

Guide for Root Pass Welding of Pipe Without Backing



American Welding Society



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Guide for **Root Pass Welding of** **Pipe Without Backing**

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Prepared by the
American Welding Society (AWS) D10 Committee on Piping and Tubing

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This standard presents guidelines for welding the root pass of metal pipe butt joints with an open root or a consumable insert. Joint designs, assembly, consumable insert configurations, base metals, filler metals, and purging are discussed. Applicable arc welding processes and techniques are described.



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Foreword

This foreword is not part of AWS D10.11M/D10.11:2007, *Guide for Root Pass Welding of Pipe Without Backing*, but is included for informational purposes only.

The AWS D10 Committee on Piping and Tubing has been in existence since 1958, during which time a great deal of information on many aspects of pipe welding has been published. The first document on root pass welding and gas purging was approved in February 1980 and published as AWS D10.11-80, *Recommended Practices for Root Pass Welding and Gas Purging*.

This publication was intended to be a “how to” guide in the use of open root and consumable insert welding techniques for root pass welding of groove welds joining metal pipe. Joint designs, fitting techniques, consumable insert configurations, filler and base metal combinations, purging, and welding processes were discussed. This publication made no provision for joints which include backing rings.

The first edition of D10.11, published in 1980, was extensively revised and updated for the second edition which was published in 1987. The 1987 edition was reaffirmed in 1992. This latest edition, AWS D10.11M/D10.11:2006 *Guide for Root Pass Welding of Pipe Without Backing*, has been extensively revised and updated to provide the user with the latest available information.

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

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Guide for Root Pass Welding of Pipe Without Backing

1. Scope

This document describes how to make root weld passes on circumferential pipe groove welds using open root joints with filler metal additions, tightly-fitted joints without the addition of filler metal, and joints with consumable inserts. Joint designs, fitting techniques, consumable insert configurations, filler and base metal combinations, purging, and welding processes are discussed. This publication does not address joints made using backing rings and techniques applicable to mechanized orbital welding.

Safety and health issues and concerns are beyond the scope of this standard, and therefore are not fully addressed herein. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and applicable federal and state regulations. See Clauses 2 and 15 and Annex A for additional safety and health references.

1.1 Introduction. When the pipe system designer has determined that the use of backing rings is unacceptable due to service conditions and that complete joint penetration, including a continuous root side surface, is needed, butt joints may be made from one side using the groove designs and techniques described in this document. Although gas tungsten arc welding (GTAW) is most commonly used for precise control in root pass welding, shielded metal arc welding (SMAW) and gas metal arc welding (GMAW) are also widely used.

1.2 Units of Measure. This standard makes use of both the International System of Units (SI) and U.S. Customary Units. The latter are shown within brackets [] or in appropriate columns in tables and figures. The measurements may not be exact equivalents; therefore, each system must be used independently.

To identify nominal pipe sizes in both SI and U.S. Customary Units, the following designations are used:

1. DN (Diameter Nominal) is the SI designation.
2. NPS (Nominal Pipe Size) is the U.S. Customary designation.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this AWS standard. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

AWS Documents:¹

1. AWS A3.0, *Standard Welding Terms and Definitions*
2. AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
3. AWS A5.5/A5.5M, *Specification for Low Alloy Steel Electrodes for Shielded Metal Arc Welding*
4. AWS A5.12/A5.12M, *Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting*
5. AWS A5.30/A5.30M, *Specification for Consumable Inserts*
6. AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*
7. AWS C5.5/C5.5M, *Recommended Practices for Gas Tungsten Arc Welding*
8. AWS C5.10/C5.10M, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting*
9. AWS D10.4, *Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing*

¹ AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

10. AWS D10.6/D10.6M, *Recommended Practices for Gas Tungsten Arc Welding Titanium Piping and Tubing*
11. AWS D10.7M/D10.7, *Guide for the Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe*
12. AWS D10.8, *Recommended Practices for Welding Chromium-Molybdenum Steel Piping and Tubing*
13. AWS D10.12M/D10.12, *Guide for Welding Mild Carbon Steel Pipe*
14. AWS F1.1M, *Methods for Sampling Airborne Particulates Generated by Welding and Allied Processes*
15. AWS F1.3, *Sampling Strategy Guide for Evaluating Contaminates in the Welding Environment*
16. AWS F3.2M, *Ventilation Guide for Welding*
17. AWS F4.1, *Recommended Safe Practices for Preparation for Welding and Cutting of Containers and Piping*
18. AWS, *Safety and Health Fact Sheets*

American National Standards Institute (ANSI) Documents:²

1. ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes* (published by American Welding Society)
2. ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*

3. Terms and Definitions

Terms used in this document should be interpreted in accordance with AWS A3.0, *Standard Welding Terms and Definitions*, except for those not defined by that standard or where these terms require further definition to clarify their usage in this standard.

air-cooled torch. A nonstandard term for a gas cooled torch.

gas-cooled torch. A welding torch where the primary cooling medium of the torch is the flow of shielding gas.

keyhole welding. A standard term for the technique in which a concentrated heat source penetrates partially or completely through a workpiece, forming a hole (keyhole) at the leading edge of the weld pool. As the heat source progresses, the molten metal fills in behind the hole to form the weld bead.

² ANSI standards are published by the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036-7406.

nozzle weld. A nonstandard term for a weld between two pipes in which a hole is made in one pipe, and the other pipe is welded onto the first pipe at the hole at a predetermined angle to provide an alternate fluid path.

purge. A standard term for the introduction of a gas to remove contaminants from a system or provide backing during welding.

purge caps. Devices made of any suitable material that can be used to seal the ends of pipes for purging.

purge dams. Barriers made of any suitable material that can be placed inside pipes to contain the purge gases within the weld area. They may be water soluble or of some other type.

walking-the-cup. A technique for manipulating the torch when manually welding groove welds. With this technique, the electrode extension is adjusted to allow the proper arc length while the edge of the shielding gas nozzle rests on both groove faces of the joint. The torch is manipulated using a wrist motion in which the nozzle (cup) is rotated at a slight angle to the axis of the root opening, increased pressure is exerted on the leading groove face while the nozzle is rotated causing forward progression. Subsequently the nozzle is rotated and increased pressure is exerted on the opposing groove face. The nozzle is again rotated causing further forward progression. This motion is repeated so that the cup appears to be “walking” along the groove faces while the arc oscillates smoothly across the joint.

water-cooled torch. A welding torch where the primary cooling medium is the flow of water or other liquid coolant through the torch.

4. Preparations for Welding

4.1 Cleanliness. Cleanliness is important in all welding operations, but it is especially important in root pass welding. Cleaning should be done on the groove faces and a minimum of 25 mm [1 in] of the base metal on both the inside and outside surfaces of the pipe. All parts of the joint should be free of grease and oil, which should be removed by use of a suitable solvent. A suitable solvent is one that does not leave a residue and is not harmful to the welder or to the weldment. Most solvents require good ventilation, and many are flammable; therefore, proper precautions should be taken. Grinding or other mechanical means should be used to remove all paint, scale, rust, and dirt.

Grinding and cleaning operations should be done just prior to welding. After cleaning, the pipe should be handled so as to preserve cleanliness.

4.2 Purging

4.2.1 Purging Applications. An internal gas purge is required for stainless and nonferrous piping systems (except aluminum) if a smooth root surface is to be obtained. Carbon steels and low alloy steels containing less than 5% chromium can be welded using an open root groove without the use of an internal gas purge. However, purging of joints is highly recommended when the chromium content of the weld metal exceeds 2% or when using a consumable insert since purging reduces the occurrence of defects and the excessive oxidation of the resultant root bead. Inert backing gas should always be used for consumable inserts of any material other than carbon steel and when using Class 1 or 2 inserts.

It should be noted that purging will increase welding speed significantly when used during welding steels that do not normally require purging, such as carbon and low alloy steel.

4.2.2 Purging Gases. Argon is most often used for internal purging and may be safely used for all materials. Helium may also be used for all materials, although it is more expensive than argon. For some materials, nitrogen is a suitable purge gas. Nitrogen can be used at lower cost than argon for specific applications, but it should be demonstrated as suitable by testing prior to use in production.

The purging gases should be specified according to AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*, or AWS C5.10, *Recommended Practices for Shielding Gases for Welding and Plasma Arc Cutting*. Argon (AWS A5.32/A5.32M Class SG-A), helium (SG-He), and nitrogen (SG-N) should have a purity of better than 99.995% and have a dew point of -51°C [-67°F], or lower.

The purging procedures in this document are based on the use of argon as the purging gas. If nitrogen or helium is used, modifications to the purging procedure may be necessary because both gases are less dense than argon.

4.3 Purge Gas Containment

4.3.1 General Requirements and Some Containment Methods. Purging requires an entrance opening, through which the purge gas can enter the weld joint area at a controlled rate, and an exit opening, through which oxygen-containing gas can leave. Purge gas hoses should not be rubber or other porous material since these are able to aspirate air when high flow rates are used. The use of plastic, teflon or other nonporous hoses is recommended. For piping where both ends can be capped, properly sized wood or plastic disks can be taped to the pipe ends. Plastic caps that are used to prevent damage to pipe ends during shipment are commonly used as purge

caps. *Note: When welding austenitic stainless steel, the tape used should have a water-soluble fluoride, chloride and other halogen compound content below 50 ppm.*

The cap on the end of the assembly where the purge gas is introduced obviously requires a hole to receive the purge gas hose. The other cap requires a hole large enough to prevent build-up of gas pressure. Since air is less dense (lighter) than argon, the exit hole should be at a higher elevation to minimize the entrapment of air. All leak paths between the gas entrance and the exit hole should be blocked; branch pipes and other areas where air may be entrapped should also be vented. Purge caps of the type discussed here are most commonly used when a large subassembly or an entire system is purged.

