

AWS D10.12M/D10.12:2000
An American National Standard

Guide for Welding Mild Steel Pipe



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Key Words—Mild steel pipe, tubing, shielded metal arc welding, oxyacetylene welding, gas tungsten arc welding, gas metal arc welding, flux cored arc welding

AWS D10.12M/D10.12:2000
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Guide for Welding

Mild Steel Pipe

Supersedes ANSI/AWS D10.12-89

Prepared by
AWS D10 Committee on Piping and Tubing

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This document presents recommended practices for welding mild steel pipe. It is intended to cover piping systems such as for low pressure heating, air conditioning, refrigeration, water supplies, as well as some gas or chemical systems. It provides welding techniques for oxyacetylene, shielded metal arc, gas tungsten arc, gas metal arc, and flux cored arc welding. This document does not address the needs of pipe steels or service conditions which may require Post Weld Heat Treatment (PWHT).



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<i>J. Tucker</i>	AIM Testing Laboratory
<i>D. F. Weaver</i>	Fluor Daniel
<i>R. R. Wright</i>	Consultant

*Advisor

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<i>T. R. Potter, Secretary</i>	American Welding Society
<i>W. L. Ballis</i>	Consultant
<i>H. W. Ebert</i>	Exxon Research and Engineering Company
<i>J. E. Hinkel</i>	Consultant, Lincoln Electric Company
<i>M. P. Lang</i>	United Association Local 501
<i>J. S. Pastorok</i>	Perry Nuclear Power Plant
<i>*W. J. Sperko</i>	Sperko Engineering Services
<i>P. A. Tews</i>	CRC-Evans Automatic Welding
<i>J. Tidwell</i>	Fluor Daniel

*Advisor

Foreword

(This Foreword is not a part of AWS D10.12M/D10.12:2000, *Guide for Welding Mild Steel Pipe*, but is included for information purposes only.)

The AWS Committee on Piping and Tubing has, during its more than forty years of service, contributed much useful information to the pipe welding field. One important item in this regard was the publishing in 1979 of the original version of AWS D10.12-79, *Recommended Practices and Procedures for Welding Plain Carbon Steel Pipe*.

D10.12-79 standard was intended as a teaching/learning aid for the welder with little or no pipe welding experience. It also presented detailed procedures for pipe welding with the shielded metal arc (SMAW), oxyacetylene (OAW), gas tungsten arc (GTAW), and gas metal arc (GMAW) welding processes.

The next revision, ANSI/AWS D10.12-89, *Recommended Practices and Procedures for Low Carbon Steel Pipe*, includes new welding procedures for flux cored arc welding (FCAW). It is the result of several years of discussion aimed at producing a revised standard which is more accurate and easier to understand. It also contains an annex which explains the use of the “nick break” test, which can be of great value in quickly determining the ability of a welding procedure or a welder to produce sound welds.

This present version, AWS D10.12M/D10.12:2000, *Guide for Welding Mild Steel Pipe*, is written with hard metric units and U.S. Customary Units and includes new welding filler materials.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, D10 Committee on Piping and Tubing, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Guide for Welding Mild Steel Pipe

1. Scope

This guide is intended to cover such piping systems as low pressure heating, air-conditioning, refrigeration, and water supply, as well as some gas and chemical systems. These procedures include detailed welding process techniques that may be useful for teaching welders. Processes included are Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Gas Tungsten Arc Welding (GTAW), Gas Shielded Flux Cored Arc Welding (FCAW-G) Flux Cored Arc Welding—Self-Shielded (FCAW-S), and Oxyfuel Welding (OFW). Qualification of these procedures to any welding standard is the responsibility of the user. This document does not address the needs of pipe steels or service conditions which may require post weld heat treatment (PWHT).

This standard makes use of both the International System of Units (SI) and U.S. Customary Units. The measurements may not be exact equivalents; therefore, each system must be used independently of the other without combining in any way. The standard with the designation D10.12:2000M uses SI Units. The standard designation D10.12M:2000 uses U.S Customary Units. The latter are shown within brackets () or in appropriate columns in tables and figures. Pipe sizes are listed as DN (diameter nominal) and NPS (nominal pipe size). The exact pipe diameters are in Table C1.

