formlabs

ENGINEERING RESIN

Flame Retardant Resin

For UL 94 V-0 Certified Parts With Excellent Part Quality and Heat Resistance

Easily and quickly create stiff, creep-resistant, and functional plastic parts that perform well long-term in indoor and industrial environments. FR Resin is self-extinguishing and halogen-free with favorable flame, smoke, and toxicity (FST) ratings.

Custom jigs, fixtures, and replacement parts for industrial environments with high temperatures or ignition sources

Interior parts in airplanes, automobiles, and railways with excellent surface finish

Protective and internal consumer or medical electronics components

V1 **FLFRGR01**

Prepared 13/04/2023

Rev. 02 26/07/2023

Flammability [1, 2]	Result			Method
UL 94	V-0 (3 mm)	V-1 (2.5 mm)	HB (1.5 mm)	Scan to view Blue Card
FAR 25.853 Appendix F, Part I (a) (1) (ii) 12 seconds Vertical Burn	Pass (2.5 mm)			

Smoke Toxicity [3, 4]	Result		Method
	Ds @ 1.5 min	Ds @ 4 min	
Smoke Generation: Flaming at 3 mm thickness	19.5	285	ASTM E662
Smoke Generation: Flaming at 5 mm thickness	5	114	ASTM E662

Gas Toxicity [3, 4]	Result				Method
Gas Toxicity at 3 mm thickness	Pass	CO: 56 PPM HCl: <1 PPM	HCN: 7 PPM HF: <1 PPM	SO2: <1 PPM (NO + NO2) NOx: <1 PPM	BSS 7239

Material Properties	METRIC [3,5]			IMPERIAL [3,5]			METHOD
	Green	Post-Cured for 60 min at 70 °C	Post-Cured for 120 min at 80 °C	Green	Post-Cured for 60 min at 70 °C	Post-Cured for 120 min at 80 °C	
Mechanical Properties [5, 6]	METRIC [3,5]			IMPERIAL [3,5]			METHOD
Ultimate Tensile Strength	24 MPa	38 MPa	41 MPa	3560 psi	5990 psi		ASTM D638-14
Tensile Modulus	1.8 GPa	2.9 GPa	3.1 GPa	263 ksi	430 ksi	446 ksi	ASTM D638-14
Elongation at Break	20%	9.4%	7.1%	20%	9.40%	7.10%	ASTM D638-14
Flexural Properties	METRIC [3,5]			IMPERIAL [3,5]			METHOD
Flexural Strength	36 MPa	72 MPa	75 MPa	5280 psi	10500 psi	10900 psi	ASTM D790-15
Flexural Modulus	1.3 GPa	2.7 GPa		188 ksi	392 ksi	401 ksi	ASTM D790-15
Impact Properties	METRIC [3,5]			IMPERIAL [3,5]			METHOD
Notched Izod	19 J/m	22 J/m		0.36 ft-lb/in	0.41 ft-lb/in	0.42 ft-lb/in	ASTM D256-10
Unnotched Izod	227 J/m	241 J/m	257 J/m	4.26 ft-lb/in	4.51 ft-lb/in	4.82 ft-lb/in	ASTM D4812-11
Fracture Properties	METRIC [3,5]			IMPERIAL [3,5]			METHOD
Maximum Stress Intensity Factor (Kmax)		1.05 MPa · $m^{1/2}$	1.11 MPa · $m^{1/2}$		956 psi · $in^{1/2}$	1009 psi · $in^{1/2}$	ISO 20795-1:2013(E), Section 8.6
Work of Fracture (Wf)		311 J/m^2	277 J/m^2		21 ft-lb/ft^2	19 ft-lb/ft^2	ISO 20795-1:2013(E), Section 8.6
Thermal Properties	METRIC [3,5]			IMPERIAL [3,5]			METHOD
Heat Deflection Temp. @ 1.8 MPa	45 °C	71 °C	83 °C	113 °F	160 °F	181 °F	ASTM D648-16
Heat Deflection Temp. @ 0.45 MPa	55 °C	94 °C	111 °C	131 °F	201 °F	232 °F	ASTM D648-16
Coefficient of Thermal Expansion, 20°- 80°C		98.6 µm/m/°C	68.1 µm/m/°C		54.8 µin/in/°F	37.8 µin/in/°F	ASTM E813-13
Glass Transition Temperature (Tg)	101 °C	130 °C	144 °C	214 °F	266 °F	291 °F	Peak of tan delta, Heating Rate: 3°Cpm

