

Specification for Automotive Weld Quality— Arc Welding of Aluminum



American Welding Society



AWS D8.14M:2008
An American National Standard

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American National Standards Institute
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Specification for Automotive Weld Quality— Arc Welding of Aluminum

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Prepared by the
American Welding Society (AWS) D8 Committee on Automotive Welding

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification covers the arc welding of automotive and light truck components that are manufactured from aluminum alloys.



American Welding Society

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American Welding Society

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Foreword

This foreword is not part of AWS D8.14M:2008, *Specification for Automotive Weld Quality—Arc Welding of Aluminum*, but is included for informational purposes only.

This specification supersedes D8.14M/D8.14:2000, *Specification for Automotive and Light Truck Components Weld Quality—Aluminum Arc Welding*, and was revised and enhanced by the D8C Subcommittee on Automotive Arc Welding of the AWS D8 Committee on Automotive Welding. This edition makes sole use of the International System of Units (SI).

Recent changes in automotive design caused by the desire to reduce fuel consumption have resulted in new automotive structures being made of aluminum. This specification was undertaken to prepare minimum standards for manual, automatic, and robotic arc welding of aluminum components associated with the body and supporting structural members such as body panels, bumpers, frames, space frames, cradles, wheels, drive shafts, and suspensions.

One objective of the committee was to prepare a specification that could be used by smaller suppliers of automotive components, who generally have no standards of their own for minimum arc welding quality.

All revisions to the 2000 edition are identified by a vertical line in the margin next to the text.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D8 Committee on Automotive Welding, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Specification for Automotive Weld Quality— Arc Welding of Aluminum

1. Scope

The purpose of this specification is to provide the minimum acceptance criteria for arc welding of various types of structural automotive parts made of aluminum for passenger cars, light trucks, and other types of vehicles.

This standard makes sole use of the International System of Units (SI).

Safety and health issues may not be fully addressed by this standard. Users of this standard should consult ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, applicable federal, state, and local regulations and other relevant documents concerning safety and health issues not addressed herein.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute mandatory 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

AWS A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*; and

AWS A5.10/A5.10M, *Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*.

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

3. Terms and Definitions

All of the terms in this clause are used in various parts of this document and require definitions for correct interpretation of the instructions. Most of these terms are not contained in AWS A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*. Some of the terms are listed in AWS A3.0 but their definitions have been enhanced to clarify their use in this document.

discrepant weld. A weld differing from the requirements of this standard. Even though this weld differs, it still may have useful engineering properties.

effective weld length. That portion of a weld meeting all the minimum acceptance requirements of the specification.

gap. The distance or air space between two base components (see Figure 1). Note: For butt weld joints, this distance can be referred to as the *root opening*.

meltback. This occurs where the base metal melts back from an edge, but does not become part of the weld. This condition leaves a void between the weld deposit and the base metal (see Figure 2).

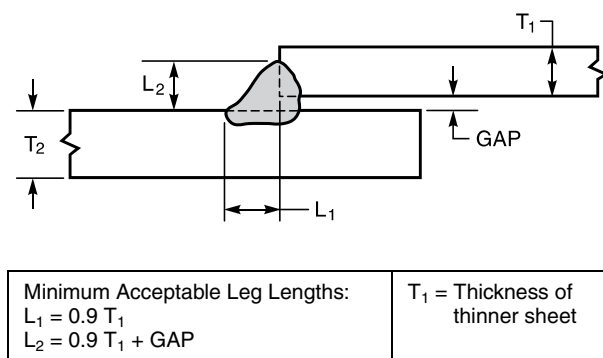


Figure 1—Minimum Acceptable Leg Length Requirements in a Lap Joint

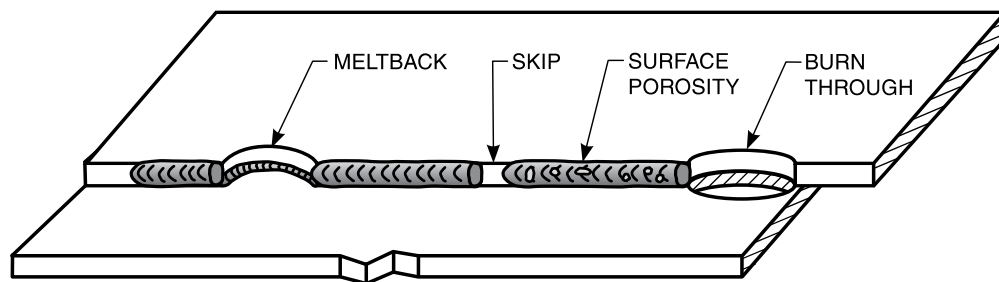


Figure 2—Examples of Discontinuities Found in Arc Welds²

notching. Gouging of the base metal at the ends or edge of the welded joint (see Figure 3).

skip. An unwelded portion of a designated weld (see Figure 2).

suck-back. A concave surface on the side of the base metal opposite the point of weld metal application. This is illustrated in Figures 4 and 5. Note: AWS A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*, refers to suck-back as “a non-standard term when used for underfill at the root surface.”

4. General Provisions

4.1 Application

4.1.1 This specification is applicable to the design and manufacture of passenger car, light truck, and similar vehicle structures when specified on engineering drawings.

