2.1 BMS 8-276

2.1.1 BMS 8-276, Type 35, Class 1 and 3, Grade 145 or 190, Form 1

This specification applies to 350°F cure toughened-epoxy resin preimpregnated carbon fiber unidirectional tape.

Type 35:	35 percent by weight resin content.
Class 1:	Unidirectional tape for manual layup.
Class 3:	Unidirectional tape for use with automated tape laying equipment or manual layup.
Form 1:	BMS 9-17 Type I high strength, intermediate modulus carbon fiber (average modulus range 38 to 43 Msi)

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Table 2.1.1-1 Ply Properties - Grade 190

TABLE 2.1.1-1		PLY PROPERTIES						
PREPREG MATERIAL SPECIFICATION: BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 190, FORM 1								
RESIN CONTENT: 35 (% WT)								
CURED PLY THICKNESS: .0074 (in)								
DENSITY: 0.056 lb/in^3								
PROCESS SPECIFICATION: BAC 5578								
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		160° F	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	20.6					
	E_2	msi	1.35	1.35	1.13	1.13	0.99	0.99
	G_{12}	msi	0.72	0.64	0.58	0.49	0.45	0.40
	G_{13}	msi	0.72	0.64	0.58	0.49	0.45	0.40
	G_{23}	msi	0.72	0.64	0.58	0.49	0.45	0.40
POISSON'S RATIO	ν_{12}	----	0.34					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F	0.02×10^{-6}				0.02×10^{-6}	
	α_2	in/in ° F	16×10^{-6}				20×10^{-6}	
COEFFECIENTS OF LINEAR MOISTURE EXPANSION ④	β_1	in/in %M	0.0					
	β_2	in/in %M	2400×10^{-6}					
THERMAL CONDUCTIVITY	κ_1	BTU/(hr ft °F)	1.9		2.1		2.2	
	κ_2	BTU/(hr ft °F)	0.31		0.33		0.35	
	κ_3	BTU/(hr ft °F)	0.28		0.31		0.33	

① E_1 is the average of tension and compression moduli. For special analyses use tension/compression modulus adjustment factors to determine tension or compression E_1.

② Modulus values are secant values at a strain level of 4000 μ in/in. For special analyses use modulus versus strain curves to determine secant values at the desired strain level.

③ CLTE values are for expansion between -75° F and 70° F, and 70° F and 180° F.

④ %M = Percent absorbed moisture by weight.

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Guidelines for Usage of Moduli and Strength Design Values

Ply Properties - Tables 2.1.1-1 and 2.1.1-2.

The room temperature (70°F) / dry condition values shown in these tables are refered to as nominal moduli values. These values are to be used for almost all laminate analyses, including the calculation of strain design values from test data. The exceptions are:

1. buckling analyses, where compression moduli values (see Figure 2.1.1-10) at the appropriate environment are used,

2. test correlation analyses where it is desired to predict actual strain gage response.

The values for the other environments are used for the two cases listed above.

Interlaminar Toughness Values - Tables 2.1.1-3 adn 2.1.1-4.

These values are used in edge delamination analyses with the computer code FCMP (see Sections 5.0 and 4.0).

Modulus versus Strain - Figures 2.1.1-1 through 2.1.1-3.

These curves are provided for use in test data (strain gage) correlation analyses and for specialized non-linear finite element applications. They should not be used for any other purpose, including ultimate strength analysis or calculation of strain design values.

Modulus Plots - Figures 2.1.1-4 through 2.1.1-10.

These curves were calculated using laminated plate theory from the values given in Table 2.1.1-1 and from the tension and compression E1 values shown on Figure 2.1.1-10. They are included for convenience. The use of a computer code (see sections 5.0 and 40.0) is recommended in order to get accurate moduli values.

Unnotched Tension, Compression and Shear Strains - Figures 2.1.1-11 through 2.1.1-18

These strain values are based on unnotched, undamaged coupon test results. These values are used with some of the notched strength analysis methods presented in Section 12.0 and with some of the damage tolerance analysis methods presented in Section 26.0. The values may also be used for test correlation analyses. The margin of safety analysis procedure in Section 5.6 should be used with the unnotched strain values.

For notched laminate strain values for use with bolted joint analyses, refer to Section 11.4.1. The notched strain values may be used with the margin of safety analysis procedures of section 5.6 for laminate checks away from bolted joint areas. For laminate

which account for impact damage, refer to the component design sections, Section 30.1 and 30.2.

Table 2.1.1-2 Ply Properties - Grade 145

TABLE 2.1.1-2		PLY PROPERTIES						
PREPREG MATERIAL SPECIFICATION: BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145, FORM 1								
RESIN CONTENT: 35 (% WT)								
CURED PLY THICKNESS: 0.0056 (In)								
DENSITY: 0.056 (lb/in^3)								
PROCESS SPECIFICATION: BAC 5578								
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		160° F	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	20.6					
	E_2	msi	1.35	1.35	1.13	1.13	0.99	0.99
	G_{12}	msi	0.72	0.64	0.58	0.49	0.45	0.40
	G_{13}	msi	0.72	0.64	0.58	0.49	0.45	0.40
	G_{23}	msi	0.72	0.64	0.58	0.49	0.45	0.40
POISSON'S RATIO	ν_{12}	----	0.34					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F	.02 x 10^{-6}				.02 x 10^{-6}	
	α_2	in/in ° F	16 x 10^{-6}				20 x 10^{-6}	
COEFFECIENTS OF LINEAR MOISTURE EXPANSION ④	β_1	in/in %M	0.0					
	β_2	in/in %M	2400 x 10^{-6}					
THERMAL CONDUCTIVITY	κ_1	BTU/(hr ft °F)	1.9		2.1		2.2	
	κ_2	BTU/(hr ft °F)	0.31		0.33		0.35	
	κ_3	BTU/(hr ft °F)	0.28		0.31		0.33	

① E_1 is the average of tension and compression moduli. For special analyses use tension/compression modulus adjustment factors to determine tension or compression E_1.

② Modulus values are secant values at a strain level of 4000 μ in/in. For special analyses use modulus versus strain curves to determine secant values at the desired strain level.

③ CLTE values are for expansion between -75° F and 70° F, and 70° F and 180° F.

④ %M = Percent absorbed moisture by weight.

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Table 2.1.1-3 Interlaminar Toughness Values - Grade 190

TABLE: 2.1.1-3	PLY PROPERTIES - INTERLAMINAR TOUGHNESS VALUES
Prepreg Material Specicification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 190, FORM 1
Resin Content:	35 (% WT)
Cured Ply Thickness:	0.0074 (In)
Density:	0.056 lb/in^3
Process Specification:	BAC 5578

MODE	INTERFACE	UNIT	ENVIRONMENTAL CONDITION					
			-75°F		70°F		180°F ①	
			DRY	WET	DRY	WET	DRY	WET
I ($G_{I,C}$)	.... 0°/0°	$\frac{\text{in-lb}}{\text{in}^2}$	1.3	1.1	1.5	1.5	1.8	2.1
II ($G_{II,C}$)	.... 0°/0°	$\frac{\text{in-lb}}{\text{in}^2}$	16.1	18.0	16.0	16.0	13.3	9.4
III ($G_{III,C}$)	.... 0°/0°	$\frac{\text{in-lb}}{\text{in}^2}$	16.1	18.0	16.0	16.0	13.3	9.4

① 180°F values are to be used for 160°F environment.

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Table 2.1.1-4 Interlaminar Toughness Values - Grade 145

TABLE: 2.1.1-4	PLY PROPERTIES - INTERLAMINAR TOUGHNESS VALUES
Prepreg Material Specicification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145, FORM 1
Resin Content:	35 (% WT)
Cured Ply Thickness:	0.0056 (In)
Density:	0.056 lb/in^3
Process Specification:	BAC 5578

MODE	INTERFACE	UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		180° F	
			DRY	WET	DRY	WET	DRY	WET
I ($G_{I,C}$)	.... 0°/0°	$\frac{\text{in-lb}}{\text{in}^2}$	1.3	1.4	1.6	1.6	1.9	2.1
II ($G_{II,C}$)	.... 0°/0°	$\frac{\text{in-lb}}{\text{in}^2}$	13.1	13.1	12.6	12.6	10.2	7.9
III ($G_{III,C}$)	.... 0°/0°	$\frac{\text{in-lb}}{\text{in}^2}$	13.1	13.1	12.6	12..6	10.2	7.9

