AWS D20.1/D20.1M:2026
An American National Standard

Specification for Additive Manufacturing of Metal Components Using Powder Bed Fusion and Powder Directed Energy Deposition

American Welding Society®

AWS D20.1/D20.1M:2026
An American National Standard

Approved by the
American National Standards Institute
September 15, 2026

Specification for Additive Manufacturing of Metal Components Using Powder Bed Fusion and Powder Directed Energy Deposition

2nd Edition

Revises AWS D20.1/D20.1M:2019

Prepared by the
AWS D20 Committee on Additive Manufacturing

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification provides the general requirements for additive manufacturing of metal components using either powder bed fusion (PBF) or powder directed energy deposition (DED). It provides guidance for the interaction between the Engineer and the Contractor. It includes the design, qualification, fabrication, inspection, and acceptance of additively manufactured components built using these powder processes. A commentary for the specification is included.

American Welding Society®

ISBN-Print: 978-1-64322-482-4
ISBN-Web: 978-1-64322-483-1
© 2026 by American Welding Society
All rights reserved
Printed in the United States of America

Photocopy Rights. No portion of this standard may be reproduced, stored in a retrieval system, or transmitted in any form, including mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner.

Authorization to photocopy items for internal, personal, or educational classroom use only or the internal, personal, or educational classroom use only of specific clients is granted by the American Welding Society provided that the appropri ate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, tel: (978) 750-8400; Internet: <www.copyright.com>.

Statement on the Use of American Welding Society Standards

All standards (codes, specifications, recommended practices, methods, classifications, and guides) of the American Welding Society (AWS) are voluntary consensus standards that have been developed in accordance with the rules of the American National Standards Institute (ANSI). When AWS American National Standards are either incorporated in, or made part of, documents that are included in federal or state laws and regulations, or the regulations of other governmental bodies, their provisions carry the full legal authority of the statute. In such cases, any changes in those AWS standards must be approved by the governmental body having statutory jurisdiction before they can become a part of those laws and regulations. In all cases, these standards carry the full legal authority of the contract or other document that invokes the AWS standards. Where this contractual relationship exists, changes in or deviations from requirements of an AWS standard must be by agreement between the contracting parties.

AWS American National Standards are developed through a consensus standards development process that brings together volunteers representing varied viewpoints and interests to achieve consensus. While AWS administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards. AWS disclaims liability for any injury to persons or to property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this standard. AWS also makes no guarantee or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this standard available, AWS is neither undertaking to render professional or other services for or on behalf of any person or entity, nor is AWS undertaking to perform any duty owed by any person or entity to someone else. Anyone using these documents should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. It is assumed that the use of this standard and its provisions is entrusted to appropriately qualified and competent personnel.

This standard may be superseded by new editions. This standard may also be corrected through publication of amendments or errata, or supplemented by publication of addenda. Information on the latest editions of AWS standards including amendments, errata, and addenda is posted on the AWS web page (www.aws.org). Users should ensure that they have the latest edition, amendments, errata, and addenda.

Publication of this standard does not authorize infringement of any patent or trade name. Users of this standard accept any and all liabilities for infringement of any patent or trade name items. AWS disclaims liability for the infringement of any patent or product trade name resulting from the use of this standard.

AWS does not monitor, police, or enforce compliance with this standard, nor does it have the power to do so.

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Director, Standards Development, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex G). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. These opinions are offered solely as a convenience to users of this standard, and they do not constitute professional advice. Such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

This standard is subject to revision at any time by the AWS D20 Committee on Additive Manufacturing. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS D20 Committee on Additive Manufacturing and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS D20 Committee on Additive Manufacturing to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

This page is intentionally blank.

Personnel

AWS D20 Committee on Additive Manufacturing

W. C. Mohr, Chair	*Edison Welding Institute*
B. K. Barnhart, 2nd Vice Chair	*Lincoln Electric Additive Solutions*
W. E. Peterson, Vice Chair	*Laser Welding Solutions*
E. Esler, Secretary	*American Welding Society*
Y. K. Bandari	*Oak Ridge National Laboratory*
A. N. Black	*Los Alamos National Laboratory*
M. P. Clemente	*US ARMY – ARDEC*
Y. Gao	*Castheon, Inc.*
F. Ghadamli	*TE Connectivity*
S. J. Gill	*Colorado School of Mines*
A. R. Gonzalez	*Colorado School of Mines*
T. D. Grohoske	*Aether Aerospace*
D. D. Harwig	*The Ohio State University*
C. Henry	*GKN Aerospace*
M. R. Hirsch	*Air Force Research Laboratory*
E. W. Karlen	*Collins Aerospace*
D. D. Kautz	*Leidos, Inc.*
K. W. Lachenberg	*Sciaky, Incorporated*
J. Lawmon	*American Engineering and Manufacturing, Inc.*
S. B. Massey	*Miller Electric Mfg., LLC*
T. Melfi	*The Lincoln Electric Company*
A. Nycz	*Oak Ridge National Laboratory*
M. Palmer	*Commonwealth Fusion Systems*
A. K. Perka	*Tata Steel*
J. D. Sugar	*Sandia National Laboratories*
J. M. Vlah	*Bechtel Plant Machinery, Inc.*
J. B. West	*Sandia National Laboratories*
C. F. Williams	*Hobart Filler Metals*