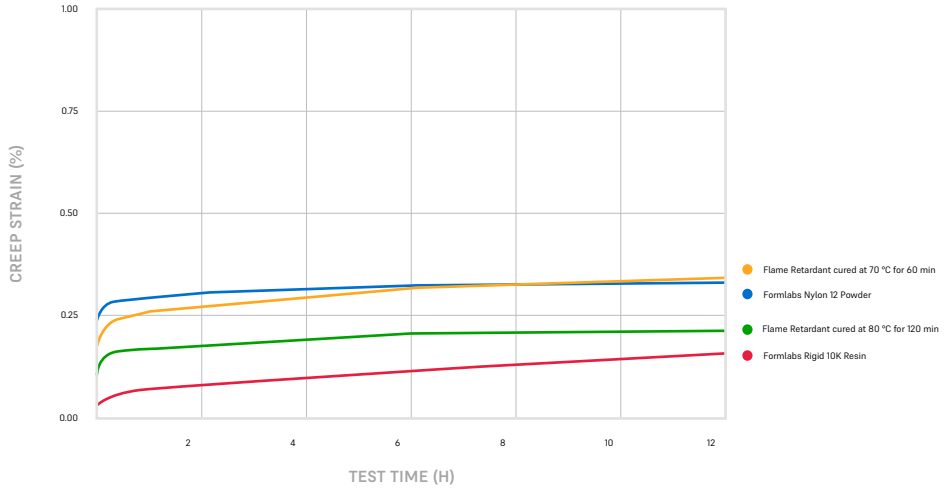
General Properties	Result		Method
Hardness	Green: 74D	Post Cured: 80D	ASTM D2240
Bulk Density	1.25 g/cm^3		ASTM D792-20
Viscosity (25 °C)	4500 - 5000 cP		
Color	Light grey		

Electrical Properties [3, 5]	Result	Method
Dielectric Strength	15.1 kV/mm	ASTM D149
Dielectric Constant	3.83	ASTM D150, 0.5 MHz
Dielectric Constant	3.82	ASTM D150, 1.0 MHz
Dissipation Factor	0.024	ASTM D150, 0.5 MHz
Dissipation Factor	0.025	ASTM D150, 1 MHz
Volume Resistivity	2.1 x 10^{15} ohm-cm	ASTM D257

Outgassing [3, 5]	Result	Method
Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment	Pass Total Mass Loss (TML): 0.87% Collected Volatile Condensable Material (CVCM): <0.01% Water Vapor Recovered (WVR): 0.2%	ASTM E595

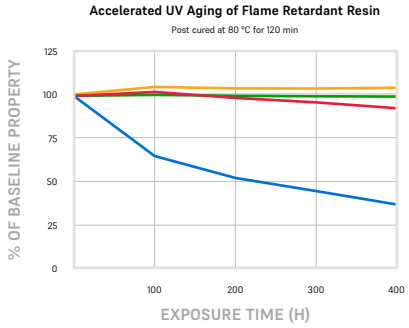
Tensile Creep Resistance (ASTM D2990-17)

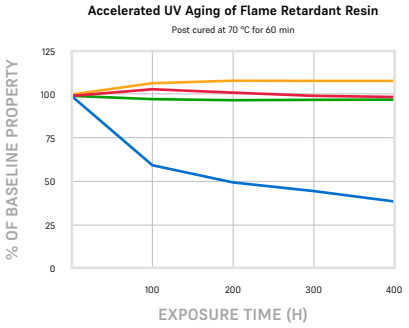
Creep resistance measurements of Formlabs materials tested at 65 °C and a 1.8 MPa load.



Formlabs Flame Retardant Resin parts have high creep resistance. Post-curing Flame Retardant Resin samples at 80 °C for 120 minutes shows improved creep resistance compared to post-curing at 70 °C for 60 minutes. Flame Retardant Resin samples post-cured at 80 °C and 120 minutes is slightly lower in creep resistance than Rigid 10K Resin samples. Flame Retardant Resin samples post-cured at 70 °C and 60 minutes showed similar creep behavior as Formlabs Nylon 12 SLS Powder.