4.3.2 Other Containment Methods

4.3.2.1 Other purge containment techniques can be used where purging the entire system is impractical. One of these is the use of water soluble paper and tape from which dams can be formed to contain the purge gas. These commercially available dams are in the form of water soluble paper disks that can be fastened inside the pipes on both sides of a weld joint prior to assembly. For small diameter piping or tubing, the soluble paper can be crumpled into a ball and stuffed into the pipe, thus eliminating the need for taping in place. After welding, the paper can be dissolved with a water rinse or left in to be dissolved during hydrostatic testing. Soluble dams are particularly advantageous because they reduce the volume which must be purged, and this represents a significant cost savings on large piping systems. More importantly, they do not have to be physically removed after welding.

4.3.2.2 When the weld will be postweld heat treated, cardboard disks held in place with masking tape are also suitable for use as purge dams since they will burn to ashes during heat treating.

4.3.2.3 Hinged collapsible or rubber gasketed disks of the types shown in Figure 1 can also be fabricated and fitted into piping. The purging techniques are similar to those used with soluble dams. At least one end of the pipe system must be left open for removal of the disks after welding.

4.3.2.4 Commercially available inflatable bladders can be used as localized purge containment devices when an opening is available to remove the bladders after welding. One bladder is inserted on each side of the joint to be welded. The bladders are inflated with purge gas or air, after which purging of the volume between the dams can proceed.

4.3.2.5 Purge dams should be far enough away from the groove to prevent burning, melting, or other

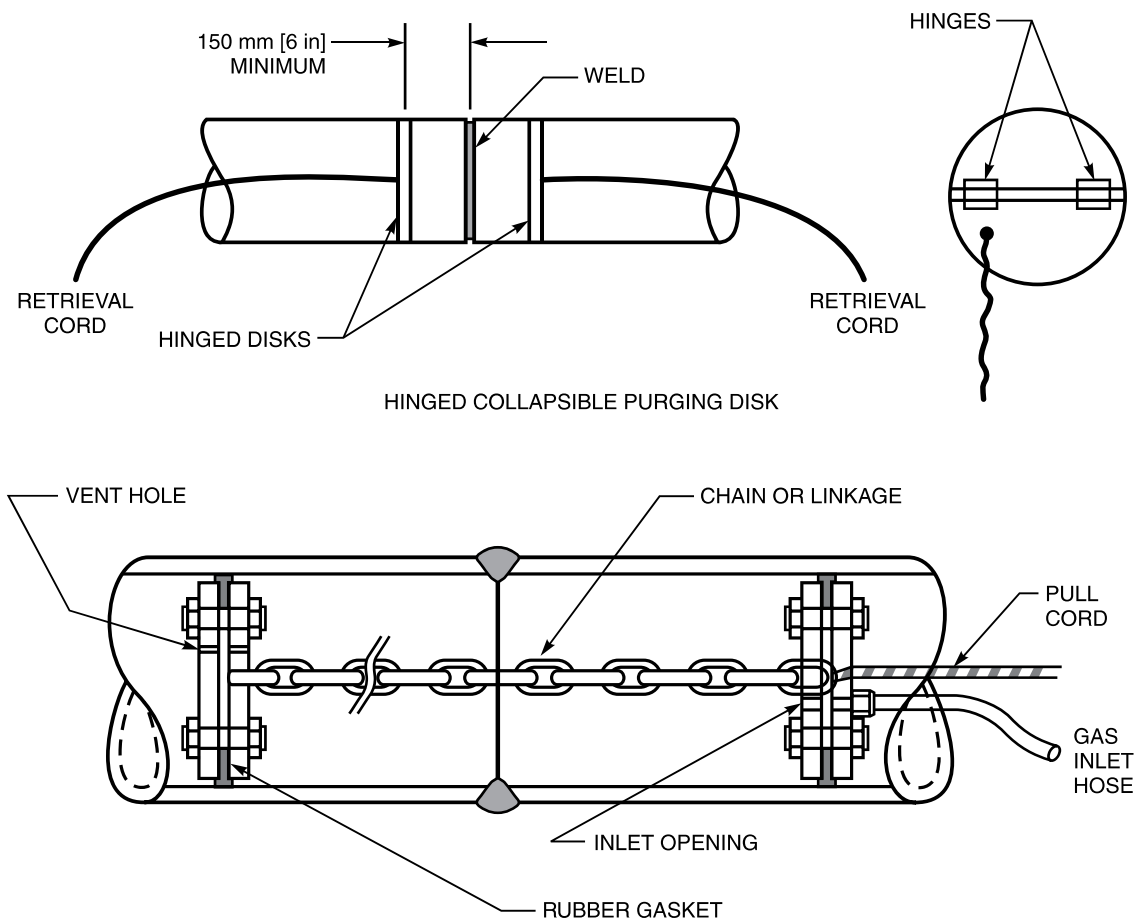


Figure 1—Purging Fixtures

damage to dams from the heat of welding. Typically, a distance of 150 mm [6 in] is adequate. Whenever preheating is used, this distance should be increased to keep the metal temperature at the dam no higher than 150°C [300°F]. However, some purge dam materials are available for service up to 300°C [570°F]. Extra consideration should be taken in the case of higher preheat temperatures and the method chosen for the heat source because the heat applied may be higher at the outer boundaries of the weld area than that at the weld groove; this would require additional spacing of the purge dams. Care should also be taken when removing dams that the weld area is cool enough to prevent heat damage to any bladders, rubber or plastic parts and to ensure that personnel do not burn their skin.

4.3.2.6 In addition to sealing branch connections and open ends of the pipe, it is also necessary to prevent the purging gas from escaping through the root opening

at the weld groove itself. This is commonly done by wrapping a single layer of tape around the outside of the joint. Tape contact with the groove face should be minimized, and all adhesive residues should be removed prior to depositing subsequent passes. Care should be taken to seal off all leak paths before introducing the purge gas into the piping system. All root openings in the system between the purge gas exit and entrance point should be taped closed.

5. Purging Prior to Welding

5.1 Step 1

5.1.1 Purging a piping system is a two-step operation. During the first step prior to tack welding, the purge gas is used to displace the air in the pipe at relatively high flow rates. This high flow rate is maintained until the gas inside the pipe reaches an acceptably low oxygen level.

5.1.2 The time required for the first stage of purging depends on the maximum oxygen level permitted by the welding procedure, the volume of the system being purged, and the purge gas flow rate. However, the relationship between purge gas flow rates and time is not linear; i.e., a system that can be purged in one hour at a flow rate of 25 L/min [50 ft³/h] will not be purged to the same degree in one-half hour if the flow rate is increased to 50 L/min [100 ft³/h]. An increase in the purge flow rate increases the turbulence within the system, which results in an increase in the mixing of air and the purge gas. This requires additional volume changes of gas within the pipe to achieve the desired level of oxygen removal.

5.2 Step 2

5.2.1 During the second stage, the purge gas flow rate is reduced so that the purge maintains a slight positive pressure on the inside of the pipe. This reduced gas flow is maintained to eliminate air re-entry into the pipe and minimize oxidation of the root surface while the root pass is welded.

5.2.2 At lower flow rates, less mixing occurs, and the heavier argon forces air upward and out of the pipe system. To take advantage of this, the argon gas inlet should be at the lowest point in the volume to be purged, and the gas outlet should be at the highest point. Higher purge flow rates will decrease the time required for preweld purging due to increased mixing, but increase the amount of gas required.

5.3 Purge Time Estimates

5.3.1 Generally, reasonable preweld flow rates and times can be derived from simple calculations of the system volume and by applying a time factor.

The time for one volume change of the system is found by dividing the volume by the gas flow rate. For example, the prepurge time for one volume change in a 6 m [20 ft] length of 450 DN [18 NPS] diameter pipe prepurged at 25 L/min [50 ft³/h] would be:

$$\text{Volume} = 0.785 \times (\text{pipe diameter})^2 \times \text{length}$$

$$\text{SI: } 0.785 \times (0.457 \text{ m})^2 \times 6 \text{ m} = 0.984 \text{ m}^3$$

$$\frac{0.984 \text{ m}^3 \times 1000 \text{ L/m}^3}{25 \text{ L/min}} = 39 \text{ minutes}$$

U.S. Customary Units:

$$0.785 \times (1.5 \text{ ft})^2 \times 20 \text{ ft} = 35.3 \text{ ft}^3$$

$$\frac{35.3 \text{ ft}^3}{50 \text{ ft}^3/\text{h}} = 0.71 \text{ hour or 42 minutes}$$

A general rule is to preweld purge at flow rates and times that will produce 5 to 6 volume changes. In the example above, one volume change occurs approximately every 40 minutes. Six changes would require 240 minutes or about 4 hours.

5.3.2 Figure 2 shows minimum preweld purge time in minutes per 300 mm [12 in] of pipe for varying pipe diameters at 25 L/min [50 ft³/h] flow rate. Suggested preweld purge times can be calculated quickly and easily from this graph.