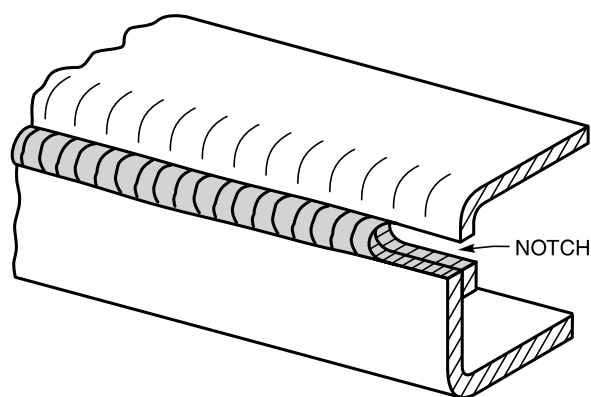


Figure 3—Examples of Notching at End of Weld

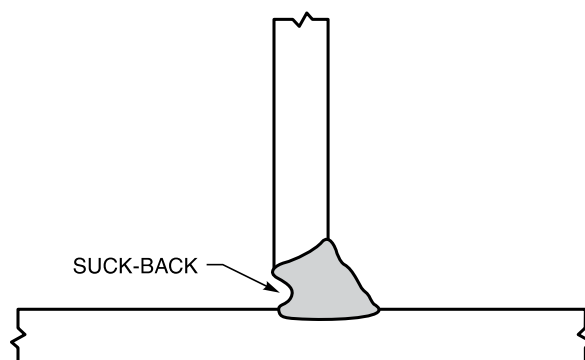


Figure 4—Suck-Back in Sheet Fillet Weld

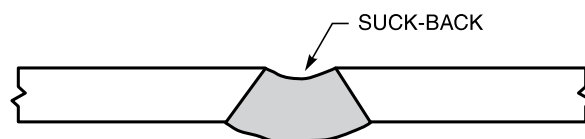


Figure 5—Suck-Back in Overhead Groove Weld

4.1.2 Any requirements deviating from the limits of this specification shall be designated on the engineering drawings.

4.1.3 If any conflict occurs between specified requirements herein and those specified on the engineering drawings, the latter has precedence.

²See AWS A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*, for information on cracks.

4.2 Welding Processes. This specification covers quality requirements for welds made by the gas metal arc welding (GMAW), plasma arc welding (PAW), and gas tungsten arc welding (GTAW) processes.

4.3 Material. This specification covers the arc welding of aluminum extrusions, castings, forgings, sheet, and plate material.

4.4 Surface Condition of Aluminum. The surface of the aluminum part in the weld area at the time of welding should be free from corrosion products, thick oxide, hydrated oxide, paint, lubricants, and other contaminants adversely affecting the quality. Prior to arc welding, the joint area should be free of detrimental condensation, hydrocarbon films, and oxides.

(1) Hydrocarbon films can be removed by an alkaline solution, vapor degreasing, or solvent wiping.

(2) Abrading with a stainless steel wire brush can be used to remove oxides to minimize weld metal porosity and ensure adequate joint fusion.

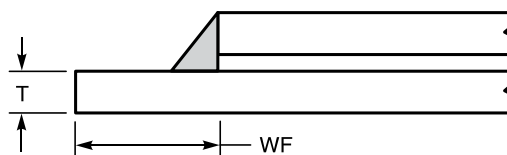
4.5 Joint Considerations

4.5.1 Automatic and robotic arc welding require consistent part fitup and joint locations to achieve consistent weld quality. To ensure proper joint fit, all parts should be fabricated, positioned, and held in place (e.g., fixturing) for maximum weld quality.

4.5.2 Maximum allowable joint gap for specific joints is determined by the structural performance required in service and the ability to accommodate the gap during welding. The maximum allowable weld joint gap between adjacent members less than 4 mm in thickness should be one-quarter the thickness of the thinner member or 1 mm, whichever is less. In the case of heavier gauges above 4 mm, the gap should not exceed 1.5 mm. The gap values listed above are the maximum allowable because tighter restrictions may be needed depending on the welding process and joint configuration used. Larger gaps than specified can adversely affect weld geometry, quality, and structural performance, i.e., fatigue life, strength.

4.5.3 On lap weld joints, the edge trim should leave adequate material to allow for a 1T-leg (T = thickness of the minimum weld flange) fillet weld. See Figure 6 for acceptable weld flange based on thickness.

4.6 Welding Equipment. Welding equipment meeting the specified welding process requirements should be used. Prior to use in production, the welding equipment should be tested and qualified for the specified structure. Failure to do so may result in welding difficulties in production, e.g., poor weld quality or equipment problems.



T (Sheet Thickness) mm	WF (Minimum Weld Flange) mm
Less than 4	10
4 to 6	T + 4 (min 11 mm)
Greater than 6	T + 6

Figure 6—Minimum Weld Flange Dimensions for Lap Welds

4.7 Welding Procedure. Welding Procedures should be qualified to demonstrate the ability to reliably produce welds on production parts over a specified range of variables. Requirements for welding procedure qualification should be specified by the Purchaser in the Contract Documents. In the absence of such requirements, welding procedures should be qualified in accordance with a nationally recognized Code. The Purchaser is encouraged to accept welding procedure qualifications performed in accordance with AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, or AWS D1.2/D1.2M, *Structural Welding Code—Aluminum*.

4.8 Filler Metals. Filler metals shall conform to the requirements of AWS A5.10/A5.10M, *Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods*. Table 1 is the list of aluminum filler metals for use with each base metal alloy. See Annex A for a guide for the selection of a filler alloy.

4.9 Shielding Gases. The shielding gas for welding aluminum should be argon, helium, or a mixture of argon and helium. The shielding gas should be of a welding grade per AWS A5.32/A5.32M, *Specification for Welding Shielding Gases*.

