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

Specification for Fusion Welding for Aerospace Applications

American Welding Society

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Specification for Fusion Welding for Aerospace Applications

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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 AWS D17.1/D17.1M:2010, *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 It was subsequently revised and superseded by MIL-STD-1595A in 1983.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 second 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.

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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).

1.2.1 Determining Classifications. The Engineering Authority must consider material and process aspects that affect mission or systems requirements. A weld joint may be zoned with multiple classifications.

1.2.2 Criteria. The Engineering Authority shall determine the weld procedure qualification requirements for all classifications in accordance with Clause 5. Should the Engineering Authority determine that alternate acceptance criteria are required for particular applications, weldment(s), or other circumstances, the criteria shall be specified on the engineering drawing.

1.3 Approval. All references to the need for approval shall be interpreted to mean approval by the Customer or the Engineering Authority. Hereinafter, the term "Engineering Authority" will be used and it is to be construed to mean the Customer or the Engineering Authority.

1.4 Mandatory Provisions and Authority. Nothing in this specification supersedes applicable laws and regulations unless a specific exemption has been obtained prior to the contract date or as a contract amendment.

1.4.1 Mandatory Provisions. Most provisions of this specification are mandatory when the use of this specification is invoked. Certain provisions are optional and apply only when specified in contractual documents for a specific project. Guidance information is indicated by the words "should" or "may."

1.4.2 Drawing Authority. When requirements in this specification conflict with those on the engineering drawing, the requirements on the engineering drawing shall take precedence.

1.4.3 Specification Authority. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification takes precedence.

1.5 Standard 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 exact equivalents; therefore, each system must be used independently.

1.6 Safety and Health. Safety and health issues and concerns are beyond the scope of this standard and therefore are not fully addressed herein. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes* and applicable federal, state, and local regulations.

In addition, users of electron beam welding equipment should follow with the safety requirements given in the latest edition of AWS C7.1, *Recommended Practices for Electron Beam Welding*; users of laser beam welding equipment should follow with the safety requirements given in the latest edition of AWS C7.2, *Recommended Practices for Laser Beam Welding, Cutting and Drilling* (see also Annex E).

NOTE: This specification may involve hazardous materials, operations, and equipment. The specification 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.

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.

2.1 Government Documents

Federal and Military Specifications, Standards, and Handbooks:[1]

1. BB-O-925, *Oxygen, Technical, Gas and Liquid*;
2. BB-A-106, *Acetylene, Technical, Dissolved*;
3. BB-C-101, *Carbon Dioxide, (CO_2): Technical and U.S.P.*;

[1] Unless otherwise indicated, Federal and Military Specifications, Standards, and Handbooks are published by DODSSP, 700 Robbins Avenue, Bldg. 4D, Philadelphia, PA 19111-5094.