

ANSI/AWS D1.4-92
An American National Standard

Structural Welding Code Reinforcing Steel



American Welding Society

Keywords — allowable stress, inspection, qualification, reinforcing steel, structural details, welded joint details, workmanship

ANSI/AWS D1.4-92
An American National Standard

Approved by
American National Standards Institute
March 20, 1992

Structural Welding Code — Reinforcing Steel

Including
Metal Inserts and Connections
in Reinforced Concrete
Construction

Fourth Edition

Superseding
AWS D1.4-79
Reinforcing Steel Welding Code

Prepared by
AWS Structural Welding Committee

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This code covers the requirements for welding reinforcing steel in most reinforced concrete applications. It contains a body of rules for the regulation of welding reinforcing steel and provides suitable acceptance criteria for such welds.



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International Standard Book Number: 0-87171-378-0

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Foreword

(This Foreword is not a part of ANSI/AWS D1.4-92, *Structural Welding Code — Reinforcing Steel*, but is furnished for information purposes only.)

In 1961, the American Welding Society published its first reinforcing steel welding standard, AWS D12.1-61, *Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction*. The D12 Committee was disbanded some time after publication of the 1961 code and before publication of the 1975 edition.

The 1961 document was replaced with a greatly revised version, AWS D12.1-75, *Reinforcing Steel Welding Code*, with the format patterned after the AWS D1.1-72, *Structural Welding Code*. The 1975 code was produced by the AWS Structural Welding Committee but was not renumbered to reflect this committee change. As with ANSI/AWS D1.1, AWS D12.1-75 was designed as a self-contained code, including within it the qualification of welders and procedures, and requirements for workmanship, quality, and inspection.

The listings of materials and welding processes were revised in the D12.1-75 code. Items newly introduced were the carbon equivalent method for determining preheat, the parenthetical inclusion of metric (SI) conversions, and the two different methods of joint strength determination.

The AWS D12.1-75 document was revised and the title changed to ANSI/AWS D1.4-79, *Structural Welding Code — Reinforcing Steel*. Since the 1979 edition of ANSI/AWS D1.4-79, *Structural Welding Code — Reinforcing Steel*, was issued, further use by designers, engineers, and fabricators has necessitated a number changes to the requirements. This edition, ANSI/AWS D1.4-92, addresses these changes. Contributions of Mr. D. L. Sprow, Former Chairman of the D1 Committee, are appreciated by the membership of the Structural Welding Committee.

Changes in Code Requirements. Where technical changes have been made in code requirements, a double vertical line appears in the outside margin immediately adjacent to the material affected. New material is also indicated in this manner. Major editorial changes in the material are indicated by a single vertical line in the outside margin immediately adjacent to the material affected. Changes in tables have been so indicated; changes in figures have not been indicated. Both tables and figures have been revised; only one new table has been added to this edition.

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

Official interpretations of any of the technical requirements of this standard may be obtained by sending a request, in writing, to the Technical Director, American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135 (See Appendix C).

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Structural Welding Code

Reinforcing Steel

1. General Provisions

1.1 Scope This code shall apply to the welding of concrete reinforcing steel.

1.2 Application

1.2.1 This code shall be used in conjunction with the prescribed general building code specifications and is applicable to all welding of reinforcing steel, using the processes listed in 1.4, and performed as a part of reinforced concrete construction.¹ When reinforcing steel is welded to primary structural steel members, the provisions of the latest edition of ANSI/AWS D1.1, *Structural Welding Code — Steel* shall apply to the structural steel component.

1.2.2 The weldments specified in this code shall not be used where impact properties are a requirement of the general specification. Impact testing

1. The following applicable general specifications are cited for information only and do not constitute all general specifications:

The American Association of State Highway and Transportation Officials *Standard Specifications for Highway Bridges*

American Concrete Institute:
Building Code Requirements for Reinforced Concrete, ACI 318, and

Recommendations for Reinforced Precast Concrete Construction, ACI 324

The American Railway Engineering Association, *AREA Manual*, Chapter 8, Masonry

Department of the Navy, *Bureau of Yards and Docks Basic Structural Engineering*, TP-Te-3.

requirements of welded reinforcing bars are not included in this code.

1.2.3 All references to the need for approval shall be interpreted to mean approval by the *Building Commissioner*, defined as the Building Commissioner or the Engineer.² Hereinafter the term *Engineer* will be used, and is to be construed to mean the *Building Commissioner* or the *Engineer*.

1.2.4 When ANSI/AWS D1.1 base metals make up the entire weld joint, the Engineer may select the use of ANSI/AWS D1.1 procedures and qualified welders to perform that weld, provided other relevant provisions of ANSI/AWS D1.4 are considered in the decision to use ANSI/AWS D1.1.

1.3 Reinforcing Steel Base Metal

1.3.1 Reinforcing steel base metal in this code shall conform to the requirements of the latest edition of one of the ASTM specifications listed below.³ Combinations of any of these reinforcing steel base metals may be welded together.

(1) ASTM A82, *Specification for Plain Steel Wire For Concrete Reinforcement*.

(2) ASTM A184/A184M, *Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement*.

2. The term *Building Commissioner* refers to the official or bureau that enforces the local building law, or specifications, or other construction regulations.

3. Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

(3) ASTM A185, *Specification for Welded Plain Steel Wire Fabric for Concrete Reinforcement*.

(4) ASTM A496, *Specification for Deformed Steel Wire for Concrete Reinforcement*.

(5) ASTM A497, *Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement*.

(6) ASTM A615/A615M, *Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement*.

(7) ASTM A616/A616M, *Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement*.

(8) ASTM A617/A617M, *Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement*.

(9) ASTM A706/A706M, *Specification for Low Alloy Steel Deformed Bars for Concrete Reinforcement*.

(10) ASTM A767/A767M, *Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement*.

(11) ASTM A775/A775M, *Specification for Epoxy-Coated Reinforcing Steel Bars*

Manufacture and testing requirements for mats and fabric are covered by the respective ASTM Specifications. For joining the mats and fabric to other reinforcing bars or structural steels, the provisions of this Code shall apply.

1.3.2 When a reinforcing steel not listed in 1.3.1 is approved under the provision of the general building code or by the Engineer, its chemical composition and carbon equivalent shall be provided and its weldability established by qualification in accordance with the requirements of 6.2 and all other requirements prescribed by the Engineer.

1.3.3 Base metal, other than those previously listed, shall be one of the structural steels listed in the latest edition of ANSI/AWS D1.1, *Structural Welding Code — Steel*.

1.3.4 The carbon equivalent (C.E., see Table 5.2) of reinforcing steel bars shall be calculated as shown in 1.3.4.1 or 1.3.4.2, as applicable.

1.3.4.1 For all steel bars, except those designated as ASTM A706, the carbon equivalent shall be calculated using the chemical composition, as shown in the mill test report, by the following formula:

$$C.E. = \%C + \%Mn/6 \quad (Eq. 1)$$

1.3.4.2 For steel bars designated ASTM A706, the carbon equivalent shall be calculated using the chemical composition, as shown in the mill test report, by the following formula:

$$C.E. = \%C + \%Mn/6 + \%Cu/40 + \%Ni/20 + \%Cr/10 - \%Mo/50 - \%V/10 \quad (Eq. 2)$$

The carbon equivalent shall not exceed 0.55%.

1.3.4.3 If mill test reports are not available, chemical analysis may be made on bars representative of the bars to be welded. If the chemical composition is not known or obtained:

(1) For bars number 6 or less, use a minimum preheat of 300°F (150°C).

(2) For bars number 7 or larger, use a minimum preheat of 400°F (200°C).

(3) For all ASTM A706 bar sizes, use Table 5.2 C.E. values of "over 0.45% to 0.55% inclusive".

1.4 Welding Processes

1.4.1 Welding shall be performed with shielded metal arc (SMAW), gas metal arc (GMAW), or flux cored arc (FCAW).

1.4.2 Other welding processes may be used when approved by the Engineer, provided that any special qualification test requirements not covered here are met to ensure that welds satisfactory for the intended application will be obtained.

1.5 Definitions. The welding terms used in this code shall be interpreted in accordance with the definitions given in the latest edition of ANSI/AWS A3.0, *Standard Welding Terms and Definitions*.

1.6 Welding Symbols. Welding symbols shall be those designated in the latest edition of ANSI/AWS A2.4, *Standard Symbols for Welding and Nondestructive Testing*. Special conditions shall be fully explained by additional notes or details.

1.7 Safety Precautions. Safety precautions shall conform to the latest edition of ANSI/ASC Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society.

See Appendix D for additional information relating to the basic elements of safety general to arc welding processes.

Note: This code may involve hazardous materials, operations, and equipment. The code does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices. The user should determine the applicability of any regulatory limitations prior to use.

1.8 Standard Units of Measurement The values stated in U. S. customary units are to be regarded as the standard. The metric equivalents of U. S. customary units may be approximate. Nominal dimensions of standard reinforcing bars are given in Appendix B.

2. Allowable Stresses

2.1 Base Metal Stresses. The allowable base metal stresses shall be those specified in the applicable code or general specification for reinforced concrete construction.

2.2 Allowable Stresses in Welds

2.2.1 Except as modified by Table 2.1, the allowable stresses for complete joint penetration bevel and V-groove welds in direct butt joints subject to tension or compression shall be the same as the corresponding allowable stresses for the reinforcing steel base metal, provided the filler metal used has a strength classification at least equal to the tensile strength of the base metal being welded.

2.2.2 The allowable stresses for fillet welds, and flare-bevel- and flare-V-groove welds, shall be in accordance with Table 2.1.

2.3 Effective Weld Areas, Lengths, Throats and Sizes

2.3.1 Complete Joint Penetration Groove Welds in Direct Butt Joints. The effective weld area shall be the nominal cross-sectional area of the bar being welded. (See Figure 3.2) If different size bars are being welded, the weld area shall be based on the smaller bar.

2.3.2 Flare-Bevel- and Flare-V-Groove Welds. The effective weld area shall be the effective weld length multiplied by the effective weld size (see Figure 2.1).

2.3.2.1 The effective weld length shall be the weld length of the specified weld size. No reduction in effective length shall be made for either the start or finish if the weld is the specified size at these locations.

2.3.2.2 The minimum effective weld length shall be not less than two times the bar diameter for equal size bars or two times the smaller bar diameter for two unequal size bars.

2.3.2.3 The effective weld size, when filled flush to the solid section of the reinforcing steel bar, shall be 0.4 of the bar radius for flare-bevel-groove welds and 0.6 of the bar radius for flare-V-groove welds. Larger effective weld sizes may be used to determine allowable stresses provided the welding procedure qualifies the larger weld size. When bars of unequal diameter are being joined, the effective weld size shall be based on the radius of the smaller bar.

2.3.3 Fillet Welds. The effective weld area shall be the effective weld length multiplied by the effective throat. (Stress in a fillet weld shall be considered as applied to this effective weld area, for any direction of applied load.)

2.3.3.1 The effective weld length shall be the overall length of the full size fillet. No reduction in effective weld length shall be made for either the start or finish, if the weld is the specified size at those locations.

2.3.3.2 The effective weld length of a curved fillet weld shall be measured along the weld axis.

2.3.3.3 The effective throat shall be the minimum distance minus any convexity between the weld root and face of the fillet weld.

3. Structural Details

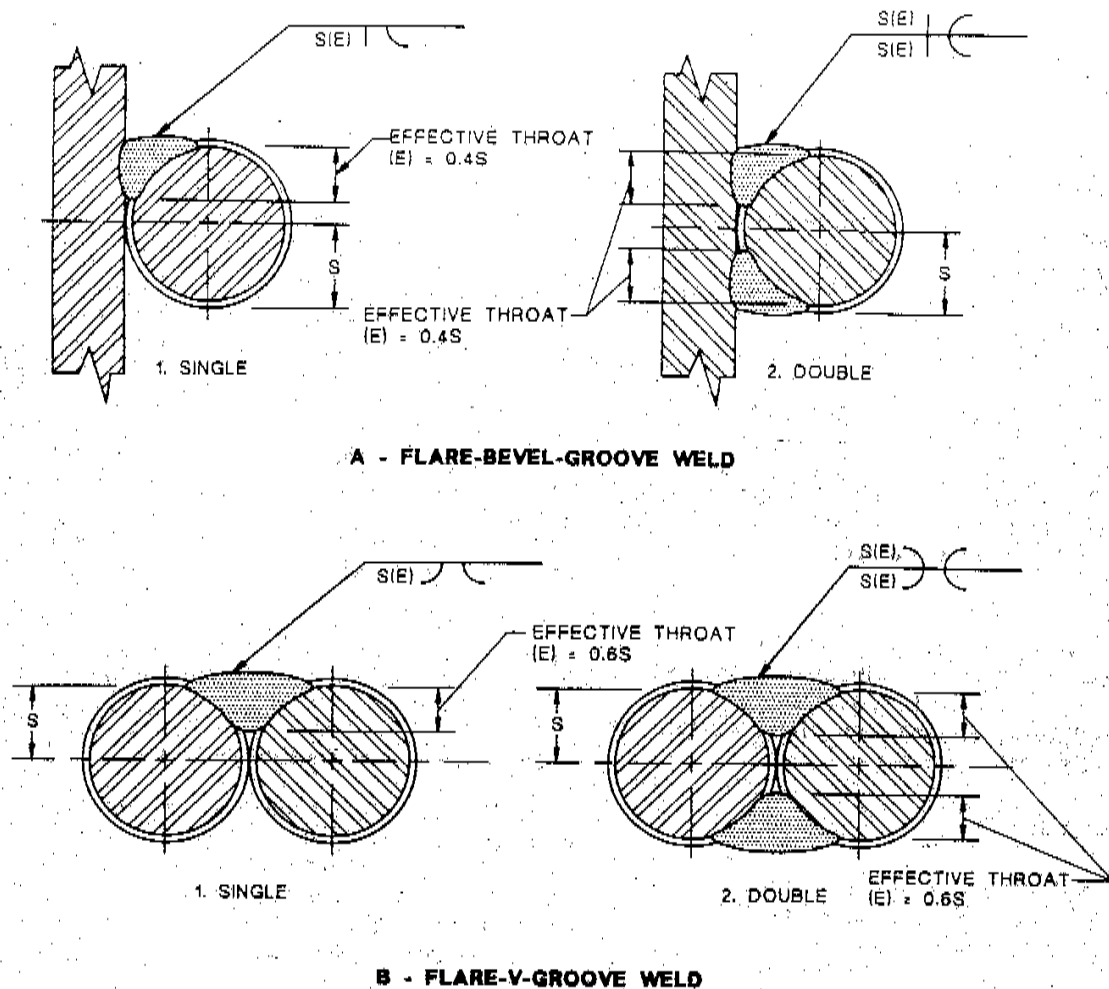
3.1 Transition in Bar Size. Direct butt joints in tension in axially aligned bars of different size shall be made as shown in Figure 3.1 (see Appendix B for bar sizes).