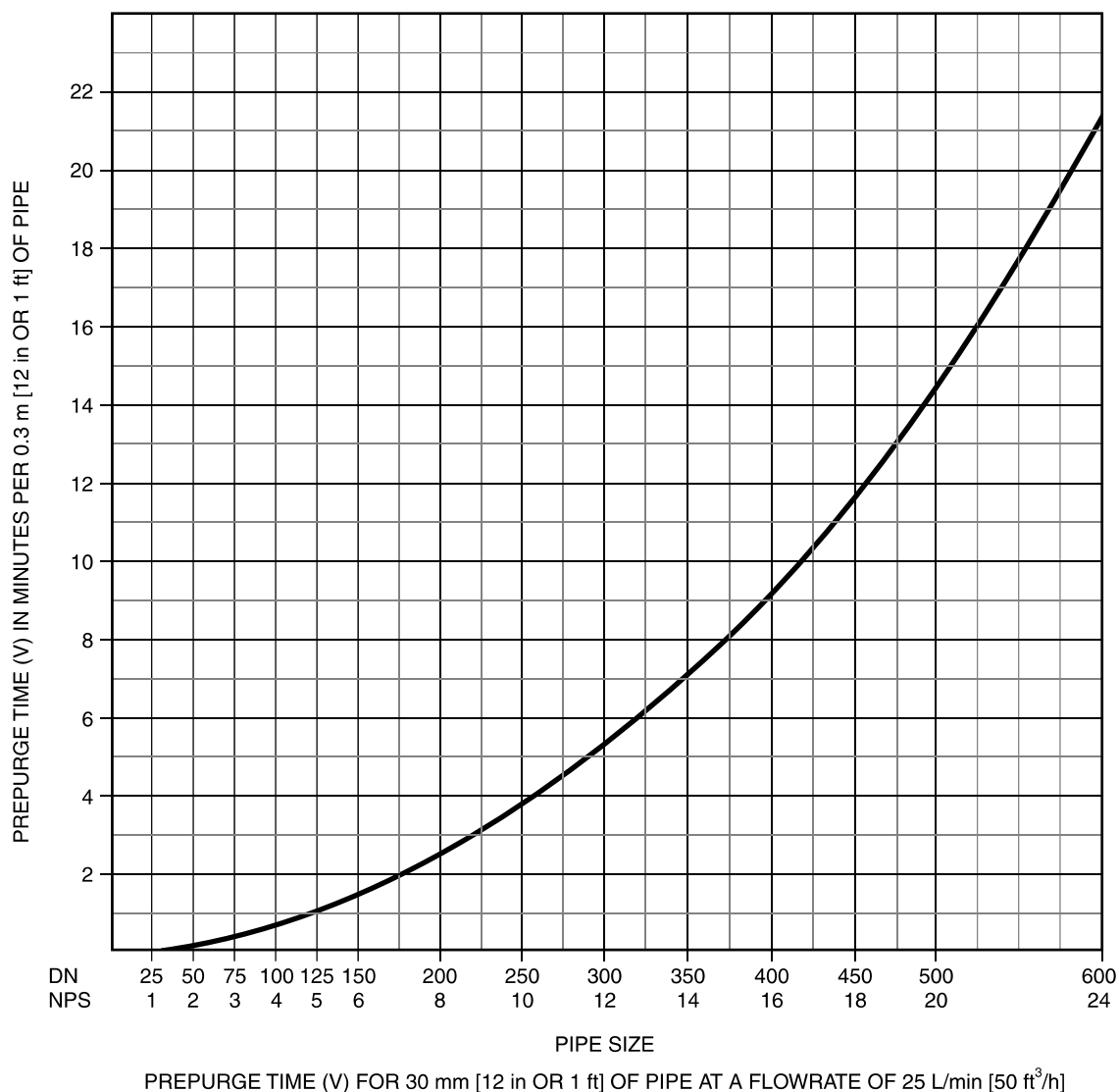
5.4 Recommended Residual Oxygen Levels

5.4.1 While the use of calculations and graphs such as those discussed above can simplify estimates for preweld purge applications, it is recommended that the residual oxygen level be measured prior to initiation of welding. This can be done quickly and easily with commercially available oxygen analyzers, which are small, durable, accurate and easy to use. The following oxygen limits are recommended:

- For carbon and low alloy steels 2% [20 000 ppm]
- For stainless steels 1/2% [5000 ppm]
- For nickel alloys 1/2% [5000 ppm]
- For titanium and zirconium alloys 1/4% [2500 ppm]

5.4.2 It should be noted that a lower oxygen level may be required to achieve cleaner root side surfaces. In addition, care should be taken that the pipe inside diameter is dry since moisture will contaminate the purge gas, and that the inside pipe surfaces near the weld are free of hydrocarbon contamination since hydrocarbons will burn and discolor the root side surface even in the presence of pure argon. An oxygen limit of 1/2% [5000 ppm] will create a higher level weld discoloration (heat-tint oxide) than is acceptable for services requiring high purity conditions (food, dairy, pharmaceutical, biotech, etc.) and maximum corrosion resistance in a number of environments. For such applications, a weld discoloration level guide such as shown in AWS D18.1, *Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications*, may be useful in establishing the required oxygen level.

5.4.3 It should also be noted that, in some shops, stainless steel welds are made using GMAW without backing gas. This is done using machine welding in which the pipe is rotated beneath a fixed torch and a sufficient supply of shielding gas is fed into the root opening to provide adequate shielding of the root surfaces to minimize oxidation.



To calculate the prepurge time for any length of weld (L), multiply the value obtained from the chart (V) by the length of the pipe divided by 0.3 m [12 in or 1 ft]:

Time = $V \times (L/0.3 \text{ m})$ for pipe lengths in meters [$V \times (L/12 \text{ in})$ for pipe lengths in inches, or $V \times (L/1 \text{ ft})$ for pipe lengths in feet]

Example: To calculate the time required for prepurging 60 m [200 ft] of DN 125 [NPS 5] pipe:

1. From the chart, the time required for prepurging 0.3 m [12 in or 1 ft] of DN 125 [NPS 5] pipe = 1 minute
2. $L/S = 60 \text{ m}/0.3 \text{ m} = 200$ or $200 \text{ ft}/1 \text{ ft} = 200$
3. Thus, $V \times L/S = 1 \text{ minute} \times 200 = 200 \text{ minutes}$ or 3 hours and 20 minutes

Note: 1 L/min = 2.1 ft³/hr.

Figure 2—Preweld Purge Time for 300 mm [12 in] Length of Pipe of Various Sizes

6. Purging During Welding

6.1 Flow Rate Reduction. Once the required oxygen level inside the pipe has been achieved, the flow rate of the entering purge gas should be reduced before root pass welding begins to eliminate excessive pressure on the inside of the pipe. Joint tape can be removed as welding progresses (see 8.3). Excessive pressure will cause unacceptable root surface concavity or holes through the root bead. The proper purge flow rate during welding is one that is barely detectable at the gas exit port.

6.2 Flow Rates for Open-Root Welds and for Joints with Consumable Inserts

6.2.1 With open root welds, flow rates of 4 L/min to 6 L/min [8 ft³/h to 12 ft³/h] are typical. It is usually necessary to reduce the flow rate as the root is closed to prevent blowout of the weld metal. Higher flow rates will be required for open groove welds. For small diameter piping or tubing, it may be necessary to reduce flow rates below the values recommended above.

6.2.2 With consumable inserts, the unfused insert seals the root and prevents the escape of gas, and flow rates of approximately 2 L/min to 3 L/min [4 ft³/h to 6 ft³/h] are recommended.

6.3 Purge Maintenance for Subsequent Weld Layers. It is normal practice to maintain the purge for the second and third layers of weld deposit to minimize internal oxidation during reheating of the root pass. This is particularly important when welding reactive metals, such as titanium (see AWS D10.6/D10.6M).

7. Tack Welding

7.1 Preparation and Spacing. Tack welding should be done with care because the tack welds normally become part of the final weld. For this reason, tack welding is not usually performed until preweld purging (when purging is used) has been completed. At least four tack welds should be made at 90° intervals around the pipe. For 250 DN [10 NPS] and larger diameters, tacks should be made at least every 150 mm [6 in] around the pipe, and they should be 20 mm to 25 mm [0.75 in to 1.0 in] long to resist weld shrinkage forces which will try to pull the root closed during root pass welding. When welding stainless steel (see AWS D10.4 and D10.8), tacks should be spaced more closely.

7.2 Inspection, Removal of Discrepancies, and Cleaning. Tack welds should be cleaned prior to root pass welding. For open root welds, both ends of each tack weld should be carefully ground and tapered to simplify complete fusion of the remainder of the root face during

root pass welding. When using an open root, the root side of tack welds should be examined by shining a flashlight through the root opening and looking at the root side of the tack through the root opening. If the root pass is not made immediately after tack welding, the joint should be covered with a clean rag, tape or other suitable covering to maintain its cleanliness. To prevent misalignment, tack welds should be checked by the welder as he or she welds around the joint to be sure that they remain intact. Cracked tack welds should be carefully ground out before proceeding.

8. Welding Using GTAW Without Consumable Inserts

8.1 General. The highest quality root welds are usually obtained by using the GTAW process. The following factors should be considered when welding with this process.

8.2 Tungsten Electrode Type and Configuration

8.2.1 For direct current electrode negative (DCEN), 2% or 1% thoriated tungsten electrodes (see AWS A5.12/A5.12M, *Specification for Tungsten and Tungsten Alloy Electrodes for Arc Welding and Cutting*, EWTh-2 or EWTh-1) have traditionally been used, but other compositions such as lanthanated and ceriated are also available and work well. During grinding of thoriated tungsten electrodes, radioactive dust is created, posing the potential hazard of internal radiation exposure by inhalation or ingestion unless care is taken to control the dust (see AWS Safety and Health Fact Sheet No. 27, *Thoriated Tungsten Electrodes*). The end of the electrode should be tapered at about 3:1 to a point, and then the point should be ground off to form a flat face. Although one can weld using a pointed tungsten electrode, the point will frequently melt off and contaminate the weld pool. The flat face on the tungsten electrode should be approximately 0.5 mm [0.020 in] for a 2.4 mm or 3.2 mm [3/32 in or 1/8 in] diameter size electrode. For a 1.5 mm [1/16 in] diameter tungsten electrode, the flat face can be somewhat smaller.

