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Recommended
Practices and Procedures
for Welding Low
Carbon Steel Pipe

Superseding AWS D10.12-79

Prepared by
AWS Committee on Piping and Tubing

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors, September 26, 1988

Abstract

This document presents recommended practices for welding low carbon 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, and gas metal arc welding.



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Foreword

(This Foreword is not a part of ANSI/AWS D10.12-89, *Recommended Practices and Procedures for Welding Low Carbon Steel Pipe*, but is included for information purposes only.)

The AWS Committee on Piping and Tubing has, during its more than thirty years 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*.

This 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) processes.

The present revision, ANSI/AWS D10.12-89, *Recommended Practices and Procedures for Welding Low Carbon Steel Pipe*, 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 additional appendix 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.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Technical Director, American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135.

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Recommended Practices and Procedures for Welding Low Carbon Steel Pipe

1. Scope

These recommended practices and procedures are 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), and oxyacetylene welding (OAW). Qualification of these procedures to any welding standard is the responsibility of the user.

2. Welding Processes

Whatever the welding process used, certain terminology, specifications, preparations, and practices apply to each. This includes the types of steel, joint preparation, joint alignment, tack welding, and welding positions used.

2.1 Pipe Steels. These procedures are intended to be used for welding piping systems composed of such carbon steels as ASTM A53, A106, A135, A179, A524, A587, and API5L. Pipe sizes to be welded with these procedures are up to 8 in. (204 mm) nominal diameter maximum, with wall thicknesses up to 1/2 in. (12.7 mm) maximum.

2.2 Cleanliness. Cleanliness is important in all welding and especially in welding of pipe. Care must 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 dirt for a distance of approximately 1 in. (25 mm) from the end of the bevel. Pipe joints must be cleaned on both the inside and outside surfaces. The 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.

2.3 Preheating. Preheating normally is not required with the pipe steels listed in 2.1. However, should any of the normal contributors to weld cracking be present, such as low base metal temperature or high restraint, preheating should be considered.

2.4 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.

2.5 Alignment and Tack Welding. Standard commercial lineup clamps (see Figure 2) are made to hold virtually any type of pipe joint. For the pipe diameters covered in these procedures, lineup clamps will be of the external type shown in Figure 2. The use of clamps to secure proper alignment is highly recommended.

External clamps with typical cross bars will not provide access for welding around the full circumference of

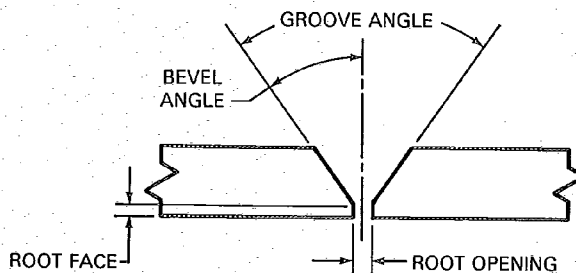


Figure 1 — Terminology for Butt Joint

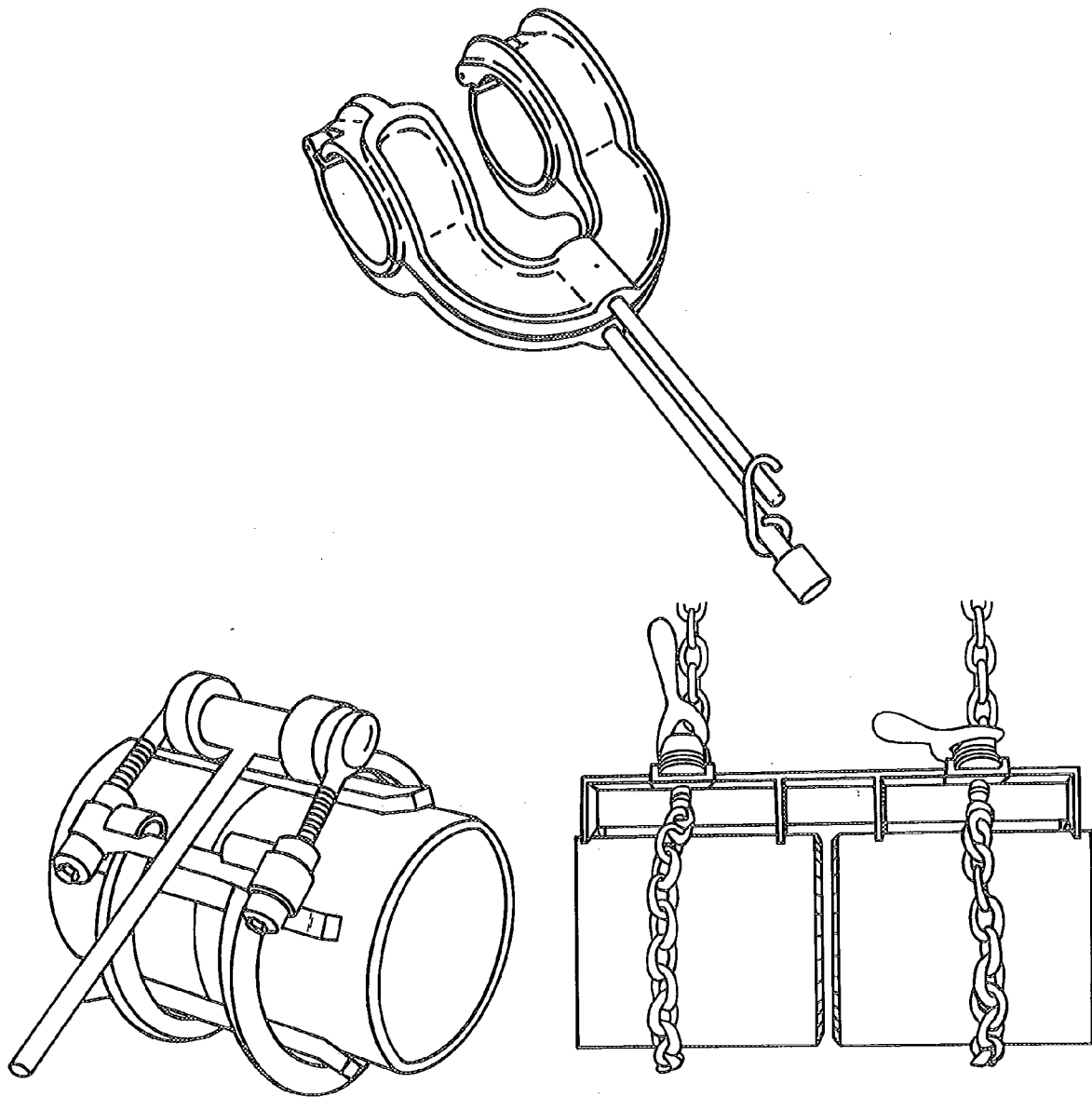


Figure 2 — External Pipe Clamps

the pipe. For this reason, tack welds must be made in three or four locations between the cross bars. Tack welds must 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 bead without risking areas of incomplete fusion or incomplete joint penetration, they should be ground to a contour that will permit complete fusion and penetration.

2.6 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, "G" stands for groove.

2.7 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

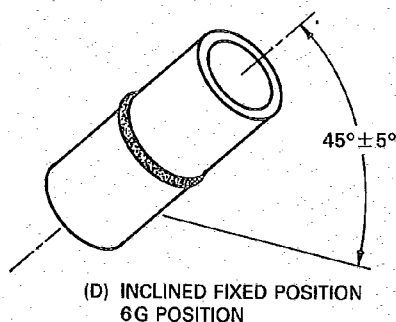
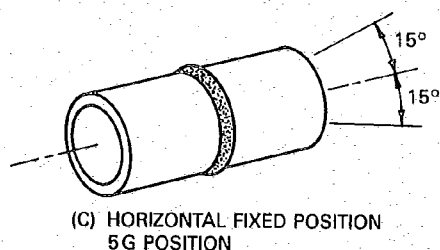
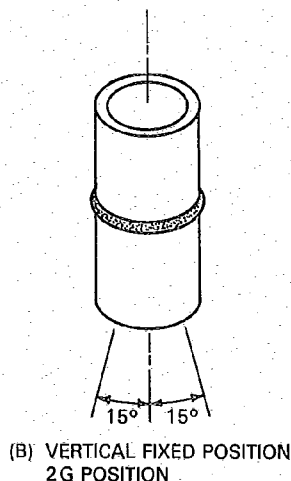
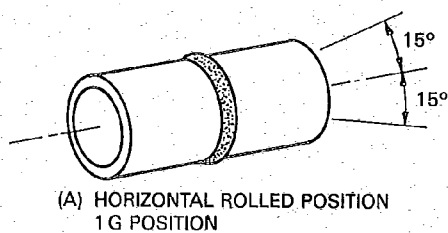


Figure 3 — Welding Position — Pipe Welds

needs to be at least flush with the outside surface of the pipe, but any reinforcement must not exceed that permitted in the applicable standard.

2.8 Small Diameter Piping. Butt joints are regularly used for large diameter piping systems, but socket joints, as illustrated in Figure 4, frequently are used for joining pipe 2 in. (51 mm) and smaller in size.

Most, if not all, socket joint alignment specifications require a gap of about 1/16 in. (1.6 mm) 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 gap, the additional stresses of differential expansion of 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 gap during welding. This can be accomplished by

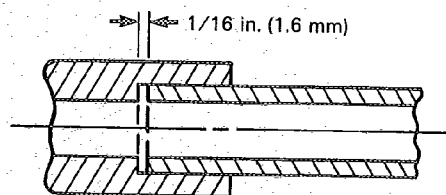
- (1) partial withdrawal after inserting the pipe, or by
- (2) providing compressible spacers such as match sticks, cardboard washers, or metallic spring-type devices.

2.9 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. Shielded Metal Arc Welding Using E6010 Electrodes and the Vertical-Down Method

3.1 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.

3.2 Tack Welding. Tack welds are considered part of the root bead and shall be of sufficient number and length to maintain the root opening and joint alignment.



NOTE: A 1/16 in. GAP MUST BE LEFT BETWEEN THE PIPE END AND SOCKET FITTING BEFORE WELDING.

Figure 4 — Socket Joint

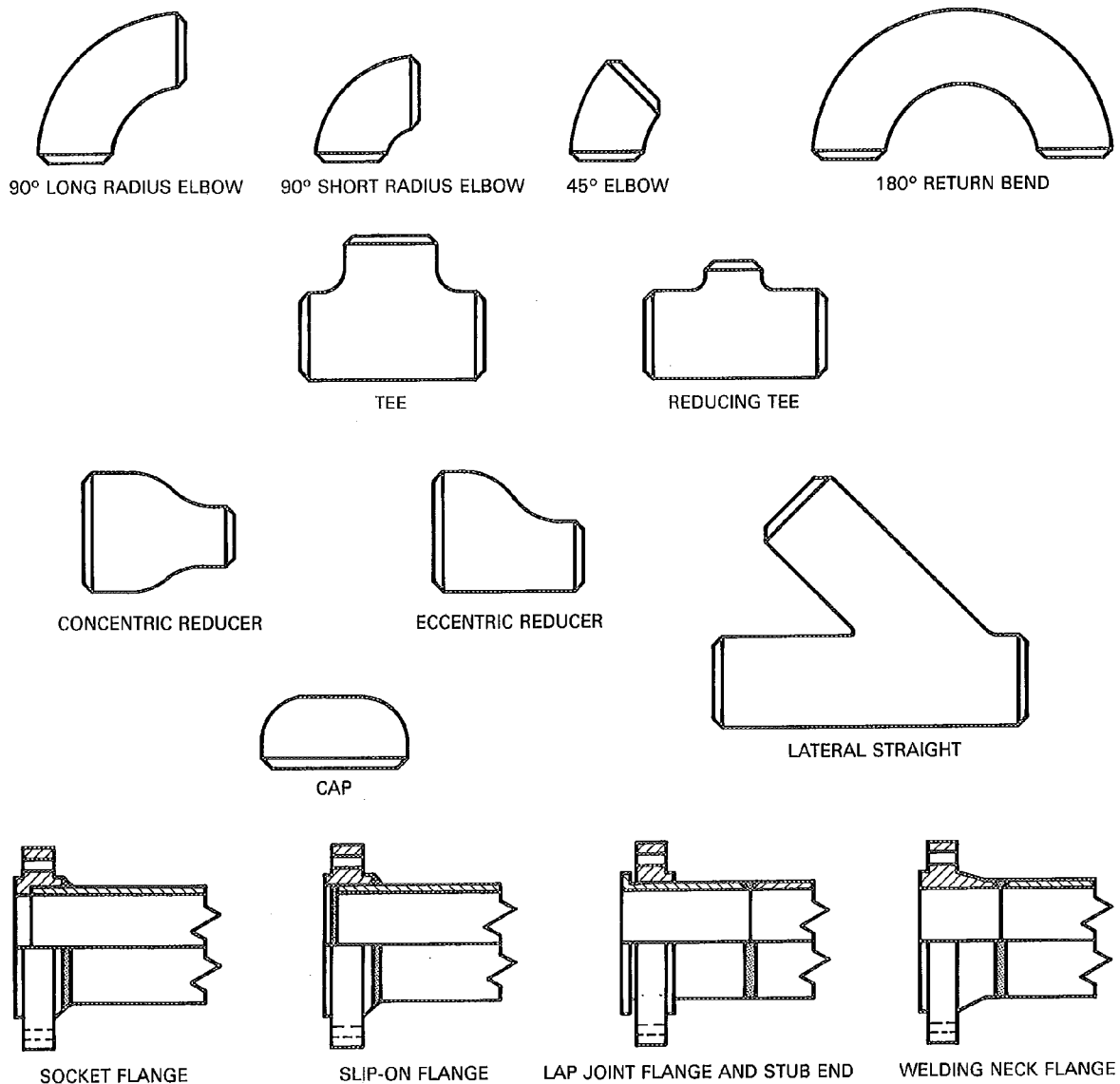


Figure 5 — Typical Welding Fittings and Flanges

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

One 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. 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. That is, 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 1 in. (25 mm) 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 from the first tack weld. In small diameter pipe, two tack welds may suffice, but large diameter pipe will require several tack welds. Homemade spacing tools, which are simple steel wedges, sometimes are driven into root openings that 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 must be prepared, as he or she reaches 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 bead. Also, the quality of the root bead is usually improved with no slag inclusions or incomplete fusion.

The start of all tack welds should 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 bead to the tack weld.

When making fixed position welds such as the 5G (pipe horizontal), the welder can make this job easier by placing a wide root opening (if one exists) at the three and nine o'clock locations while any tight root opening should be placed at the top or twelve o'clock location. The reason for this is the effect of gravity on the molten weld pool. That is, it is easier to get complete joint penetration at the top and bottom locations of a 5G position weld than on the sides.

3.3 Root Bead (First Pass). The root bead is made using a drag technique consisting of the following steps:

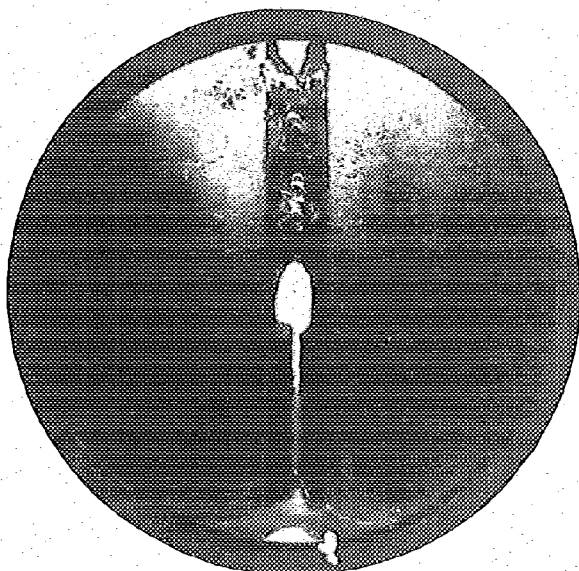


Figure 6 — Picture of Large Hole at End of Tack Weld

- (1) Strike electrode on groove face at start location.
- (2) Withdraw electrode to establish welding arc.
- (3) Quickly push electrode into contact with groove faces.
- (4) Drag electrode along the groove.
- (5) Maintain electrode pressure against groove faces during welding.