Table 2.1
Allowable Stresses in Welds (see 2.2.1)

Type of Weld	Stress in Weld ¹		Allowable Stress ^{3,4}	Required Weld Strength Level ²
Complete Joint Penetration Groove Welds	Tension normal to the effective area		Same as base metal	Matching filler metal shall be used. See Table 5.1
	Compression normal to the effective area		Same as base metal	Filler metal with a strength level equal to or one classification (10 ksi) less than matching weld metal may be used
	Shear on the effective areas		$0.30 \times$ nominal tensile strength of weld metal, except shear stress on base metal shall not exceed $0.40 \times$ yield strength of base metal.	Filler metal with a strength level equal to or less than matching weld metal may be used
Flare-Bevel and Flare-V Groove Welds	Compression normal to effective area	Joint not designed to bear	$0.50 \times$ nominal tensile strength of weld metal, except stress on base metal shall not exceed $0.60 \times$ yield strength of base metal	Filler metal with a strength level equal to or less than matching weld metal may be used
		Joint designed to bear	Same as base metal	
	Shear on the effective area		$0.30 \times$ nominal tensile strength of weld metal, except shear stress on base metal shall not exceed $0.40 \times$ yield strength of base metal	
	Tension normal to effective area		$0.30 \times$ nominal tensile strength of weld metal, except tensile stress on base metal shall not exceed $0.60 \times$ yield strength of base metal	
Fillet welds	Shear on effective area		$0.30 \times$ nominal tensile strength of weld metal	Filler metal with a strength level equal to or less than matching weld metal may be used

Notes:

1. For definition of effective area, see 2.3.1 and 2.3.3.
2. For matching filler metal, see Table 5.1.
3. For fatigue or dynamic loading refer to the applicable construction code or specification for allowable stress values.
4. The Engineer should be aware that the strength of cold drawn wire may be reduced when welded.



- NOTE: 1. RADIUS OF REINFORCING BAR = S
 2. THESE ARE SECTIONAL VIEWS. BAR DEFORMATIONS ARE SHOWN ONLY FOR ILLUSTRATIVE PURPOSES.

Figure 2.1 — Effective Weld Sizes for Flare-Groove Welds (See 2.3.2.3)

3.2 Eccentricity

3.2.1 Where welded lap or indirect butt joints are used (Figure 3.4 and Figure 3.3, respectively), the concrete surrounding the joint in the finished structure shall be sufficiently strengthened with

transverse reinforcement (splice plate) to prevent splitting of the concrete caused by the tendency of the joint to flex during eccentric loading.

3.2.2 Welded lap joints shall be limited to bar size No. 6 and smaller.

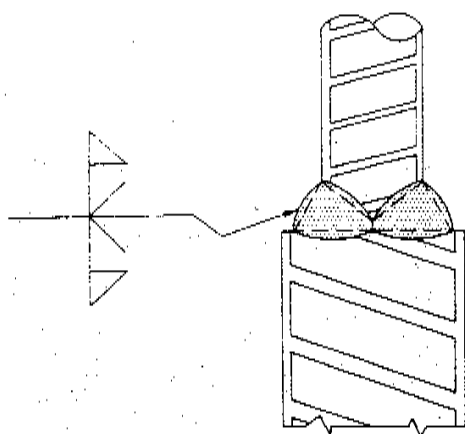


Figure 3.1 — Direct Butt Joint Showing Transition Between Bars of Different Sizes (See 3.1)

3.3 Joint Types With the exception of 3.2.2, reinforcing bars may be welded with direct or indirect butt joints, lap joints, or T-joints (Figures 3.2, 3.3, 3.4, and 3.5); however, direct butt joints are preferable for bars greater than No. 6.

3.4 Direct Butt Joints

3.4.1 A direct butt joint shall be single welded or double welded and shall have complete joint penetration and complete fusion.

3.4.2 Except as provided in 3.4.4, a direct butt joint with both axes horizontal, shall be made as either a single- or double-V-groove weld. The weld shall be backgouged to sound metal before welding the second side. See Figures 3.2(A) and 3.2(B).

3.4.3 Except as provided in 3.4.4, a direct butt joint with the bar axes vertical shall be made as either a single- or double-bevel-groove weld. The weld shall be backgouged to sound metal before welding the second side. See Figures 3.2(D) and 3.2(E).

3.4.4 Direct butt joints in bars of the same size, where the bar size is No. 8 (1 in. diameter) or smaller, should be made with split pipe backing. Such joints with the bar axis vertical should be

made as a single bevel-groove weld with the bevel in the upper bar. Such joints with the bar axis horizontal should be made as a single V-groove weld. As an alternate to the provisions of 3.4.2 and 3.4.3, bars of the same size, where the bar size is greater than No. 8, may be welded in the same manner as bars with a size of No. 8 or smaller. See Figure 3.2(C).

3.5 Indirect Butt Joints

3.5.1 An indirect butt joint shall be made with either single- or double-flare-groove welds between the bars and the splice member. See Figure 3.3.

3.6 Lap Joints

3.6.1 A lap joint shall be made with double-flare-V-groove welds [see Figure 3.4(A)], except that single-flare-V-groove welds may be used when the joint is accessible from only one side, and approved by the Engineer.

3.6.2 An indirect lap joint shall be made with single-flare-bevel groove welds between the bars and the splice plate, with the bars being separated. See Figure 3.4(B).

3.7 Interconnection of Precast Members

3.7.1 Precast members may be interconnected by welding reinforcing bars that project through the ends of the precast members or by welding together insert plates which have been cast into the precast members. The heat of welding may cause localized damage to the concrete.

3.7.2 Joints of projecting reinforcing bars shall conform to 3.3 through 3.6, as applicable.

3.7.3 Insert plate joints may be made using either a direct or indirect welded butt joint, or may be made with either direct or indirect welded lap joints. Either type joint may be exposed or recessed.

3.7.4 When welding insert plate joints, requirements for weld size and length shall be in accordance with this code.

3.7.5 Anchors, rods, and dowels shall be welded to anchorage, base plates, and inserts by peripheral fillet welds at their ends, by complete joint penetration groove welds, or in the case of lap joints by flare-groove welds.

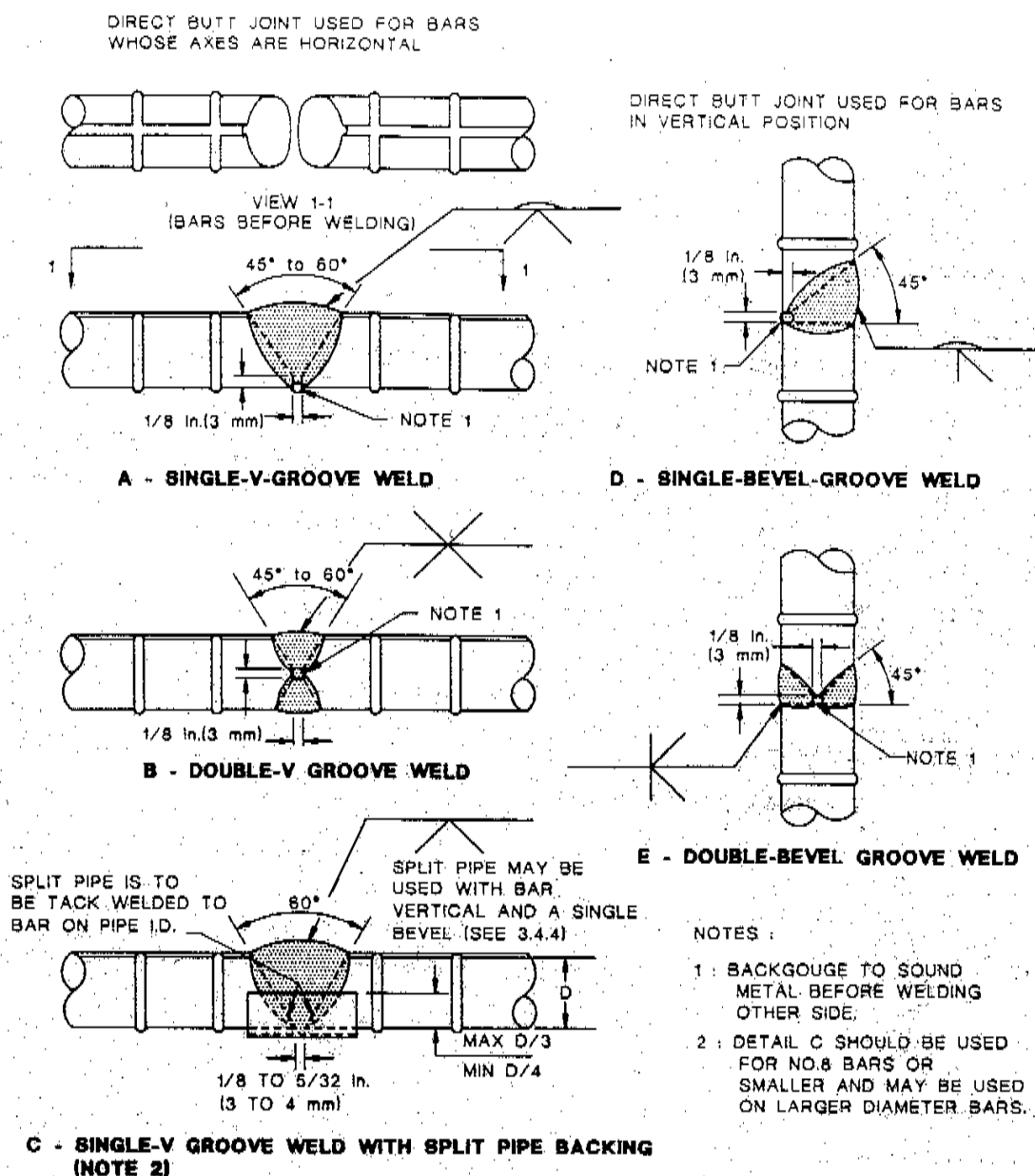


Figure 3.2 — Direct Butt Joints (See 3.4)

4. Workmanship

4.1 Preparation of Base Metal

4.1.1 Surfaces to be welded shall be free from fins, tears, cracks, or other defects that would ad-

versely affect the quality or strength of the weld. Surfaces to be welded, and surfaces adjacent to a weld shall also be free from loose or thick scale, slag, rust, moisture, grease, epoxy coating, or other foreign material that would prevent proper welding or produce objectionable fumes. Mill scale that

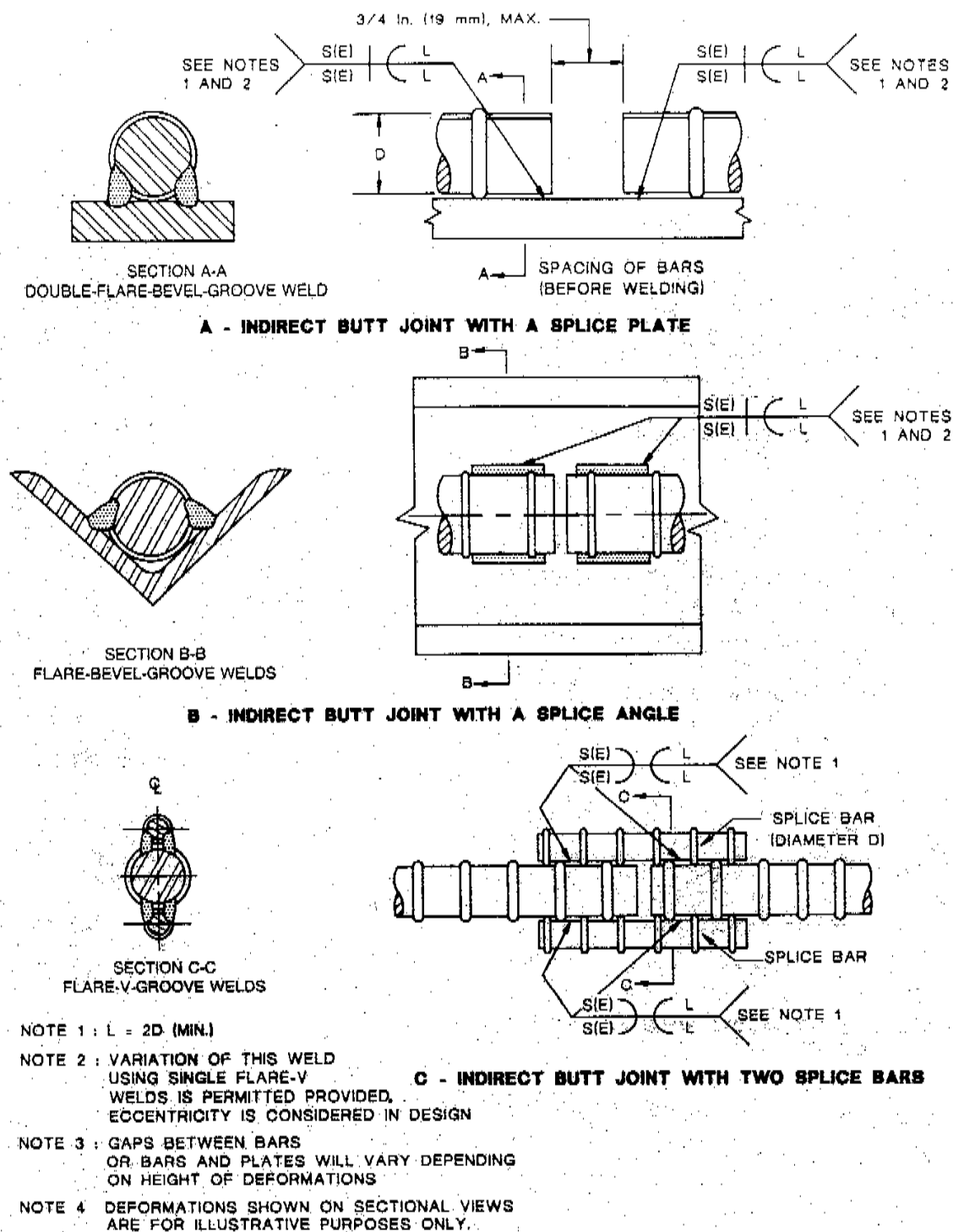
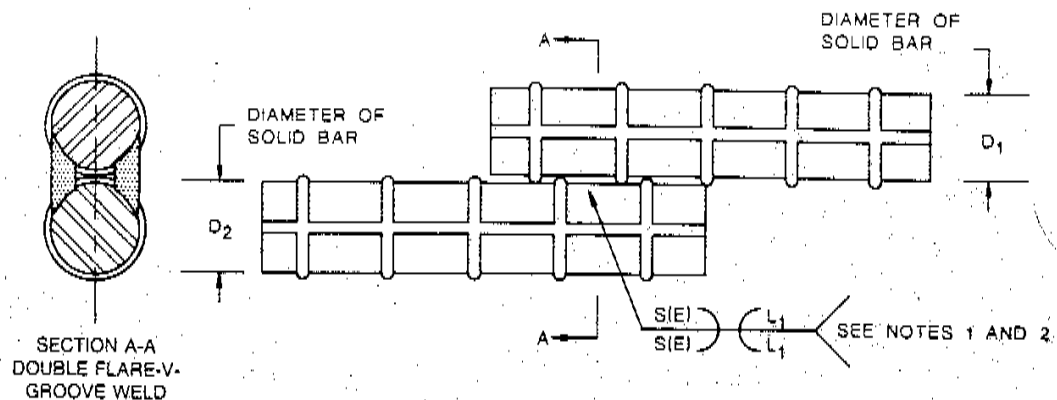
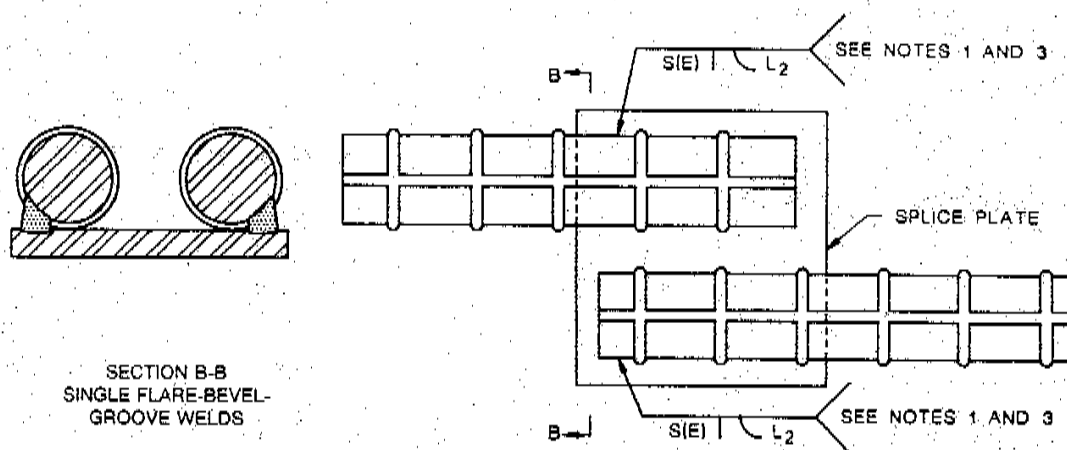