2. Reference Documents

AWS D10.11, *Recommended Practices for Root Pass Welding of Pipe Without Backing*

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

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes* (available from the American Welding Society)

AWS *Safety and Health Facts Sheets*

AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*

AWS A5.2, *Specification for Carbon and Low-Alloy Steel Rods for Oxyfuel Gas Welding*

AWS A5.12/A5.12M, *Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting*

AWS A5.18, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*

AWS A5.20, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*

AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*

AWS B1.10, *Guide for Nondestructive Examination of Welds*

AWS B1.11, *Guide for the Visual Inspection of Welds*

AWS B2.1, *Standard for Welding Procedure and Performance Qualification*

AWS B4.0, *Standard Methods for Mechanical Testing of Welds*

AWS F4.1, *Recommended Safe Practices for Preparation for Welding and Cutting of Containers and Piping*

ASME Boiler and Pressure Vessel Code; Section IX, *Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators*¹

API 1104, *Standard for Welding Pipelines and Related Facilities*²

1. American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016, (212) 591-8500.

2. Available from the American Welding Society and from the American Petroleum Institute, 1220 L Street NW, Washington DC 20005, (202) 682-8000.

ASME Code for Pressure Piping, B31¹

2.1 AWS Pipe Standard Welding Procedure Specifications. Pipe Standard Welding Procedure Specifications for pipe are found in Annex A.

3. General

With different welding processes, certain terminology, specifications, preparations, and practices apply. This includes the types of steel, joint preparation, joint alignment, tack welding, and welding positions used.

3.1 Pipe Steels. These procedures are intended to be used for welding piping systems composed of such carbon steels as ASTM A 53, A 106, A 135, A 179, A 524, A 587, and API-5L, Grades A25, A and B, and X42. Pipe sizes to be welded with these procedures are not greater than DN 200 (NPS 8) maximum, with wall thicknesses up to 13 mm (0.5 in.) maximum. If this information is applied to larger diameters, or greater wall thicknesses, consideration should be given to service conditions which may go beyond the scope of this document.

3.2 Cleanliness. Cleanliness is important in all welding. Care should be taken to ensure that both members of the joint are properly cleaned. Each side of a weld joint should be mechanically cleaned of all paint, scale, rust or other hydrocarbon containing materials (i.e., oils) for a distance of approximately 25 mm (1 in.) from the end of the expected toe of the weld. Pipe joints should be cleaned on both the inside and outside surfaces. Grinding and cleaning should be done just prior to joint alignment. Improper or insufficient cleaning can result in discontinuities such as porosity, undercut, incomplete fusion, and cracks.

3.3 Preheating. Preheating is not normally required when welding the pipe, fittings and other components of similar nominal composition to those listed in paragraph 3.1 except when the ambient temperature is below 0°C (32°F) or there is visible moisture on the pipe. In these cases, the pipe should be heated using a fuel gas torch or by other suitable methods to 38°C (100°F) minimum.

Where the parts welded are:

- (1) greater than 13 mm (0.5 in.) in thickness and
- (2) the carbon content of the steel exceeds 0.30% or the carbon equivalent (CE) exceeds 0.45%, where:

$$CE = \%C +$$

$$\frac{\%Mn + \%Si}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Ni + \%Cu}{15}$$

Preheating to 107°C (225°F) is recommended. In addition, use of a low-hydrogen welding process or, when E6010 or E6011 is used for root pass welding, use of a low-hydrogen process or electrodes for fill passes is recommended for metals meeting the above conditions.

3.4 Joint Preparation. The joint preparation details and dimensions given in the following procedures are necessary to attain the required quality. Figure 1 shows the proper terminology for describing joint preparation.

3.5 Alignment and Tack Welding. The use of clamps to secure proper alignment is highly recommended. For pipe diameters covered in this document, external lineup clamps are usually employed. A few representative designs have been illustrated in Figure 2.

External clamps with typical cross bars will not allow access for welding around the full circumference of the pipe. For this reason, tack welds should be made in three or four locations between the cross-bars. Tack welds should be of sufficient size to hold the pipe together after the clamp is released and before the root pass is completed. If the shape and size of tack welds are not conducive to their subsequent inclusion in the root pass without risking areas of incomplete fusion or incomplete joint penetration, they should be ground to a contour that will permit complete fusion and penetration.

3.6 Welding Positions. Pipe can be welded in all positions. Welders may be qualified in one or more of the positions shown in Figure 3. Each position is identified by a "G" number in Figure 3 where "G" stands for groove.

3.7 Weld Appearance. The completed weld should be reasonably smooth and even, with a minimum of external undercut. Grinding, filing, and brushing may be used to remove smoke residue, slag, and spatter. The weld needs to be at least flush with the outside surface of the pipe. Any reinforcement should not exceed that permitted in the applicable standard.