8.2.2 When welding aluminum, AC current and pure tungsten electrodes are usually used. Rather than the tapered and truncated electrode geometry described above, a balled end is typically used. The balled end is produced by striking an arc on a metal plate and increasing the current until a ball forms at the electrode tip. (See AWS C5.5/C5.5M, *Recommended Practices for Gas Tungsten Arc Welding*, for additional details on electrode preparation.)

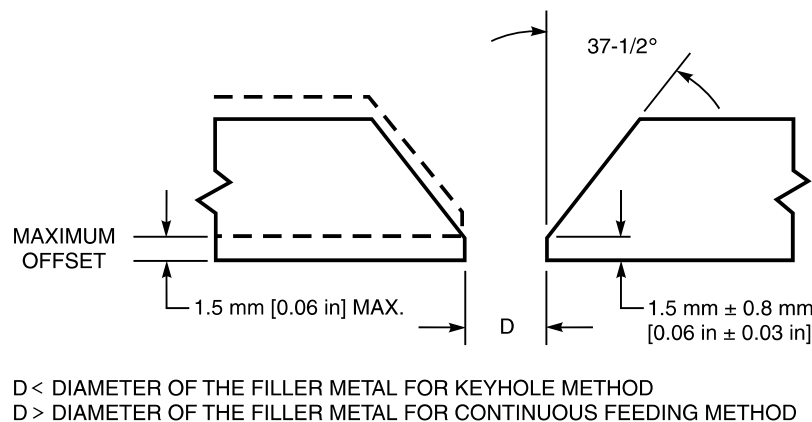


Figure 3—Typical Open Root Joint Design

8.3 Joint Design

8.3.1 Open Root Joint. A typical groove design for open root welding is shown in Figure 3. Internal alignment (1.5 mm [0.06 in] maximum) is very important. It is usually necessary to counterbore or grind heavy-walled pipe to achieve the correct internal surface match. Weld metal can also be added to the inside surface of the pipe prior to machining or grinding to achieve the required internal alignment. The open root groove design may be used for both butt welds and nozzle welds.

8.3.2 Root Opening—Open Root Groove. The amount of root opening is determined by the method to be used in adding filler metal. A root opening equal to or slightly smaller than the filler metal wire diameter is used with the keyhole technique. In this technique, the filler metal is introduced intermittently as necessary to fill the gap.

A larger opening is used with the continuous feed technique in which the filler metal is always in the opening and can be melted continuously if desired. Welders who prefer the continuous method should also be able to use the keyhole technique, since it is sometimes required when weld shrinkage decreases the root opening as the root pass is made. In either case, the filler metal can be used as a spacer or guide in determining the opening prior to tack welding. However, it should be noted that shrinkage during solidification and cooling of any tack weld will reduce this spacing. The amount of shrinkage varies with the coefficient of expansion of both the base and filler metals and with changes in total heat input. For example, a stainless steel tack weld will shrink more than a carbon steel tack weld made under similar conditions

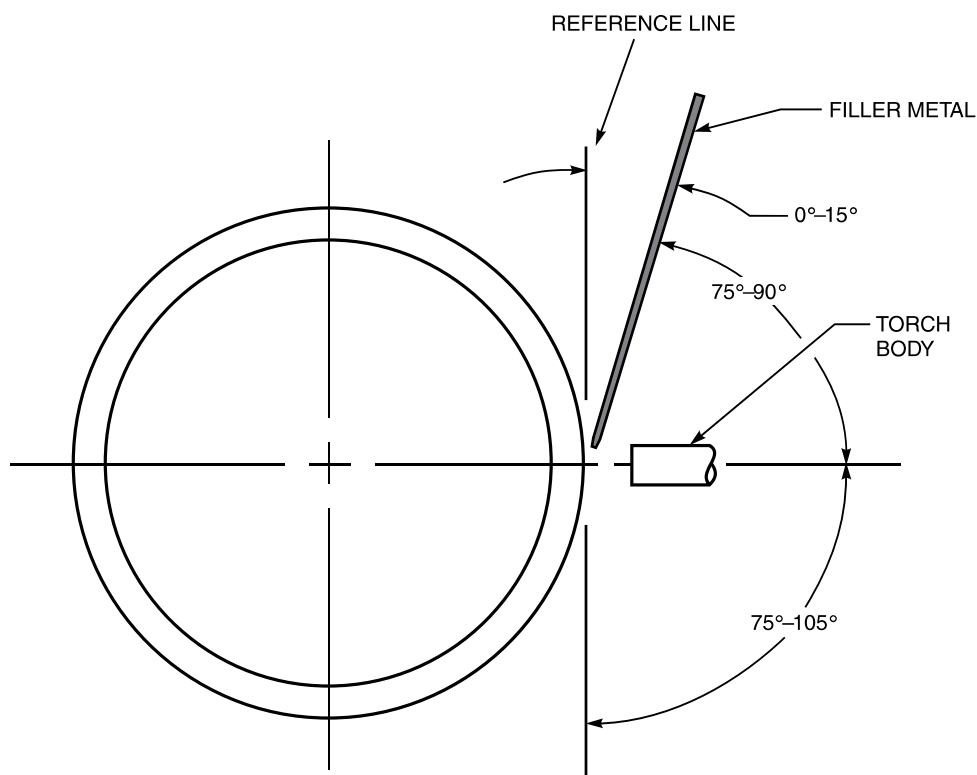
since austenitic stainless steel has a larger coefficient of thermal expansion than ferritic steel.

8.4 Purge Containment. The weld opening should be covered with tape on the outside surface of the pipe to prevent the escape of the purge gas. During the welding of the root pass, the welder should peel the tape off the joint in short increments just prior to welding that increment. Any tape residue should be removed prior to applying the reinforcement or cap pass.

8.5 Arc Initiation. High frequency starting is used for easiest arc ignition. However, caution is advised since high-frequency emissions may interfere with electronic components in the vicinity of or attached to the workpiece, and may be prohibited at some work sites. Where high frequency is not available and the touch-starting method is used, the arc should always be initiated against a groove face or a striking bar, not against the base metal outside the groove. The arc should then be moved into the root and held stationary until the root faces just begin to melt.

8.6 Welding Technique—Open Root Groove. When the arc is established, the filler metal should be introduced to the leading edge of the arc forming the weld pool. The filler metal may then be fed into the pool as described in the following sections. The basic angular relationships between the workpieces, filler metal, and torch are shown in Figure 4; other relationships may be developed for specific situations. The method of adding filler metal depends upon which of two following techniques is used.

8.6.1 Keyhole Method. The wire filler metal should always rest on the joint root ahead of the leading edge of



Note: Reference line is tangent to pipe surface.

Figure 4—Angular Relations Between Pipe, Torch, and Filler Metal for Open Root Welding

the weld pool. When additional filler metal is required, the wire filler metal is moved back into the leading edge of the weld pool, and a segment is melted off. The wire filler metal is then retracted while the pool is moved between the groove faces with an oscillating motion. With practice, welders can learn to “dab” wire into the pool and then retract the end of the wire far enough from the leading edge of the arc to prevent melting, but yet remain within the inert gas shield to prevent oxidation of the wire tip. Should the end of the filler metal become contaminated or oxidized, that end should be cut off or abrasively cleaned before further welding.

8.6.2 Continuous Feeding of Filler Metal. This technique allows continuous feeding of the wire into the molten weld pool. The filler metal wire fits in between the root faces and is fed continuously into the weld pool. The filler metal wire is melted as the arc passes over it keeping the pool width to a minimum and still achieving complete penetration. The amount of root reinforcement varies with the amount of filler metal that is fed into the pool. The root reinforcement on the inside pipe surface

should not be larger than 1.5 mm [0.06 in]. Excess root reinforcement is a detriment and should be avoided, the same as excess reinforcement on the face of the weld. Where a joint is being made in close quarters, a helpful technique is to feed the wire filler metal through the root opening into the pool, adding it from the root side surface instead of adding it from the more conventional face side surface (see Figure 5).

8.6.3 Walking-the-Cup Method. Similar to the key-hole method, the filler metal should always rest on the joint root, however it is rarely moved towards or away from the weld pool. Rather it is held stationary and the torch cup (nozzle) is rotated or “walked” in forward progressive fashion, consuming the filler metal similar to a consumable insert. Occasionally the filler metal may be moved towards the weld pool when a void or gouge in the bevel edge is encountered. Alternately, the filler metal may be moved away from the weld pool when shrinkage has occurred or poor tacking techniques were used, which cause the root opening to be significantly less than the width of the electrode.