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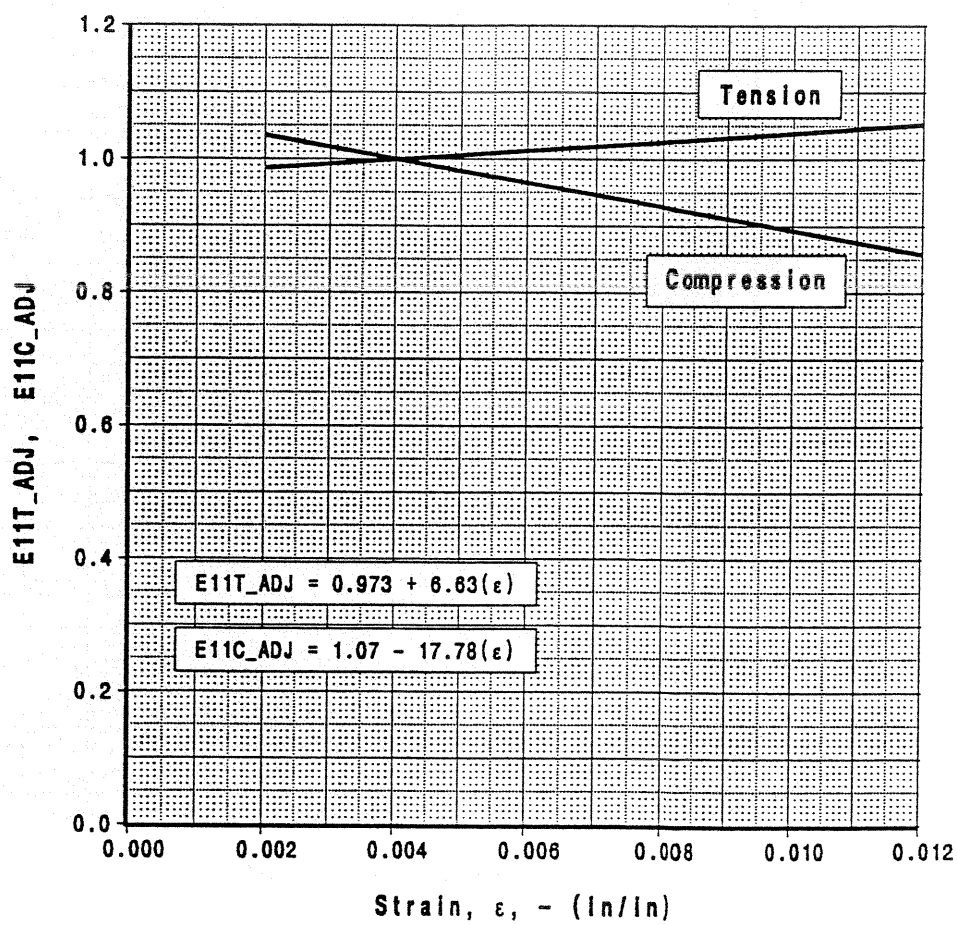
Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



E_{1_T} = E11T_ADJ X $E_{1T(4000\mu in/in)}$

E_{1_C} = E11C_ADJ X $E_{1C(4000\mu in/in)}$

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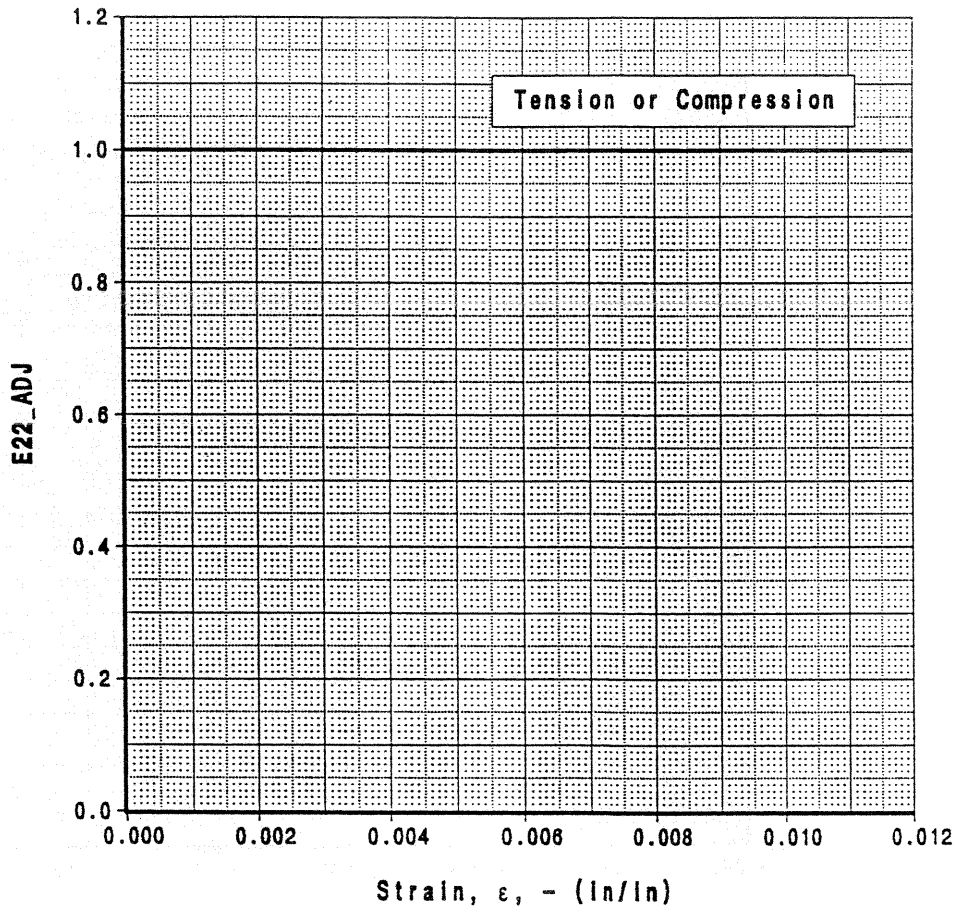
Figure 2.1.1-1 E_1 Modulus Adjustment Factor Versus Strain

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



$E_2 = E22\_ADJ \times E_{2(4000\mu in/in)}$

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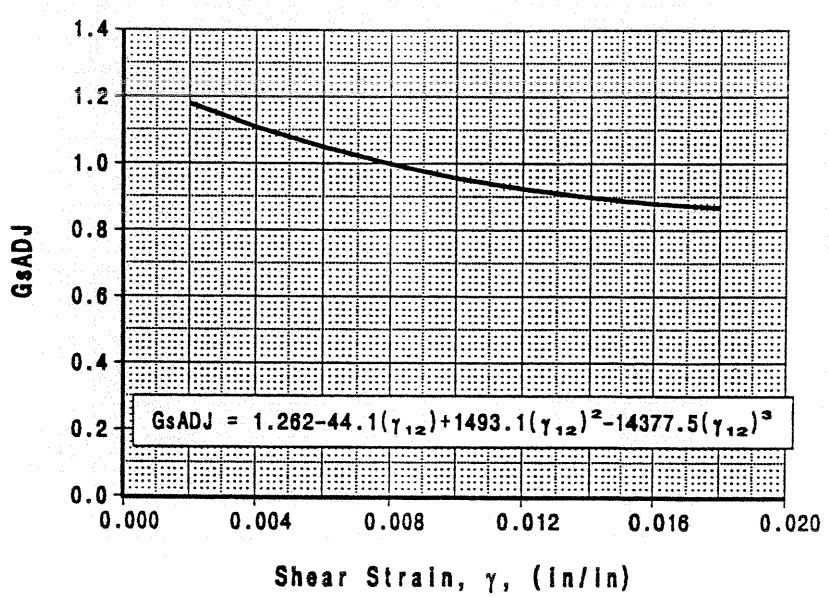
Figure 2.1.1-2 E_2 Modulus Adjustment Factor Versus Strain

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



$$G_{12} = GsADJ \times G_{12(6000\mu in/in)}$$

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Figure 2.1.1-3 G_{12} Modulus Adjustment Factor Versus Strain

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145 or 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70° F/DRY ENVIRONMENT, (0/ ±45/90) LAMINATES	

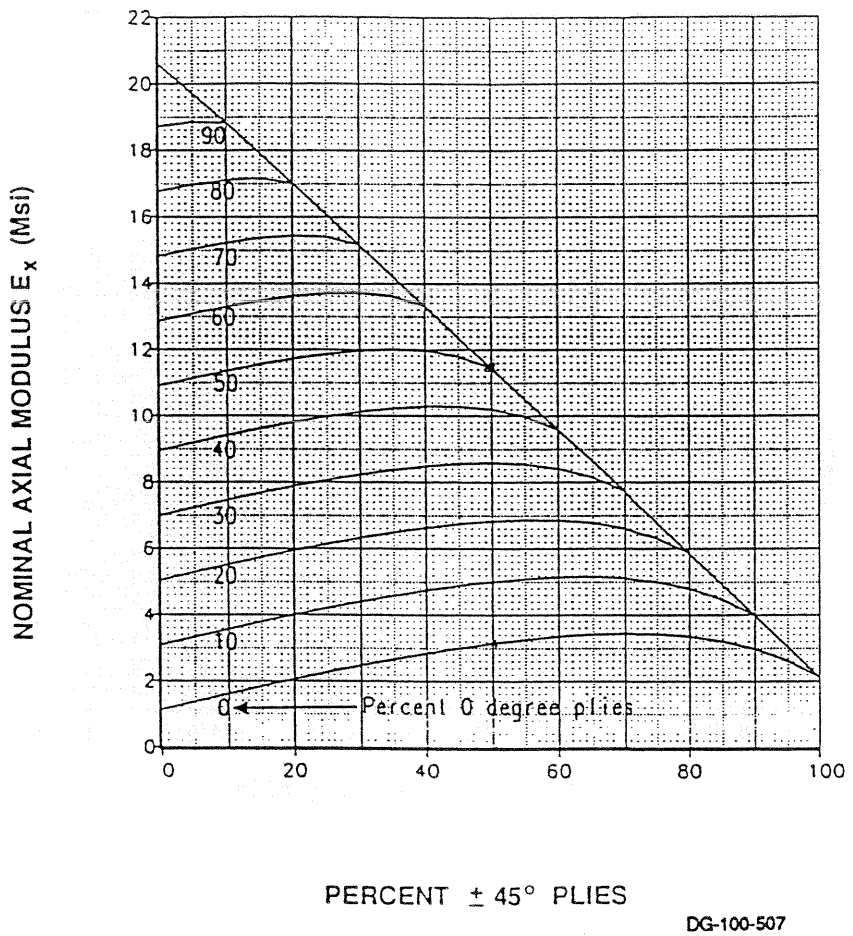


Figure 2.1.1-4 Nominal E_x Modulus

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145 or 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70° F/DRY ENVIRONMENT, (0/ ±45/90) LAMINATES	

