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DEPARTMENT OF DEFENSE
MANUFACTURING PROCESS STANDARD

MATERIALS DEPOSITION, DDM: DIRECT DEPOSITION OF METAL FOR REMANUFACTURE, RESTORATION AND RECOATING

AMSC N/A AREA MFFP

FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense.

2. This standard defines the requirements for material selection, qualification, and inspection of components that will be repaired by Direct Deposition of Metal (DDM) of a metallic feedstock to a metallic substrate. This process is used for, but is not limited to, remanufacture of damaged and or worn parts, restoration of dimensionally discrepant parts, or part performance enhancement with corrosion, wear and thermal protection.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army RDECOM, Tank Automotive Research, Development and Engineering Center, ATTN: RDTA-EN/STND/TRANS MS #268, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or emailed to usarmy.detroit.rdecom.mbx.tardec-standardization@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

SUMMARY OF CHANGE 1 MODIFICATIONS

1. Changed word from “DDMP” to “DDM” in 4.2.1.

2. In figure 3, the size of the first decision triangle was increased, which added existing wording that was truncated.

3. In figure 6, the size of both decision triangles were increased, which added existing wording that was truncated.

CONTENTS

1. SCOPE

1.1 Purpose. This standard defines the requirements for material selection, qualification, and inspection of components that will be repaired by Direct Deposition of Metal (DDM) of a metallic feedstock to a metallic substrate. This process is used for, but is not limited to, remanufacture of damaged and or worn parts, restoration of dimensionally discrepant parts, or part performance enhancement with corrosion, wear and thermal protection.

1.2 Process. Direct Deposition of Metal is an additive manufacturing process, as defined in ASTM F2921, facilitating the building of surface layers to remanufacture or restore parts. In general, the process involves a preparatory effort to the substrate and fixture development, as required, to retain the work piece during the deposition process. Following Direct Deposition of Metal, the work piece undergoes post deposition processing such as grinding to meet dimensional requirements. Figure 1 below displays the DDM process.

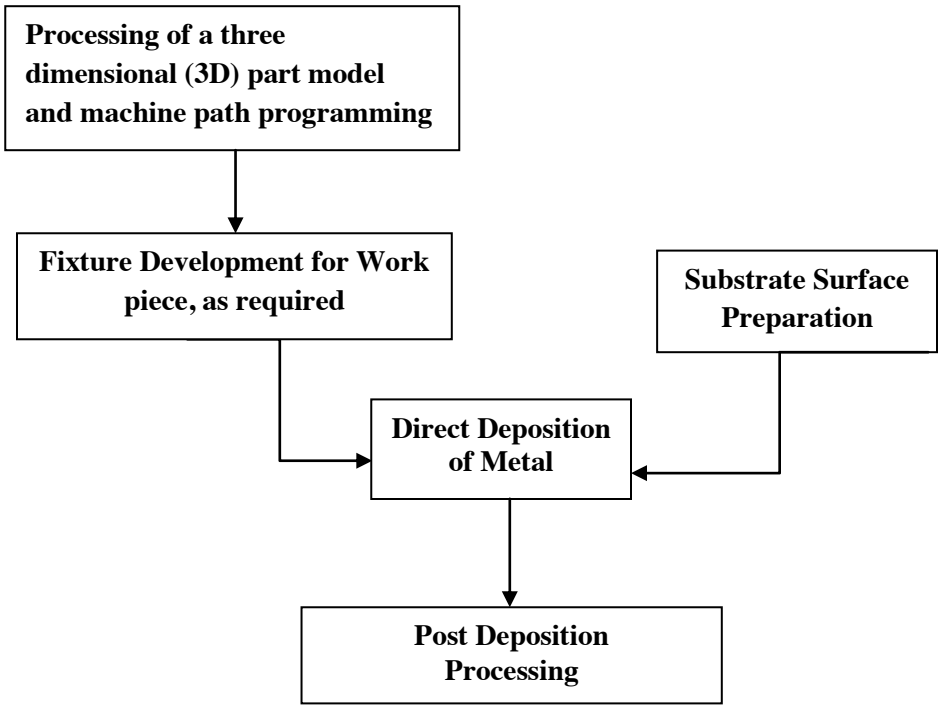

FIGURE 1. Direct Deposition of Metal Process.

The process is conducted under an inert atmosphere or under vacuum. The surface of a substrate is prepared and then heated using a heat input such as laser or electron beam to form a melt pool. A feed material such as metal powder or filler wire is directed onto the substrate melt pool. The feedstock melts and upon cooling, solidifies unto the substrate to form a deposit as shown in Figure 2. The deposition thickness and width can vary and multiple layers can be applied to increase the deposition thickness.

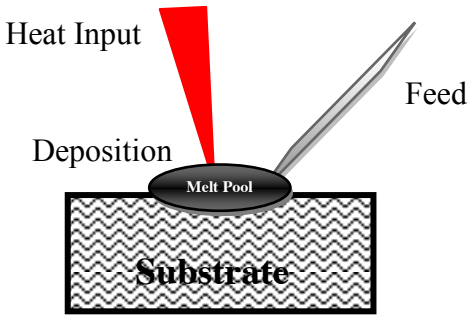

FIGURE 2. Deposition on Substrate.