4.10 Welding Symbols. Welding symbols on product drawings should be those in the latest edition of AWS A2.4, *Standard Symbols for Welding, Brazing, and Non-destructive Examination*. All weld symbols on the engineering drawing should be approved by the engineering authority. Special conditions and symbols shall be fully explained by added notes or details.

4.11 Types of Weld Joints and Applicable Welds

- (1) Fillet weld (see Figure 7)
- (2) Square-groove weld

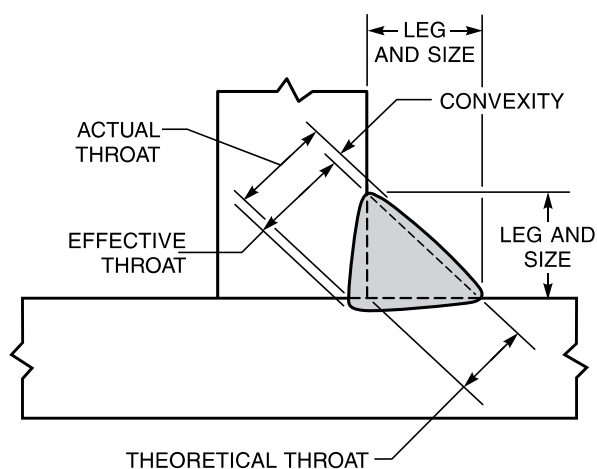
Table 1
Aluminum Filler Metal Selection Guide for Structural Automotive Components

For Welding These Alloys ➔		2036	5052 ^a 5454 ^a	5182 5754	6005 6005A 6016 6063 6082 6116 6463	6009 6010 6111 6016 6022	Al-Si Castings		Al-Mg Castings	7003 7004 7005
To These Alloys ↓							319.0	356.0 443.0	511.0 512.0 513.0 514.0 535.0	
7003, 7004, 7005		4043 4145	4043 ^a 5356 5554	5356	4043 5356	4043 5356	4043 4145	4043 4145	5356	4043 5356
Al-Mg Castings 511.0, 512.0, 513.0, 514.0, 535.0		NR	5356	5356	5356	5356	4043	NR	5356	
Al-Si Castings	356.0 443.0	4043 4145	4043 ^a 5554	NR	4043 4145	4043 4145	4043 4145	4043 4010		
	319.0	4043 4145 2319	4043 ^a 5554	4043	4043 4145	4043 4145	4043 2319	4043 4145		
6009, 6010, 6111 6016, 6022		4043 4145	4043 ^a 5356 5554	5356	4043 5356	4043 5356				
6005, 6005A, 6115, 6063, 6082, 6016, 6463		4043 4145	4043 ^a 5356 5554	5356	4043 5356					
5182, 5754		NR	5356	5356						
5052 ^a , 5454 ^a		NR	5356 4043 ^a 5554							
2036		4043 4145 2319								

^a Filler alloy 4043 may be used for base alloy 5052 but is not recommended for base alloy 5454. Filler alloy 5554 is recommended for base alloy 5454 for sustained elevated temperature service.

Notes:

1. NR = Not recommended.
2. Filler alloy 4047 may be interchanged with 4043 filler alloy.
3. Filler alloy 5356 may be replaced by 5183 or 5556 for improved shear strength.
4. Filler alloys 5356, 5185, and 5556 are not recommended for sustained elevated temperature service above 66°C; filler alloy 5554 may replace these filler alloys for sustained elevated temperature service.
5. AWS filler metal classifications prefix letters "ER" and "R" have not been included.
6. Filler metal selection should be based on performance criteria (reference Annex C).



Source: Adapted from AWS A3.0:2001, *Standard Welding Terms and Definitions*, Figure 25, American Welding Society.

Figure 7—Convex Fillet Weld Measurement

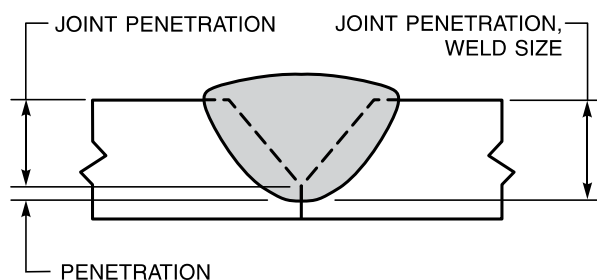
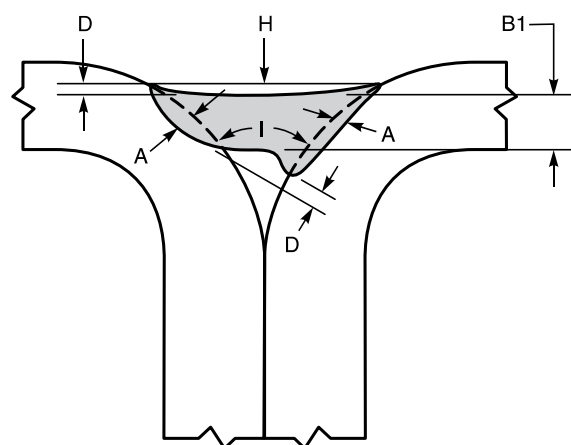


