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NCAMP Material Specification

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Standard Operating Procedures, NSP 100*

Stratasys Inc. ULTEM™ 9085 Resin

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REVISIONS:

Rev	By	Date	Pages Revised or Added
N/C	Royal Lovingfoss, Rachael Andrulonis, and John Tomblin	4/12/2019	Document Initial Release

1. SCOPE:

1.1 Form:

This detailed specification along with the base specification NMS 085 establishes the requirements for the manufacturing of ULTEM 9085 Aerospace Fused Deposition Modeling (FDM) filament. The filament is produced using an extrusion process.

This detailed specification follows the section and table numbering scheme of the base specification. It contains additional or superseding requirements. The base specification shall govern where no additional requirement is specified; in such cases, the applicable sections are omitted from this detail specification.

2. **Type:** All products qualified to this detail specification have the following classification:
Type 1, ULTEM 9085

7.1 Material Testing Requirements:

7.1.1 In-Process Canister Requirements

TABLE 1 – In-Process Canister Requirements (Type 1)⁽¹⁾

Property	Test Method ⁽²⁾	Number of Replicates	Requirements ⁽³⁾
Moisture	ASTM D7191	First, middle (roughly) and end per batch ⁽⁴⁾	≤ 0.04%, ind
Melt Flow	ASTM D1238	First, middle (roughly) and end per batch ⁽⁵⁾	6.5 to 11.0 g/10 min, ind

⁽¹⁾ The testing defined in this section is the responsibilities of the manufacturer and need not to be repeated by the purchaser.

⁽²⁾ Specific procedures should be identical to those used in the original material qualification program.

⁽³⁾ “ind” refers to individual measurements. “avg” refers to the average measurements. “min” refers to minimum measurement.

⁽⁴⁾ Results are reported for the first canister.

⁽⁵⁾ Results are reported for all three canisters.

7.1.2 Filament Physical Properties

TABLE 2 – Filament Physical Properties (Type 1)

Property ⁽¹⁾	Number of Replicates	Requirements ⁽²⁾
Pull Force	One of the first three canisters in the batch	≤ 1.75 lbs, ind ⁽³⁾
Diameter ⁽⁵⁾	'Continuously'	0.0675 to 0.0739 inch, ind ⁽⁴⁾
		0.07070 ± 0.00040 inch, avg ⁽⁴⁾
Ovality ⁽⁵⁾	'Continuously'	0.0028 inch (max), ind
DSC ⁽⁶⁾	Three canisters per batch	177.86 to 183.09 °C, ind
		352.14 to 361.57 °F, ind

(1) Specific procedures should be identical to those used in the original material qualification program.

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

(3) Pull force spikes up to 3.75 lbs with SSYS 106194-0000 Stratasys proprietary test method are acceptable provided it meets one of the following criteria:

(a) Length of spike above 1.75 lbs does not exceed 3 feet.

(b) Length of spike above 2.75 lbs does not exceed 1 ft.

This testing is the responsibilities of the manufacturer and need not to be repeated by the purchaser.

(4) Diameter exception due to local flaw is permitted if it is within 0.0739 inch (max) diameter x 0.60 inch length. The diameters of the flaw areas must be included in the diameter average calculation and additionally, it must meet the requirement that 99.73% of diameter readings fall within the given range 0.0679 to 0.0735 inch.

(5) Manufacturer is to measure 'continuously' on one spool once it is cooled and packaged. This testing is the responsibilities of the manufacturer and need not to be repeated by the purchaser.

(6) Tested in filament form with ASTM D1356 test method, not as-printed. Limits computed at $\alpha=0.01$.

7.1.3 As-printed Specimen Physical Properties

TABLE 3 – As-printed Specimen Physical Properties (Type 1)

Property	Test Method ⁽¹⁾	Requirements ⁽²⁾
Thickness	ASTM D3171 or applicable mechanical test method	0.1172 to 0.1402 inch, avg ⁽³⁾

⁽¹⁾ Specific procedures should be identical to those used in the original material qualification program.

