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1. GENERAL PROVISIONS

Purpose:

1.1.1. This document provides testing, data, and documentation requirements for vendor qualification of metallic additive manufacturing processes for military ground vehicle applications.

1.1.2. The requirements define the testing and documentation necessary to demonstrate that a specific vendor, material, machine configuration, and parameter set produce material with consistent mechanical properties. The qualification dataset provides the basis for evaluating process stability, manufacturing variability, and the ability of the process to repeatedly meet the specified minimum property requirements.

1.1.3. These requirements are adaptable; however, any exception shall demonstrate a comparable or greater level of technical rigor and requires prior approval by the cognizant engineering authority. Furthermore, all such exceptions and their corresponding justifications must be formally documented and included in the qualification report.

1.1.4. Where information is not provided, approval will be limited to applications which do not require the expected performance.

1.1.5. Additively manufactured material intended to replace conventionally produced material shall demonstrate mechanical performance that meets or exceeds the minimum requirements of the material being substituted. Qualification shall include demonstrating process consistency and repeatability rather than characterizing the properties of a single build. This document shall be used in conjunction with 19207-12759073 and 19207-12759072.

Background:

1.1.6 Many qualification frameworks currently established for metal additive manufacturing originate from aerospace applications, where the consequences of failure drive extremely conservative testing and inspection requirements. While these frameworks provide valuable technical guidance, the requirements defined herein are tailored for military ground vehicle applications and reflect the different risk posture associated with that mission. The qualification approach focuses on demonstrating repeatable process performance and consistent mechanical properties through representative multi-build testing and spatial sampling across the build envelope. The requirements defined in this document are therefore derived from, but represent a subset of, those established in the referenced flight qualification guidance and are informed by work conducted by GVME and its partners.

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THIRD ANGLE PROJECTION

MATL ENGR | MODELED BY

CONTRACT NUMBER
CONTRACTOR
CCDC GROUND VEHICLE SYSTEM CENTER
DRAWN BY R. GEORGI | DATE (YR-MO-DA) 20-04-14
CHECKER | ENGINEER J. BURDICK
ENGINEER | QUALITY ENGINEER
DRAWING APPROVAL E. WALKER
DESIGN APPROVAL C. SPANGLER

DESIGN ACTIVITY
US ARMY
TANK AUTOMOTIVE & ARMAMENTS COMMAND
WARREN, MICHIGAN 48397-5000

ADDITIVE MANUFACTURING PROCESS QUALIFICATION AND MATERIAL EVALUATION REQUIREMENTS

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Approval

1.1.7 All reference to a need for approval shall be interpreted to mean approval by the Government's Cognizant Engineering Authority (CEA), in all matters within the scope of this document. Vendors shall submit all documentation to: usarmy.detroit.devcom-gvsc.mbx.armygroundamqual@army.mil.

1.1.8 In addition, where Contractor approvals are required, the term "Contractor" shall refer to the appropriate Prime Contractor Process Engineering and/or Quality Engineering personnel. All Contractor and Government approvals must be traceable and included in the qualification report.

Qualification Scope

1.1.9 Qualification performed under this specification applies only to the specific additive manufacturing process, material, machine configuration, parameter set, and post-processing conditions used during qualification testing. The qualification dataset demonstrates the capability of the defined process configuration to consistently produce material meeting the specified performance requirements. Any changes to these parameters require evaluation for re-qualification as described in section 2.2.4

1.1.10 Changes to the qualified process configuration, including but not limited to material specification, feedstock supplier, machine configuration, process parameters, build orientation, or post-processing conditions, may require additional evaluation or requalification as determined by the Cognizant Engineering Authority. A change log shall be maintained for all process changes with Cognizant Engineering Authority approval documented for each.

Previously Qualified Vendors

1.1.11 Vendors with an existing qualified additive manufacturing process utilizing the same material, machine configuration, parameter set, and post-processing conditions may submit documentation of that qualified process to the Cognizant Engineering Authority (CEA) or usarmy.detroit.devcom-gvsc.mbx.armygroundamqual@Army.mil for review and approval.