Accelerated UV Aging [3, 5]	Method
Indoor UV Stability Formlabs evaluated the UV aging performance of Flame Retardant Resin using ASTM D4459, a test standard for xenon-arc exposure of plastics for indoor applications. This test simulates polymer aging due to solar radiation exposure through glass.	ASTM D4459 Standard practice for Xenon-Arc exposure of plastics intended for indoor applications



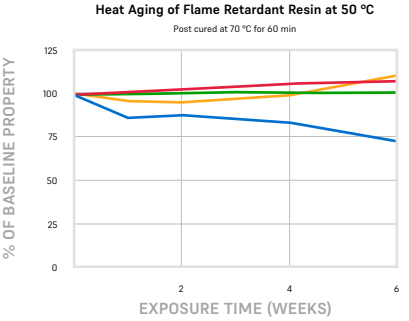


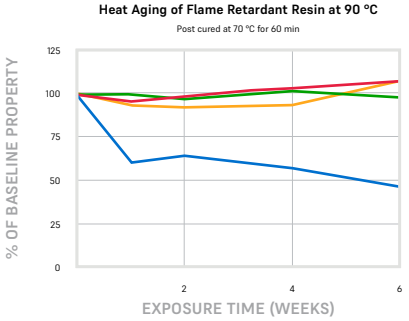
Accelerated UV Aging

ASTM 4459: Xenon-Arc, 0.8 W/m² at 420 nm, 55 °C, 50% RH
ASTM D638: Type 4, 5 mm/min

- EAB (%)
- Modulus (%)
- UTS (%)
- Impact (%)

Long Term Aging [3, 5]	Method
Heat Aging Formlabs evaluated the heat aging performance of Flame Retardant Resin using ASTM D3045, a test method for evaluating heat aging of plastics without load. In this test, mechanical properties of samples placed at 50 °C or 90 °C environments are measured at different durations of time for up to 6 weeks.	ASTM D3045 A test time of 6 weeks at 50 or 90 °C





Accelerated Heat Aging

ASTM D3045: 50 and 90 °C for 1, 2, 4 and 6 weeks each
ASTM D638: Type 4, 5 mm/min

- EAB (%)
- Modulus (%)
- UTS (%)
- Impact (%)

SOLVENT COMPATIBILITY

Percent weight gain over 24 hours for a printed and post-cured 1 x 1 x 1 cm cube immersed in respective solvent:

Cleaning Chemicals	**24 hr weight gain, %**
Acetone	2.1
Bleach ~5% NaOCl	0.3
Windex Powerized Formula	0.3
Hydrogen Peroxide (30%)	1
Soapy water	0.2
TPM	0.1
Distilled Water	0.2
Strong Acid/Base/Alcohol	
Hydrochloric Acid (10%)	< 0.1
Sodium Hypochlorite Solution	< 0.1
Sodium hydroxide solution (0.025% pH = 10)	0.3
Salt Water (3.5% NaCl)	0.2
Isopropyl Alcohol	0.2
Hydrogen peroxide (3%)	0.2
Butyl Acetate	0.4
Sulfuric Acid (30%)	Disintegrated
Industrial Fluids	
Gasoline ISO 1817, liquid C	< 0.1
Transmission Fluid (Havoline Synthetic ATF)	< 0.1
Engine Oil (Havoline SAE 5W-30	< 0.1
Brake Fluid (Castrol DOT-4)	< 0.1
Diesel (Chevron #2)	< 0.1
Power Steering Fluid	< 0.1
Skydrol 5	< 0.1
Hydraulic Oil	< 0.1
Diethyl glycol monomethyl ether	0.3
Mineral oil, heavy	< 0.1
Mineral oil, light	< 0.1

[1] UL flammability rating bars were printed on Form 3+/Form 3 printers with 50µm Flame Retardant Resin settings, washed in a Form Wash for (a) 10 minutes in ≥99% Isopropyl Alcohol or (b) 15 minutes in ≥99% Tripropylene glycol monomethyl ether, with a quick water rinse, and then post-cured at 70°C for 60 minutes in a Form Cure. This rating can be achieved printing in any orientation and any available layer height on a Form 3, Form 3+, Form 3B, Form 3B+, Form 3L or Form 3BL

[2] FAR 25.853 Appendix F Part I (a) bars were printed on a Form 3L printer with 100µm Flame Retardant Resin settings, washed in a Form Wash L for 10 min in ≥99% Isopropyl Alcohol, and then post-cured at 70°C for 60 min in a Form Cure L.

[3] Data for post-cured samples were printed on a Form3+ printer with 100 µm Flame Retardant Resin settings, washed in a Form Wash for 10 minutes in ≥99% Isopropyl Alcohol, and post-cured at 70°C for 60 minutes in a Form Cure unless specified otherwise.

[4] 5mm thickness samples pass Smoke Tests based on a passing criteria of <200 for Ds @ 4 min in flaming mode for ASTM E 662. Users can additionally test samples for thicknesses between 3mm-5mm based on their design constraints. Samples pass Gas Toxicity at 3mm thickness.

