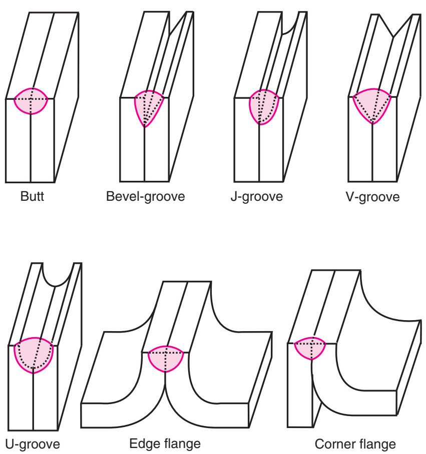

Figure 6-6. Types of welds that may be made with a basic edge joint.

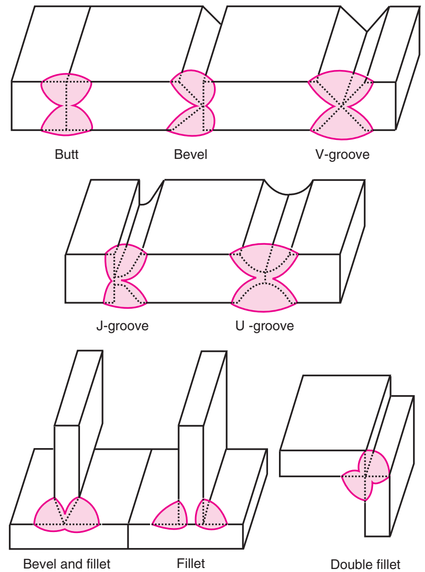

Figure 6-7. Applications of double welds.

Weldment Configurations

The basic joint often is changed to assist in a component's assembly. A weld joint might be modified to gain access to the weld joint or to change a weld's metallurgical properties. Some common weldment configuration designs are described here. ***Joggle-type joints*** are used in cylinder and head assemblies where backing bars or tooling cannot be used. See Figure 6-8. Another application of joggle joints is in the repair of unibody automobiles where skin panels are placed together and welded. A built-in backing bar is used when enough material is available for machining the required backing or when tooling cannot be inserted (as in some tubular applications). An example in which tubing is being joined to heavy wall tube is shown in Figure 6-9. Pipe joints often use special backing rings or are machined to fit specially designed mated parts. Types of backing rings are shown in Figure 6-10. Figure 6-11 shows a fabricated backing bar. These bars must fit tightly or problems will be encountered in heat flow and penetration. Weld joints specially designed for controlled penetration are used where excessive weld penetration would cause a problem with assembly or liquid flow. This type of joint is shown in Figure 6-12.

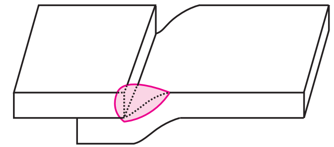

Figure 6-8. Joggle-type joint.

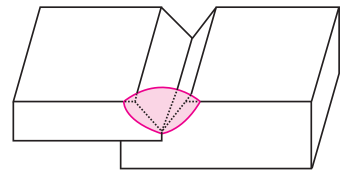

Figure 6-9. Tubular butt joint with a built-in backing bar.

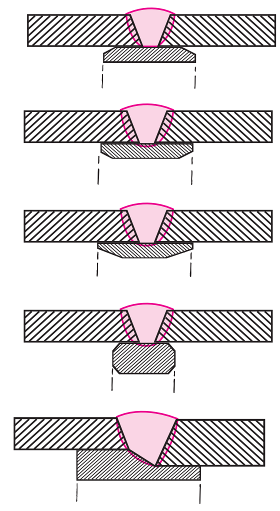

Figure 6-10. Various types of backing rings for pipe joints.

A series of bead welds overlaid on the face of a joint is called ***buttering,*** Figure 6-13. Buttered welds are often used to join dissimilar metals. A series of overlaid welds on the surface of a part to protect the base material is called ***surfacing*** or ***cladding***. Refer to Figure 6-14.