Figure 3.3 — Indirect Butt Joints (See 3.5)



**A - DIRECT LAP JOINT
WITH BARS IN CONTACT**

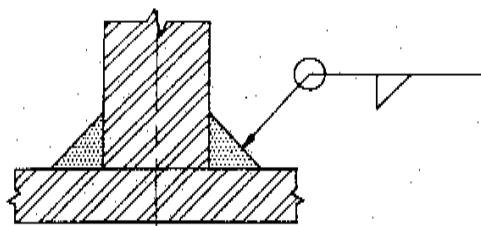
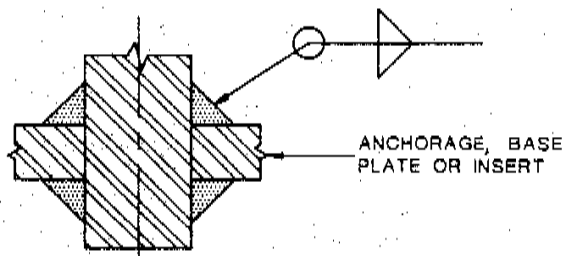
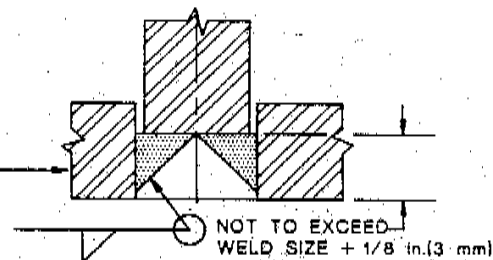
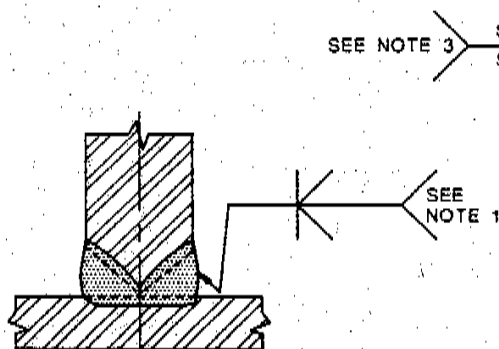


**B - INDIRECT LAP JOINTS
WITH BARS SEPARATED**

NOTES :

1. THE EFFECTS OF ECCENTRICITY SHALL BE CONSIDERED OR RESTRAINT PROVIDED IN THE DESIGN OF THE JOINT
2. $L_1 = 2 D_1$ (MIN.) ; $D_1 \leq D_2$
3. L_2 MIN = 2 X DIAMETER OF BAR
4. GAPS BETWEEN BARS AND PLATES WILL VARY BASED ON HEIGHT OF DEFORMATIONS.

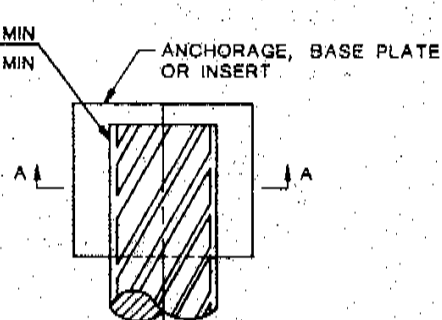
Figure 3.4 — Lap Joints (See 3.2.1)

**A - EXTERNAL FILLET WELD****B - EXTERNAL FILLET WELD****C - INTERNAL FILLET WELD****D - COMPLETE JOINT PENETRATION GROOVE WELD - T-JOINT**

NOTE 1 : BACKGOUGE TO SOUND METAL BEFORE WELDING OTHER SIDE

NOTE 2 : FOR BAR SIZES 8 OR SMALLER, THE SINGLE-BEVEL WELD WITH BACKGOUGING AND BACK WELDING IS RECOMMENDED

NOTE 3 : $L_{MIN} = 2 \times \text{BAR DIAMETER}$

**E - LAP JOINTS IN AN ANCHORAGE USING FLARE-BEVEL-GROOVE WELDS****Figure 3.5 — Details of Joints of Anchorages, Base Plates, and Inserts (See 3.7.4)**

withstands vigorous wire brushing, a thin rust inhibitive coating, or antispatter compound may remain.

4.1.2 The ends of reinforcing bars in direct butt joints shall be shaped to form the weld groove by oxygen cutting, air carbon arc cutting, sawing, or other mechanical means. Roughness of oxygen cut surfaces shall be no greater than the 2000 $\mu\text{in.}$ (50 μm) limit defined in ANSI B46.1, *Surface Texture*. Roughness exceeding this value and occasional notches or gouges not more than 3/16 in. (5 mm) deep, on otherwise satisfactory surfaces, shall be removed by machining or grinding. Bars for direct butt joints that have sheared ends shall be trimmed back beyond the area deformed by shearing.

4.2 Assembly

4.2.1 Joints shall be arranged to provide the most favorable position for welding.

4.2.2 Each joint shall have adequate clearance and accessibility for welding to suit the process being used.

4.2.3 The joint members shall be aligned so as to minimize eccentricities. After welding, bars in direct butt joints shall not be offset at the joint by

more than the following:

Bar sizes No. 10 or smaller	1/8 in. (3 mm)
Bar sizes No. 11 and No. 14	3/16 in. (5 mm)
Bar size No. 18	1/4 in. (6 mm)

4.2.4 For indirect butt joints with splice plates, the maximum joint clearance between the bars shall be not more than 3/4 in. (19 mm). See Figure 3.3(A).

4.2.5 For direct lap joints, if the bar deviates by more than one-half of the bar diameter, or by no more than 1/4 in. (6.4 mm) from each other while the bars remain in approximately the same plane, the joint shall be made through a splice bar or plate, and the requirements for an indirect lap joint shall apply (see 3.7.2 and 4.2.6).

4.2.6 For indirect lap joints [see Figure 3.4(B)], the maximum separation between the bar and the splice plate shall be no more than one-quarter of

the bar diameter, but not more than 3/16 in. (5 mm).

4.2.7 Welding of bars which cross shall not be permitted unless authorized by the Engineer.

4.3 Control of Distortion, Shrinkage, and Heat

4.3.1 In assembling and joining parts of a structure or precast member, the procedure and sequence followed shall minimize distortion and shrinkage.

4.3.2 When welding is performed on bars or other structural components that are already embedded in concrete, allowance shall be made for thermal expansion of the steel to prevent spalling or cracking of the concrete or significant destruction of the bond between the concrete and the steel.

4.4 Quality of Welds

4.4.1 The fillet weld faces shall be slightly convex or slightly concave as shown in Figures 4.1(A) and 4.1(B) or flat, and with none of the unacceptable profiles exhibited in Figure 4.1(C).

4.4.2 Welds shall have no cracks in either the weld metal or heat-affected zone.

4.4.3 There shall be thorough fusion between weld metal and base metal and between successive passes in the weld.

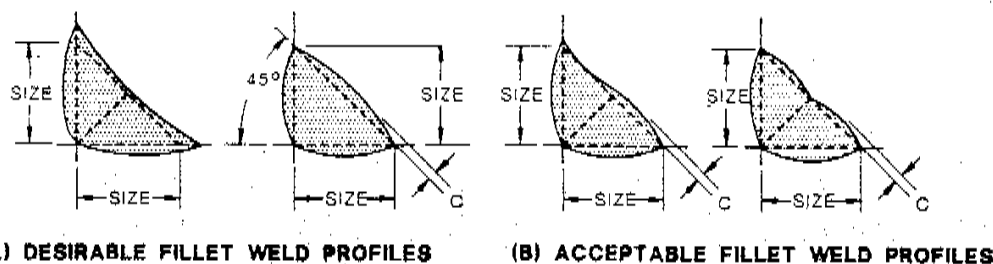
4.4.4 All craters shall be filled to the full cross section of the weld.

4.4.5 Welds shall be free from overlap.

4.4.6 Undercut depth greater than 1/32 in. (1 mm) in the solid section of the bar or structural member shall not be allowed.

4.4.7 The sum of diameters of piping porosity in flare-groove, and fillet welds shall not exceed 3/8 in. (10 mm) in any linear inch (25 mm) of weld and shall not exceed 9/16 in. (14 mm) in any 6 in. (150 mm) length of weld.

4.4.8 When radiographic inspection of direct butt joints is required, the maximum dimension of any single porosity or fusion type discontinuity, or the sum of the maximum dimensions of all porosity or fusion-type discontinuities, shall not exceed



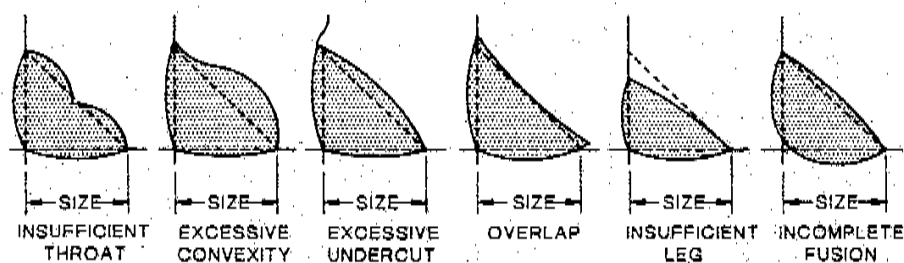
NOTE : CONVEXITY, G, OF A WELD OR INDIVIDUAL SURFACE BEAD SHALL NOT EXCEED THE VALUE OF THE FOLLOWING TABLE:

MEASURED LEG SIZE OR WIDTH
OF INDIVIDUAL SURFACE BEAD, L

$L \leq 5/16$ in. (8mm)
 $5/16$ in. < $L < 1$ in. (25mm)
 $L \geq 1$ in.

MAX. CONVEXITY

$1/16$ in. (1.6mm)
 $1/8$ in. (3mm)
 $3/16$ in. (5mm)



(C) UNACCEPTABLE FILLET WELD PROFILES

Figure 4.1 — Acceptable and Unacceptable Weld Profiles (See 4.4)

the limits given in Table 4.1. For radiographic inspection, see 7.7.3.

4.4.9 Ultrasonic inspection of direct butt joints in deformed reinforcing bars is not considered feasible except by highly specialized techniques and is not recommended.

4.4.10 Welds which do not meet the quality requirements of 4.4.1 through 4.4.8, inclusive, shall be repaired by removal of unacceptable portions or by rewelding, whichever is applicable.

4.4.11 Repairs to welds made with the shielded metal arc, gas metal arc, or flux cored arc processes

shall be made in accordance with an approved procedure specification applicable to these processes.

5. Technique

5.1 Filler Requirements

5.1.1 For direct butt joints, indirect butt joints, lap joints, and anchorage, base plate and insert connections, the filler metal, filler metal-gas combinations, or classification of filler metal shall be in accordance with Table 5.1.

5.1.2 When joining different grades of steels, the filler metal shall be selected for the lower strength base metal.

Table 4.1
Radiographic Acceptance Criteria¹
(See 4.4.9)

Bar Size	Sum of Discontinuity Dimensions		Single Discontinuity Dimension	
	in.	mm	in.	mm
8	3/16	5	1/8	3
9	3/16	5	1/8	3
10	1/4	6	1/8	3
11	1/4	6	3/16	5
14	5/16	8	3/16	5
18	7/16	11	1/4	6

Note:

1. Acceptance criteria for bar sizes less than No. 8 shall be established by the Engineer.

5.2 Minimum Preheat and Interpass Temperature Requirements

5.2.1 Minimum preheat and interpass temperatures shall be in accordance with Table 5.2 using the highest carbon equivalent number of the base metal as determined in accordance with 1.3.4.