1.1.12 Upon review and at the discretion of the CEA, vendors may be authorized to waive the qualification testing requirements described herein, provided the existing process demonstrates equivalency in material properties, process stability, and meets the intent of this specification for military ground vehicle applications.

1.1.13 The submitted documentation shall demonstrate that the existing qualification dataset adequately represents the capability of the defined process configuration to consistently produce material meeting the performance.

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2 REQUIREMENTS

Quality Systems

2.1.1 The vendor shall operate under a documented quality management system appropriate for the manufacture of additively manufactured metallic components. The quality system shall define and control procedures governing feedstock procurement and handling, machine operation, process parameter control, equipment maintenance, inspection, and testing. The vendor's quality management system shall include digital data management and traceability for all process and test data, including build ID, machine/laser ID, powder lot, and operator. The vendor shall maintain documented procedures and records sufficient to demonstrate process control, material traceability, and compliance with the requirements defined herein. Documentation describing the applicable quality procedures and process controls shall be provided as part of the qualification package for review by the Cognizant Engineering Authority.

2.1.2 Industry standards may be used to satisfy these requirements; however, the vendor shall provide documentation demonstrating that the applicable quality procedures and controls meet or exceed the intent of the requirements defined in this specification (e.g., a cross-reference matrix). Examples of commonly used industry standards applicable to additive manufacturing quality systems are shown in Table 1.

Table 1 - Representative Industry Standards Supporting Quality System Requirements (Examples Only, Not Exhaustive)

Requirement	Representative Standard
Feedstock	AMS7001, ASTM F3049, ASTM B215
Process	AMS7003A, ASTM F3122, ASTM F3303
Material	AMS7000, ASTM F3055, ASTM F3184
Maintenance	AMS7003A, OEM maintenance procedures
Quality control plan	ISO 9001, AS9100, NADCAP AC7110

Process Requirements

2.1.3 For certain additive manufacturing processes and material combinations, industry standards exist that define qualification requirements and expected mechanical and material performance. Vendors may elect to qualify their material and process in accordance with such standards where applicable. Use of such standards shall be documented and approved by the Cognizant Engineering Authority and shall not relieve the vendor from meeting the requirements defined in this specification unless explicitly approved.

2.1.4 If a vendor elects not to qualify to an existing additive manufacturing standard, the qualification approach shall demonstrate an equivalent or greater level of technical and statistical rigor to establish consistent process performance and material properties. The proposed qualification methodology, including the testing scope and statistical basis for acceptance, shall be

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documented and agreed upon between the supplier and the Cognizant Engineering Authority prior to qualification.

2.1.5 All monitored or controlled process parameters shall be documented and maintained as part of the vendor's process control records which must be traceable to each build. Vendors shall provide this documentation upon request by the procuring entity or the Cognizant Engineering Authority.

2.1.6 Changes to the approved manufacturing process, including but not limited to machine configuration, process parameter sets, feedstock specification, or post-processing procedures, shall be documented and reviewed by the Cognizant Engineering Authority. Vendors shall notify the procuring entity prior to implementation of any process changes that may affect material properties or part performance. A formal change management process shall be in place, and all changes shall be included in the qualification documentation. Such changes shall require partial or full requalification as determined by the Cognizant Engineering Authority.

2.1.7 For many additive manufacturing processes, machine original equipment manufacturers (OEMs) implement internal sensors, monitoring systems, and control strategies that are not fully accessible to the user. In such cases, the machine configuration shall be considered fixed and controlled under the vendor's formal change management system. Any modification to the machine configuration, including but not limited to software updates, firmware changes, or recalibration of subsystems, shall be documented and reported to the Cognizant Engineering Authority. Such changes shall require partial or full requalification as determined by the Cognizant Engineering Authority.

2.1.8 Changes to the machine model, machine configuration, or approved parameter sets shall be documented and reviewed by the Cognizant Engineering Authority to determine if partial or full requalification is required.

2.1.9 The vendor shall maintain documented control of the manufacturing process parameters used to produce qualified material. These parameters shall be defined in controlled procedures or parameter sets and shall be maintained under configuration control. Any modification to approved process parameters shall be documented and reviewed through the vendor's change management system and reported to the Cognizant Engineering Authority.

