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MATERIAL DATA SHEET
FDM

FDM Nylon 12CF

FDM Thermoplastic Filament

The information presented are typical values intended for reference and comparison purposes only. They should not be used for design specifications or quality control purposes.



Overview

FDM® Nylon 12CF™ is a PA12 (polyamide 12) thermoplastic filament reinforced with chopped carbon fiber, 35% by weight. It has the highest flexural strength of any FDM thermoplastic, resulting in the highest stiffness-to-weight ratio. The combination of high strength, stiffness and light weight makes it an optimal replacement for heavier metal components in appropriate use cases.

Typical applications include strong, lightweight tooling, functional prototyping, and select end-use parts.

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Ordering Information

Table 1: Printer and Support Material Compatibility

Printer	Model Tip	Layer Height	Support Material	Support Tip
F870™	N20H	0.254 mm (0.010 in.)	SR-35™	N14
Fortus 450mc™	T20C	0.254 mm (0.010 in.)	SR-110™	T12SR100
	T40C	0.508 mm (0.020 in.)		T20
F900®	T20C	0.254 mm (0.010 in.)	SR-110	T12SR100
	T40C	0.508 mm (0.020 in.)		T20
F3300™	N500H	0.25 mm (0.010 in.)	SR-110	N410
	N750H	0.50 mm (0.020 in.)		N750

Build Sheet

F870 Nylon Build Sheet

- 0.51 x 762 x 1,041 mm (0.02 x 30 x 41 in.)

Fortus Nylon Build Sheet

- 0.51 x 660 x 965 mm (0.02 x 26 x 38 in.)
- 0.51 x 406 x 470 mm (0.02 x 16 x 18.5 in.)

F3300 Nylon Build Sheet

- 0.51 x 660 x 711 mm (0.02 x 26 x 28 in.)

System Requirements[1]

F870

- N20H Hardened Extrusion Head – Model (dark blue cover, carbon fiber label)
- N14 Extrusion head - Support (dark blue cover, dark blue label)
- No material license required

Fortus® 450mc

- Hardened machine upgrade
- Hardened Fortus 450mc head
- Nylon 12CF material license (included if new system)
- Fortus FDC™ (enables use of XTEND™ 250 Fortus® Plus spool)

F900

- Hardened F900 head
- Nylon 12CF material license
- Fortus FDC (enables use of XTEND™ 250 Fortus® Plus spool)

F3300

- F3000 Series Extruder Drive
- Hardened Hot End (model)
- Standard Hot End (support)
- No material license required

[1] Contact your Stratasys representative for ordering information.

Table 2: FDM Nylon 12CF Ordering Information

Part Number	Description	System Compatibility
Filament Consumables		
Fortus Plus Canister (black snout)		
355-02411	FDM Nylon 12CF, 92.3 cu in. - Plus	Fortus 450mc, F900
355-03130	SR-110 Soluble Support, 92.3 cu in. - Plus	
XTEND 250 Fortus Plus Spools		
361-00300	XTEND™ 250 Fortus® Plus Nylon 12CF	Fortus 450mc and F900 with the Fortus FDC
F3000 Series and F870 Spools		
363-00300	MTRL, F3000 Series and F870, (M), Nylon 12CF, 4100 cc	F870, F3300
363-00700[1]	MTRL, F3000 Series and F870, (S), SR-35, 4100 cc	F870
363-00710	MTRL, F3000 Series, (S), SR-110, 4100 cc	F3300
Printer Consumables		
F870		
123-90102-S	F870 Nylon build sheet, 0.02 x 30.04 x 41.06 in. (0.5 x 762 x 1,041 mm), 10 pack	F870
Fortus		
511-10720	TIP, FDM, T20C, 0.010 in. (0.254 mm) layer height	Fortus 450mc, F900
511-10100	TIP, FDM, T12SR100, 0.010 in. (0.254 mm) layer height	
511-10760	TIP, FDM, T40C, 0.020 in. (0.508 mm) layer height	
511-10701	TIP, FDM, T20[2], 0.020 in. (0.508 mm) layer height	
325-00750-S	Nylon build sheet, 0.02 x 16 x 18.5 in. (0.51 x 406 x 470 mm), 20 pack	
325-00650-S	Nylon build sheet, 0.02 x 26 x 38 in. (0.51 x 660 x 965 mm), 10 pack	F900
F3000 Series		
533-00505-S	Hardened Hot End, FDM, N500H (0.25 mm/0.010 in. layer height)	F3300
533-00410-S	Hot End, FDM, N410 Support (0.25 mm/0.010 in. layer height)	
533-00755-S	Hardened HOT END, FDM, N750H (0.50 mm/0.020 in. layer height)	
533-00750-S	Hot End, FDM, N750 Support (0.50 mm/0.020 in. layer height)	
363-30100-S	F3300 sheet bundle, Nylon 0.02 x 26 x 28 in., 10 pack	
Print Heads		
F870		
123-00901-S	Hardened Extrusion Head, N20H (model, dark blue cover, carbon fiber label)	F870
123-00900-S	Standard Head, N14 (support, dark blue cover, dark blue label)	
Fortus		
821726-XXXX	Hardened Fortus 450mc head (blue handle)	Fortus 450mc
380-30400-S	OpenAM Hardened Fortus 450mc head (blue handle, additional sticker)	
325-63500	Hardened F900 head (folded sheet metal handle)	F900
325-63500-S	OpenAM Hardened F900 head (folded sheet metal handle, additional sticker)	
F3000 Series		
533-10000-S	F3000 Series Extruder Drive	F3300