1.3 Application. This standard is to be used for the remanufacture, restoration or resurfacing of components by Direct Deposition of Metal. The Direct Deposition of Metal process is used to produce dense, pure, thick and well-bonded deposits of various metals and alloys, such as aluminum (Al), copper (Cu), nickel (Ni), titanium (Ti), as well as stainless steel, nickel-base alloys. Direct Deposition of Metal can be used to provide protective coatings and performance enhancing layers, such as corrosion, wear, thermal properties.

1.4 Limitations. This standard is not intended to be guidance for:

a. Safety – This standard does not purport to address all of the safety concerns associated with the Direct Deposition of Metal process. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Personnel involved with Direct Deposition of Metal machinery such as lasers or electron beam should always read, understand, and follow all of the safety guidelines provided by the machine tool manufacturer, as well as all other applicable pertinent safety standards.

b. Machine and Equipment - This standard does not cover specific machine and equipment requirements. Personnel involved with the use of Direct Deposition of Metal machinery are to follow equipment installation and system verification guidelines provided by the machine tool manufacturer.

c. Manufacturing Components – This standard is intended for remanufacture, restoration or resurfacing processes only and does not cover the manufacture of net shape or components from seed.

d. Non-metallic materials – The standard is restricted to the primary use of various metallic feedstocks and metallic substrates.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to

ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Non-Government documents. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

GENERAL MOTORS CORPORATION (GM)

GMW14872 - Cyclic Corrosion Laboratory Test

(Copies of this document are available from General Motors North America, c/o Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112 or www.ihs.com or as directed by the contracting officer.)

AMERICAN SOCIETY FOR QUALITY (ASQ)

ANSI/ASQ Z1.4 - Sampling Procedures and Tables for Inspection by Attributes

(Copies of this document are available from www.asq.org or American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME Y14.43 - Dimensioning and Tolerancing Principles for Gages and Fixtures

(Copies of these documents are available online at http://www.asme.org or from American Society of Mechanical Engineers, Orders/Inquiries, P.O. Box 2300, Fairfield, NJ 07007-2300.)

ASTM INTERNATIONAL

ASTM B557M - Standard Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

ASTM C633 - Standard Test Method for Adhesion or Cohesion Strength of Thermal Spray Coatings

ASTM E8 / E8M - Standard Test Methods for Tension Testing of Metallic Materials

ASTM E94 - Standard Guide for Radiographic Examination

ASTM E606 / E606M - Standard Test Methods for Strain-Controlled Fatigue Testing

ASTM F2921	-	Standard Terminology for Additive Manufacturing—Coordinate Systems and Test Methodologies
ASTM G65	-	Standard Test Method for Measuring Abrasion Using the Dry Sand/Rubber Wheel Apparatus
ASTM D1002	-	Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)
ASTM D2295	-	Standard Test Method for Strength Properties of Adhesives in Shear by Tension Loading at Elevated Temperatures (Metal-to-Metal)
ASTM D3846	-	Standard Test Method for In-Plane Shear Strength of Reinforced Plastics
ASTM E1030	-	Standard Test Method for Radiographic Examination of Metallic Castings
ASTM E18	-	Standard Test Methods for Rockwell Hardness of Metallic Materials
ASTM E10	-	Standard Test Method for Brinell Hardness of Metallic Materials
ASTM E384	-	Standard Test Method for Knoop and Vickers Hardness of Materials
ASTM B117	-	Standard Practice for Operating Salt Spray (Fog) Apparatus

(Copies of these documents are available from www.astm.org or ASTM International, P.O. Box C700, West Conshohocken, PA 19428-2959.)

AMERICAN WELDING SOCIETY (AWS)

AWS A5.32 / A5.32M - Filler Metal Specification For Shielding Gases For Welding

(Copies of these documents are available from www.aws.org or American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.)

SAE INTERNATIONAL

SAE AMS 2680C - Aerospace Material Specification Electron Beam-Welding For Fatigue Critical Applications

(Copies of these documents are available from www.sae.org or SAE Customer Service, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.3 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Control Parameters. Those process elements that are important in the deposition procedure and generally remain constant or within a limited tolerance. These elements should be documented in the PQR and often include elements associated with specific equipment and feedstock being used for the deposition.

3.2 Direct Deposition of Metal. Additive manufacturing process that builds layers of feedstock (e.g. powder or wire) metal onto a substrate.

3.3 Essential Variables. Those elements, either material or process, that are critical in establishing the deposition procedure. These elements and the values should be documented as part of the Part Qualification Record (PQR), e.g. power, scanning velocity, energy source diameter, feedstock feed rate. Changes in these elements, after a part has been qualified, require a change in the written PQR and may require requalification, depending on the element being changed and the magnitude of the change.

3.4 Feed. A material delivery mechanism, that delivers material in the form of powder or wire to create the deposition.

3.5 Feedstock. The feedstock for the direct metal deposition process should be either metallic wire or powder.

3.6 Heat input on substrate. Measurement of the heat applied to the substrate (combination of power and scanning velocity) which is an example of an Essential Variable.

3.7 Layer. Multiple passes over the work piece that result in complete coverage.

3.8 Major Parts (fixturing). Parts that have specific GD&T requirements on drawing (nominal and allowed tolerance).

3.9 Minor Parts (fixturing). Parts that do not have specific GD&T requirements on drawing.

3.10 Pass. A single traverse by the nozzle over the work piece.

3.11 Procedure Qualification Record. The Procedure Qualification Record (PQR) is a record that contains all the essential variables and control parameters of the process that are used to remanufacturer, restore or resurface components. PQR also contains fixturing requirements and test records.

