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NCAMP Material Specification This specification is generated and maintained in accordance with NCAMP Standard Operating Procedures, NSP 100

Hexcel Corporation HexPEKK®-100 powder for Laser Powder Bed Fusion

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Revisions:

Rev	By	Date	Pages Revised or Added
-	Michelle Man	10/25/2021	Document Initial release
A	Jonathan John	10/4/2024	 -Page 8, table 3, added footnotes "See approved PCD for accepted ASTM deviations" -Page 7, section 7.1.2 (2), updated footnotes to use a caliper as the primary measuring tool -Page 12, section 18, removed the statement " Alternatively, Supplier may send the KC data to NCAMP for inclusion in the NCAMP's control charts which are available to the public." As its not applicable -Appendix A, added a note "Note: All dimensions are reference only. Width, length, and radius to read and record only.

1. Scope

This specification establishes the requirements for the manufacturing of aerospace laser powder bed fusion (LPBF) powder. The requirements herein are intended for lot release testing. Use of material allowable is subject to material equivalency tests that are defined in DOT/FAA/AR-03/19; which is beyond the scope of this specification.

2. Classification

This is the specification of the following material:

HexPEKK®-100 Powder

HexPEKK®-100 is a registered trademark of Hexcel Corp. or affiliates.

3. References

ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D695	Standard Test method for Compressive Properties of Rigid Plastics
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative
	Density) of Plastics by Displacement
ASTM D790	Standard Test Methods of Unreinforced and Reinforced Plastics and
	Electrical Insulating Materials
ASTM D3418	Standard Test Method for Transition Temperatures and Enthalpies of
	Fusion and Crystallization of Polymers by Differential Scanning
	Calorimetry
ASTM E1252	Standard Practice for General Techniques for Obtaining Infrared
	Spectra for Qualitative Analysis

4. Definitions

The following definitions apply to terms that have special meaning as used in this material specification:

Carbon Fiber Lot	The quantity of Carbon Fiber manufactured at one time that is used to create a Lot.
Flake Lot	Total quantity of a unique lot as defined by original flake manufacturer.
Powder Lot	The quantity of Hexcel consumables manufactured at one time to a single set of defined properties. A product of combined Carbon Fiber and processed Flake Lot(s).
Material Supplier	The organization that manufacturers the polymer powder material.
Recycled Material	Unsintered powder material that has been previously used in at least one build. This is not sintered pieces which have been reground (regrind).

- Regrind Material from fabricated parts that has been reclaimed by shredding or granulating after manufacturing process. Note that this is not the same as Recycled Powder.
- Purchaser The material user (e.g. the operator of the additive manufacturing machine using the powder)
- Virgin Material Feedstock from a material supplier that has not been used in the laser sintering process.

5. Process Control Document

The Supplier shall prepare and control a Process Control Document (PCD). The PCD shall be considered proprietary and shall be protected in accordance with disclosure agreements signed by the Supplier and NCAMP. The established Process Control Document (PCD) shall be presented to NCAMP upon request. NCAMP shall treat any information contained in the PCD as proprietary. Formal change notification and approval is required before a change may be implemented. NCAMP approval is required for major changes, and is granted through Advance Change Notices (ACN).

Changes to the PCD of a qualified material are subject to the written approval of NCAMP. Such changes may require substantial testing to demonstrate equivalency.

6. Material Requirements

Powder materials shall meet NMS 800/1. If equivalency is met, Recycled powder shall meet the minimum requirements of NMS 800/1. Regrind shall not be used for any material supplied to this specification.

7. Qualification

All requests for additional material qualification shall be directed to NCAMP or the governing regulatory body.

7.1. Qualification Of A Material

Supplier will submit a signed test report/Certificate of Conformance that demonstrates the candidate material's ability to meet the specifications in Table 1 and Table 2. The report will include the following information:

- 1) Supplier name and product designation
- 2) Test Results, including individual specimen values, to prove material meets the requirements of this specification
- 3) Powder lot number
- 4) Date of Manufacture
- 5) A statement that no changes in product formulation, raw materials, basic methods of manufacture, or plant site have occurred since the material was qualified

7.1.1 Powder Physical Properties

Property ⁽¹⁾⁽²⁾	Test Method	Number of Tests per Lot
FTIR Match % ⁽³⁾	ASTM E1252	1
Particle Size (4)	ISO 13319	3
DSC ⁽⁵⁾	ASTM D3418	1

Table 1 Powder Physical Properties

⁽¹⁾ Specific procedures should be identical to those used in the original material qualification program. See Section 8 for material test methods

⁽²⁾ "ind" refers to individual measurements. "avg" refers to the average measurements. "max" refers to maximum measurement.

⁽³⁾ Fourier-Transform Infrared (FTIR) spectroscopy comparison versus powder standard. Powder standard shall be the same standard used in qualification. This testing is the responsibility of the powder manufacturer and need not to be repeated by the purchaser.

