

# Onyx FR-A and Carbon Fiber FR-A

AEROSPACE-READY MATERIALS



## Overview

Onyx FR is a flame-retardant short carbon fiber filled nylon designed for use in applications where parts must resist burning. The material earned a UL Blue Card, and is considered V-0 (self-extinguishing) at thicknesses greater than or equal to 3mm. It can be reinforced with any Continuous Fiber and is compatible with industrial composite 3D printers.

Carbon Fiber FR is a flame-retardant variant of Markforged's unique, ultra-high-strength Continuous Carbon Fiber — when used to reinforce a Composite Base material like Onyx FR, it can yield parts as strong as 6061-T6 Aluminum. It's extremely stiff and strong, and can be precisely laid down in a wide variety of geometries. Programmatically trace curved features, reinforce holes, and mimic unidirectional fiber layups — all within a few clicks.

Onyx FR-A and Carbon Fiber FR-A are purpose-built for the requirements of the aerospace, transportation and automotive industries. FR-A materials establish lot-level material traceability and pass the test suite necessary for qualification under 14 CFR 25.853 for most 3D-printable parts. Onyx FR-A and Carbon Fiber FR-A as printed on the Markforged X7 have been qualified by NCAMP.

For specific inquiries please contact [aerospace@markforged.com](mailto:aerospace@markforged.com)

## Material Performance

The FR-A variants of Onyx and Carbon Fiber are used in a similar manner to their standard counterparts. Carbon Fiber FR-A can enhance the mechanical properties of Onyx FR-A parts. The rule of mixtures can be used to approximate bulk mechanical properties of printed composites. Your results may vary based on a number of factors including environmental conditions, feature geometry, print orientation, and loading conditions.

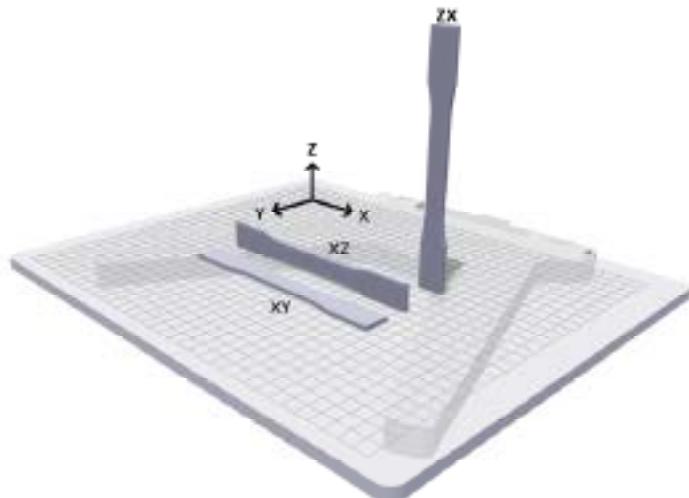
### Mechanical Properties

Property	Unit	Test (ASTM)	Onyx FR-A	CF Test (ASTM)	Carbon Fiber FR-A
Tensile Strength	MPa (ksi)	D638	40 (5.8)	D3039	760 (110.2)
Tensile Modulus	GPa (ksi)	D638	3 (440)	D3039	57 (8267.2)
Tensile Strain at Break	%	D638	18	D3039	1.6
Flexural Strength	MPa (ksi)	D790	71 (10.3)	D790	540 (78.3)
Flexural Modulus	GPa (ksi)	D790	3.6 (520)	D790	51 (7396.9)
Flexural Strain at Break	%		—	D790	1.6
Izod Impact - notched	J/m (/in)	D256-10 A	—	D256-10 A	810 (15.2)
Density	g/cm <sup>3</sup>	—	1.2	—	1.4
Heat Deflection Temp	deg C (deg F)	D648 B	145 (293)	D648 B	105 (221)
Mean XY CTE, 25-145 °C	μm/(m·°C)	—	30	—	—

### Directional Mechanical Properties of Onyx FR

The mechanical properties of 3D printed materials may vary with print orientation. In tension, most parts are strongest when the print orientation and loading direction are parallel, and weakest when the print orientation and loading direction are perpendicular.

Property	Print Orientation	Average	St. Dev.
Yield Strength* (MPa)	XY	46.6	0.16
	ZX	15.7	0.9
	XZ	40.6	0.6
Tensile strength (MPa)	XY	46.7	0.3
	ZX	16.2	0.8
	XZ	40.3	1.2
Tensile modulus (GPa)	XY	3.27	0.08
	ZX	1.05	0.08
	XZ	2.94	0.11
Elongation at break (%)	XY	14.0	0.4
	ZX	3.9	0.4
	XZ	25.5	7.6



## Flame, Smoke, and Toxicity (FST) Performance

Onyx FR-A alone and Onyx FR-A with Carbon Fiber FR-A reinforcement have demonstrated Flammability test performance that passes CFR 25.853 specifications at 3.7mm thickness with the exception of Heat Release. For information on how this limits potential applications see PS-ANM-25.853-01-R2. Smoke test performance passed CFR 25.853 specifications at 3.7mm thickness, but not at 2mm

thickness. Combustion toxicity test performance passed Boeing BSS 7239 Flaming specifications at 2mm thickness. Generally thinner specimens have greater difficulty passing testing. Performance of the thinnest specimens that passed testing (and Heat Release at the thickest tested specimen, which did not pass) are shown below. All samples were printed with solid fill.