The electrode covering rests on the groove face as the electrode is dragged vertical-down around the circumference of the pipe. Assuming proper alignment and welding technique, the current is adjusted until a small keyhole is visible (Figure 7). If the keyhole closes, the current is too low. If the keyhole becomes too large, the current is too high. The size of the keyhole is an indication of the quality of the root surface. While it is possible to get a good root surface without a visible keyhole, greater skill is required.

Insufficient root opening or low welding current can result in incomplete joint penetration or incomplete fusion between weld metal and base metal. Excessive root opening or high current can cause a series of holes in the root bead. A recommended root bead trouble shooting guide, indicating general tendencies, is presented in Figure 8. For example, to reduce undercut at the weld root, reduce the welding current, decrease the root opening, or increase the root face. Bead sequence and terminology for vertical-down welding are also shown in Figure 8.

3.4 Handling the Electrode. Figures 9 and 10 show techniques for controlling the quality of the root bead by electrode manipulation.

3.5 Cleaning Between Passes. The root pass must be thoroughly cleaned before the second pass is started. Power wire brushing may be sufficient, but disc grinding is sometimes necessary to remove root bead areas with excessive thickness or improve root bead contour before the second pass is applied (see Figure 11).

3.6 Second Pass (Hot Pass). The second pass should be made with sufficient heat to float any remaining slag to the surface. A rapid oscillation is helpful in removing slag, especially at the twelve and six o'clock locations. The welding current must be higher than that used on the root bead, since the hot pass must fuse into both groove faces and the root bead, plus float slag to the surface.

3.7 Fill, Stripper, and Cap Passes. All of these passes are made with weave techniques to reach the full width required for each bead. The required width of the weave will vary with the diameter of the electrode, and ideally the electrode diameter should be increased as the wall thickness increases, as shown in Table 1. Slag should be removed after each pass to eliminate the possibility of its being trapped in the weld metal.

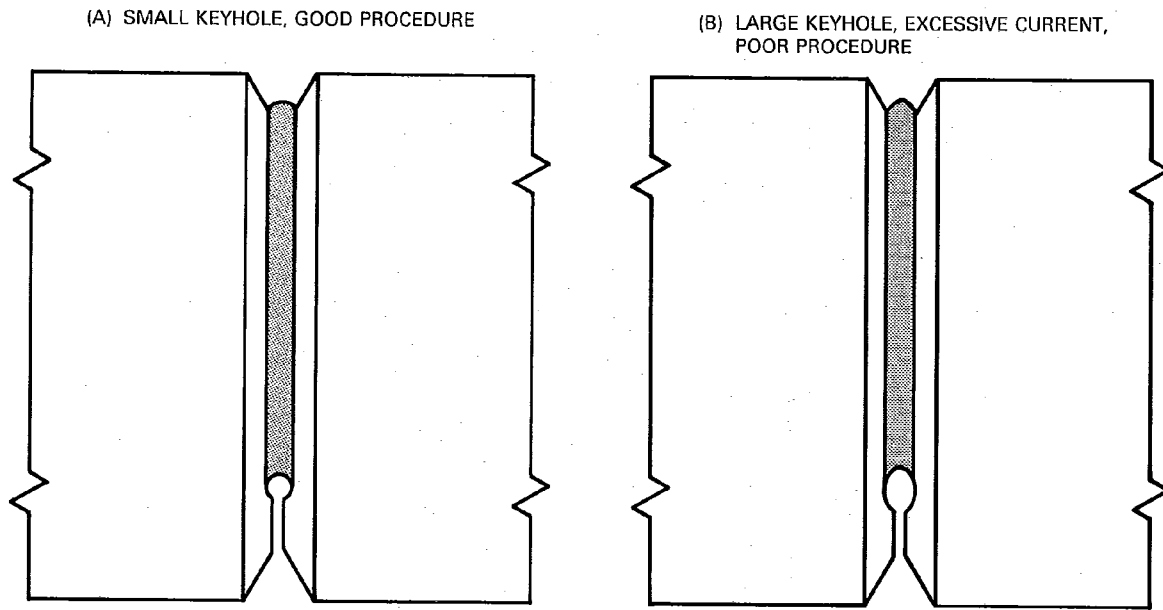
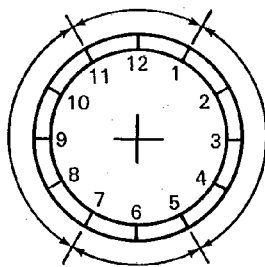


Figure 7—Keyhole Size Controls Weld Quality

CLOCK FACE USED FOR PIPE LOCATIONS



ROOT BEAD TROUBLE-SHOOTING GUIDE

TO ELIMINATE	CURRENT	ROOT OPENING	ROOT FACE	PIPE WALL OFFSET	BEVEL ANGLE
INTERNAL UNDERCUT	DEC.	DEC.	INC.	DEC.	DEC.
INCOMPLETE FUSION	INC.	INC.	DEC.	DEC.	INC.
CRACKING	DEC.	—	DEC.	DEC.	INC.

DEC. = DECREASE

INC. = INCREASE

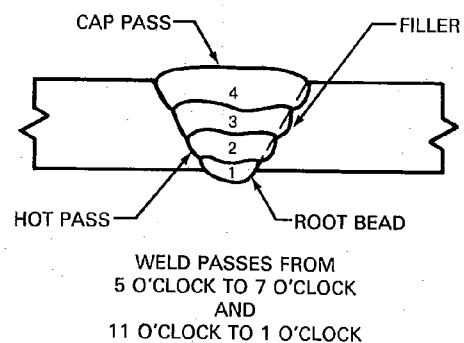
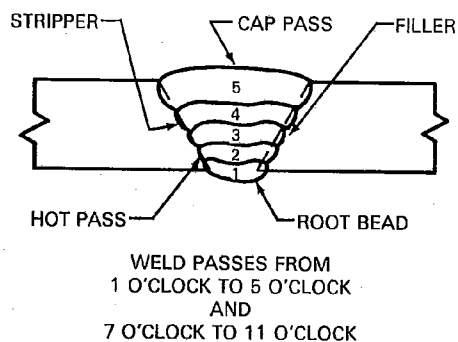


Figure 8—Typical Pass Sequence and Terminology for Vertical-Down Welding

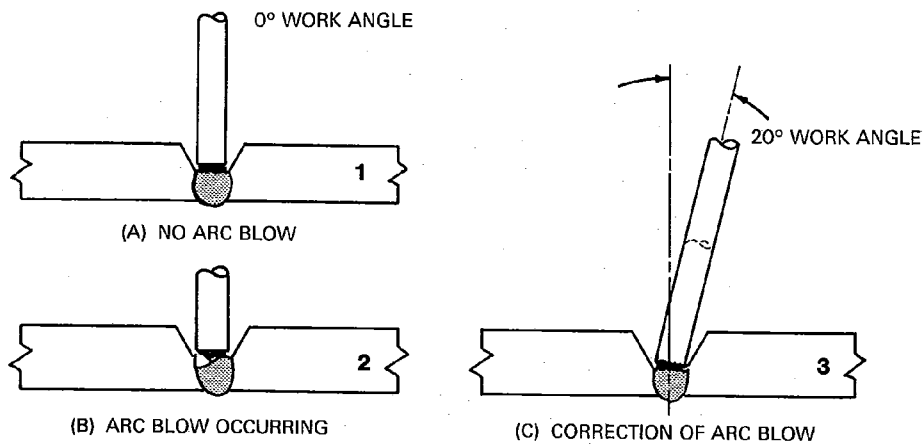
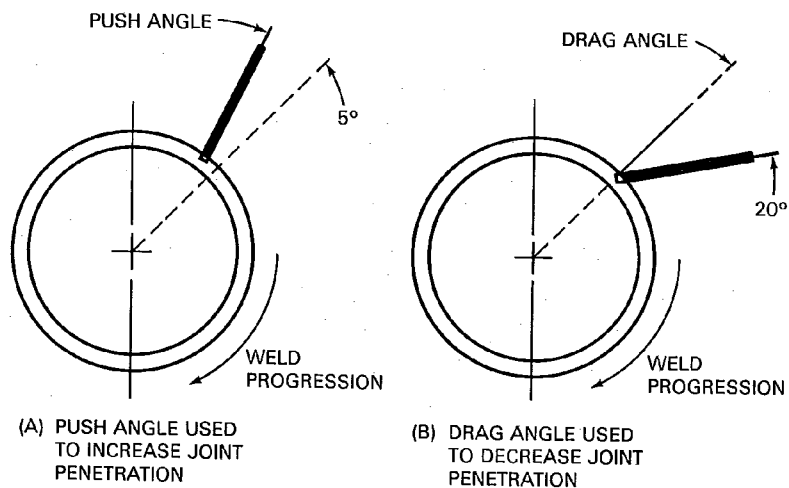


Figure 9 — Effect of Electrode Work Angle on Bead Shape



NOTE: THE KEYHOLE SIZE CAN BE CONTROLLED BY VARYING THE ELECTRODE TRAVEL ANGLE

Figure 10 — Effect of Electrode Travel Angle on Joint Penetration

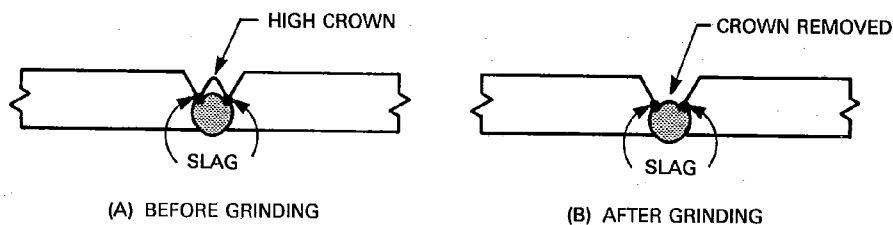
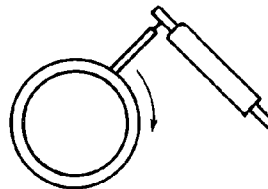
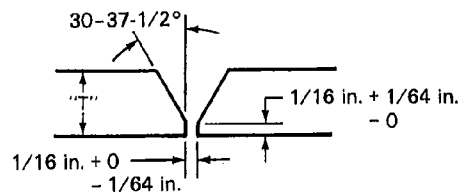


Figure 11 — Grinding To Improve Root Bead Contour

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



Pipe Wall Thickness, "T" (in.)	Passes	Pass ¹ No.	E6010 Electrode ² Size (in.)	Amperes (DCEP) ³	Direction of Travel
0.188 and thinner	2	1	3/32	55 to 60	↓ Vertical-down
		2	3/32	60 to 75	
0.188 to 0.250	3	1,2,3	1/8	80 to 120	↓ Vertical-down
0.250 to 0.375	5	1,2	1/8	90 to 115	↓ Vertical-down
		3,4,5	5/32	110 to 125	
0.375 to 0.50	7	1	5/32	130 to 140	↓ Vertical-down
		2	5/32	150 to 160	
		3-7	3/16	160 to 175	
0.188 and thinner	3	1	3/32	55 to 60	→ Horizontal
		2-3	3/32	60 to 75	
0.188 to 0.250	4	1	1/8	90 to 115	→ Horizontal
		2,3,4	1/8	80 to 115	
0.250 to 0.375	7	1,2,3	1/8	90 to 115	→ Horizontal
		4,5,6,7	5/32	110 to 125	
0.375 to 0.50	9	1,2	5/32	130 to 140	→ Horizontal
		3-9	3/16	160 to 180	

1. Where two electrode sizes are shown, the smaller size may be used for all beads.

2. E6011 may be used if a D.C. welding machine is not available. Refer to manufacturers recommendations for storage and handling of electrodes.

3. DCEP = Direct Current Electrode Positive. DCEN = electrode negative will give a finer spray arc transfer with less arc force. It may be used only for the root bead.

4. Shielded Metal Arc Welding Using E6010 or E6011 Electrodes and the Vertical-Up Method

When pipe is welded vertical-up, several changes in joint preparation and welding technique from those used for vertical-down welding are in order:

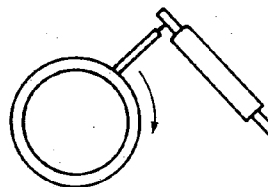
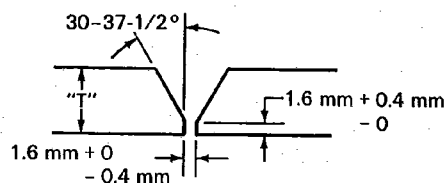
- (1) The root opening is increased slightly.
- (2) The root face is increased slightly.
- (3) Smaller electrode diameters are used.
- (4) Lower currents are used.
- (5) Travel speeds are slower.

(6) The root bead is made without the electrode in contact with the groove face.

4.1 Joint Preparation. When welding pipe, the finished weld quality is partially dependent on the dimensional control of the tack welded assembly. These dimensions and tolerances are shown in Table 2.

4.2 Setting the Current. Appropriate current ranges for each bead are given in Table 2. The welder should select a current setting within the range given and fine tune the machine to a current setting that feels comfortable.

Table 1A (Metric)
Procedures for Circumferential Butt Joints Welded with SMAW Process
Using E6010 Electrodes with Electrode Pressure for Root Bead



Pipe Wall Thickness, "T" (mm)	Passes	Pass ¹ No.	E6010 Electrode ² Size (mm)	Amperes (DCEP) ³	Direction of Travel
4.8 and thinner	2	1	2.4	55 to 60	↓
		2	2.4	60 to 75	↓
4.8 to 6.35	3	1,2,3	3.2	80 to 120	↓
6.35 to 9.6	5	1,2	3.2	90 to 115	↓
		3,4,5	4.0	110 to 125	↓
9.6 to 12.7	7	1	4.0	130 to 140	↓
		2	4.0	150 to 160	↓
		3-7	4.8	160 to 175	↓
4.8 and thinner	3	1	2.4	55 to 60	→
		2-3	2.4	60 to 75	→
4.8 to 6.35	4	1	3.2	90 to 115	→
		2,3,4	3.2	80 to 115	→
6.35 to 9.6	7	1,2,3	3.2	90 to 115	→
		4,5,6,7	4.0	110 to 125	→
9.6 to 12.7	9	1,2	4.0	130 to 140	→
		3-9	4.8	160 to 180	→

1. Where two electrode sizes are shown, the smaller size may be used for all beads.

2. E6011 may be used if a D.C. welding machine is not available. Refer to manufacturers recommendations for storage and handling of electrodes.

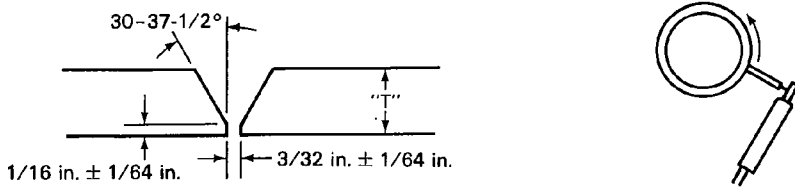
3. DCEP = Direct Current Electrode Positive. DCEN = electrode negative will give a finer spray arc transfer with less arc force. It may be used only for the root bead.

4.3 Root Bead. The position of the electrode is a zero degree work angle and a ten degree push travel angle. The electrode is held over the starting point until the edges of the groove face begin to melt; then it is shortened to obtain the correct arc length for welding. A small but obvious keyhole should be formed, and the weld is made as a series of tiny additions of weld metal across the keyhole area. Maintaining and controlling a keyhole is essential to making a good root bead. The electrode movement consists of holding a close arc on the weld pool, then quickly moving the electrode upward approximately one electrode diameter and downward approx-

imately one-half electrode diameter. After a short pause on the weld pool, the movement of electrode is repeated (see Figure 12). If the keyhole shape becomes straight on one or both sides, it indicates incomplete joint penetration is occurring.