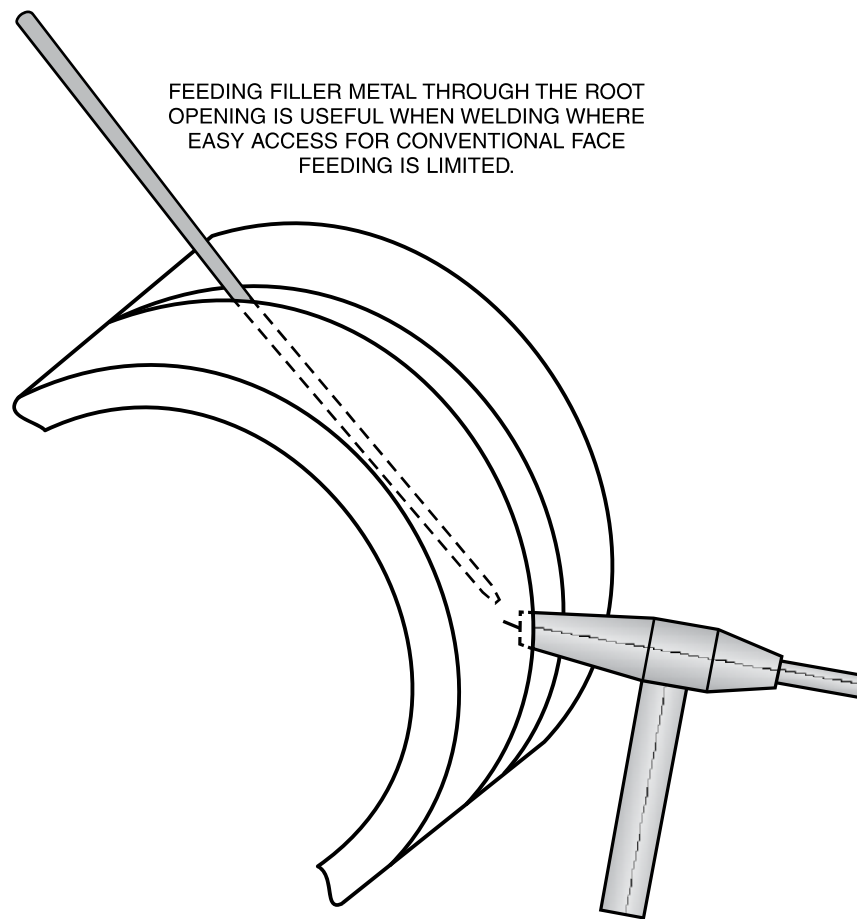
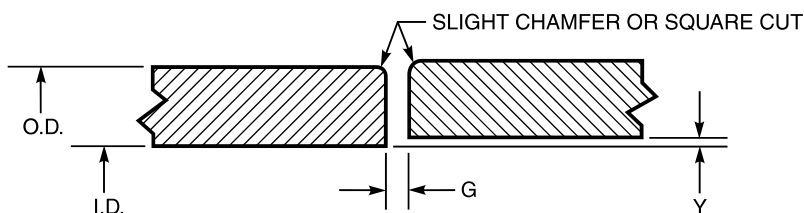
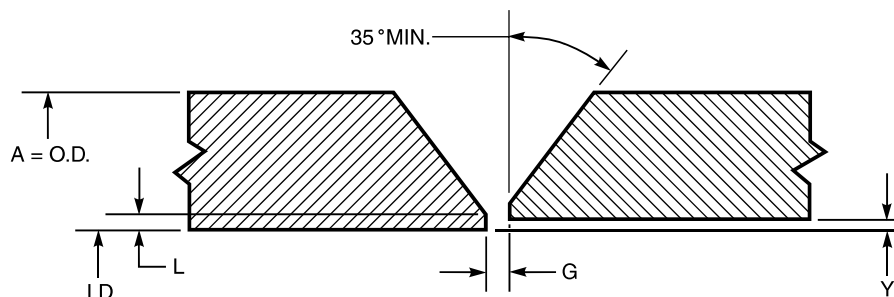
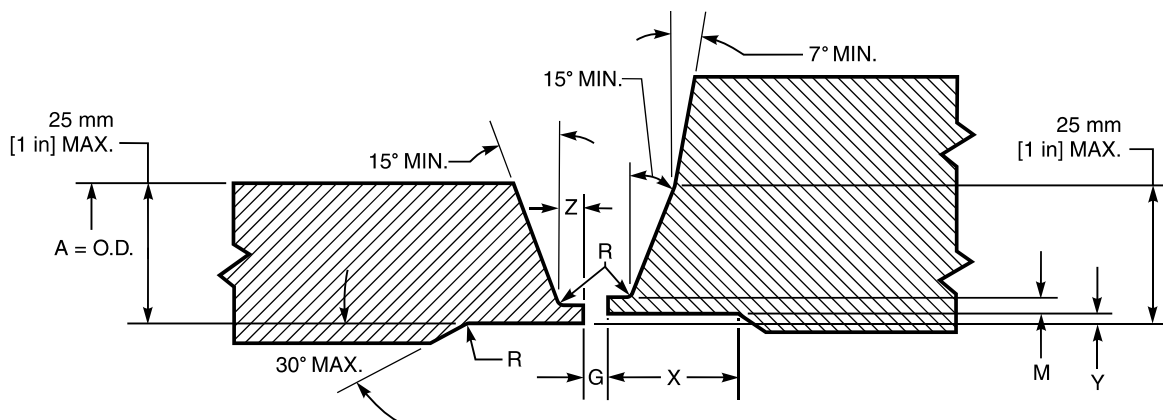


Figure 5—Feeding Filler Metal Through the Root Opening in Limited Access Areas

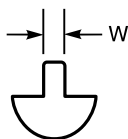
8.7 Welding Technique—Groove with Zero Root Opening. Groove Types A and C, shown in Figure 6, may be used with a root opening of zero (“tight butt”) for welding stainless steels and silicon killed carbon steels as an alternative to adding filler metal or using consumable inserts. When this technique is used, the root opening G should not exceed 0.8 mm [0.03 in]. With Groove Type C, the arc should be located over the joint root and held stationary until the weld pool width is two-thirds the width of the bottom of the groove. The torch should then be moved smoothly around the joint, holding the pool width constant. Filler metal should be added only where the root opening is greater than zero. For Groove Type C, the root pass weld should be made using a stringer bead technique and the minimum pool width possible; the further up the radius of the end preparation the weld pool extends, the more root concavity will be formed. Care should be taken to keep the tungsten electrode centered over the joint root.

8.8 Welding Pipe in Various Positions. Welding should be done in the upward direction from all orientations, from when the pipe is in the horizontal fixed position (5G) to within 20° of vertical. (Refer to AWS A3.0, *Standard Welding Terms and Definitions*, for welding positions.) This normally requires starting the weld at the lowest point of the joint and proceeding uphill from that point. Other starting points can also be used to control shrinkage distortion. When the pipe axis is within 20° of vertical, welding may start at any location around the groove and proceed using the forehand welding technique in either direction.

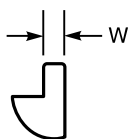
8.9 Stop and Start Areas. As the welder progresses around the pipe, he or she may have to stop welding for repositioning. A foot control or a manual remote current is the best way to gradually reduce the current level prior to extinguishing the arc. If such equipment is not available, the arc should be slowly moved up the groove face

**GROOVE TYPE A—FOR WALLS OF LESS THAN 5 mm [0.20 in] THICK****GROOVE TYPE B—FOR WALLS 5 mm TO 13 mm [0.20 in TO 0.5 in] THICK****GROOVE TYPE C—FOR WALLS OVER 13 mm [0.5 in] THICK**

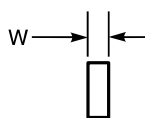
Legend	Groove Type	Joint Dimensions and Tolerances for Use with Consumable Insert Classes		
		Classes 1 and 4	Class 2	Classes 3 and 5
G	A, B, C	W +0.8 mm [0.03 in] MAX.	W +0.8 mm [0.03 in] MAX.	W +0.4 mm [0.02 in] MAX.
Y	A	0 to 0.8 mm [0.03 in] MAX.	1.5 mm [0.06 in] MAX.	0 mm to 0.8 mm [0.03 in] MAX.
Y	B, C	0 to 0.8 mm [0.03 in] MAX.	0 mm to 1.5 mm [0.06 in] MAX.	0 mm to 2.4 mm [0.09 in] MAX.
R	C	2.4 mm to 3.2 mm [0.09 to 0.13 in]		
L	B	2.4 mm +0, -0.8 mm [0.09 in +0, -0.03 in]		
M	C	2.4 mm ± 0.4 mm [0.09 in ± 0.02 in]		
X	C	5 mm [0.20 in]		
Z	C	3.2 mm [0.13 in]		



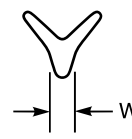
CLASS 1



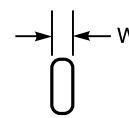
CLASS 2



CLASS 3



CLASS 4



CLASS 5

Figure 6—Groove Design, Dimensions, and Tolerances for Use with Consumable Inserts

at increasing travel speed so that the size of the weld pool is as small as possible before extinguishing the arc. Extinguishing the arc rapidly without using one of these techniques may produce crater cracks.

9. Welding Using GTAW with Consumable Inserts

9.1 Description and Specifications of Consumable Inserts

9.1.1 Consumable inserts are used for root pass welding of pipe where high quality welds are consistently required with minimum repairs or rejects. Detailed information on chemical composition, dimensions, sizes, and styles are given in AWS A5.30/A5.30M, *Specification for Consumable Inserts*. The five shapes of consumable inserts (Classes 1 through 5) are illustrated in Figure 6. Recommended groove designs for inserts are also shown in Figure 6.

With consumable inserts, consideration should be given to the unusually large effect of dilution. As much as one half (50%) of the weld root pass is comprised of fused

base metal, compared with 25% or less fused base metal for the remainder of the weld fill passes. Factors such as effects on mechanical properties and crack and corrosion resistance should be considered when consumable inserts are used.

For aluminum pipe, inserts are not recommended.

9.1.2 For wall thicknesses of 5 mm [0.20 in] or less, the smaller insert sizes are generally used, i.e., 3.2 mm [0.12 in] size for Classes 1, 2, and 4, and 1.5 mm [0.06 in] $\times$ 3.2 mm [0.12 in] size for Classes 3 and 5. There is no thickness where the use of one insert size abruptly becomes unfeasible and another size becomes mandatory. There are ranges of thicknesses where two different sizes of the same shape of insert may be used. The choice may depend upon fabricator preference, welder training, the pipe chemical composition, and availability.