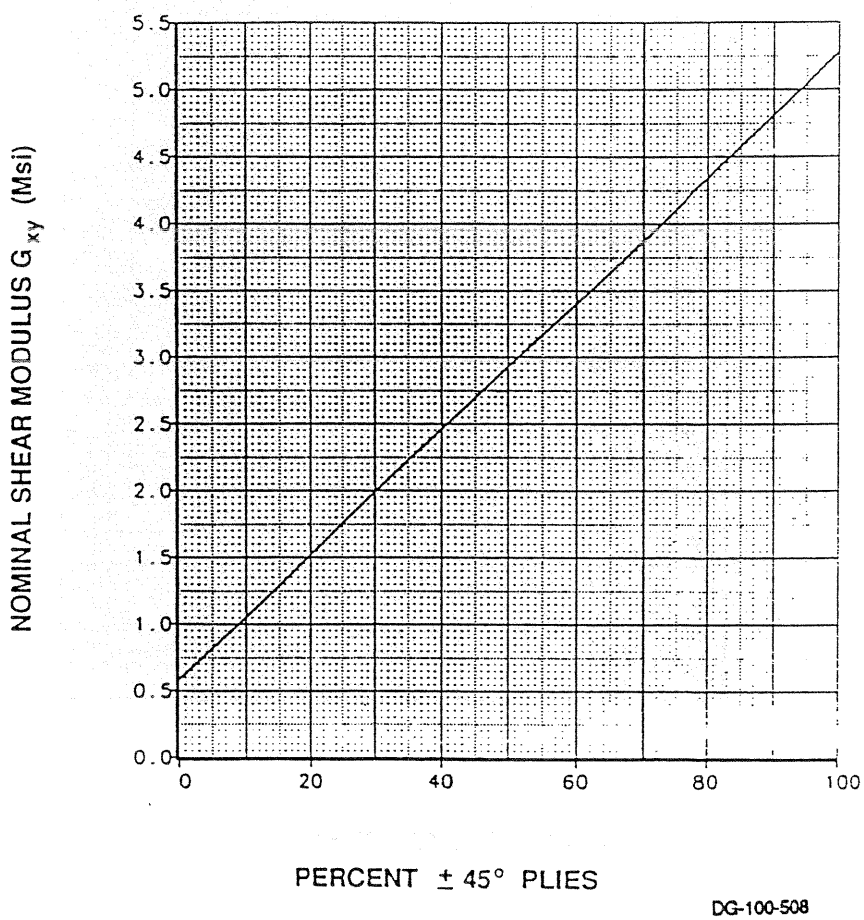


Figure 2.1.1-5 Nominal G_{xy} Modulus

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145 or 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70° F/DRY ENVIRONMENT, (0/ ±45/90) LAMINATES	

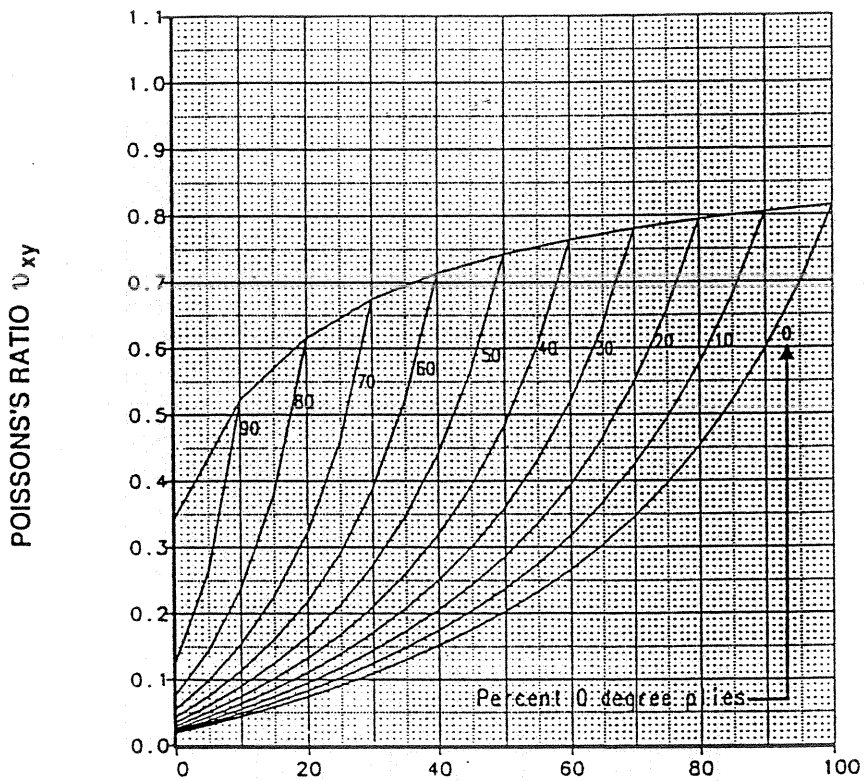


Figure 2.1.1-6 Nominal ν_{xy} Poisson's Ratio

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145 or 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70° F/DRY ENVIRONMENT, (0/ ±45/90) LAMINATES	

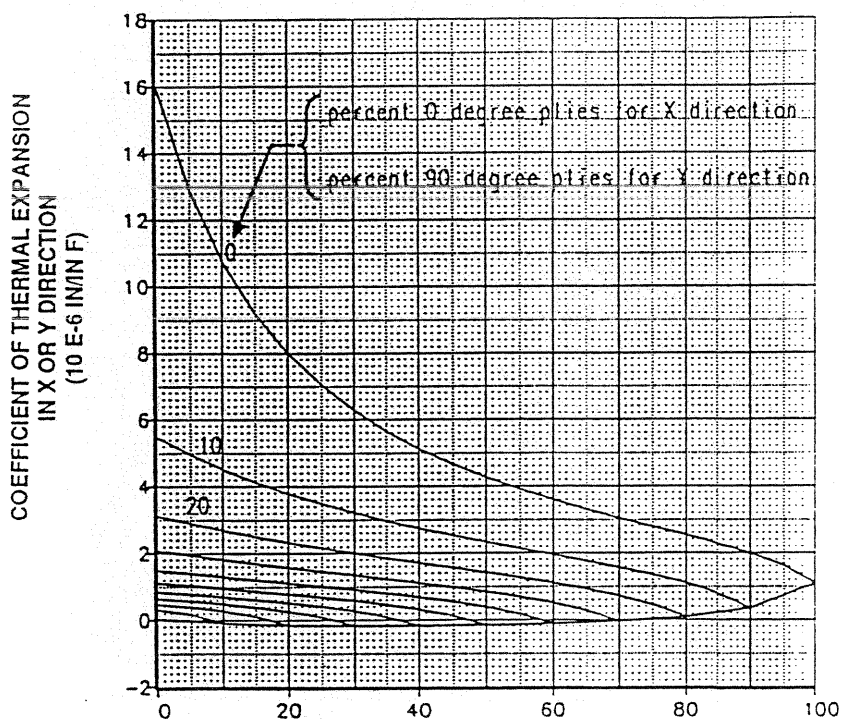
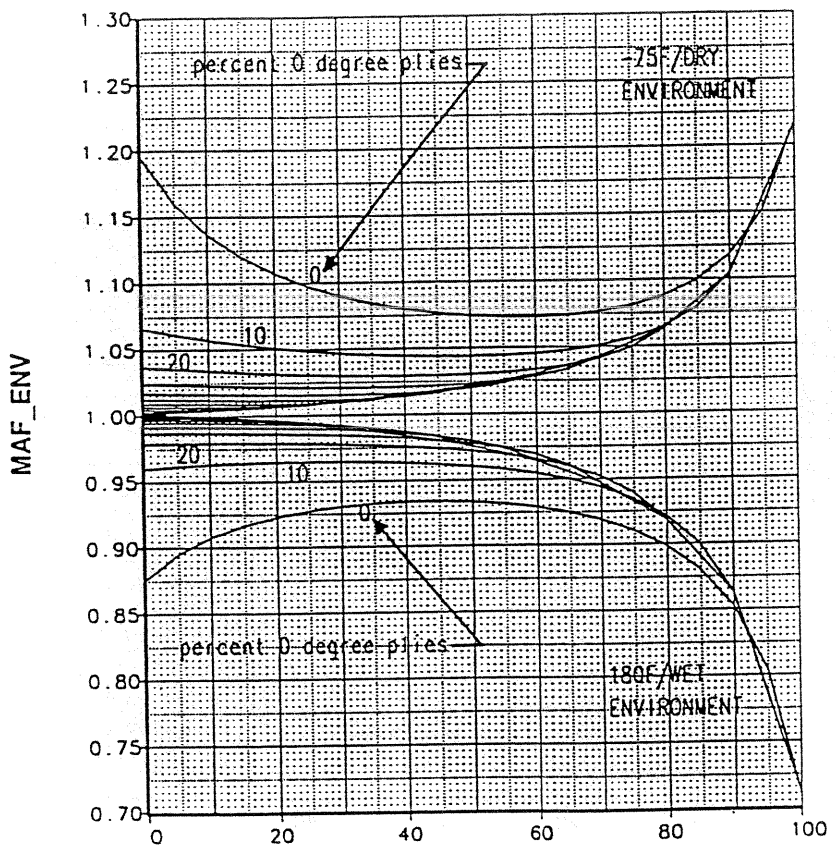


