

Additively Manufactured Polymer-Based Components for Use in the Petroleum and Natural Gas Industries

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Additively Manufactured Polymer-Based Components for Use in the Petroleum and Natural Gas Industries

1 Scope

1.1 Purpose

This standard specifies requirements for qualification of the manufacturing process, production, marking, and documentation of additively manufactured polymer-based components used in the petroleum and natural gas industries when referenced by an applicable API equipment standard or otherwise specified as a requirement for conformance. The qualification process flowchart is shown in Figure 1.

1.2 Applicability

This standard applies to additively manufactured polymer-based components (including composites) produced by material extrusion [also referred to as fused filament fabrication (FFF) or fused deposition modeling (FDM) and fused granulate fabrication (FGF)] and powder bed fusion [also referred to as selective laser sintering (SLS) or multi jet fusion (MJF)].

1.3 Additive Manufacturing Specification Levels (AMSL)

This standard establishes requirements for three additive manufacturing specification levels (AMSL). These three designations—AMSL 1, AMSL 2, and AMSL 3—define increasing levels of additive manufacturing (AM) technical, quality and qualification requirements.

NOTE An AMSL can be assigned to a component by a product specification or standard, the purchaser, or the additive manufacturer.

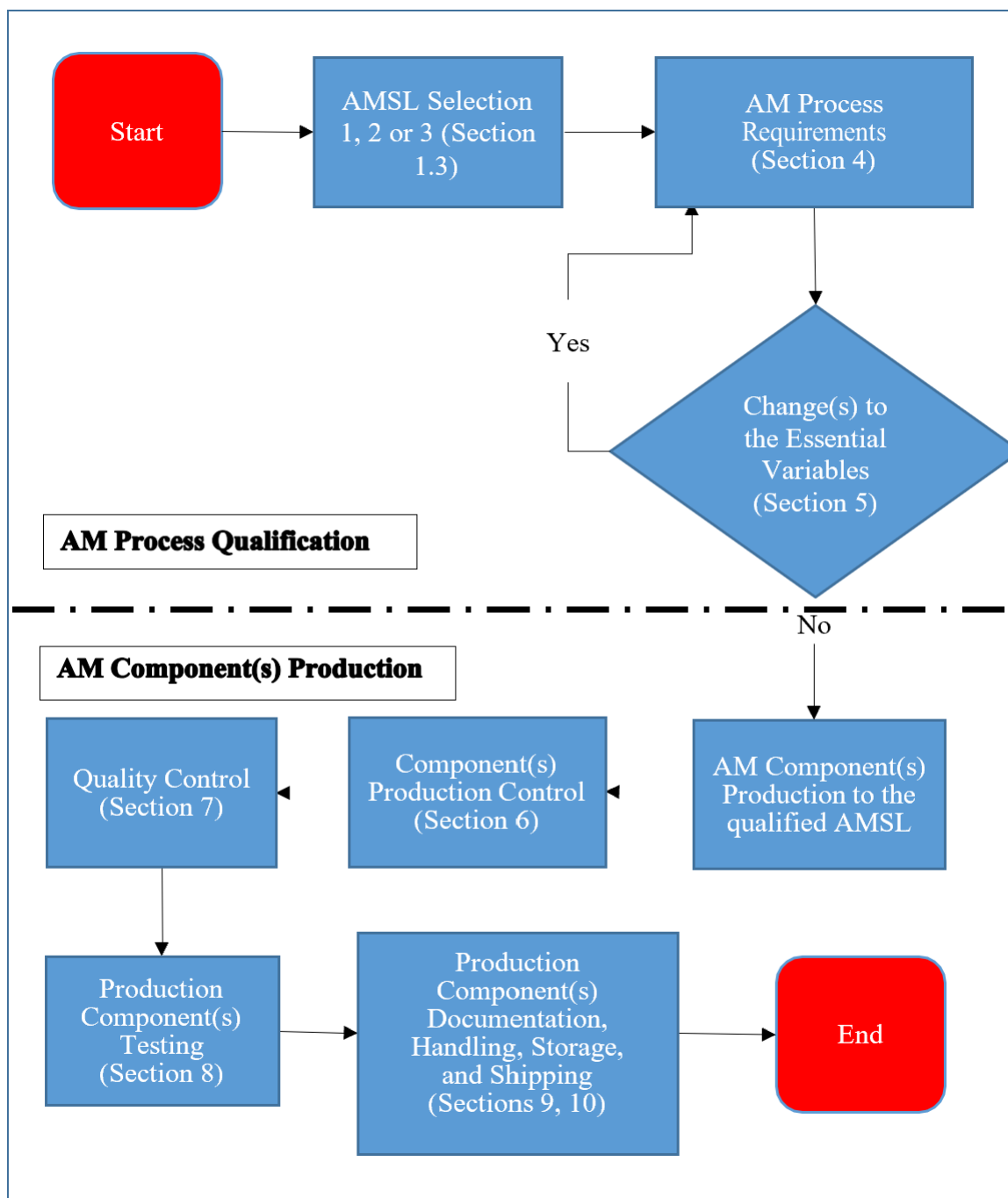


Figure 1—Qualification Process Flowchart.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

ANSI¹ /ASQ Z1.4,² *Sampling Procedures and Tables for Inspection by Attributes*

ASNT SNT-TC-1A,³ *Personnel Qualification and Certification in Nondestructive Testing*

ASTM D471,⁴ *Standard Test Method for Rubber Property—Effect of Liquids*

ASTM D543, *Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents*

ASTM D638, *Standard Test Method for Tensile Properties of Plastics*

ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM D792, *Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement*