9.1.3 For carbon, low alloy and stainless steel welding, assembly tolerances for the various shape inserts are shown in Figure 7. In some critical applications, the fabricator's internal process specifications for assembly

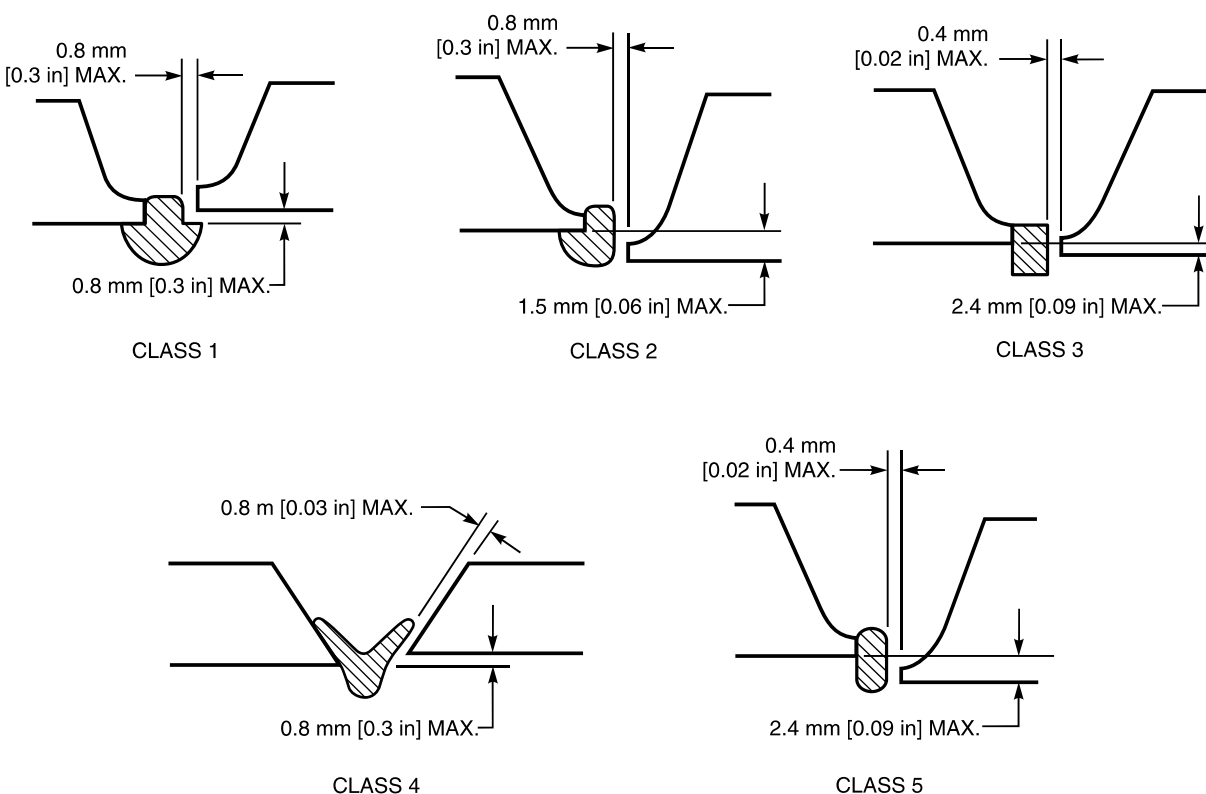


Figure 7—Assembly Tolerances for Welding Pipe, Using Five Classes of Consumable Inserts

tolerances may be more restrictive than those listed in Figure 6. Some alloys, such as copper-nickel or nickel-copper, require closer tolerances for successful use of the inserts. Assembly tolerances may also be related specifically to wall thickness as shown in Figure 6.

9.1.4 All insert shapes are supplied in a wide variety of alloys covering many weldable pipe compositions. Normally, the chemical composition of the consumable inserts meets the same specification limits for filler metal used with inert gas welding processes.

9.1.5 For carbon steel inserts, properly deoxidized material should be used to assure sound, low-porosity welds, especially if a purge gas is not used. Contamination of Class 1 inserts (see AWS A5.30/A5.30M, *Specification for Consumable Inserts*, Inverted T-shape) and Class 2 inserts (see AWS A5.30/A5.30M, J-shape) by dirt or hydrocarbons is a common source of porosity, therefore inserts should be cleaned thoroughly using a solvent immediately prior to being tack welded in place. Once inserts are tacked in place, the groove should be covered to prevent dirt and dust from collecting between the insert and the pipe root faces.

9.2 Welding Techniques for Consumable Inserts

9.2.1 Figures 8 and 9 illustrate typical steps required for root pass welding with consumable inserts. Arc initiation should be as previously described, i.e., either high frequency starting or striking the arc on the groove face.

9.2.2 The electrode should be kept perpendicular to the work and be pointed radially toward the center of the pipe. An arc length of about 3 mm [0.12 in] is satisfactory. Forward progression is governed by the melting rate of the consumable insert and the characteristics of the weld pool. Evidence of sufficient melting is shown by the increased fluidity and wetting, flow, increase in weld pool diameter and/or silicone island stirring. When this occurs, the arc is gradually moved forward around the groove. As the arc is extinguished, care should be exercised to prevent crater cracks (see 8.8).

9.3 Pipe Axis Horizontal. When the pipe axis is horizontal and the pipe is not rotated, flat inserts (A5.30/A5.30M, Class 3 and 5) are positioned eccentrically to promote good weld bead shape on the internal surface of the pipe. Figure 10 illustrates this.

10. GTAW of Stainless Steels with Flux Cored Filler Metals and Backing Fluxes

10.1 Flux Cored Filler Metals. Recent product developments provide another option for protecting the root side

of the joint for a limited number of chemical compositions when using GTAW; this involves the use of flux cored filler metals. During welding, a thin layer of slag will cover the root side of the bead. This eliminates the need for back purging, provided the heat-tint oxide in the heat-affected zone (HAZ) is acceptable for the intended service. However, it is important that adequate root gaps are provided or keyhole welding are utilized to ensure some of the flux will reach the underside of the bead and form a slag covering.

At this time the existence of welding rods appears to be limited to the following deposit compositions, but others may become available in the future: 308L, 316L, 309L, and 347.

10.2 Backing Fluxes. Similar success has also been obtained using powdered flux that is mixed with a solvent and painted on the inside surfaces of pipe ends before assembly and tack welding. Such fluxes prevent the severe oxidation of stainless steel that occurs when welding without backing gas, but, like flux cored wires, a residual flux is left on the inside surfaces of the pipe, and the presence of that flux must be acceptable to the end user of the piping system

10.3 Limitations. Depending upon the specific service, the slag and heat-tint oxide may have to be removed from the pipe root surface since it may interfere with the purity of the product and/or the corrosion resistance of the alloy. The end user of the piping system should be advised that residual flux and oxidized heat-affected zones will be present when either flux-containing wires or paint-on backing fluxes are used. Also, this type of filler metal has not been designed for fill passes and thus should not be used for any application other than root passes.

11. Welding Carbon and Low Alloy Steels with SMAW and GMAW

11.1 Introduction. Both the shielded metal arc welding process and the gas metal arc welding process are frequently used for open root welding of carbon and some low alloy steels. For additional information, see the latest edition of AWS D10.12M/D10.12, *Guide for Welding Mild Steel Pipe*.

11.2 Shielded Metal Arc Welding (SMAW) with Cellulosic Covered Electrodes

11.2.1 E6010 and E6011 electrodes are frequently used for welding the root pass of low-carbon steel pipe. These and other higher-strength cellulosic electrodes such as (E7010-A1, EXX10-P1, and EXX11-A1 as classified in AWS A5.5/A5.5M, *Specification for Low Alloy*

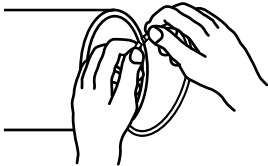
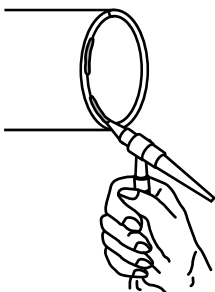
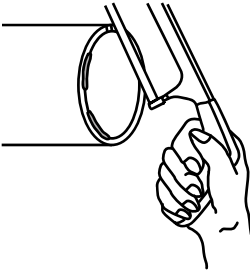
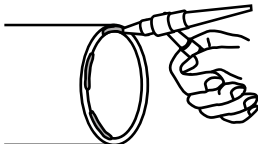
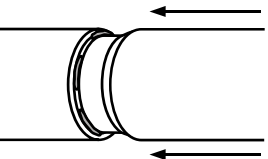
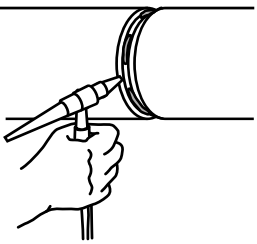
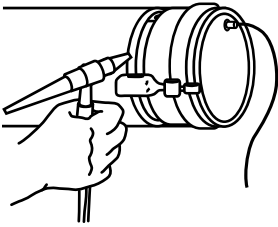
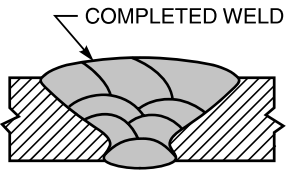
 1. PLACE THE INSERT (IN RING FORM) ON ONE PIPE END THAT HAS BEEN PROPERLY PREPARED.	 2. USING A GTAW TORCH, MAKE SMALL TACK WELDS APPROPRIATELY SPACED TO OBTAIN A CLOSE FIT, STARTING AT ONE END OF THE INSERT AND CONTINUING HALF WAY AROUND THE CIRCUMFERENCE.	 3. IF AN OVERLAP RING IS USED, CUT OFF THE OVERLAP CAREFULLY SO THAT THE GAP BETWEEN THE ENDS OF THE INSERT DOES NOT EXCEED 0.8 mm [0.03 in]. EITHER A HACKSAW OR HAND SHEARS CAN BE USED TO TRIM THE INSERT.	 4. IF AN OPEN RING IS USED, ONE OF THE TACK WELDS SHOULD BE LOCATED AT THE SPOT WHERE THE INSERT ENDS ARE BUTTED TOGETHER.
 5. ALIGN MATING PIPE SECTION.	 6. MIDWAY BETWEEN THE ORIGINAL TACKS, TACK WELD THE SECOND PIPE TO THE INSERT AND CONTINUE THE TACK ACROSS THE INSERT TO INCLUDE THE FIRST PIPE.	 Note: Shown entry of purge gas is for helium. For argon, the entry must be from the bottom. 7. PURGE THE INSIDE OF THE PIPE ADJACENT TO THE JOINT WITH AN APPROPRIATE PURGE GAS AS OUTLINED IN CLAUSES 4, 5, AND 6 OF THIS DOCUMENT. WHEN WELDING IN THE HORIZONTAL FIXED POSITION (PIPE AXIS HORIZONTAL), WELD UPWARDS FIRST ONE SIDE THEN THE OTHER, FUSING THE INSERT WITH THE PIPE ENDS TO COMPLETE THE ROOT PASS.	 COMPLETED WELD 8. COMPLETE THE JOINT BY ANY CONVENTIONAL WELDING PROCESS USING FILLER METAL. USE LOW HEAT ON SECOND AND THIRD PASSES TO AVOID MELTING THROUGH.