Figure 2.1.1-7 Nominal α_x Coefficient of Thermal Expansion

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145 or 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
(0/ ±45/90) LAMINATES	



$$E_{x\ ENVIRONMENT} = E_{x\ NOMINAL} \times MAF\_ENV$$

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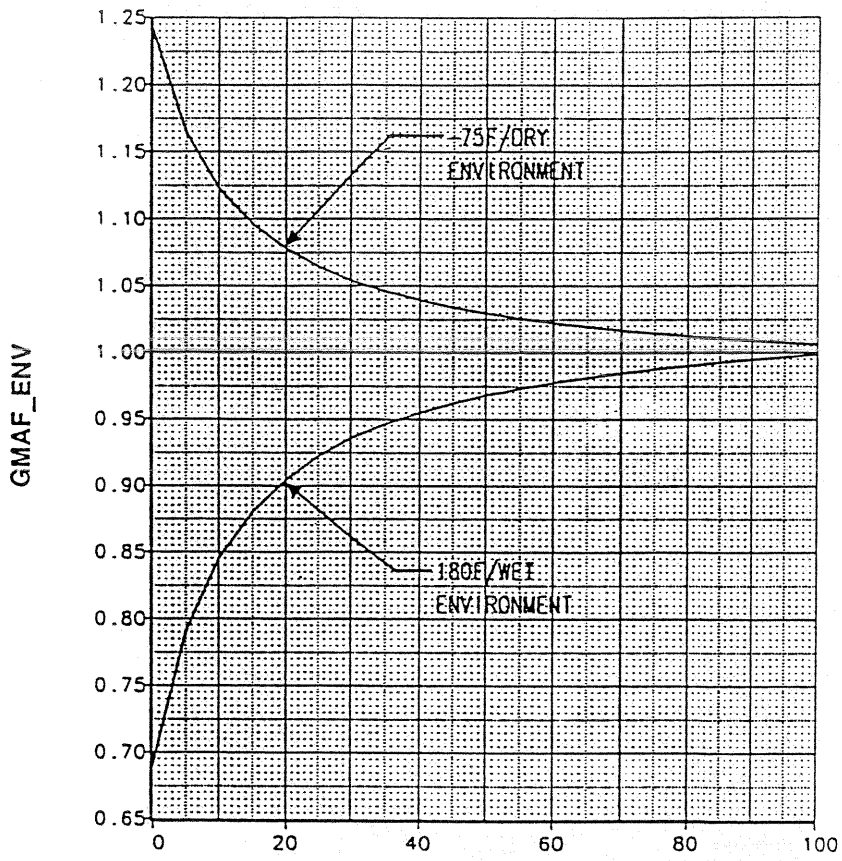
Figure 2.1.1-8 E_x Environmental Adjustment Factor

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145 or 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
(0/ ±45/90) LAMINATES	



$G_{xy\ ENVIRONMENT} = G_{xy\ NOMINAL} \times GMAF\_ENV$

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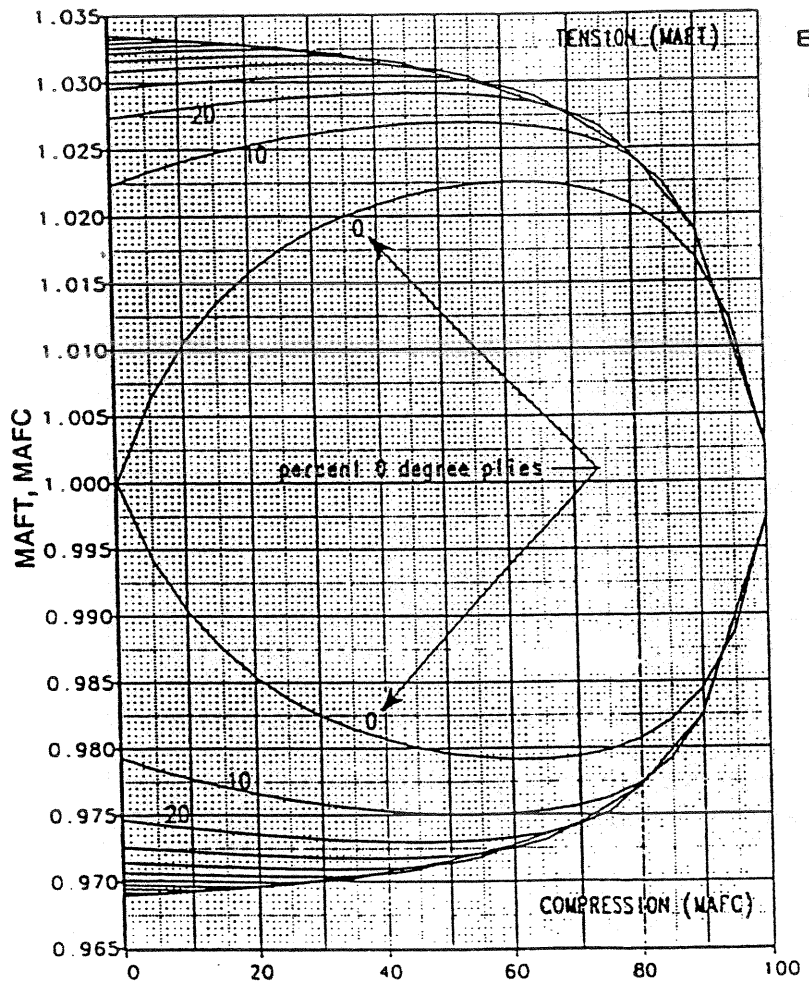
Figure 2.1.1-9 G_{xy} Environmental Adjustment Factor

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 or 3, GRADE 145 or 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70° F/DRY ENVIRONMENT, (0/ ±45/90) LAMINATES	



E_{1C} = 19.9 Msi

E_{1T} = 21.3 Msi

$E_{x\ TENSION} = E_{x\ NOMINAL} \times MAFT$

$E_{x\ COMPRESSION} = E_{x\ NOMINAL} \times MAFC$

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Figure 2.1.1-10 E_x Tension/Compression Adjustment Factors