5.2.2 Welding shall not be done when ambient temperature is lower than 0°F (-18°C), when surfaces to be welded are exposed to rain, snow, or wind velocities greater than five miles per hour (eight kilometers per hour), or when welders are exposed to inclement conditions.

5.3 Arc Strikes. Arc strikes outside the area of permanent welds shall be avoided, especially on reinforcing bars. Cracks or blemishes resulting from arc strikes shall be ground to a smooth contour and checked to ensure soundness.

5.4 Tack Welds. Tack welds that do not become a part of permanent welds are prohibited unless authorized by the Engineer. Tack welds shall be made using preheat and welded with electrodes meeting the requirements of final welds. They shall be thoroughly cleaned and subjected to the same quality requirements as the final welds.

5.5 Progression of Welding. Welds made in the vertical position [Figure 6.1(C), Position 3G or Figure 6.2(C), Position 3G], shall use vertical-up progression.

5.6 Welding of Coated Base Metal

5.6.1 Preparation for welding on coated base metal shall preferably be made after coating. After

welding to a qualified procedure, suitable coating protection shall be applied to the finished joint to restore the corrosion resistant properties of the coated bars.

5.6.2 When welding galvanized base metal, one of the following options shall be met:

5.6.2.1 Option 1. Welding of galvanized base metal, without prior removal of the coating, shall be performed in accordance with a welding procedure qualified to the requirements of this Code. Note that the welding procedure will normally involve larger root openings in joints, electrodes with lower silicon content, and slower welding speeds.

5.6.2.2 Option 2. Welding of galvanized base metal may be done after removing all coating from within 2 in. (50 mm) of the weld joint. In this option, the welding shall be performed using a welding procedure for uncoated reinforcing bar qualified in accordance with this code. The galvanized coating may be removed with oxyfuel gas flame, abrasive shot blasting, or other suitable means.

5.6.3 When welding galvanized surfaces, suitable ventilation shall be provided to prevent the concentration of fumes. See ANSI/ASC Z49.1, *Safety in Welding and Cutting*, and Appendix D.

5.6.4 When welding or preheating epoxy coated base metal, the epoxy coating shall be removed from the surfaces to be heated.

Table 5.1
Matching Filler Metals Requirements
(See 5.1)

Group	Steel Specification Requirements				Filler Metal Requirements			
	Steel Specification	Minimum Yield Point/Strength ksi	Minimum Tensile Strength ksi	Minimum Tensile Strength MPa	Electrode Specification ⁴	Yield Point/Strength ¹ ksi	Yield Point/Strength ¹ MPa	Tensile Strength ¹ ksi
I	ASTM A615 Grade 40	40	70	—	SMAW AWS A5.1 and A5.5 E7015, E7016, E7018, E7028, E7015-X, E7016-X, E7018-X	60	415	72
	ASTM A615M Grade 300	—	300	500		57	390	70
	ASTM A617 Grade 40	40	70	—	GMAW AWS A5.18 ER70S-X	60	415	72
	ASTM A617M Grade 300	—	300	500	FCAW AWS A5.20 E7XT-X (Except -2, -3, -10, -GS)	60	415	72
II	ASTM A616 Grade 50	50	80	—	SMAW AWS A5.5 E8015-X, E8016-X, E8018-X	67	460	80
	ASTM A616M Grade 350	—	350	550				550
	ASTM A706 Grade 60	60	80	—	GMAW AWS A5.28 ER80S-X	68	470	80
	ASTM A706M Grade 400	—	400	550	FCAW AWS A5.29 E8XTX-X	68	470	80-100
III	ASTM A615 Grade 60	60	90	—	SMAW AWS A5.5 E9015-X, E9016-X, E9018-X	77	530	90
	ASTM A615M Grade 400	—	400	600				620
	ASTM A616 Grade 60	60	90	—	GMAW AWS A5.28 ER90S-X	78	540	90
	ASTM A616M Grade 400	—	400	600				620
	ASTM A617 Grade 60	60	90	—	FCAW AWS A5.29 E9XTX-X	78	540	90-110
	ASTM A617M Grade 400	—	400	600				620-760

(Continued)

Table 5.1
(Continued)

G r o u p	Steel Specification Requirements				Filler Metal Requirements			
	Steel Specification	Minimum Yield Point/Strength ksi	Minimum Tensile Strength ksi	Minimum Yield Point/Strength ¹ MPa	Electrode Specification ⁴	Yield Point/Strength ¹ ksi	Yield Point/Strength ¹ MPa	Tensile Strength ¹ ksi
IV	ASTM A615 Grade 75 ²	75	100	—	SMAW AWS A5.5 E10015-X, E10016-X, E10018-X	87	600	100
					E10018-M	88-100	610-690	100
	ASTM A615M Grade 500 ³	—	500	700	GMAW AWS A5.28 ER100S-X	88-102	610-700	100
					FCAW AWS A5.29 E10XTX-X	88	610	100-120

Notes:

1. This table is based on filler metal as-welded properties. Single values are minimums. Hyphenated values indicated minimum and maximum.
2. Applicable to bar sizes Nos. 11, 14, and 18.
3. Applicable to bar sizes Nos. 35, 45, and 55.
4. Filler metals classified in the postweld heat treated (PWHT) condition by the AWS filler metal specification may be used when given prior approval by the Engineer. Consideration shall be made of the differences in tensile strength, ductility and hardness between the PWHT versus as-welded condition.

Table 5.2
Minimum Preheat and Interpass Temperature^{1,2}
(see 5.2.1)

Carbon Equivalent ^{3,4} (C.E.) Range, %	Size of Reinforcing Bar	Shielded Metal Arc Welding with Low Hydrogen Electrodes, Gas Metal Arc Welding, or Flux Cored Arc Welding	
		Minimum Temperature	
		°F	°C
Up to 0.40	up to 11 inclusive 14 and 18	none ⁵ 50	none ⁵ 10
Over 0.40 to 0.45 inclusive	up to 11 inclusive 14 and 18	none ⁵ 100	none ⁵ 40
Over 0.45 to 0.55 inclusive	up to 6 inclusive 7 to 11 inclusive 14 to 18	none ⁵ 50 200	none ⁵ 10 90
Over 0.55 to 0.65 inclusive	up to 6 inclusive 7 to 11 inclusive 14 to 18	100 200 300	40 90 150
Over 0.65 to 0.75	up to 6 inclusive 7 to 18 inclusive	300 400	150 200
Over 0.75	7 to 18 inclusive	500	260

1. When reinforcing steel is to be welded to main structural steel, the preheat requirements of the structural steel shall also be considered (see ANSI/AWS D1.1, table titled "Minimum Preheat and Interpass Temperature." The minimum preheat requirement to apply in this situation shall be the higher requirement of the two tables. However, extreme caution shall be exercised in the case of welding reinforcing steel to quenched and tempered steels, and such measures shall be taken as to satisfy the preheat requirements for both. If not possible, welding shall not be used to join the two base metals.
2. Welding shall not be done when the ambient temperature is lower than 0°F (-18°C). When the base metal is below the temperature listed for the welding process being used and the size and carbon equivalent range of the bar being welded, it shall be preheated (except as otherwise provided) in such a manner that the cross section of the bar for not less than 6 in. (150 mm) on each side of the joint shall be at or above the specified minimum temperature. Preheat and interpass temperatures shall be sufficient to prevent crack formation.
3. After welding is complete, bars shall be allowed to cool naturally to ambient temperature. Accelerated cooling is prohibited.
4. Where it is impractical to obtain chemical analysis, the carbon equivalent shall be assumed to be above 0.75%. See also 1.3.4.
5. When the base metal is below 32°F (0°C), the base metal shall be preheated to at least 70°F (20°C), or above, and maintained at this minimum temperature during welding.

5.7 Electrodes for Shielded Metal Arc Welding

5.7.1 Electrodes for shielded metal arc welding shall conform to the requirements of the latest edition of ANSI/AWS A5.1, *Specification for Covered Carbon Steel Arc Welding Electrodes*, or to the requirements of ANSI/AWS A5.5, *Specification for Low Alloy Steel Covered Arc Welding Electrodes*.

5.7.2 Low Hydrogen Electrode Storage Conditions. All electrodes in Table 5.1 have low hydrogen coatings. Those electrodes conforming to ANSI/AWS A5.1 and A5.5 shall be purchased in hermetically sealed containers or shall be dried in accordance to manufacturer's instructions. Electrodes shall be dried prior to use if the hermetically sealed container shows evidence of damage. Immediately after opening of the hermetically sealed

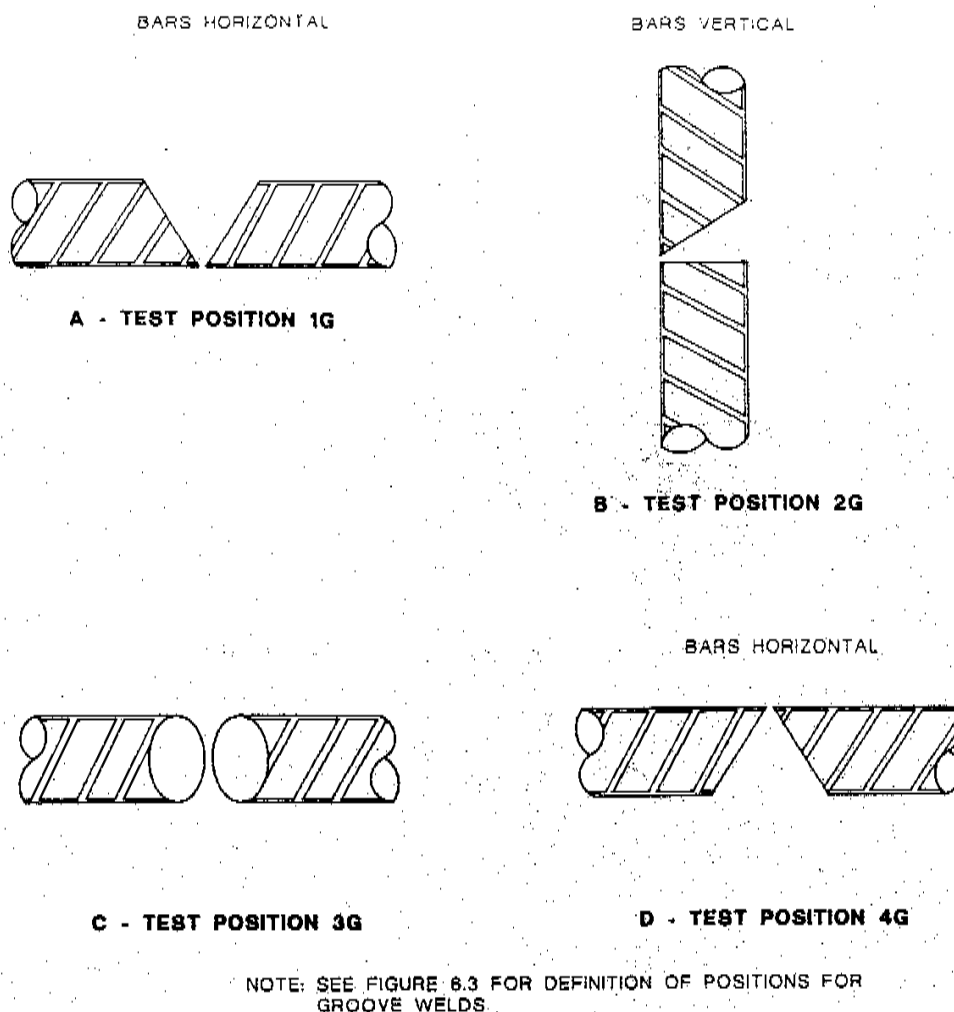


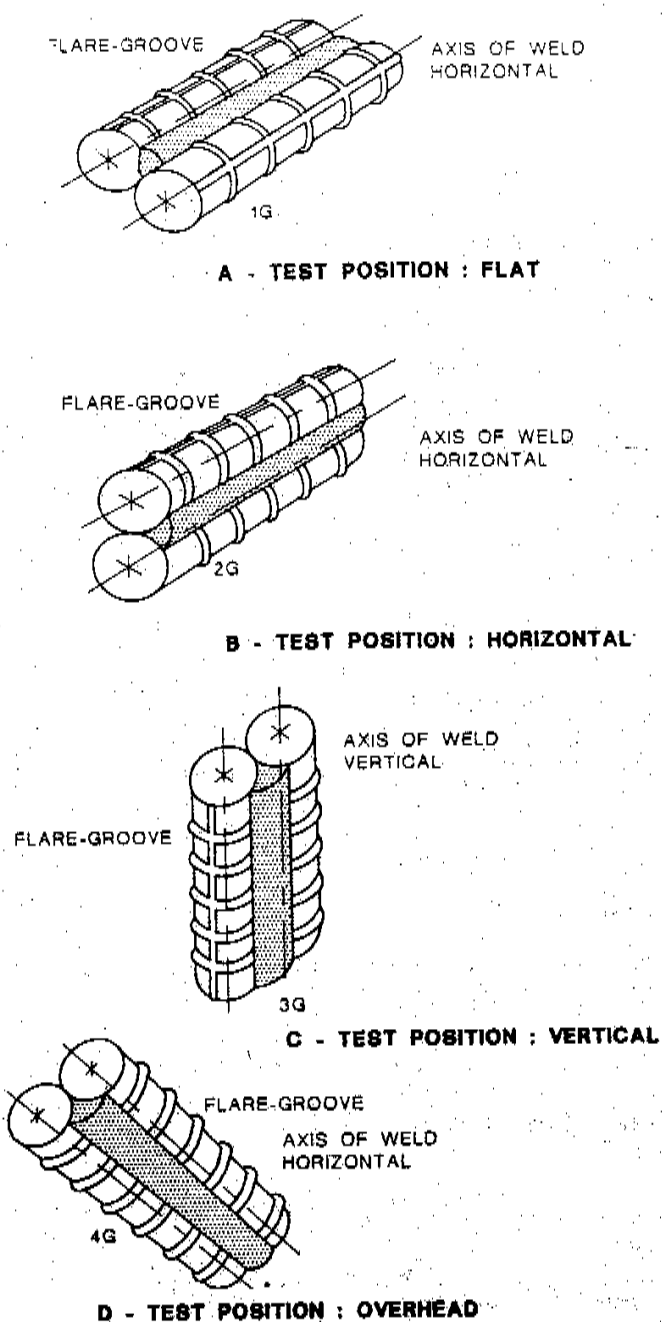
Figure 6.1 — Direct Butt Joint Test Positions for Groove Welds (See 6.2.4.1)

container or removal of the electrodes from drying ovens, electrodes shall be stored in ovens held at a temperature of at least 250°F (120°C). After the opening of hermetically sealed containers or removal from drying or storage ovens, electrode exposure to the atmosphere shall not exceed the requirements of either 5.7.2.1 or 5.7.2.2.