2.1.10 Process control documentation shall ensure that material properties demonstrated during qualification are representative of normal production conditions.

Multi-Machine Qualification

2.1.11 Qualification performed under this specification applies only to the specific additive manufacturing machine model, configuration, and approved parameter set used during qualification testing. Production on additional machines of the same model may require demonstration of equivalency or separate qualification as determined by the Cognizant Engineering Authority. Factors considered when determining equivalency shall include, but not limited to, machine configuration, calibration procedures, parameter control, and demonstrated process stability.

Feedstock Control

2.1.12 Feedstock used for additive manufacturing shall conform to a defined material specification and shall be controlled to ensure consistency and traceability throughout the

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manufacturing process. The vendor shall document the feedstock manufacturer, material designation, lot number, and any applicable certification or test reports associated with the feedstock used for qualification builds.

2.1.13 Feedstock used during qualification shall be representative of the feedstock condition expected during normal production operations. Feedstock lot numbers, suppliers, and all test reports must be traceable to each build. The vendor shall maintain documented procedures governing feedstock handling, storage, reuse (if applicable), and contamination prevention. These procedures shall ensure that feedstock properties remain within acceptable limits for the additive manufacturing process being used.

2.1.14 Traceability shall be maintained between feedstock lots and the parts or test specimens produced during qualification. Records shall allow identification of the specific feedstock lot or lots used for each build.

2.1.15 Where feedstock reuse or recycling is employed as part of the manufacturing process, the vendor shall document the reuse methodology and controls used to maintain feedstock quality. The vendor shall demonstrate that the use of recycled or blended feedstock does not adversely affect the mechanical properties or performance of the produced material.

2.1.16 Changes to feedstock supplier, material specification, or feedstock processing procedures shall be documented and reported to the Cognizant Engineering Authority. Such changes may require partial or full requalification as determined by the Cognizant Engineering Authority.

2.1.17 The vendor shall maintain records describing the feedstock usage history for material used in qualification and production builds. These records shall include feedstock lot identification, reuse cycles (if applicable), and any blending of feedstock lots.

Build Traceability and Production Records

2.1.18 The vendor shall maintain build records for each additive manufacturing build used in qualification or production. These records shall document the machine used, machine configuration, process parameter set, feedstock lot identification, and build identification. Records shall provide sufficient information to ensure traceability between the produced parts or test specimens and the manufacturing conditions under which they were produced. Build records must include digital data files (e.g., build logs, parameter files) and be archived for a minimum of seven years or as otherwise specified by the Cognizant Engineering Authority.

2.1.19 The build record shall include, at minimum, the additive manufacturing machine identification, build date, process parameter set, feedstock lot or lots used, and identification of parts or test specimens produced during the build. Where applicable, the build record shall also document post-processing operations, including heat treatment, hot isostatic pressing, or other thermal or mechanical processing steps applied to the material. All records must be submitted in a machine-readable format (CSV, XML, or equivalent) and available for audit upon request.

2.1.20 All test specimens used to support qualification shall be traceable to the specific build from which they were produced. The specimen identification designation (SID) system shall provide traceability to the build identification and build plate location, where applicable.

2.1.21 Qualification records and supporting test data shall be retained by the vendor for a minimum period of seven years or as otherwise specified by the procuring authority. The records shall be made available to the procuring entity or Cognizant Engineering Authority.

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Mechanical and Physical Test Specimens

2.1.22 All mechanical testing, hardness evaluation, and density measurements shall be conducted on specimens in the final condition intended for service. Where heat treatment is specified as part of the manufacturing process, all specimens shall undergo the complete heat treatment cycle prior to testing. Test specimen geometry, orientation, and location within the build envelop must be documented and reported.