⁽⁴⁾ Manufacturer is to measure particle size D50 from a single unique lot. This testing is the responsibility of the powder manufacturer and need not to be repeated by the purchaser.

⁽⁵⁾ Measure glass transition temperature in accordance with ASTM D3418.

7.1.2 As-printed Specimen Physical Properties

Property	Test Method ⁽¹⁾
Thickness	In accordance with applicable mechanical test method ⁽²⁾
Density	ASTM D792

Table 2 As-printed Specimen Physical Properties

⁽¹⁾ Specific procedures should be identical to those used in the original material qualification program. See approved PCD for accepted ASTM deviations.

⁽²⁾ Computed from actual qualification printed specimens thicknesses. A minimum of 3 thickness measurements across the specimen width and length from each specimen listed in Table 3 using a caliper or equivalent.

7.1.3 As-printed Specimen Mechanical Properties

Property ⁽²⁾	Test Temperature	Test Method ⁽¹⁾	Number of Replicates
Tension Strength and Modulus ⁽³⁾ Orientation: ZX	Room Temperature, Ambient	ASTM D638 DF2 geometry	5
Compression Strength and Modulus ⁽⁴⁾ Orientation: TBD	Room Temperature, Ambient	ASTM D695 Prism	5
Flex Strength and Modulus ⁽⁵⁾ Orientation: TBD	Room Temperature, Ambient	ASTM D790	5

- ⁽¹⁾ Specific procedures should be identical to those used in the original material qualification program.
- ⁽²⁾ To be conducted by either Manufacturer or Purchaser: A set of 5 specimens is required from each powder lot that may be used to produce multiple powder drums by the manufacturer.

Limits computed at α =0.01 and modified CV. Specimens should be distributed randomly within the build volume and shall not be sampled from one build location only.

⁽³⁾ Specimens are printed per "Tension SL.SLI" derivatives and controlled data set procedures. Material supplier is required to print the specimens per NPS 89800

latest version. Modulus strain range: 1,000 to 3,000 $\mu\epsilon$. per ASTM D638 modified DF2 geometry as shown in Appendix A: Coupon Geometry.

⁽⁴⁾ Specimens are printed per "Compression SL.SLI" derivatives and controlled data set procedures. Material supplier is required to print the specimens per NPS 89800

latest version. Modulus strain range: 1,000 to 3,000 $\mu\epsilon$ per ASTM D695.

⁽⁵⁾ Specimens are printed per "Flex SL.SLI" derivatives and controlled data set procedures. Material supplier is required to print the specimens per NPS 89800

latest version. Modulus strain range: 5,000 to 20,000 $\mu\epsilon$ using deflectometer. Span length is 16T, T=Average Specimen Thickness.

7.2. Retention of Qualification Status

No changes in approved product formulation, raw materials, and basic methods of manufacture, or plant site, for a material qualified to this specification and associated slash sheets specifications shall be made without notification to NCAMP via the ACN process.

8. Material Test Methods

All in-process testing requirements must be met as stated in the PCD. Any changes made to the in-process testing requirements must be reported to NCAMP via the ACN

process.

All tests are performed in a temperature and humidity controlled environment. Temperature is maintained at 75° F +/- 15° F and humidity maintained below 60% RH.

8.1. FTIR

Fourier Transform Infrared Spectroscopy measures the infrared (IR) spectra of the powder composition. A known acceptable spectrum shall be kept on record used as the reference spectra. The in-process powder shall be compared to the reference spectra. Method for obtaining infrared spectra shall follow ASTM E1252.

8.2. Particle Size

Particle size distribution shall be performed in accordance with the PCD or approved method.

8.3. DSC

Glass transition temperature shall be measured in accordance with ASTM D3418. Heat rate of 20°C/min and a 9-11 mg sample size.

8.4. Test Failure

If during the testing, a lot of powder material does not meet the specifications given in Table 1 and Table 2, re-testing may be performed based on failure type. All test results must be reported to the Purchaser, along with assignable causes for discarded test results. All of the material and physical property requirements must be met prior to material release.

Defects, as defined by this specification, which are not communicated by the Supplier but found in the material after acceptance shall be cause for rejection and the defective material may be returned to the supplier. Defects caused by Purchaser mishandling, improper storage, or expiration of storage or out-life are not the responsibility of the Supplier and shall not be cause for rejection back to the supplier.

9. Drum Identification

Each powder drum will be labeled with the following information:

- 1) Part Number
- 2) Name and Product Designation
- 3) Powder Lot Number
- 4) Date of Manufacture
- 5) Manufacturing Location
- 6) Purchase Order Number

10. Traceability

All drums must be assigned a unique serial number that ties them to a manufactured lot of powder. The manufacturing lot number is tied to flake lot number(s).

11. Storage and Handling of Powder

Feedstock, after fabrication and testing (if applicable), shall be properly stored in sealed containers according to the feedstock manufacturer's recommendations with a recommended temperature range of 60-90 °F and 60% maximum relative humidity.

