



Document No.: NMS 085 Rev B, April 12, 2019

NCAMP Material Specification

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Standard Operating Procedures, NSP 100*

Stratasys Inc. ULTEM™ 9085 Resin
ULTEM™ is a registered trademark of Sabic or affiliates

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1. SCOPE

This specification establishes the requirements for the manufacturing of Aerospace fused deposition modeling (FDM) filament.

2. CLASSIFICATION

This is the specification of the following material TYPE

TYPE I ULTEM™ 9085 resin

ULTEM™ is a registered trademark of SABIC or affiliates.

3. REFERENCES

ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1238	Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics
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 D7191	Standard Test Method for Determination of Moisture in Plastics by Relative Humidity Sensor
ASTM D6980	Standard Test Method for Determination of Moisture in Plastics by Loss in Weight

4. DEFINITIONS

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

Raw Resin Lot or Batch	Total quantity of a unique lot or batch identifier as defined by original resin manufacturer
Filament Lot	The quantity of Stratasys consumables manufactured at one time to a single set of defined properties using a single raw resin lot or batch
Recycle Resin	Thermoplastic material that has an additional heat history from the supplier after polymerization
Regrind	Material that had been reclaimed by shredding or granulating after Stratasys processing

Virgin Resin	Material that has no other heat history other than polymerization, compounding, and pelletization performed by the resin supplier
Qualification	The process of validation of the Stratasys filament material complying with internal and external standards

For definitions that are not provided in this specification or other applicable NCAMP specifications, the definitions in DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3 shall apply. For definitions not provided in DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3, the definitions in ASTM D3878 shall apply. For definitions not provided in ASTM D3878, the definitions in MMPDS (formerly MIL-HDBK-5) or CMH-17 (formerly MIL-HDBK-17) shall apply.

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 (as defined by DOT/FAA/AR-06/10, DOT/FAA/AR-07/3) are subject to the written approval of NCAMP. Such changes may require substantial testing to demonstrate equivalency.

6. **MATERIAL REQUIREMENTS**

Raw resin materials shall meet a controlled specification. Recycle resin and regrind shall not be used for any material supplied to this specification.

The extruders qualified to run the ULTEM 9085 are: 1.25 inch 24:1 L/D David-Standard extruders located at 6855 Shady Oak Road, Eden Prairie, MN 55344.

7. **QUALIFICATION**

All requests for 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, TABLE 2, TABLE 3 and TABLE 4. 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) Filament lot number
- 4) Date of Manufacture
- 5) Raw Resin lot or batch number
- 6) 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 In-Process Canister Requirements

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

Property⁽³⁾	Test Method⁽²⁾	Number of Replicates
Moisture	ASTM D7191	First, middle (roughly) and end per batch ⁽⁴⁾
Melt Flow	ASTM D1238	First, middle (roughly) and end per batch ⁽⁵⁾

⁽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⁾⁽²⁾	Number of Replicates
Pull Force ⁽³⁾	One of the first three canisters in the batch
Diameter ⁽⁴⁾⁽⁵⁾	‘Continuously’
Ovality ⁽⁴⁾⁽⁵⁾	‘Continuously’
DSC ⁽⁶⁾	Three canisters per batch

(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 Stratasy's 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 ⁽²⁾	Test Method ⁽¹⁾
Thickness ⁽³⁾	ASTM D3171 or applicable mechanical test method

⁽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.

7.1.4 As-printed Specimen Mechanical Properties

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

Property ⁽²⁾	Test Method ⁽¹⁾
Tension Strength and Modulus ⁽³⁾ Room Temperature, Ambient Orientation: XY	ASTM D638 Type 1
Compression Strength and Modulus ⁽⁴⁾ Room Temperature, Ambient Orientation: XY	Modified ASTM D695
Flex Strength and Modulus ⁽⁵⁾ Room Temperature, Ambient Orientation: XY	ASTM D790

(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 ~~µε~~.

(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 ~~µε~~ 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 ~~µε~~ 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 +/- 10° F and humidity maintained below 60% RH.

8.1. PULL FORCE TESTING

Pull force testing can be performed once the material has reached room temperature. The pull force test is conducted in accordance with Stratasys proprietary test method 106194-0000 using a unique test stand equipped with a standard Stratasys FDM system filament drive block and a force transducer and that measures the force required to remove filament from the canister, across the entire length of the canister.