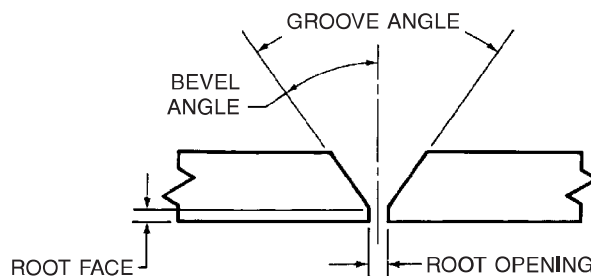


Figure 1—Terminology for Butt Joint

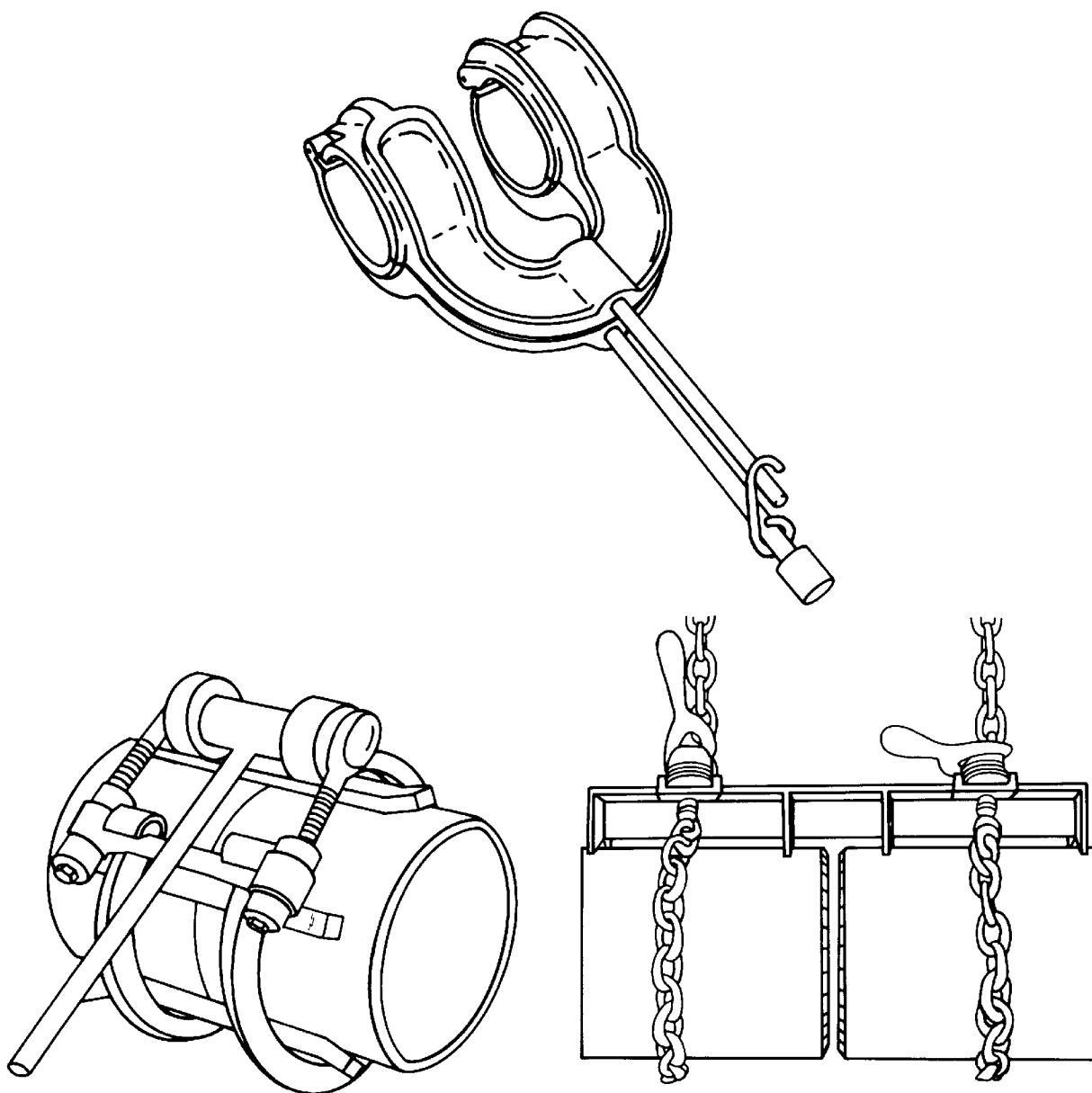


Figure 2—External Pipe Clamps

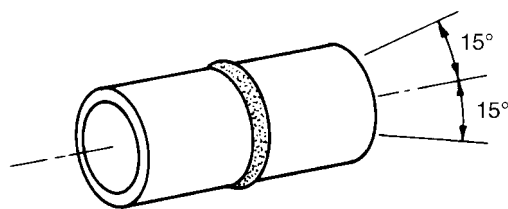
3.8 Small Diameter Piping. Butt and slip-on joints are regularly used for large diameter piping systems, but socket joints, as illustrated in Figure 4, frequently are used for joining pipe DN 60 (NPS 2) and smaller in size.

Most, if not all, socket joint alignment specifications require a spacing of about 1.6 mm (0.06 in.) between the end of the pipe and the seat of the coupling, fitting, or valve. Shrinkage during welding will push the pipe deeper into the socket. With no spacing, the additional stresses of differential expansion between the pipe and the fitting can initiate cracks at the root of the fillet weld.

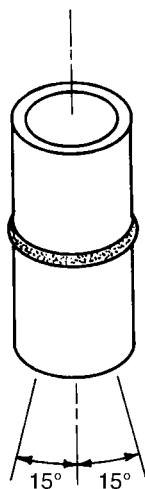
Depending upon the severity of the stresses, such cracks can propagate through the fillet weld.

Thus, it is important to establish and maintain proper spacing during welding.³ This can be accomplished by (1) partial withdrawal after inserting the pipe, or (2) by

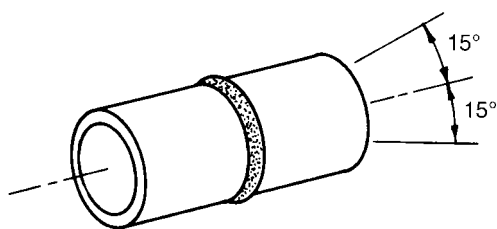
3. The face of most socket weld fittings is flat and perpendicular to the pipe axis. However, if a socket weld fitting is received with a beveled or rounded face, special techniques may need to be used to ensure the fillet weld is the adequate size.



