AWS D17.1/D17.1M:2010-AMD1
An American National Standard

# Specification for Fusion Welding for Aerospace Applications

American Welding Society®

Approved American National Standard
ANSI

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**AWS D17.1/D17.1M:2010-AMD1**
**An American National Standard**

**Approved by the**
**American National Standards Institute**
**November 18, 2010**
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# Specification for Fusion Welding for Aerospace Applications

**2nd Edition**

**Supersedes AWS D17.1:2001**

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 AWS D17.1/D17.1M:2010-AMD1, *Specification for Fusion Welding for Aerospace Applications*, but is included for informational purposes only.

Aviation welding specifications were primarily dependent on government standards for contract purposes and were based on welding technology from the 1950's. Those specifications were MIL-W-8611 (steel), MIL-W-8604 (aluminum), MIL-W-18326 (magnesium), and MIL-T-5021 for welder performance. 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 It was subsequently revised and superseded by MIL-STD-1595A in 1983.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 represent 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 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 1950's, 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.

In keeping with the welding and material technology advancements, this committee is committed to produce additional welding specifications as necessary, including Resistance Welding (RW) and Friction Stir Welding (FSW) to meet the demands of the ever-changing aviation and aerospace welding industry.

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

(1) Renamed Applicable Documents to Normative References in Clause 2;
(2) Relocated the Terms and Definitions from an Annex to Clause 3;
(3) Updated the standard units of measure to reflect both U.S. Customary Units and the equivalent International System of Units (SI);
(4) Updated Figure 5.1 to reflect space for bend test results and restrictions;
(5) Updated 5.3.3.1 (2) and 5.3.3.1 (3) with notes for clarification purposes;
(6) Updated inspection methods for Class A welds;
(7) Inserted subclauses within Clause 5.4, Welding Procedure Specification (WPS) that more clearly address essential variables, test methods for WPS qualification, and test record forms (Figures 5.13 and 5.14);
(8) Added Normative Annex C that covers bend testing criteria;
(9) Added Informative References Annex D.

Underlined areas in text or tables indicate changes from the previous edition. A vertical line in the margin next to a figure, equation, or other item indicates a revision to that item from the previous edition.

# Amendment

The following Amendment has been identified and is incorporated in this reprint.

**AWS Standard:** D17.1/D17.1M:2010
**Amendment #:** 1
**Subject:** Table 7.1 Acceptance Criteria in [mm], Face or Root Underfill (Groove Welds), Individual defect-maximum depth

**Table 7.1**
**Acceptance Criteria in [mm]**

| Face or Root Underfill (Groove Welds) | | | |
|---|---|---|---|
| Individual defect - maximum depth | 0.07 T or 0.030 [0.76] whichever is less | 0.10 T or 0.050 [1.27] whichever is less | 0.20 T or 0.070 [1.78] whichever is less |

# Errata

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

Page 7—**5.2.1 Physical Requirements.**—*Correct "*Alternately, the fabricator may establish other reasonable and appropriate physical requirements for welders and welding operators." to "In addition, the fabricator may establish other reasonable and appropriate physical requirements for welders and welding operators."

Page 9—**Figure 5.1, S.S. No.**—*Remove* "S.S. No." from the top of the suggested test record form.

Page 11—**Table 5.2, Samples of Alloys Contained in Material Groups I through VIII[a]**—*Correct* "Ti-6Al-4V 2/" to "Ti-6Al-4V[c]"

Page 18—**Figure 5.7, 8[200]**—*Remove " ' "* after "8[200]"

Page 18—**Figure 5.7, Note**—*Correct* "Suggested dimension" to "Where member differ in thickness more than 10% of the thicker member, the cap sheet shall be the thicker member"

Page 18—**Figure 5.7, Footnote a**—*Correct* "Where member differ in thickness more than 10% of the thicker member, the cap sheet shall be the thicker member" to "Suggested dimension"

Page 22—**5.4.2 Procedure Qualification, Numbering sequence**—*Correct* "(8) filler metal used" to "(9) filler metal used", "(9) joint design" to "(10) joint design", "(10) electrical characteristics" to "(11) electrical characteristics", "(11) preheat requirements" to "(12) preheat requirements", "(12) postweld heat requirements" to "(13) postweld heat requirements", and "(13) other variables required by the Engineering Authority" to "(14) other variables required by the Engineering Authority"