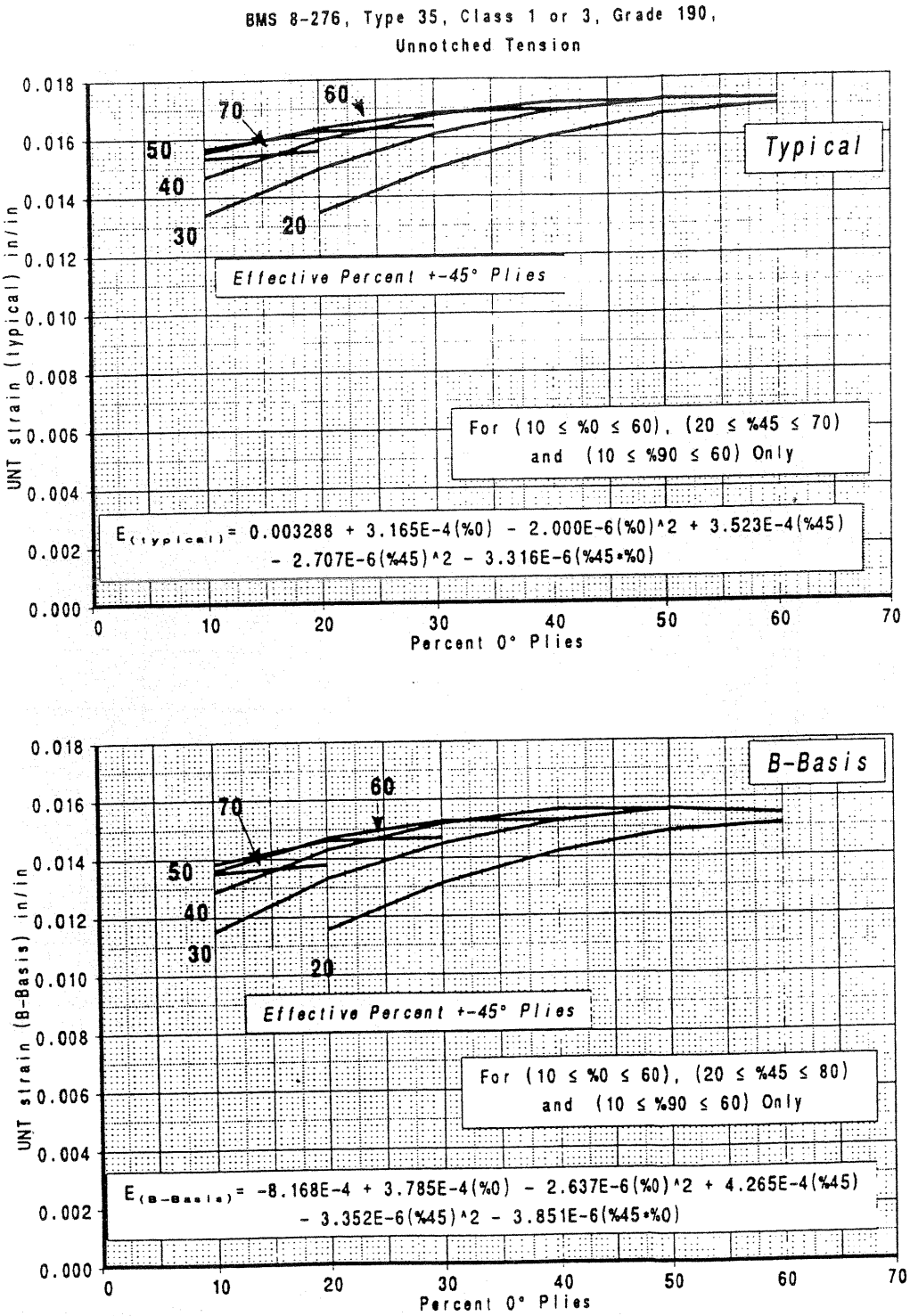


Figure 2.1.1-11 Unnotched Tension Strength - 70°F

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
(0/±45/90) LAMINATES	

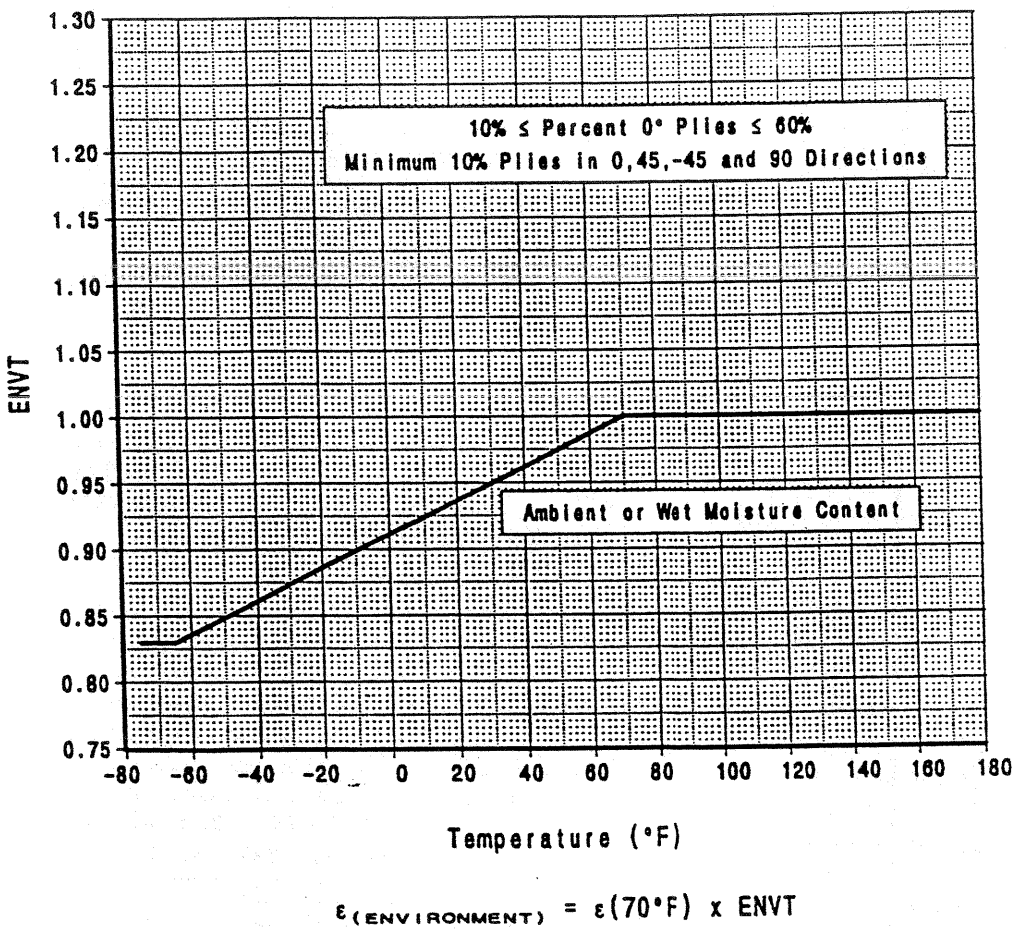


Figure 2.1.1-12
Unnotched Tension Strength - Environmental Adjustment Factors

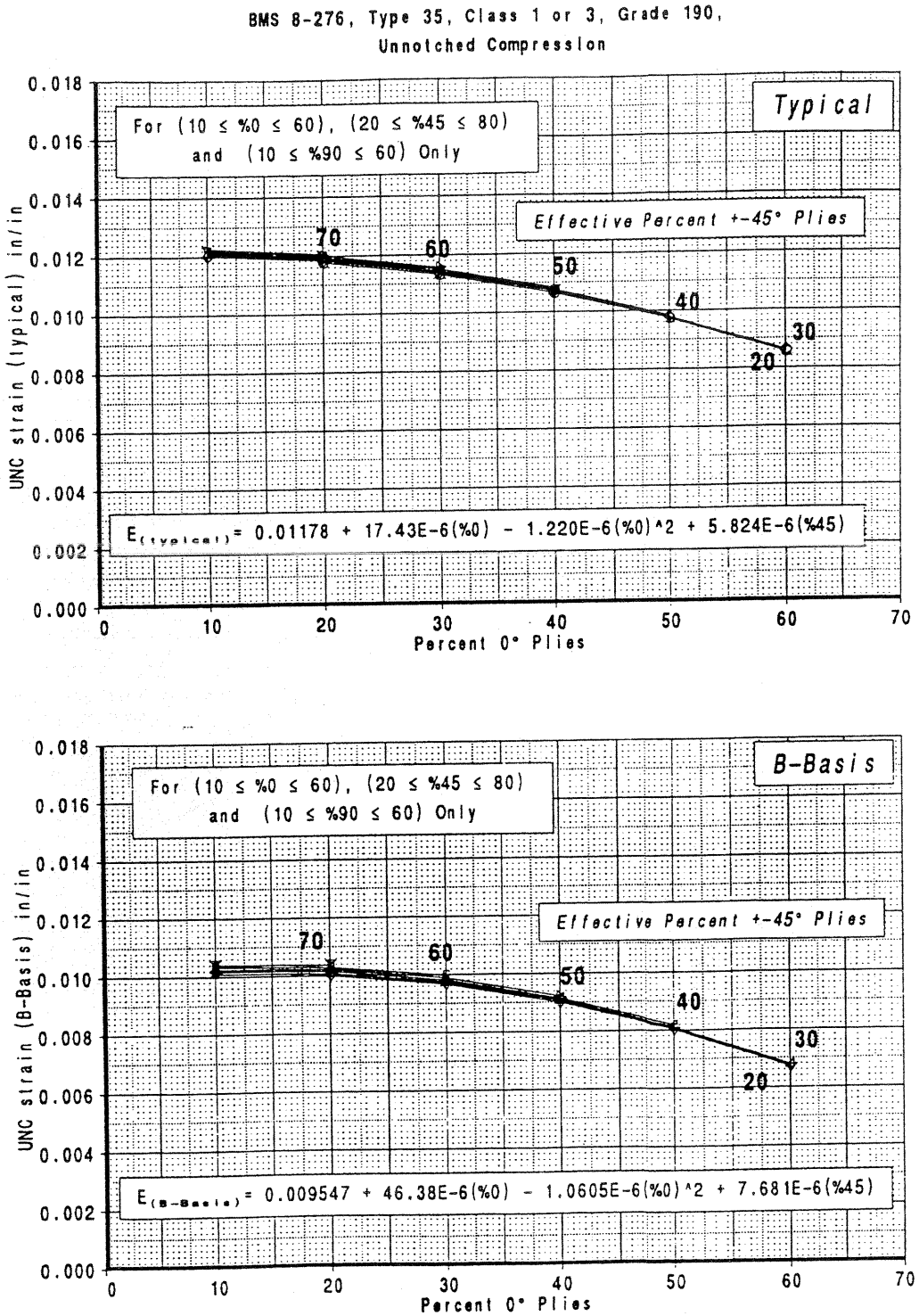
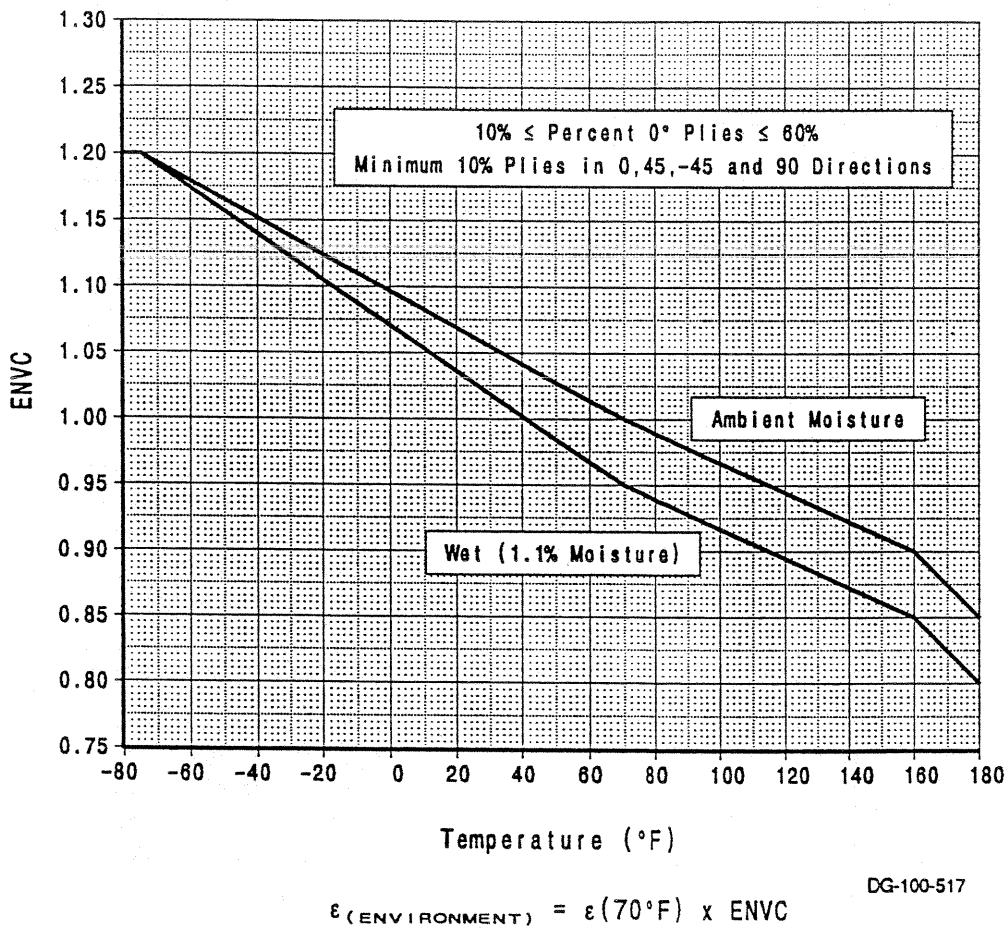