[1] SR-35 soluble support is not compatible with Nylon 12CF on the F3300 but is compatible with ASA on the F3300.
[2] The T20 tip is for 0.508 mm (0.020 in.) support material and should not be confused with the T20C 0.254 mm (0.010 in.) model material tip.

Physical Properties

Values are measured as molded and printed. XY and XZ orientations were tested. For full details refer to the Stratasys Materials Test Procedure. DSC and TMA curves can be found in the Appendix.

Table 3: FDM Nylon 12CF Physical Properties

Physical Properties - Printed			
Property	**Test Method**	**Typical Values**	
		XY	**XZ**
HDT @ 66 psi	ASTM D648 Method B	160 °C (320 °F)	168 °C (334 °F)
HDT @ 264 psi	ASTM D648 Method B	130 °C (266 °F)	154 °C (309 °F)
Unidirectional Toolpaths HDT @ 66 psi	ASTM D648 Method B	175 °C (347 °F)	-
Unidirectional Toolpaths HDT @ 264 psi	ASTM D648 Method B	157 °C (315 °F)	-
Mean CTE	ASTM E831 (-50 °C to 20 °C)	115.7 µm/[m*°C] (67.28 µin/[in*°F])	37.31 µm/[m*°C] (20.73 µin/[in*°F])
	ASTM E831 (20 °C to 60 °C)	180.5 µm/[m*°C] (100.3 µin/[in*°F])	-
	ASTM E831 (60 °C to 115 °C)	195.8 µm/[m*°C] (108.8 µin/[in*°F])	-
	ASTM E831 (115 °C to 150 °C)	296.5 µm/[m*°C] (164.7 µin/[in*°F])	-
	ASTM E831 (20 °C to 105 °C)	-	46.15 µm/[m*°C] (25.64 µin/[in*°F])
	ASTM E831 (105 °C to 150 °C)	-	58.43 µm/[m*°C] (32.46 µin/[in*°F])
Dielectric Constant	ASTM D150 1 kHz test condition	Too conductive	
	ASTM D150 2 MHz test condition	11.4	10.0
Dissipation Factor	ASTM D150 1 kHz test condition	Too conductive	
	ASTM D150 2 MHz test condition	0.100	0.000

Physical Properties - Non Printed		
Property	**Test Method**	**Molded Plaques**
Tg	ASTM D7426 Inflection Point	37.5 °C (99.5 °F)
Volume Resistivity	ASTM D257	>2.84*10^7 Ω*cm

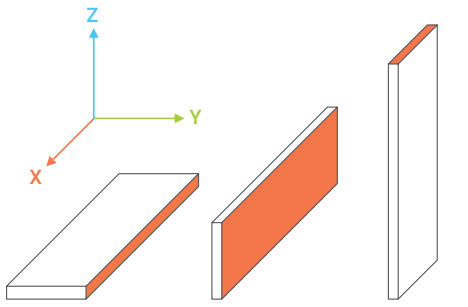
Property	Test Method	Molded Plaques
Thermal Conductivity	ASTM E1952 at 0 °C	0.5884 W/[m*K] (0.3400 BTU/[hr*ft*°F])
	ASTM E1952 at 30 °C	0.5988 W/[m*K] (0.3460 BTU/[hr*ft*°F])
	ASTM E1952 at 60 °C	0.5800 W/[m*K] (0.3352 BTU/[hr*ft*°F])
	ASTM E1952 at 90 °C	0.6153 W/[m*K] (0.3556 BTU/[hr*ft*°F])
Thermal Diffusivity	ASTM E1952 at 0 °C	0.363 mm^2/s ($5.63*10^{-4}$ in^2/s)
	ASTM E1952 at 30 °C	0.324 mm^2/s ($5.02*10^{-4}$ in^2/s)
	ASTM E1952 at 60 °C	0.266 mm^2/s ($4.12*10^{-4}$ in^2/s)
	ASTM E1952 at 90 °C	0.255 mm^2/s ($3.95*10^{-4}$ in^2/s)
Specific Gravity	ASTM D792 at 23 °C	1.190

Mechanical Properties

FDM Nylon 12CF samples were printed with 0.25 mm (0.010 in.) and 0.50 mm (0.020 in.) layer heights on the F870, Fortus 450mc, F900, and F3300. For the full test procedure please see the Stratasys Materials Test Procedure. For more information on compression testing and reporting please see the Refining Compressive Yield Stress Measurement for FDM Materials one pager.