4.4 Fill and Cap Passes. All fill and cap beads are made with a short but rapid manipulation of the electrode together with whatever side-to-side weave is necessary to provide the full width required. This might vary from a very slight weave in the first few passes to a full "U" or box weave near the surface of the pipe. Various combinations of weaves, together with vertical-up travel and

Table 2
Procedures for Circumferential Butt Joints Welded with
SMAW Process, Using E6010 Electrode



Pipe Wall Thickness, "T" (in.)	Passes	Pass ¹ No.	E6010 Electrode ² Size (in.)	Amperes (DCEP) ³	Direction of Travel
0.188 and thinner	2	1,2	3/32 or 1/8	55 to 75 85 to 115	↑ Vertical-up
0.188 to 0.250	3	1,2,3	1/8	90 to 115	↑ Vertical-up
0.250 to 0.375	4	1,2,3,4	1/8	90 to 115	↑ Vertical-up
0.375 to 0.50	5 or 6	1,2 3-6	1/8 5/32	90 to 115 110 to 130	↑ Vertical-up

1. Where two electrode sizes are shown, the smaller size may be used for all beads.

2. E6011 may be used. Refer to manufacturers recommendations for storage and handling of electrodes.

3. DCEP = Direct Current Electrode Positive.

hesitation at the outer edges of the bead, may be used. The technique will vary slightly from one bead to the next. The ideal technique can best be developed by experimentation and practice. The bead surface appearance and shape will indicate to what extent the technique should be varied (see Figures 13 and 14). Reinforcement on the cap should not exceed 1/8 in. (3.2 mm).

4.5 Cleaning Between Passes. Each bead shall be reasonably smooth and even and must be cleaned with a chipping hammer or wire brush, or both, to remove slag, spatter, etc. Any porosity, humpy starts and stops, etc., should be removed by grinding before proceeding with the next bead.

5. Shielded Metal Arc Welding Using E7018 Low Hydrogen Electrodes

Since the scope of this document is limited to relatively thin, low carbon steel in small diameter pipe, it is not likely that low hydrogen E7018 electrodes would be required to control cold cracking, and it is not generally preferred or recommended over E6010 from the usability standpoint, except for fillet welds on a socket fitting.

5.1 Low Hydrogen Limitations on Pipe. When welding with E7018 electrodes, a backing ring should be used, or the root pass should be made with an E6010 or E6011 electrode (Table 3), or with the gas tungsten arc welding process. Porosity and incomplete joint penetration can result when low hydrogen electrodes are used to weld a root pass in an open root joint (joint without backing and no consumable insert).

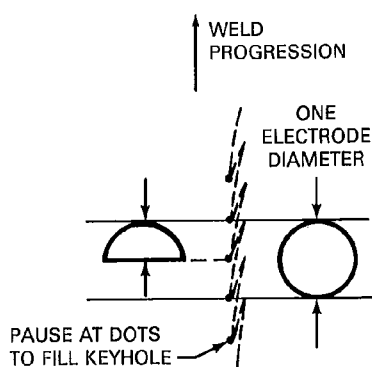
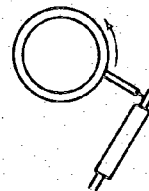
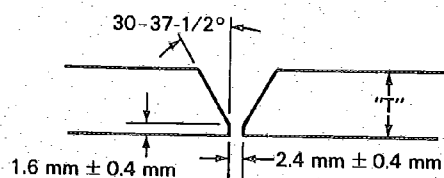


Figure 12 — Electrode Movement
for Vertical-Up Welding Root Bead

Table 2A (Metric)
Procedures for Circumferential Butt Joints Welded with
SMAW Process, Using E6010 Electrode

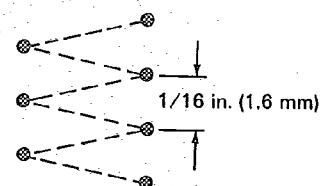
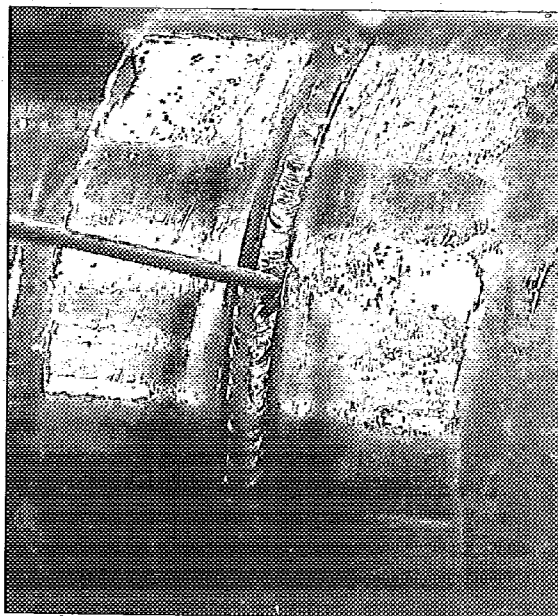


Pipe Wall Thickness, "T" (mm)	Passes	Pass ¹ No.	E6010 Electrode ² Size (mm)	Amperes (DCEP) ³	Direction of Travel
4.8 and thinner	2	1,2	2.4 or 3.2	55 to 75 85 to 115	↑ Vertical-up
4.8 to 6.35	3	1,2,3	3.2	90 to 115	↑ Vertical-up
6.35 to 9.6	4	1,2,3,4	3.2	90 to 115	↑ Vertical-up
9.6 to 12.7	5 or 6	1,2 3-6	3.2 4.0	90 to 115 110 to 130	↑ Vertical-up

1. Where two electrode sizes are shown, the smaller size may be used for all beads.

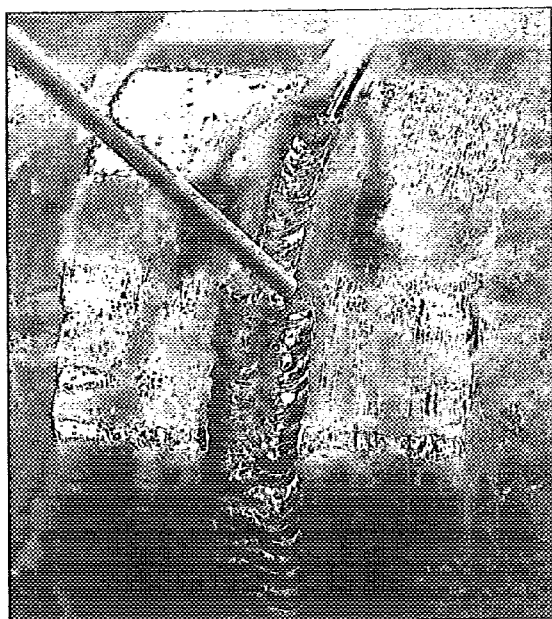
2. E6011 may be used. Refer to manufacturers recommendations for storage and handling of electrodes.

3 DCEP = Direct Current Electrode Positive.



**ELECTRODE MOVEMENT,
 PAUSE AND WEAVE**

Figure 13 — Electrode Movement for Vertical-Up Fill Passes



**Figure 14 — Typical Side-to-Side Weave
Used for Vertical-Up Last Pass (Cap pass)**

Low hydrogen electrodes have the following characteristics:

- (1) They usually do not work well in the vertical-down progression.
- (2) Closer arc length is required.
- (3) Smaller electrode diameters must be used.
- (4) Better storage conditions must be used to protect the electrode from moisture absorption.
- (5) Restriking the arc with a partially used electrode may be more difficult than with either E6010 or E6011 electrodes.
- (6) They are capable of producing welds with better mechanical properties and improved metallurgical characteristics (i.e., strength and notch toughness).

5.2 Striking the Arc. Care must be taken and skill must be developed in striking the arc properly to avoid electrode sticking, starting porosity, or both. Once the arc is established, a very short arc must be maintained. Holding a long arc is almost certain to result in both surface and subsurface porosity. Often the arc is struck in the joint $3/4$ in. (19 mm) ahead of the area where welding is to begin and a short arc is carried back to the starting point before welding is begun.

5.3 Welding Technique. As noted, a very short arc should be used when welding the root bead with the

E7018 electrode. The arc is shortened immediately after it is established. The electrode must be kept very close to the root face to assure complete joint penetration. The electrode movement shown in Figure 12 should not be used; instead, a V-shaped weave is recommended. The weave should be made by smooth movements of the welder's wrist. The electrode should be moved out of the weld pool and up along the groove face with a quick movement. The return movement is slowed to allow just enough time for the weld pool to lose some of its fluidity, and the arc is returned to the weld pool and held there for a short pause. This movement is then repeated up and along the other groove face.

On beads after the root bead, the welder concentrates on the groove faces and moves quickly across the center. The arc is held on the groove face until it melts and the molten metal rises to fill the cavity created by the arc action on the groove face. The arc never leaves the weld pool as it is brought across to the other side just above the top of the previous bead. Most of the molten metal that fills the center comes from the sides, so that the time during which the arc is kept at the groove face is determined by the need to keep the bead flat.

The weld pool must never be allowed to solidify during the weave. Some of the slag may solidify, and, if that occurs along the edges of the weld, the slag may be difficult to remelt, which may result in slag entrapment. If the weld pool is always kept liquid, the slag will not solidify because it has a melting temperature lower than that of the weld metal. Since the arc does not penetrate deeply, the movement must be smooth and precise to avoid slag entrapment.

5.4 Slag Removal. The slag must be removed before making the next pass. This can be done with a chipping hammer followed by wire brushing, preferably power brushing. Any porosity, bad starts, or excessive bead heights can be removed by grinding.

6. Oxyacetylene Welding of Pipe $1/4$ in. (6.4 mm) or Less in Thickness

6.1 Welding Techniques. Oxyacetylene welding of pipe may be done by either one-pass forehand welding, one-pass backhand welding, or a combination of first-pass backhand welding with second-pass forehand welding. The combination is commonly referred to as two-pass welding, and is preferred for thicker walled pipe. It is done by partially filling the groove using backhand welding, followed by finishing the weld with forehand welding. Most production welding by the oxyacetylene welding process is done by two-pass welding. This technique is especially useful for welding pipe less than 2 in.

(51 mm) in diameter and less than 0.156 in. (3.9 mm) in wall thickness.

All oxyacetylene welding of carbon steel pipe should be done with a neutral flame and a work angle of zero degrees for both the welding torch and the welding rod. The pipe should be heated to 1400–1800°F (760–980°C) before welding is started, particularly on thicker walled pipe.

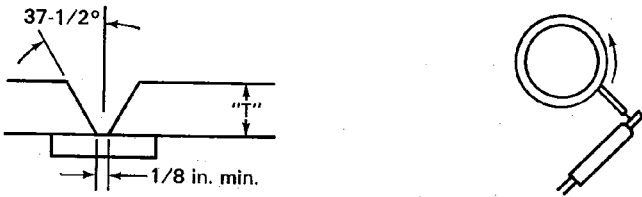
The oxygen pressure is set at 8 to 16 psig (56 to 112 kPa) and the acetylene pressure is set at 4 to 5 psig (28 to 35 kPa) for injector type torches, and the oxygen and acetylene pressure is set at 4 to 5 psig (28 to 35 kPa) for equal pressure torches.

Forehand welding (single pass) is illustrated in Figure 15. The welding flame points in the direction of welding

travel, with the welding rod leading the torch. Forehand welding involves repeated movement of the flame from one groove face to the other. The rod is held to the side opposite the flame. In the 5G welding position, welding starts at the six o'clock location and proceeds vertical up to the twelve o'clock location.

Backhand welding (single pass) is illustrated in Figure 16. The welding flame points opposite to the direction of welding travel, with the welding rod following the torch. The flame is directed into the root opening until the edges of both groove faces are melted to form a keyhole. As the molten keyhole is formed, the welder moves the welding rod towards the forward edge of the weld pool. The flame is moved alternately slightly forward towards the unmelted joint root and back towards the weld pool.

Table 3
Procedures for Circumferential Butt Joints Welded with SMAW Process, Using E6010 and E7018 Electrodes



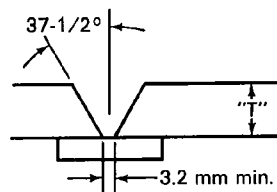
Pipe Wall Thickness, "T" (in.)	Passes	Pass ¹ No.	Electrode ²		Amperes (DCEP) ³	Direction of Travel
			Size (in.)	Class		
0.188 to 0.250	2	1	3/32	E6010	55 to 75	↑ Vertical-up
		2	3/32	E7018	70 to 90	
0.250 to 0.375	4	1	3/32	E6010	55 to 75	↑ Vertical-up
		2	3/32	E7018	70 to 90	
		3,4	1/8	E7018	90 to 110	
0.375 to 0.50	5	1	3/32	E6010	55 to 75	↑ Vertical-up
		2	3/32	E7018	70 to 90	
		3,4,5	1/8	E7018	90 to 110	
0.188 to 0.250	3	1	3/32	E6010	55 to 75	→ Horizontal
		2,3	3/32	E7018	70 to 90	
0.250 to 0.375	4–5	1	3/32	E6010	55 to 75	→ Horizontal
		2	3/32	E7018	70 to 90	
		3,4,5	1/8	E7018	90 to 110	
0.375 to 0.50	6–7	1	3/32	E6010	55 to 75	→ Horizontal
		2	3/32	E7018	70 to 90	
		3–7	1/8	E7018	90 to 110	

1. Where two electrode sizes are shown, the smaller size may be used for all beads.

2. E6011 may be used for first pass. Refer to manufacturers' recommendations for storage and handling of electrodes.

3. DCEP = Direct Current Electrode Positive.

Table 3A (Metric)
Procedures for Circumferential Butt Joints Welded with
SMAW Process, Using E6010 and E7018 Electrodes



Pipe Wall Thickness, "T" (mm)	Passes	Pass ¹ No.	Electrode ²		Amperes (DCEP) ³		Direction of Travel
			Size (mm)	Class			
4.8 to 6.35	2	1	2.4	E6010	55 to 75	↑	Vertical- up
		2	2.4	E7018	70 to 90		
6.35 to 9.6	4	1	2.4	E6010	55 to 75	↑	Vertical- up
		2	2.4	E7018	70 to 90		
		3,4	3.2	E7018	90 to 110		
9.6 to 12.7	5	1	2.4	E6010	55 to 75	↑	Vertical- up
		2	2.4	E7018	70 to 90		
		3,4,5	3.2	E7018	90 to 110		
4.8 to 6.35	3	1	2.4	E6010	55 to 75	→	Horizontal
		2,3	2.4	E7018	70 to 90		
6.35 to 9.6	4-5	1	2.4	E6010	55 to 75	→	Horizontal
		2	2.4	E7018	70 to 90		
		3,4,5	3.2	E7018	90 to 110		
9.6 to 12.7	6-7	1	2.4	E6010	55 to 75	→	Horizontal
		2	2.4	E7018	70 to 90		
		3-7	3.2	E7018	90 to 110		

1. Where two electrode sizes are shown, the smaller size may be used in all passes.

2. E6011 may be used for first pass. Refer to manufacturers' recommendations for storage and handling of electrodes.

3. DCEP = Direct Current Electrode Positive.

In the 5G welding position, welding starts at the twelve o'clock location and proceeds vertical down to the six o'clock location.

Further information on oxyacetylene welding of pipe is given in Table 4.

6.2 Appearance of Finished Weld. Welds shall be reasonably smooth and uniform with a minimum of undercut, inside and outside. The surface of the weld shall be at least flush with the inside and outside surfaces of the pipe.

7. Gas Tungsten Arc Welding of Pipe

7.1 Application. The use of GTAW for welding carbon steel pipe is usually limited (except for thin wall tubing).

It normally is used only for the root pass, and then only when exceptional quality is required. Since GTAW root beads tend to be thin, a second GTAW pass sometimes is made to prevent melting through the first bead when other processes are used to complete the weld. When the quality requirements are especially high, GTAW may be used for the entire joint, even in thicker materials.

7.2 Purging. Back purging generally is not required when welding carbon steel pipe. When the gas flow and nozzle sizes specified in Table 5 are used, a sufficient quantity of the shielding gas, usually argon, reaches the root surface to provide adequate protection, and a blanket of the gas covers the weld face.