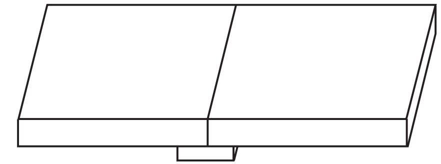

Figure 6-11. Plate butt weld with a fabricated backing bar.

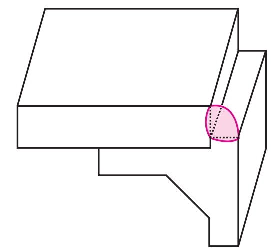

Figure 6-12. Controlled weld penetration joint.

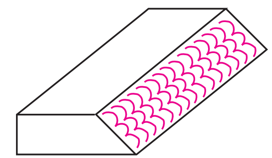

Figure 6-13. Buttered weld joint face.

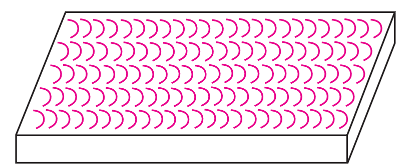

Figure 6-14. Overlaid welds, called surfacing or cladding, protect the base metal from wear or contamination.

Welding Terms and Symbols

Communication from the weld designer to the welder is essential to proper completion of most weldments. Some of the common terms used to describe parts of the weld joint are found in Figure 6-15. Other terms used to describe welds are given in Figure 6-16. The ***AWS welding symbol*** shown in Figure 6-17 was developed as a standard by the American Welding Society. This symbol is used on drawings to indicate the type of joint, placement, and the type of weld to be made. The symbol may also include other information, such as finish and contour of the completed weld.

It is important to study and understand each part of the welding symbol. Figure 6-18 is a table showing basic ***weld symbols*** that are used with the AWS welding

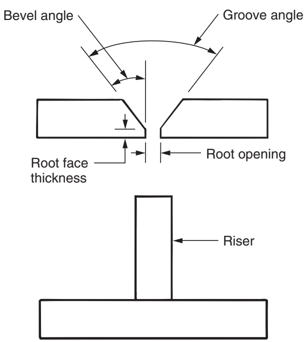

Figure 6-15. Weld joint terms.

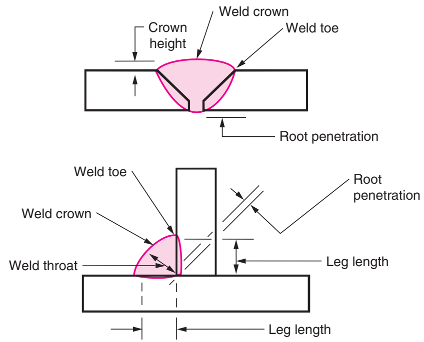

Figure 6-16. Weld and weld area terms.

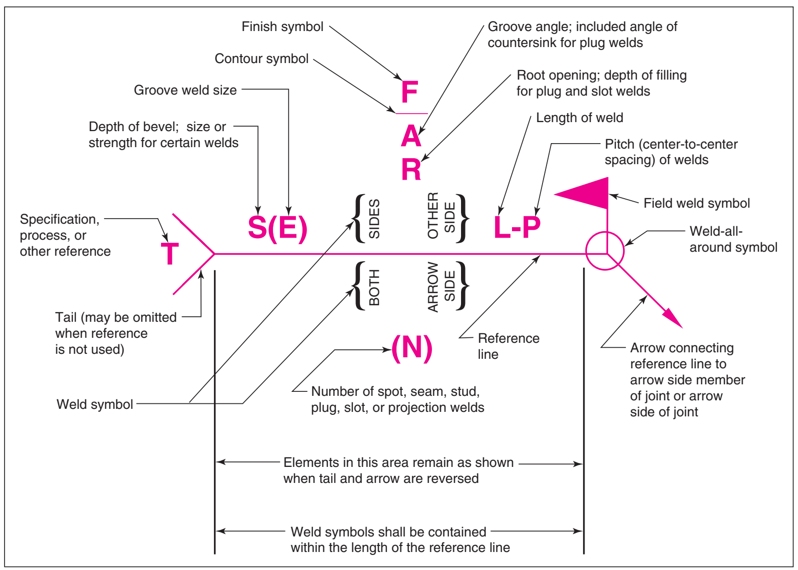

Figure 6-17. The AWS welding symbol conveys specific and complete information to the welder. (Printed with permission of the American Welding Society)

