

AWS D17.1/D17.1M:2017-AMD2
An American National Standard



Specification for Fusion Welding for Aerospace Applications



third printing, January 2019



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An American National Standard

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Specification for Fusion Welding for Aerospace Applications

3rd Edition

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Prepared by the
American Welding Society (AWS) D17 Committee on Welding in the Aircraft and Aerospace Industries

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification provides the general welding requirements for welding aircraft and space hardware. It includes but is not limited to the fusion welding of aluminum-based, nickel-based, iron-based, cobalt-based, magnesium-based, and titanium-based alloys using electric arc and high energy beam processes. There are requirements for welding design, personnel and procedure qualification, inspection, and acceptance criteria for aerospace, support, and non-flight hardware. Additional requirements cover repair welding of existing hardware. A commentary for the specification is included.



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Foreword

This foreword is not part of this standard but is included for informational purposes only.

Prior to 1977, aviation welding specifications were primarily dependent on government standards for contract purchases and were based on welding technology from the 1950s. Those specifications were MIL-W-8611 (steel), MIL-W-8604 (aluminum), MIL-W-18326 (magnesium), and MIL-T-5021 for welder performance requirements. In 1977, the aviation and aerospace industry and government moved to update some of these standards by consolidating the welder's performance of MIL-T-5021 into MIL-STD-1595. MIL-STD-1595 was issued as a supplement to the ASME Section IX code in 1977. It was subsequently revised and superseded by MIL-STD-1595A in 1983. The first update to the 1950's welding process specifications came with the release of MIL-W-8604A in 1982, almost 30 years after its initial release. The material welding specifications MIL-W-8604, MIL-W-8611, and MIL-W-18326 were consolidated into MIL-STD-2219 in 1988 and represented the most significant change to aviation welding standards in more than 30 years.

After two unsuccessful attempts to change the military standards, the American Welding Society contacted the industry and proposed a meeting to develop a national specification. Interested welding personnel from the aviation industry gathered together in the autumn of 1993 to lay the foundation for a national aviation and aerospace specification for fusion welding to replace MIL-STD-1595A and MIL-STD-2219. This meeting led to the formation of the AWS D17 Committee on Welding in the Aircraft and Aerospace Industries. The overriding theme the welding committee members brought to the table was that the aviation industry had changed. Those changes affected the welding processes and procedures, base metal and filler metal types, quality, and the inspection equipment, just to name a few. Since the 1950s, the welding specifications had not completely kept pace during the revision process to reflect those technology changes. The writing of this specification was a prime opportunity for the industry and government to create a document to include those changes. Through an industrial effort and committee consensus, this specification represents several years of work, bringing the aviation and aerospace industry together to acknowledge the technological advances of welding and materials. Included in this document is weld repair technology to enable the use of weld repair beyond those areas originally designated for a weld.

Changes to this third edition of D17.1 include the following:

- (1) Removed Annex B—Effective Throat of 2010 edition
- (2) Added Annex D—Materials in Table 5.4 with cross-referenced UNS numbers to [proprietary tradenames].
- (3) Added Annex G—Samples of Welding Forms for WPSs, PQRs, and Welder Performance Qualifications by removing the samples from elsewhere in the standard.
- (4) Added Annex H—Qualified Positions for Production Welding
- (5) Added Annex I—Common Acronyms Used in this Standard for quick user reference.
- (6) Added Figures 5.11C and 5.11D to the standard.
- (7) Separated Table B.3 into B.3 and B.3M, one for U.S. Customary Units and one for the International System of Units.
- (8) Conversion values were updated to reflect AWS A1.1, *Metric Practice Guide for the Welding Industry*.

Underlined areas in text indicate an addition and vertical lines adjacent to text, figures, tables, and equations indicate where changes (additions, modifications, corrections, deletions) from the 2010 edition were made.

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Amendment

The following Amendments have been identified and are incorporated in this reprint.

Amendment Number: 2

Subject: Clause 5.3.3.1: Item 3 added

5.3.3.1 Welder Qualification Variables. The qualification variables for performance qualification are as follows:

- (1) welding process (see 5.4.1)
- (2) base metal composition group (see 5.4.2)
- (3) base metal thickness (see 5.4.3)
- (4) welding position (see 5.4.4)
- (5) base metal form, sheet or tube (see 5.4.5)
- (6) type of weld, groove or fillet
- (7) other welding conditions (see 5.4.6)

NOTE: Filler metal alloy type used for test welds shall be the same as those used in production welding of the base metal.

Amendment Number: 2

Subject: Clause 5.4.3: ‘tack welders’ removed

5.4.3 Base Metal Thickness. The qualification limits, with regard to base metal thickness (sheet thickness or tube wall thickness), are given below for welders and welding operators. These limits apply to both groove welds and fillet welds.

Amendment Number: 2

Subject: New table 5.5, footnotes, table 5.5 references have been modified: 5.4.4.1, 5.4.5.1

Table 5.5
Welder Qualification – Positions and Base Metal Forms Qualified by Sheet or Tube Tests

Qualification Test ^a			Positions Qualified ^b			
			Sheet		Tube	
Base Metal Form	Weld Type	Test Position	Groove	Fillet	Groove	Fillet
Sheet	Groove	1G	F	F, H ^c	F ^d	F, H ^{c, d}
		2G	F, H	F, H ^c	F, H ^d	F, H ^{c, d}
		3G	F, V	F, H, V ^c	F, V ^d	F, H, V ^{c, d}
		4G	F, O	F, H, O ^c	F, O ^d	F, H, O ^{c, d}
	Fillet	1F		F		F ^d
		2F		F, H		F, H ^d
		3F		F, H, V		F, H, V ^d
		4F		F, H, O		F, H, O ^d
Tube	Groove	1G	F	F, H ^c	F	F, H ^c
		2G	F, H	F, H ^c	F, H	F, H ^c
		5G	F, V, O	All ^c	F, V, O	All ^c
		6G	All	All ^c	All	All ^c
	Fillet	1F		F		F
		2F		F, H		F, H
		4F		F, H, O		F, H, O
		5F		All		All

^a Use of heat sinks is optional.