3.12 Substrate. The material, work piece, part, component or substance on which metal is deposited by a feed.

4. GENERAL REQUIREMENTS

4.1 Part Eligibility. The parts shall be identified as candidate for Direct Deposition of Metal processing. Eligible candidates shall have no through-fractures and application of Direct Deposition of Metal requires approval by a design responsible engineer. Completely fractured parts are ineligible for remanufacturing, restoration or surface enhancement.

4.1.1 Incoming Inspection. Received part(s) shall be inspected to verify suitability, for repair, using NDT methods including, but not limited to the following:

a. Visual (see 5.5.1.1)
b. Magnetic Particle Inspection (see 5.5.1.4)
c. Dye Penetrant (see 5.5.1.3)
d. X-Ray (see 5.5.1.2)

4.1.2 Surface Preparation

4.1.2.1 Cleaning of Surfaces. All surfaces, to receive deposits shall be thoroughly cleaned to remove oil, grease, dirt, paint, oxidation and other foreign materials. Cleaning procedures shall not embrittle, pit, or damage surfaces to be coated. Specifically noted is a restriction of acidic chemical cleaning, which shall not be used on hardened steel surfaces above HRC 35 due to risk of hydrogen embrittlement. Cleaning shall take place no more than four hours prior to processing using Direct Deposition of Metal.

4.1.2.2 Surface Modification. Existing surfaces can be modified by machining, grinding or other as appropriate process. All carburized, nitrated or otherwise surface modified substrates shall be removed prior to DDM. Hardened surfaces above HRC 35 of substrates may require pre-annealing to soften material for improved Direct Deposition of Metal processing.

4.1.2.3 Abrasive Blast. To decrease the surface reflectance, the surfaces designated for Direct Deposition of Metal shall be abrasive blasted. Aluminum shall not be abrasive blasted due to entrapment of particles and potential porosity.

4.1.2.3.1 Blast Contamination. All blast media shall be free of contamination that will affect the substrate material, for example a blasting cabinet and media that had been used on ferrous substrates in the past, shall not be used to blast nonferrous substrates such as aluminum or magnesium alloys.

4.1.3 Handling. Part handling shall be conducted in a manner in which the surface to be processed will not be contaminated with oil, dirt, etc. during and following completion of all surface preparation steps.

4.1.4 Storage. During and following completion of all surface preparation, all parts designated for Direct Deposition of Metal shall be stored in an enclosure at minimum temperature of 18.3 °C (65 °F). Cleaning shall take place no more than four hours prior to Direct Deposition of Metal.

4.2 Feedstock

4.2.1 Deposition Powder. Powder shall be dry, free flowing, and thoroughly blended. Mixtures of powder stock with varying density and/or size particulates shall be kept from settling or stratifying in the feeder as long as a powder charge is utilized. The particle size median and size range shall be in accordance with the equipment manufacturer's requirements. If the powder to be used is additionally controlled by a specification from a powder manufacturer, median particle size and range, and intended DDM process shall be so specified in the purchase order to and contract with said powder manufacturer. In addition, a Materials Safety Data Sheet shall be required with each delivery

4.2.2 Deposition Wire. Wire shall be spooled and validated for composition, cleanliness, and packaging based on requirements of the application.

4.2.3 Storage. Feedstock shall be stored in accordance with the requirements of the manufacturer for the intended process. Opened packaging that has been removed from its original packaging shall be repackaged, resealed, protected and stored to prevent moisture absorption into the feedstock.

4.2.4 Handling. The user is cautioned to the importance manufacturer's instructions pertaining to the storage and handling of fine metal powders or wire feedstocks.

4.2.5 Preheating. Feedstock exposed to moisture shall be preheated to 160°C (320 °F)or in accordance with the equipment manufacturer's requirements before the Direct Deposition of Metal process to prevent oxidation or contamination. Powders, such as Ti and Al, shall be preheated in an inert atmosphere in accordance with the supplier's instructions.

4.3 Gas. The gases shall be inert and gas shall be in accordance with the equipment manufacturer's requirements for the feedstock to be deposited.

4.3.1 Gas quality. Gas quality shall be in accordance with AWS A5.32 / 5.32M.

4.3.2 Gas delivery system. Gas delivery system shall be in accordance with equipment manufacturer's requirements.

4.4 Fixturing. Components shall be processed in fixtures and held securely into position. Minor parts may be fixtured by means that will insure secure and proper positioning.

The fixtures shall be designed to not distort parts being processed and certification shall be necessary if required by procuring activity. Major component fixtures with critical dimensions shall be designed in accordance with ASME Y14.43. Geometric Dimension and Tolerance (GD&T) may be applied to achieve dimensions within tolerances of drawings. If GD&T is unknown, consult design responsible engineer.

4.5 Deposition Process Control. The Direct Deposition of Metal process is optimized through the adjustment of essential variables and established control parameters (see figure 3). Control factors can include, but are not limited to, gas flow rate, nozzle geometry, throat size, feedstock feed rate, feedstock flow rate, work piece standoff distance from energy source and work piece feed rate, work piece preheat temperature, substrate material, surface preparation history, deposition feedstock supplier lot number, feedstock storage history, etc..

