

American Welding Society D20 Committee Additive Manufacturing

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**TECHNOLOGY EXCHANGE ON COORDINATION
OF U.S. STANDARDS DEVELOPMENT FOR
ADDITIVE MANUFACTURING**

**October 7-8, 2015
Penn Stater Conference Center
University Park, PA**

How Does a Welder Look at Additive Manufacturing?

It starts with the definition of Additive Manufacturing*:

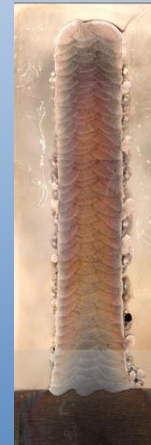
additive manufacturing (AM), *n*—a process of **joining** materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.

Multi-Pass Weld in Thick Section Alloy 690



Directed Energy Deposition Wall Builds

Inconel® 625



Ti-6Al-4V



Both processes involve the deposition of multiple molten metal beads.
Many similarities in the physical processes governing welding and AM.

* ASTM F2792

Many Similarities in the Physical Processes Governing Welding and AM



American Welding Society®

Processes

Similar energy sources can be used for both welding and AM

- Lasers
- Electron Beam
- Arc Sources
- Solid State



Materials

Both processes use powder and wire feedstock forms.

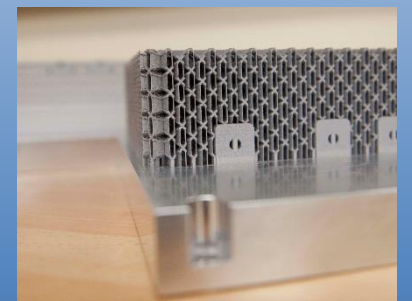
Existing alloy systems are used for both processes

- Titanium
- Nickel
- Steels
- Aluminum



Testing/Properties

Mechanical testing of weldments provides a pathway for evaluating AM components.



AWS documents cover a wide range of these issues and are used in a range of related processes to AM.

AWS Has a Rich History in Codes and Standards



A standard is a document used repeatedly as a rule, guideline or definition. It is developed by a committee of experts who work within different areas of a particular industry – this ensures that the standard is well-rounded.



Over 1,500 volunteers in 200+ committees, sub-committees, and task groups.

Documents developed by AWS are used across industries and are recognized standards.

Structural Steel Welding Codes (D1.1) widely used across all industries.

Recommended Practices for a range of welding processes are common resource documents.

Process Specifications provide critical quality control tools across industry.

AWS also sets the standard for filler metal chemistries.