Figure 8—Single V-Groove Weld—Partial Joint Penetration

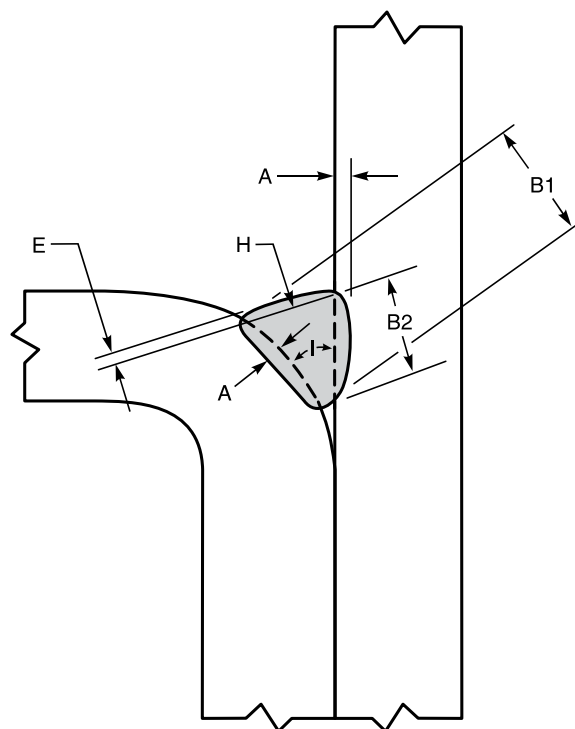
- (3) V-groove weld (see Figure 8)
- (4) Bevel-groove weld
- (5) U-groove weld
- (6) J-groove weld
- (7) Flare-V-groove weld (see Figure 9)
- (8) Flare-bevel-groove weld (see Figure 10)
- (9) Plug weld (see Figures 11A, B, C, and D)
- (10) Single fillet weld in a slot (see Figure 12)
- (11) Double fillet weld in a slot (see Figure 13)

4.12 Classification of Welds. Safety, critical, federal, structural, and process welds should be designated on the Engineering Drawing.



A—DEPTH OF FUSION
B1—EFFECTIVE WELD SIZE
D—CONCAVITY
H—THEORETICAL WELD FACE
I—FUSION FACE

Figure 9—Flare-V-Groove Weld



A—DEPTH OF FUSION
B1—ACTUAL WELD SIZE
B2—EFFECTIVE WELD SIZE
E—CONVEXITY
H—THEORETICAL WELD FACE
I—FUSION FACE

Figure 10—Flare-Bevel-Groove Weld

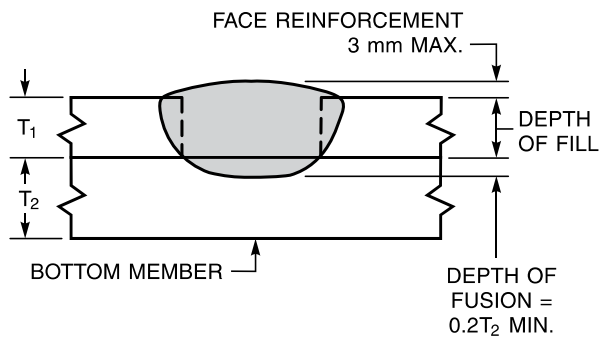
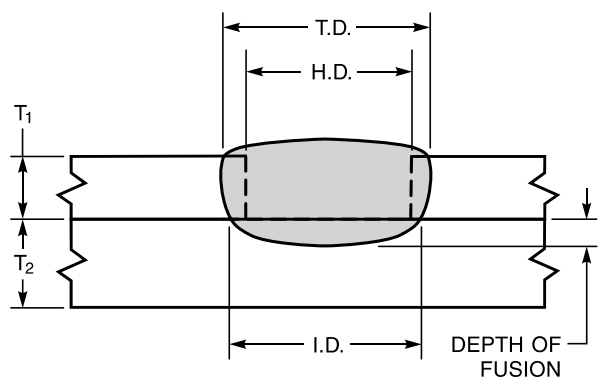


Figure 11A—Arc Plug Weld Profile—Convexity



TOP DIAMETER (T.D.) = H.D. + 3 mm (MIN.)
HOLE DIAMETER (H.D.) = $5 \times T_1$ (MIN.)
INTERFACE DIAMETER (I.D.) = $4 \times T_1$ (MIN., IF $T_2 - T_1 < [T_1 \times 1.5]$)

Figure 11D—Arc Plug Weld Geometry

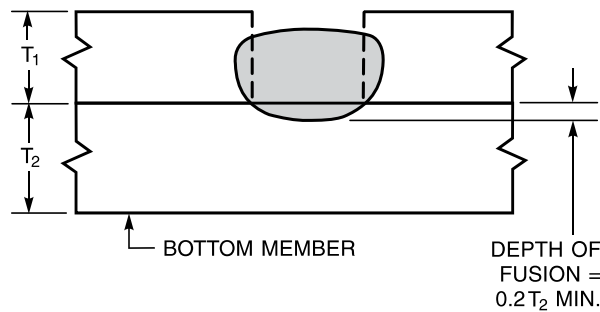
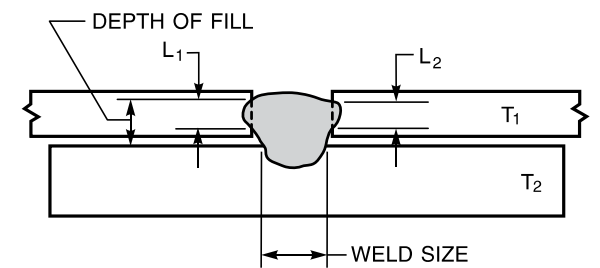
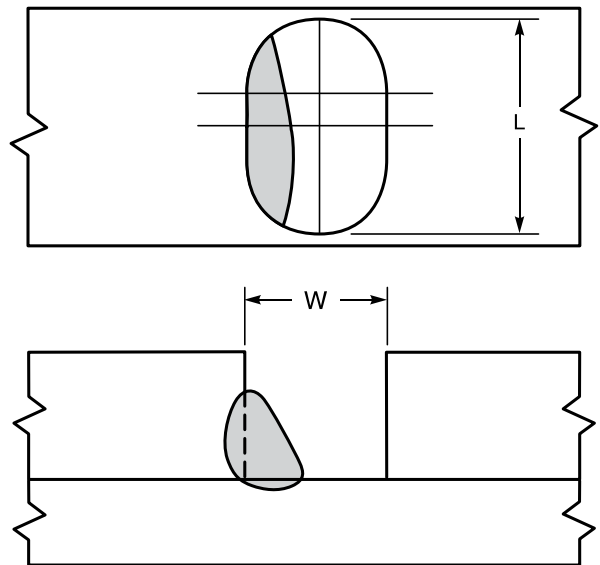