Figure 8—Steps for Root Pass Welding with Classes 1, 2, 3, and 5 Consumable Inserts

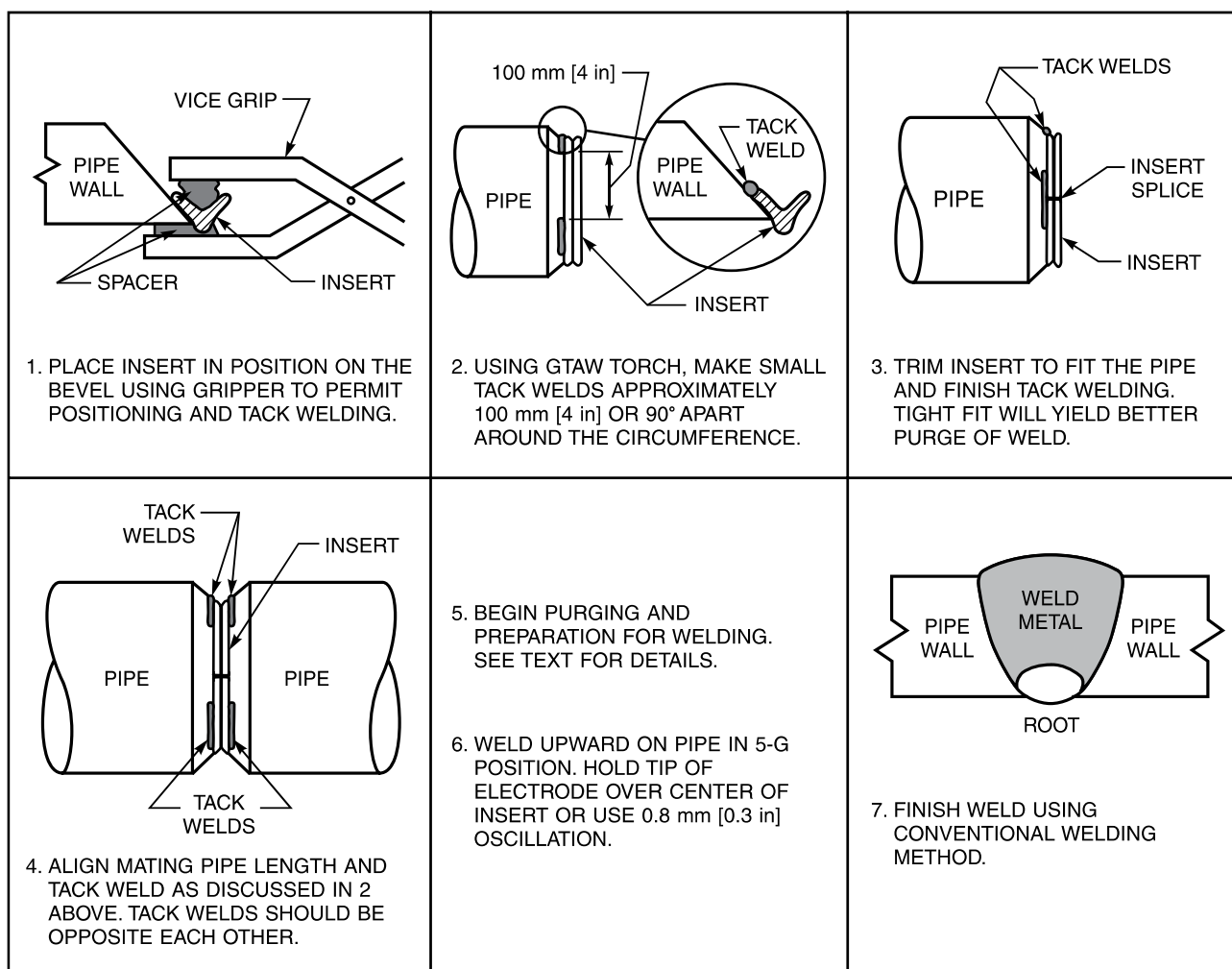


Figure 9—Steps for Root Pass Welding with Class 4 Consumable Inserts

Steel Electrodes for Shielded Metal Arc Welding) may also be used for root pass welding of higher strength pipe where hydrogen cracking is not a particular concern. See AWS D10.12M/D10.12, *Guide for Welding Mild Steel Pipe*.

11.2.2 The SMAW process is not recommended for root pass welding of alloys such as chromium-molybdenum steels, stainless steels, nickel, or copper alloys because most SMAW electrodes for these base metals are of the low hydrogen type, and complete joint penetration is difficult to obtain. Purging of SMAW open root joints is not done because the turbulence of the arc defeats the effectiveness of gas shielding on the underside of the root bead by aspirating large amounts of air into the weld and negating the effects of the purge.

11.3 Low Hydrogen (Basic) SMAW for Open Gap Root Pass Welding

11.3.1 Some low hydrogen electrodes are designed for vertical up root pass welding with an open gap. The root passes are generally welded with small diameter electrodes (2.5 mm to 3.2 mm) [3/32 in to 1/8 in] with low current and DC straight (electrode negative) polarity. As with vertical down cellulosic SMAW (EXX10 and EXX11) electrodes, a keyhole technique is used. Welding proceeds vertically upward with the electrode coating touching the pipe edges. The electrode angle and the current are controlled to maintain a small keyhole behind the arc. The crater is normally ground before starting a new electrode. Better results are seen when faster travel speeds are used than with slow travel speeds, as the root

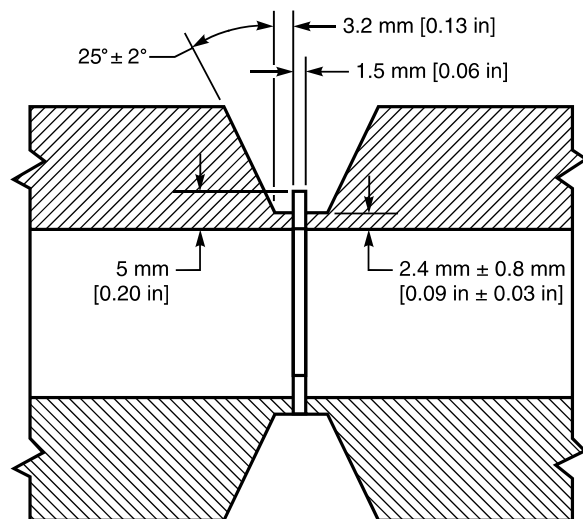


Figure 10—Eccentric Positioning of Classes 3 and 5 Consumable Inserts in 5G Position (Axis Horizontal, Pipe Not Rotated During Welding) to Prevent Sag

reinforcement is smaller and there is less chance of burn-through.

11.3.2 The recommended joint preparation is a 2.5 mm [3/32 in] root opening, with a 2.0 mm to 2.5 mm [5/64 in to 3/32 in] root face with a 60° included angle. A 2.5 mm [3/32 in] diameter electrode would normally be welded with 70 amps, while a 3.2 mm [1/8 in] diameter electrode would be welded with 100 amps.

11.3.3 Vertical down low hydrogen electrodes are currently available as AWS classifications E8045-P2, E9045-P2, and E10045-P2. They are not generally recommended for root pass welding. These basic coated electrodes have very little arc force other than that provided by the welding machine, so joint preparation is critical to assure full root penetration. Very little alignment mismatch (high/low) can be tolerated. These electrodes are designed to freeze very quickly to enable them to run downhill. As a result, they do not “wet in” very well. This limits the tolerance for variable gap openings, and there is a higher risk of either burning through or internal lack of fusion or internal undercut.

11.4 Shielded Metal Arc Welding (SMAW) with Rutile Covered Electrodes

11.4.1 Some rutile-type covered electrodes (such as E6013) are designed for root pass welding of pipe. These electrodes are identified by the manufacturer as suitable

for root pass welding of piping. They exhibit more penetration than ordinary E6013 but not as much as E6010. Because of the reduced penetration, a root opening of 2 mm to 4 mm [0.08 in to 0.16 in] and a root face thickness of about 1.5 mm [0.06 in] is recommended when using a 3.2 mm [0.12 in] electrode and either uphill or downhill progression.