7.3 Electrode Shape. The shape of the tungsten electrode tip has a substantial effect on the contour and

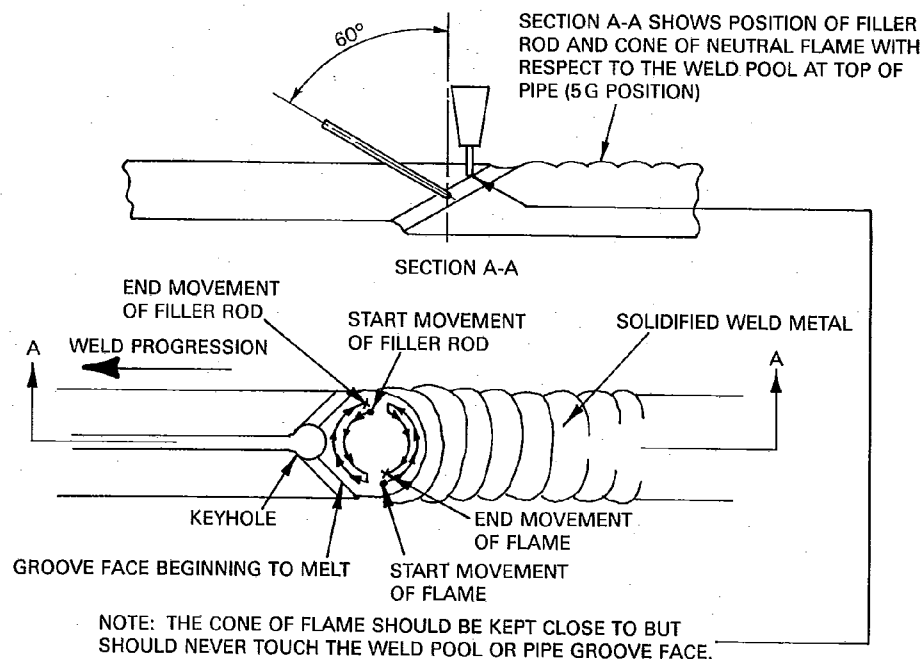


Figure 15 — One-Pass Forehand Oxyacetylene Welding

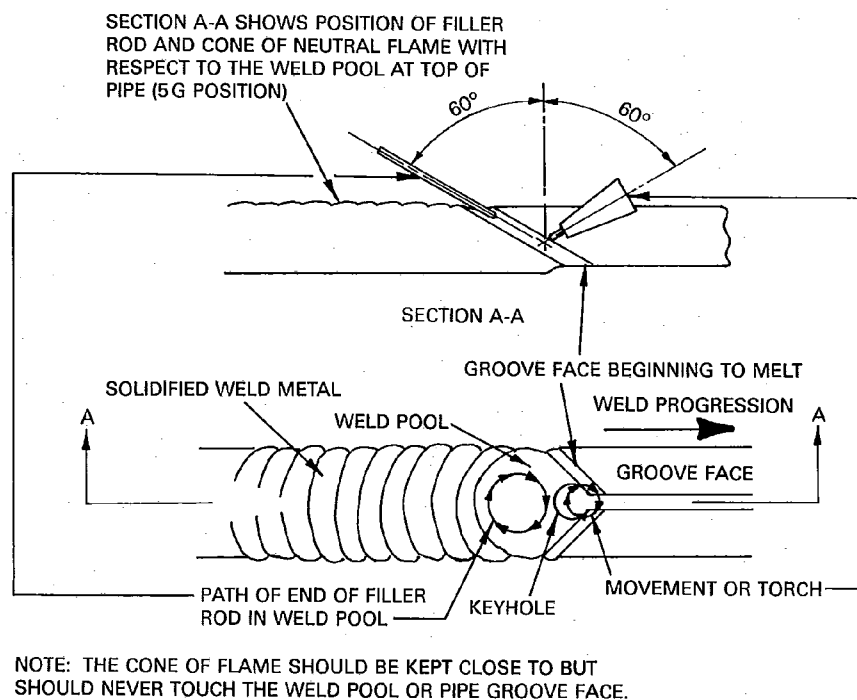


Figure 16 — One-Pass, Backhand Oxyacetylene Welding

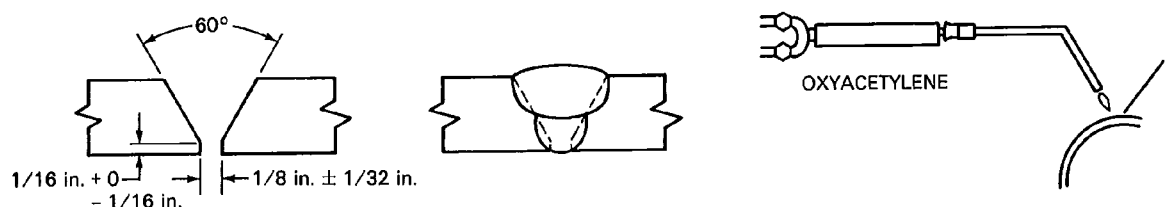
width of the weld face and on joint penetration. It must be shaped properly (similar to a sharpened pencil). Shaping is done on a fine grit grinding wheel. A 60 grit, O to M grade silicon carbide grinding wheel is recommended, and it should be used only for the purpose of grinding tungsten. Best results are obtained when grinding is done so that grinding marks are parallel with the electrode axis.

7.4 Welding Technique. To make a root pass, the electrode must be correctly positioned within the torch. With

the welding torch in an upright position and the nozzle resting on the groove face, the electrode is adjusted so that the end is almost flush with the bottom of the joint.

The welding current should be direct current electrode negative, using the amperage and gas flow given in Table 5. In the 5G position, tack welds should be made at the 7:30, 4:30, 1:30 and 10:30 locations. The root bead, whether 5G or 6G position, is started in the six o'clock location, and the weld is made uphill to the twelve o'clock location on one side of the pipe. The same sequence is followed on the other side.

Table 4
Procedures for Butt Joints Welded with OAW Process



Welding Position	Location on Pipe	Wall Thickness* in.	Tip Size	Method of Welding	Travel Angle	
					Torch	Welding Rod
5G Pipe Horizontal Fixed	Top	0.188 or less	54 to 56	one pass backhand welding	60° drag	60° push
5G Pipe Horizontal Fixed	Side	0.188 or less	54 to 56	one pass backhand welding	45° drag	45° push
5G Pipe Horizontal Fixed	Bottom	0.188 or less	54 to 56	one pass backhand welding	0° drag	60° push
5G Pipe Horizontal Fixed	Top	0.188 to 0.250	51 to 53	1st pass backhand welding	60° drag	60° push
				2nd pass forehand welding	0° push	60° drag
5G Pipe Horizontal Fixed	Side	0.188 to 0.250	51 to 53	1st pass backhand welding	45° drag	45° push
				2nd pass forehand welding	45° push	45° drag
5G Pipe Horizontal Fixed	Bottom	0.188 to 0.250	51 to 53	1st pass backhand welding	0° drag	60° push
				2nd pass forehand welding	0° push	80° drag
2G Pipe Vertical Fixed		0.188 or less	54 to 56	one pass backhand welding	45° drag	45° push
2G Pipe Vertical Fixed		0.188 to 0.250	51 to 53	one pass backhand welding	45° drag	45° push

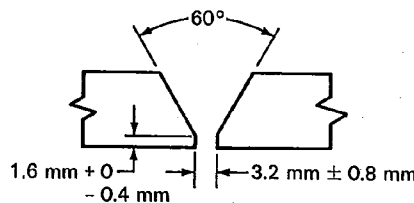
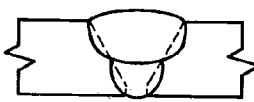
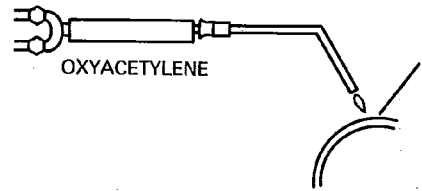
*For 0.188 or less wall thickness, use AWS RG-60 filler rod and 3/32 in. or 1/8 in. diameter rod size and for 0.188 to 0.250 wall thickness, use AWS RG-60 filler rod and 1/8 in. diameter rod size.

The weld is started by placing the nozzle against the bevels of the groove face with the torch at a work angle of zero, and a push angle up to about fifty five degrees. Both the torch and the welding rod remain at a work angle of zero during welding. The welding rod is positioned, with a large drag angle, close to the joint in preparation for insertion into the joint after the arc is started. When the switch is turned on, the torch is pivoted to a push angle of about twenty degrees and the arc ignited. The filler rod is then brought to a drag angle of forty five to seventy degrees, and welding proceeds with the electrode and the welding rod about sixty five to ninety degrees apart.

7.5 Joint Preparation and Alignment. In the welding of pipe, the finished weld quality is a function of the alignment and dimensional control of the tack welded assembly. The dimensions shown in the Table 5 procedures should be treated as mandatory requirements.

7.6 Appearance of Finished Welds. The beads shall be reasonably smooth and even. Any porosity or other defects shall be removed to clean, bright metal before proceeding. The final face reinforcement should not exceed 1/8 in. (3.2 mm).

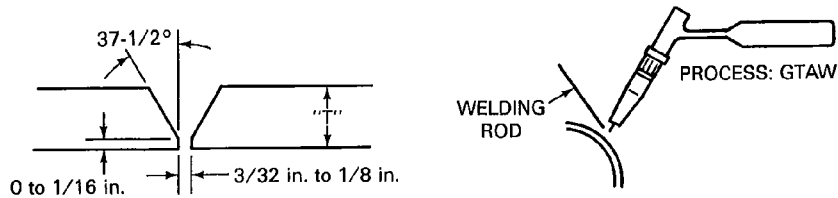
Table 4A (Metric)
Procedures for Butt Joints Welded with OAW Process

Welding Position	Location on Pipe	Wall Thickness* mm	Tip Size	Method of Welding	Travel Angle	
					Torch	Welding Rod
5G Pipe Horizontal Fixed	Top	4.8 or less	54 to 56	one pass backhand welding	60° drag	60° push
5G Pipe Horizontal Fixed	Side	4.8 or less	54 to 56	one pass backhand welding	45° drag	45° push
5G Pipe Horizontal Fixed	Bottom	4.8 or less	54 to 56	one pass backhand welding	0° drag	60° push
5G Pipe Horizontal Fixed	Top	4.8 to 6.35	51 to 53	1st pass backhand welding	60° drag	60° push
				2nd pass forehand welding	0° push	60° drag
5G Pipe Horizontal Fixed	Side	4.8 to 6.35	51 to 53	1st pass backhand welding	45° drag	45° push
				2nd pass forehand welding	45° push	45° drag
5G Pipe Horizontal Fixed	Bottom	4.8 to 6.35	51 to 53	1st pass backhand welding	0° drag	60° push
				2nd pass forehand welding	0° push	80° drag
2G Pipe Vertical Fixed		4.8 or less	54 to 56	one pass backhand welding	45° drag	45° push
2G Pipe Vertical Fixed		4.8 to 6.35	51 to 53	one pass backhand welding	45° drag	45° push

*For 4.8 or less wall thickness, use AWS RG-60 filler rod and 2.4 mm or 3.2 mm diameter rod size and for 4.8 to 6.35 wall thickness, use AWS RG-60 filler rod and 3.2 mm diameter rod size.

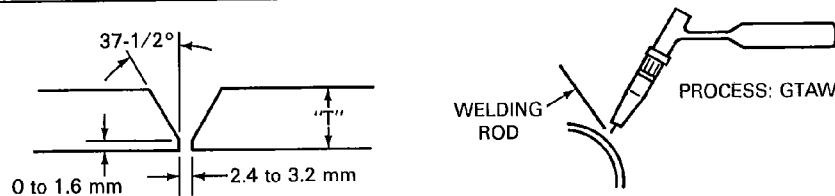
Table 5
Procedures for Circumferential Butt Joints Welded with GTAW Process



Pipe Wall Thickness "T" (in.)	Passes	Pass No.	Filler Metal ¹ Size (in.)	Amperes (DCEN) ²	Arc Volts	Nozzle Size	Shielding Gas Flow ³ (ft ³ /hr)	EWTh-2 Tungsten Electrode	Direction of Travel
0.188 and thinner	2	1,2	3/32	65 to 75	13	5	15	3/32	↑ Vertical-up
0.188 to 0.250	2+	1 2,3	3/32 1/8	75 to 85 90 to 100	13 14	6 6	15 15	3/32	↑ Vertical-up
0.250 to 0.375	2+	1 2+	3/32 1/8	90 to 100 90 to 100	14 14	6 7	15 18	1/8	↑ Vertical-up
0.375 to 0.50	2+	1 2+	3/32 1/8	90 to 100 100 to 120	14 14	6 7	15 18	1/8	↑ Vertical-up

1. ER70S-2 is preferred; ER70S-3 or ER70S-6 may be used. Refer to manufacturers' recommendations for storage and handling of filler metal.
 2. DCEN = Direct Current Electrode Negative.
 3. Welding Grade Argon.

Table 5A (Metric)
Procedures for Circumferential Butt Joints Welded with GTAW Process



Pipe Wall Thickness "T" (mm)	Passes	Pass No.	Filler Metal ¹ Size (mm)	Amperes (DCEN) ²	Arc Volts	Nozzle Size	Shielding Gas Flow ³ (L/min)	EWTh-2 Tungsten Electrode (mm)	Direction of Travel
4.8 and thinner	2	1,2	2.4	65 to 75	13	5	7	2.4	↑ Vertical-up
4.8 to 6.35	2+	1 2+	2.4 3.2	75 to 85 90 to 100	13 14	6 6	7 7	2.4	↑ Vertical-up
6.35 to 9.6	2+	1 2+	2.4 3.2	90 to 100 90 to 100	14 14	6 7	7 8.5	3.2	↑ Vertical-up
9.6 to 12.7	2+	1 2+	2.4 3.2	90 to 100 100 to 120	14 14	6 7	7 8.5	3.2	↑ Vertical-up

1. ER70S-2 is preferred; ER70S-3 or ER70S-6 may be used. Refer to manufacturers' recommendations for storage and handling of filler metal.
 2. DCEN = Direct Current Electrode Negative.
 3. Welding Grade Argon.

8. Gas Metal Arc Welding of Steel Pipe

8.1 Initiating the Arc. Good arc striking can best be achieved, providing the proper conditions of amperage (wire feed speed) and voltage have been selected (see Table 6), by cutting off the end of the electrode to leave about 5/8 in. (16 mm) maximum electrode extension beyond the contact tip.

The gas nozzle should then be positioned to either touch the workpiece or be very near it until the arc is established. This technique will avoid excessively long electrode extension, which complicates arc striking (see Figure 17).

8.2 Travel Speed. The travel speed should always be fast enough to cause the electrode to arc on the leading edge of the weld pool. If the travel speed and manipulation of the electrode are such that the electrode is arcing elsewhere on a large weld pool, discontinuities, such as incomplete fusion, may occur. Because of this tendency, it is recommended that no more than two passes be run

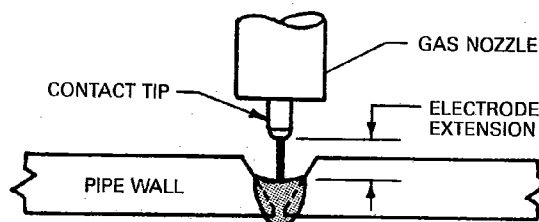
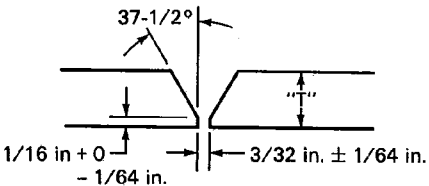
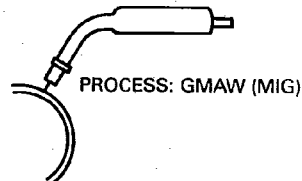


Figure 17 — Position of Gas Nozzle, Contact Tip and Pipe

vertical-down. If more passes are required, it is recommended that they be run vertical-up. Welding vertical-up gives greater assurance that the electrode will be arcing on the leading edge of the weld pool.