[5] Material properties may vary based on part geometry, print orientation, print settings, temperature, and disinfection or sterilization methods used.

[6] Data for tensile samples were measured on Type I tensile bars printed on a Form 3+ printer with 100 µm Flame Retardant Resin settings, washed in a Form Wash for 10 minutes in ≥99% Isopropyl Alcohol, and post-cured at 70°C for 60 minutes or 80°C for 120 minutes in a Form Cure.

UL Product iQ®

Flame Retardant Resin v1 - Plastics for Additive Manufacturing - Component

Plastics for Additive Manufacturing - Component

File Number: E530674

Blue Card®

ALSO CERTIFIED TO IEC REQUIREMENTS

Printing Process Designation Number 1

COMPANY

Formlabs Inc
35 Medford St. Suite 201
Somerville, MA 02143 United States

MODEL INFO

Flame Retardant Resin v1
Acrylate based Photosensitive Polymer, furnished as Liquid

FLAMMABILITY PROPERTIES	VALUE	TEST METHOD
Flammability		ANSI/UL 94
1.5 mm, Color: GY	HB	
2.5 mm, Color: GY	V-1	
3.0 mm, Color: GY	V-0	

ISO/IEC FLAMMABILITY PROPERTIES	VALUE	TEST METHOD
Flammability		IEC 60695-11-10
1.5 mm, Color: GY	HB75	
2.5 mm, Color: GY	V-1	
3.0 mm, Color: GY	V-0	

THERMAL PROPERTIES	VALUE	TEST METHOD
Relative Thermal Index - Electrical Strength		UL 746B
1.5 mm	50 °C	
2.5 mm	50 °C	
3.0 mm	50 °C	
Relative Thermal Index - Mechanical Impact		UL 746B
1.5 mm	50 °C	
2.5 mm	50 °C	
3.0 mm	50 °C	
Relative Thermal Index - Mechanical Strength		UL 746B
1.5 mm	50 °C	
2.5 mm	50 °C	
3.0 mm	50 °C	

PROCESSING PARAMETER	VALUE	TEST METHOD

APPENDIX

Process Category	Vat Polymerization - Stereolithography (SLA)
Build Plane	Horizontal & Vertical
Layer Thickness	50.00 to 100.00 µm
Post Process Method	Form Cure default time and temperature for the material, Form Wash in IPA or TPM
Printer	Formlabs Form 3, Form 3(B), Form 3(+), Form 3(B)(+), Form 3L, Form 3(B)L

Report Date: 2023-03-22
Revision Date: 2023-04-18

FAR 25.853 VERTICAL FLAMMABILITY TESTING (12 SEC.) FOR FORMLABS ON 2.5 MM VTEC #100-7544-1 TESTED: MARCH 29, 2023

VTEC Laboratories Inc.

March 29, 2023

Client: Formlabs
35 Medford Street
Somerville, MA 02143

I. SCOPE:

This report contains the reference to the test method, sample description, and test results.

II. TEST METHOD:

This test was conducted in accordance with the FAR 25.853, Appendix F, Part 25 Vertical Flammability (12 sec.) specification.

III. PASSING CRITERIA:

Fabrics, tested in both the weft and warp directions, must have an average burn length not exceeding 6 inches, an average after flame time not exceeding 15 seconds, and any dripping may not continue to flame for more than an average of 3 seconds after falling.

212 Manida Street, Bronx, New York 10474 · Tel 718-542-8248 · Fax 718-542-8759

III. SAMPLE DESCRIPTION:

1) Manufacturer:	Formlabs
2) Product Description:	2.5 mm
3) Color:	Grey
4) Number of Specimens:	3
5) Specimen Dimensions:	3 x 13 inches
6) Material Description:	By Manufacturer
7) Date of Selection:	March 2023
8) Purpose of Test:	Showing compliance with 25.853 Vertical (12 sec.) Flammability Test
9) Sample Mounting Method:	Vertically in a metal frame with the two long edges and the upper edge secured
10) Conditioning:	70°F and 50% RH for 24 hours

IV TEST RESULTS:

Flame Application Time: 12 Seconds				
	Sample 1	Sample 2	Sample 3	Average
After Flame Time (sec.)	2.00	0.00	0.00	0.67
Burn Length (in.)	0.19	0.13	0.18	0.17
Dripping Flaming Time (sec.)	0.00	0.00	0.00	0.00

Based upon the results shown above, the material met the passing criteria per the FAR 25.853 (12 sec.) vertical flammability specification.