Build Plate Requirements

2.1.23 The vendor shall produce a qualification build plate capable of generating the test specimens required by this specification. A representative build plate layout may be provided by the procuring entity; however, vendors may propose an alternative build plate design provided it produces the required test specimens and maintains the sampling intent defined in this specification. At a minimum, the build plate configuration shall allow for the production of tensile specimens with a minimum 1-inch gage length in accordance with applicable tensile testing standards. The build layout shall provide sufficient spatial distribution of specimens across the build plate to support evaluation of process variability, including any additional sampling required for multi-laser systems or stitch zones. The proposed build plate design, including detailed layout and specimen placement, shall be documented and submitted to the Cognizant Engineering Authority for review and approval prior to qualification testing.

Sampling Plan

2.1.24 The sampling plan defined in this specification is intended to capture representative variability in the additive manufacturing process, including differences associated with build orientation, build location, and machine processing zones. The resulting dataset provides the basis for evaluating process stability and consistency of material performance.

2.1.25 The sampling plan includes multiple builds, spatial distribution of specimens across the build plate, and orientation sampling to capture process variability. Additional sampling is required for additive manufacturing systems utilizing multiple lasers to evaluate potential variability associated with stitch regions between adjacent processing zones.

2.1.26 Test specimens shall be distributed across the build plate in a manner that captures potential spatial variability in the manufacturing process. Specimens shall not be clustered in a single region of the build plate unless specifically approved by the Cognizant Engineering Authority.

2.1.27 Verbiage about sampling plan shall be delivered and approved by CAE. Number and location of all specimen shall be recorded and reported and included in sampling plan.
The vendor shall develop and submit a comprehensive sampling plan with the build plate layout to the Cognizant Engineering Authority (CEA) or [insert mailbox email/address] for review and approval prior to qualification testing of the build plate test specimens. The plan shall be designed to capture representative variability inherent to the additive manufacturing process, including differences associated with build orientation, build location, and machine processing zones.

To adequately characterize process variability, the sampling plan shall include multiple build cycles, spatial distribution of test specimens across the build plate, and orientation sampling. For additive manufacturing systems utilizing multiple lasers, the plan shall also incorporate

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additional specimens positioned in stitch regions between adjacent processing zones to evaluate potential localized variability.

Test specimens shall be evenly distributed across the build plate to capture spatial variability and shall not be clustered within a single region unless explicitly approved by the CEA. The plan shall clearly define specimen selection criteria, sampling locations, specimen orientations, and the number of specimens per build. The number and precise location of all specimens shall be recorded, reported, and clearly documented within the sampling plan.

Qualification testing shall not commence until written CEA approval is received.

Mechanical Testing

2.1.28 Qualification testing shall be performed across a minimum of three independent builds , unless otherwise approved by the Cognizant Engineering Authority, produced using the same process parameters, machine configuration, and feedstock as intended for production.

2.1.29 Mechanical property verification shall be performed using tensile testing in accordance with ASTM E8/E8M. For additive manufacturing systems utilizing a single laser, a minimum of 10 tensile specimens shall be produced from the qualification build plate. Six specimens shall be oriented in the build direction (Z orientation) and four specimens shall be oriented in the transverse plane (XY orientation).

2.1.30 For additive manufacturing systems utilizing multiple lasers, the same baseline specimen population shall be produced. In addition, supplemental specimens shall be included to evaluate potential variability associated with laser stitch regions and/or other process boundaries. For each stitch zone present on the build plate, one additional tensile specimen oriented in the build direction and one additional tensile specimen oriented in the XY direction shall be produced. The reduced section (gage length) of these supplemental specimens shall be positioned within the laser stitch zone such that the tensile test directly samples the interface between adjacent laser processing regions.

2.1.31 Each specimen shall be assigned a unique specimen identification designation (SID) providing full traceability to its specific location on the build plate. A comprehensive table or database of all SIDs shall be maintained, providing traceability to the build, plate position, orientation, and processing zone for each. Such traceability enables correlation of mechanical properties with build location and laser assignment.

Hardness

2.1.32 Hardness testing shall be performed to verify the material condition and consistency of the produced material. Hardness measurements shall be conducted in accordance with applicable ASTM standards, including ASTM E18, ASTM E10, or ASTM E384, as appropriate for the material and hardness scale being used.