4.5.1 Gauges, meters. All gauges and meters shall be calibrated, annually, in accordance with the manufacturers recommendations, or at a minimum, annually.

4.5.2 Checks. Process control procedures shall be checked during Direct Deposition of Metal processing to assure the control parameters as documented in the Procedure Qualification Record (PQR) are maintained and recorded. Maintenance shall be performed in accordance with the manufacturers' preventative maintenance schedule.

4.5.3 Deposition Thickness. The feedstock shall be deposited on the designated surfaces at a layer thickness to yield, after subsequent post deposition operations, a finished thickness that will meet the specified form and fit and function.

4.6 Identification. Unless otherwise specified in the contract or purchase order (see 6.2), each remanufactured, restored or recoated part shall be identified by applying the symbol AM as a prefix to the serial number (e.g., AM S/N 1234) or as a prefix to the Federal manufacturer code on non-serialized parts. The prefix shall be applied in the same manner as specified on the engineering drawing for the part number unless otherwise specified in the contract or purchase order (see 6.2). In the event that available space precludes application of the symbol as a prefix, the symbol shall be applied as closely as possible to the serial number or Federal manufacturer code. In no case shall the symbol be applied as a suffix to the serial number or Federal manufactures code.

5. DETAILED REQUIREMENTS

5.1 Procedure Qualification Record. The Procedure Qualification Record (PQR) shall be specific to a part and shall contain the information strictly pertaining to the area of repair by Direct Deposition of Metal processing. The PQR will also contain the test results and records used to qualify the repair of the part.

5.2 Material Process Development. The process, as defined in figure 3, will be used to produce a coupon, manufactured of the substrate material and feedstock, as indicated by the engineering drawing or as otherwise directed by design responsible engineer. The analysis determines if adjustments are required to the initial Essential Variables and Control Parameters

based on inspection as defined in 5.5.1 and Testing as defined in 5.5.2. Material Process Development is not required if processing a component with identical work piece material and deposition feedstock as indicated by the engineering drawing or as otherwise directed by design responsible engineer.

5.2.1 Material Process Validation. The process, as shown in figure 3, defines the methodology to produce an output of Material Process Development that shall be inspected and tested as defined in 5.5.1 and 5.5.2 respectively or as directed by the design responsible engineer. The evaluation determines optimized Essential Variables and Control Parameters based on the material properties and performance requirements of the feedstock material as deposited to the substrate. Material Process Validation is not required if processing a component with identical substrate material and feedstock as indicated by the engineering drawing or as otherwise directed by design responsible engineer. The optimized Essential Variables and Control Parameters are extracted from the appropriate component Procedure Qualification Record of identical substrate material and feedstock to create another Procedure Qualification Record.