Neil Schultz
Executive Director

A. Rahim

Amirudin Rahim
Technical Director

ASTM E662 TESTING
FOR
FORMLABS
ON
FR RESIN V1 3MM
VTEC #100-7571-2
TESTED: APRIL 12, 2023

VTEC Laboratories Inc.

April 12, 2023

Client: Formlabs
35 Medford Street
Somerville, MA 02143

I. SCOPE:

This report contains the reference to the test method, purpose, limitations, description of materials, operating data, and test results.

II. TEST METHOD:

The test was conducted in accordance with ASTM Designation E-662, "Standard Test Method for Specific Optical Density of Smoke Generated by Solid Material".

III. PURPOSE:

The purpose of the test is to measure the smoke generated by solid materials and assemblies in thickness up to and including one inch. The test is based on the attenuation of a light beam by smoke accumulating within a closed chamber. Both non-flaming and flaming exposures are conducted. Results are expressed in terms of specific optical density, which is derived from measuring optical density (absorbance).

IV. DISCLAIMER:

This is a factual report of the results obtained from the laboratory tests of sample products. The results may be applied only to the products tested and should not be construed as applicable to other similar products of the manufacturer. The report is not a recommendation or a disapprobation by VTEC Laboratories Inc. of the material tested. While this report may be used for obtaining product acceptance, it may not be used in advertising.

TEST DATA: LIGHT TRANSMITTANCE

TEST:	NON-FLAMING			FLAMING		
Time (min.)	Test #1	Test #2	Test#3	Test#4	Test#5	Test#6
0.0	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
0.5	99.94%	99.94%	100.00%	100.00%	102.37%	97.45%
1.0	100.00%	102.43%	97.69%	100.00%	90.22%	87.73%
1.5	100.00%	99.94%	97.74%	95.63%	59.38%	63.49%
2.0	100.00%	102.43%	97.69%	73.33%	10.01%	24.70%
2.5	95.75%	100.24%	97.69%	37.25%	1.23%	5.38%
3.0	85.42%	95.14%	93.00%	8.04%	0.26%	1.48%
3.5	63.49%	80.90%	78.58%	0.98%	0.98%	0.26%
4.0	47.63%	64.41%	61.96%	0.26%	1.23%	1.04%
4.5	29.67%	49.09%	46.84%	0.98%	1.48%	0.98%
5.0	20.87%	37.08%	33.77%	0.95%	1.24%	1.23%
5.5	13.17%	25.48%	25.70%	1.23%	0.98%	0.98%
6.0	7.70%	18.07%	17.66%	0.98%	1.48%	0.75%
6.5	6.60%	12.54%	12.86%	1.48%	1.48%	0.98%
7.0	6.32%	9.80%	10.41%	1.48%	0.98%	1.06%
7.5	3.68%	7.85%	7.86%	1.48%	0.75%	0.32%
8.0	3.19%	5.96%	6.45%	0.98%	0.75%	0.98%
8.5	2.70%	4.76%	5.50%	1.78%	0.86%	0.78%
9.0	2.21%	4.06%	4.58%	0.75%	0.75%	0.98%
9.5	2.21%	3.48%	4.57%	1.47%	0.98%	0.26%
10.0	1.55%	3.01%	3.87%	0.98%	0.75%	0.75%
10.5	2.35%	2.87%	5.01%	0.98%	0.98%	0.73%
11.0	1.62%	2.64%	3.12%	0.75%	0.50%	0.50%
11.5	1.48%	2.55%	3.12%	0.75%	0.50%	0.26%
12.0	1.59%	1.69%	2.64%	0.75%	0.34%	0.26%
12.5	1.23%	2.18%	2.64%	0.98%	0.35%	0.26%
13.0	1.96%	2.15%	2.80%	0.98%	0.71%	0.11%
13.5	1.25%	1.83%	2.15%	0.75%	0.20%	0.26%
14.0	1.28%	1.91%	2.64%	0.75%	0.25%	0.26%
14.5	0.83%	2.39%	2.52%	0.50%	0.26%	0.26%
15.0	1.23%	2.41%	1.86%	0.26%	0.86%	0.49%
15.5	0.81%	2.16%	2.15%	0.74%	0.03%	0.75%
16.0	1.48%	2.64%	2.15%	0.24%	0.72%	0.75%
16.5	0.98%	2.83%	2.41%	0.27%	0.77%	0.98%
17.0	1.48%	3.17%	2.15%	0.27%	0.98%	0.98%
17.5	1.49%	2.17%	2.15%	0.27%	0.65%	0.98%
18.0	1.07%	3.11%	2.64%	0.26%	0.82%	2.21%
18.5	1.96%	3.26%	3.31%	0.24%	0.98%	1.15%
19.0	1.39%	3.14%	2.16%	0.21%	0.69%	1.62%
19.5	1.96%	3.81%	2.99%	0.29%	1.71%	1.96%
20.0	2.21%	3.35%	3.35%	0.26%	1.48%	2.35%