5.7.2.1 Approved Atmospheric Exposure Time Periods. After hermetically sealed containers are

opened or after electrodes are removed from drying or storage ovens, the electrode exposure to the atmosphere shall not exceed the values shown in Column A, Table 5.3, for the specific electrode classification.

5.7.2.2 Alternative Atmosphere Exposure Hours Established by Tests. The alternative exposure time values shown in Column B in Table 5.3 may be used provided testing establishes the maxi-



NOTE: SEE FIGURES 6.3 AND 6.4 FOR DEFINITIONS OF POSITIONS FOR FLARE-GROOVE AND FILLET WELDS.

Figure 6.2 — Indirect Butt Joint Test Positions for Flare-Groove Welds or Fillet Welds (See 6.2.4.2)

Table 5.3
Permissible Atmospheric Exposure of Low-Hydrogen Electrodes
(See 5.7.2.1)

Electrode	Column A (hours)	Column B (hours)
A5.1		
E70XX	4 max	over 4 to 10 max
A5.5		
E70XX-X	4 max	over 4 to 10 max
E80XX-X	2 max	over 2 to 10 max
E90XX-X	1 max	over 1 to 5 max
E100XX-X	1/2 max	over 1/2 to 4 max
E110XX-X	1/2 max	over 1/2 to 4 max

Notes:

1. Column A: Electrodes exposed to the atmosphere for longer periods than shown shall be redried before use.
2. Column B: Electrode exposure to the atmosphere for longer periods than those established by test shall be redried before use.
3. Entire Table: Electrodes shall be issued and held in quivers, or other small containers which may be open. Heated containers are not mandatory.

imum allowable time. The testing shall be performed in accordance with ANSI/AWS A5.5, subsection 3.10, for each electrode classification and each electrode manufacturer. Such tests shall establish that the maximum moisture content values of ANSI/AWS A5.5 (table titled "Coating Moisture Content Requirements") are not exceeded. Additionally, E70XX or E70XX-X (ANSI/AWS A5.1 or A5.5) low hydrogen electrode coverings shall be limited to a maximum moisture content not exceeding 0.4% by weight.

Those electrodes that are used for Column B hours shall not be used at relative humidity — temperature combinations that exceed either the relative humidity or moisture content in the air that prevailed during the testing program.⁴

5.7.2.3 Electrodes exposed to the atmosphere for periods less than those permitted by Table 5.3

4. For proper application of this provision, see the latest edition of ANSI/AWS D1.1, appendix titled "Temperature-Moisture Content Requirements" for the temperature-moisture content chart and its examples. The chart shown in the latest edition of ANSI/AWS D1.1, in the aforementioned appendix, or any standard psychrometric chart, should be used in the determination of temperature-relative humidity limits.

may be returned to a holding oven maintained at 250°F (121°C) min; after a minimum holding period of four hours at 250°F min the electrodes may be reissued.

5.7.3 Electrode Restrictions for ASTM A514 or A517 Steels. When used for welding ASTM A514 or A517 steels, electrodes of any classification lower than E100XX-X shall be dried at least one hour at temperatures between 700°F and 800°F (370°C and 430°C) before being used, whether furnished in hermetically sealed containers or otherwise.

5.7.4 Redrying Electrodes. Electrodes that conform to the provisions of 5.7.2 shall subsequently be redried no more than one time. Electrodes that have been wet shall not be used.

5.7.5 Manufacturer's Certification. When requested by the Engineer, the contractor shall furnish an electrode manufacturer's certification that the electrode will meet the requirements of the classification.

5.8 Electrodes and Shielding Gas for Gas Metal Arc and Flux Cored Arc Welding

5.8.1 Electrodes

5.8.1.1 The electrodes and the shielding for GMAW or FCAW, for producing weld metal with minimum specified yield strengths of 60 ksi (415 MPa) or less, shall conform to the requirements of the latest edition of ANSI/AWS A5.18, *Specification for Carbon Steel Filler Metals for Gas Shielded Arc Welding*, or ANSI/AWS A5.20, *Specification for Carbon Steel Electrodes for Flux Cored Arc Welding*, as applicable.

5.8.1.2 Weld metal having a minimum specified yield strength greater than 60 ksi (415 MPa) shall conform to the following requirements:

(1) The electrodes and shielding for gas metal arc welding for producing weld metal with a minimum specified yield strength greater than 60 ksi (415 MPa) shall conform with the latest edition of ANSI/AWS A5.28, *Specification for Low Alloy Steel Filler Metals for Gas Shielded Arc Welding*.

(2) The electrodes and shielding gas for flux cored arc welding for producing weld metal with a minimum specified yield strength greater than 60 ksi (415 MPa) shall conform to the latest edition of ANSI/AWS A5.29, *Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding*.

(3) When requested by the Engineer, the contractor shall furnish the electrode manufacturer's certification that the electrode will meet the above requirements of classification.

5.8.2 Shielding Gas. When a gas or gas mixture is used for shielding in gas metal arc or flux cored arc welding, it shall be of a welding grade having a dew point of -40°F (-40°C) or lower. When requested by the Engineer, the gas manufacturer shall furnish certification that the gas or gas mixture will meet the dew point requirement.

6. Qualification

6.1 General

6.1.1 Responsibility

6.1.1.1 All welding performed to contracts involving ANSI/AWS D1.4 shall utilize written welding procedure specifications that meet the requirements of this code.

6.1.1.2 Each contractor shall conduct the tests required by section 6 to qualify the welding proce-

dures and the welders who will apply these procedures.

6.1.1.3 At the Engineer's discretion, evidence of previous qualification of the welding procedures and welders to be employed may be accepted.

6.1.2 Welding Procedures

6.1.2.1 Welding procedures for reinforcing bar joints, anchorage, base plate, and insert connections that are to be employed in executing contract work under this section shall be established in a procedure specification and shall be qualified prior to use by tests as prescribed in 6.2 to the satisfaction of the Engineer.

6.1.2.2 Subject to the approval of the Engineer, welding procedures meeting the requirements of this code may be used for work being performed under the provisions of previous editions of this code and AWS D12.1.

6.1.2.3 Welding procedure qualification shall be required for complete joint penetration groove welds and flare-groove welds for each welding position (see Figures 6.1 and 6.2.)

6.1.2.4 Welding procedures for fillet welds which conform to the applicable provisions of sections 1 through 5 of this code shall be exempt from qualification.

6.1.2.5 Each joint welding procedure shall be prepared by the contractor as a procedure specification and shall be available to those authorized to examine them. A suggested form showing the information required in the procedure specification is given in Appendix A.

6.1.2.6 Welding procedure qualifications performed prior to publication of this edition of the code may be updated to the requirements of this code, provided the variables required by this edition of the code were previously recorded.

6.1.3 Welders

6.1.3.1 All welders to be employed under this code shall have been qualified by tests as prescribed in 6.3.

6.1.3.2 Welders who successfully complete a procedure qualification for either complete joint penetration groove welds or flare-groove welds

shall be considered qualified for welding the type of weld joint used in the procedure qualification and other joint types as permitted in 6.3.3.2. The position of welding may be changed to the extent permitted by 6.3.4.

6.1.3.3 Subject to the approval of the Engineer, welders who qualify to the requirements of this edition of the code may be used for work being performed under provisions of previous editions of this code.

6.2 Welding Procedure Qualification

6.2.1 Limitation of Variables

6.2.1.1 The largest bar size to be production welded shall be used for qualification. Qualification for each specification and grade of reinforcing bar is not required.

6.2.1.2 Procedure qualification shall be performed using a steel that has a carbon equivalent (C.E.) at least equal to the highest C.E. to be encountered in production. The procedure is then qualified for the highest C.E. value qualified and all lower values.

6.2.1.3 A change from uncoated bars or steel to coated bars or steel where the coating lies within 2 in. (50 mm) of the weld joint preparation, shall require requalification.

6.2.1.4 Changes in 6.2.1.5 through 6.2.1.7 shall be considered changes in essential variables. Joint welding procedures including such changes shall require requalification.

6.2.1.5 Preheat and Interpass Temperature. A decrease of more than 25°F (14°C) in the minimum specified preheat or interpass temperature shall require requalification.

6.2.1.6 Shielded Metal Arc Welding

(1) A change increasing filler metal strength level, e.g., a change from E70XX to E80XX-X, but not vice versa

(2) An increase in the diameter of the electrode used over that required by the welding procedure specification

5. The 2 in. limit should keep any coating from melting and contaminating the weld where the bars are in the vertical plane.

(3) A change of electrode amperage and voltage values that are not within the ranges recommended by the electrode manufacturer

(4) A change in position in which welding is performed as defined in 6.2.4.1 and 6.2.4.2

(5) A change in the type of groove, e.g., a change from a flare-V-groove to flare-bevel-groove

(6) A change in the shape of any one type of groove involving:

(a) A decrease in the included angle of the groove exceeding 5°

(b) A decrease in the root opening of the groove exceeding 1/16 in. (1.6 mm)

(c) An increase in the root face of the groove exceeding 1/16 in. (1.6 mm)

(d) The omission, but not inclusion, of backing material

6.2.1.7 Gas Metal Arc Welding and Flux Cored Arc Welding

(1) A change in electrode or method of shielding not covered by ANSI/AWS A5.18 (GMAW), ANSI/AWS A5.20 (FCAW), ANSI/AWS A5.28 (GMAW), or ANSI/AWS A5.29 (FCAW)

(2) A change increasing filler metal strength level; e.g., E70S to E80S, or E70T to E80T, respectively, but not vice versa

(3) A change in electrode diameter in GMAW, or an increase in the diameter of the electrode used over that required by the welding procedure specification for FCAW

(4) Change from a single gas to any other single gas or to a mixture of gases or a change of more than 25% in any of the minor elements of the gas mixture; or change from a gas mixture to a single gas; or change from external shielding gas to self shielding, i.e., no external shielding gas

(5) A change of more than 10% above or below the specified mean amperage for each size electrode used

(6) A change of more than 7% above or below the specified mean arc voltage for each size electrode used

(7) A change of more than 10% above or below the specified mean travel speed

(8) An increase of 25% or more or a decrease of 10% or more in the rate of flow of shielding gas or mixture

(9) A change in the position in which welding is performed as defined in 6.2.4.1 and 6.2.4.2

(10) A change in the type of groove; e.g., a change from a flare-V- to flare-bevel-groove

(11) A change in the shape of any one type of groove involving:

(a) A decrease in the included angle of the groove exceeding 5° , or

(b) A decrease in the root opening of the groove exceeding 1/16 in. (1.6 mm), or

(c) An increase in the root face of the groove exceeding 1/16 in. (1.6 mm), or

(d) The omission, but not inclusion, of backing material

(12) A change in the type of welding current (AC or DC), polarity, or mode of metal transfer across the arc

6.2.2 Types of Tests and Their Purposes. The tests listed below are to determine the tensile strength and degree of soundness of welded joints made under a given procedure specification:

(1) Full section tension test (for tensile strength)

(2) Macroetch test (for soundness)

6.2.3 Base Metal and Its Preparation. The base metal and its preparation for welding shall comply with the welding procedure specification.

6.2.4 Position of Test Welds

6.2.4.1 All direct butt joints and T-joints shall be classified in accordance with definitions of welding positions for groove welds and shall be welded in the position for which the procedure is to be qualified (see Figures 6.1 and 6.3).

6.2.4.2 All indirect butt joints, lap joints, and lap joints in connections involving either flare-groove or fillet welds shall be classified in accordance with definitions of welding positions for flare-groove welds, and shall be welded in the position for which the procedure is to be qualified (see Figures 6.2, 6.3, and 6.4).

6.2.5 Test Assemblies Number, Type and Preparation

6.2.5.1 Number and Type of Test Assemblies. The number and type of assemblies that shall be tested to qualify a welding procedure are shown in Table 6.1

6.2.5.2 Test assemblies for groove welds in T-joints may be either direct butt joints having the same groove configuration as the T-joint to be used in construction, or the T-joint assembly shown in Figure 6.5(B).

6.2.5.3 Tension Test Assemblies. The size and length of tension test assemblies shall be as follows:

(1) Direct Butt Joint and T-Joint. Unless a greater length is required for testing, welded test assemblies for direct butt joints shall have a minimum length of at least 16 times the diameter of the bar, with the weld located centrally [see Figures 6.5(A) and 6.5(B), as appropriate].

(2) Indirect Butt Joint. For indirect butt joint welded test assemblies, the minimum length in (1) above shall be increased by the length of the joint [see Figure 6.5(C)]. The length of the connecting welds shall be such that the total shear capacity is equal to 0.6 times the minimum specified tensile strength times the nominal area of the solid bar. Note that for two bars of unequal tensile strengths, the lesser of the two values shall be used.

6.2.5.4 Macroetch Specimens. The macroetch test specimen may be removed from the remnant of the tension test assembly and shall be prepared as follows:

(1) Direct Butt Joints and T-Joints. The welded test assembly shall be mechanically cut at one location perpendicular to the direction of welding. The test specimen shall show the full longitudinal cross section of the weldment, the root of the weld, and any reinforcement. [See Figures 6.5(A) or 6.5(B), as appropriate].

(2) Indirect Butt Joints. The welded test assembly shall be mechanically cut at two locations transverse to the direction of welding. These specimens shall show the full transverse cross section of the weldment in each of the welded bars. [See Figure 6.5(C)].