Figure 11B—Arc Plug Weld Profile—Depth of Fusion

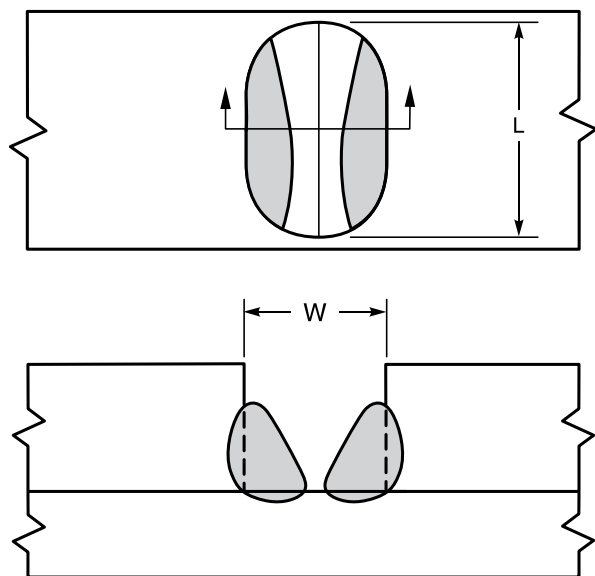


Minimum Acceptable Dimensions: Leg Lengths: $L_1 = 0.6 T_1$ $L_2 = 0.6 T_1$ Weld Size = $4 \sqrt{T_1}$	T_1 = Thickness of thinner sheet Depth of Fill = $1.0 T_1$
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Figure 11C—Arc Plug Weld Profile—Depth of Fill

Metal Thickness mm	Minimum Slot Width (W) mm	Minimum Slot Length (L) mm
0.7–3	10	25
Over 3–5	13	32

Figure 12—Single Fillet Weld in a Slot



Metal Thickness mm	Minimum Slot Width (W) mm	Minimum Slot Length (L) mm
0.7–3	13	25
Over 3–5	16	32

Figure 13—Double Fillet Weld in a Slot

5. Requirements

5.1 Weld Length

5.1.1 Unless specifically noted on engineering drawings, the effective weld length shall not be less than 90% of the specified weld length.

5.1.2 Any portion of a weld not meeting the individual quality requirements shall not be included in the effective weld length.

5.1.3 Welds may be permitted to be longer than specified, providing the part configuration remains functional, meets targeted dimensional tolerances and satisfies the performance specifications. For welds 300 mm and over in normal or noncritical locations, an additional 13 mm per 300 mm of weld is permissible.

5.2 Weld Location

5.2.1 Any portion of the weld off-seam or off-joint shall not be included in the effective weld length.

5.2.2 Where a specified weld start or stop location is given, the start or stop points of the weld shall be within

6 mm of those shown on the drawing for welds under 150 mm and within 13 mm for welds over 150 mm.

5.3 Weld Size

5.3.1 Fillet Welds

5.3.1.1 Fillet weld size should be determined by engineering and stated on the drawing. The actual weld size is governed by 5.3.1.3 and 5.3.1.2. Figure 7 identifies the nomenclature which describes the cross section of a T-fillet. Figures 14A and 14B illustrate both convex and concave fillet welds in lap joints.

5.3.1.2 The length of the legs of a fillet weld on each side of the joint determines the fillet size and shall conform to the following dimensions:

(1) The minimum leg size shall be equal to 90% of the thickness of the thinner material being welded.

(2) When gaps are present, the leg shall be increased by the width of the gap (see Figure 1).

5.3.1.3 The weld throat thickness shall conform to the following:

(1) The minimum measured effective throat thickness shall not be less than 60% of the thinner material being welded (see Figure 7).

(2) When applicable, convexity limits shall be specified. Concavity will be limited by throat requirements (see Figure 14B).