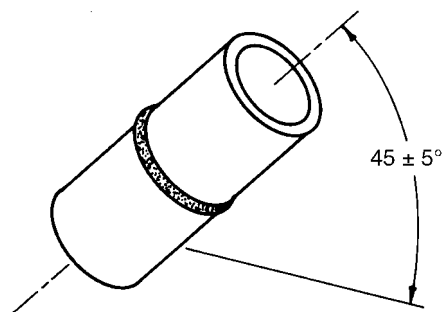
(A) HORIZONTAL ROLLED POSITION—1G POSITION



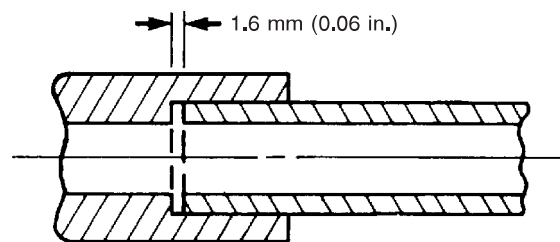
(B) VERTICAL FIXED POSITION—2G POSITION



(C) HORIZONTAL FIXED POSITION—5G POSITION



(D) INCLINED FIXED POSITION—6G POSITION

Figure 3—Welding Position—Pipe Welds**General Notes:**

1. A 1.6 mm (0.06 in.) gap should be left between the pipe end and socket fitting before welding.
2. The size of the fillet weld may have to be increased if the face of the socket weld fitting is not perpendicular to the pipe axis.

Figure 4—Socket Joint

providing compressible spacers or metallic spring-type devices.

3.9 Welding Fittings. Welding fittings and flanges are commercially available in all of the common pipe sizes (see Figure 5). Groove weld fittings are supplied with beveled ends which will permit welding with any of the common welding processes.

3.10 Safety and Health. All processes and procedures have potentially and health hazards. Refer to Section 12 for details.

4. Shielded Metal Arc Welding (SMAW) Using E6010 Electrode and the Downhill Method

4.1 Application. Downhill welding is primarily used to weld relatively thin walled pipe since it allows fast travel speeds.