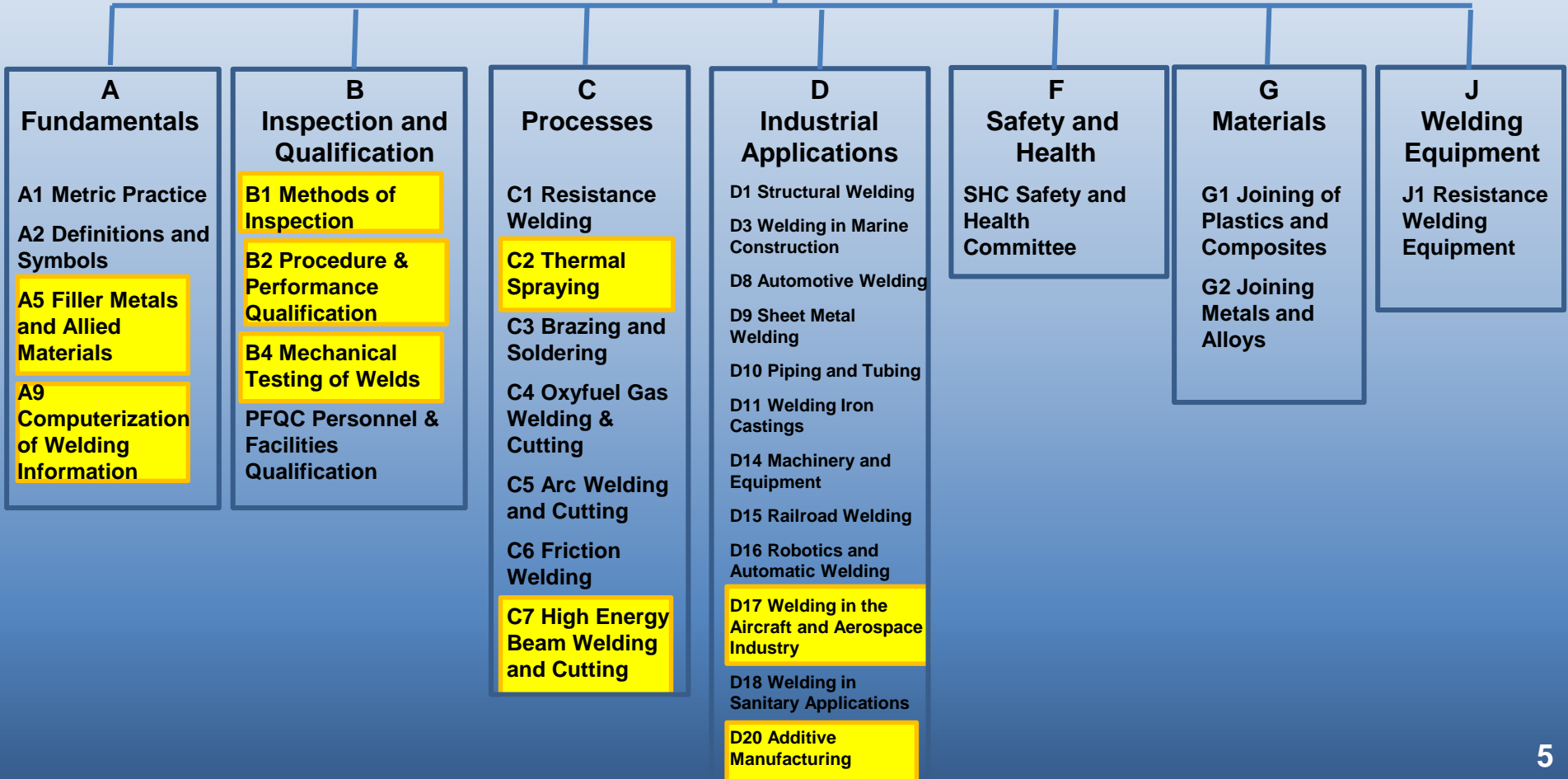
AWS has significant experience in code documents and recommended practices for a wide range of welding processes and materials.

Breakdown of AWS Technical Activities



Technical Activities Committee

TAC oversees more than 150 documents and standards

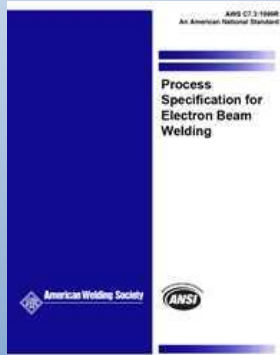


Types of Documents that AWS Produces



Welding Codes

D committees produce these documents.



Recommended Practices and Process Specifications
C committees produce these documents