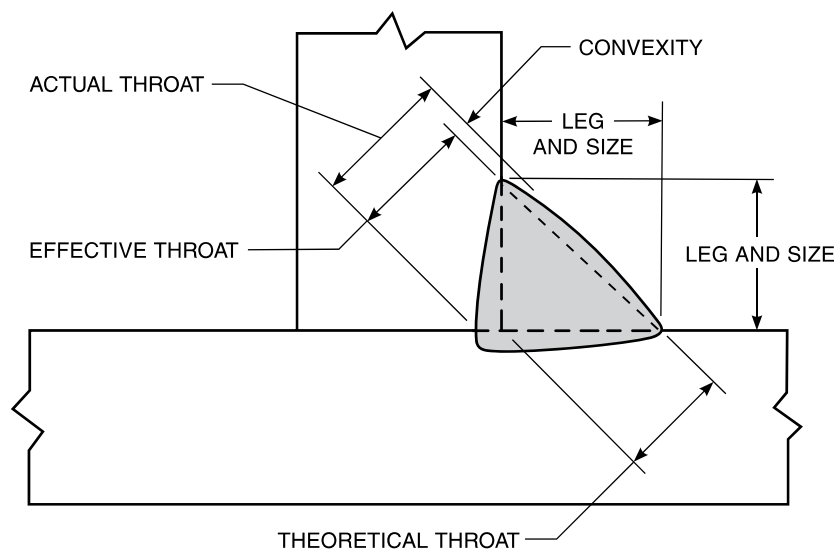
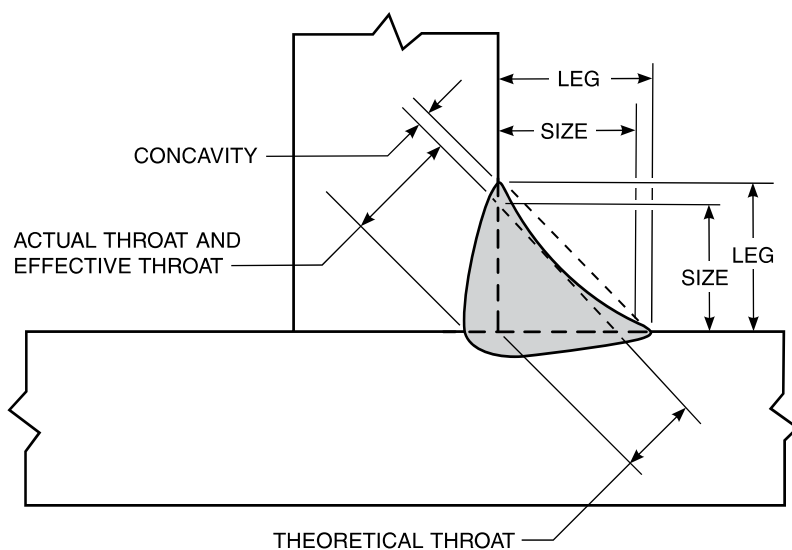
5.3.2 Welds in Butt Joints

5.3.2.1 Butt Joints. Applicable butt joint welds are as follows:

- (1) Square-groove welds
- (2) V-groove welds
- (3) Bevel-groove welds
- (4) U-groove welds
- (5) J-groove welds
- (6) Flare-V-groove welds
- (7) Flare-bevel-groove welds

5.3.2.2 The effective weld size shall be equal to the thickness of the thinner material being joined unless otherwise specified.

5.3.2.3 No limit should be set on the height of the weld reinforcement if all other provisions of this specification are satisfied and the part remains functional (see Figure 15).

**(A) CONVEX FILLET WELD****(B) CONCAVE FILLET WELD**

Source: Reproduced from AWS A3.0:2001, *Standard Welding Terms and Definitions*, Figure 25—Weld Sizes, American Welding Society.

Figure 14—Convex and Concave Fillet Welds

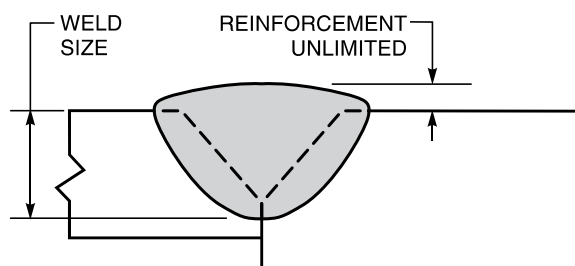


Figure 15—Groove Weld Size

5.3.2.4 Weld size and definitions for flare-bevel- and flare-V-groove welds should be used as shown in Figures 9 and 10.

5.3.3 Plug and Slot Welds

5.3.3.1 Depth of Fill. The effective depth of fill shall be the thickness of the thinner material being joined (see Figure 11C).

5.3.3.2 Weld Profile. The weld profile shall conform to the following provisions:

(1) The maximum reinforcement shall not exceed 3 mm, unless otherwise specified on the drawing (see Figure 11A); and

(2) Any underfill requirement shall be specified on the drawings (see Figure 11C).

5.3.3.3 Weld Dimensions. The following minimum dimensions should be observed when welding plug and fillet welds in slot welds:

(1) **Plug Welds.** The top diameter (weld size) should be at least 3 mm larger than the hole size. The interface diameter (weld size) should be at least four times T_1 , where T_1 is the thickness of the thinner material being welded (see Figure 11D). The hole should be five times T_1 diameter if the hole is in the thinner member and the thickness differential is less than one and a half times T_1 . All other combinations should be experimentally qualified prior to production.

(2) **Fillet Welds in Slot.** Single-side fillet welds in slots on material thicknesses of 3 mm, or less, should have a slot width of at least 10 mm and a minimum weld length of 25 mm. Material thicknesses over 3 mm for single-side slot welds should have a minimum slot width of 13 mm and a minimum weld length of 32 mm (see Figure 12). Double-sided fillet welds in slots on material thicknesses of 3 mm or less, should have a slot width of

at least 13 mm and a minimum weld length of 25 mm on each of the two sides of the slot. Double-sided fillet welds in slot on material thicknesses over 3 mm should have a slot width of at least 16 mm and a minimum weld length of 32 mm on each of the two sides of the slot (see Figure 13).