Figure 2.1.1-13 Unnotched Compression Strength - 70°F

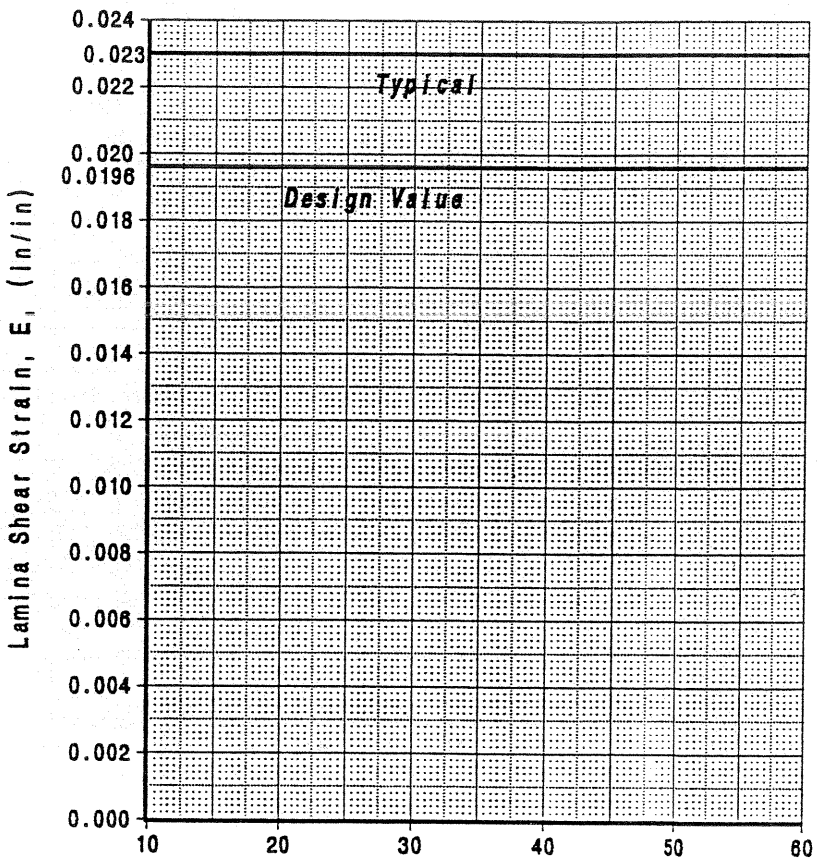
Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
(0/±45/90) LAMINATES	



$$\varepsilon_{(ENVIRONMENT)} = \varepsilon(70°F) \times ENVC$$

Figure 2.1.1-14
Unnotched Compression Strength - Environmental Adjustment Factors

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



Note: These are NOT Laminate Shear Strains

For sizing purposes, a laminate shear strain can be estimated as twice the compression strain design value for the %+-45 plies. For margin calculations, the ply interaction equation must be used.

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Figure 2.1.1-15 Unnotched Lamina Shear Strength - 70°F

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
(0/±45/90) LAMINATES	

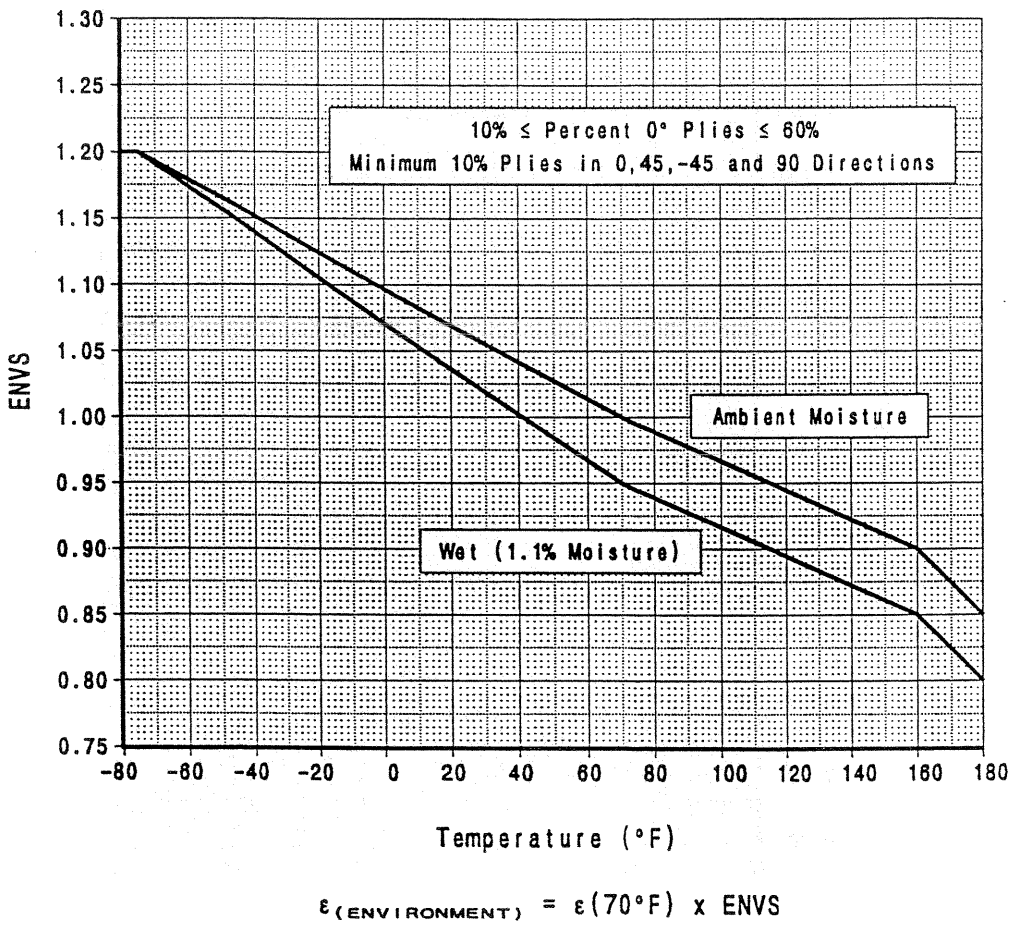

Figure 2.1.1-16
Unnotched Lamina Shear Strength - Environmental Adjustment Factors

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

Note: Ply angles (0°, +-45°, 90°) are RELATIVE to the fiber direction being analyzed. (See Section 5.6)