DATE:	4/12/2023
PROJECT #:	100-7571-2
SUPPLIER:	Formlabs
CONDITIONING:	140°F for 24 hours.
TEST ROOM TEMP:	76 ± 5°F
RELATIVE HUMIDITY:	50 ± 10 %
CHAMBER WALL TEMP:	95 ± 4°F
SPECIMEN MOUNTING:	Standard
SPECIAL PREPARATION:	None
SPECIMEN COMPOSITION:	Homogeneous
SPECIMEN COLOR:	Grey
SPECIMEN DESCRIPTION:	FR Resin v1 3mm

	NON-FLAMING			FLAMING		
SAMPLE #:	**1**	**2**	**3**	**4**	**5**	**6**
Thickness (in):	0.1165	0.1165	0.1165	0.1165	0.1165	0.1165
Weight (g):	21.86	21.71	22.09	21.79	21.52	21.82
Tmin (%):	0.81%	1.69%	1.86%	0.21%	0.03%	0.11%
Dm (20.0 min.):	276.22	233.91	228.50	354.41	464.30	390.87
T (clear):	91.80%	79.54%	76.97%	54.45%	54.50%	58.63%
Dc (clear):	4.91	13.12	15.00	34.84	34.79	30.61
Dm (corr):	271.31	220.78	213.50	319.57	429.51	360.27
Ds (1.5 min.):	0.00	0.03	1.31	2.56	29.88	26.05
Ds (4.0 min.):	42.52	25.22	27.44	342.30	251.98	261.81
Color of smoke:	Grey	Grey	Grey	Grey	Grey	Grey

OBSERVATIONS: During the flaming mode, the samples ignited at 0m06s and burned until 8m57s.

OPTICAL DENSITY TEST RESULT SUMMARY

	NON-FLAMING	FLAMING
Ds @ 1.5 min. (average):	0.4	19.5
Ds @ 4.0 min. (average):	31.7	285.4
Dm (average):	246.2	403.2
Dm(corr) (average):	235.2	369.8

Neil Schultz
Executive Director

A. Rahim

Amirudin Rahim
Technical Director

ASTM E662 TESTING
FOR
FORMLABS
ON
FR RESIN V1 5MM
VTEC #100-7571-1
TESTED: APRIL 12, 2023

VTEC Laboratories Inc.

April 12, 2023

Client: Formlabs
35 Medford Street
Somerville, MA 02143

I. SCOPE:

This report contains the reference to the test method, purpose, limitations, description of materials, operating data, and test results.

II. TEST METHOD:

The test was conducted in accordance with ASTM Designation E-662, "Standard Test Method for Specific Optical Density of Smoke Generated by Solid Material".

III. PURPOSE:

The purpose of the test is to measure the smoke generated by solid materials and assemblies in thickness up to and including one inch. The test is based on the attenuation of a light beam by smoke accumulating within a closed chamber. Both non-flaming and flaming exposures are conducted. Results are expressed in terms of specific optical density, which is derived from measuring optical density (absorbance).

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TEST DATA: LIGHT TRANSMITTANCE