Print Orientation

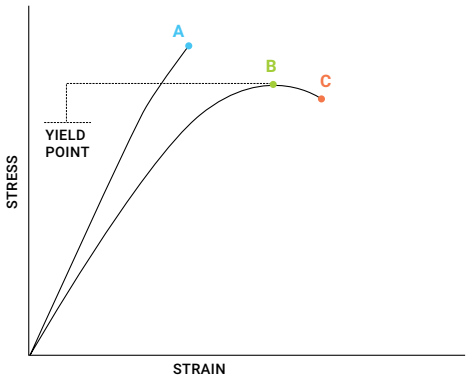
Parts created using FDM are anisotropic as a result of the printing process. Below is a reference of the different orientations used to characterize the material.



Flat (XY) On Edge (XZ) Upright (ZX)

Tensile Curves

Due to the anisotropic nature of FDM, tensile curves look different depending on orientation. Below is a guide of the two types of curves seen when printing tensile samples and what reported values mean.



A = Tensile at break, elongation at break (no yield point)
B = Tensile at yield, elongation at yield
C = Tensile at break, elongation at break

Table 4: Nylon 12CF Mechanical Properties - F870 - N20H head

0.25 mm (0.010 in.) Layer Height		XZ Orientation[1]	ZX Orientation[1]
Tensile Properties: ASTM D638			
Yield Strength	MPa	88 (6.7)	30.7 (1.9)
	psi	12,800 (970)	4,460 (270)
Elongation at Yield	%	2.1 (0.33)	2 (0.26)
Strength at Break	MPa	81.2 (7.1)	30.8 (1.7)
	psi	11,800 (1,000)	4,460 (250)
Elongation at Break	%	2.4 (0.38)	2 (0.26)
Modulus (Elastic)	GPa	10.1 (1.4)	2.23 (0.098)
	ksi	1,460 (210)	324 (14)
Flexural Properties: ASTM D790, Procedure A			
Strength at Break	MPa	172 (13)	64.1 (5)
	psi	25,000 (1,800)	9,300 (730)
Strain at Break	%	2.8 (0.22)	3.6 (0.2)
Modulus	GPa	12.2 (1.2)	2.22 (0.085)
	ksi	1,780 (180)	322 (12)
Compression Properties: ASTM D695			
0.2% Offset Yield	MPa	46.4 (3.1)	55.8 (2.5)
	psi	6,720 (450)	8,090 (360)
1.0% Offset Yield	MPa	64.1 (3.9)	73.4 (3.4)
	psi	9,300 (570)	10,600 (490)
Modulus	GPa	3.33 (0.29)	2.39 (0.067)
	ksi	483 (42)	346 (9.8)
Impact Properties: ASTM D256, ASTM D4812			
Notched	J/m	123 (30)	23.8 (5)
	ft*lb/in	2.31 (0.55)	0.445 (0.093)
Unnotched	J/m	991 (140)	112 (16)
	ft*lb/in	18.6 (2.6)	2.1 (0.3)

[1] Values in parentheses are standard deviations.

Table 5: FDM Nylon 12CF Mechanical Properties - Fortus 450mc - T20C tip

0.25 mm (0.010 in.) Layer Height		XZ Orientation[1]	ZX Orientation[1]
Tensile Properties: ASTM D638			
Yield Strength	MPa	77.5 (2.4)	38.3 (1.6)
	psi	11,200 (350)	5,500 (230)
Elongation at Yield	%	3.1 (0.2)	2.2 (0.17)
Strength at Break	MPa	76.5 (3.5)	38.4 (1.5)
	psi	11,100 (500)	5,570 (220)
Elongation at Break	%	3.2 (0.28)	2.2 (0.16)
Modulus (Elastic)	GPa	7.91 (0.31)	2.64 (0.078)
	ksi	1,150 (45)	384 (11)
Flexural Properties: ASTM D790, Procedure A			
Strength at Break	MPa	152 (3.8)	67.4 (3.5)
	psi	22,100 (550)	9,770 (510)
Strain at Break	%	2.7 (0.1)	3.6 (0.23)
Modulus	GPa	11 (0.26)	2.18 (0.11)
	ksi	1,600 (38)	317 (16)
Compression Properties: ASTM D695			
Peak Strength	MPa	105 (5.4)	135 (3.5)
	psi	15,200 (780)	19,600 (510)
Modulus	GPa	2.73 (0.33)	2.44 (0.13)
	ksi	397 (48)	354 (19)
Impact Properties: ASTM D256, ASTM D4812			
Notched	J/m	102 (3.8)	22.4 (2.2)
	ft*lb/in	1.91 (0.071)	0.42 (0.041)
Unnotched	J/m	619 (58)	125 (12)
	ft*lb/in	11.6 (1.1)	2.35 (0.22)

[1] Values in parentheses are standard deviations.