6.2.6 Method of Testing Specimens

6.2.6.1 Full Section Tension Test. The minimum distance between the jaws of the testing machine shall be equal to:

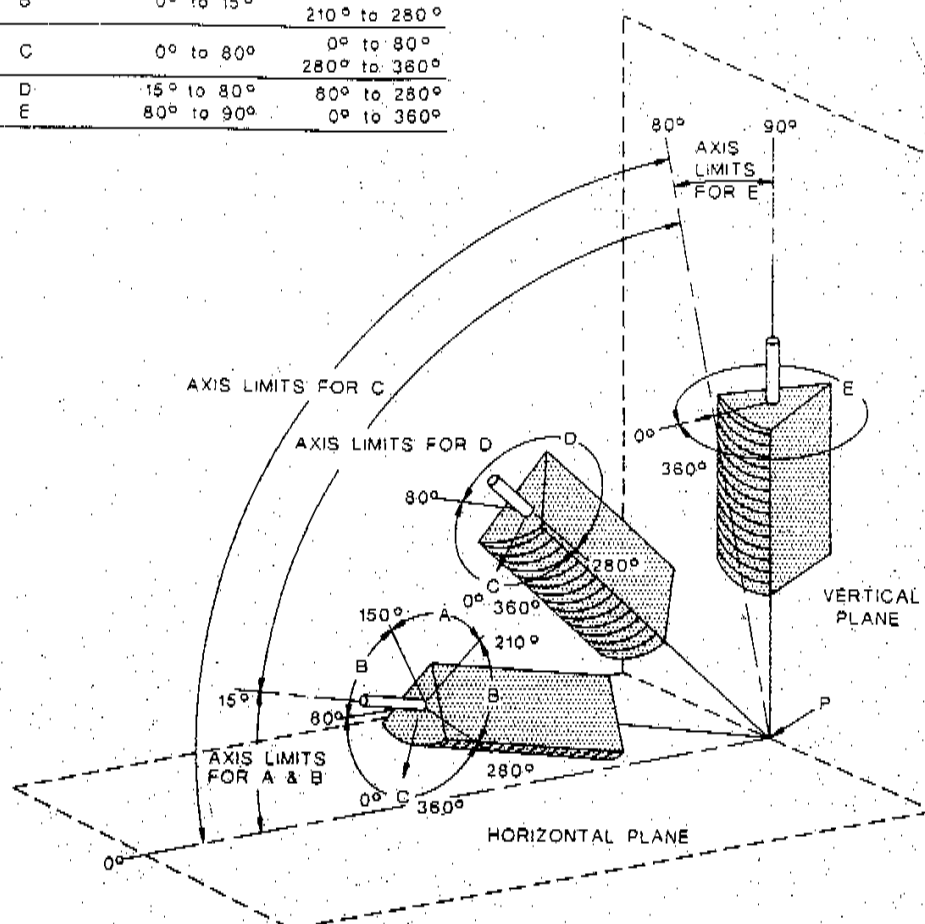
(1) At least eight times the diameter of the bars for direct butt joints

(2) At least eight times the diameter of the bar, plus the length of the joint for indirect butt joints

The test specimen shall be ruptured under tension load, and the maximum load shall be determined. The tensile strength shall be obtained by dividing the maximum load by the nominal cross-sectional area of the bar.

6.2.6.2 Macroetch Test. All cross sections shall be polished and etched with a suitable solution to give a clear definition of the weld.

TABULATION OF POSITIONS OF GROOVE WELDS			
POSITION	DIAGRAM REFERENCE	INCLINATION OF AXIS	ROTATION OF FACE
FLAT	A	0° to 15°	150° to 210°
HORIZONTAL	B	0° to 15°	80° to 150° 210° to 280°
OVERHEAD	C	0° to 80°	0° to 80° 280° to 360°
VERTICAL	D	15° to 80°	80° to 280°
	E	80° to 90°	0° to 360°



Notes:

1. The horizontal reference plane is always taken to lie below the weld under consideration.
2. The inclination of axis is measured from the horizontal reference plane toward the vertical reference plane.
3. The angle of rotation of the face is determined by a line perpendicular to the theoretical face of the weld which passes through the axis of the weld. The reference position (0°) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. When looking at point P, the angle of rotation of the face of the weld is measured in a clockwise direction from the reference position (0°).

Figure 6.3 — Positions of Groove Welds

TABULATION OF POSITIONS OF FILLET WELDS			
POSITION	DIAGRAM REFERENCE	INCLINATION OF AXIS	ROTATION OF FACE
FLAT	A	0° to 15°	150° to 210°
HORIZONTAL	B	0° to 15°	125° to 150° 210° to 235°
OVERHEAD	C	0° to 80°	0° to 125° 235° to 360°
VERTICAL	D	15° to 80°	125° to 235°
	E	80° to 90°	0° to 360°

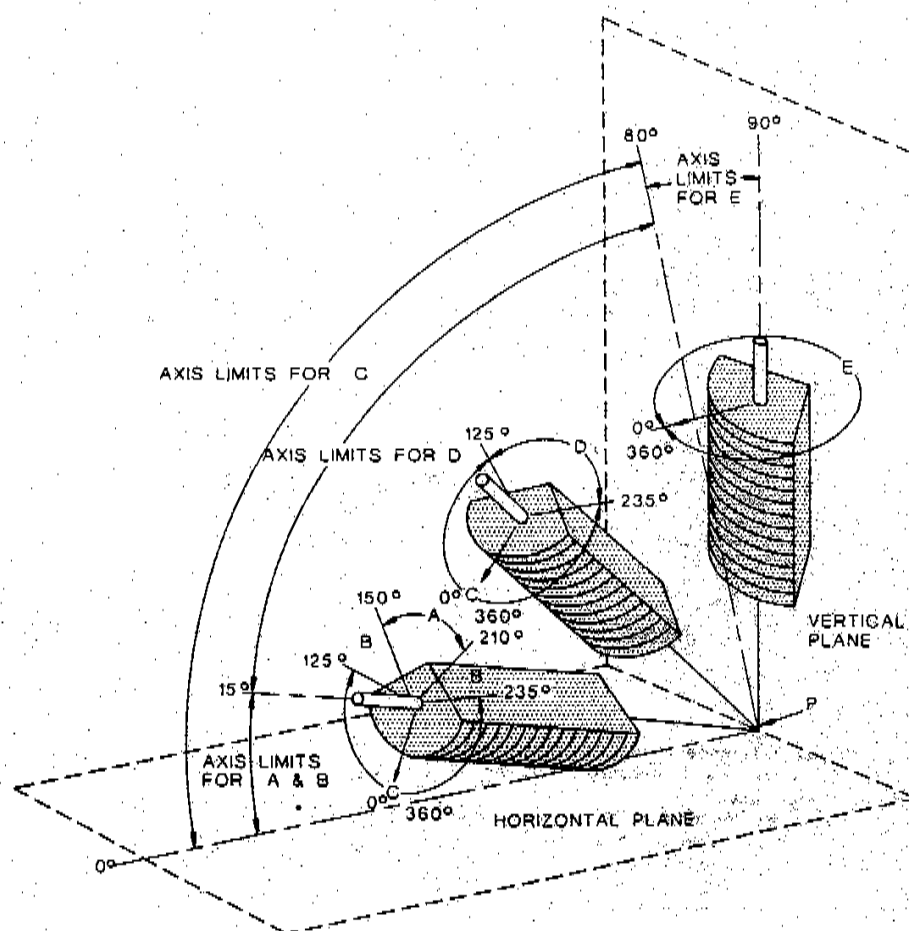
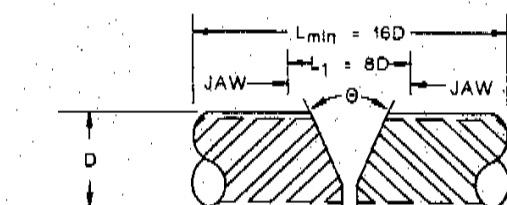


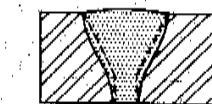
Figure 6.4 — Positions of Fillet Welds

Table 6.1
Number and type of tests for procedure qualification
(See 6.2.5.1)

Type of Joint (Figure)	Min. No. of Test Assemblies	Production		Joints Qualified (Figure)
		Tension Tests 6.2.5.3	Macro-etch Tests 6.2.5.4	
Direct Butt [6.5(A)]	2	2	2	3.1, 3.2, 3.3(D)
T-Joint [6.5(B)]	2	2	2	3.1, 3.3(D)
Indirect Butt [6.5(C)]	2	2	2	3.3, 3.4 3.5(E)

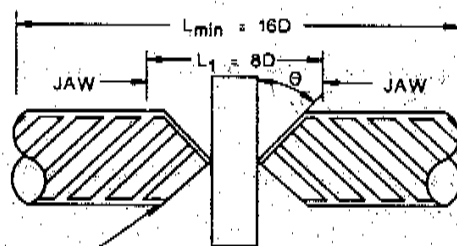


GROOVE CONFIGURATION SHOWN IS FOR ILLUSTRATION ONLY. THE GROOVE USED SHALL CONFORM TO THAT BEING QUALIFIED.

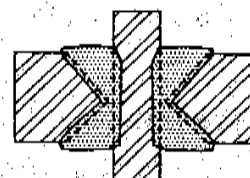


MACROETCH SPECIMEN OF WELDED JOINT

A - COMPLETE JOINT PENETRATION GROOVE WELD-DIRECT BUTT JOINT



GROOVE CONFIGURATION SHOWN IS FOR ILLUSTRATION ONLY. THE GROOVE USED SHALL CONFORM TO THAT BEING QUALIFIED.



MACROETCH SPECIMEN OF WELDED JOINT

B - ALTERNATE COMPLETE JOINT PENETRATION GROOVE WELD - T-JOINT

Figure 6.5 — Full Section Tension Test Specimens for Procedure Qualification Tests (See 6.2.5)

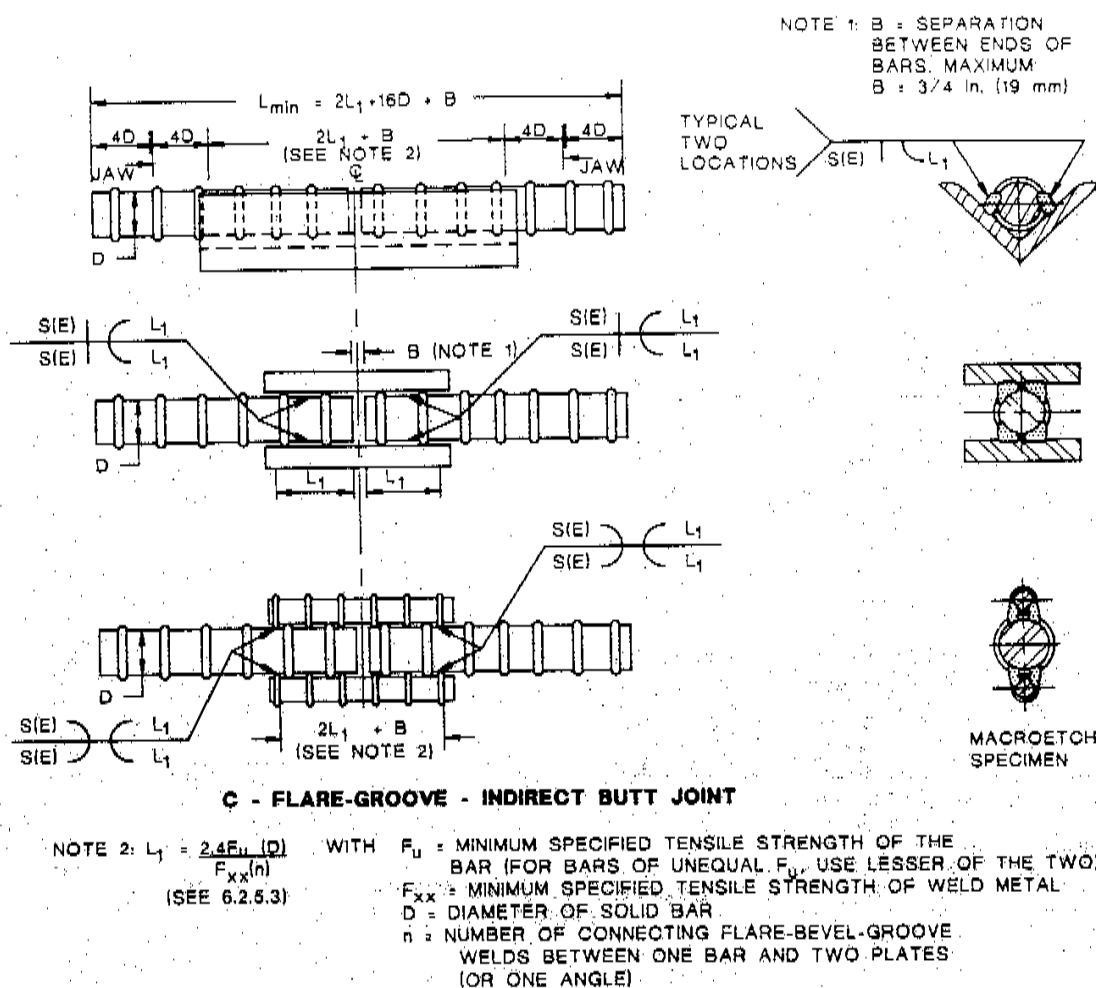


Figure 6.5 (continued) — Full Section Tension Test Specimens for Procedure Qualification Tests (See 6.2.5)

6.2.7 Test Results Required

6.2.7.1 Full Section Tension Test. The tensile strength shall be no less than 125% of the minimum specified yield strength of the type and grade of bars to be joined, unless otherwise stipulated by the general specification.

6.2.7.2 Macroetch Test. The specimens shall be examined for discontinuities, and any that have discontinuities prohibited by 4.4 shall be considered as failed. The etched cross sections shall have complete penetration and complete fusion with the

base metal for single-V- or double-V-groove welds. For flare-bevel- and flare-V-groove welds, the designated weld size shall be obtained.

6.3 Welder Qualification

6.3.1 The qualification tests described here are especially devised to determine the welder's ability to produce sound welds. It is not intended that the qualification tests be used as a guide for welding during actual construction. The latter shall be performed in accordance with the requirements of the procedure specification.

6.3.2 Limitation of Variables

6.3.2.1 Qualification with a particular process and with any of the steels permitted by this code shall be considered as qualification to weld any of the other approved steels with that process except that qualification for galvanized steel shall be performed using galvanized steel. Qualification for galvanized steel shall be with galvanized steel.

6.3.2.2 A welder shall be qualified for each process to be used in fabrication.

6.3.2.3 A welder qualified with an approved electrode and shielding medium combination shall be considered qualified to weld with any other approved electrode and shielding medium combination (see Table 5.1) for the process used in the qualification test.

6.3.2.4 A change in the position of welding to one for which the welder is not qualified requires qualification in that position.

6.3.3 Qualification Tests Required

6.3.3.1 A welder may also be qualified for fillet welding of anchorage, base plate and insert plate connections (Figure 3.5) by welding a satisfactory test in accordance with the provisions of 6.3.3.3(2).

6.3.3.2 Qualification tests for welders shall be as follows:

(1) Direct butt joint groove weld test made using SMAW, GMAW, or FCAW processes qualifies for complete joint penetration groove welds and for fillet welds.