⁽²⁾ “ind” refers to individual measurements. “avg” refers to the average measurements. Limits computed at $\alpha=0.01$.

⁽³⁾ 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 4 using spherical faced micrometer or equivalent.

7.3.3. As-printed Specimen Mechanical Properties

TABLE 4 – As-printed Specimen Mechanical Properties (Type 1)

Property	Test Method ⁽¹⁾	Requirements ⁽²⁾
Tension Strength and Modulus ⁽³⁾ Room Temperature, Ambient Orientation: XY	ASTM D638 Type 1	Strength: Min. Ind. \geq 7.94 ksi Strength: Average \geq 9.06 ksi Modulus: 0.31 to 0.36 msi, avg
Compression Strength and Modulus ⁽⁴⁾ Room Temperature, Ambient Orientation: XY	Modified ASTM D695	1.0% Offset Strength: Min. Ind. \geq 9.72 ksi 1.0% Offset Strength: Average \geq 11.31 ksi Modulus: 0.35 to 0.41 msi, avg
Flex Strength and Modulus ⁽⁵⁾ Room Temperature, Ambient Orientation: XY	ASTM D790	Strength: Min. Ind. \geq 13.64 ksi Strength: Average \geq 15.58 ksi Modulus: 0.33 to 0.38 msi, avg

(1) Specific procedures should be identical to those used in the original material qualification program.

(2) “ind” refers to individual measurements. “avg” refers to the average of 5 specimens.

Manufacturer: A set of 5 specimens is required from each “first”, “middle” and “end” of a resin batch that may be used to produce multiple filament lots by the manufacturer.

- A set of 5 specimens from “first” filament will be used to represent filament lot 1 to 1/3 of the total number of the filament lots from the same raw resin batch.
- A set of 5 specimens from “middle” filament will be used to represent filament lot 1/3 to 2/3 of the total number of the filament lots from the same raw resin batch.
- A set of 5 specimens from “end” filament will be used to represent filament lot 2/3 to the last filament lot from the same raw resin batch.

Purchaser: A set of 5 specimens is required from each a resin batch that may be used to produce multiple filament lots by the manufacturer.

Limits computed at $\alpha=0.01$ and modified CV.

(3) Specimens are printed per “D638_XY_T16A.cmb”. Material supplier is required to print the specimens per NPS 89085 latest version. Modulus strain range: 1,000 to 3,000 $\mu\epsilon$.

(4) Specimens are printed per “D695_XY_T16A.cmb”. Material supplier is required to print the specimens per NPS 89085 latest version. Modulus strain range: 2,000 to 6,000 $\mu\epsilon$ using modified ASTM D695 test fixture listed in CAMP-RP-2018-013 Section 1.4.3.4.

(5) Specimens are printed per “D790_XY_T16A.cmb”. Material supplier is required to print the specimens per NPS 89085 latest version. Modulus strain range: 5,000 to 20,000 $\mu\epsilon$ using deflectometer. Span length is 16T, T=Average Specimen Thickness.

QUALIFIED PRODUCTS LIST

Supplier Product Designation	Supplier Name and Production Location	Date Qualified	Specification Callout ⁽¹⁾
ULTEM 9085	Supplier Name: Stratasys Inc. Production Location: Stratasys 6855 Shady Oak Rd. Eden Prairie Minnesota 55344	4/17/2019	NMS 085/1 Classification callout is optional because Type 1 is the only classification allowed in this QPL.

⁽¹⁾ In accordance with NCAMP Standard Operating Procedures, NSP 100, this QPL shall not contain alternate materials/products. Additional production location may be included in the QPL only after successful equivalency demonstration and approval per NCAMP Process Control Document (PCD) Preparation and Maintenance Guide, NRP 101.

⁽¹⁾ The proper specification callout for material procurement purpose is "NMS 085/1." This specification is developed based on the material properties that are available publicly. The purchaser may specify additional requirements beyond those specified in this specification, especially when the purchaser has generated additional material properties beyond those available publicly or when the application requires additional requirements. The additional requirements are subject to supplier review and approval.