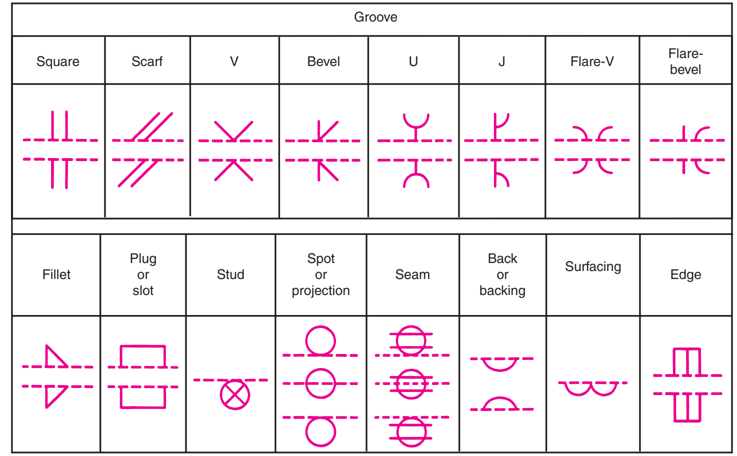

Figure 6-18. Basic weld symbols. (Printed with permission of the American Welding Society)

symbol to direct the welder in producing the proper weld joint. The arrow of the welding symbol indicates the point at which the weld is to be made. The line connecting the arrow to the ***reference line*** is always at an angle. Whenever the basic weld symbol is placed below the reference line, as shown in Figure 6-19, the weld is made on the side where the arrow points (referred to as the ***arrow side***). Whenever the basic symbol is placed above the reference line, the weld is to be made on the ***other side*** of the joint, as shown in Figure 6-20. By placing dimensions on the symbol and drawings, the exact size of the weld may be indicated. Study the

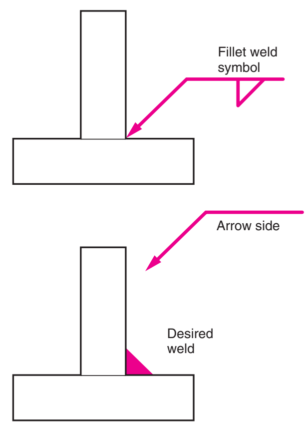

Figure 6-19. Fillet weld symbol shown on the bottom side of the reference line indicates that the weld is located where the arrow points.

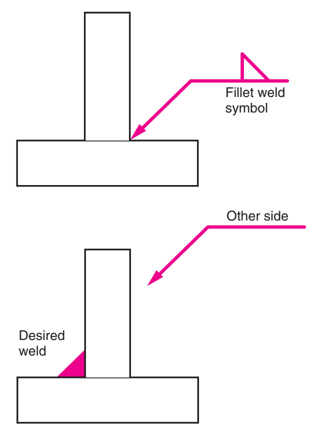

Figure 6-20. Fillet weld symbol shown on the upper side of the reference line indicates that the weld is located on the opposite side of the joint.

examples of typical weld symbols and weldments shown in Figure 6-21.

The complete weld symbol gives the welder instructions on how to prepare the base metal, the welding process to use, and the finish for the completed weld. Through careful use of these symbols, the weld designer can convey all the information needed to complete a weldment.

Classes are offered that provide advanced study in the area of print reading for welders. By taking such classes, the welder can improve his or her ability to read and interpret welding drawings. Studying texts on print reading is another method of gaining ability to read prints.