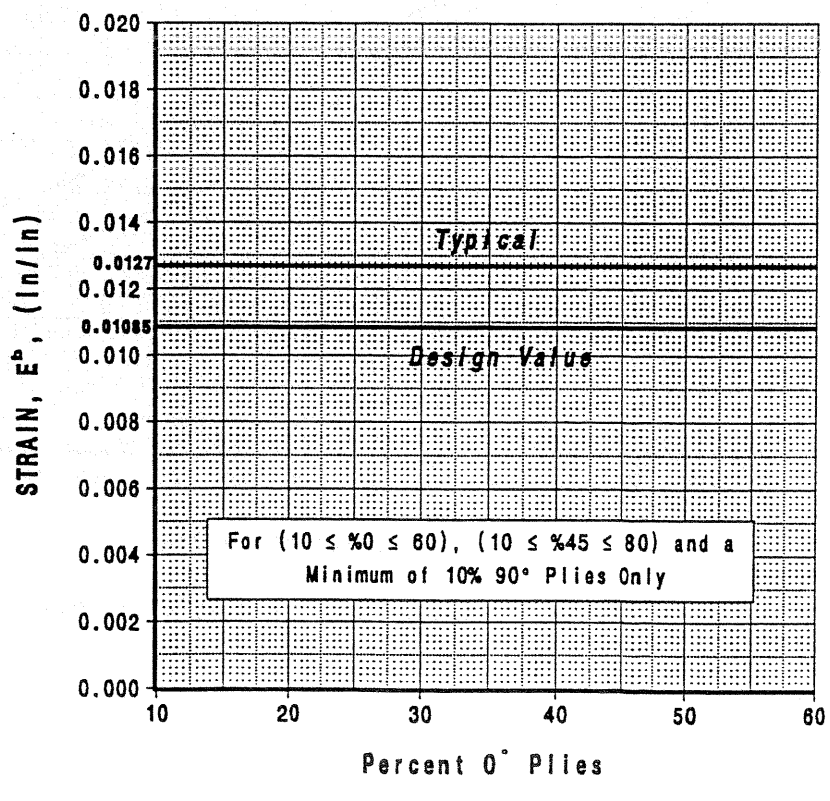

Figure 2.1.1-17 Unnotched Compression Bending Strain - 70°F

Prepreg Material Specification:	BMS 8-276, TYPE 35, CLASS 1 OR 3, GRADE 145 OR 190, FORM 1
Resin Content:	35 (% WT)
Process Specification:	BAC 5578
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

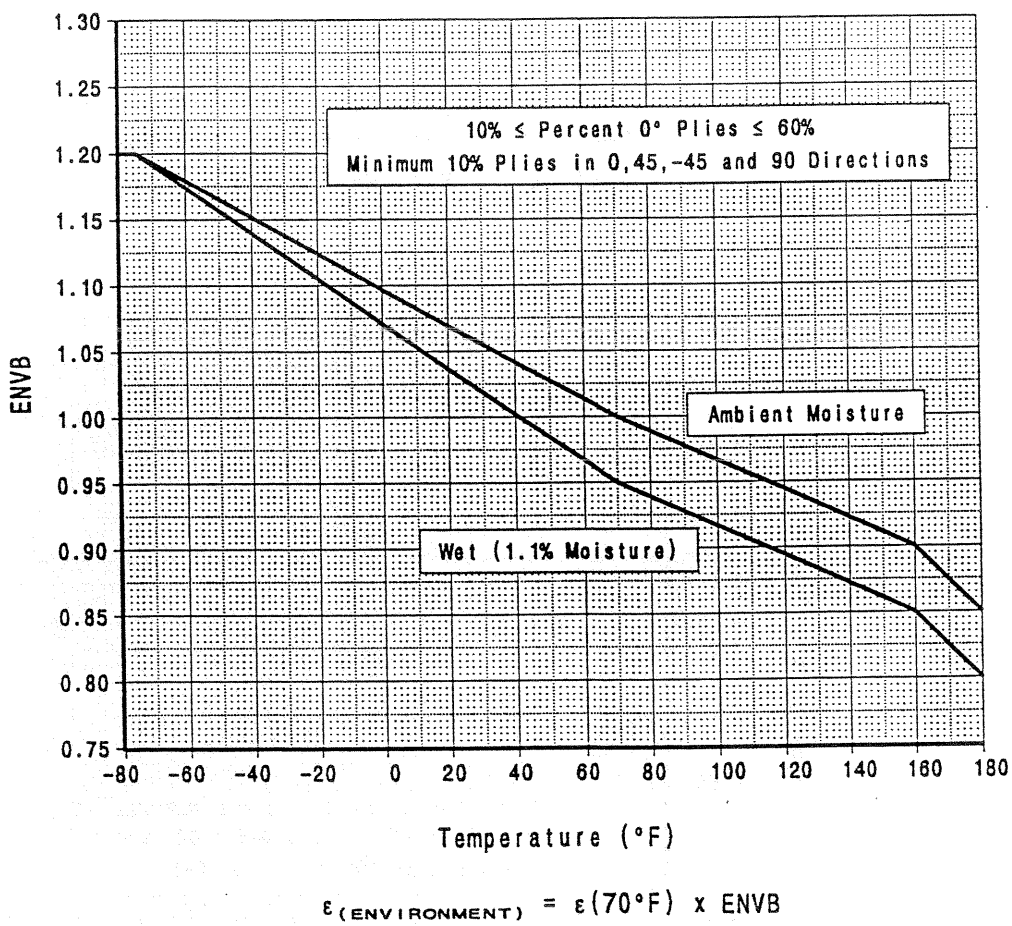

Figure 2.1.1-18
Unnotched Compression Bending Strain - Environmental Adjustment Factor

2.1.2 BMS 8-276, Type 40, Class 2, Style 3K-70-PW, Form 2

This specification applies to 350°F cure toughened-epoxy resin preimpregnated woven fabric.

Type 40: 40 percent by weight resin content.
Class 2: Woven Fabric.
Form 2: BMS 9-8 Type I carbon fiber (average modulus range 32 to 35 msi)

Note: **Applications are limited to single ply, simple contour.** (Reference, A-44-2020-973)

Contents:

Table 2.1.2-1 Ply Properties

Table 2.1.2-1 Ply Properties

TABLE 2.1.2-1		PLY PROPERTIES							
PREPREG MATERIAL SPECIFICATION: BMS 8-276, TYPE 40, CLASS 2, STYLE 3K-70-PW, FORM 2									
RESIN CONTENT: 40 (% WT)									
CURED PLY THICKNESS: .0085 (in)									
DENSITY: .055 (lb/in^3)									
PROCESS SPECIFICATION: BAC 5578									
PROPERTY		UNIT	ENVIRONMENTAL CONDITION						
			-75° F		70° F		160° F		
			DRY	WET	DRY	WET	DRY	WET	
MODULUS ②	E_1 ①	msi	8.10						
	E_2	msi	8.10						
	G_{12}	msi	0.90	0.90	0.70	0.60	0.50	0.45	
	G_{13}	msi	0.90	0.90	0.70	0.60	0.50	0.45	
	G_{23}	msi	0.90	0.90	0.70	0.60	0.50	0.45	
POISSON'S RATIO	ν_{12}	----	0.06						
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F	1.6×10^{-6}				1.6×10^{-6}		
	α_2	in/in ° F	1.6×10^{-6}				1.6×10^{-6}		
COEFFECIENTS OF LINEAR MOISTURE EXPANSION ④	β_1	in/in %M							
	β_2	in/in %M							
THERMAL CONDUCTIVITY	κ_1	BTU/(hr ft °F)							
	κ_2	BTU/(hr ft °F)							
	κ_3	BTU/(hr ft °F)							

① E_1 & E_2 are the average of tension and compression moduli. $E_{1c} = E_{2c} = 7.7$ Msi.

② Modulus values are secant values at a strain level of 4000 μ in/in. For special analyses use modulus versus strain curves to determine secant values at the desired strain level.

③ CLTE values are for expansion between -75° F and 70° F, and 70° F and 180° F.

④ %M = Percent absorbed moisture by weight.

DG-100-522

2.2 BMS 8-212

2.2.1 BMS 8-212, Type II, Class 1 or 3, Grade 145 or 190

This specification applies to 350°F cure epoxy resin impregnated BMS 9-8 Type I carbon fiber (average modulus range 32 to 35 msi) unidirectional tape.

Type II: 35 percent by weight resin content.
Class 1: Unidirectional tape for manual layup.
Class 3: Unidirectional tape for use with automated tape laying equipment or manual layup.