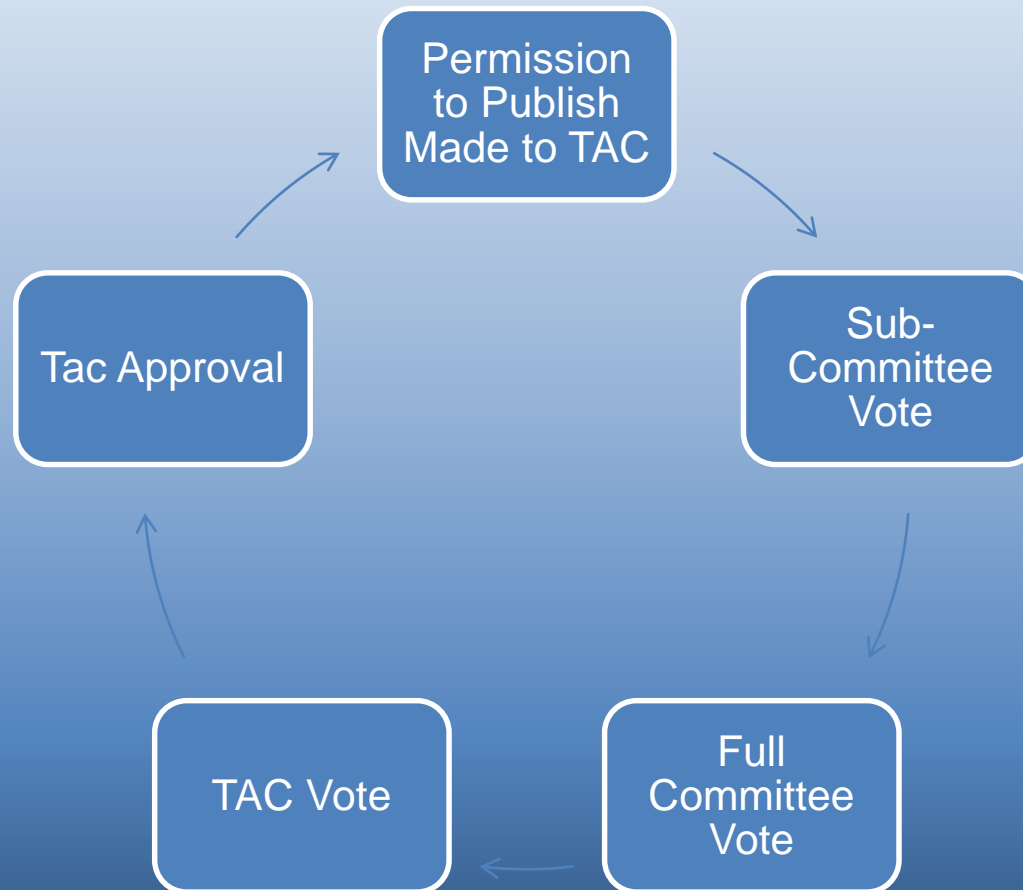
Process Material Specifications

A5 committee produces these documents

Basics of Code Development in AWS

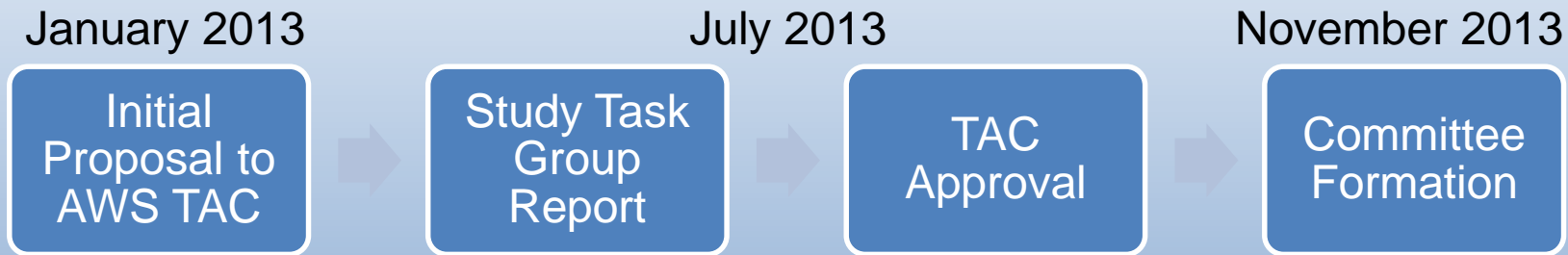
Standards developed by AWS meet the ANSI consensus voting requirements.

Balloting and approval of all standards is a five stage process with several checks and balances at each stage.



Brief History of AWS Interest in Additive Manufacturing

AWS assigned a task group to study whether additive manufacturing fell within its charter and whether there was a need for standards developed by AWS.



A stand-alone committee was needed to pull together across the several processes and material types used in AM.

AWS provides an existing set of committees to pull together the processing, properties, and qualification aspects of AM.

- **A committees for consumables**
- **B committees for qualification and testing**
- **C committees for processes**
- **G committees for materials**

Current Make-Up of D20 Committee



AWS has several existing committees that provide for the ability to pull together the processing, properties, and qualification aspects of AM into a standard for utilization by a very fast growing industry.

Current committee has more than 19 active members and 3 advisors.

- **9 industry members**
- **5 government**
- **2 academics**
- **3 professional societies**

Between equipment manufacturers, users, educators, and general interest members, this committee is balanced.

Additional members are being added on a constant basis as interest within AWS grows.

AWS provides an existing set of committees to pull together the processing, properties, and qualification aspects of AM into a standard for fabricated products.

Current Objectives of D20 Committee



A standard for structures made by AM could cut across all committees within the AWS standards program since AM has such a broad use of processes and materials.