Weld Positions

For a welder, it is important to be able to weld in different positions. The American Welding Society has defined the positions of welding to include:

- Flat.
- Horizontal.
- Vertical.
- Overhead.

Figure 6-22 demonstrates the four positions for fillet welds, grooved butt welds, and pipe welds. While practicing welding in these positions, you should note how *gravity* affects the molten weld pools. In addition to this, *heat distribution* also varies with each position. These factors make the skills needed for each position distinct. Practice is required to produce good welds in all positions.

Design Considerations

Design of the weld type and weld joint to be used is of prime importance if the weldment is to do the intended job. The weld should be made at reasonable cost. Several factors concerning the weld design must be considered:

- Material type and condition (annealed, hardened, tempered).
- Service conditions (pressure, chemical, vibration, shock, wear).
- Physical and mechanical properties of the completed weld and heat-affected zone.
- Preparation and welding cost.
- Assembly configuration and weld access.
- Equipment and tooling.

Butt Joints and Welds

Butt joints are used where high strength is required. They are reliable and can withstand stress better than any other type of weld joint. To achieve full stress value, the weld must have 100 percent penetration through the joint. This can be done by welding completely through from one side. The alternative is working from both sides, with the welds joining in the center.

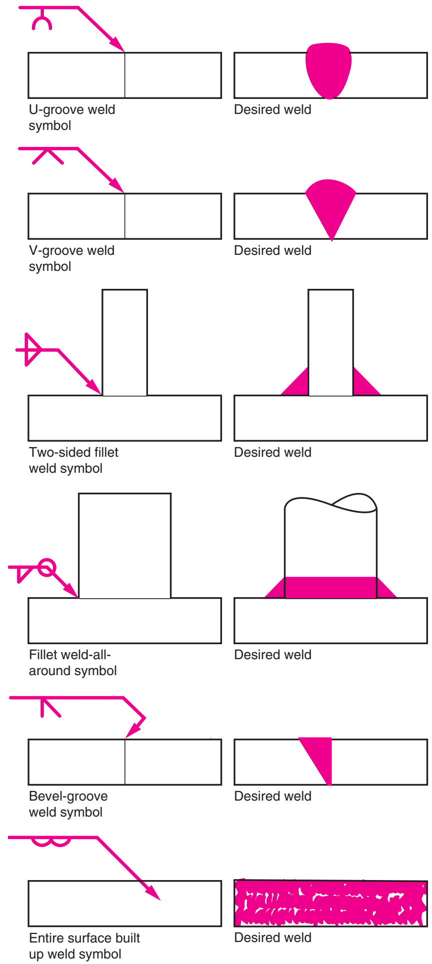

Figure 6-21. Typical weld symbols and weld applications.

Thinner-gauge metals are more difficult to fit up for welding. Thin metals also require more costly tooling to maintain the proper joint configuration. ***Tack welding*** may be used as a method of holding the components during assembly. However, tack welds present many problems:

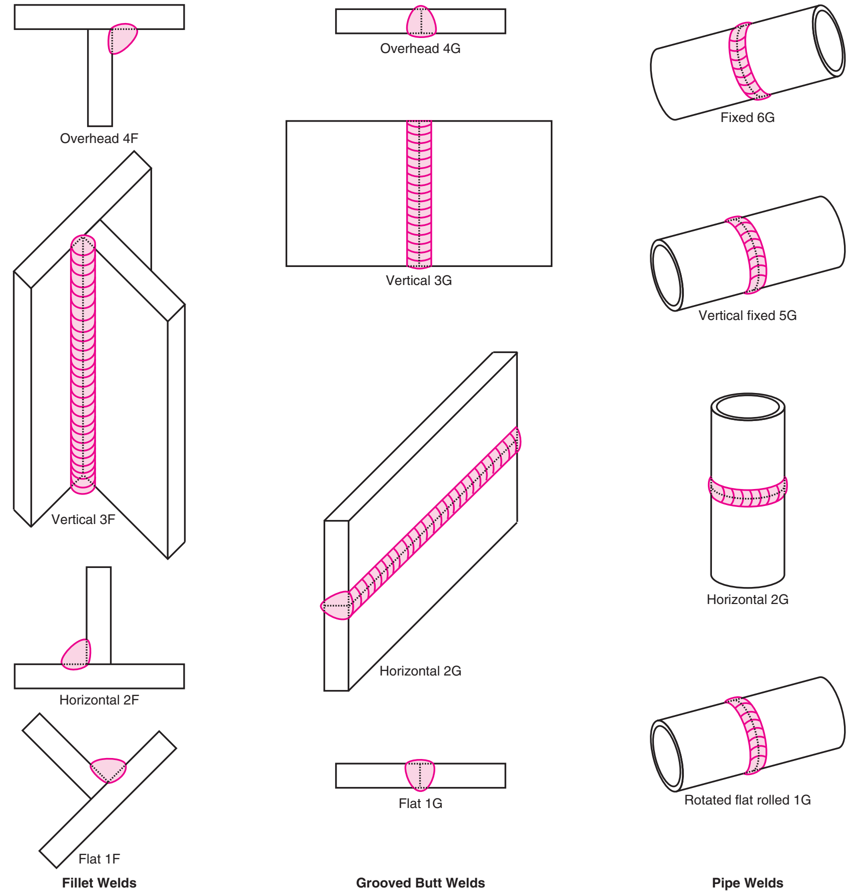

Figure 6-22. American Welding Society definitions of welding positions.

- They conflict with penetration of the final weld into the weld joint.
- They add to the crown dimension (height).
- They often crack during welding due to the heat and expansion of the joint.

Expansion of the base metal during welding often will cause a condition known as ***mismatch***, Figure 6-23. When mismatch occurs, the weld generally will not penetrate completely through the joint. Many specifications limit highly stressed butt joints to a 10 percent maximum mismatch of the joint thickness.

Whenever possible, butt joints should mate at the bottom, Figure 6-24. Joints of unequal thickness should be tapered in the weld area to prevent incomplete or inadequate fusion. This is shown in Figure 6-25. When this cannot be done, the heavier piece may be tapered on the upper part of the joint as well.

Weld shrinkage. Butt welds always shrink across the joint (transversely) during welding. For this reason, a shrinkage allowance must be made if the “after welding” overall dimensions have a small tolerance. Butt welds in pipe, tubing, and cylinders also shrink on the diameter of

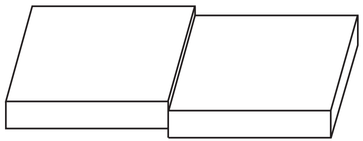

Figure 6-23. Welds made on mismatched joints often will fail below the rated load when placed in stress conditions.

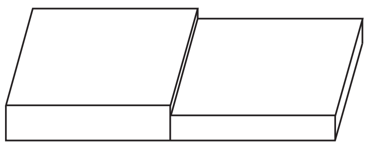

Figure 6-24. Mating the joint at the bottom equalizes the load during stress when the weld is made from the top and penetrates completely through the joint.

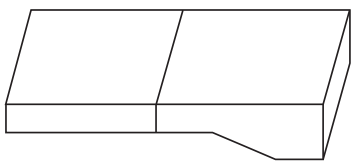

Figure 6-25. Joints of unequal thickness absorb different amounts of heat and expand at different ratios. Equalize the heat flow by tapering the heavier material to the thickness of the thinner material.

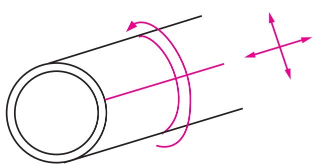

Figure 6-26 Butt welds shrink during welding in both transverse and circumferential directions.

the material. This shrinkage is shown in Figure 6-26. In areas where these dimensions must be maintained, a shrinkage test must be done to establish the amount of shrinkage. Figure 6-27 shows how such a test is made. Heavier materials will shrink more than thinner materials. Double-groove welds will shrink less than single-groove welds. This is because less welding is involved and less filler material is used.