5.4 Weld Quality. Weld quality can be determined by visual and/or metallographic inspection of a cross section. See Figure 2 for arc weld discontinuities. See Table 2 for an example of a cross section report. Unless otherwise specified, the following discontinuities shall not be permitted in welds:

5.4.1 Undercut. A weld is discrepant if the parent metal is undercut by more than 0.1T of its thickness for more than 20% of the length of weld or within the first 13 mm of the ends of the welds.

5.4.2 Craters. Weld craters shall not be considered a part of the designated weld length unless the crater meets all the requirements of an acceptable weld.

5.4.3 Cracks. Cracks shall not be permitted in the effective weld length unless allowed by the engineering drawing.

5.4.4 Porosity and Inclusions

5.4.4.1 Surface Porosity. Individual pores, separated by at least their own diameter, and other scattered surface porosity shall be permitted. The total length of porosity (sum of diameters) shall not exceed 6 mm in any 25 mm of weld. The maximum pinhole diameter shall not exceed 1.6 mm.

5.4.4.2 Internal Porosity and Inclusions. Internal porosity and inclusions shall not exceed 15% of the area of the weld being examined.

5.4.5 Burn-Through. Holes caused by melting through the base metal shall not be permitted.

5.4.6 Meltback. Meltback in lap fillet welds shall not exceed the material thickness at top and shall decrease to zero at the root of the joint (see Figure 2). Complete fusion shall be obtained at the root of the joint.

5.4.7 Notching. Notching or gouging of the base metal at the ends or at the edge of the joint shall not be permitted (see Figure 3).

5.4.8 Root Concavity. A concave root surface (suck-back) on the side of the base metal opposite the weld metal shall be permitted. This concavity shall not exceed 0.1T of its thickness, and reinforcement shall be added to the weld with a height equal to the concavity dimension.

5.4.9 Depth of Fusion. Metallographic sampling shall be used to determine weld fusion in all welds. Depth of

Table 2
Weld Evaluation Cross Section Report

[illegible]

fusion at its deepest point must be greater than or equal to 5% of the material thickness being welded for all joint types not covered in 5.4.10.

5.4.10 Combination of Discontinuities. The presence of more than one of the above discontinuities in any weld shall not be permitted if any one of the evaluated discontinuities (inclusions, undercut, porosity, or melt-back) is at the maximum permissible limit.

5.4.11 Metallographic Sampling. Metallographic sampling shall be used to determine weld fusion to side

walls of fillet welds in holes, slot welds and flared joints, and depth of fusion in arc spot, plug, slot welds, and welds in holes and slots. Minimum side wall fusion shall be 0.1T (min) and depth of fusion on bottom plate shall be 0.2T (min).

5.5 Rework of Discrepant Welds. A procedure agreed upon by the customer and supplier shall be used for the rework of discrepant weld(s). For information on rework of discrepant welds refer to Annex B, Methods to be Used for Rework of Discrepant Welds.

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Annex A (Informative)

Aluminum Filler Alloys for Arc Welding of Automotive Components

This annex is not part of AWS D8.14M:2008, *Specification for Automotive Weld Quality—Arc Welding of Aluminum*, but is included for informational purposes only.

Often it is possible to weld one specific aluminum base alloy with a number of different filler alloys. In order to select the most appropriate filler alloy for a particular application, we must understand the various filler alloys and their potential performance characteristics. Such characteristics are: ease of welding/crack sensitivity, strength of welded joint, ductility, corrosion resistance, sustained temperature service, color match, and ability to respond to postweld heat treatment.

The selection of a filler alloy for welding aluminum, whether it is for manual, semiautomatic, hard automation, or a robotic welding application, must be based on the welded component's performance requirements and the completed component's operating conditions.

The following are some common considerations for the selection of a filler alloy:

A1. Ease of Welding

This is the relative freedom from weld cracking. By use of solidification cracking sensitivity curves for the various aluminum alloys, and through the consideration of dilution between filler alloy and base alloy, it is possible to estimate the filler alloy/base alloy crack sensitivity and probability rating. A good example of an alloy's effect on crack sensitivity is the 6xxx series base alloys. Base alloy 6061, for instance, if GTAW welded, should not be welded autogenously (without filler material) as the chemical composition of the base material is such that it will usually crack during solidification. Filler alloy of a different chemical composition than the base alloy must be used in order to dilute the base alloy chemical composition and thereby reduce the crack sensitivity. This is the reason why we do not see a 6xxx series filler alloy.

A2. Strength of Welded Joint

The tensile strength of groove welds and shear strength of fillet welds are considered when welding with different filler alloys. Typically, in aluminum, the as-welded transverse tensile strength of a groove weld is controlled by the condition of the heat-affected zone of the base material. The condition of the HAZ is the fully annealed strength of the base alloy in the case of the nonheat-treatable alloys and usually the partially annealed strength in the case of the heat-treatable alloys. However, the filler alloy and not necessarily the condition of the base alloy largely determine the shear strength of a fillet weld. The typical shear strength properties of the various filler alloys are quite different and can be seen in Table A.1.

Table A.1
Shear Strength

Minimum Shear Strength of Fillet Welds		
Filler Alloy	Longitudinal Shear Strength (MPa)	Transverse Shear Strength (MPa)
1100	52	52
2319	110	110
4043/4047	79	103
4643	93	138
5183	128	193
5356	117	179
5554	103	159
5556	138	207
5654	83	124

A3. Ductility

This is a consideration when forming operations are to be used after welding and it is a design consideration for service. Typically, the 5xxx series filler alloys will have improved ductility characteristics over that of the 4xxx series.