(2) Indirect butt joint flare-groove weld test made using SMAW, GMAW or FCAW processes. This test qualifies welders for welding indirect butt joints, lap joints, and for fillet welds.

(3) Complete joint penetration groove weld, T-joint made using SMAW, GMAW, or FCAW processes qualifies welders for welding complete joint penetration groove welds (both direct butt joints and T-joints) and fillet welds.

6.3.3.3 The qualification test assembly shall have joint details as follows:

(1) The direct butt joint groove weld test assembly shall be a complete joint penetration groove weld made by SMAW, GMAW, or FCAW processes. See Figure 6.6(A). The smallest bar size to be fabricated shall be used.

(2) The indirect butt joint flare-groove weld test shall be an indirect butt joint made by SMAW, GMAW, or FCAW processes using a double-flare-bevel-groove and flat bar, as shown in Figure 6.6(B).

(3) The complete joint penetration T-joint made by SMAW, GMAW, or FCAW processes shall be as shown in Figure 6.6(C).

6.3.4 Position of Test Welds and Related Validity of Qualification

6.3.4.1 Direct Butt Joint Groove Weld Test

(1) Qualification in the 1G (flat) position qualifies for direct butt joints in the 1G flat position, and for fillet welds in the 1F (flat) and 2F (horizontal) positions (see Figure 6.1).

(2) Qualification in the 2G (horizontal) position qualifies for direct butt joints in the 1G (flat) and 2G (horizontal) positions and for fillet welds in 1F (flat) and 2F (horizontal) positions (see Figure 6.1).

(3) Qualification in the 3G (vertical) position qualifies for direct butt joints in the 1G (flat), 2G (horizontal), and 3G (vertical) positions; and for fillet welds in the 1F (flat), 2F (horizontal), and 3F (vertical) positions (see Figure 6.1).

(4) Qualification in the 4G (overhead) position qualifies for direct butt joints in the 1G (flat) and 4G (overhead) positions and for fillet welds in 1F (flat), 2F (horizontal), and 4F (overhead) positions (see Figure 6.1).

6.3.4.2 Indirect Butt Joint Flare-Groove Weld Test

(1) Qualification in the 1G (flat) position qualifies for indirect butt joints and lap joints in the 1G (flat) position, and for fillet welds in 1F (flat), and 2F (horizontal) positions (see Figure 6.2).

(2) Qualification in the 2G (horizontal) position qualifies for indirect butt joints and lap joints in the 1G (flat) and 2G (horizontal) positions and for fillet welds in 1F (flat), and 2F (horizontal) positions (see Figure 6.2).

(3) Qualification in the 3G (vertical) position qualifies for indirect butt joints and lap joints in the 1G (flat), 2G (horizontal), and 3G (vertical) positions and for fillet welds in the 1F (flat), 2F (horizontal), and 3F (vertical) positions (see Figure 6.2).

(4) Qualification in the 4G (overhead) position qualifies for indirect butt joints and lap joints in the 1G (flat) and 4G (overhead) positions and for fillet welds in 1F (flat), 2F (horizontal), and 4F (overhead) positions (see Figure 6.2).

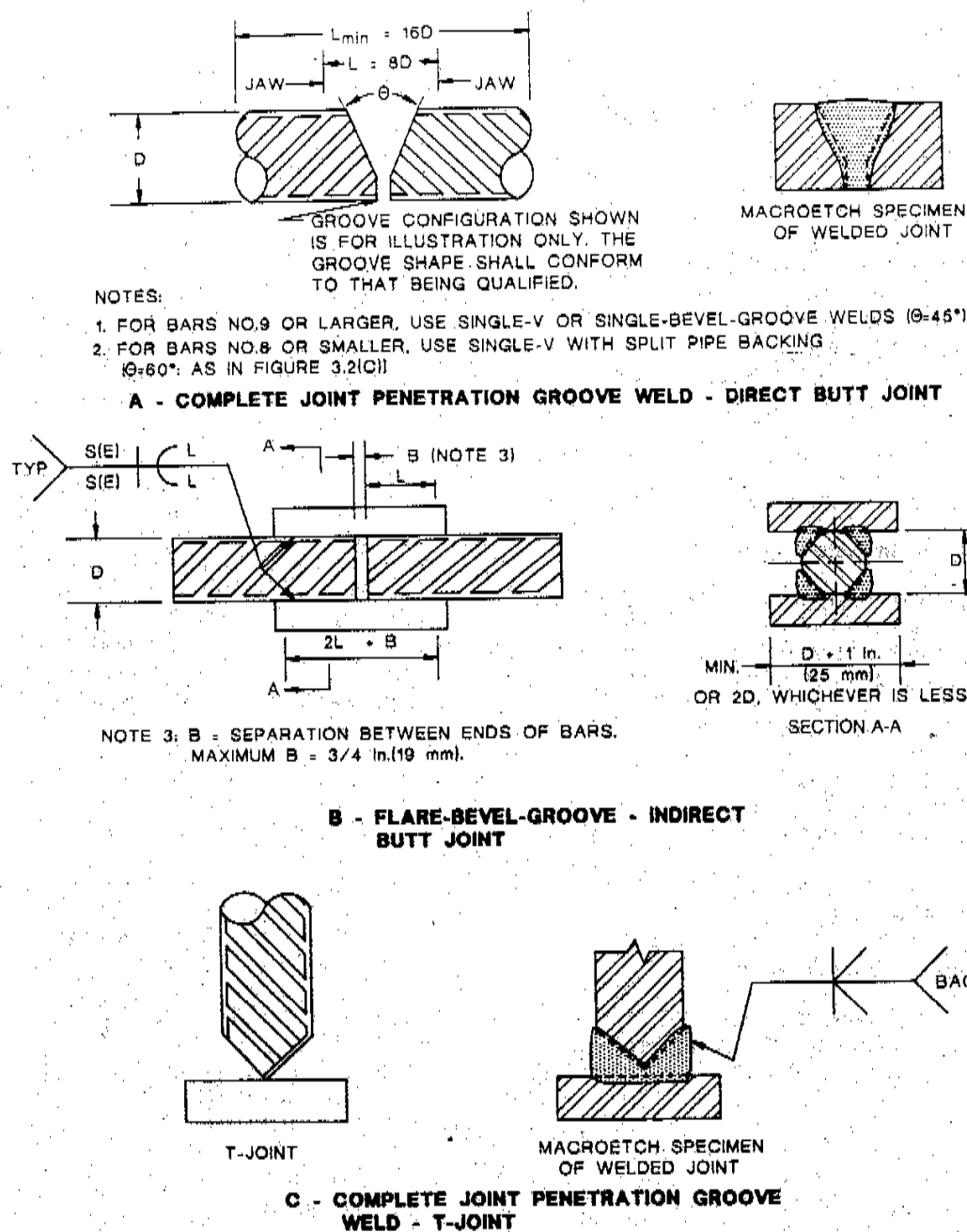


Figure 6.6 — Full Section Tension Test and Macroetch Test Specimens for Welder Qualification Tests (See 6.3.3.3)

6.3.4.3 T-Joint Groove Weld Test. The position requirements for groove welds shall govern the weld position qualified by the welder (see Figure 6.1).

6.3.5 Qualified Bar Sizes. The smallest bar size used in qualification shall qualify the welder for welding that bar size and any larger size.

6.3.6 Base Metal. The base metal used shall comply with 1.2 or the procedure specification. The base metal may be uncoated or galvanized, as required by 6.3.2.1.

6.3.7 Welding Procedure. The welder shall follow the welding procedure specified by the procedure specification.

6.3.8 Test Specimens — Number, Type, and Preparation

6.3.8.1 The number and type of test assemblies that shall be tested to qualify a welder are shown in Table 6.2. Two test assemblies welded in accordance with 6.3.3.3 are required to qualify welders.

6.3.8.2 Direct Butt Joints. Direct butt joint welded test assemblies made by GMAW (except short circuiting transfer), SMAW, or FCAW, shall be tested by radiography; or one test assembly shall be subjected to the full section tension test and the other test assembly to the macroetch test. Radiography shall not be used on joints where split pipe backing is used.

6.3.8.3 Direct Butt Joints By GMAW-S. Direct butt joint welded test assemblies made by GMAW using short circuiting transfer shall have one test assembly subjected to the full section tension test and the other to the macroetch test.

6.3.8.4 Indirect Butt Joints. Both indirect butt joint welded test assemblies shall be subjected to the macroetch test.

6.3.8.5 T-Joint Test Assembly. The two welded T-joint test assemblies shall both be subjected to the macroetch test.

6.3.8.6 Tension Test Specimens. Unless a greater length is required for testing, the full section tension test specimen for direct butt joints shall have a minimum length of at least 16 times

Table 6.2
Number and Type of Tests and Weld Qualified for Welder Qualification
(See 6.3.8.1)

Qualification Test Assembly	Number of Test Assemblies Required	Welds Qualified for	Number and Type of Tests Required			
			Radiography (6.3.8.2)	Tension (6.3.9.1)	Macroetch (6.3.9.2)	
Direct butt joint Fig. 6.6(A)	2	Fig. 3.1 Fig. 3.2 and Fig. 3.5(D)	2 ^a	or 1 ^b	+	1 ^b
Indirect butt joint Fig. 6.6(B)	2	Fig. 3.3 Fig. 3.4 Fig. 3.5(A) (B),(C),(E)	—	—		2
Complete joint penetration T-joint Fig. 6.6(C)	2	Fig. 3.1 or Fig. 3.5(D)	—	—		2

Notes:

- Radiography not permitted for welds made by GMAW using short circuiting transfer.
- Required for welds made by GMAW using short circuiting transfer. Tension and macroetch tests may be used in lieu of radiography for all other welding processes, at contractor's option.

the diameter of the bar with the weld centrally located [see Figure 6.6(A)].

6.3.8.7 Tension Test Specimen With Split Pipe Backing. The split pipe backing need not be removed for tension testing.

6.3.8.8 Macroetch Test Specimens. Macroetch test specimens shall be prepared as follows (see Figure 6.5):

(1) **Direct Butt and T-Joints.** The test assembly shall be mechanically cut at one location transverse to the direction of welding. The test specimen shall show the full longitudinal cross section of the weld, the root of the weld, and any reinforcement [see Figures 6.5(A) and 6.5(B)].

(2) **Indirect Butt Joint.** Each test assembly shall be cut mechanically at one location to provide a transverse cross section of each welded assembly [see Figure 6.5(C)].

6.3.9 Method of Testing Specimens

6.3.9.1 Full Section Tension Test. The minimum distance between jaws of the testing machine shall be equal to at least eight times the diameter of the bar for direct butt joints. The test specimen shall be ruptured under tensile load, and the maximum load shall be determined. The tensile strength shall be obtained by dividing the maximum load by the nominal cross-sectional area of the bar.

6.3.9.2 Macroetch Test. All cross sections shall be polished and etched with a suitable solution to give a clear definition of the weld.

6.3.10 Test Results Required

6.3.10.1 Radiographic Test. For acceptable qualification, the weld as revealed by the radiograph shall conform to the requirements of 4.4.2 and 4.4.8.

6.3.10.2 Full Section Tension Test. The tensile strength shall not be less than 125% of the minimum specified yield strength of the type and grade of bars joined, unless otherwise stipulated by the general specification.

6.3.10.3 Macroetch Test. The specimen shall be examined for discontinuities and if any are found that are prohibited by 4.4, it shall be considered as failed. The etched cross section shall show

complete fusion for the direct butt joints or the designated effective weld size for the flare groove test assemblies.

6.4 Rerests. In case a welder fails to meet the requirements of one or more test welds, a retest may be allowed under the following conditions:

6.4.1 Immediate Retest. An immediate retest may be made consisting of two welds of each type and position that the welder failed. All retest specimens shall meet all of the specified requirements.

6.4.2 Retest After Further Training or Practice. A retest may be made, provided there is evidence that the welder has had further training or practice. A complete retest of the types and positions failed shall be made.

6.5 Period of Effectiveness. The welder's qualification as specified in this Code shall be considered as remaining in effect indefinitely unless (1) the welder is not engaged in a given process of welding for which the welder is qualified for a period exceeding six months, or unless (2) there is some specific reason to question a welder's ability.

6.6 Records. Records of the test results shall be kept by the manufacturer or contractor and shall be available to those authorized to examine them.

7. Inspection

7.1 General Requirements

7.1.1 The inspector shall ascertain that all fabrication by welding is performed in accordance with the requirements of this code.

7.1.2 Inspectors responsible for acceptance or rejection of material and workmanship shall be qualified. The basis of Inspector qualification shall be documented. If the Engineer elects to specify the basis of inspector qualification, it shall be so stated in contract documents.

The following are acceptable qualification bases:

(1) Current or previous certification as an AWS Certified Welding Inspector (CWI) in accordance with the provisions of AWS QC1, *Standard and Guide for Qualification and Certification of Welding Inspectors*

(2) Current or previous qualification by the Ca-

nadian Welding Bureau (CWB) to the requirements of the Canadian Standard Association (CSA) Standard W178.2, *Certification of Welding Inspectors*

(3) An Engineer or technician who, by training, or experience, or both, in metals fabrication, inspection and testing, is competent to perform inspection of the work

7.1.3 The Inspector shall be furnished with complete detail drawings showing the size, length, type, and location of all welds to be made.

7.1.4 The Inspector shall be notified, in advance, of the start of any welding operations.

7.2 Inspection of Base Metals The inspector shall make certain that only base metals are used that conform to the requirements of this code.

7.3 Inspection of Welding Procedure Qualification and Equipment The Inspector shall verify the welding and subsequent testing of any procedure qualification specimens that are required. The Inspector shall inspect the welding equipment to be used for the work to make certain that it is in such condition as to enable qualified welders to apply qualified procedures and attain results prescribed elsewhere in this code.

7.4 Inspection of Welder Qualifications

7.4.1 The Inspector shall permit welding to be performed only by welders who are qualified in accordance with the requirements of this code. The Inspector shall witness the welding and testing of qualification specimens for each welder, or shall make certain that each welder has previously demonstrated those qualifications under other acceptable supervision.

7.4.2 When the quality of the welder's work appears to be below the requirements of this code, the Inspector may require testing of a welder's qualification by means of partial or complete requalification in accordance with 6.3.

7.5 Inspection of Work and Records

7.5.1 The Inspector shall verify that the size, length, and location of all welds conform to the requirements of this code and to the detail drawings, that no specified welds are omitted, and that no

unspecified welds have been added without approval.

