

Composites

| Composite Base | Test (ASTM) | Onyx | Onyx FR | Onyx ESD | Nylon | |
|-------------------------------|--------------------------------|------|------------------|-----------------------------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tensile Modulus (GPa) | D638 | 2.4 | 3.0 | 4.2 | 1.7 | Markforged parts are primarily composed of Composite Base materials. Users may reinforce parts with one type of Continuous Fiber. |
| Tensile Stress at Yield (MPa) | D638 | 40 | 41 | 52 | 51 | |
| Tensile Stress at Break (MPa) | D638 | 37 | 40 | 50 | 36 | Dimensions and construction of test specimens: |
| Tensile Strain at Break (%) | D638 | 25 | 18 | 25 | 150 | |
| Flexural Strength (MPa) | D790 ¹ | 71 | 71 | 83 | 50 | |
| Flexural Modulus (GPa) | D790 ¹ | 3.0 | 3.6 | 3.7 | 1.4 | <ul style="list-style-type: none"> Tensile: ASTM D638 type IV beams Flexural: 3-pt. Bending, 4.5 in (L) x 0.4 in (W) x 0.12 in (H) Heat-deflection temperature at 0.45 MPa, 66 psi (ASTM D648-07 Method B) |
| Heat Deflection Temp (°C) | D648 B | 145 | 145 | 138 | 41 | 1. Measured by a method similar to ASTM D790. Composite Base -only parts do not break before end of flexural test. |
| Flame Resistance | UL94 | — | V-0 ² | — | — | 2. Onyx FR is UL 94 V-0 Blue Card certified down to a thickness of 3mm. |
| Izod Impact - notched (J/m) | D256-10 A | 330 | — | 44 | 110 | 3. Surface resistance measured on multiple part surfaces using recommended print settings by an accredited third party test facility. See Onyx ESD technical data sheet for more details. |
| Surface Resistance (Ω) | ANSI/ESD STM11.11 ³ | — | — | 10 ⁵ - 10 ⁷ | — | |
| Density (g/cm ³) | — | 1.2 | 1.2 | 1.2 | 1.1 | |

| Continuous Fiber | Test (ASTM) | Carbon | Kevlar® | Fiberglass | HSHT FG |
|---------------------------------|-------------------|--------|---------|------------|---------|
| Tensile Strength (MPa) | D3039 | 800 | 610 | 590 | 600 |
| Tensile Modulus (GPa) | D3039 | 60 | 27 | 21 | 21 |
| Tensile Strain at Break (%) | D3039 | 1.5 | 2.7 | 3.8 | 3.9 |
| Flexural Strength (MPa) | D790 ¹ | 540 | 240 | 200 | 420 |
| Flexural Modulus (GPa) | D790 ¹ | 51 | 26 | 22 | 21 |
| Flexural Strain at Break (%) | D790 ¹ | 1.2 | 2.1 | 1.1 | 2.2 |
| Compressive Strength (MPa) | D6641 | 320 | 97 | 140 | 192 |
| Compressive Modulus (MPa) | D6641 | 54 | 28 | 21 | 21 |
| Compressive Strain at Break (%) | D6641 | 0.7 | 1.5 | — | — |
| Heat Deflection Temp (°C) | D648 B | 105 | 105 | 105 | 150 |
| Izod Impact - notched (J/m) | D256-10 A | 960 | 2000 | 2600 | 3100 |
| Density (g/cm ³) | — | 1.4 | 1.2 | 1.5 | 1.5 |

Dimensions and Construction of Fiber Composite Test Specimens:

- Test plaques used in these data are fiber reinforced unidirectionally (0° Plies)
- Tensile test specimens: 9.8 in (L) x 0.5 in (H) x 0.048 in (W) (CF composites), 9.8 in (L) x 0.5 in (H) x 0.08 in (W) (GF and Kevlar® composites)
- Compressive test specimens: 5.5 in (L) x 0.5 in (H) x 0.085 in (W) (CF composites), 5.5 in (L) x 0.5 in (H) x 0.12 in (W) (Kevlar® and FG composites)
- Flexural test specimens: 3-pt. Bending, 4.5 in (L) x 0.4 in (W) x 0.12 in (H)
- Heat-deflection temperature at 0.45 MPa, 66 psi (ASTM D648-07 Method B)

Tensile, Compressive, Strain at Break, and Heat

Deflection Temperature data were provided by an accredited 3rd party test facility. Flexural data was prepared by Markforged, Inc. These represent typical values.

Markforged tests plaques are uniquely designed to maximize test performance. Fiber test plaques are fully filled with unidirectional fiber and printed without walls. Plastic test plaques are printed with full infill. 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.

Part and material performance will vary by fiber layout design, part design, specific load conditions, test conditions, build conditions, and the like.

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