A4. Corrosion Resistance

This is the consideration of the environmental service conditions of the weld. It is not a major consideration for normal operating environments but can be of major importance when operating in corrosive chemical environments. There are some aluminum base alloys and filler alloys designed for specific chemical applications.

A5. Sustained Temperature Service

The reaction of some filler alloys and base alloys at sustained elevated temperatures may promote premature component failure due to stress corrosion cracking. Temperature applications for aluminum alloys are generally accepted as being operating temperatures above 20°C. As a general rule the magnesium base alloys and filler alloys with more than 3.0% Mg content are considered not suitable for these temperature applications. There are specific base alloys such as 5052 and 5454 and filler alloys such as 5554, which have been designed with controlled magnesium and are suitable for temperature applications. The 4xxx series filler alloys are also suitable for elevated temperature applications.

A6. Color Match

Base alloy and filler alloy color match after anodizing can be of major concern in some cosmetic applications. The most common problem is welding the 6xxx series base materials with the 4xxx series filler alloys. This will result in the weld turning a very dark gray color after the anodizing operation.

A7. Postweld Heat Treatment

Consideration is given to the ability of the filler alloy to respond to postweld heat treatment associated with joint design. It is sometimes required for the weld metal to respond to postweld heat treatment. The common filler alloys are not heat treatable alloys, however there are some specialized filler alloys which have been designed to respond to heat treatment. The most common of these is filler alloy 4643, which was designed to weld the 6xxx series base materials and fully respond to postweld heat treatment.

A8. General

The common filler alloys used in the automotive industry are 4043, 4047, 5356, and 5554.

Filler alloy 4043, which is a 5% silicon alloy, is used for some structural applications and some thin wall seal tight joints.

Filler alloy 4047, which is a 12% silicon alloy, has higher fluidity than 4043, and for this reason, is often used for heat exchangers such as radiators and air conditioning systems.

Filler alloy 5356 can be used for structural applications and will provide higher shear strength over that of 4043.

Filler alloy 5554 is usually used for structural components such as wheels, which are made from base alloy 5454 and operate at elevated temperature.

A9. Summary

There are many considerations relating to the selection of the most suitable filler alloy for a specific base alloy and completed product application. The understanding of these variables is a significant aspect in the correct design and development of a successful welding procedure specification.

For additional information on Aluminum Filler Alloys for Arc Welding, please consult the filler or metal manufacturer and/or relevant AWS A5 standards.

Annex B (Informative)

Methods to be Used for the Rework of Discrepant Welds

This annex is not part of AWS D8.14M:2008, *Specification for Automotive Weld Quality—Arc Welding of Aluminum*, but is included for informational purposes only.

B1. Approval

A procedure agreed upon by the customer and supplier should be used for the rework of discrepant weld(s). See below for recommended rework procedures.

B2. Short or Missing Welds

Short or missing welds can be reworked with the original process using production parameters.

B3. Preparation of Repair

The removal of weld metal should be done by machining, grinding, chipping, or gouging. It should be done in a manner such that the adjacent base metal is not nicked or gouged. Unacceptable portions of welds should be removed without substantial removal of base metal. The surfaces should be thoroughly cleaned before repair welding.

B4. Repair of Notching or Burn-Through

Notching or burn-through should not be repaired unless access is available to the root of the joint to inspect repair.

B5. Notching and Burn-Through

Notching and burn-through should not be repaired when its largest dimension exceeds 6 mm.

B6. Repair of Undercut, Meltback, Craters, and Skips

The surface should be cleaned and prepared to remove sharp grooves and additional weld metal deposited.

B7. Repair of Porosity and Inclusions

Unacceptable portions of the weld should be removed and rewelded.

B8. Repair of Cracks

The entire cracked weld area should be removed.

B9. Inspection of Repairs

The repaired weld should be retested by the method originally used, and the same technique and quality acceptance criteria should apply.

B10. Repairs

Only one attempt to repair a weld should be made. If not successful, the part should be scrapped.

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Annex C (Informative)

Informative References

This annex is not part of AWS D8.14M:2008, *Specification for Automotive Weld Quality—Arc Welding of Aluminum*, but is included for informational purposes only.

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, American Welding Society.

AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*, American Welding Society.

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

AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, American Welding Society.

AWS D1.2/D1.2M, *Structural Welding Code—Aluminum*, American Welding Society.

Arc Welding with Robots: Do's and Don'ts, American Welding Society.

Welding Handbook, Eighth Edition, Volume 3, Materials and Applications—Part 1, American Welding Society.

Welding Aluminum: Theory and Practice, Fourth Edition, The Aluminum Association.

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Annex D (Informative)

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS D8.14M:2008, *Specification for Automotive Weld Quality—Arc Welding of Aluminum*, but is included for informational purposes only.

D1. 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.

D2. 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.

D2.1 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.

D2.2 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.

D2.3 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.

D2.4 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.

D3. 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.

D4. Publication of Interpretations

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

D5. 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 of Directors' policy 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.

D6. 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 Automotive Welding

Designation	Title
D8.1M	<i>Specification for Automotive Weld Quality—Resistance Spot Welding of Steel</i>
D8.6	<i>Specification for Automotive Resistance Spot Welding Electrodes</i>
D8.7M	<i>Recommended Practices for Automotive Weld Quality—Resistance Spot Welding</i>
D8.8M	<i>Specification for Automotive Weld Quality—Arc Welding of Steel</i>
D8.9M	<i>Recommended Practices for Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials</i>

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