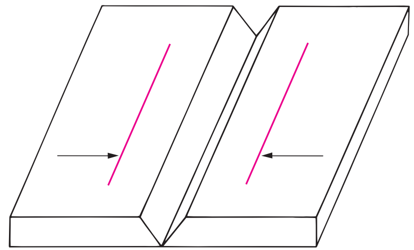

Figure 6-27. Weld joint shrinkage can be determined in four steps. 1. Tack weld the test joint together. 2. Scribe parallel lines, as shown, on approximately 2" centers. Record this dimension. 3. Weld joint with test weld procedure. 4. Measure linear distance and compare with original dimension.

T-Joints and Welds

Various T-joint designs are used to join parts at an angle to each other. Depending on the intended use of the weldment, the joint may be made with a single fillet, double fillet, or a groove and fillet weld combination. Figure 6-28 shows these designs.

Fillet welds are made to specific sizes that are determined by the allowable design load. They are measured as shown in Figure 6-29. Where design loads are not known, a "rule of thumb" may be used for determining the fillet size. In these cases, the fillet weld leg lengths must equal the thickness of the thinner material.

The main problem in making fillet welds is lack of penetration at the joint intersection. To prevent this condition, always make stringer beads at the intersection. Weave beads do not provide the desired penetration on fillet welds.

Lap Joints and Welds

Lap joints may be either single fillet, double fillet, plug slot, or spot-welded. They require very little joint preparation. They are generally used in static load applications or in the repair of unibody automobiles. Where corrosive liquids are involved, both edges of the joint must be welded. See Figure 6-30. One of the major problems with lap joint design is shown in Figure 6-31. Where the component parts are not in close contact, a ***bridging fillet weld*** must then be made. This leads to incomplete fusion at the root of the weld and oversize fillet weld dimensions. When using this type of design in sheet or plate material, clamps or tooling must be used to maintain adequate contact of the material at the weld joint.

An ***interference fit*** eliminates this problem in assembly of cylindrical parts, Figure 6-32. The inside diameter of the outer part is made several thousandths of an inch smaller than the outside diameter of the inner

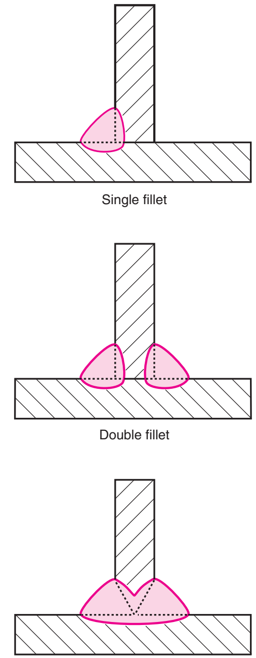

Figure 6-28. Various types of T-joints and welds.

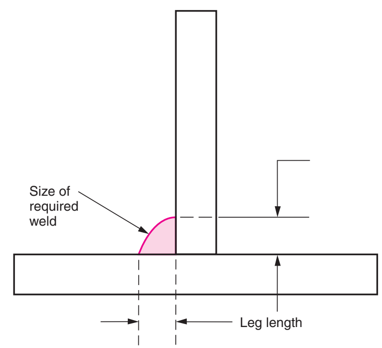

Figure 6-29. Fillet weld leg lengths from the root of the joint should be equal. Unequal leg length, unless otherwise specified, will not carry the designed load and may fail under stress.

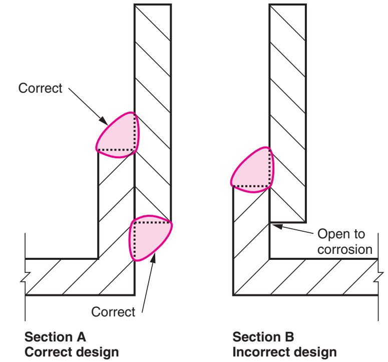

Figure 6-30. Corrosive liquids must not be allowed to enter the penetration side of the weld joint. In Section A, the back of the weld is closed to corrosion. In Section B, the back of the weld is open to corrosion.