4.2 Setting the Current. Current ranges are given in Table 1. Within the range noted, the welder should adjust the current to obtain the optimum setting. Appropriate protective clothing such as gloves, boots and overalls will protect the welder from electric shock. Protect face and eyes using a suitable welding shield equipped with eye protection filter. Protect the body by wearing suitable clothing. Protect persons in the vicinity of the arc by means of non-reflective curtains or screens. The arc can generate three types of radiation: ultraviolet, visible, and infrared (heat) radiation, which can be injurious.

4.3 Tack Welding. Tack welds are considered part of the root pass and shall be of sufficient number and length to maintain the root opening and joint alignment. If a tack

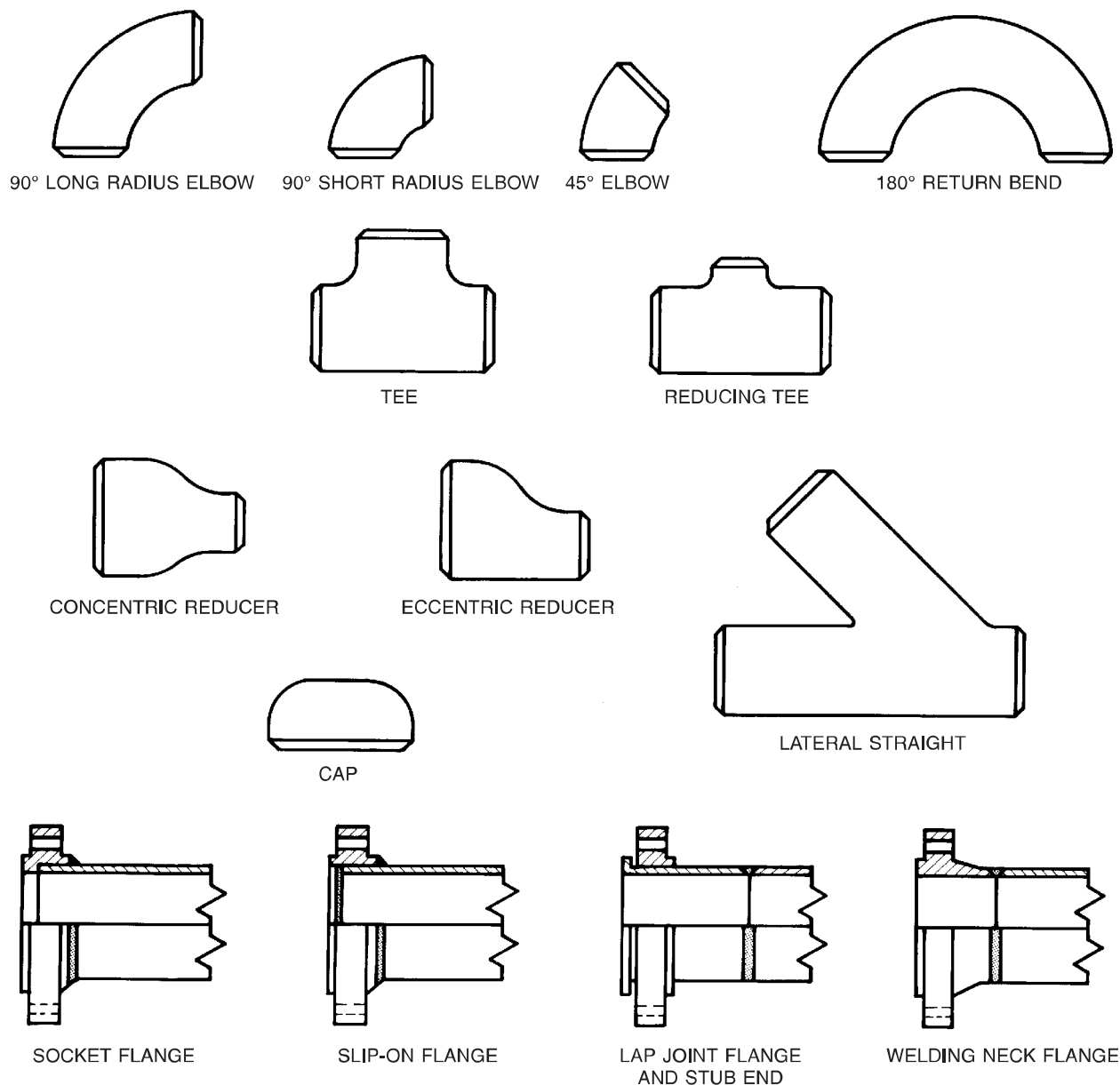


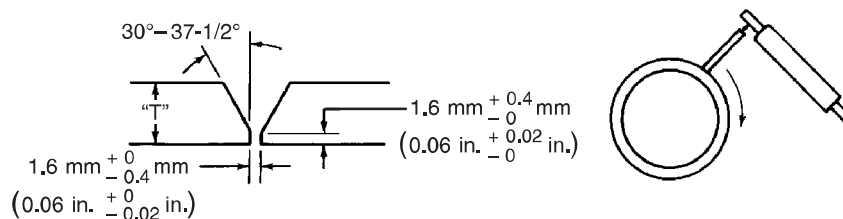
Figure 5—Typical Welding Fittings and Flanges

weld cracks, it shall be removed. Tack welds of excessive thickness shall be thinned with a power grinder or round nose chisel.