ASTM D1238, *Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer*

ASTM D2240, *Standard Test Method for Rubber Property—Durometer Hardness*

ASTM D2583, *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*

ASTM D3418, *Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry*

ASTM D4000, *Standard Classification System for Specifying Plastic Materials*

ASTM D6980, *Standard Test Method for Determination of Moisture in Plastics by Loss in Weight*

ASTM E1131, *Standard Test Method for Compositional Analysis by Thermogravimetry*

ISO 9001,⁵ *Quality management systems — Requirements*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10005, *Quality management — Guidelines for quality plans*

ISO 23936(all components) *Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production*

ISO/ASTM 52900, *Additive manufacturing — General principles — Terminology*

ISO/ASTM 52921, *Standard Terminology for Additive Manufacturing — Coordinate Systems and Test Methodologies*

NORSOK M-710,⁶ *Qualification of non-metallic materials and manufacturers — Polymers*

¹ American National Standards Institute, 1899 L Street, NW, Washington, DC 20036, www.ansi.org.

² American Society for Quality, P.O. Box 3005, Milwaukee, Wisconsin 53201-3005, www.asq.org.

³ American Society for Nondestructive Testing, P.O. Box 28518, 1711 Arlingate Lane, Columbus, Ohio 43228, www.asnt.org.

⁴ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

⁵ International Organization for Standardization, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

⁶ Standards Norway, P.O. Box 242, NO-1326, Lysaker, Norway, www.standard.no.

SAE AMS7100 (2019),⁷ *Process Specification and Material for Fused Filament Fabrication*

3 Terms, Definitions, Acronyms and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the terms and definitions given in ISO/ASTM 52900 and the following apply. Where identical terms and definitions are given, the terms and definitions provided in this specification supersede the terms and definitions contained in ISO/ASTM 52900.

3.1.1

acceptance number

The maximum number of defects or defective units in the sample that will permit acceptance of a lot or batch.

3.1.2

additive manufacturer

An entity that fabricates the additively manufactured components.

3.1.3

build

See “build cycle” in ISO/ASTM 52900.

3.1.4

by agreement

agreed between the additive manufacturer and the purchaser.

3.1.5

certificate of conformance

CoC

A document containing the statement by the additive manufacturer certifying that the component(s) meets the requirements of this standard.

3.1.6

component build file

A file that defines the geometry and arrangement of the components, witness specimens, and support structures, as applicable, that will be built by printing equipment.

NOTE This file will be converted to printing instructions.

3.1.7

first article

A new component or a component with a revised design (drawing, material, manufacturing equipment, etc.) or a new manufacturing location.

3.1.8

feedstock

Bulk raw material supplied to the additive manufacturing building process.

3.1.9

feedstock lot

The quantity of feedstock produced under traceable, controlled conditions, from a single manufacturing process cycle.

⁷ SAE International, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096, www.sae.org



3.1.10**feedstock supplier**

The provider of material/feedstock to be processed in the additive manufacturing system.

NOTE Typically, it is the feedstock manufacturer.

3.1.11**material extrusion**

An additive manufacturing process in which material is selectively dispensed through a nozzle orifice.

3.1.12**on-site**

The additive manufacturer's facility.

3.1.13**powder bed fusion**

An additive manufacturing process in which thermal energy selectively fuses regions of a powder bed.

3.1.14**printing equipment**

See "AM Machine" in ISO/ASTM 52900.

3.1.15**process consumables**

Material inputs to the additive manufacturing process that are specified in accordance with the item being manufactured (e.g. feedstock, substrate, as applicable to the process used).

3.1.16**production lot**

All components of the same build with the same post-processing.

3.1.17**removable components**

Items that are removed/replaced as components of the manufacturing process (e.g. build platform, recoater blade).

3.1.18**serviceable components**

Items that are removed/replaced/cleaned as components of a maintenance event (e.g. filters, lenses, laser).

3.1.19**substrate**

The surface onto which the initial layer of feedstock is deposited. This may be a build platform (e.g. for PBF), a surface that becomes an integral portion of the component, or a surface of an existing component.

3.2 Acronyms and Abbreviations

For the purposes of this standard, the following abbreviations apply.

3MF	tridimensional manufacturing format
AM	additive manufacturing
AMF	additive manufacturing file format
AMSL	additive manufacturing specification level
CAD	computer-aided design

CoC	certificate of conformance
CT	computed tomography
DMA	dynamic-mechanical analysis
DPD	digital product definition
DSC	differential scanning calorimetry
FDM	fused deposition modeling
FFF	fused filament fabrication
FGF	fused granulate fabrication
FTIR	Fourier transform infrared
IGES	initial graphics exchange specification
NDE	nondestructive examination
MEx	material extrusion
MFI	melt flow index
MJF	multi jet fusion
MPS	manufacturing process specification
NCR	nonconformance report
OEM	original equipment manufacturer
PBF	powder bed fusion
QMS	quality management system
SDS	safety data sheet.
SEC	size-exclusion chromatography
SLS	selective laser sintering
STEP	standard for the exchange of product model data
T_g	glass transition temperature
TGA	thermal-gravimetric analysis
T_m	melting temperature
X_c	degree of crystallinity

4 Requirements for the Additive Manufacturing Process

4.1 General

Material extrusion (MEx) and powder bed fusion (PBF) processes are covered in this section of the document. Other processes can be included by agreement; therefore, the additive manufacturer shall develop a specification aligned with this document's requirements as applicable.

This standard gives the requirements for three additive manufacturing specification levels (AMSL). The following subparagraphs describe the conditions which, when met, allow the additive manufacturing (AM) process to receive the appropriate AMSL classification.

When additively manufactured polymer-based components are ordered to an API product specification or API product standard, the functional requirements shall fulfill the API product specification or API product standard. The qualification requirements shall be by agreement for non-API standard products.