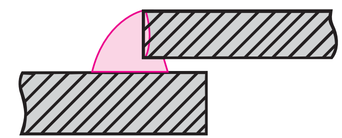

Figure 6-31. Lap joint problem areas that result from improper fit-up.

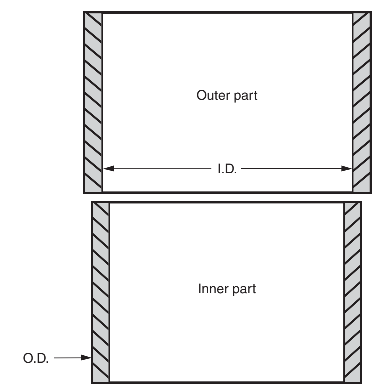

Figure 6-32. The diameters of the parts to be assembled with an interference fit may be found by using a "pi" tape around the inner and outer cylinder components. The tape measures in thousandths of an inch and full inches.

part. Before assembly, the outer part is heated until it expands enough to slide over the inner part. As the part cools, it shrinks and locks the two pieces together.

Corner Joints and Welds

Corner joints are similar to T-joints, since they consist of sheets or plates mating at an angle to one another. They are usually used in conjunction with groove welds and fillet welds. Some of the many different corner weld designs are shown in Figure 6-33. When using thinner gauges of metal, it may be difficult to assemble component parts without proper tooling. Tack welding and welding often will cause distortion and buckling of thinner materials. For the most part, use of corner joints should be limited to heavier materials in structural assemblies.

Edge Joints and Welds

Edge welds are used where the edges of two sheets or plates are adjacent and are in approximately parallel planes at the point of welding. Figure 6-34 shows several types of edge weld designs. These designs are common only in structural use. Since the weld does not penetrate completely through the joint thickness, it should not be used in stress or pressure applications.

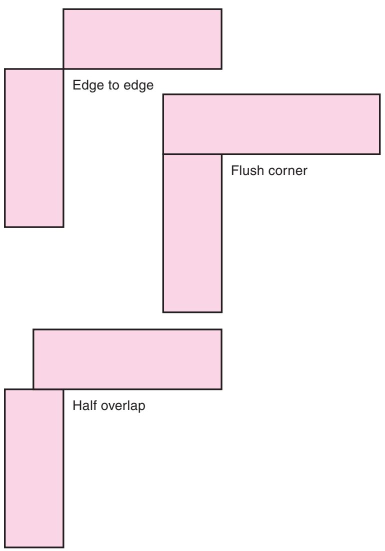

Figure 6-33. Common corner weld joint designs that may be used in fabrication.

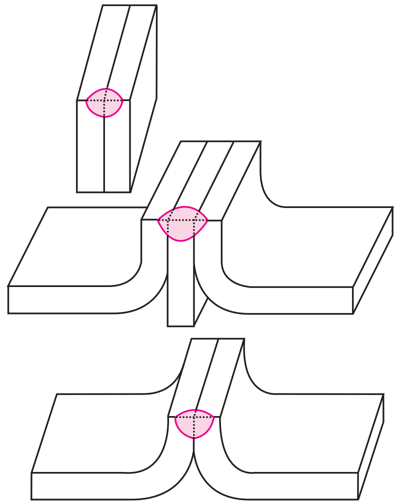

Figure 6-34. Common edge weld joint designs that may be used in fabrication.

Special Designs and Procedures

Special designs are often used in the fabrication of a weldment where:

- Welds cannot be thermally treated after welding because of configuration or size. Material is added to the joint thickness, as shown in Figure 6-35, and the weld is made restricting the heat flow into the thinner metal. This type of joint will achieve the full mechanical values of the base material.
- Joining of dissimilar materials can be done by buttering the face of one material to match the other, as shown in Figure 6-36.