11.4.2 These types of covered electrodes are also available in electrodes that will produce low-alloy steel weld metal with strengths up to 550 MPa [80 ksi] minimum tensile strength. However, when using these electrodes, the higher preheat that would be used for cellulosic covered electrodes, such as E7010-G, E7010-A1, or E7010-P1, should be used since rutile-type covered electrodes are not low hydrogen electrodes.

11.5 Gas Metal Arc Welding (GMAW)

11.5.1 Root passes can also be made using GMAW in the short-circuiting transfer mode and an open root joint design when using an argon/CO₂ shielding gas mixture. Welding voltages of 17 V to 19 V and wire feed speeds in the vicinity of 64 mm/s [150 in/min] will provide a good starting point in the development of the welding procedure when using 0.9 mm [0.035 in] diameter wire. Where a complex waveform machine is used, the manufacturer’s recommended settings should be used as a starting point for procedure development (see 14.4.3). Progression of vertical welds for root pass welding is usually downward. Purging is recommended for stainless and low alloy steels and nonferrous alloys, except aluminum. A V-groove design with a 75° groove angle, nominal 2.4 mm [0.09 in] root face and a 2.4 mm [0.09 in] root opening is recommended. Heat input and travel speed should be controlled to prevent excessive root reinforcement. The arc should be kept at the leading edge of the pool to ensure complete joint penetration.

11.5.2 When welding aluminum, copper or nickel alloy pipe using GMAW, the normal practice is to weld the root using GTAW, and fill the weld using GMAW.

12. Intermediate Weld Layers

12.1 Inspection and Purging. Once the root has been welded, visual inspection is recommended. Care should be taken to minimize melting through the root when depositing the second and third weld layers. Gas purging, when used, should be maintained until at least two additional layers have been deposited. Maintaining the purge for these two layers is necessary regardless of which welding process is used for the fill layers.

12.2 Processes and Limitations. These intermediate layers may be made with the GTAW, SMAW, FCAW, or

GMAW process. To prevent lack of fusion, the use of GMAW-S should be limited to a maximum pipe wall thickness of 10 mm [0.39 in] and fill passes should be made using uphill progression when in the vertical position.

13. Welding of Aluminum Alloys

13.1 Characteristics of Aluminum that Affect Welding Techniques. Techniques for welding aluminum alloy pipe should be designed around the fundamental characteristics of aluminum. The most relevant ones are:

1. the high melting temperature of aluminum oxide;
2. the low melting temperature of the aluminum;
3. the tenacious attachment of the oxide to the metal and its rapid reformation when removed;
4. the high thermal conductivity of aluminum—about 2.5 times that of steel;
5. the high fluidity of molten aluminum; and
6. the ability of molten aluminum to dissolve large quantities of hydrogen gas, which causes porosity.

13.2 Welding Techniques. Successful techniques have been developed using the gas shielded arc welding processes (GTAW, PAW, and GMAW) which remove the oxide and prevent its reformation by shielding the weld pool under an inert gas. They are high energy processes so that they permit relatively high welding speeds to overcome the effects of high thermal conductivity and fluidity of the molten weld metal.

A joint design consisting of a V-groove with a wide bottom (Figure 11), has been developed to permit control of the root pass and to ensure that a sound weld can be made with the gas tungsten or plasma arc welding processes. Control of porosity is mainly a matter of ensuring

thorough joint cleanliness before welding. Any residual oily substance or moisture will cause porosity. For this reason, the pipe ends should be carefully cleaned with a solvent just before assembly and wire brushed to remove the oxide just before welding. The details of these and all other necessary factors are given in AWS D10.7, *Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe*.

14. Welding Equipment

14.1 GTAW Torches. An assortment of gas tungsten arc torches is readily available from welding equipment suppliers. Torches are either air-cooled or water-cooled. For most root pass welding, an air-cooled torch is adequate. The water-cooled torches require an auxiliary water supply. Water-cooled torches should be considered whenever high currents are used, such as for fill passes in large diameter piping, and for aluminum or copper welding.

14.2 Gas Nozzles. Gas nozzles are available in various sizes and configurations, including those with long nozzles for reaching into deep groove joints. For most root pass welding applications, gas nozzles with 10 mm to 13 mm [0.39 in to 0.5 in] (#6 to #12) orifice diameters should be used.

14.3 Gas Lenses. A gas lens is a screen insert which is located between the torch body and the gas nozzle. These lenses promote lamellar flow of the shielding gas and reduce turbulence and mixing of shielding gas with air as the gas exits the torch. This reduces the risk of porosity and provides a cleaner weld surface. Gas lenses are widely used in welding critical systems, particularly where radiographic inspection is required.

14.4 Power Supplies

14.4.1 Standard Power Supplies. Standard DC (direct current) power supplies with drooping volt-ampere curves (the type commonly used for shielded metal arc welding) are used for gas tungsten arc welding. Machines best suited for gas tungsten arc welding of root passes are those in which the 10 V to 15 V and 75 A to 150 A ranges are well within the operating capacity of the power supply. Power supplies equipped with high frequency arc initiation and current upslope and downslope capabilities, or a remote current control (e.g., a foot pedal), make it easier to achieve high quality welds and should be used whenever possible.

While constant current power supplies are used for the GTAW and the SMAW processes, they are not suitable for GMAW. The latter requires a constant potential (constant voltage) power supply. This applies to both automatic and semiautomatic applications.

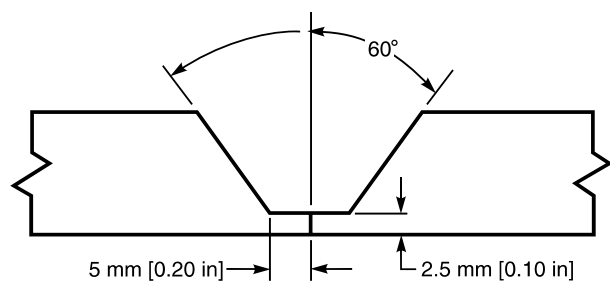


Figure 11—Joint Design for Aluminum Pipe

14.4.2 Pulsed Power Supplies. GTAW and GMAW power supplies with pulsed current capabilities are available. These power supplies rapidly alternate the welding current from a low background level to a high peak level. The pulsing frequency and current wave shapes vary among different types of power supplies. The pulsed current provides easier control of the weld pool. It also allows the use of a lower total heat input which reduces distortion, especially in stainless steel, and cracking tendencies in alloys that are subject to cracking of the weld bead down its centerline during solidification (i.e., “hot short” alloys), like UNS N08020 (Alloy 20Cb3 or 320). For GMAW of aluminum, constant current power supplies are usually recommended.

14.4.3 Multiprocess Power Sources. Power sources are available that can offer output in CV, CC, AC/DC, pulsed modes, and/or complex waveform modes. This equipment uses high-speed electronics to control the output wave form and shape, enabling one to affect the bead shape, penetration, tie-in, and the level of spatter. When using such power supplies, one may not be able to directly transfer settings from one manufacturer’s model to another model, or to a similar power supply made by another manufacturer.

14.5 Machine and Automatic Welding Equipment

14.5.1 Equipment is commercially available for welding root and fill passes for pipe that is in a fixed position or being rolled. Equipment for welding pipe that can be rolled is mounted on a boom or a side-beam carriage, and the pipe is rotated beneath it.

14.5.2 Equipment for welding in fixed positions is more sophisticated and the application must be carefully evaluated to ensure that the productive gains justify the capital expenditure for the work to be done. Most designs have a motorized orbital welding head which is fastened to the pipe. Voltage sensing and automatic torch oscillating capabilities are available.

14.5.3 Automatic voltage control is essential for maintaining a constant arc length when the surface of the workpiece is uneven. Oscillation of the welding head allows the use of weaving instead of stringer beads. This may reduce the number of weld passes required to fill the joint. The total welding time may thereby be reduced. Pulsed current equipment is also available. It is especially useful for fixed position welding where greater weld pool control is required.

Annex A (Informational)

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS D10.11M/D10.11:2007, *Guide for Root Pass Welding of Pipe Without Backing*, but is included for informational purposes only.

A1. Introduction

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

A2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

A2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry

along with the edition of the standard that contains the provision(s) the inquirer is addressing.

A2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

A2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

A2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry or provide the wording for a proposed revision, if this is what the inquirer seeks.

A3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS technical committee. The secretary of the committee refers all inquiries to the chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon approval by the committee, the interpretation is an official

interpretation of the Society, and the secretary transmits the response to the inquirer and to the *Welding Journal* for publication.

A4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal* and will be posted on the AWS web site.

A5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The *AWS Board Policy Manual* requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be

obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

A6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

List of AWS Documents on Piping and Tubing

Designation	Title
D10.4	<i>Recommended Practices for Welding Austenitic Chromium Nickel Stainless Steel Piping and Tubing</i>
D10.6/D10.6M	<i>Recommended Practices for Gas Tungsten Arc Welding Titanium Piping and Tubing</i>
D10.7M/D10.7	<i>Recommended Practices for Gas Shielded Arc Welding Aluminum and Aluminum Alloy Pipe</i>
D10.8M/D10.8	<i>Guide for Welding Chromium Molybdenum Steel Piping and Tubing</i>
D10.10/D10.10M	<i>Recommended Practices for Local Heating of Welds in Piping and Tubing</i>
D10.11M/D10.11	<i>Recommended Practices for Root Pass Welding</i>
10.12M/D10.12	<i>Guide for Welding Mild Steel Pipe</i>
D10.13/D10.13M	<i>Recommended Practices for Brazing of Copper Pipe and Tubing for Medical Gas Systems</i>

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