T40C Tensile Part Processing: XZ tensile coupon printed dimensions were 165 x 22 x 5 mm (6.500 x 0.875 x 0.200 in.). ZX tensile coupons were precision-cut via water jet machining from larger printed plaques to produce final coupon dimensions of 165 x 22 x 5 mm (6.500 x 0.875 x 0.200 in.). XZ and ZX tensile coupons were then tested using the standard D638 procedure, including coupon conditioning and pulling.

T40C Flexural Part Processing: XZ flexural coupon printed dimensions were 165 x 12.7 x 5 mm (6.500 x 0.500 x 0.200 in.). ZX flexural test coupons were precision-cut via water jet machining from larger printed plaques to produce final coupon dimensions of 165 x 12.7 x 5 mm (6.500 x 0.500 x 0.20 in.). XZ and ZX flexural coupons were then tested using the standard D790 procedure, including coupon conditioning.

Table 6: FDM Nylon 12CF Mechanical Properties - Fortus 450mc - T40C tip

0.50 mm (0.020 in.) Layer Height		XZ Orientation[1]	ZX Orientation[1]
Tensile Properties: Modified ASTM D638			
Yield Strength	MPa	124 (8)	38.3 (2.2)
	psi	17,900 (1,200)	5,550 (310)
Elongation at Yield	%	2 (0.21)	2.7 (0.34)
Strength at Break	MPa	124 (6.6)	38.1 (2.3)
	psi	18,000 (960)	5,530 (330)
Elongation at Break	%	2 (0.18)	2.7 (0.35)
Modulus (Elastic)	GPa	15.4 (1.3)	2.38 (0.069)
	ksi	2,230 (190)	345 (10)
Flexural Properties: Modified ASTM D790, Procedure A			
Strength at Break	MPa	200 (9.7)	61.1 (2.8)
	psi	28,900 (1,400)	8,860 (410)
Strain at Break	%	2.7 (0.17)	3.5 (0.32)
Modulus	GPa	13.5 (1.2)	2.25 (0.039)
	ksi	1,950 (170)	327 (5.7)

[1] Values in parentheses are standard deviations.

Table 7: FDM Nylon 12CF Mechanical Properties - F900 - T20C tip

0.25 mm (0.010 in.) Layer Height		XZ Orientation[1]	ZX Orientation[1]
Tensile Properties: ASTM D638			
Yield Strength	MPa	No yield	No yield
	psi	No yield	No yield
Elongation at Yield	%	No yield	No yield
Strength at Break	MPa	83.5 (1.7)	32.7 (3.5)
	psi	12,100 (250)	4,750 (510)
Elongation at Break	%	2.4 (0.29)	1.2 (0.27)
Modulus (Elastic)	GPa	9.46 (0.46)	3.00 (0.43)
	ksi	1,370 (67)	434 (63)
Flexural Properties: ASTM D790, Procedure A			
Strength at Break	MPa	153 (2.1)	62.4 (3.4)
	psi	22,200 (310)	9,080 (490)
Strain at Break	%	2.65 (0.086)	3.10 (0.26)
Modulus	GPa	11.1 (0.28)	2.34 (0.085)
	ksi	1,610 (40)	339 (12)
Compression Properties: ASTM D695			
Peak Strength	MPa	110 (3.0)	141 (2.6)
	psi	16,000 (440)	20,400 (380)
Modulus	GPa	6.78 (0.55)	3.67 (0.11)
	ksi	984 (79)	532 (16)
Impact Properties: ASTM D256, ASTM D4812			
Notched	J/m	106 (6.6)	24 (3.2)
	ft*lb/in	1.99 (0.12)	0.45 (0.060)
Unnotched	J/m	346 (40)	121 (18)
	ft*lb/in	6.48 (0.74)	2.27 (0.33)

[1] Values in parentheses are standard deviations.

T40C Tensile Part Processing: XZ tensile coupon printed dimensions were 165 x 22 x 5 mm (6.500 x 0.875 x 0.200 in.). ZX tensile coupons were precision-cut via water jet machining from larger printed plaques to produce final coupon dimensions of 165 x 22 x 5 mm (6.500 x 0.875 x 0.200 in.). XZ and ZX tensile coupons were then tested using the standard D638 procedure, including coupon conditioning and pulling.

T40C Flexural Part Processing: XZ flexural coupon printed dimensions were 165 x 12.7 x 5 mm (6.500 x 0.500 x 0.200 in.). ZX flexural test coupons were precision-cut via water jet machining from larger printed plaques to produce final coupon dimensions of 165 x 12.7 x 5 mm (6.500 x 0.500 x 0.20 in.). XZ and ZX flexural coupons were then tested using the standard D790 procedure, including coupon conditioning.