Advisors to the AWS D20 Committee on Additive Manufacturing

R. Adams	*Consultant*
P. E. Daum	*Rolls-Royce Corporation*
R. R. Grant	*Federal Aviation Administration*
R. L. Holdren	*ARC Specialties Inc*
E. D. Levert	*EDL & Associates*
J. O. Milewski	*Los Alamos National Laboratory (Retired)*
R. A. Miller	*RA Miller Materials Engineering*
T. A. Palmer	*Pennsylvania State University*
K. C. Roy	*Honeywell FM&T*
M. E. Sapp	*US NAVY (Retired)*
W. J. Sperko	*Sperko Engineering Services, Inc*
B. T. Thompson	*GE Aerospace*

AWS D20A Subcommittee on AM Using Powder

L. Smith, Chair	*Oak Ridge National Laboratory*
E. Esler, Secretary	*American Welding Society*
R. M. Cooper	*Airgas, an Air Liquide Company*
R. J. Durda	*M.I.&T*
F. Ghadamli	*TE Connectivity*
R. A. Gourley	*Curtiss Wright – EMD*
D. D. Harwig	*Ohio State University*
M. R. Hirsch	*Air Force Research Laboratory*
J. P. Manjarres	*Sintavia, LLC*
W. C. Mohr	*Edison Welding Institute*
M. Patel	*Larsen & Toubro LTD India*
S. J. Present	*Northrop Grumman*
K. L. Sham	*Eurofins EAG Laboratory, LLC*
L. N. Tomko	*Bechtel Plant Machinery, Inc.*
J. B. West	*Sandia National Laboratories*

Advisors to the AWS D20A Subcommittee on AM Using Powder

R. Adams	*Consultant*
Y. K. Bandari	*Oak Ridge National Laboratory*
A. N. Black	*Los Alamos National Laboratory*
P. E. Daum	*Rolls-Royce Corporation*
R. A. Miller	*RA Miller Materials Engineering*

Foreword

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

The predecessors to additive manufacturing started in the early 1900's, but control systems that allowed its use for mainstream manufacturing have only become prevalent in recent years. This qualification and certification standard provides a structure for manufacturers and their customers to specify high quality components across many industries. Metal additive manufacturing (AM) systems first started as very small pieces of equipment using lasers and electron beams to make fine features using expensive to fabricate materials to produce difficult components. More recently, the equipment has become quite large with the capability to make large structures and has now incorporated the use of many arc welding processes and common structural materials. The growth in this segment of the welding industry has been fast due to its ability to make quick changes in designs and its ability to support just-in-time manufacturing methods.

The information contained in this standard was compiled by the American Welding Society's D20 Committee on Additive Manufacturing and has been carefully reviewed by a number of experts in the field. It must be noted that any operating parameters given in this standard will not be the only possible parameter combinations that can be employed for successfully processing the materials shown. Changes in material composition, dimensional tolerances, and machine calibration will cause changes in the resulting products. This is the first revision of the AWS D20.1/D20.1M standard that covered both wire and powder additive AM processes. The AWS D20.1/D20.1M standard was split into this standard, AWS D20.1/D20.1M that covers powder based processes, and AWS D20.2/D20.2M that covers wire DED. The original AWS D20.1/D20.1M standard is no longer valid.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D20 Committee on Additive Manufacturing, American Welding Society, 8669 NW 36th St., # 130, Doral, FL 33166.

This page is intentionally blank.

Table of Contents

Page No.

Personnel v
Foreword vii
List of Tables xi
List of Figures xi

1. General Requirements 1
1.1 Scope 1
1.2 Units of Measure 2
1.3 Safety 2
1.4 Classification 2
1.5 Responsibilities 2

2. Normative References 3

3. Terms and Definitions 4

4. Design Requirements for Additively Manufactured Components 5
4.1 Scope 5
4.2 Material Requirements 5
4.3 Witness Specimens 5
4.4 Product Definition Data Set Requirements 6

5. Additive Manufacturing Machine and Procedure Qualification 6
5.1 General 6
5.2 Qualification Test Builds 7
5.3 Examination and Testing Requirements for Qualification Builds 9
5.4 Qualification Variables 9
5.5 Additive Manufacturing Procedure Specification Acceptance 9

6. Additive Manufacturing Machine Operator Performance Qualification 14
6.1 General 14
6.2 Qualification Requirements 14
6.3 Maintenance of Qualification 16
6.4 Qualification Expiration 16
6.5 Qualification Records 16