8.3 Gas Shielding. It is imperative that the weld pool be protected by the shielding gas. If the gas is not present at the arc, severe porosity will result. For this reason,

Table 6
Procedures for Circumferential Butt Joints Welded with GMAW Process

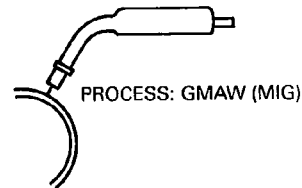
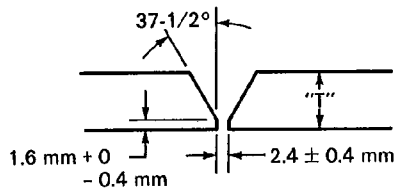
Pipe Wall Thickness "T" (in.)	Passes	Pass No.	Electrode ¹ Size (in.)	Amperes (DCEP) ²	Arc Volts	Wire Feed Speed in./min.	Shielding Gas Flow (ft ³ /hr)	Direction of Travel
0.188 and thinner	2	1,2	0.035	120 to 130	20 to 21	180 to 190	26 to 30	↓ Vertical-down
0.188 to 0.250	3	1,2,3	0.035	120 to 130	20 to 21	180 to 190	26 to 30	↓ Vertical-down
0.250 to 0.375 ³	4	1,2,3,4	0.035	120 to 130	20 to 21	180 to 190	26 to 30	↓ Vertical-down
0.375 to 0.50 ³	5	1-5	0.035	120 to 130	20 to 21	180 to 190	26 to 30	↓ Vertical-down
0.188 and thinner	3	All	0.035	120 to 130	20 to 21	180 to 190	26 to 30	→ Horizontal
0.188 to 0.250	3	All	0.035	120 to 130	20 to 21	180 to 190	26 to 30	→ Horizontal
0.250 to 0.375	4	All	0.035	120 to 130	20 to 21	180 to 190	26 to 30	→ Horizontal
0.375 to 0.50	5	All	0.035	120 to 130	20 to 21	180 to 190	26 to 30	→ Horizontal

1. ER70S-2, -3, -6 refer to manufacturer's recommendations for storage and handling of filler metal.

2. DCEP = Direct Current Electrode Positive.

3. First two passes vertical-down; remaining passes vertical-up.

Table 6A (Metric)
Procedures for Circumferential Butt Joints Welded with GMAW Process



Pipe Wall Thickness "T" (in.)	Passes	Pass No.	Electrode ¹ Size (mm)	Amperes (DCEP) ²	Arc Volts	Wire Feed Speed mm/s	Shielding Gas Flow L/min	Direction of Travel
4.8 and thinner	2	1,2	0.89	120 to 130	20 to 21	76 to 80	12 to 14	↓ Vertical-down
4.8 to 6.35	3	1,2,3	0.89	120 to 130	20 to 21	76 to 80	12 to 14	↓ Vertical-down
6.35 to 9.6 ³	4	1,2,3,4	0.89	120 to 130	20 to 21	76 to 80	12 to 14	↓ Vertical-down
9.6 to 12.7 ³	5	1-5	0.89	120 to 130	20 to 21	76 to 80	12 to 14	↓ Vertical-down
4.8 and thinner	3	All	0.89	120 to 130	20 to 21	76 to 80	12 to 14	→ Horizontal
4.8 to 6.35	3	All	0.89	120 to 130	20 to 21	76 to 80	12 to 14	→ Horizontal
6.35 to 9.6	4	All	0.89	120 to 130	20 to 21	76 to 80	12 to 14	→ Horizontal
9.6 to 12.7	5	All	0.89	120 to 130	20 to 21	76 to 80	12 to 14	→ Horizontal

1. ER70S-2, -3, -6 refer to manufacturer's recommendations for storage and handling of filler metal.

2. DCEP = Direct Current Electrode Positive.

3. First two passes vertical-down; remaining passes vertical-up.

some form of wind shield protection must be provided if there is any possibility that the gas will be blown away. An Argon-CO₂ mixture or CO₂ is normally used for shielding.

8.4 Cleaning. Before the welding is started, the bevels and the weld area must be ground, filed, or wire brushed to clean metal. Between passes, silicon deposits on the surface may be removed by filing or wire brushing. If proper contours are not obtained at the start of the bead or the crater, these conditions should be corrected by grinding.

9. Safety and Health

Use of the welding processes and consumables described in this document is safe, provided proper procedures are followed and precautions taken. If these procedures and precautions are followed, welding can be done safely with minimal health risk.

9.1 Fumes and Gases. Fumes and gases can be dangerous to health. The welders' head should be kept out of the fumes. Use of enough ventilation, exhaust at the work, or both, to keep fumes and gases from the breathing zone and the general area is very important.

9.2 Radiation. Arc rays can injure the eyes. Infrared (heat) radiation can cause burns. Ultraviolet radiation can cause skin injury similar to sunburn.

9.3 Electric Shock. Electric shock can kill. Contact with live electrical components should be strictly avoided. Reading and understanding the manufacturer's instructions and employer's safety practices should be mandatory.

9.4 Fire Prevention. A high temperature heat source is always present in welding. Sparks can travel horizontally up to 35 ft (10.7 m) and fall much greater distances. They can pass through or lodge in cracks or holes in floors and walls. Combustibles should always be removed from the work area or shielded from the welding operation.

9.5 Explosion. Flammable gases, vapors, and dust can form explosive mixtures with air or oxygen. Welding should never be done in an atmosphere where such materials could possibly be present.

9.6 Burns. Eye protection, welding helmets, and protective clothing should always be worn when welding.

9.7 Further Information. It should be recognized that the above paragraphs give only a very brief coverage of the subject of safety in welding. Detailed coverage is available in the publications listed in Appendix D. The primary source is ANSI Z49.1, *Safety in Welding and Cutting*, available from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

Appendix A

Required Filler Metal per Joint for Carbon Steel Pipe

(This Appendix is not a part of ANSI/AWS D10.12, *Recommended Practices and Procedures for Welding Low Carbon Steel Pipe*, but is included for informational purposes only.)

The following tables give the weight of filler metal required for the typical joint illustrated. The values listed are weights of filler metal; they do not include allowances for stub loss or deposition efficiency of the process.

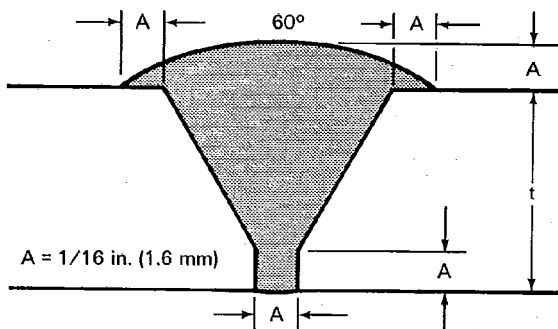


Figure A1 — Typical Joint

Table A1
Filler Metal Required for NPS 1-1/2
Pipe [OD = 1.900 in. (48 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.065	1.65	40	0.02	0.009
0.109	2.77		0.03	0.014
0.145	3.68		0.04	0.018

Table A2
Filler Metal Required for NPS 2
Pipe [OD = 2.375 in. (60 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.065	1.65	40	0.02	0.009
0.083	2.11		0.03	0.014
0.109	2.77		0.04	0.018
0.154	3.91		0.05	0.023
0.167	4.24		0.06	0.027
0.188	4.78		0.07	0.032

Table A3
Filler Metal Required for NPS 2-1/2
Pipe [OD = 2.875 in. (73 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.083	2.11	40	0.04	0.018
0.120	3.05		0.05	0.023
0.203	5.16		0.09	0.041
0.217	5.51		0.10	0.045

Table A4
Filler Metal Required for NPS 3
Pipe [OD = 3.500 in. (89 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.083	2.11	40	0.04	0.018
0.120	3.05		0.06	0.027
0.125	3.18		0.06	0.027
0.148	3.76		0.08	0.036
0.156	3.96		0.08	0.036
0.188	4.78		0.10	0.045
0.216	5.49		0.13	0.059
0.241	6.12		0.15	0.068
0.250	6.35		0.16	0.073
0.281	7.14		0.19	0.086

Table A5
Filler Metal Required for NPS 3-1/2
Pipe [OD = 4.0 in. (102 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.125	3.18	40	0.07	0.032
0.156	3.96		0.09	0.041
0.241	6.12		0.17	0.077
0.250	6.35		0.18	0.082
0.254	6.45		0.18	0.082
0.289	7.34		0.23	0.104

Table A6
Filler Metal Required for NPS 4
Pipe [OD = 4.5 in. (114 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.156	3.96	40	0.11	0.049
0.172	4.37		0.12	0.054
0.188	4.78		0.14	0.063
0.203	5.16		0.15	0.068
0.219	5.56		0.17	0.077
0.237	6.02		0.19	0.086
0.250	6.35		0.20	0.091
0.281	7.14	80	0.24	0.109
0.312	7.92		0.29	0.122
0.337	8.56		0.33	0.150
0.438	11.13	100	0.50	0.227

Table A7
Filler Metal Required for NPS 5
Pipe [OD = 5.5625 in. (141 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.156	3.96	40	0.13	0.059
0.188	4.78		0.17	0.077
0.219	5.56		0.21	0.095
0.258	6.55		0.27	0.122
0.281	7.14		0.30	0.136
0.312	7.92		0.36	0.163
0.344	8.74		0.42	0.190
0.375	9.52	80	0.48	0.218
0.500	12.70	120	0.79	0.358

Table A8
Filler Metal Required for NPS 6
Pipe [OD = 6.625 in. (168 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.156	3.96	40	0.16	0.073
0.172	4.37		0.18	0.082
0.188	4.78		0.20	0.091
0.203	5.16		0.22	0.100
0.219	5.56		0.25	0.113
0.250	6.35		0.30	0.136
0.280	7.11		0.36	0.163
0.312	7.92	80	0.43	0.195
0.344	8.73		0.50	0.227
0.375	9.53		0.58	0.263
0.432	10.97		0.74	0.336
0.500	12.70		0.95	0.431

Table A9
Filler Metal Required for NPS 8
Pipe [OD = 8.625 in. (219 mm)]

Wall Thickness		Schedule	Weight of Required Filler Metal	
in.	mm		lb	kg
0.188	4.78	20	0.26	0.118
0.203	5.16		0.29	0.132
0.219	5.56		0.33	0.150
0.250	6.35		0.40	0.181
0.277	7.04		0.47	0.213
0.312	7.92		0.56	0.254
0.322	8.18		0.59	0.268
0.344	8.74	40	0.66	0.299
0.375	9.53	60	0.76	0.345
0.406	10.31		0.87	0.395
0.438	11.13		1.00	0.454
0.500	12.70	80	1.25	0.567
0.562	14.27	100	1.54	0.698
0.594	15.09		1.70	0.771
0.625	15.88		1.87	0.848

Appendix B

Nick Break Test

(This Appendix is not a part of ANSI/AWS D10.12, *Recommended Practices and Procedures for Welding Low Carbon Steel Pipe*, but is included for informational purposes only.)

B1. Introduction

The nick break test is used to determine the welding conditions necessary to obtain sound groove or fillet welded joints in plate or pipe. It is often used to verify nondestructive testing results. American Petroleum Institute Standard 1104 is the only National Standard that incorporates the use of the nick break test as a required test for qualification of welding procedures and welders.

B2. Specimen Preparation

B2.1 For Butt Joints. Nick break test specimens shall be prepared by cutting the weld and the base metal as shown in Figure B1. The specimens shall be a minimum of 6 in. (152 mm) long and 1 in. (25.4 mm) wide and shall be notched approximately 1/8 in. (3.2 mm) deep with a hacksaw (or bandsaw) on each side at the center of the weld metal. The weld face reinforcement may be notched approximately 1/16 in. (1.6 mm) deep with a hacksaw at the center of the weld. All three notched areas shall be located as shown in Figure B1.

Pipe branch joints are tested by machine-cut or oxygen cut specimens from the crotch areas and 90 degrees from crotch (point) areas as shown in Figure B2. The specimens should be approximately 2 in. (51 mm) wide and 3 in. (76 mm) in length.

B2.2 For Fillet Welds. There are different types of nick break test specimens for evaluating fillet welded joints.

Fillet welded pipe joints (Figure B3) are tested by machine cut or oxygen cut specimens equally spaced around the circumference. The specimens should be at least 3 in. (76 mm) wide and 6 in. (152 mm) long.

Plate fillet welded joints are tested by machine-cut or oxygen-cut specimens from a lap joint design shown in Figure B4. The specimens should be approximately 3 in. (76 mm) wide and 6 in. (152 mm) long.

B3. Test Method

The specimen shall be broken by supporting the ends and striking one side in the center with a hammer.

One side should be hit twice with a hammer, then the specimen is turned 180 degrees, and the other side is hit twice. This procedure is continued until the specimen is broken. The fractured area shall be at least 3/4 in. (19 mm) wide.

B4. Test Requirements

The fracture surfaces shall be examined visually for evidence of weld discontinuities and evaluated in accordance with the acceptance standards in the applicable fabrication documents. Common weld discontinuities such as porosity, incomplete joint penetration, slag inclusions, incomplete fusion, and cracks can be detected.

B5. Test Fixture

The purpose of the test fixture is to hold or support the specimen ends while the notched weld area is hit with a hammer [weight 1 lb. to 8 lbs. (1/2 kg to 3 kg)] so that any weld discontinuities in the weld metal will propagate and fracture. The test fixture can be fabricated from 6 in. (152 mm) diameter pipe as shown in Figure B5. The 6 in. pipe is contoured to open up the area receiving the hammer blows and is notched at the other two ends to receive the nick break specimen.

A vise can be utilized to hold the specimen, as shown in Figure B6, but the disadvantages of this method are safety and speed. The broken specimen may hit someone or something when it breaks. Also the time to continually adjust the vise jaws may be too time consuming.

The fillet weld specimens described in B2.2 may be difficult to hold and break, particularly the crotch specimens. A blacksmith anvil may be utilized to break the

crotch specimens as shown in Figure B7. The specimen is held with tongs over a square hardy tool rest on the anvil, and the weld is hit with a hammer. This operation may require the use of two people.

B6. Interpretation of Results

The reading or interpretation of nick break specimens is more difficult than other destructive weld metal tests because the fractured surfaces must be evaluated to distinguish defective areas within the surrounding sound weld metal.

Weld metal discontinuities are stress risers; therefore, the weld metal fractures from the sawed notch through any discontinuities that are present. Some of the more common weld defects are described in the following paragraphs.

B6.1 Slag Inclusions. AWS defines slag inclusion as "non-metallic solid material entrapped in weld metal or between weld metal and base metal." The nick break fracture will travel from the cut notch to the slag inclusions and through the center of the inclusion. Therefore, the slag inclusion is visible on both fractured surfaces of the nick break.

The slag inclusion may have a black glass-like appearance or may have a smooth yellow colored contoured surface. The location of the slag inclusion is sometimes smooth because the slag has been dislodged by the force of the hammer blows breaking the specimen.

It is useful to match the two broken specimens together and rotate the specimen in good light. Observe both fractured specimens at the defect area. Sometimes it is easier to read one fracture surface than the other matching side. One side may be smooth while the other side may still have slag trapped on the fractured surface. Figure B8 shows an elongated slag inclusion.

B6.2 Porosity. AWS defines porosity as "cavity type discontinuities formed by gas entrapment during solidification." Porosity type defects may be spherical or cylindrical in shape and may be isolated or grouped in clusters. The key to the identification of porosity is the shape and the absence of non-metallic solid material. Porosity has a bright white or silvery appearance if it is not open to the atmosphere. Surface connected porosity usually has a black oxide appearance. The sound metal fracture surface has a gray color without voids. An example of porosity is shown in Figure B9.