Table 8: Nylon 12CF Mechanical Properties - F900 - T40C tip

0.50 mm (0.020 in.) Layer Height		XZ Orientation[1]	ZX Orientation[1]
Tensile Properties: Modified ASTM D638			
Yield Strength	MPa	107.9 (5.3)	36.2 (1.4)
	psi	15,600 (800)	5,200 (200)
Elongation at Yield	%	1.9 (0.2)	2.9 (0.4)
Strength at Break	MPa	106.7 (4.9)	36.0 (1.5)
	psi	15,500 (700)	5,200 (200)
Elongation at Break	%	1.9 (0.2)	2.9 (0.4)
Modulus (Elastic)	GPa	12.7 (0.5)	2.13 (0.07)
	ksi	1,840 (80)	310 (10)
Flexural Properties: Modified ASTM D790, Procedure A			
Strength at Break	MPa	187.4 (4.9)	64.7 (2.1)
	psi	27,200 (700)	9,400 (300)
Strain at Break	%	2.4 (0.2)	4.0 (0.3)
Modulus	GPa	12.5 (0.3)	2.30 (0.07)
	ksi	1,820 (40)	330 (10)

[1] Values in parentheses are standard deviations.

Table 9: Nylon 12CF Mechanical Properties - F3300 - N500H Hot End

0.25 mm (0.010 in.) Layer Height		XZ Orientation[1]	ZX Orientation[1]
Tensile Properties: ASTM D638			
Yield Strength	MPa	107 (2.6)	36.6 (2.2)
	psi	15,500 (370)	5,310 (320)
Elongation at Yield	%	2.6 (0.18)	2.1 (0.17)
Strength at Break	MPa	107 (2.6)	36.7 (2.1)
	psi	15,500 (380)	5,330 (310)
Elongation at Break	%	2.6 (0.19)	2.1 (0.17)
Modulus (Elastic)	GPa	12.1 (0.36)	2.6 (0.073)
	ksi	1,760 (53)	377 (11)
Flexural Properties: ASTM D790, Procedure A			
Strength at Break	MPa	197 (4)	72.7 (4.7)
	psi	28,500 (580)	10,500 (680)
Strain at Break	%	2.8 (0.085)	3.9 (0.35)
Modulus	GPa	13.4 (0.57)	2.26 (0.1)
	ksi	1,940 (83)	328 (15)
Compression Properties: ASTM D695			
Peak Strength	MPa	109 (12)	129 (4.3)
	psi	15,700 (1,700)	18,700 (620)
Modulus	GPa	3.37 (0.21)	2.63 (0.13)
	ksi	489 (30)	382 (18)
Impact Properties: ASTM D256, ASTM D4812			
Notched	J/m	138 (7)	45.5 (73)
	ft*lb/in	2.58 (0.13)	0.852 (1.4)
Unnotched	J/m	1,030 (93)	139 (23)
	ft*lb/in	19.3 (1.7)	2.61 (0.43)

[1] Values in parentheses are standard deviations.

Mechanical Performance with Unidirectional Toolpaths

The Stratasys typical testing procedure follows our default “45/-45” raster toolpath generation where the first raster layer is 45° in the XY plane and the next layer is perpendicular to that (-45°). The data in this section has unidirectional toolpaths, where all toolpaths are aligned in the XY plane and along the axis for the mechanical test. This method of optimizing toolpaths is appropriate to show the maximum strength for filled materials, but should be used with caution as it is not representative of typical part toolpaths and strength. For further information on this test method, refer to the Stratasys Materials Testing Procedure and the Unidirectional Material Testing May Mislead Manufacturing white paper.

Table 10: FDM Nylon 12CF Mechanical Properties with Unidirectional Toolpaths - F900 - T20C

0.25 mm (0.010 in.) Layer Height		XY Orientation[1]
Tensile Properties: ASTM D638		
Yield Strength	MPa	No Yield
	psi	No Yield
Elongation at Yield	%	No Yield
Strength at Break	MPa	111 (1.6)
	psi	16,100 (240)
Elongation at Break	%	1.6 (0.08)
Modulus (Elastic)	GPa	15.1 (0.15)
	ksi	2,180 (21)
Flexural Properties: ASTM D790, Procedure B		
Strength at Break	MPa	183 (2.2)
	psi	26,600 (320)
Strain at Break	%	2.4 (0.7)
Modulus	GPa	11.9 (0.11)
	ksi	1,730 (16)
Impact Properties: ASTM D256		
Notched	J/m	122 (3.1)
	ft*lb/in	2.28 (0.058)

[1] Values in parentheses are standard deviations.

