THE GUND COMPANY

Manufacturers & fabricators of engineered material solutions

Item:	NEMA Grade FR4 Glass Epoxy Laminate			
Description:	NEMA Grade FR4 materials are glass fabric reinforced laminates, bonded with flame resistant epoxy resin. The material has the ability to maintain excellent mechanical, electrical and physical properties at elevated temperature to 130 °C. FR4 from The Gund Company is UL, RoHS, and REACH certified to ensure reliability, safety, and consistency (UL File No. E339275)			
Standards:	NEMA LI-1: Grade FR4	MIL-I-24768/27 GEE-F	IEC 60893: EP GC 202 (sheet)	
Availability:			English Units (in)	SI Units (mm)
	Laminate Sheets:	Thickness:	0.010 to 5.0	0.125 to 127
		Standard Sheet Size	48 x 120	122 x 305
	Convolute Tubing:	FR4 convolute tubes are available from The Gund Company in nearly any custom size of inside and outside diameter, per customer requirements		
	Fabricated Parts:	The Gund Company custom fabricates insulation material to the exact specifications and drawings of our customers.		

Key Characteristics	Units - English (SI)	Typical Values
Standard Color	--	Green[1]
Specific Gravity	lb/in^3 (g/cc)	0.067 (1.85)

[1] Custom colors are available upon request

NEMA LI-1 FR4 Required Properties

Key Characteristics		Test Method	Units	NEMA Required	Typical Values
Breakdown Voltage (0.062")	Condition A Condition D-48/50	ASTM D-149	kV	45 min 40 min	66 65
Permittivity @ 1 MHz (0.062")	Condition A Condition D-48/50	ASTM D-150	--	5.2 max 5.4 max	4.4 4.5
Dissipation Factor @ 1 MHz (0.062")	Condition A Condition D-48/50	ASTM D-150	--	0.025 max 0.035 max	0.014 0.015
IZOD Strength (0.062")	Length-Wise Cross-Wise	ASTM D-229	ft-lb/in Notched	7.0 min 5.5 min	13 12
Flexural Strength (0.062")	Length-Wise Cross-Wise	ASTM D-790	ksi (MPa)	60.0 (414) min 50.0 (345) min	80 (552) 70 (483)
Bonding Strength (0.500")	Length-Wise Cross-Wise	ASTM D-229	Lb (kg)	2000 (907) min 1600 (725) min	2,500 (1,133) 1,900 (862)
Moisture Absorption (0.125")		ASTM D-570	%	0.15 max	0.10
Flammability Rating		UL94	Class	V-I	V-0

THE GUND COMPANY

Manufacturers & fabricators of engineered material solutions

Material Data Sheet

NEMA Grade FR4

IEC 60893-3-2 EPGC 202 Required Properties

Key Characteristics	Test Method	Units	IEC Requirement	Typical Values
Flexural Strength	ISO 179	MPa	340 min	560
Charpy Impact Strength	ISO 179	kJ/m^2	33 min	49
Perpendicular Electric Strength (90 oC in Oil, 1.5mm)	IEC 60243-1	kV/mm	13 min	25
Parallel Breakdown Voltage (Stepped, 90 oC in Oil, 3mm)	IEC 60243-1	kV	35 min	>45
Insulation Resistance (After Water Immersion)	--	MΩ	$5(10)^4$	$>10^7$
Flammability Rating	UL94	Class	V-0	V-0
Moisture Absorption (1.5mm)	--	mg	19 max	13

Additional Engineering Properties

Key Characteristics	Test Method	Units - English (SI)	Typical Values
Tensile Strength (0.125") Length-Wise	ASTM D-638	ksi (MPa)	62 (430)
Compressive Strength, Flat-Wise (0.500")	ASTM D-695	ksi (MPa)	66 (455)
Flexural Modulus (0.062") Length-Wise Cross-Wise	--	ksi (GPa)	2,900 (20) 2,600 (18)
Shear Strength (punch type, 0.062")	ASTM D-732	psi (MPa)	21,500 (148)
Coefficient of Thermal Expansion	ASTM E-228	"/"°C$x10^{-6}$	15
Temperature Index	ASTM D-2304	°C	130
Glow Wire Flame Index & Ignition Temperature	IEC 60695-2-12	°C	960
Hot Wire Ignition	UL 746A	Sec	120
High Current Arc Ignition (3mm)	UL 746A	Arcs	120
Arc Resistance (0.125")	ASTM D-495	Sec	140
Comparative Tracking Index (0.125")	ASTM D-3638*	V	230
Dielectric Strength (Condition A)	ASTM D-149	V/mil	635
Volume Resistivity (0.062")	ASTM D-257	Ω - cm	$3(10)^{15}$
High Voltage Arc Resistance	UL 746A	Sec	300
High Voltage Arc Tracking Rate	UL 746A	mm/min	0

*ASTM D-3638 & IEC 112 are the same test method - IEC 60112 is slightly different, but the results are similar.