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NCAMP Material Specification

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

Filament Specification (Onyx FR-A™)

(Markforged - MFD)

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Revisions:

Rev	By	Date	Pages Revised or Added
N/C	John Tomblin, Brian Smith	TBD	Document Initial Release
A	Neville Tay and Jorge Chavez-Salas	10/16/23	1. Table 1: Notes and reference to notes were added to specify incoming raw feedstock lot requirements. 2. Table 2: Notes and reference to notes were added to specify in-process filament material requirements. 3. Filament class, glass transition, melt temperature and composition requirements for outgoing filament testing were removed from Table 3 and revised with cross-sectional area, and single-axis diameter requirements. 4. Table 3: Notes and reference to notes were added to specify out-going filament lot requirements. 5. Specification limits added to Table 4 and Table 5 6. Table 5 note 2: The appropriate amount of material lot to represent a set of specimens was detailed for both the OFRA and CFRA material.
B	Neville Tay	11/13/23	1. Added "The value for the Class must be immediately appended to the Composition abbreviation (e.g. CF30 for 30% carbon fiber and the remaining 70% is a Type 1 and FR blend)." to the end of the sentence in section 1.1 2. Units were added to the Requirement columns in Table 1 and 2.

1. SCOPE

This detailed specification along with the base specifications NMS 754 and NMS 755 establishes the requirements for the manufacturing of Onyx FR-A with Carbon Fiber FR-A Aerospace Fused Filament Fabrication (FFF) filament/fiber. The filament/fiber is produced using an extrusion process.

This detailed specification contains additional superseding requirements. The base specifications must govern where no additional requirement is specified; in such cases, the applicable sections are omitted from this detailed specification.

1.1. TYPE

All products qualified to this detailed specification have the following classification: Type 1, Onyx FR-A (OFRA) with Carbon Fiber FR-A (CFRA). The value for the Class must be immediately appended to the Composition abbreviation (e.g. CF30 for 30% carbon fiber and the remaining 70% is a Type 1 and FR blend).

2. FILAMENT FEEDSTOCK REQUIREMENTS

The Filament Lot supplied must meet all requirements specified in NMS 754. Filament Lots that do not meet specified requirements must be segregated and handled via the Filament Lot Supplier's MRB process.

3. FIBER FEEDSTOCK REQUIREMENTS

The Fiber Lot supplied must meet all requirements specified in NMS 755. Fiber Lots that do not meet specified requirements must be segregated and handled via the Fiber Lot Supplier's MRB process

4. AS-PRINTED SPECIMEN PHYSICAL PROPERTIES:

Table 1 – As printed Specimen Physical Properties

Property	**Test Method(1)**	**Requirements(2)**
Thickness	ASTM D3171 or applicable mechanical test method	**0.1396 to 0.1439 inch (3)**

(1) Specific procedures should be identical to those used in the original material qualification program.
(2) "ind" refers to the individual measurements. "avg" refers to the average measurements. Limits computed at α=0.01.
(3) Computed from actual qualification printed specimen thicknesses. A minimum of 3 thickness measurements across the specimen width and length from each specimen listed in Table 2 using spherical faced micrometer or equivalent.

5. AS-PRINTED SPECIMEN MECHANICAL PROPERTIES:

Table 2 – As-printed specimen Mechanical Properties

Property	**Fiber Fill**	**Test Method(1)**	**Requirements(2)**
Tension Strength and Modulus(3) Room Temperature, Dry Orientation: XZ	PF	ASTM D3039	Strength: Min. Ind. ≥ **29.82 ksi** Strength: Average ≥ **33.31 ksi** Modulus: **2.744 to 2.918 Msi**
Tension Strength and Modulus(4) Room Temperature, Dry	PF	ASTM D3039	Strength: Min. Ind. ≥ **0.4594 ksi** Strength: Average ≥ **0.9930 ksi**

Orientation: ZX			Modulus: **0.1858 to 0.3304 Msi**
Compressive Strength and Modulus[5] Room Temperature, Dry Orientation: XZ	PF	ASTM D6641	Strength: Min. Ind. ≥ **8.000 ksi** Strength: Average ≥ **13.02 ksi** Modulus: **1.672 to 2.521 Msi**
Flexural Strength and Modulus[6] Room Temperature, Dry Orientation: XZ	PF	ASTM D790	Strength: Min. Ind. ≥ **20.24 ksi** Strength: Average ≥ **24.16 ksi** Modulus: **1.174 to 1.512 Msi**

(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. Mechanical testing is performed by either the manufacturer or the purchaser, or both manufacturer and purchaser. Specimens will be used to represent the material lot from which they are fabricated. There must be 5 specimens per set. The minimum number of sets required are determined below:

- Manufacturer:
  i. One set of specimens must represent up to 1650 lbs. of Onyx FR-A material per material lot.
  ii. One set of specimens must represent up to 363 lbs. of Carbon Fiber FR-A material per material lot.
- Purchaser:
  i. One set of specimens must represent up to 5070 cm^3 of Onyx FR-A spools of material per material lot.
  ii. One set of specimens must represent up to 532 cm^3 of Carbon Fiber FR-A spools of material per material lot.

Material lot information is listed in the material Certificate of Conformance. Limits computed at α=0.01 and modified CV. Specimens should be printed on the three different build platform locations (2 at each corner, and 1 in the center location).

(3) Specimens are printed per "D3039-XZ-RTD.stl", it is required to print the specimens per NPS 86754 Rev B. Modulus strain range: 1,000 to 3000 με

(4) Specimens are printed per "D3039-ZX-RTD.stl", it is required to print the specimens per NPS 86754 Rev B. Modulus strain range: 1,000 to 3000 με

(5) Specimens are printed per "D6641-XZ-RTD.stl", it is required to print the specimens per NPS 86754 Rev B. Modulus strain range: 1,000 to 3000 με

(6) Specimens are printed per "D790-XZ-RTD.stl", it is required to print the specimens per NPS 86754 Rev B. Modulus strain range: 1,000 to 3000 με 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
Onyx FR-A with Carbon Fiber FR-A	Supplier Name: Markforged Production Location: Markforged 4 Suburban Park Drive, Billerica, MA 01821	11/7/23	NMS 751/1 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 must 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.

(2) The proper specification callout for material procurement purpose is “NMS 754/1”. 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.