UV Aging

Nylon 12CF coupons were built on the F900 using the T20C tip with 0.254 mm (0.010 in.) layer height. The coupons were then tested before and after UV exposure. Ten ASTM D638 upright (ZX) coupons were tested in tensile after UV exposure and an additional 10 ASTM D638 ZX coupons were the control (no UV exposure). The UV exposed samples were cycled in the QUV chamber per ASTM G154 (Standard Practice for Operation Fluorescent UV Light Apparatus for Exposure of Nonmetallic Materials) for 1,000 hours, alternating for eight hours at 60 ˚C (140 ˚F) and four hours at 50 ˚C (122 ˚F) with humidity and condensation. The increase in stress at break is from the control samples. For more information see the Impact of UV Exposure on FDM 3D Printing Materials white paper.

Table 11: Nylon 12CF UV Exposure Test Results - F900 - T20C tip

Material	Conditioning	Yield Strength		Stress at Break		Elongation at Break	Increase in Stress at Break	Modulus	
		(psi)	(MPa)	(psi)	(MPa)	%	%	(ksi)	(GPa)
Nylon 12CF	No UV Exposure	4,760	32.8	4,720	32.5	1.7	-	361	2.49
	UV Exposure	6,500	44.8	6,460	44.5	2.2	36.80	421	2.9

Performance at Temperature

Nylon 12CF coupons were built on the F900 using the T20C tip with 0.254 mm (0.010 in.) layer height and tested at various temperatures. Ten ASTM D638 upright (ZX) coupons were tested in tensile. The percent change from the reported room temperature results are listed below. For more information see the Impact of Temperature on High-Performance FDM Materials white paper.

Table 12: Performance of FDM Nylon 12CF at Temperature - F900 - T20C tip

Material	Temperature (°F)	Temperature (°C)	Strength at Break	Elongation at Break	Modulus
Nylon 12CF	-65	-54	176%	60%	126%
	-40	-40	160%	57%	128%
	110	43	95%	77%	80%
	180	82	66%	173%	41%
	220	104	50%	223%	30%
	270	132	34%	257%	21%

Appendix

Figure 1: 2nd heating scan DSC data for the Nylon 12CF Flat (XY) sample.

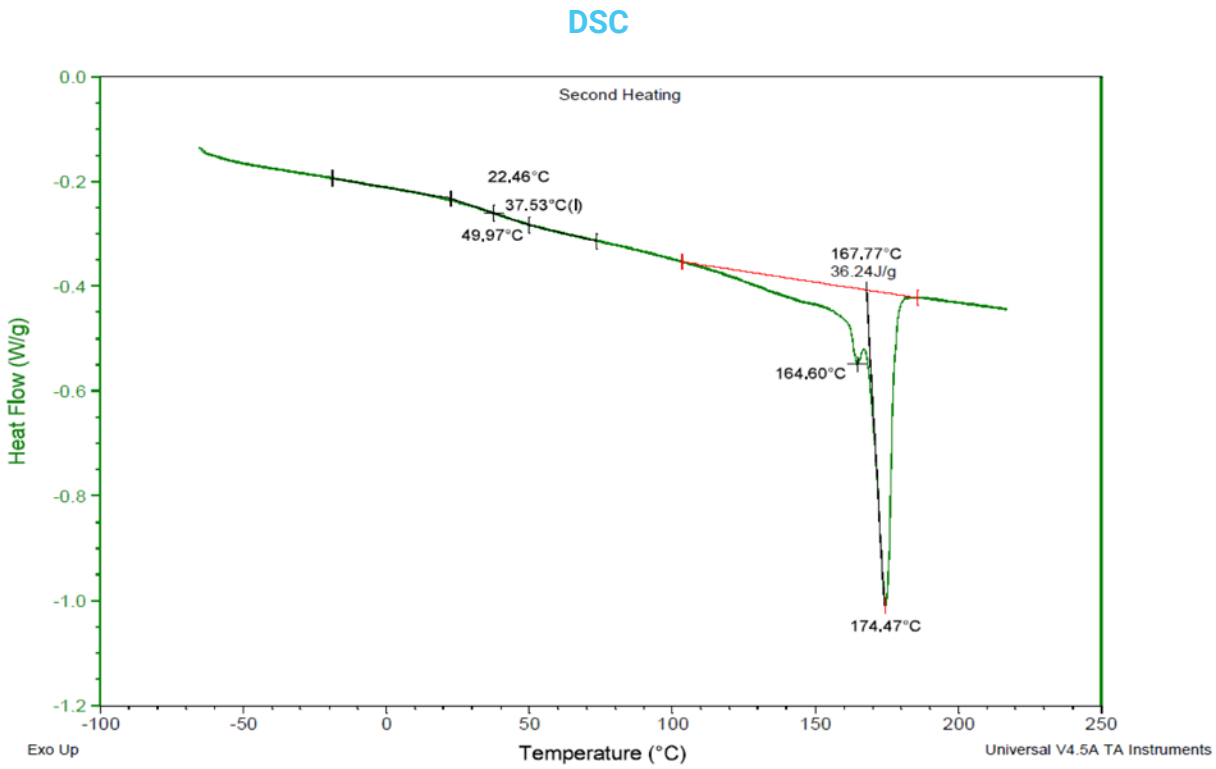


Figure 2: Dimension change data as a function of temperature for the Nylon 12CF Flat (XY) sample.