7. Fabrication 16
7.1 Scope 16
7.2 Digital File Control Plan 16
7.3 Additive Manufacturing System 17
7.4 Additive Manufacturing Feedstock and Substrate 17
7.5 Preheating and Interpass Temperature Control 18
7.6 Additive Manufacturing Environment 18
7.7 Additive Manufacturing Build 18
7.8 Build Interruptions 18
7.9 Witness Specimens 19
7.10 Component Identification Requirements 19
7.11 Acceptance Inspection 19
7.12 Post-AM Processing 19
7.13 Record Requirements 19

8. Inspection 20
8.1 Qualification of Inspection Personnel 20
8.2 Nondestructive Examinations. 20
8.3 Destructive Evaluation 22
8.4 Acceptance Criteria 24

Annex A (Normative)—Additive Manufacturing Qualification Records. 27
Annex B (Informative)—Informative References 45
Annex D (Informative)—Suggested Format for Fabrication Records 51
Annex E (Informative)—Process Flowcharts for Producing Components using AWS D20.1/D20.1M 55
Annex F (Informative)— Examples of Machine Qualification Build Designs for Powder Bed Fusion 59
Annex G (Informative) —Requesting an Official Interpretation on an AWS Standard 61

Commentary on the Specification for Additive Manufacturing of Metal Components using Powder Bed Fusion and Powder Directed Energy Deposition 63

List of AWS Documents on Additive Manufacturing 81

List of Tables

Table		Page No.
1.1	Additive Manufacturing Processes	1
5.1	Inspection and Testing Requirements for Machine and Procedure Qualification	8
5.2	Qualification Variables for Powder Bed Fusion Processes	10
5.3	Qualification Variables Approach Options for Directed Energy Deposition	12
5.4	Qualification Variables for Directed Energy Deposition Processes	13
8.1	NDE of Production Builds	20
8.2	RT Sampling Plan Requirements for Class B Production Builds	22
8.3	Chemical Analysis Sampling Plan Requirements for Class B Powder Bed Fusion Production Builds	23
8.4	Acceptance Criteria in USC units (in)	25
8.5	Acceptance Criteria in SI units (mm)	26
C-7.6	Minimum Requirements on Purities and Moisture Contents of Gases and Gas Mixtures	74
C-8.4.3.1(1)	Example *k* Values as a Function of Number of Specimens	77
C-8.4.3.1(2)	Example Dataset of Static Strength Properties	77
C-8.4.3.1(3)	Example for a Nonnormal Data Set	79

List of Figures

Figure		Page No.
D.1	Planned Build Interruption Record	51
D.2	Production Witness Specimen Tension Testing Documentation Form	52
D.3	Production Witness Specimen Metallographic Examination Documentation Form	52
D.4	In-Process Correction Record	53
E.1	Process for Producing Class A Components in accordance with AWS D20.1/D20.1M	56
E.2	Process for Producing Class B Components in accordance with AWS D20.1/D20.1M	57
E.3	Process for Producing Class C Components in accordance with AWS D20.1/D20.1M	58
F.1	Example of Machine Qualification Build Design for Powder Bed Fusion Utilizing As-Built Tension Test Specimens	59
F.2	Alternative Configuration for Machine Qualification Build Design for Powder Bed Fusion Utilizing As-Built Tension Test Specimens	60
C-8.4.2	Examples of the determination of T for different porosity locations	76
C-8.4.3.1(1)	Example 1: Yield Data	78
C-8.4.3.1(2)	Example 3: Yield Data	80

This page is intentionally blank.

Specification for Additive Manufacturing of Metal Components using Powder Bed Fusion (PBF) and Powder Directed Energy Deposition (DED)

1. General Requirements

1.1 Scope. This standard contains the requirements for fabricating metal components by use of additive manufacturing (AM) processes. Annex E provides flowcharts, for information, to assist the user of this standard in following the process for producing AM components in accordance with this document. When this standard is stipulated in contract documents, conformance with all provisions of the standard shall be required, except those provisions that the Engineer (see 1.5.1) or contract documents specifically modify or exempt. Additive manufacturing processes covered include those listed in Table 1.1, using powder.

The following is a summary of the standard clauses:

Clause 1. **General Requirements**: Basic information on the scope and requirements of this standard.

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

Clause 3. **Terms and Definitions**: A list of technical terms and definitions required for the application of this standard.

Clause 4. **Design Requirements for Additively Manufactured Components**: Requirements for the design of additively manufactured components.

Clause 5. **Additive Manufacturing Machine and Procedure Qualification**: Qualification requirements for additive manufacturing machines and procedures.

Clause 6. **Additive Manufacturing Machine Operator Performance Qualification**: Qualification requirements for the operators of additive manufacturing machines.

Clause 7. **Fabrication**: Requirements for fabricating additively manufactured components.

Clause 8. **Inspection**: Requirements for the qualification of inspection personnel. Nondestructive and destructive examination requirements and acceptance criteria for qualification and production builds.

Table 1.1
Additive Manufacturing Processes

Process	Abbreviation
Laser Powder Bed Fusion	L-PBF
Electron Beam Powder Bed Fusion	EB-PBF
Laser Directed Energy Deposition	L-DED
Plasma Arc Directed Energy Deposition	PA-DED