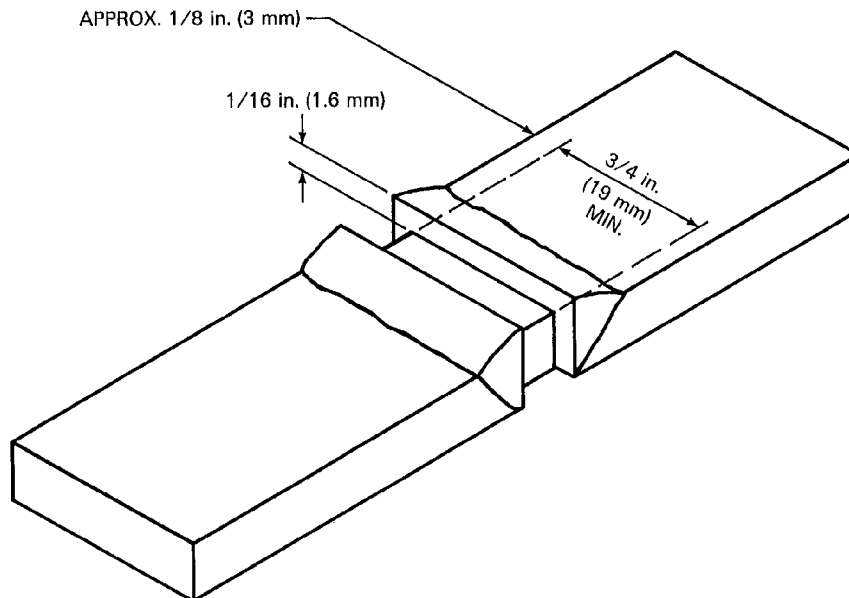


Figure B1 — Nick Break Test Specimen

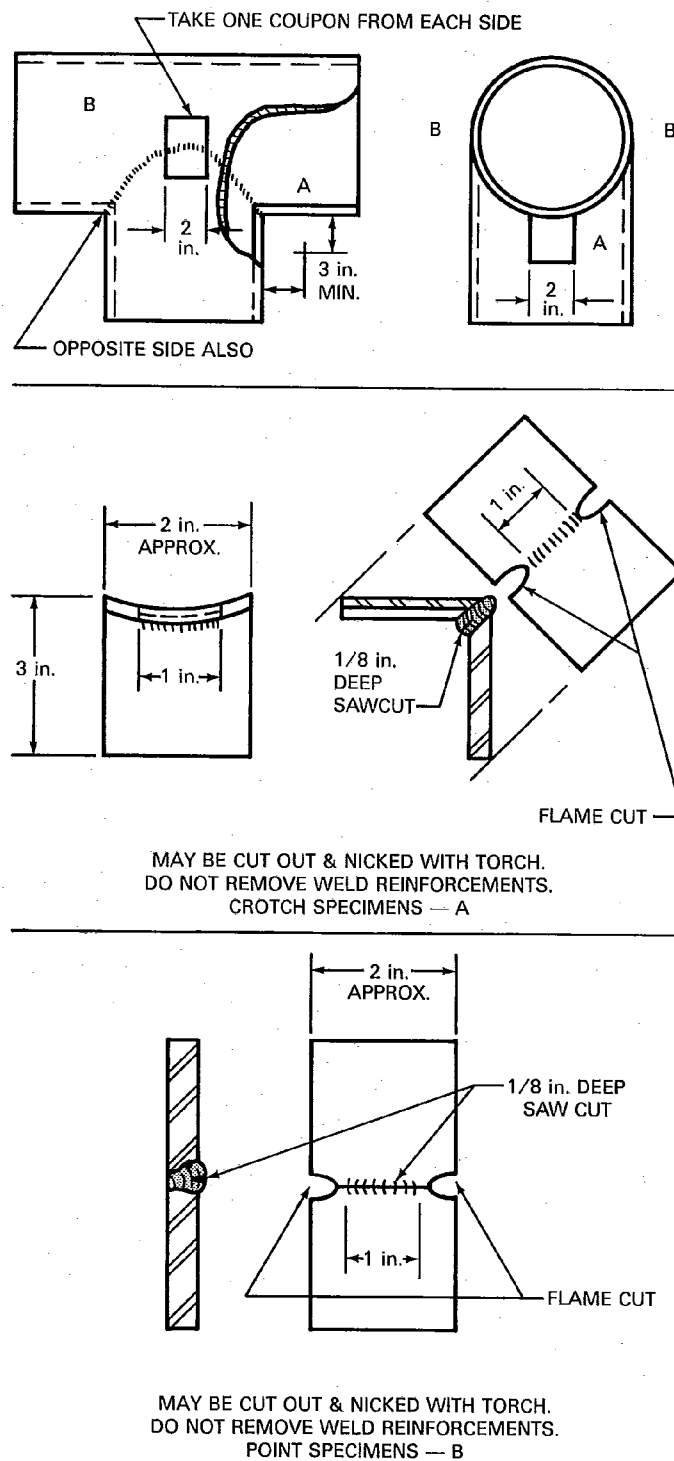
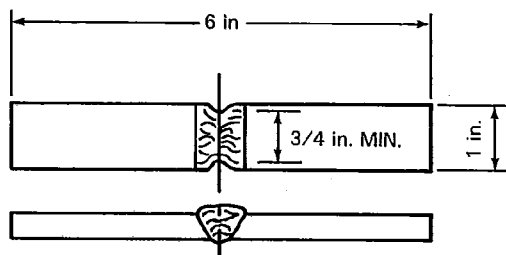


Figure B2 — Coupons for Nick Break Test of Branch Joint Connections

B6.3 Incomplete Fusion. AWS defines fusion as "the melting together of filler metal and base metal or of base metal only which results in coalescence." Incomplete fusion results from a solid surface not being melted (welded), commonly called "no weld" condition. Therefore, the shape of the defect depends on the weld joint design. If the joint design is a single-V, the base metal incomplete fusion would be planar in shape showing the area of the groove face which is not fused. In some cases, the grind marks on the original groove face can be identified. It is helpful to match the two broken nick



NOTE: NICK BREAK TEST MAY BE CUT OUT & NICKED WITH TORCH. DO NOT REMOVE WELD REINFORCEMENT.

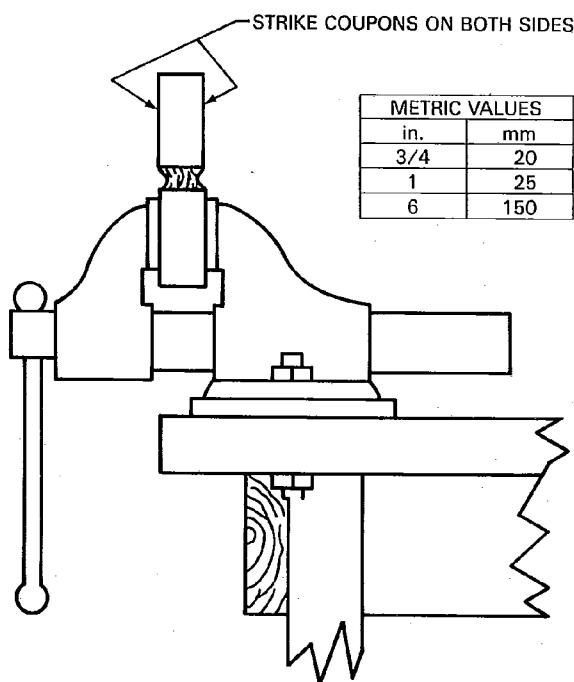


Figure B6 — Nick Break Tested Using Vise

break specimens together and identify the location of the first weld pass and the last, as well as the weld bevel area. If the defect is located on the groove face or between weld passes and is planar in shape, it could be incomplete fusion.

Sometimes the planar surface defect extends beyond the fractured surface showing a laminar type appearance. The incomplete fusion defects are shown in Figure B10. The incomplete fusion area will be brownish to black in color as compared to the gray weld metal that is clear of defects.

B6.4 Incomplete Joint Penetration. AWS defines joint penetration as "the depth a weld extends from its face into a joint, exclusive of reinforcement." The fracture path will extend from the sawed notch through sound

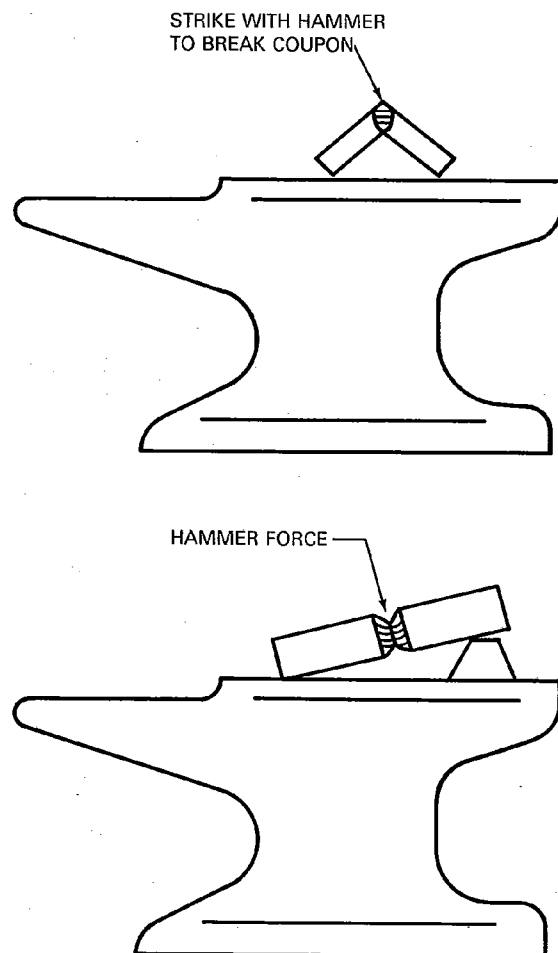


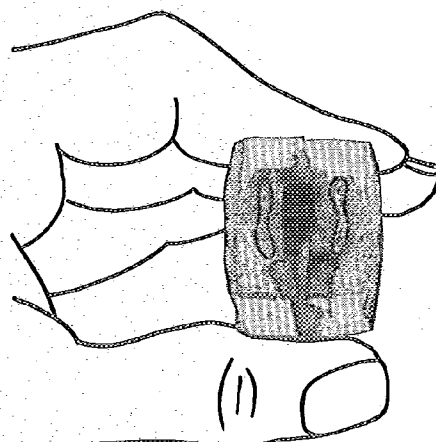
Figure B7 — Testing of Fillet Welded Coupons

weld metal to the incomplete joint penetration area. The defect is easy to identify in that it is always located at the weld root face and is planar in shape. An incomplete joint penetration can be detected in the nick break specimen before it is broken. The nick break specimen will

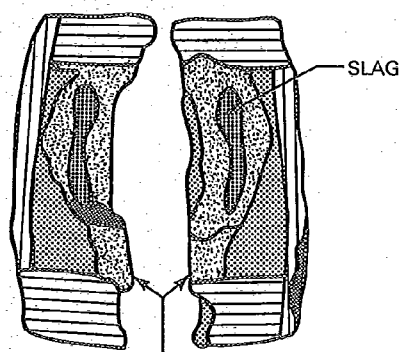
show how deep the incomplete joint penetration extends into the weld metal. The incomplete joint penetration is black to bluish in color. An example is shown in Figure B11.



I. D.



NICK BREAK

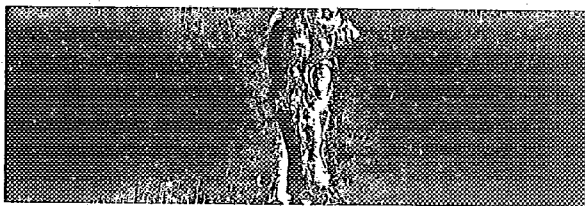


CRATER CRACK

Figure B8 — Illustration of Crack and Slag

B6.5 Cracks. AWS defines a crack as, "a fracture type discontinuity characterized by a sharp tip and high ratio of length and width to opening displacement." A crack is a discontinuity located in the weld metal or base metal. The crack fracture surface is flat and is silvery in color if the crack occurs after the welding is completed. If the

fractured surface of the crack shows a blue oxide color, the metal cracked before the final weld passes were completed. The crack surface was heated to the temper color range by later weld passes. A cracked weld nick fracture is shown in Figure B12.



I. D.

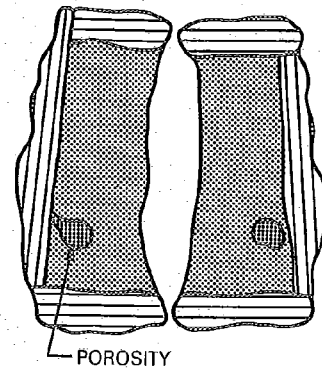
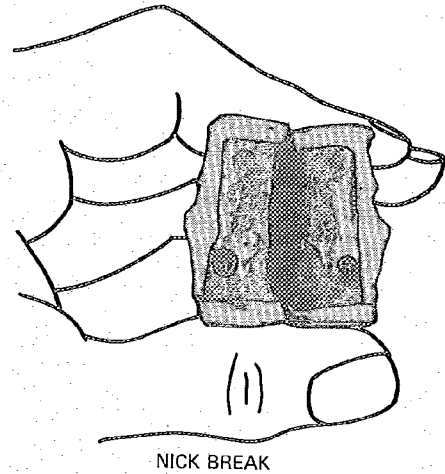