2.1.33 Cross-sectional hardness measurements shall be performed on dedicated test blocks produced as part of the qualification build. A minimum of three hardness test blocks shall be distributed across the build plate to capture potential spatial variability in the manufacturing process. For additive manufacturing systems utilizing multiple lasers, one additional hardness test

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block shall be produced for each stitch zone or other process boundaries present on the build plate, with the measurement location positioned within the region.

2.1.34 Alternatively, cross sectional hardness measurements on the grip section of tensile specimens may be performed as an optional verification of the material condition following completion of tensile testing. When tensile specimen hardness measurements are performed, a minimum of three tensile specimens shall be selected from locations distributed across the build plate to ensure representative sampling of the build area. Hardness measurements shall be performed in the grip section of the tested tensile specimens and recorded as part of the qualification dataset with traceability to the corresponding build and specimen identification designation (SID).

Density

2.1.35 Density measurements may be performed using Archimedes-based methods (ASTM B962 or ASTM B311) or metallographic image analysis methods (ASTM E1245), as appropriate for the material and inspection method. All results must be traceable to the specific specimen and build.

2.1.36 Density measurements shall be performed on dedicated density test specimens produced as part of the qualification build. A minimum of three density specimens shall be distributed across the build plate to capture potential spatial variability in the manufacturing process. For additive manufacturing systems utilizing multiple lasers, one additional density specimen shall be produced for each stitch zone or other process boundaries present on the build plate, with the measurement location positioned within the region.

Table 2 - Summary of Testing Requirements

Test Type	Applicable Standard	Minimum Sample Requirement	Additional Requirement for Multi-Laser Systems	Notes
Tensile Testing	ASTM E8/E8M – Tension Testing of Metallic Materials	6 specimens in build direction (Z) and 4 specimens in XY direction per build plate	1 additional specimen per direction per stitch zone with gage length located in stitch region	Tensile specimens shall have a minimum 1-inch gage length and be spatially distributed across the build plate. Sample counts apply per qualification build.
Density	ASTM B962 – Density by Archimedes Method (or equivalent method approved by the Cognizant Engineering Authority)	Minimum 3 density specimens distributed across the build plate	1 additional density specimen per stitch zone	Density specimens shall be dedicated samples and shall not be taken from tensile specimens

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Hardness (Test Blocks)	ASTM E18 – Rockwell, ASTM E10 – Brinell, or ASTM E384 – Microindentation	Minimum 3 hardness test blocks distributed across the build plate	1 additional hardness test block per stitch zone	Used to verify material condition and evaluate spatial variability
Hardness (Tensile Specimens – Optional)	ASTM E18, ASTM E10, or ASTM E384	Minimum 3 tensile specimens selected from spatially separated locations across the build plate	Not required	Measurements performed in the grip section after tensile testing
Qualification Builds	—	Minimum of 3 independent builds	Not applicable	Builds shall be produced under nominally identical processing conditions

Retesting

2.1.37 If a test result fails to meet the specified requirements, the vendor shall request a retest to determine whether the failure was caused by an identifiable testing anomaly, specimen preparation issue, or other documented nonconformance. The vendor shall document the basis for the retest request and provide supporting information for review by the Cognizant Engineering Authority.

2.1.38 Retesting shall be limited to replacement specimens taken from the same qualification build unless otherwise approved by the Cognizant Engineering Authority. Replacement specimens shall be selected from locations representative of the original sampling plan and shall maintain traceability to the corresponding build and specimen identification designation (SID).

2.1.39 Retest results shall be reported together with the original test results as part of the qualification dataset. The qualification report shall identify the original result, the retest result, the basis for retesting, and the Cognizant Engineering Authority approval for use of the retest result in the statistical evaluation. Removal, omission, or replacement of original test results without documentation and approval by the Cognizant Engineering Authority shall not be permitted. Acceptance of retest results and determination of qualification status shall be made by the Cognizant Engineering Authority. Retesting shall not be used to selectively remove data that reflects normal process variability.

2.1.40 When a retest is performed in accordance with this section and the original result is determined by the Cognizant Engineering Authority to be invalid due to a documented testing anomaly, specimen preparation issue, specimen nonconformance, or other approved non-representative condition, the approved retest result shall replace the original invalid result for purposes of statistical evaluation. The original result shall remain reported in the qualification record but shall be excluded from the statistical calculation.