TEST:	NON-FLAMING			FLAMING		
Time (min.)	Test #1	Test #2	Test#3	Test#4	Test#5	Test#6
0.0	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
0.5	100.00%	97.73%	99.28%	97.79%	97.69%	100.00%
1.0	100.00%	97.73%	97.73%	95.36%	97.69%	98.84%
1.5	100.00%	97.68%	97.68%	88.73%	95.07%	91.14%
2.0	100.00%	97.68%	97.68%	72.65%	77.81%	78.98%
2.5	100.00%	97.68%	95.57%	51.09%	60.19%	62.88%
3.0	98.17%	97.68%	95.57%	36.53%	36.75%	41.75%
3.5	97.68%	95.57%	93.30%	23.51%	21.10%	26.86%
4.0	95.57%	93.30%	93.25%	13.43%	12.26%	15.78%
4.5	88.99%	86.72%	86.72%	9.99%	7.03%	7.90%
5.0	78.03%	75.54%	75.48%	6.20%	4.00%	5.00%
5.5	64.53%	62.26%	60.54%	3.20%	3.27%	2.80%
6.0	47.70%	49.06%	47.92%	2.29%	1.27%	0.94%
6.5	37.04%	37.48%	38.14%	1.04%	1.01%	0.24%
7.0	26.07%	27.52%	29.95%	0.70%	0.55%	0.51%
7.5	18.42%	19.17%	23.77%	0.24%	0.71%	0.24%
8.0	13.55%	13.76%	18.42%	0.67%	0.26%	0.19%
8.5	10.45%	11.10%	14.39%	0.24%	0.27%	0.16%
9.0	7.26%	8.67%	11.54%	0.92%	0.77%	0.24%
9.5	6.45%	7.33%	9.77%	1.10%	0.26%	0.47%
10.0	5.78%	6.85%	7.82%	0.96%	0.26%	0.72%
10.5	5.12%	5.79%	6.67%	1.38%	0.46%	0.94%
11.0	4.72%	6.45%	6.12%	1.38%	0.26%	0.94%
11.5	4.79%	5.33%	4.45%	1.38%	0.51%	0.94%
12.0	4.23%	4.83%	4.23%	1.25%	0.77%	0.94%
12.5	4.23%	5.12%	4.00%	1.38%	0.33%	0.93%
13.0	4.57%	5.03%	3.55%	1.38%	0.91%	0.93%
13.5	4.23%	4.23%	3.60%	1.38%	0.74%	0.94%
14.0	4.32%	4.23%	3.12%	0.92%	0.77%	0.71%
14.5	3.62%	4.01%	2.91%	1.37%	0.51%	0.71%
15.0	3.79%	3.53%	3.00%	1.15%	0.73%	0.90%
15.5	4.01%	3.55%	2.71%	1.15%	0.50%	1.13%
16.0	3.79%	3.13%	2.00%	0.91%	0.75%	0.47%
16.5	4.23%	2.91%	2.47%	1.00%	0.26%	0.71%
17.0	3.97%	2.46%	2.65%	1.15%	0.26%	0.71%
17.5	3.88%	2.46%	2.91%	1.15%	0.77%	0.38%
18.0	3.77%	3.55%	3.13%	1.19%	0.16%	0.24%
18.5	4.01%	2.99%	3.55%	1.13%	0.26%	0.31%
19.0	4.01%	2.09%	2.87%	1.16%	0.96%	0.40%
19.5	3.55%	2.46%	3.35%	1.38%	0.77%	0.21%
20.0	3.60%	2.23%	3.12%	0.92%	0.26%	0.50%

VTEC #100-7571-1 **FORMLABS** **ASTM E662**

DATE:	4/12/2023
PROJECT #:	100-7571-1
SUPPLIER:	Formlabs
CONDITIONING:	140°F for 24 hours.
TEST ROOM TEMP:	76 ± 5°F
RELATIVE HUMIDITY:	50 ± 10 %
CHAMBER WALL TEMP:	95 ± 4°F
SPECIMEN MOUNTING:	Standard
SPECIAL PREPARATION:	None
SPECIMEN COMPOSITION:	Homogeneous
SPECIMEN COLOR:	Grey
SPECIMEN DESCRIPTION:	FR Resin v1 5mm

	NON-FLAMING			FLAMING		
SAMPLE #:	**1**	**2**	**3**	**4**	**5**	**6**
Thickness (in):	0.1970	0.1970	0.1970	0.1950	0.1965	0.1965
Weight (g):	36.43	36.44	36.30	36.34	36.19	36.71
Tmin (%):	3.55%	2.09%	2.00%	0.24%	0.16%	0.16%
Dm (20.0 min.):	191.32	221.69	224.33	346.33	368.31	370.38
T (clear):	88.77%	93.25%	88.77%	74.97%	84.48%	78.92%
Dc (clear):	6.83	4.01	6.83	16.51	9.67	13.57
Dm (corr):	184.49	217.68	217.50	329.82	358.64	356.81
Ds (1.5 min.):	0.00	1.35	1.35	6.85	2.90	5.32
Ds (4.0 min.):	2.60	3.97	4.01	115.11	120.33	105.85
Color of smoke:	Grey	Grey	Grey	Grey	Grey	Grey

OBSERVATIONS: During the flaming mode, the samples ignited at 0m33s and burned until 11m44s.