Figure B9 — Illustration of Porosity

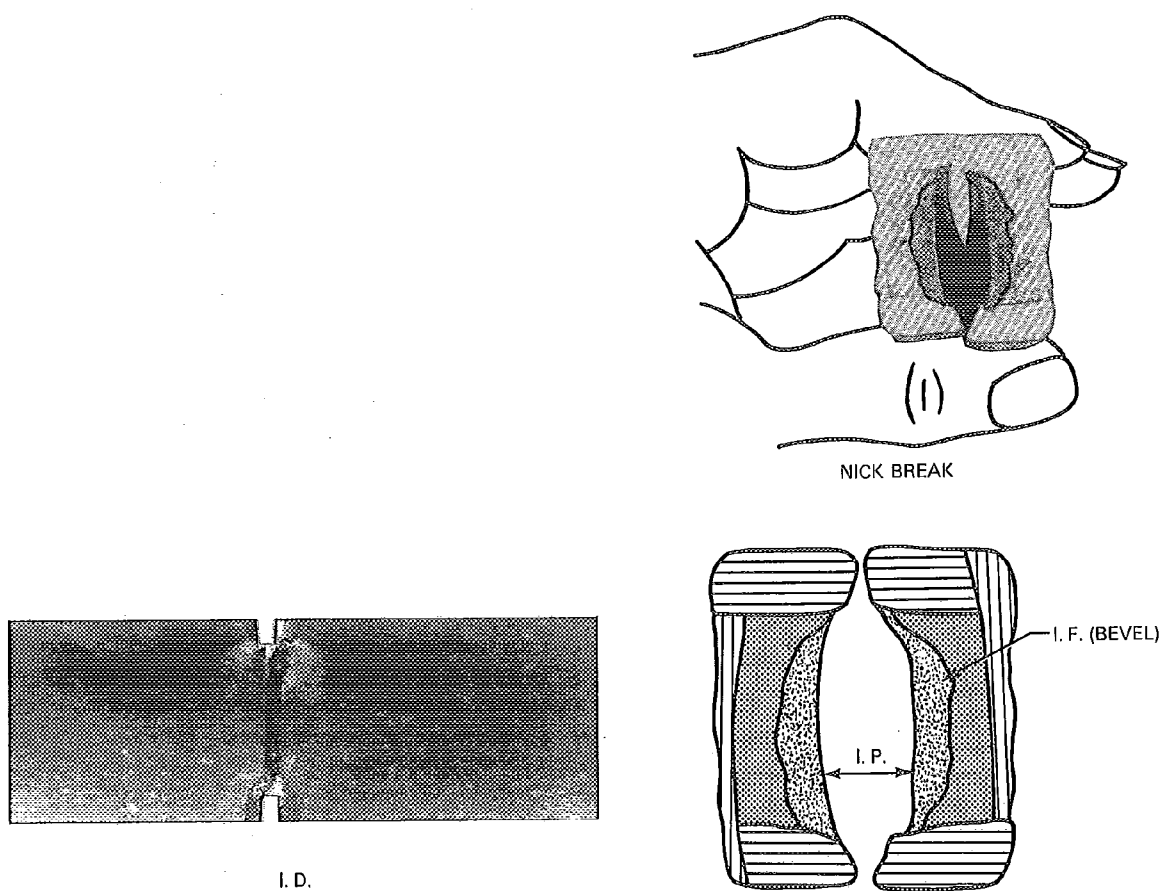


Figure B10 — Illustration of Incomplete Fusion

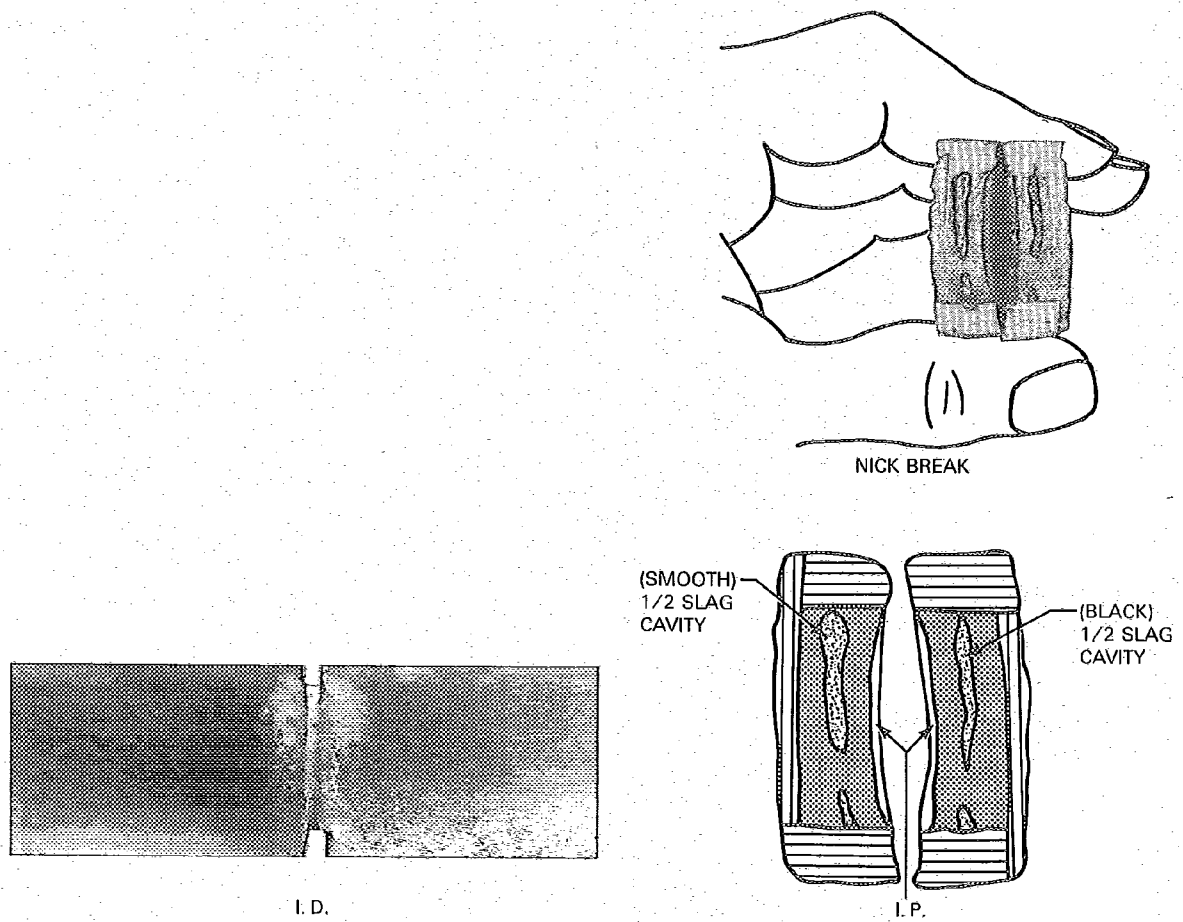
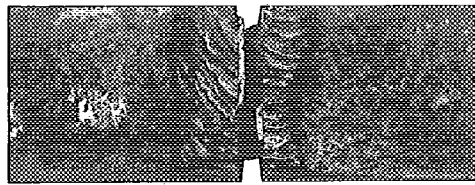
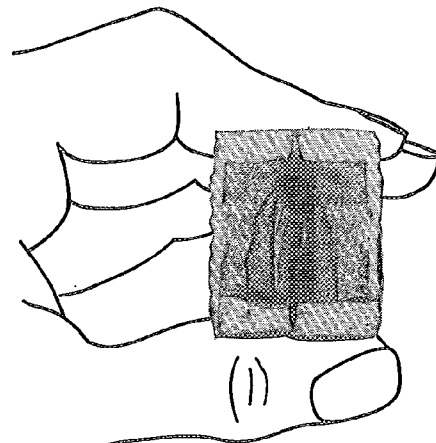


Figure B11 — Illustration of Incomplete Penetration

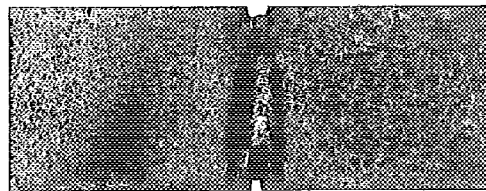
34



O. D.



NICK BREAK



I. D.

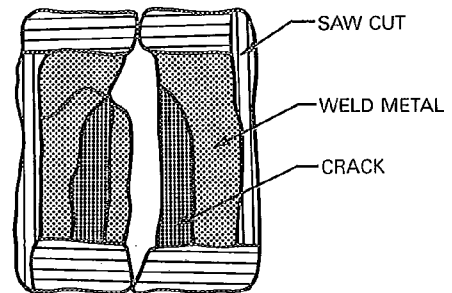


Figure B12 — Illustration of Crack Weld

Appendix C

Document List

(This Appendix is not part of ANSI/AWS D10.12, *Recommended Practices and Procedures for Welding Low Carbon Steel Pipe*, but is included for informational purposes only.)

The following is a complete list of the Standards prepared by the AWS Committee on Piping and Tubing:

- | | | | |
|-----------|---|------------|--|
| AWS D10.4 | Austenitic Chromium Nickel Stainless Steel Piping and Tubing, Recommended Practices for Welding | AWS D10.8 | Chromium-Molybdenum Steel Piping and Tubing, Recommended Practices for Welding |
| AWS D10.6 | Titanium Piping and Tubing, Recommended Practices for Gas Tungsten Arc Welding | AWS D10.9 | Qualification of Welding Procedures and Welders for Piping and Tubing, Specification for |
| AWS D10.7 | Aluminum and Aluminum Alloy Pipe, Recommended Practices for Gas Shielded Arc Welding | AWS D10.10 | Piping and Tubing, Local Heat Treatment of Welds in |
| | | AWS D10.11 | Root Pass Welding, of Pipe Without Backing, Recommended Practices for |
| | | AWS D10.12 | Low Carbon Steel Pipe, Recommended Practices and Procedures for Welding |

Appendix D

Safety and Health

(This Appendix is not a part of ANSI/AWS D10.12, *Recommended Practices and Procedures for Welding Low Carbon Steel Pipe*, but is included for informational purposes only.)

D1. General

The following pages present seven short articles (Fact Sheets) on Safety and Health topics which appeared in the *Welding Journal* during the period from August 1982 through January 1984.

Each article is followed by a list of reference material from which further detailed information may be obtained.

FACT SHEET NO. 1 — FUMES AND GASES

Many welding, cutting and allied processes produce fumes and gases which may be harmful to health. Fumes are solid particles which originate from welding consumables, the base metal, and any coatings present on the base metal. Gases are produced during the welding process or may be produced by the effects of process radiation on the surrounding environment. You — the reader — should acquaint yourself with the effects of these fumes and gases. The amount and composition of these fumes and gases depend upon the composition of the filler metal and base material, welding process, current level, arc length and other factors.

The possible effects of over-exposure range from irritation of eyes, skin, and respiratory system to more severe complications. Effects may occur immediately or at some later time. Fumes can cause symptoms such as nausea, headaches, dizziness, and metal fume fever. The possibility of more serious health effects exists when especially toxic materials are involved. In confined spaces gases might displace breathing air and cause asphyxiation.

Keep your head out of the fumes. Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and general area. In some cases, natural air movement will provide enough ventilation. Where ventilation may be questionable, air sampling should be used to determine if corrective measures should be applied.

Refer to the following sources for more detailed information on fumes and gases produced by the various welding processes:

1. The permissible exposure limits required by OSHA can be found at CFR Title 29, Chapter XVII, Part 1910. The OSHA General Industry Standards are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

2. The recommended threshold limit values for these fumes and gases may be found in *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment* published by the American Conference of Governmental Industrial Hygienists (ACGIH), 6500 Glenway Avenue, Building D-5, Cincinnati, OH 45211.

3. The results of an AWS-funded study are available in the report entitled *Fumes and Gases in the Welding Environment* available from the American Welding Society, P.O. Box 351040, Miami, FL 33135.

Source: August 1982 *Welding Journal*

FACT SHEET NO.2 — RADIATION

Welding, cutting and allied operations may produce radiant energy (radiation) harmful to health. You should acquaint yourself with the effects of this radiant energy.

Radiant energy may be ionizing (such as x-rays) or nonionizing (such as ultraviolet, visible light, or infrared). Radiation can produce a variety of effects such as skin burns and eye damage, depending on the radiant energy's wavelength and intensity, if excessive exposure occurs.

Ionizing Radiation

Ionizing radiation is produced by the electron beam welding process. It is ordinarily controlled within acceptable limits by use of suitable shielding enclosing the welding area.

Nonionizing Radiation

The intensity and wavelengths of nonionizing radiant energy produced depend on many factors such as the process, welding parameters, electrode and base metal composition, fluxes, and any coating or plating on the base material.

Some processes such as resistance welding and cold pressure welding ordinarily produce negligible quantities of radiant energy. However, most arc welding and cutting processes (except submerged arc when used properly), laser welding and torch welding, cutting, brazing, or soldering can produce quantities of nonionizing radiation such that precautionary measures are necessary.

Protection from possible harmful effects caused by nonionizing radiant energy from welding include the following measures.

1. Do not look at welding arc except through welding filter plates which meet the requirements of ANSI Z87.1 *Practice for Occupational and Educational Eye and Face Protection*, published by American National Standards Institute, 1430 Broadway, New York, NY 10018. Note: Transparent welding curtains are not intended as welding filter plates, but rather are intended to protect passersby from incidental exposure.
2. Protect exposed skin with adequate gloves and clothing as specified in ANSI Z49.1 *Safety in Welding and Cutting*, published by American Welding Society, P.O. Box 351040, Miami, FL 33135.
3. Beware of reflections from welding arcs, and protect all persons from intense reflections. Note: Paints using pigments of substantially zinc oxide or titanium dioxide have a low reflectance for ultraviolet radiation.
4. Avoid exposing passersby to welding operations by use of screens, curtains, or adequate distance from aisles, walkways, etc.
5. Safety glasses with UV protective side shields have been shown to provide some beneficial protection from ultraviolet radiation produced by welding arcs.

Ionizing Information Sources Include:

1. AWS F2.1-78, "*Recommended Safe Practices for Electron Beam Welding and Cutting*", available from American Welding Society, P.O. Box 351040, Miami, FL 33135.
2. Manufacturer's Product Information Literature.

Nonionizing Information Sources Include:

1. J.F. Hinrichs, "Project Committee on Radiation — Summary Report", *Welding Journal*, January 1978.
2. Nonionizing Radiation Protection Special Study No. 42-0053-77, *Evaluation of the Potential Retina Hazards from Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs* available from the National Technical Information Service, Springfield, Virginia. ADA-033768.

FACT SHEET NO. 2 — RADIATION**(Continued)**

3. Nonionizing Radiation Protection Special Study No. 42-0312-77, *Evaluation of the Potential Retina Hazards from Optical Radiation Generated by Electric Welding and Cutting Arc* available from the National Technical Information Service, Springfield, Virginia. ADA-043023.
4. C.E. Moss and W.E. Murray, "Optical Radiation Levels Produced in Gas Welding, Torch Brazing and Oxygen Cutting," *Welding Journal*, September 1979.
5. "Optical Radiation Levels Produced by Air-Carbon Arc Cutting Processes", *Welding Journal*, March 1980.
6. *Safe Use of Lasers*, Z136.1, published by ANSI — 1430 Broadway, New York, NY 10018.
7. ANSI Z49.1, *Safety in Welding and Cutting*, Z49.1 published by American Welding Society, P.O. Box 351040, Miami, FL 33135.
8. ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, published by American National Standards Institute, 1430 Broadway, New York, NY 10018.
9. C.E. Moss, "Optional Radiation Transmission Levels Through Transparent Welding Curtains," *Welding Journal*, March 1979.

Source: January 1983 *Welding Journal*

FACT SHEET NO. 3 — NOISE

Excessive noise is a known health hazard. Exposure to excessive noise can cause a loss of hearing. The loss of hearing can be either full or partial, and temporary or permanent. In welding, cutting, and allied operations, noise may result from the process, the power source, or other equipment. Air-carbon arc and plasma arc are examples of processes which are frequently noisy. Engines of engine-driven generators may also be quite noisy.

Excessive noise adversely affects hearing capability. This adverse effect in hearing capability may be temporary threshold shift from which the ears may recover if removed from the noise source. However, if a person is exposed to this same noise level for a longer time, then the loss of hearing may become permanent. The time required to develop permanent hearing loss depends upon factors such as individual susceptibility, noise level, and exposure duration. In addition, there is evidence that excessive noise affects other bodily functions and behavior.

A direct method to protect against excessive noise is to reduce the intensity of the source. Another method is to shield the source, but this has limitations. The acoustical characteristics of a room will also affect the level of noise. When engineering control methods fail to reduce the noise, personal protective devices such as ear muffs or ear plugs may be employed. Generally, these devices are only accepted when engineering controls are not fully effective.

The permissible noise exposure limits can be found in CFR Title 29, Chapter XVII, Part 1910. This is available from the U.S. Government Printing Office, Washington, D.C. 20402. Additional information may be found in *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment* published by the American Conference of Governmental Industrial Hygienists, 6500 Glenway Avenue., Bldg. D-5, Cincinnati, OH 45211.

A recommended method for measuring noise emitted by arc welding processes may be found in ANSI F6.1-78, *Method for Sound Level Measurement of Manual Arc Welding and Cutting Processes* published by American Welding Society, P.O. Box 351040, Miami, FL 33135.

Source: August 1982 *Welding Journal*

FACT SHEET NO. 4 — CHROMIUM AND NICKEL IN WELDING FUME

To protect against the effect of overexposure to chromium and nickel in welding fume, do not breathe fumes and gases. Keep your head out of the fumes. Use enough ventilation or exhaust at the arc or both to keep fumes and gases from your breathing zone and general area. In some cases, natural air movement will provide enough ventilation. Where ventilation may be questionable, air sampling should be used to determine if corrective measures should be applied.

Refer to the following sources for more detailed information on welding fumes which may contain chromium and nickel compounds.

1. NIOSH publication No. 76-129, *Criteria for a Recommended Standard-Occupational Exposure to Chromium (VI)*. This is available from: National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.
2. NIOSH publication No. 77-164, *Criteria for a Recommended Standard-Occupational Exposure to Inorganic Nickel*. This is available from: National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.
3. AWS report, *Fumes and Gases in the Welding Environment*, available from: American Welding Society, P.O. Box 351040, Miami, FL 33135.
4. American Conference of Governmental Industrial Hygienists publication *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment*, available from the American Conference of Governmental Industrial Hygienists (ACGIH), 6500 Glenway Ave., Bldg. D-5, Cincinnati, OH 45211.
5. OSHA Standard 29 CFR 1910, Section 1910.1000, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The following references include the specific precautionary methods which can be used to protect against exposure to fumes and gases:

1. ANSI Z49.1, *Safety in Welding and Cutting*, available from American National Standards Institute, 1430 Broadway, New York, NY 10018.
2. NIOSH publication No. 78-138, *Safety and Health in Arc Welding and Gas Welding and Cutting*, available from National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226. This is also available from the U.S. Government Printing Office.
3. OSHA Standard 29 CFR 1910, Section 1910.252, available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Source: November 1982 *Welding Journal*

FACT SHEET NO. 5 — ELECTRICAL HAZARDS

Electric shock can kill. However, it can be avoided. Do not touch live electrical parts. Read and understand the manufacturer's instructions and recommended safe practices. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are all sources of danger.

Ground all electrical equipment and the workpiece. The work lead is not a ground lead. It is used only to complete the welding circuit. A separate connection is required to ground the workpiece. Do not mistake the work lead for a ground connection.