^b Qualified positions for production welding are defined in AWS A3.0 as Flat (F), Horizontal (H), Vertical (V), Overhead (O). All = Flat, Horizontal, Vertical and Overhead.

^c A fillet weld test is required to qualify fillet welds in material thickness equal to or less than 0.063 in [1.6 mm].

^d For Qualified thickness and tube diameter range see clause 5.4.3.1 (3).

5.4.4.1 Welders. The welding positions qualified by a given test weld position are denoted in Table 5.5. The welding position designations are identified and illustrated in Figures 5.1, 5.2, 5.3, and 5.4.

5.4.5.1 Welders. The base metal forms and weld types qualified by a given test weld are denoted in Table 5.5. Welders qualified to perform groove welds are also qualified to perform plug and slot welding in the qualified position.

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Amendment Number: 2

Subject: Table 7.1 footnotes b – f have been modified (footnote g was removed), ‘Acceptable’ and ‘Rejectable’ have been changed to ‘Accept’ and ‘Reject’; Discolorations of: Titanium; Stainless Steel, Nickel, and Cobalt Alloys; and Steel. Portions of the table not shown remain unchanged.

Table 7.1
Acceptance Criteria (in [mm])

Discoloration^{c, f}—Titanium			
Bright Silver	Accept	Accept	Accept
Silver	Accept	Accept	Accept
Light Straw	Accept	Accept	Accept
Dark Straw	Accept	Accept	Accept
Bronze	Accept	Accept	Accept
Brown	Accept	Accept	Accept
Violet	Reject ^d	Accept	Accept
Blue	Reject ^d	Reject ^e	Reject ^e
Green	Reject ^d	Reject ^e	Reject ^e
Gray	Reject	Reject	Reject
White	Reject	Reject	Reject
Discontinuity	Class A	Class B	Class C
Discoloration—Stainless Steel, Nickel, and Cobalt Alloys			
All oxidation colors, except for Black	Accept	Accept	Accept
Black discoloration or the presence of scale	Reject	Reject	Reject
Discoloration—Steel			
All oxidation colors, except for Black	Accept	Accept	Accept
Black	Reject	Reject	Reject

^a For groove weld only.

^b Discontinuity of size 0.005 in [0.13 mm] or less shall not be considered when determining compliance to the spacing requirements.

^c Discoloration determined to be acceptable shall be removed prior to additional welding.

^d This discoloration is acceptable on the base metal outside of 0.030" from the toe of the weld.

^e This discoloration is acceptable on finished welds but must be removed prior to additional processing.

^f Discoloration that is not acceptable per the table may be determined acceptable through testing. Test methods, acceptance criteria and approval requirements shall be as specified by the engineering authority.

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Specification for Fusion Welding for Aerospace Applications

1. General Requirements

1.1 Scope. This specification contains requirements for fusion welding and non-destructive examination (NDE) of aerospace flight hardware as well as for the welding and NDE of non-flight hardware. When this specification is stipulated in contract documents, conformance with all provisions of the specification shall be required, except for those provisions specifically exempted or modified by the Engineering Authority or contract documents.

The following is a summary of the specification clauses:

Clause 1. **General Requirements:** basic information on the scope and provisions of this specification.

Clause 2. **Normative References:** a listing of the documents that are required for the application of this specification.

Clause 3. **Terms and Definitions:** a list of technical terms and definitions of particular importance to this specification.

Clause 4. **Design of Welded Connections:** requirements and guidance information for the design of welded connections.

Clause 5. **Welding Procedure and Performance Qualification:** qualification requirements for welding procedures, welders, welding operators, and tack welders.

Clause 6. **Fabrication:** requirements for preparation, assembly, and workmanship when welding aerospace hardware.

Clause 7. **Inspection:** criteria for inspector qualification, responsibilities of inspectors, acceptance of production welds, and standard requirements for performing visual inspection and nondestructive examination (NDE).

Clause 8. **Repair of Existing Structures:** requirements for repair of existing aerospace flight hardware.

Clause 9. **Nonflight Hardware:** requirements for welding nonflight hardware.

1.1.1 Flight Hardware. The purpose of this specification is to provide requirements for commonly used fusion welding processes, materials, and acceptance criteria for production welds. This specification also provides requirements for materials, processes, and acceptance criteria that are not listed in this specification when approved by the Engineering Authority.

1.1.1.1 Aircraft, Rotorcraft, and Engines Subject to Federal Aviation Administration (FAA) Regulation. When applying welding in the design, construction, and repair of aircraft, rotorcraft, or engines subject to FAA regulation, the Engineering Authority must perform the appropriate design analyses and impose process control measures that will ensure compliance with the applicable requirements of the Code of Federal Regulations, Title 14.

1.1.2 Nonflight Hardware. Nonflight hardware, tooling, ground support equipment, and related nonconventional aerospace facilities shall be designed and welded in accordance with the requirements of Clause 9.

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

1.3 Safety. Safety and health issues and concerns are beyond the scope of this standard and therefore are not addressed herein.