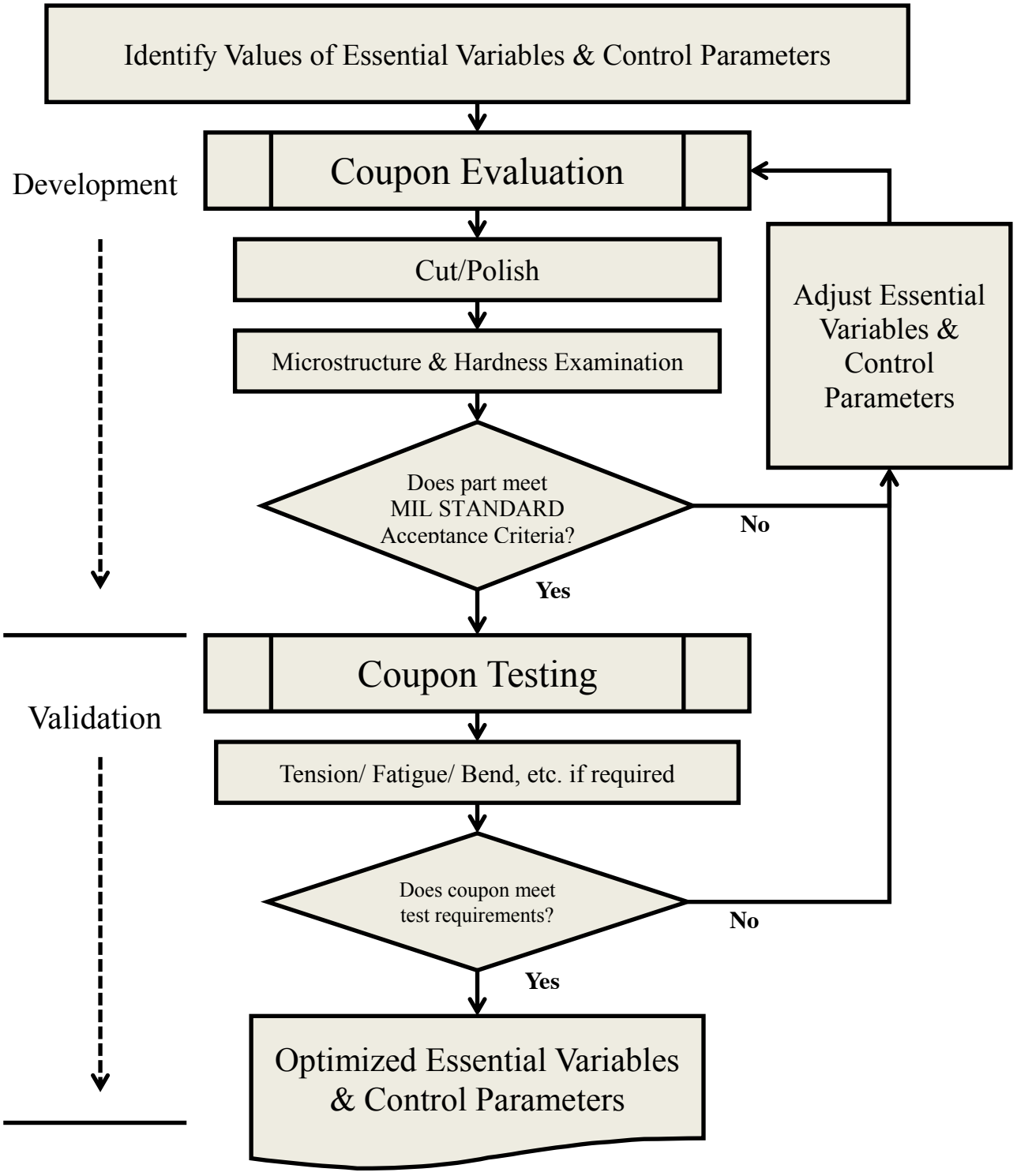

FIGURE 3. Materials Process Development & Validation.

5.3 Part Repair Process Development. Figure 4 outlines the process to create a Procedure Qualification record (see 5.1) based on the characterization of the material properties on the repaired location of the work pieces using inspection defined in 5.5.1.

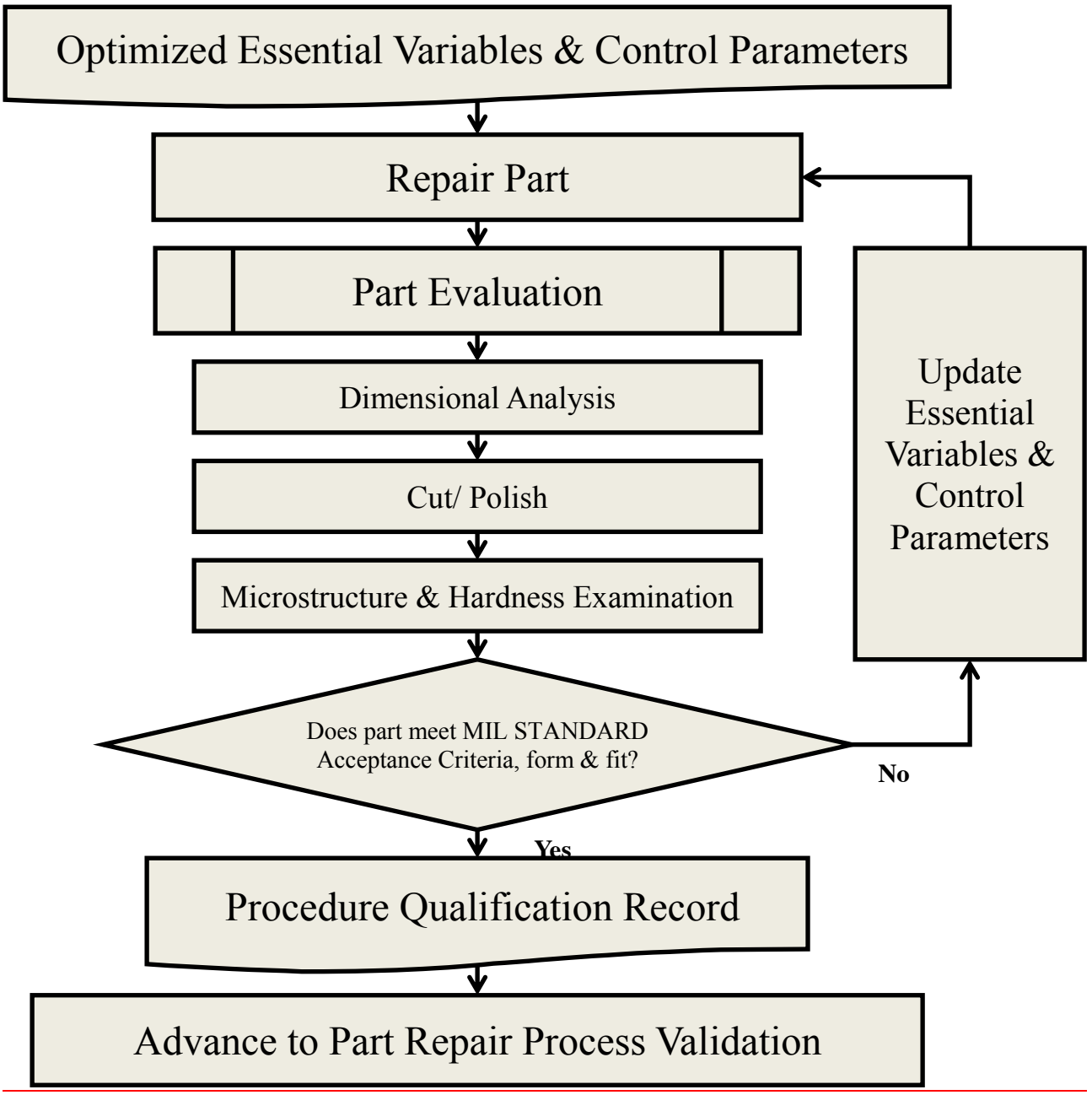

FIGURE 4. Part Repair Process Development.