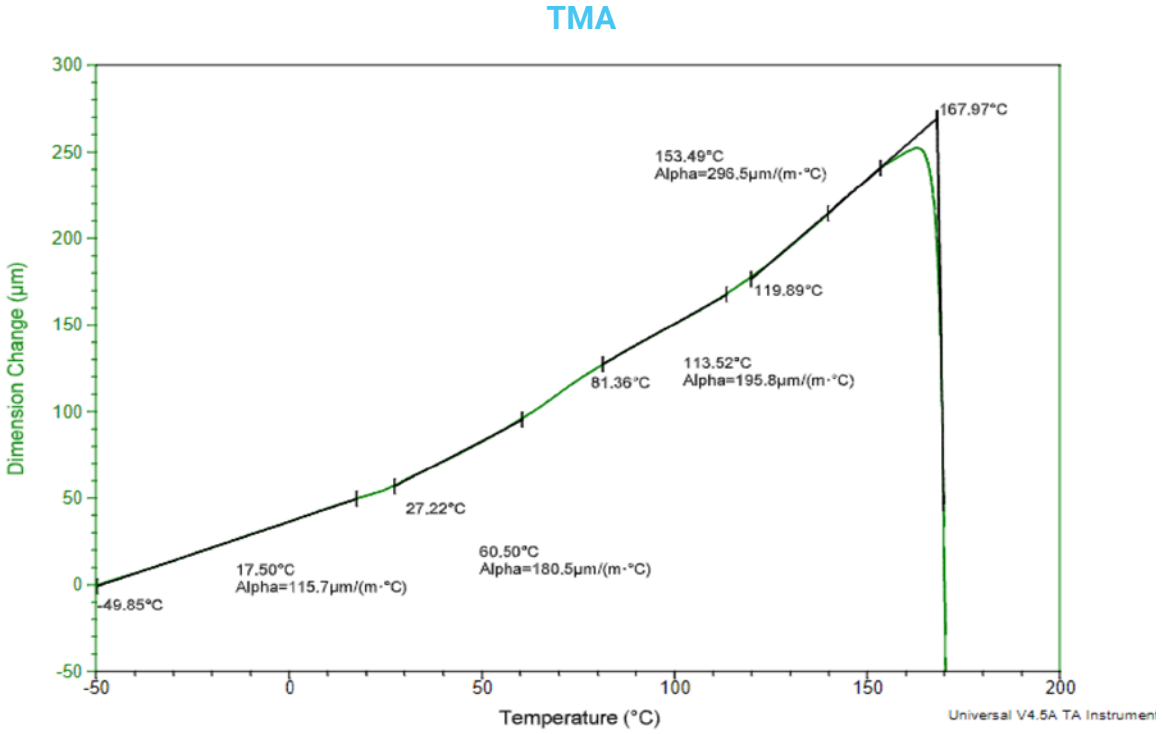


Figure 3: Dimension change data as a function of temperature for the Nylon 12CF On Edge (XZ) sample.