12. Safety – Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address all the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

13. Rounding of Values

The following applies to all specified limits or requirements in this specification. For purposes of determining conformance with this specification, an observed value or a calculated value shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding method of ASTM E29.

14. Applicable Documents

The latest issue of the NCAMP publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order unless otherwise specified. When a referenced document has been canceled and no superseding document has been specified, the last published issue of that document shall apply.

14.1. NCAMP Publications:

NPS 89800	NCAMP Proce Qualification, E	ss Specification, quivalency, and Ac	Fabrication ceptance Test	of t Co	NMS upons	800
NMS 800/1 NSP 100	NCAMP Materia	I Specification for	HexPEKK®-1 edures	00		

14.2. US Government Publications

29 CFR 1910.1200	Hazard Communication, Occupational Safety and Health
	Standards
MIL-D-3464	Desiccants, Activated, Bagged, Packaging Use and Static
	Dehumidification
MIL-PRF-131	Barrier Materials, Water vapor proof, Greaseproof, Flexible,
	Heat-Sealable
CMH-17	Composite Materials Handbook (formerly MIL-HDBK-17)

15. Environmental, Health, and Safety

Equipment, materials, solutions, and emissions (if applicable) shall be controlled, handled, used, and disposed of in accordance with all local, State, and Federal Government Safety, Health, and Environmental Affairs (SHEA).

The delivered system shall fulfill the local requirements of the health and safety laws of the country of the Purchaser. When processing the material, there shall be no health hazards or emissions that require special measures to be taken to protect the environment.

The Supplier shall inform the Purchaser about the safe handling procedures of the material. The Material Safety Data Sheet (MSDS) shall be made available to the purchaser.

16. Powder Manufacturer's Responsibility

The powder manufacturer is responsible for the development and manufacture of any material submitted in accordance with this specification. Quality control by the manufacturer shall be in accordance with this specification.

Changes to the powder require review and approval by NCAMP in accordance with 7.2. Any testing required to validate the changes or adjustment of manufacturing materials, techniques and/or procedures is the manufacturer's responsibility.

17. Classification of Tests and Inspections

17.1. Additional Testing:

The Purchaser reserves the right to perform additional testing to confirm the Supplier's certification data, and to approve incoming material for use in the fabrication of production parts. Each drum of material may be examined by the Purchaser for appearance, color uniformity, imperfections which would be detrimental for use in the fabrication of parts, and for quality of workmanship.

17.2. Receiving Inspection Tests:

The receiving inspection tests shall be those tests performed by the Purchaser or approved test lab on representative samples taken from each production lot of each type of material delivered by the Supplier.

Before the material is accepted, the purchaser shall perform the following:

17.2.1 Verification:

Material shall be inspected to assure that:

- a. The material identification is correct.
- b. The quantity is correct.
- c. The required Table 1, 2 and 3 lot release test data is received and meet the requirements of this specification.
- d. The Certificate of Conformance is received.

17.2.2 Testing:

The Purchaser may repeat the supplier lot release test per Table 1, Table 2, and Table 3 as part of the receiving inspection tests on each lot of material. As use and confidence increase, the receiving inspection testing may be modified based on proven performance in cooperation with the material supplier, customer (if purchaser is supplying composite parts to another aircraft company), and appropriate certification agency.

17.2.3 Re-Testing:

One retest is allowed for each test property. Additional re-test(s) is allowed only when one or more of the following conditions exist:

- a. The initial test was performed in significant deviation to the appropriate procedure. Significant deviations are those expected to affect the measured response.
- b. Standard statistical analysis procedures establish the suspect individual data point(s) as an outlier and there is a probable, if not provable, relationship to a deviation from required procedure.

18. Supplier Statistical Process Control

The Supplier shall establish and maintain procedures and requirements for an SPC system based on Key Characteristics (KC) and Controlled Process Parameters (CPP). The KC are the material properties required for lot release per Section 7.1. The CPP are any process parameter that is controlled by either the machine OEM, operator of the machine, or required by the machine to be chosen or dedicated for a specific run or build on the machine. The parameters must be controlled by a set point, range, or choice. For example, build chamber temperature, feed rate, feedstock moisture content, print speed, etc. may all be controlled process parameters. This list is not exhaustive and may contain many other items that may change from machine to machine.

The KC monitoring, typically using control charts, must be provided to material users, certification agencies, and NCAMP staff upon request. The CPP monitoring must also be provided to material users, certification agencies, and NCAMP staff upon request, but proprietary information may be coded or normalized.

19. Acknowledgement

A Supplier shall mention this specification number and the applicable detail specification number and their revision letters, if any, in all quotations and when acknowledging purchase orders.

20. Rejection

Materials not conforming to this specification and the applicable detail specification, or to modifications authorized by Purchaser, will be subject to rejection.

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Appendix A: Coupon Geometry