



# Thermoset Industrial Laminate Properties

Minimum Values

Properties	NEMA grades reinforcements resin binders	G10, FR4 glass cloth epoxy	G11, FR5 glass cloth epoxy HT	G5, G9 glass cloth melamine	G7 glass cloth silicone	GPO1 glass mat polyester	GPO3 glass mat polyester	X Paper phenolic	XX Paper phenolic	XXX Paper phenolic	C, CE Canvas phenolic	L, LE Canvas phenolic
<b>Tensile Strength</b>												
	lengthwise, PSI	40,000	40,000	37,000	23,000	12,000	11,000	20,000	16,000	15,000	9,500	12,500
	crosswise, PSI	35,000	35,000	30,000	18,000	-	-	16,000	13,000	12,000	7,500	8,750
<b>Compressive Strength</b>												
	Flatwise, PSI	60,000	60,000	70,000	45,000	40,000	30,000	36,000	34,000	32,000	37,000	37,000
	Edgewise, PSI	35,000	35,000	25,000	14,000	-	-	19,000	23,000	25,500	23,500	25,000
<b>Flexural Strength</b>												
	lengthwise, PSI	55,000	55,000	55,000	23,000	23,000	20,000	25,000	15,000	13,500	17,000	15,000
	crosswise, PSI	45,000	45,000	35,000	20,000	-	-	22,000	14,000	11,800	15,000	13,750
<b>Modulus of Elasticity in flex <math>\times 10^{-3}</math></b>												
	lengthwise, PSI	2,700	2,700	2,500	1,400	-	-	1,800	1,400	1,300	950	1,050
	crosswise, PSI	2,200	2,200	200	1,200	-	-	1,300	1,100	1,000	850	850
<b>Shear strength, PSI</b>												
		19,000	19,000	20,000	17,000	-	-	12,000	11,000	10,000	11,500	11,750
<b>IZOD Impact</b>												
	Flatwise, ft-lb/in of notch	7	7	12	8.5	-	-	4	1.3	1	3.2, 2.3	2.5, 1.8
	edgewise, ft-lb/in of notch	5.5	5.5	8	7.5	-	-	0.5	0.35	0.35	1.9, 1.4	1.1, 1
<b>Rockwell Hardness M scale</b>												
		110	110	120	100	-	-	110	105	110	104	105
<b>Specific Gravity</b>												
		1.82	1.82	1.9	1.68	1.8	1.85	1.36	1.34	1.32	1.35	1.34
<b>Coefficient of Thermal Expansion <math>\text{cm/cm-}^{\circ}\text{C} \times 10^{-5}</math></b>												
		0.9	0.9	1	1	-	-	6	2	1.4	2	2
<b>Water Absorption</b>												
	.062" thick, % per 23 hrs	0.25	0.25	0.80	0.30	0.35	0.40	6.00	2.00	1.40	4.4, 2.2	2.5, 1.95
	.125" thick, % per 23 hrs	0.15	0.15	0.70	0.20	-	-	3.30	1.30	0.95	2.5, 1.6	1.6, 1.3
	.500" thick, % per 23 hrs	0.10	0.10	0.40	0.15	-	-	1.10	0.55	0.45	1.2, 0.75	0.9, 0.7
<b>Dielectric Strength, volt/mil</b>												
Perpendicular to laminations; Short												
	.062" thick	500	500	400	400	370	400	700	700	650	200,500	200,500
	.125" thick	400	400	350	350	-	-	500	500	470	150,360	150,360
<b>Dissipation Factor</b>												
	Condition A, 1 megacycle	0.025	0.025	0.017	0.003	-	-	0.060	0.045	0.038	0.1, 0.055	.01, 0.55
<b>dielectric Constant</b>												
	Condition A, 1 megacycle	5.20	5.20	7.12	4.20	-	-	6.00	5.50	5.30	-5.80	-5.80
<b>Insulation Resostance</b>												
Condition: 96 hours at 90% relative humidity (in megaohms)												
		200,000	200,000	10,000	200,000	-	-	-	-	-	-	-
<b>Flame Resistance</b>												
	Underwriter Labs, Classification	94V-0	94V-0	94V-0	94V-0	94HB	94V-0	94HB	94HB	94HB	94HB	94HB
		2,000	1,600	1,700	650	-	-	700	800	950	1,800	1,600
<b>Bond Strength, in lbs</b>												
		2,000	1,600	1,700	650	-	-	700	800	950	1,800	1,600
<b>Max Operating Temperature</b>												
	Approximate $^{\circ}\text{F}$	285	300	285	465	265	265	285	285	285	265	265
<b>sheet mil spec: Mil-I-24768 / <math>\underline{\hspace{1cm}}</math></b>												
	Type	2,GEE	3,GEE	8,GMG	17	4	6	12	11	10	16,FBM	15,FBI
		27,GEE-F	28,GEB-F	1,GME	GSG	GPO1	GPO3	PBM	PBG	PBE	14,FBG	13,FBE

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