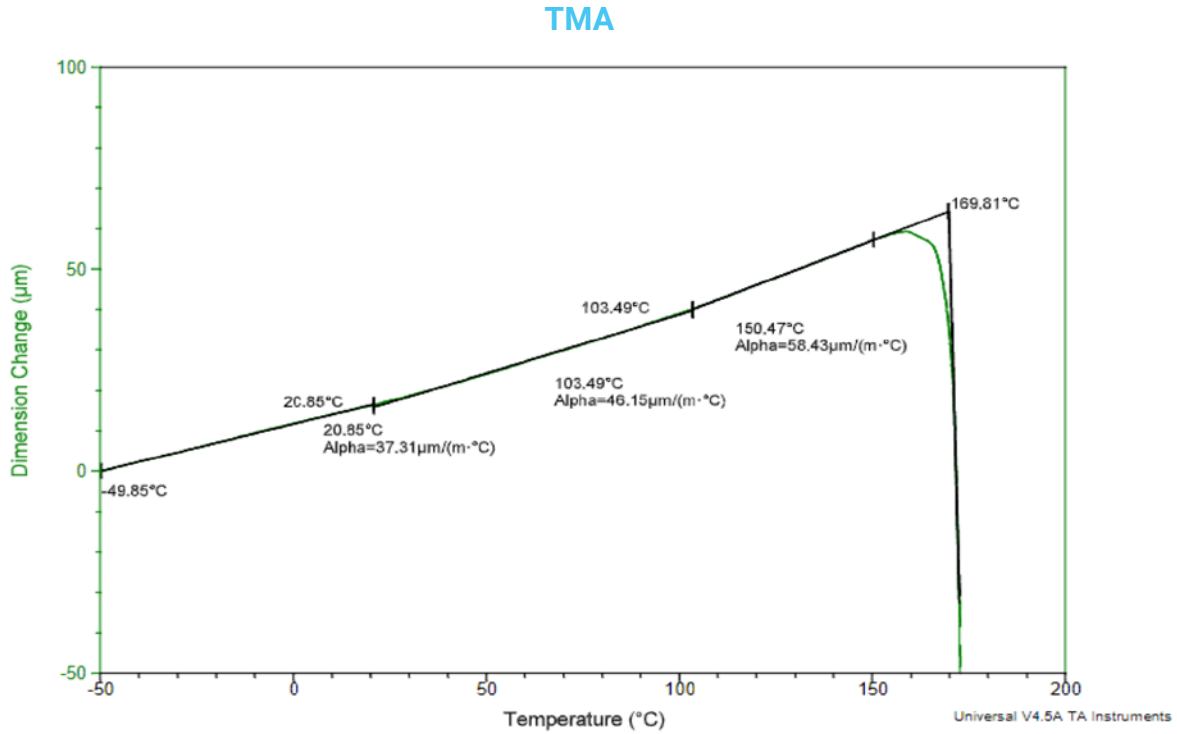
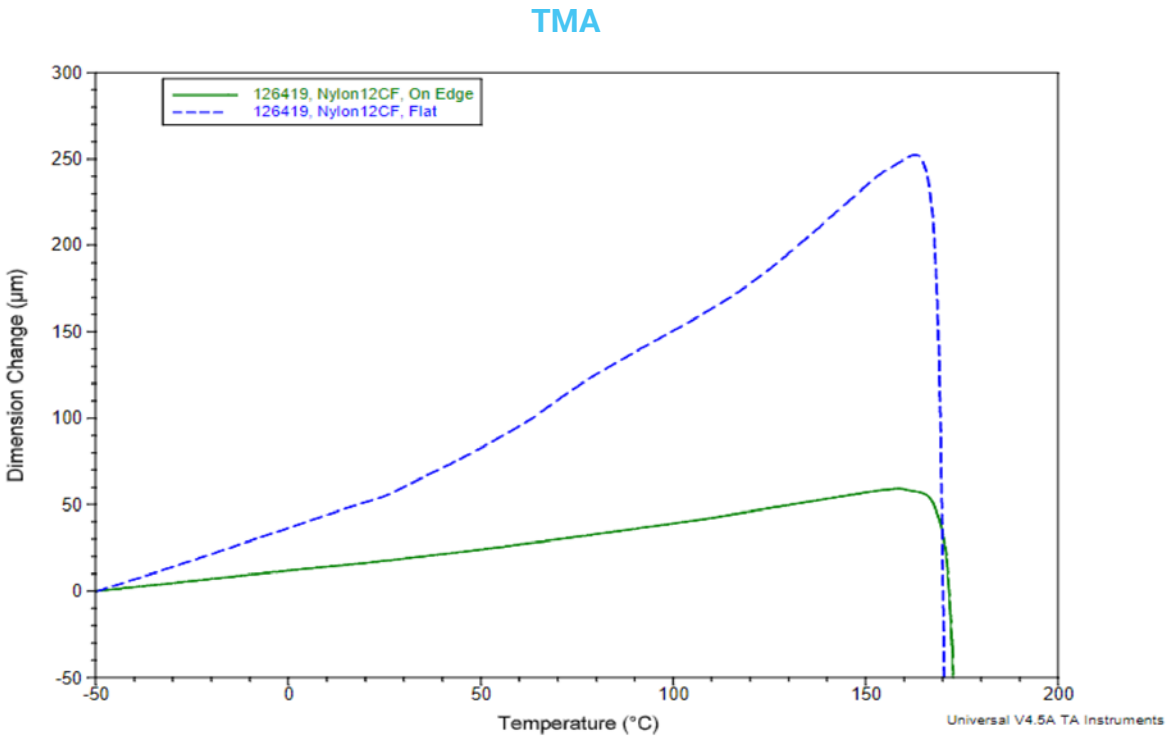


Figure 4: Overlay of the dimension change data for the Flat (XY) and On Edge (XZ) Nylon 12CF samples.



alphacam GmbH
Erlenwiesen 16
D-73614 Schorndorf
Tel.: +49 7181 9222-0
info@alphacam.de

alphacam austria GmbH
Handelskai 92, Gate1 / 2. OG / Top A
A-1200 Wien
Tel.: +43 1 3619 600-0
info@alphacam.at

alphacam swiss GmbH
Zürcherstrasse 14
CH-8400 Winterthur
Tel.: +41 52 26207-50
info@alphacam.ch

alphacam.de
.at
.ch

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