OPTICAL DENSITY TEST RESULT SUMMARY

	NON-FLAMING	FLAMING
Ds @ 1.5 min. (average):	0.9	5.0
Ds @ 4.0 min. (average):	3.5	113.8
Dm (average):	212.4	361.7
Dm(corr) (average):	206.6	348.4

Neil Schultz
Executive Director

A. Rahim
Amirudin Rahim
Technical Director

BSS 7239
TOXIC GAS TESTING
FOR
FORMLABS
ON
FR RESIN V1 3MM
VTEC #100-7571-3
TESTED: APRIL 12, 2023

VTEC Laboratories Inc.

April 12, 2023

Client: Formlabs
35 Medford Street
Somerville, MA 02143

Subject:

Measure amount of toxic gas generation per BSS 7239 specification.

Test Description:

The gas analysis was made after 4 minutes of exposure to 2.5 w/cm² in the flaming mode. Toxic gas was analyzed in accordance to BSS 7239 specification.

Disclaimer:

This test result alone does not assess the fire hazard of the material, or a product made from this material, under actual fire conditions. Consequently, the results of this test alone are not to be quoted in support of claims with respect to the fire hazard of the material or product under actual fire conditions. The results when used alone are only to be used for research and development, quality control and material specifications.

212 Manida Street, Bronx, New York 10474 · Tel 718-542-8248 · Fax 718-542-8759

VTEC #100-7571-3 **FORMLABS** **BSS 7239**

Material Tested:

DATE: 4/12/2023
VTEC #: 100-7571-3
PRODUCT DESCRIPTION: FR Resin v1 3mm

SUPPLIER: Formlabs
COLOR: Grey
SPECIMEN COMPOSITION: Homogeneous

AVERAGE THICKNESS: 0.1165 in.

Results:

	SPECIMEN #1	SPECIMEN #2		
Weight (g)	21.5	21.8		
	CORRECTED	CORRECTED	AVERAGE	STD. DEVIATION
GAS	PPM	PPM	PPM	PPM
CO	50	63	56	9
HCN	6	8	7	2
SO_2	<1	<1	<1	<1
HCl	<1	<1	<1	<1
HF	<1	<1	<1	<1
$(NO+NO_2)$ NO_X	<1	<1	<1	<1

Neil Schultz
Executive Director

Amirudin Rahim
Technical Director

PACIFIC TESTING LABORATORIES, INC.
24950 Avenue Tibbitts, Valencia, CA 91355-3426, USA • TEL (661) 257-1437 • FAX (661) 257-2411

TEST REPORT

In Account With **Formlabs Inc.** **35 Medford St. Suite 201** **Somerville, MA 02143**	**Date** **March 31, 2023**	**Page 1 of 2 Pages**
	W.O. Number **76078**	**Test Report Number** **TR76078**
		Received **03/13/2023**

IDENTIFICATION: One (1) 3D printed plastic sample material was submitted for Outgas Testing in accordance with ASTM E595. The test sample was identified as follows:

1) FR Resin

SPECIFICATION : ASTM E595.

TESTING : Outgas Testing.

SUMMARY : The test results, reported herein, are submitted for customer evaluation.

Respectfully submitted,
PACIFIC TESTING LABORATORIES, INC.

Hans Shin
Laboratory Director

OUTGAS TESTING

REFERENCE:

ASTM E595.

REQUIREMENT:

ASTM E595, paragraph 1.5: The criteria used for the acceptance and rejection of materials shall be determined by the user and based upon specific component and system requirements. Historically, a total mass loss (TML) of 1.00% and collected volatile condensable material (CVCM) of 0.10% have been used as screening levels for rejection of spacecraft materials.

TEST METHOD:

The Outgas Test was performed in a vacuum environment of less than 5 X 10^{-5} torr according to ASTM E595, for a duration of 24 hours, at 125°C on three specimens per sample (unless otherwise noted). The TML, CVCM, and the amount of Water Vapor Recovered (WVR) were measured after the test and the average values reported.

RESULTS:

The following tables list the results of the testing:

Table 1. Average Outgas test results.

Sample	TML (%)	CVCM (%)	WVR (%)
FR Resin	0.87	<0.01	0.20

Table 2. Testing observation results (for information/reference only).

Sample	Visible Condensate (CVCM)	Percent Covered (CVCM)	Thin / Heavy (CVCM)	Opaque / Transparent (CVCM)	Interference Fringes (CVCM)	Colored Fringes (CVCM)	Appearance After Test (Sample)
FR Resin	No	0%	N/A	N/A	N/A	N/A	No change

REMARKS:

The test results, reported herein, are submitted for customer evaluation.