Special procedures and tooling may be used to provide a preheating, interpass, and postheating operation to control grain size. ***Preheating*** is generally used to slow down the cooling rate of the weld to prevent cracking. *Interpass temperature* is the Min/Max temperature at which a weld can be made on a multi-pass weld. Individual chapters regarding the welding of various metals will define the requirements for preheating, interpass, and postheating temperatures. These temperatures may be checked by the use of special crayons, paints, or pellets like those in Figure 6-37.

Special procedures, tooling, and chill bars may be used to localize and remove welding heat during the welding application. Figure 6-38 shows an application of tooling used to remove heat from the part.

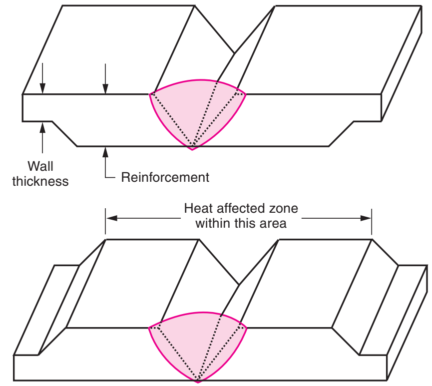

Figure 6-35. The joint thickness and the filler material tensile strength is equivalent to the strength of the base material in this design.

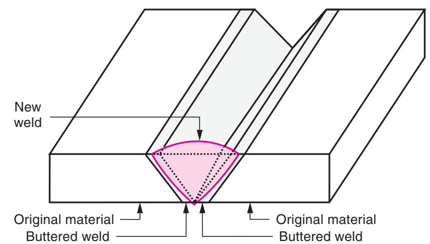

Figure 6-36. Buttering techniques are commonly used to adapt dissimilar metals for welding.

Review Questions

Write your answers on a separate sheet of paper. Do not write in this book.

1. What are the five basic types of joints?
2. Welds made from both sides of the joint are called _____ welds.
3. _____ welds are often used where dissimilar materials are joined.
4. Weld material placed on the surface of a joint for protection of the base material is called _____ or _____.
5. The oxyacetylene and the plasma arc processes are _____ cutting processes.
6. Where high-strength welds are required, a _____ joint weld with 100 percent penetration is used.

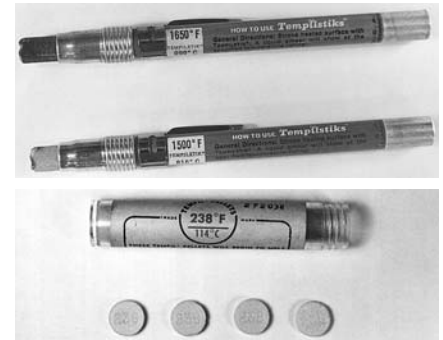

Figure 6-37. Temperature crayons and pellets may be used to determine preheating temperatures prior to welding.

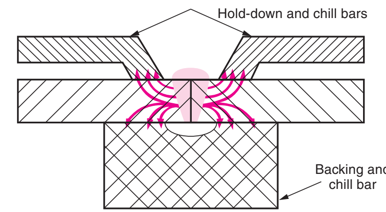

Figure 6-38. Tooling and bars used to remove heat from the weld and resist heat flow into the base material are sometimes called "chill bars."

7. Unless tack welds are made properly, they often _____ during the welding operation.
8. Fillet welds are always measured by the length of the fillet _____.
9. Where fillet weld dimensions are not specified, the size of the weld should equal the thickness of the _____ material.
10. The condition of a butt joint where neither the top nor the bottom edge of the material is flush is called _____.
11. _____ joints always shrink across the weld joint.
12. The main problem in making fillet welds is _____ _____ _____ into the root of the joint.
13. Edge-type joints without full penetration of the weld should not be used in _____ _____.
14. _____ bars are used during welding to localize and remove heat from the weld area.
15. The American Welding Society defines four positions of welding: _____, _____, _____, and _____.