Contents:

Table 2.2.1-1 Ply Properties

Figure 2.2.1-1 Nominal E_x Modulus Plot
Figure 2.2.1-2 Nominal G_{xy} Modulus Plot
Figure 2.2.1-3 Nominal ν_{xy} Poisson's Ratio Plot
Figure 2.2.1-4 Nominal α_x Coefficient of Thermal Expansion Plot

Figure 2.2.1-5 E_x Environmental Adjustment Factors Plot
Figure 2.2.1-6 G_{xy} Environmental Adjustment Factors Plot
Figure 2.2.1-7 E_x Tension/Compression Adjustment Factors Plot

Table 2.2.1-1 Ply Properties

TABLE: 2.2.1-1		PLY PROPERTIES						
Prepreg Material Specicification:		BMS 8-212, TYPE II CLASS 1 or 3, GRADE 145 or 190						
Resin Content:		35 (% WT)						
Cured Ply Thickness:		0.0056 (in) - GRADE 145		0.0074 (in) - GRADE 190				
Density:		0.056 lb/in^3						
Process Specification:		BAC 5317-1						
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		180° F ⑤	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	Msi	← 18.1 →					
	E_2	Msi			1.30			
	G_{12}	Msi	0.82		0.66			0.54
	G_{13}	Msi	0.82		0.66			0.54
	G_{23}	Msi	0.82		0.66			0.54
POISSON'S RATIO	ν_{12}	----	← 0.34 →					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F	.02 x 10^{-6}				.02 x 10^{-6}	
	α_2	in/in ° F	15 x 10^{-6}				15 x 10^{-6}	
COEFFECIENTS OF LINEAR MOISTURE EXPANSION ④	β_1	in/in %M	← →					
	β_2	in/in %M	← →					
THERMAL CONDUCTIVITY	κ_1	BTU/(hr ft °F)						
	κ_2	BTU/(hr ft °F)						
	κ_3	BTU/(hr ft °F)						

① E_1 is the average of tension and compression moduli. For special analyses use tension/compression modulus adjustment factors to determine tension or compression E_1.

② Modulus values are secant values at a strain level of 4000 μ in/in. For special analysis use modulus versus strain curves to determine secant values at the desired strain level.

③ Values are for expansion between -75° F and 70° F, and 70° F and 180° F.

④ %M = Percent absorbed moisture by weight.

⑤ 180°F values are to be used for 160°F environment.

DG-100-523

Prepreg Material Specification:	BMS 8-212, TYPE II, CLASS 1 or 3, GRADE 145 or 190
Resin Content:	35 (% WT)
Process Specification:	BAC 5317-1
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

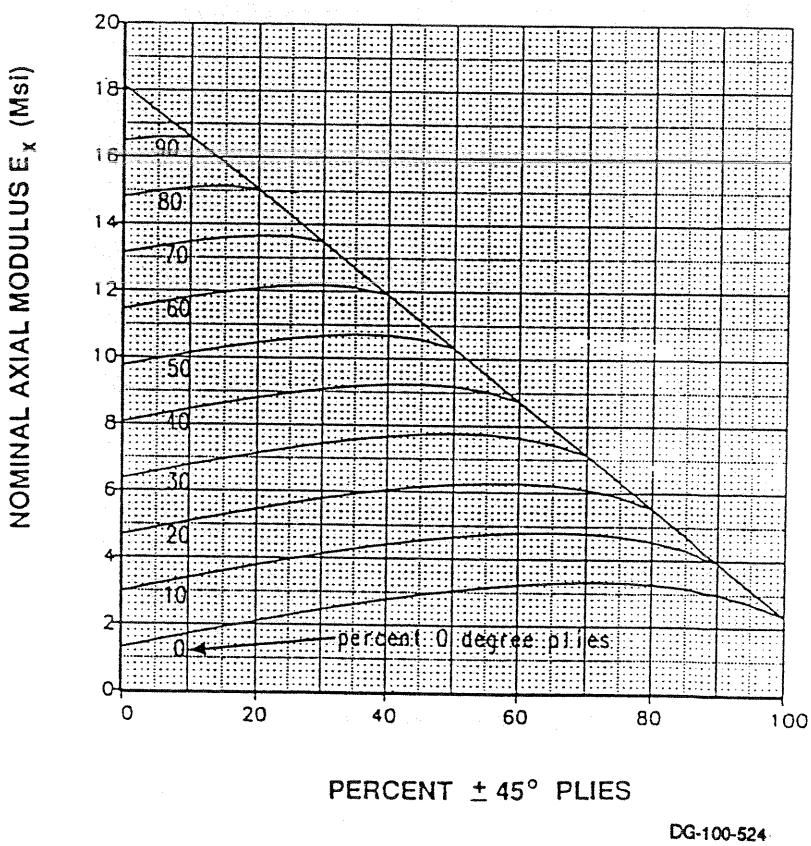

Figure 2.2.1-1 Nominal E_x Modulus

Prepreg Material Specification:	BMS 8-212, TYPE II, CLASS 1 or 3, GRADE 145 or 190
Resin Content:	35 (% WT)
Process Specification:	BAC 5317-1
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

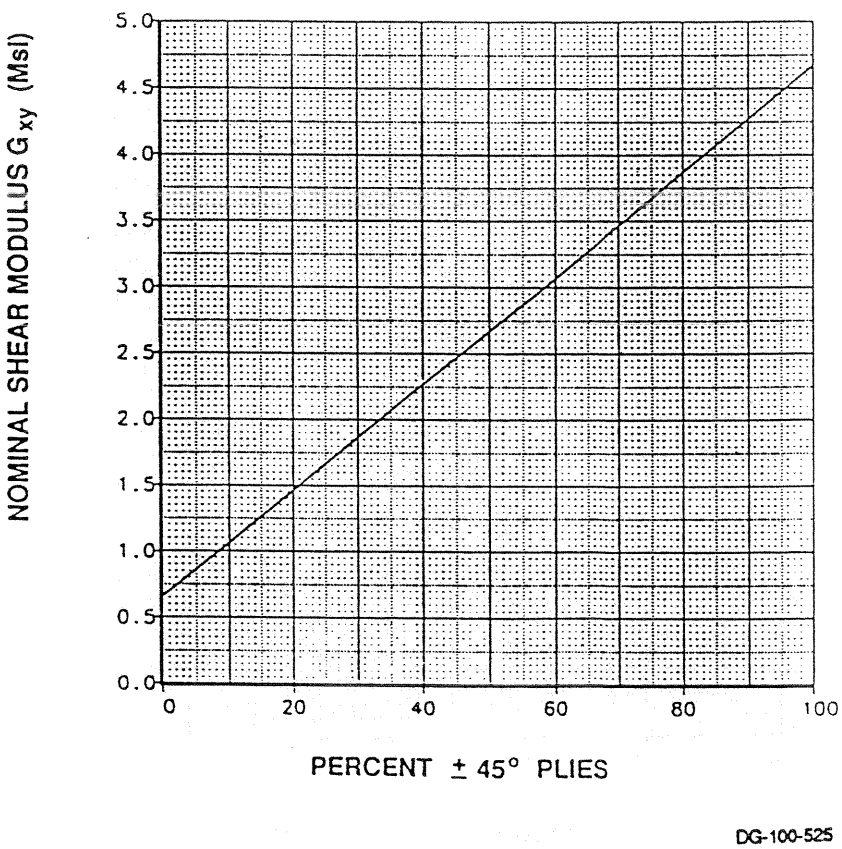

Figure 2.2.1-2 Nominal G_{xy} Modulus

Prepreg Material Specification:	BMS 8-212, TYPE II, CLASS 1 or 3, GRADE 145 or 190
Resin Content:	35 (% WT)
Process Specification:	BAC 5317-1
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

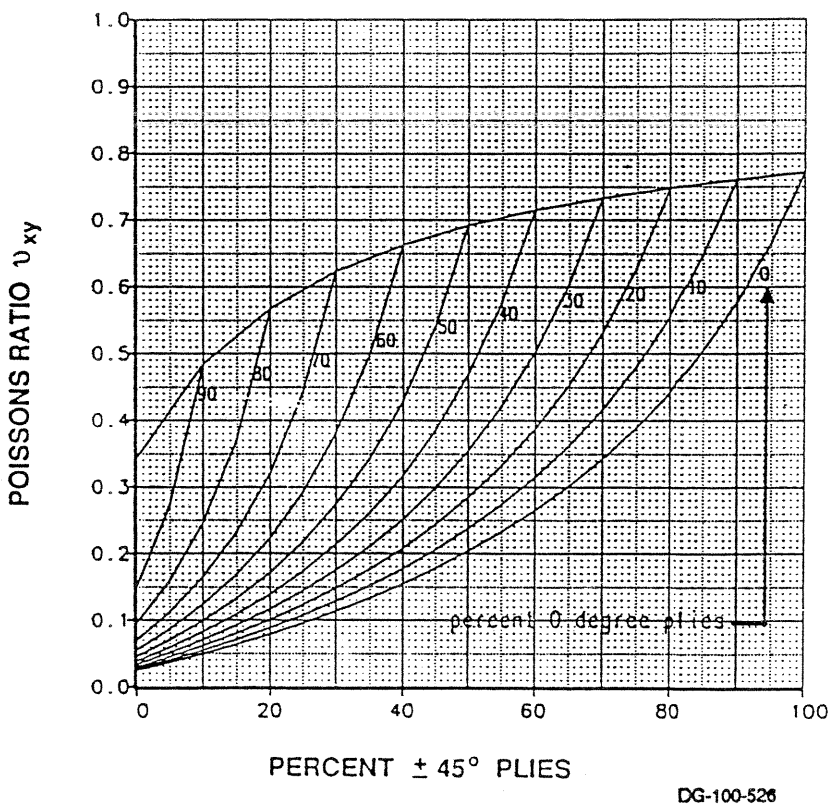

Figure 2.2.1-3 Nominal ν_{xy} Poisson's Ratio