ASME PTB-13-2021

Criteria for Pressure Retaining Metallic Components Using Additive Manufacturing

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ASME PTB-13-2021

CRITERIA FOR PRESSURE RETAINING METALLIC COMPONENTS USING ADDITIVE MANUFACTURING

Prepared by:

The ASME BPTCS/BNCS Special Committee on Use of Additive Manufacturing for Pressure Retaining Equipment

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FOREWORD

This report provides specific criteria completed by the ASME Board on Pressure Technology Codes and Standards (BPTCS)/Board on Nuclear Codes and Standard (BNCS) Special Committee on Use of Additive Manufacturing. These first criteria address the Additive Manufacturing (AM) Powder Bed Fusion Process.

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EXECUTIVE SUMMARY

Recognizing a need to keep pace with rapid advancements in AM technology and AM's growing acceptance in industry the ASME BPTCS appointed a project team to evaluate the additive manufacturing technology as it applies to the construction of pressure equipment in 2015.

The first meeting of the ASME Project Team on Evaluation of Additive Manufacturing for Pressure Retaining Equipment was held in December 2015. The project team drafted and issued a gap analysis to the BPTCS in June 2016. The ASME NCS was also evaluating implementation of AM technology and was part of the membership of the ASME Project Team on AM. Following thorough review and discussion of the gap analysis, a recommendation was made to BPTCS to form a Special Committee on Use of Additive Manufacturing for Pressure Retaining Equipment. The formation of the committee was approved as a joint committee reporting to both the BPTCS and the BNCS.

The first meeting of the BPTCS/BNCS Special Committee on Use of Additive Manufacturing for Pressure Retaining Equipment was held in August 2017. The Special Committee began work on background information needed to support a technical baseline for the development of criteria for the AM Powder Bed Fusion Process. This report provides the specific criteria completed by the BPTCS/BNCS Special Committee on Use of Additive Manufacturing. These first criteria address the AM Powder Bed Fusion Process.

This additive manufacturing document provides criteria followed by commentary for the following areas:

- Scope
- Additive Manufacturing Specification
- Materials
- Thermal Treatment
- Powder Requirements
- Additive Manufacturing Design Requirements
- Additive Manufacturing Procedure
- Additive Manufacturing Procedure Qualification
- Qualification Testing of Additive Manufactured Components
- Production Build Cycles
- Chemical Composition Testing
- Mechanical Property Testing
- Metallographic Evaluation
- In-Process Monitoring
- Quality Program
- Records
- Definitions
- Referenced Standards

Description of the Powder Bed Fusion Additive Manufacturing Process

The build process begins by placing a baseplate into the machine. The printed component is constructed on this plate. The plate serves as a method of securing the component during printing, a method of preventing warping of the component, and a path for the removal of heat during the build process. The build chamber is sealed and is either purged and backfilled with an inert gas such as argon when using a laser energy source, or is left with a vacuum when using an electron-beam energy source. A thin layer of powder on the order of 100μm is deposited. Then, the energy source selectively melts specified areas of the powder in a prescribed geometry conforming to the component being manufactured.

At the completion of the layer, the fabricated portion of the component and the build plate are lowered, and another layer of powder is deposited. This process is repeated through the build until the full component height has been accomplished. At the end of the build, the component and build plate are extracted from the machine for thermal treatment and post processing.

1 SCOPE

(a) These criteria address the construction of pressure retaining component using the AM Powder Bed Fusion process using both Laser and Electron Beam energy sources.

(b) Additively Manufactured components shall meet the requirements of the applicable ASME Construction Code or Standard in addition to these criteria.

(c) Hybrid construction incorporating AM components joined (welded or brazed) to non-AM components is acceptable. Additive manufactured components joined to other AM components or non-AM components shall follow the requirements of the applicable ASME Construction Code or Standard.

(d) The maximum design temperature shall be at least 50°F (25°C) colder than the temperature where time-dependent material properties begin to govern for the equivalent wrought ASME material specification, as indicated in ASME Section II, Part D [1].

(e) The materials allowed for use in powder bed fusion under these criteria include

(1) austenitic stainless-steel alloys; and

(2) nonferrous alloys

Commentary

The criteria provided in this Pressure Technology Book (PTB) address the construction of pressure retaining components by means of the AM Powder Bed Fusion process (PBF) using both Laser and Electron Beam energy sources.

When additively manufacturing components, these criteria are intended to be used with an existing ASME Construction Code or Standard. This PTB provides criteria to address the additional information necessary to supplement construction code requirements for materials, design, fabrication, examination, inspection, testing and quality control. These supplementary criteria are essential for any proposed standard or code action for the construction of metallic pressure retaining components using powder bed fusion.

The AM process is not intended for the manufacture of pressure components when traditional manufacturing methods will provide a cost and efficiency advantage. AM has advantage in the fabrication of complex components and applications with high-cost materials. AM provides a cost advantage when subtractive manufacturing processes result in large amounts of material waste. AM also provides schedule advantages and improved lead time compared to current forging and casting methods. A market for AM is developing for replacement components in the nuclear industry where the plant operating basis requires specific replacement parts. AM provides a manufacturing method to fabricate components to the design code of record when the original components are no longer available. These initial drivers for AM will require the installation of AM components into both existing systems and new construction. The criteria allow hybrid construction incorporating AM components joined (welded or brazed) to non-AM components.

The ASME AM Special Committee did not investigate data for AM components operating in the material creep regime. Creep data were discussed but sufficient material property data was not available to accept AM components operating at elevated temperature in the scope of the current AM criteria. The maximum design temperature is limited to at least 50°F (25°C) colder than the temperature where time-dependent material properties begin to govern for the equivalent wrought ASME material specification, as indicated by the T-Notes in ASME Section II, Part D [1].