5.4 Part Repair Process Validation. Figure 5 outlines the process to continue developing the work piece Procedure Qualification Record through dimensions, Non Destructive Testing

(5.5.1.1 - 5.5.1.4) and testing (5.5.2) on the repaired location of the work pieces as directed by design responsible engineer.

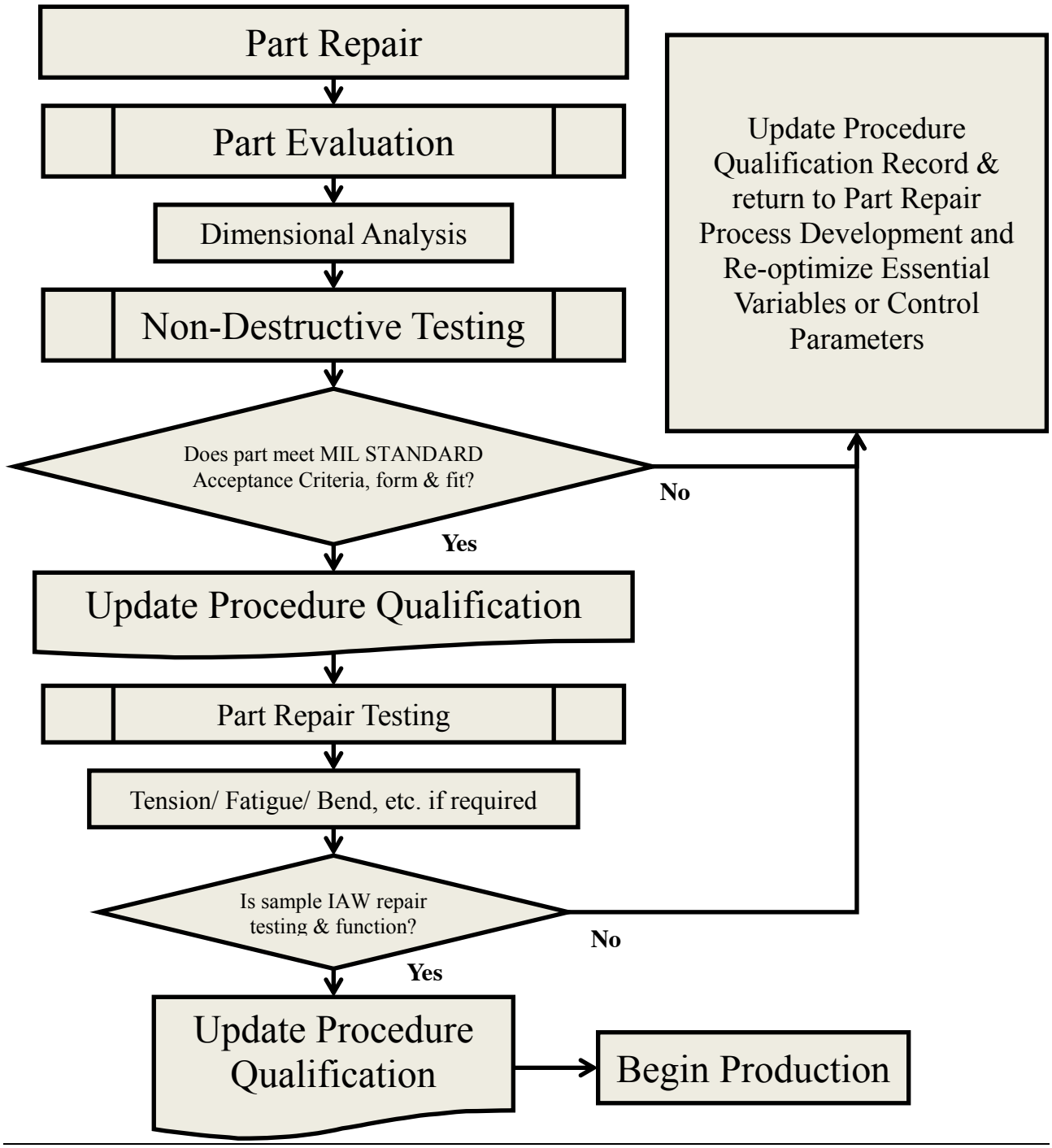

FIGURE 5. Part Repair Process Validation.

5.4.1 Production Process Monitoring. Figure 6 defines the process to monitor Direct Deposition of Metal in production. Sampling procedures shall be in accordance with ANSI/ASQ Z1.4. Unless otherwise specified by a design responsible engineer, all inspection (see 5.5.1) and non-destructive test results (see 5.5.2) shall be recorded on the PQR (see 5.1).