Page 26—**Table 6.1, Gas Requirements[a]**—*Correct* Oxygen Specification "B-O-925" to "BB-O-925"

Page 34—**Table 7.1, Mismatch Between members after Welding**—*Correct* "Refer to Paragraph 6.14.4 & Figure 6.2 Includes A, B & C Class of Welds" to "Refer to Paragraph 7.5.2.1 & Figure 7.2 Includes A, B, & C Class of Welds"

Page 35—**Table 7.1, Acceptance Criteria in [mm], Discoloration[b]—Titanium, Green, Class B** —*Correct* "Acceptance[a]" to "Acceptance[c]"

Page 35—**Table 7.1, Acceptance Criteria in [mm], Discoloration[b]—Titanium, Green, Class C** —*Correct* "Acceptance[a]" to "Acceptance[c]"

Page 36—**Figure 7.1, WIDTH OF WELD FACE OR INDIVIDUAL SURFACE BEAD, W**—*Correct* "W > in. TO W < 1 in [25mm]" to "W > in [8mm] TO W < 1 in [25mm]"

Page 36—**Figure 7.1, Footnote a**—*Correct* "[a] Refer to 4.3.8.2" to "[a] Refer to 5.3.8.2"

Page 37—**Figure 7.2, Extra horizontal line within table**—*Remove horizontal line between* "OFW, SMAW, GTAW, GMAW" and "PAW, VP-PAW, FCAW, SAW"

Page 42— **9.2.4.4 NDE of Nonflight Hardware, (3) Class C Inspection (for structural welds only)** —*Correct* "All Class C inspections require only the visual inspection described in 9.6.3." to "All Class C inspections require only the visual inspection described in 9.2.4.3."

Page 49—**Figure A.1(d), Missing horizontal line within table**—*Add horizontal line between* "PAW[a]" and "GMAW FCAW SAW"

Page 58—**Table A.1, Comparable Fillet Weld Size for Same Strength (in[mm])**—*Correct* "1.23 [21.2]" to "1.23 [31.2]"

Page 62—**Table C.1, Base Metal Group**—*Correct* "Ia" to "IA", "Ib" to "IB", "IIa" to "IIA", "IIb" to "IIB", "IIIb" to "IIIB"

Page 62—**Table C.1, Unified Number & Common Description**—*Remove* "S15500 & 15-5PH stainless steel", "S17400 & 17-4PH stainless steel", "S35000 & AM350 PH stainless steel", "S35500 & AM355 PH stainless steel", "S4500 & Custom 450", "S45500 & Custom 455"

Page 65—**Table C.3, Missing line within table**—*Add vertical line between* "T1" and "W", "Max." and "Min.", and "6" and "7"

Page 82—**G4.14 Welding and Weldments**—*Correct* "Figure 6.2 dictates maximum mismatch at the completed weld joint." to "Figure 7.2 dictates maximum mismatch at the completed weld joint."

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# Specification for Fusion Welding of Aerospace Applications

## 1. Scope and General Requirements

**1.1 Scope.** This specification contains requirements for fusion welding of aerospace hardware. It is to be used in conjunction with the Engineering Authority's design handbooks or their accepted data. When conformance to this specification is stipulated in contract documents, all provisions of this specification shall be complied with, except for those provisions that the Engineering Authority or contract documents specifically exempt, or those optional provisions that shall be applied when specified by the contract documents.

The following is a summary of the specification Clauses:

Clause 1. **Scope and 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 Performance and Procedure Qualification**: qualification requirements for welders, welding operators and welding procedures.

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 hardware.

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

**1.1.1 Flight Hardware.** The fundamental premise of this specification is to provide general requirements for currently recognized aerospace fusion welding processes and materials. However, this specification provides for the application of new materials, new welding processes, or acceptance criteria for production welds differing from those defined in this specification. These new applications shall be documented by the proposer and approved by the Engineering Authority.

**1.1.1.1 Aircraft, Rotorcraft, and Engines Subject to 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 Classification.** All welds produced in accordance with this specification shall be classified on the engineering drawings. Weld classifications shall be as follows: Class A, Class B, or Class C. These classifications refer to the level of inspection required and to the acceptance criteria. Alternate acceptance criteria and inspection methods may be applied if specified on the engineering drawing. The Engineering Authority shall also determine the weld procedure qualification requirements (see Annex G—Commentary).