Use the correct cable size, since sustained overloading will cause cable failure and result in possible electric shock or fire hazard. Make sure all electrical connections are tight, clean and dry. Poor connections can overheat and even melt. Further, they can produce dangerous arcs and sparks. Do not allow water, grease, or dirt to accumulate on plugs, sockets or electrical units. Moisture can conduct electricity. To prevent shock, keep the work area, equipment, and clothing dry at all times. Wear dry gloves, rubber soled shoes, or stand on a dry board or insulated platform.

Keep cables and connectors in good condition. Improper or worn electrical connections may set up conditions that could cause electrical shock or short circuits. Do not use worn, damaged or bare cables. Avoid open circuit voltage.

When several welders are working with arcs of different polarities, or when a number of alternating current machines are being used, the open circuit voltages can be additive. The added voltages increase the severity of the shock hazard.

In case of electric shock, turn off the power. If the rescuer must resort to pulling the victim from the live contact, use nonconducting materials. If the victim is not breathing, administer cardiopulmonary resuscitation (CPR) as soon as contact with the electrical source is broken. Call a physician and continue CPR until breathing has been restored, or until a physician has arrived. Treat electrical burns as thermal burns; that is, apply clean, cold (iced) compresses. Prevent contamination and cover with a clean, dry dressing. Call a physician.

Follow recognized safety standards such as ANSI Z49.1, *Safety in Welding and Cutting*, available from the American Welding Society, P.O. Box 351040, Miami, FL 33135. Also follow the National Electrical Code NFPA 70, available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

Source: December 1982 *Welding Journal*

FACT SHEET NO. 6 — FIRE PREVENTION

Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting, and allied processes. These can cause fire or explosion if precautionary measures are not used.

Many of the fires associated with welding, cutting, and allied processes have been caused by sparks which can travel up to 35 feet in a horizontal direction from the work area. Sparks can pass through or become lodged in cracks, clothing, pipe holes, and other small openings in floors or partitions. (Note: Sparks and molten metal can travel greater distances when falling.)

Typical combustible materials commonly involved in fires are floors, partitions, roofs, and building contents such as wood, paper, clothing, plastics, chemicals and flammable liquids and gases. Outdoors, the combustible materials involved are dry leaves, grass and brush. Explosions have occurred where welding or cutting have been performed in spaces containing flammable gases, vapors, liquids or dusts.

Remove any combustible material from the work area. Where possible, move the work to a location well away from combustible materials. If neither action is possible, protect combustibles with a cover of fire resistant material. Remove or make safe all combustible materials for a radius of 35 feet around the work area. All open doorways, windows, cracks and other openings should be covered or blocked with fire resistant material. If possible, enclose the work area with portable fire resistant screens. Protect combustible walls, ceilings, etc. from sparks and heat with fire resistant covers. If work is to be performed on a metal wall, ceiling, etc. prevent ignition of combustibles on the other side by moving the combustibles to a safe location. If this cannot be done, designate someone to serve as a fire watch, equipped with a fire extinguisher during the welding operation and for one-half hour after welding is completed. Welding or cutting should not be performed on material having a combustible coating or combustible internal structure, as in walls or ceilings, without an approved method for eliminating the hazard. Do not dispose of hot slag in containers holding combustible material. Keep fire extinguisher nearby. Make a thorough examination for evidence of fire. Remember that easily visible smoke or flame may not be present for some time after the fire has started.

Overloading and improper sizing can cause overheating of electrical equipment. Be sure all electrical equipment and wiring is installed properly with recommended circuit protection.

Be sure the work cable is connected to the work as close to the welding area as practical. Work cables connected to the building framework or other locations some distance from the welding area increase the possibility of the welding current passing through lifting chains, crane cables or other alternate circuits. This can create fire hazards or overheat lifting chains or cables until they fail.

Do not weld or cut in atmospheres containing dangerously reactive or flammable gases, vapors, liquids, or dust. Do not apply heat to a container that has held an unknown substance or a combustible material whose contents when heated can produce flammable or explosive vapors. Heat should not be applied to a workpiece covered by an unknown substance or whose coating can produce flammable, toxic or reactive vapors when heated. Adequate procedures should be developed and proper equipment used to do the job safely. Provide adequate ventilation in work area to prevent accumulation of flammable gases, vapors or dusts. Clean and purge containers before applying heat.

Closed containers, including castings, should be vented before preheating, welding or cutting. Venting will prevent the buildup of pressure and possible explosion due to the heating and the resultant expansion of gases.

Refer to the following sources for more detailed information on fire hazards from welding and cutting operations:

1. ANSI Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, P.O. Box 351040, Miami, FL 33135.
2. NFPA Standard 51B, *Cutting and Welding Processes*, National Fire Protection Association, Batterymarch, Quincy, MA 02269.

FACT SHEET NO. 6 — RADIATION**(Continued)**

3. Code of Federal Regulations, Title 29, Labor, Chapter XVII, Part 1910, OSHA General Industry Standards available from the U.S. Government Printing Office, Washington, DC 20402.

4. AWS F4.1, *Recommended Safe Practices for the Preparation for Welding and Cutting Containers that Have Held Hazardous Substances*, American Welding Society, P.O. Box 351040, Miami, FL 33135.

Source: August 1983 *Welding Journal*

FACT SHEET NO. 7 — BURN PROTECTION

Molten metal, sparks, slag, and hot work surfaces are produced by the welding, cutting, and allied processes. These can cause burns if precautionary measures are not used.

Workers should wear protective clothing made of fire resistant material. Do not wear pant cuffs or have open pockets or other places on clothing that can catch and retain molten metal or sparks. Wear high top shoes or leather leggings and fire resistant gloves. Pant legs should be worn over the outside of high top boots. Use helmets or hand shields that provide protection for the face, neck, and ears, and wear a head covering to protect the head. In addition, appropriate eye protection should be used. When welding overhead or in confined spaces, wear ear plugs to prevent weld spatter from entering the ear canal and goggles or equivalent to give added eye protection. Keep clothing free of grease and oil. Do not carry combustible materials in pockets. If any combustible substance has been spilled on clothing, change to clean fire resistant clothing before working with open arcs or flame. Use aprons, cape-sleeves, leggings, and shoulder covers and bibs designed for welding service. Where usually heavy welding or cutting is involved, sheet metal shields should be used for extra protection. Mechanization of highly hazardous processes or jobs should be considered.

Other personnel in the work area should be protected by the use of noncombustible screens or by the use of appropriate protection as described in the previous paragraph. Before leaving a work area, mark hot work pieces to alert other persons of this hazard. Do not attempt to repair or disconnect electrical equipment under load. Disconnecting under load produces arcing of the contacts and may cause burns and/or shocks. (Note: Burns can be caused by touching hot equipment such as electrode holders, tips and nozzles. Therefore, insulated gloves should be worn when these items are handles unless an adequate cooling period has been allowed before touching.)

Refer to the following sources for more detailed information on personal protection:

1. ANSI Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, P.O. Box 351040, Miami, FL 33135.
2. *Code of Federal Regulations*, Title 29 Labor, Chapter XVII, Part 1910, OSHA General Industry Standards available from the U.S. Government Printing Office, Washington, DC 20402.
3. ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, American National Standards Institute, 1430 Broadway, New York, NY 10018.
4. ANSI Z41.1, *Safety — Toe Footwear*, American National Standards Institute, 1430 Broadway, New York, NY 10018.

Source: September 1983 *Welding Journal*

FACT SHEET NO. 8 — MECHANICAL HAZARDS

Welding operations involve the use of mechanical equipment. The use of, or the proximity of, mechanical equipment can present hazards to the welder. Know and understand the proper and safe way to use all equipment. This knowledge includes portable power tools such as grinders, chippers, and power drills. Use the appropriate guards and personal protective equipment. Know and understand the safe limits and proper use of cranes, positioners, and other material handling equipment. Be aware of other operations in your area which can affect your safety. Do not permit unsafe acts by others. Other examples of safety considerations include the following:

1. Be aware of grinding wheel speed limitations.
2. Don't grind on the side of the wheel.
3. Foresee results of unexpected occurrences such as tools getting away, binding, grinding wheel breakage, and tools coming loose. Any tool that has become jammed or otherwise overstressed should be checked for damage before reuse. Foresee the reactive force from tools.
4. Wear proper hand protection. Watch out for sharp objects, pinch points, and moving objects.
5. Use face shields, safety glasses and goggles as appropriate.
6. Always wear safety glasses or goggles when using compressed air for cleaning procedures. Use only approved safety nozzles when compressed air is employed for cleaning.
7. Avoid wearing items that can be caught in machinery such as rings, necklaces, bracelets, long hair, loose clothing, etc.
8. Be sure that all tool guards are in place.
9. Use the right tool for the job.
10. Keep a firm grip on tools to assure they will not get away.
11. Do not overload or force a tool beyond its expected capabilities.
12. Stand aside from a new wheel when starting until it has been up to speed and then wait the recommended time. Any abnormality should be corrected before further use.
13. Get the feel of a tool before working in difficult places or applying force.
14. Be aware of others around you and make sure they cannot be harmed.
15. Watch out for the acts of others.
16. Be aware of the concept of zero energy. This means balance weights should beat the bottom of their travel, and spring pressure should be released in a safe manner. Be aware of zero energy concept in hydraulic systems and air systems. Be aware that when unbolting a component what will happen when the bolts are loosened or removed.
17. Follow lock-out procedures. Intermittent or bypassed interlocks create a definite hazard which requires special care and concern.

For additional information on the safe operation and guarding of mechanical equipment, refer to the manufactures' safe operating procedures for the equipment being used and the following publications:

1. ANSI Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, P.O. Box 351040, Miami, FL 33135.
2. NIOSH publication No. 78-138, *Safety and Health in Arc Welding and Gas Welding and Cutting*, Department of Health and Human Services, National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.

FACT SHEET NO. 8 — RADIATION**(Continued)**

3. *Code of Federal Regulations*, Title 29 Labor, Chapter XVII, Part 1910, OSHA General Industry Standards available from the U.S. Government Printing Office, Washington, D.C. 20402.

4. ANSI Z244.1, *Safety Requirements for the Lockout/Tagout of Energy Sources*, available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

FACT SHEET NO. 9 — TRIPPING AND FALLING

Trips and falls are a frequent cause of occupational injury and can result in serious injury or death. Welding, cutting and heating can take place in a variety of locations. Therefore, welders are exposed to the same tripping and falling hazards as those in other occupations. Proper precautions should be observed. Be alert to the conditions in the work area. Good housekeeping is essential to minimize tripping and falling. Actions to prevent falls include the use of safety belts and harnesses that are tied off, secured ladder, guardrails, proper scaffolding, and nets. Scaffolds and other climbing and elevating equipment must be installed and used properly. Do not carry items which obstruct your view. Proper protective wear, such as skid resistant soles on shoes, should be used when conditions warrant. Electrical equipment should be grounded and other precautions taken to prevent shock. Shock can cause a fall due to involuntary movements.

An alert, professional approach needs to be taken at all times. Do not tolerate horseplay, tossing tools to each other, bumping someone in a precarious position, or other distractions such as shouting when there is no reason to shout. All these acts can contribute to tripping and falling.

For further information on tripping and falling protection, refer to the following publications:

1. NIOSH publication No. 78-138, *Safety and Health in Arc Welding and Gas Welding and Cutting*, Department of Health and Human Service, National Institute of Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.
2. *Code of Federal Regulations*, Title 29, Labor, Chapter XVII, Part 1910, General Industry Standards, OSHA, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
3. ANSI Z49.1, *Safety in Welding and Cutting*, available from the American Welding Society, P.O. 351040, Miami, FL 33135.

Source: December 1983 *Welding Journal*

FACT SHEET NO. 10 — FALLING OBJECTS

Welding, cutting and heating operations are often performed in areas where falling objects may be present. Falling objects may seriously injure or kill. A safety net or equivalent placed below overhead work is recommended. Protect yourself and others by being aware of situations which might cause objects to fall from structures. Use toe boards with guardrails. Cover floor and wall openings. When working under overhead activities ensure that others are following safe work practices. Use a warning system to notify others of overhead work. Be certain that material being welded or cut is secured from falling. Wear approved head and foot protection. Remember, a welding hood or goggles restricts vision and may prevent taking the action necessary to avoid falling objects.

For further information on safe practices, refer to the following publications:

1. ANSI Z49.1, *Safety in Welding and Cutting*, available from the American Welding Society, P.O. Box 351040, Miami, FL 33135.
2. NIOSH publication No. 78-138, *Safety and Health in Arc Welding and Gas Welding and Cutting*, Department of Health and Human Services, National Institute for Occupational Safety and Health, 4676 Columbus Parkway, Cincinnati, OH 45226.
3. *Code of Federal Regulations*, Title 29, Labor, Chapter XVII, Part 1910, General Industry Standards, OSHA, which are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Source: January 1984 *Welding Journal*

FACT SHEET NO. 11 — CONFINED SPACES

Welding, cutting and heating operations can take place in a variety of locations. Some of these locations may be considered "confined spaces" having characteristics such as:

- (a) limited space, entry or exit, and/or
- (b) unfavorable ventilation which could contain or trap hazardous air contaminants and/or prevent replenishment of safe breathing air.

Typical confined spaces include small rooms, storage tanks, compartments of ships, process vessels, pits, silos, vats, degreasers, reactor vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines. They can also include even the unventilated corner of a room. Death and serious injury have resulted from welding operations in confined spaces due to fire, explosions, asphyxiation, and exposure to hazardous air contaminants.

1. Open all covers and secure them from closing.
2. Test the atmosphere of the confined space to assure
 - (a) The oxygen content is suitable for breathing.
 - (b) The atmosphere is not combustible or reactive.
 - (c) The atmosphere is not toxic.

Note: Special equipment and training is required to perform the above testing.

3. Isolate lines by capping or double valving and venting, if feasible. Make sure the vent is free of any obstruction and the valves do not leak.
4. Lock out all systems not required during welding, cutting, or heating.
5. Provide means for readily turning off power, gas, and other supplies from outside the confined space.

Verify that personnel designated by the responsible management person have begun the following actions to protect the occupants of a confined space and consulted the list of references for detailed information on implementation.

1. Ventilate and continually monitor the space to assure safe conditions.
 - (a) Make safe or remove any hazardous materials or materials which may become hazardous when heated or exposed to an arc.
 - (b) Continuously ventilate the space to assure that fumes and gases do not exceed safe exposure limits. These limits may be found in references #2 and #5. Use NIOSH/MSHA approved breathing apparatus when proper ventilation cannot be provided, or when the material being welded or heated has such toxicity as to require this type of apparatus either by code, instruction or good practice.

2. Keep nonessential equipment to a minimum. Do not permit required equipment to impede exit or rescue efforts.

Locate as much of the required equipment as possible outside the confined space.

3. Do not occupy a confined space unless someone, properly equipped and trained for rescue, is outside the confined space and in continuous communication with the occupants.
4. Provide means for turning off power, gases, and fuel from inside the confined space, if feasible, especially if outside turn-off means is not provided, feasible, or certain.

Refer to the following sources for more detailed information on confined welding space work:

1. NIOSH Publication No. 80-106, *Criteria for a Recommended Standard — Working in Confined Spaces*, Department of Health and Human Services, 4676 Columbia Parkway, Cincinnati, OH 45226.

FACT SHEET NO. 11 — CONFINED SPACES**(Continued)**

2. *Code of Federal Regulations*, Title 29 Labor, Chapter XVII, Part 1910, General Industry Standards, OSHA. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.
3. *Modern Safety and Health Technology*, De Reamer, Russel, John Wiley & Sons, New York, NY.
4. *Safety Requirements for Working in Tanks and Other Confined Spaces*, American National Standards Institute Standard Z117-1-1977, ANSI — 1430 Broadway, New York, New York 10018.
5. *Threshold Limit Values for Chemical Substances and Physical Agents in the Work Room Environment*, American Conference of Governmental Industrial Hygienists, 6500 Glenway Avenue, Bldg. D-5, Cincinnati, OH 45211.
6. ANSI Z86.1, *Commodity Specification for Air*, Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, Virginia.
7. ANSI Z49.1, *Safety in Welding and Cutting*, American Welding Society, P.O. Box 351040, Miami, FL 33135.