Test Category	Test Detail	Specification	Thickness	Continuous Fiber Loading	Test	Passing Criteria	Test Result	Outcome
Flammability	Vertical (60 seg.)	FAR 25.853 Appendix F, Part I (a) (1) (i)	2 mm	None	Burn Time Burn Length Longest Burning	≤ 15 sec ≤ 6 in ≤ 3 sec	9 sec 4.1 in None	Pass
			2 mm	Full	Burn Time Burn Length Longest Burning	≤ 15 sec ≤ 6 in ≤ 3 sec	9 sec 4.3 in None	Pass
	Vertical (12 seg.)	FAR 25.853 Appendix F, Part I (a) (1) (ii)	2 mm	None	Burn Time Burn Length Longest Burning	≤ 15 sec ≤ 8 in ≤ 5 sec	2 sec 1.0 in None	Pass
			2 mm	Full	Burn Time Burn Length Longest Burning	≤ 15 sec ≤ 8 in ≤ 5 sec	0 sec 1.3 in None	Pass
	Horizontal (15 seg.)	FAR 25.853 Appendix F, Part I (a) (1) (iv)	2 mm	None	Avg. Burn Length	≤ 2.5 in/min	0 in/min	Pass
			2 mm	Full	Avg. Burn Length	≤ 2.5 in/min	0 in/min	Pass
Smoke	Heat release*	FAR 25.853 Appendix F, Part IV	3.7 mm	None	Avg. Max Avg. 2-min total	≤ 65 kW/m <sup>2</sup> ≤ 65 kW-min./m <sup>2</sup>	196 kW/m <sup>2</sup> 158 kW-min./m <sup>2</sup>	Not pass
			3.7 mm	Full	Avg. Max Avg. 2-min total	≤ 65 kW/m <sup>2</sup> ≤ 65 kW-min./m <sup>2</sup>	97 kW/m <sup>2</sup> 114 kW-min./m <sup>2</sup>	Not pass
		Smoke Density - flaming mode	3.7 mm	None	Ds	≤ 200	191	Pass
		FAR 25.853 Appendix F, Part V	3.7 mm	Partial**	Ds	≤ 200	139	Pass
			3.7 mm	Full	Ds	≤ 200	115	Pass
Toxicity	Combustion Toxicity	BSS 7239	2 mm	None	HCN CO NO / NO <sub>2</sub> SO <sub>2</sub> HF HCL	≤ 150 PPM ≤ 3500 PPM ≤ 100 PPM ≤ 100 PPM ≤ 200 PPM ≤ 500 PPM	—/— 351 / 368 20 / 34 7 / 9 <1 / <1 15 / 25	Pass
			2 mm	Full	HCN CO NO / NO <sub>2</sub> SO <sub>2</sub> HF HCL	≤ 150 PPM ≤ 3500 PPM ≤ 100 PPM ≤ 100 PPM ≤ 200 PPM ≤ 500 PPM	35 / 40 81 / 49 5 / 3 0 / 0 <1 / <1 25 / 30	Pass

\* Per PS-ANM-25.853-01-R2, the Heat Release test is not required for most interior-facing parts printable on the X7, as they have exposed-surface area below the specified threshold for cabin components.

\*\*Partial sample produced as a 2-layer sandwich panel

## Printer & Material Compatibility

### Onyx FR-A

Available for use on the X7, FX10, and FX20.

Can be reinforced with available continuous fibers.

### Carbon Fiber FR-A

Available for use on the X7, FX10, and FX20.

Only compatible as a reinforcement for Onyx FR-A.

Printer	Composite Base	Continuous Fiber
X7	Onyx FR-A	Carbon Fiber FR-A Carbon Fiber HSHT Fiberglass Kevlar Fiberglass No reinforcement
FX10	Onyx FR-A	Carbon Fiber FR-A Carbon Fiber No reinforcement
FX20	Onyx FR-A	Carbon Fiber FR-A Carbon Fiber Fiberglass No reinforcement

## Additional Data

Onyx FR-A and Carbon Fiber FR-A, as printed on the X7, have been qualified by NCAMP. The following additional test results are available in the [NCAMP report](#):

Expanded directional mechanical data

Environmental mechanical data

Glass transition temperature

Coefficient of thermal expansion (CTE)

UV Exposure

Fluid sensitivity to common aerospace fluids including fuels, lubricants, and cleaning agents



To learn more about specific testing conditions or to request test parts for internal testing, contact a Markforged representative. All customer parts should be tested in accordance to customer's specifications.

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