7.5.2 The Inspector shall verify that the welding procedures used meet the provisions of this code.

7.5.3 The Inspector shall verify that electrodes are used only in the positions and with the type of welding current and polarity for which they are classified.

7.5.4 The Inspector shall, at suitable intervals, observe the technique and performance of each welder to verify that the applicable requirements of this code are met.

7.5.5 The Inspector shall examine the work to verify that it meets the requirements of this code. Size and length of welds shall be measured with suitable gages. Visual inspection for cracks and other discontinuities in the welds and base metal should be aided by a strong light, magnifiers, or other helpful devices as necessary.

7.5.6 Inspectors shall identify with a distinguishing mark or other recording methods all parts or joints that they have inspected and accepted. Any recording method which is mutually agreeable may be used. Die stamping of dynamically loaded members is not permitted without the approval of the Engineer.

7.5.7 The Inspector shall keep a record of qualifications of all welders, all procedure qualifications or other tests that are made, and other such information as may be required.

7.6 Obligations of the Contractor

7.6.1 The contractor shall be responsible for visual inspection and necessary correction of all deficiencies in materials and workmanship in accordance with the requirements of sections 3 and 4, and 4.4 or other parts of the code, as applicable.

7.6.2 The contractor shall comply with all requests of the Inspector(s) to correct deficiencies in materials and workmanship as provided in the contract documents.

7.6.3 In the event that faulty welding or its removal for rewelding damages the base metal so that in the judgment of the Engineer its retention is

not in accordance with the intent of the contract documents, the contractor shall remove and replace the damaged base metal or shall compensate for the deficiency in a manner approved by the Engineer.

7.6.4 When nondestructive testing other than visual inspection is specified in the information furnished to bidders, it shall be the contractor's responsibility to ensure that all specified welds meet the quality requirements of 4.4.

7.6.5 If nondestructive testing other than visual inspection is not specified in the original contract agreement but is subsequently requested by the owner, the contractor shall perform any requested testing or shall permit any testing to be performed in accordance with 7.7. The owner shall be responsible for all associated costs including handling, surface preparation, nondestructive testing, and repair of discontinuities other than those listed in 4.4.1 to 4.4.7 inclusive, at rates mutually agreeable between owner and contractor. However, if such testing should disclose an attempt to defraud or gross nonconformance to this code, repair work shall be done at the contractor's expense.

7.7 Nondestructive Testing

7.7.1 When nondestructive testing other than visual is required, it shall be so stated in the information furnished to the bidders. This information shall designate the welds to be examined, the extent of the examination of each weld, and method of testing.

7.7.2 Welds tested nondestructively that do not meet the requirements of this Code shall be repaired using the applicable provisions of this code.

7.7.3 When radiographic testing is used, the procedure and technique shall be in accordance with standard industry practice.⁶ See ANSI/AWS D1.1,

6. Inspection of flare-V- and flare-bevel-groove welds or fillet welds by the radiographic testing method is, in gen-

section 6, except for 6.10, radiographic procedure, for an example of such practice. The standards of acceptance shall be in accordance with 4.4.2 and 4.4.8 of this code.

7.7.4 When magnetic particle testing is used, the procedure and technique shall be in accordance with ASTM E709, *Standard Practice for Magnetic Particle Examination*, and the standard of acceptance shall be in accordance with 4.4 of this code.

7.7.5 For detecting discontinuities that are open to the surface, liquid penetrant inspection may be used. The standard methods set forth in ASTM Specification E165, *Standard Practice for Liquid Penetrant Inspection*, shall be used for liquid penetrant inspection, and the standards of acceptance shall be in accordance with 4.4 of this code.

7.7.6 Personnel Qualification

7.7.6.1 Personnel performing nondestructive testing other than visual shall be qualified in accordance with the current edition of the American Society for Nondestructive Testing's *Recommended Practice No. SNT-TC-1A*.⁷ Only individuals qualified for NDT LEVEL I and working under the NDT LEVEL II or individuals qualified for NDT LEVEL II may perform nondestructive testing.

7.7.6.2 Certification of Level I and Level II individuals shall be performed by a Level III individual who has been certified by (1) The American Society for Nondestructive Testing, or (2) has the education, training, experience, and has successfully passed the written examination prescribed in SNT-TC-1A.

eral, not considered feasible, except by highly specialized techniques, and is not recommended.

7. Available from the American Society for Nondestructive Testing, 4153 Arlingate Plaza, Columbus, Ohio 43228

Appendix A

Sample Welding Procedure Form (Nonmandatory Information)

(This Appendix is not a part of ANSI/AWS D1.4-92, *Structural Welding Code — Reinforcing Steel*, but is included for information purposes only.)

Welding Procedure Specification, Procedure Qualification Record, and Welder Qualification Test Record

Specification No. _____

Welder _____

PROCEDURE SPECIFICATION

Material specification _____

Rebar size

Rebar coating type _____

Backing material _____

Backing size

Welding process _____

Carbon equivalent _____

Manual or machine _____

Position of welding _____

Filler-metal specification _____

Filler metal classification

Shielding gas _____

Gas flow rate _____

Single or multiple pass _____

Single or multiple arc _____

Welding current _____

Polarity

Root treatment

Preheat and interpass temperature _____

Test Results

Tensile Strength, psi

1. _____

2. _____

Macroetch Tests

1. _____ 2. _____

Visual Inspection

Appearance _____

Undercut _____

Porosity: _____

NDT

Type _____

Results

WELDING PROCEDURE

Pass No.	Elect. Size	Welding Current		Joint Detail
		Amperes	Voltage	

This procedure may vary due to fabrication sequence, fit-up, pass size, etc. within the Limitations of Variables given in 6.2.1. We the undersigned certify that the statements made in this record are correct and that the tests were prepared, welded, and tested in accordance with the requirements of 6.2 of ANSI/AWS D1.4 _____ Structural Welding Code — Reinforcing Steel.

Procedure No. _____ Manufacturer or contractor _____

Revision No. _____

Date _____

Appendix B

Nominal Dimensions of Standard Reinforcing Bars

(This Appendix is not a part of ANSI/AWS D1.4-92, *Structural Welding Code — Reinforcing Steel*, but is included for information purposes only.)

Bar size†	Unit Weight		Diameter		Cross-Sectional Area	
	lb/ft	kg/m	in.	mm	in. ²	mm ²
3	0.376	0.56	0.375	9.52	0.11	71.0
4	0.668	1.00	0.500	12.70	0.20	129.0
5	1.043	1.55	0.625	15.88	0.31	200.0
6	1.502	2.26	0.750	19.05	0.44	283.9
7	2.044	3.64	0.875	22.22	0.60	387.1
8	2.670	3.98	1.000	25.40	0.79	509.7
9	3.400	5.07	1.128	28.65	1.00	645.2
10	4.303	6.41	1.270	32.26	1.27	819.4
11	5.313	7.92	1.410	35.81	1.56	1006.5
14	7.65	11.40	1.693	43.00	2.25	1451.7
18	13.60	20.26	2.257	57.33	4.00	2580.8

*The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight per foot as the deformed bar.

†The bar size number is based on the number of eighths of an inch in the nominal diameter of the bar.

Appendix C

Guidelines for Preparation of Technical Inquiries for the Structural Welding Committee (Nonmandatory Information)

(This Appendix is not a part of ANSI/AWS D1.4-92, *Structural Welding Code — Reinforcing Steel*, but is included for information purposes only.)

C1. Introduction

The AWS Board of Directors has adopted a policy whereby all official interpretations of AWS standards will be handled in a formal manner. Under that policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is 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.

C2. Procedure

All inquiries must be directed to:

Technical Director
American Welding Society
550 N. W. LeJeune Road
Post Office Box 351040
Miami, FL 33135

All inquiries must contain the name, address, and affiliation of the inquirer and they must provide

enough information for the Committee to fully understand the point of concern in the inquiry. Where that point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and should also be in the format used here.

C2.1 Scope. Each inquiry must address one single provision of the Code, unless the point of the inquiry involves two or more interrelated provisions. That provision must be identified in the Scope of the inquiry, along with the edition of the code that contains the provisions or that the Inquirer is addressing.

C2.2 Purpose of the Inquiry. The purpose of the inquiry must be stated in this portion of the inquiry. The purpose can be either to obtain an interpretation of a code requirement, or to request the revision of a particular provision in the code.

C2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the Committee to quickly and fully understand the point of the inquiry. Sketches should be used when appropriate and all paragraphs, figures, and tables (or the appendix), which bear on the inquiry must be cited. If the point of the inquiry is to obtain a revision of the code, the inquiry must provide technical justification for that revision.

C2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry, or the wording for a proposed revision, if that is what inquirer seeks.

C3. Interpretation of Code Provisions

Interpretations of code provisions are made by the Structural Welding Committee. The secretary of the committee refers all inquiries to the chairman of the particular subcommittee that has jurisdiction over the portion of the code 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 Structural Welding Committee for review and approval. Upon approval by the committee, the interpretation will be an official interpretation of the American Welding Society, and the secretary will transmit the response to the inquirer and to the *Welding Journal* for publication.

C4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal*.

C5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning the *Structural Welding Code* should be limited to questions of a general nature or to matters directly related to the use of the code. The Board of Directors' Policy requires that all 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. AWS Headquarters Staff can not provide consulting services. The staff can, however, refer a caller to any of those consultants whose names are on file at AWS Headquarters.

C6. The Structural Welding Committee

The Structural Welding Committee's activities, in regard to interpretations, are limited strictly to the Interpretation of code provisions or to consideration of revisions to existing provisions on the basis of new data or technology. Neither the committee nor the staff is in a position to offer interpretive or consulting services on: (1) specific engineering problems, or (2) code requirements applied to fabrications outside the scope of the code or points not specifically covered by the code. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

Appendix D

Safe Practices

(This Appendix is not a part of ANSI/AWS D1.4-92, *Structural Welding Code — Reinforcing Steel*, but is included for information purposes only.)

This appendix covers many of the basic elements of safety general to arc welding processes. It includes many, but not all, of the safety aspects related to structural welding. The hazards that may be encountered and the practices that will minimize personal injury and property damage are reviewed here.

D1. Electrical Hazards

Electric shock can kill. However, it can be avoided. Live electrical parts should not be touched. 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.

All electrical equipment and the workpiece should be grounded. A separate connection is required to ground the workpiece. The work lead should not be mistaken for a ground connection.

To prevent shock, the work area, equipment, and clothing should be kept dry at all times. Dry gloves and rubber-soled shoes should be worn. The welder should stand on a dry board or insulated platform.

Cables and connectors should be kept in good condition. Worn, damaged, or bare cables should not be used. In case of electric shock, the power should be turned off immediately. If the rescuer must resort to pulling the victim from the live contact, nonconducting materials should be used. A physician should be called and CPR continued un-

til breathing has been restored, or until a physician has arrived. See References 8, 9, and 14.

D2. Fumes and Gases

Many welding, cutting, and allied processes produce fumes and gases which may be harmful to one's health. Fumes 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. Everyone associated with the welding operation should acquaint themselves with the effects of these fumes and gases.

The possible effects of over-exposure to fumes and gases 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.

Sufficient ventilation, exhaust at the arc, or both, should be used to keep fumes and gases from breathing zones and the general work area.

For more detailed information on fumes and gases produced by the various welding processes, see References 1, 5, and 15.

D3. Noise

Excessive noise is a known health hazard. Exposure to excessive noise can cause a loss of hearing.

This loss of hearing can be either full or partial, and temporary or permanent. Excessive noise adversely affects hearing capability. In addition, there is evidence that excessive noise affects other bodily functions and behavior.

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. For more information see References 1 and 15.

D4. Burn Protection

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

Workers should wear protective clothing made of fire retardant material. Pant cuffs or clothing with open pockets or other places on clothing that can catch and retain molten metal or sparks should not be worn. High-top shoes or leather leggings and fire retardant gloves should be worn. Pant legs should be worn over the outside of high-top boots. Helmets or hand shields that provide protection for the face, neck, and ears should be worn, as well as a head covering to protect the head. Clothing should be kept free of grease and oil. Combustible materials should not be carried in pockets. If any combustible substance is spilled on clothing, it should be replaced with clean fire retardant clothing before working with open arcs or flame.

Appropriate eye protection should be used at all times. Goggles or equivalent also should be worn to give added eye protection.

Insulated gloves should be worn at all times when in contact with hot items or handling electrical equipment.

For more detailed information on personal protection, References 1, 6, 8, and 15 should be consulted.

D5. 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.

Explosions have occurred where welding or cutting has been performed in spaces containing flammable gases, vapors, liquids, or dust. All

combustible material should be removed from the work area. Where possible, move the work to a location well away from combustible materials. If neither action is possible, combustibles should be protected with a cover of fire retardant material. All combustible materials should be removed or safely protected within a radius of 35 ft (11 m) around the work area.

Welding or cutting should not be done in atmospheres containing dangerously reactive or flammable gases, vapors, liquids, or dust. Heat should not be applied to a container that has held an unknown substance or a combustible material and whose contents when heated can produce flammable or explosive vapors. Adequate ventilation should be provided in work areas to prevent accumulation of flammable gases, vapors or dusts. Containers should be cleaned and purged before applying heat.

For more detailed information on fire hazards from welding and cutting operations, see References 2, 8, and 15.

D6. Radiation

Welding, cutting, and allied operations may produce radiant energy (radiation) harmful to health. Everyone associated with the welding operation should acquaint themselves 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, if excessive exposure occurs.

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 radiation effects include the following:

(1) Welding arcs should not be viewed except through welding filter plates (see Reference 3). Transparent welding curtains are not intended as welding filter plates, but rather are intended to protect passersby from incidental exposure.

(2) Exposed skin should be protected with adequate gloves and clothing as specified. See Reference 8.

(3) The casual passerby to welding operations should be protected by the use of screens, curtains, or adequate distance from aisles, walkways, etc.

(4) Safety glasses with ultraviolet protective side shields have been shown to provide some beneficial protection from ultraviolet radiation produced by welding arcs.

D7. Radiographic Procedures

The problems of personnel protection against X-rays and gamma rays are not covered in this standard. Radiographic procedures should be carried out under protected conditions so that the radiographer will not receive a maximum whole-body radiation dosage exceeding that permitted by city, state, or national codes. Mandatory rules and regulations are published by governmental licensing agencies. Careful radiation surveys should be made in accordance with appropriate regulations and codes and should be conducted in the inspection area as well as adjacent areas under all possible operating conditions.

For more complete information the user should refer to References 4, 10, 11, 12, and 16.

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