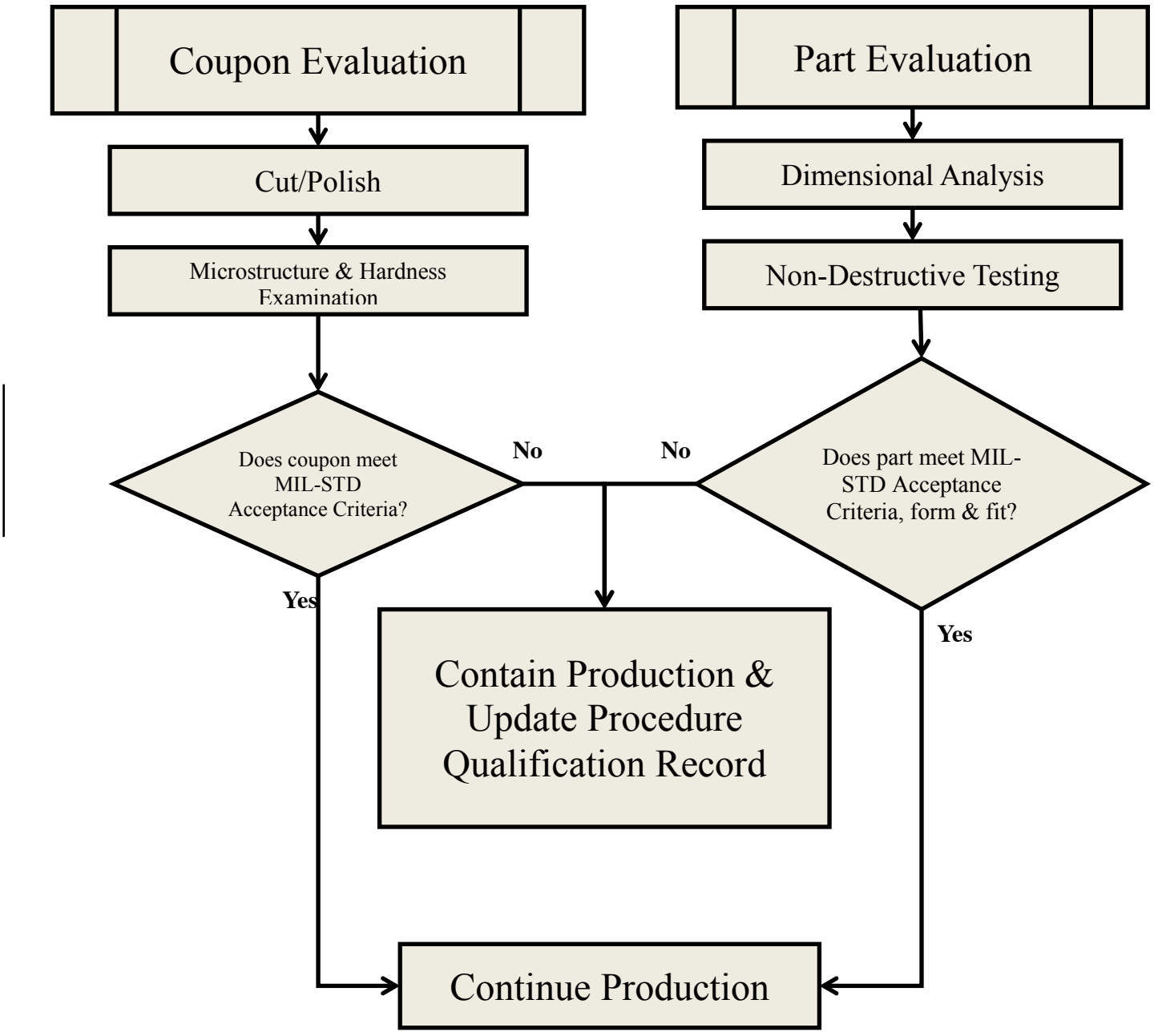

FIGURE 6. Production Process Monitoring.

5.4.2 Production Monitoring. Upon first part set-up or after routine maintenance, the Direct Deposition of Metal system shall be verified for capability of achieving Direct Deposition of Metal requirements as documented in the PQR by performing coupon inspection (see 5.5.1). To assure performance of the system has not been altered, verification of system performance can be made at any interval and shall consist micro-hardness testing as defined in table II.

5.5 Validation of PQR. PQR Validation shall include inspection techniques and testing requirements.

5.5.1 Inspection.

5.5.1.1 Visual Inspection. All depositions examined at 10X magnification or greater, shall meet the following criteria:

a. Cracks - Cracks shall not be acceptable in the deposition, heat affected zone or adjacent parent metal except where micro fissuring is specifically permitted by the engineering drawing.

b. Voids and Pores - Voids and pores open to the surface shall not be acceptable unless they are subsequently to be removed by post deposition machining.

5.5.1.2 Radiographic Inspection. All depositions shall be radiographically inspected in accordance with ASTM E 1742 to determine conformance to the following acceptance criteria.

5.5.1.2.1 Cracks. The presence of cracks, as a result of deposition, heat-affected zone or adjacent parent metal shall not be acceptable. Should microfissuring be acceptable in any specific alloy (e.g. precipitation hardenable nickel alloys), acceptance criteria shall be designated in the contract or by the responsible authority.