2.1.41 All data, records, and reports required by this specification must be submitted in a machine-readable format (CSV, XML, or equivalent) and include metadata for traceability (build ID, coupon ID, machine/laser ID, powder lot, test method, operator, date).

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3 NON-DESTRUCTIVE INSPECTION (NDT)

3.1 Non-destructive inspection requirements for additively manufactured components shall be defined by the applicable engineering drawing, material specification, or procurement documentation for the production part. The inspection method and acceptance criteria shall be appropriate for the material, additive manufacturing process, and intended service application. Unless otherwise specified by the Cognizant Engineering Authority, inspection requirements for additively manufactured components shall be equivalent to or more stringent than those applied to the conventionally manufactured material or component being replaced.

4 QUALIFICATION ACCEPTANCE CRITERIA

4.1 Qualification acceptance shall be based on demonstration that the additive manufacturing process consistently produces material meeting the specified minimum performance requirements. Evaluation of qualification data shall consider both the average material performance and the variability of the dataset.

4.2 For mechanical properties with minimum specified values, acceptance shall be demonstrated when the calculated mean value minus three standard deviations ($\mu - 3\sigma \geq$ Specified Minimum) of the qualification dataset is greater than or equal to the specified minimum property requirement. The standard deviation used in this calculation shall be the sample standard deviation calculated from the qualification dataset defined by the sampling plan. The Cognizant Engineering Authority may require additional evaluation where sample size or data variability indicates that the calculated statistics may not adequately represent the underlying process capability.

4.3 This criterion provides a statistical basis for demonstrating that the additive manufacturing process is capable of consistently producing material meeting the specified performance requirements while accounting for normal process variability. The statistical method and dataset used for qualification must be documented in the report. All valid qualification test results must be included in the statistical evaluation unless exclusion is approved by the Cognizant Engineering Authority.

4.4 Unless otherwise approved by the Cognizant Engineering Authority, the statistical evaluation shall include all valid qualification test results generated under the sampling plan defined in this specification. Where retesting is performed in accordance with the Retest section, the retest result shall replace the original invalid test result in the dataset used for statistical evaluation.

4.5 When an applicable industry material specification or standard does not define minimum design properties for the material and process combination, statistical design minimums shall be established in accordance with the methods described in MMPDS Chapter 9. The vendor shall explicitly identify the statistical basis used for establishing minimum properties, including Basic (mean), C-basis, D-basis, or S-basis values, as applicable and provide rationale for the chosen basis in the report. The statistical methodology, dataset used for the analysis, and resulting design minimum values shall be clearly documented in the qualification report and submitted for review and approval by the Cognizant Engineering Authority.

4.6 The Cognizant Engineering Authority may require additional evaluation or alternative statistical methods where appropriate based on the intended application, dataset size, or observed variability.

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TOLERANCES ON ANGLES ± 0.5°
2 PLACE DECIMALS ± 0.01
3 PLACE DECIMALS ± 0.001

SIZE	CAGE CODE	DWG NO
E	19207	12760074
SCALE 1.000	UNIT WT. 0.0 LB REF	SHEET 10 OF 12

REVISIONS				
ZONE	REVISION	DESCRIPTION	DATE(YR-MO-DA)	APPROVED
	-	MATERIAL DATA TABLE INSERTION INITIAL RELEASE ERR TACY4104	2026-04-14	MM
	A	DISTRO NOTE WAS "D", NOTES REVISED, ERR TACY4179	2026-06-14	MM

4.7 If alternative statistical methods are used, the vendor must provide justification and obtain Cognizant Engineering Authority approval prior to use.