One other purpose of tack welding is to hold the root opening to the correct dimension and to hold the two joint members together. If the root opening is too wide, it can result in a hole, or melt-through. If the root opening is too tight, it can result in incomplete joint penetration. Most welding procedures specify the root opening, but do not state what the root opening should be just before each tack weld is made. Experienced welders know that

tack welds will draw the two pipe ends closer together; therefore, they allow for the shrinkage of the tack welds. Furthermore, the first tack weld should be no longer than 25 mm (1 in.) since the longer the tack weld, the more the pipe ends will be pulled out of alignment. The second tack weld should be approximately 180 degrees around the pipe circumference from the first tack weld. In small diameter pipe, two tack welds may suffice, but large diameter pipe will require several tack welds spaced 0.2 to 0.3 m (8 to 12 in.) apart. Homemade spacing tools, which are simple steel wedges, sometimes are driven into root

Table 1
Procedures for Circumferential Butt Joints Welded with SMAW Process
Using E6010 Electrode with Electrode Pressure for Root Pass



Pipe Wall Thickness, "T"		Passes	Pass ¹ No.	E6010 Electrode Size ²		Amperes (DCEP) ³	Direction of Travel
mm	(in.)			mm	(in.)		
5 and thinner	(0.20 and thinner)	2	1 2	2.4 2.4	(3/32) (3/32)	55-60 60-75	Vertical-down
5-6	(0.20-0.24)	3	1, 2, 3	3.2	(1/8)	80-120	Vertical-down
6-10	(0.24-0.39)	5	1, 2 3, 4, 5	3.2 4.0	(1/8) (5/32)	90-115 110-125	Vertical-down
10-13	(0.39-0.51)	7	1 2 3-7	4.0 4.0 4.8	(5/32) (5/32) (3/16)	130-140 150-160 160-175	Vertical-down
5 and thinner	(0.20 and thinner)	3	1 2-3	2.4 2.4	(3/32) (3/32)	55-60 60-75	Horizontal
5-6	(0.20-0.24)	4	1 2, 3, 4	3.2 3.2	(1/8) (1/8)	90-115 80-115	Horizontal
6-10	(0.24-0.39)	7	1, 2, 3 4, 5, 6, 7	3.2 4.0	(1/8) (5/32)	90-115 110-125	Horizontal
10-13	(0.39-0.51)	9	1, 2 3-9	4.0 4.8	(5/32) (1/8)	130-140 160-180	Horizontal

General Notes:

- Where two electrode sizes are shown, the smaller size may be used for all beads.
- E6011 may be used if a DC welding machine is not available. Refer to manufacturers recommendations for storage and handling of electrodes.
- DCEP = direct current electrode positive. DCEN (electrode negative) may also be used for root pass welding with E6010 provided specifications permit such. This will give a finer spray transfer with lower arc force. The resultant root pass will be thinner than that produced with DCEP in vertical-down welding and an immediate cover (hot) pass with DCEP may be required to develop sufficient weld thickness to prevent cracking of this thinner root pass.

openings when they are too tight. These wedges are sometimes left in place to hold the root opening until the tack weld is completed.

Inexperienced or poorly trained welders will usually leave a large hole at the end of the tack weld (see Figure 6). This hole size can be minimized by utilizing the following technique: The welder should be prepared, when reaching the end of the tack weld, to increase the pressure on the electrode and, at the same time, flip the electrode out of the pipe joint with the free hand. This prevents the

keyhole from increasing in size. The advantage of the small hole is that it is easier for the welder to make the root pass. Also, the quality of the root pass is usually improved with no slag inclusions or incomplete fusion.

The start and the end of all tack welds must be ground thin and tapered back to the main body of the tack weld. The reason for this feathering is that it is then easier for the welder to fuse the root pass to the tack weld.

When making fixed position welds such as the 5G (pipe horizontal), the welder can make this job easier by