5.5.1.2.2 Porosity, Voids, and Inclusions. Discontinuities, such as porosity, voids, and inclusions (metallic and nonmetallic), within the deposited feedstock or immediately adjacent in the parent substrate shall be restricted and sized as follows:

a. Porosity - The size of internal porosity, cavities, voids, and inclusions shall be determined by largest dimension.

b. Inclusions - Inclusions (metallic or nonmetallic) shall be treated the same as porosity (see 5.5.1.2.2a).

c. Voids - Interconnected porosity, inclusions, and cavities (voids) - shall be considered as one single pore for sizing purposes (see 5.5.1.2.2a).

d. Pores and voids identified with the operation are acceptable provided they do not exceed the limits of 5.5.1.2.3.

5.5.1.2.3 Internal Discontinuity Limits. For the purpose of this standard, all references to weld thickness in SAE AMS 2680 shall be interpreted as deposition thickness.

5.5.1.2.3.1 Maximum Pore Diameter. Two or more adjacent discontinuities, other than aligned (see 5.5.1.2.3.3) shall be treated as a single discontinuity (excluding the space between them) when the spacing between them is less than three times the greatest dimension of the smaller adjacent discontinuity. The allowable limits for various parent metal thicknesses are established in accordance with SAE AMS 2680, table 2, Column B(2), for aluminum alloys, and in table 2, Column B(1), for all other materials.

5.5.1.2.3.2 Maximum Defect Area. Shall be the sum of the areas of the pores within a 1.0-inch (25-mm) length of deposition not to exceed the limits in accordance with SAE AMS 2680, Table 2, Column C(2), for aluminum alloys, and Table 2, Column C(1), for all other materials. Pores under 0.010 inch (0.25 mm) shall not be considered in calculating total defect area deposition thicknesses 0.25 inch (6.4 mm) or over.

5.5.1.2.3.3 Maximum Aligned Defect Area. Shall be any group of five or more individual pores within a 1.0-inch (25-mm) length of deposition whose images can be intersected by a straight line (regardless of orientation within the deposition) and the distance between adjacent discontinuities within the group being considered is less than four times the longest dimension of the smaller adjacent discontinuity. The limits of aligned defects are established in accordance with SAE AMS 2680, table 2, Column C(4), for aluminum alloys, and in table 2, Column C(3), for all other materials.

5.5.1.3 Liquid Penetrator Inspection: All depositions, including validation testing, of non-magnetic materials shall be fluorescent penetrant inspected in accordance with ASTM E 1417 to locate imperfections open to the surface. No defects are permissible except as permitted by 5.5.1.2.3, unless otherwise authorized by the engineering activity.

5.5.1.4 Magnetic Particle Inspection: All depositions, including validation tests, of magnetic materials shall be magnetic particle inspected in accordance with ASTM E 1444. No defects are permissible unless otherwise authorized by the engineering activity.

5.5.2 Testing. Testing for essential variables can consist of any of the following tests as applicable to the application, environment and loading conditions of part to be repaired. The design responsible engineer shall determine the parts application situation and the subsequent testing required. Table I below has possible, but not limited to, tests that will assist in choosing the proper test versus application.

TABLE I. PQR Validation Testing.

TEST	APPLICATION				
	High Stress	Fatigue	Wear	Corrosion	Load Bearing
Tensile	X	X			X
Fatigue	X	X			X
X-Ray	X	X	X	X	X
Micro-Hardness	X	X	X		X
Wear Abrasion	X	X	X		X
Salt Spray				X	
Side Bend	X	X			X
Lap Shear	X	X	X		X
Cohesion	X	X	X	X	X

5.5.2.1 Testing Requirements.

Table II below contains recommended, but not limited to, standards that will assist in selecting the proper test(s) based on the part application(s) from table I.

TABLE II. Recommended Testing Standards.

MATERIAL ATTRIBUTE	RECOMMENDED STANDARDS		
Tensile	ASTM E8/E8M	ASTM B557/ 557M	
Fatigue	ASTM E606/ 606M		
X-Ray	ASTM E94	ASTM E1030	
Micro-Hardness	ASTM E18	ASTM E10	ASTM E384
Wear Abrasion	ASTM G65		
Corrosion	ASTM B117	GMW 14872	
Side Bend	ASTM E290		
Lap Shear	ASTM D1002	ASTM D2295	ASTM D3846 (1)
Cohesion	ASTM C633		

(1) Test samples have the possibility of becoming significantly distorted in non-shear plane areas, therefore invalidating the test. If this occurs, the recommended practice is to use ASTM D3846. In this standard, the samples are tested using compressive force instead of tensile force, and the shear area is surrounded in a fixture to prevent buckling.

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory.)

6.1 Intended Use. This process is intended for the remanufacture of damaged and or worn parts, restoration of dimensionally discrepant parts, or part performance enhancement with

corrosion, wear and thermal protection. This process is not intended for net shape or components from seed.

6.2 Acquisition Requirements. Acquisition documents should specify the following:

a. Title, number and date of this standard.
b. If the symbol to be applied is different (see 4.6).
c. If the prefix to be applied is different than as specified on the drawing (see 4.6).

6.3 Change notations. The margins of this standard are marked with vertical lines to indicate modifications generated by this change. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations.

6.4 Subject term (key word) listing.

Additive manufacturing
Metallic wire
Metallic powder
Metallic substrate

Custodian:
Army - AT
Navy -AS
Air Force - 11

Preparing Activity:
Army - AT

Review Activity:
Army - MR

(Project MFFP-2014-001)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.