8.2. DIAMETER TESTING

Post process diameter testing is performed if in-line temperature measurement is not used in conjunction with in-line diameter measurement during the production run. Post process diameter testing can be performed once the material has reached room temperature. The diameter test is conducted in accordance with Stratasys proprietary test method 106195-0000 by measuring the diameter across the entire length of a canister using a laser micrometer similar to what is used in-line.

8.3. MOISTURE TESTING

Moisture testing is performed in compliance to ASTM D7191 prior to shipping.

8.4. MELT FLOW RATE

The melt flow rate (MFR) is determined with respect to ASTM D1238 using temperatures and loads defined in TABLE 5. Material will have moisture content meeting limits defined in TABLE 5 prior to testing.

TABLE 5 – Melt Flow Index Testing Parameters

Type	Mass (kg)	Dwell (s)	Cut time (s)	Number of Cuts	Time Reference (s)	Temp. (°C)	MFR (g/10 min)
I	6.6	360	20	3	600	295	6.5 – 11.0

8.5. TEST FAILURE

If during the testing of a canister of material does not meet the specifications given in TABLE 1, TABLE 2, TABLE 3 and TABLE 4, re-testing will be performed based on failure type. All of the material and physical property requirements must be met prior to material release.

If moisture content fails to meet the requirement then the entire lot of product will be allowed to dry for additional time and moisture will be retested. This is repeated until an acceptable moisture content measurement is achieved, at which time the entire lot of material is released. Material may be vacuum dried if necessary.

For any initial test failure besides moisture content two follow-up canisters will be tested. If either of those two canisters fail to meet the specifications additional canisters will be tested until four consecutive canisters pass. Material that does not meet the specifications will not be used to fulfill Aerospace filament orders.

Defects, as defined by this specification, which are not marked 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 user 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. CANISTER IDENTIFICATION

Each canister and canister box will be labeled with the following information:

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

10. TRACEABILITY

All canisters must be assigned a unique serial number that ties them to a manufactured lot of filament. The manufacturing lot number is tied to the raw resin lot or batch number.

11. STORAGE AND HANDLING OF FILAMENT

Feedstock, after fabrication and testing (if applicable), shall be properly stored in sealed containers according to the feedstock manufacturer's recommendations with a temperature range of 55-75 °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:

NMS 085	Aerospace Filament Specification (ULTEM 9085)
NMS 085/1	Aerospace Filament Specification (ULTEM 9085)
NPS 89085	NCAMP Process Specification, Fabrication of NMS 085 Qualification, Equivalency, and Acceptance Test Coupons
NRP 101	Prepreg Process Control Document (PCD) Preparation and Maintenance Guide

14.2. US GOVERNMENT PUBLICATIONS:

29 CFR 1910.1200	Hazard Communication, Occupational Safety and Health Standards
DOT/FAA/AR-03/19	Material Qualification and Equivalency for Polymer Matrix Composite Material Systems: Updated Procedure

DOT/FAA/AR-06/10	Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs
DOT/FAA/AR-07/3	Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs Update
MIL-D-3464	Desiccants, Activated, Bagged, Packaging Use and Static Dehumidification
MIL-PRF-131	Barrier Materials, Watervaporproof, 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 in the composite shop, there shall be no health hazards or emissions that require special measures to be taken to protect the environment.

The manufacturer 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. MANUFACTURER'S RESPONSIBILITY:

The 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 filament 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 canister 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 batch 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 test data is received and meet the requirements of this specification.
- d. The Certificate of Conformance is received.

17.2.2 Testing:

The purchaser shall repeat the supplier batch release test per Table 2, Table 3 and Table 4 as part of the receiving inspection tests on each batch 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 batch release per 7.1. 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. Alternatively, supplier may send the KC data to NCAMP for inclusion in the NCAMP's control charts which are available to the public.

19. ACKNOWLEDGEMENT:

A vendor 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.

Revision:

Rev	By	Date	Pages Revised or Added
-	Rachael Andrulonis, and John Tomblin	3/22/2017	Initial release
A	Royal Lovingfoss	3/28/2019	Formatting Revised and Added Table 1, Table 2, Table 3, and Table 4 Added section 8.2.1, 8.2.2, 8.2.2 and 21
B	Royal Lovingfoss	4/12/2019	Removed AS9100 Updated Section 11, Storage Handling and Filament Updated Table 1, Table 2, Table 3, and Table 4 Fixed numbering in Section 17.2, Receiving Inspection Tests