Table 3 - Summary of Qualification Acceptance Criteria

Evaluation Element	Requirement	Notes
Mechanical property verification	Mean minus three standard deviations ($\mu - 3\sigma$) shall be greater than or equal to the specified minimum property requirement	Evaluated using the complete qualification dataset defined in the sampling plan
Qualification dataset*	All valid test results generated under the sampling plan shall be included in the statistical evaluation	Exclusion of data requires approval by the Cognizant Engineering Authority and shall be included in final report
Retesting	Where retesting is performed in accordance with the Retest section, the retest result shall replace the original invalid test result	Retesting shall not be used to selectively remove valid results. All test data shall be documented and submitted to the Cognizant Engineering Authority and be included in final report
Statistical design minimums	When no applicable material standard exists, design minimums shall be established in accordance with MMPDS Chapter 9	Vendor shall identify Basic, C-basis, D-basis, or S-basis values

* EACH QUALIFICATION DATASET MUST BE TRACEABLE TO A SPECIFIC BUILD ID, POWDER LOT, AND MACHINE/LASER ID IAW 12759072.

5 REPORTING REQUIREMENTS

5.1 The vendor shall document and report all qualification test results generated under this specification. Testing shall be performed by a laboratory accredited to ISO/IEC 17025 or an equivalent recognized accreditation. Vendors that do not maintain internal ISO/IEC 17025 accredited testing capabilities shall utilize an external laboratory accredited to ISO/IEC 17025 or equivalent for the required testing. The vendor shall demonstrate the capability to conduct the required testing, perform appropriate analysis of the results, and present the data in a clear and traceable format suitable for engineering review by the Cognizant Engineering Authority.

5.2 Reported analysis of mechanical properties shall address variability in material performance and shall at minimum include evaluation of differences associated with build location, build orientation, and other controlled or monitored process parameters where applicable. Test results shall be presented in a manner that allows assessment of the consistency and repeatability of the manufacturing process.

5.3 Statistical analysis shall be performed for the mechanical and material property testing required by this specification. Analysis shall include evaluation of relevant property distributions and goodness-of-fit for the selected statistical model. Distribution types may include, where applicable,

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normal distributions for tensile properties and two-parameter Weibull distributions for fatigue life data. Goodness-of-fit evaluation methods such as the Anderson–Darling test may be used to assess the suitability of the selected distribution. Appropriate statistical methods and distribution models are described in MMPDS Chapter 9.

5.4 Reported results shall maintain traceability to the corresponding qualification build, specimen identification designation (SID), build location, and processing condition. Documentation shall include sufficient detail to allow independent engineering review of the reported results and analysis.

5.5 The vendor shall provide the complete raw and processed test data associated with all testing performed under this specification. Data shall include coupon ID, build ID, machine/laser ID, powder lot, all measured properties individual specimen results, test conditions, and any associated measurements necessary to independently verify the reported results and statistical analyses. Raw data shall be provided in a format that allows independent statistical analysis of the dataset.

6 QUALIFICATION DURATION AND MAINTENANCE

6.1 Qualification granted under this specification shall remain valid provided the qualified additive manufacturing process configuration is maintained. The vendor shall maintain configuration control of the qualified machine, process parameter set, feedstock specification, and post-processing procedures used during qualification.

6.2 Any changes to the qualified process configuration, including but not limited to machine replacement, major equipment repair, machine configuration modification, process parameter changes, feedstock specification changes, or post-processing procedure changes, shall be documented and submitted for review to the Cognizant Engineering Authority. The Cognizant Engineering Authority shall determine whether partial or full re-qualification is required. All change requests/deviations must be included in a process change log and maintained in qualification records.

6.3 Routine maintenance, calibration, or repair activities performed in accordance with the vendor's documented quality system shall not require requalification provided such activities do not alter the qualified process configuration. The vendor shall maintain records of all maintenance, calibration, and repair activities which must be available upon request for review or audit.

6.4 Vendors are not required to periodically resubmit qualification data provided the qualified process configuration remains unchanged and continues to be maintained under the vendor's documented quality system. Production and quality records maintained in accordance with Section 2.4, Build Traceability and Production Records, must be maintained in a machine-readable format (CSV, XML, or equivalent) and readily available for review/audit. These records shall provide objective evidence that the qualified process configuration continues to be controlled and operated in accordance with the requirements of this specification. Any lapse in configuration control, failure to maintain require records, or failed audits may result in suspension or revocation of qualification status as the discretion of the Cognizant Engineering Authority.

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