The standard will have the same general clauses as most other AWS Standard documents:

- **General Requirements**
- **Material Characteristics/Properties**
- **Prequalification of WPS**
- **Qualification**
- **Fabrication**
- **Inspection**

Task groups have been formed to draft clauses for each subject

General Requirements Task Group



The General Requirements Task Group will work the following areas in the standard:

- **Scope – Description of the document and what is and is not covered**
- **Terms and Definitions – This standard has several terms that are new to the AWS lexicon**
- **Very general safety precautions**
- **General contractual definitions and requirements**
- **Units used in the document – This will be a mixed standard, using both U.S. Customary and SI Units**
- **Reference documents – Other documents useful to users of the standard**

Material Characteristics/ Properties Task Group

The Material Characteristics/Properties Task Group will work the following areas in the standard:

- **General design information**
- **Materials information for determination of expected properties**
- **Material transitions/splices – Both spool and dissimilar metal transitions**
- **Backing plate materials**

Prequalification of WPS Task Group



The Prequalification of WPS Task Group will work the following areas in the standard:

- **This will be a small section in the first edition**
- **Will work with fabricators to provide general AM schedules for use by general industry**
- **Will develop standard WPS templates that are applicable to AM**

Qualification Task Group

The Qualification Task Group will work the following areas in the standard:

- **Develop methodologies for AM qualification**
- **Develop test methods appropriate for AM**
- **Develop limits for WPS qualification**
- **Develop methods for performance qualification, essential variables, and testing required**

Fabrication Task Group

- **The Fabrication Task Group will work the following areas in the standard:**
 - **Process variables – develop guidance and requirements for important process variables for each AM source**
 - **Welding conditions – provide requirements for the AM environments used for various materials**
 - **Dimensional control – develop requirements and tolerances to ensure that distortion and deposits meet expectations**
 - **Materials properties – develop expected properties information for AM deposits**

Inspection Task Group

The Inspection Task Group will work the following areas in the standard:

- **General Requirements – covers receipt inspection methods, records, and recordkeeping**
- **Requirements and acceptance criteria for various inspection methods:**
 - **Visual**
 - **Penetrant**
 - **Radiographic**
 - **Ultrasonic**
 - **Other methods**

Initial Work Has Begun on a Specification Document

AWS D20.1/D20.1M:201X

**Specification for Fabrication of Metal Components
using Additive Manufacturing**

This specification provides the general requirements for fabrication of metal components using additive manufacturing.

It provides contractual guidance for the interaction between the engineer and the contractor.

It includes the design, fabrication, qualification, inspection, and acceptance of additively manufactured parts and processes.

Material classes include aluminum alloys, titanium alloys, nickel based alloys, iron based alloys, and refractory materials.

Current Table of Contents Covers Wide Range of Topics

4. Design of Additively Manufactured Components

5. Welding Performance and Procedure Qualification

6. Development and Qualification of an Additive Manufacturing Procedure

6.1 General

6.2 Selection of a Test Piece Geometry for Qualification for an Additive Manufacturing WPS

6.3 Test Piece Manufacturing

6.4 Evaluation of Test Pieces

6.5 Preparation of an Additive Manufacturing Procedure Specification (AMPS)

6.6 Additive Manufacturing Procedure Qualification Record (AMPQR)

6.7 Qualification Limits

6.8 Additive Manufacturing Procedure Specification (AMPS)

6.9 Revising a AMPQR or AMPS

7. Inspection

7.1 Qualification of Inspection Personnel

7.2 Vision Test

7.3 Visual Weld Inspection

7.4 Nondestructive Inspection

7.5 Acceptance Criteria

7.6 Inspection Records

8. Repair of Existing Structures

8.1 Scope

8.2 Design

8.3 Welding Procedures

8.4 Welder and Welding Operator Qualification

8.5 Welding Equipment

8.6 Weld Repair Inspection

8.7 Grounding

8.8 Repair Documentation

9. Nonflight Hardware

Summary

- **Additive manufacturing fits in with the standards that are presently developed by AWS**
- **A standard for structures made by additive manufacturing will be required to be able to sell actual products developed using the various additive manufacturing processes**
- **Documents produced by this committee can support an important industrial process that is very closely related to the work that we already do.**
- **Collaboration with other standards writing organizations will best serve the community.**