2.3 BMS 8-256

2.3.1 BMS 8-256, Type II, Class 1, Grade 190

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

Type II: 38 percent by weight resin content.
Class 1: Unidirectional Prepreg Tape

Contents:

Table 2.3.1-1 Ply Properties

TABLE 2.3.1-1		PLY PROPERTIES						
PREPREG MATERIAL SPECICIFICATION: BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190 RESIN CONTENT: 38 (% WT) CURED PLY THICKNESS: .0080 (In) DENSITY: .055 lb/in^3 PROCESS SPECIFICATION: BAC 5317								
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		180° F ⑤	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	16.7					
	E_2	msi	(1.28)	(1.28)	1.28	(1.20)	(1.10)	(1.00)
	G_{12}	msi	0.83	(0.83)	0.66	(0.62)	(0.58)	0.54
	G_{13}	msi	0.83	(0.83)	0.66	(0.62)	(0.58)	0.54
	G_{23}	msi	0.83	(0.83)	0.66	(0.62)	(0.58)	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	0.0					
	β_2	In/In %M	2400 x 10^{-6}					
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 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.

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

⑥ Values In ( ) are estimates.

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Guidelines for Usage of Moduli and Strength Design Values

Ply Properties - Table 2.3.1-1

The room temperature (70°F) / dry condition values shown in this table 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 2.3.1-7) 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.

Modulus Plots - Figures 2.3.1-2 through 2.3.1-7.

These curves were calculated using laminated plate theory from the values given in Table 2.3.1-1 and from the tension and compression E1 values shown on Figure 2.3.1-7. 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.

Basic Cutoff Strains - Figures 2.3.1-8 and 2.3.1-9

The basic cutoff design value strains are used for laminate or facesheet mid-plane strain checks and are intended to apply to all areas of the structure, with the exception of peak strains at point of localized concentrations (see below). The basic cutoff values apply at a distance of 0.50 inch from the laminate edge at the strain concentraion. The basic cutoff strains apply as strain cutoffs in bolted joint areas of the structure, however geometry correction factors are not applied to the basic cutoff values.

The mid-plane strength margin of safety analysis procedure in Section 5.6.3 should be used with the basic cutoff strain values. Use the open hole lamina shear strain design value in Figure 2.3.1-12.

The basic cutoff tension strain is very similar to the filled hole tension strain design values in Section 11.4. The slight difference is an historical artifact related to translation of the B2 program design values into 777 program design values. The corresponding typical tension strain values are the typical filled hole tension strains in Section 11.4.

The basic cutoff compression strains are intended to reflect the lower of a open hole compression strain (refer to Section 11.4) and a compression after impact (barely visible) strain. The corresponding typical compression strain values are the typical open hole

compression strains in Section 11.4. The open hole strains represent a 0.25 inch diameter, width/diameter = 5.0 and no countersink configuration.

Peak Bending Strains - Figures 2.3.1-8 and 2.3.1-9

The peak bending design value strains are used for laminate or facesheet bending strain checks. They apply to the same areas as the basic cutoff strains. The bending strength margin of safety analysis procedure in Section 5.6.3 should be used with peak bending strain values. Use the unnotched lamina shear strain design value in Figure 2.3.1-12.

The peak bending strains are based on flexure tests of open and filled hole laminate coupons.

The corresponding tension typical strain value is the unnotched tension typical in Figure 2.3.1-8. The corresponding compression typical strain value is the filled hole compression typical in Section 11.4.

Peak Stress Concentration and Peak Stress Concentration with Bending Strains - Figures 2.3.1-8 and 2.3.1-9

The peak stress concentration and peak stress concentration with bending design value strains are used for laminate or facesheet strain checks at the laminate free edge at a strain concentration. These values correspond to the basic cutoff strains and peak bending strains which are used for locations 0.50 inches away from the laminate free edge. Margins of safety are calculated using applied strains from a detailed analysis (usually a finite element model) and the procedures in Sections 5.6.4.

The peak stress concentration strains are derived from element level tests which contained in-plane strain concentrations. The peak stress concentration with bending strains are derived from unnotched, undamaged coupon test results.

The corresponding tension typical strain value is the unnotched tension typical in Figure 2.3.1-8. The corresponding compression typical strain value is the unnotched compression typical in Figure 2.3.1-9.

Unnotched Tension and Compression Typical Strains - Figures 2.3.1-8 and 2.3.1-9

These typical strain values are based on unnotched, undamaged coupon test results. The values may be used for test correlation analyses. The margin of safety analysis procedure in Section 5.6.3 should be used with the unnotched strain values.

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 or 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

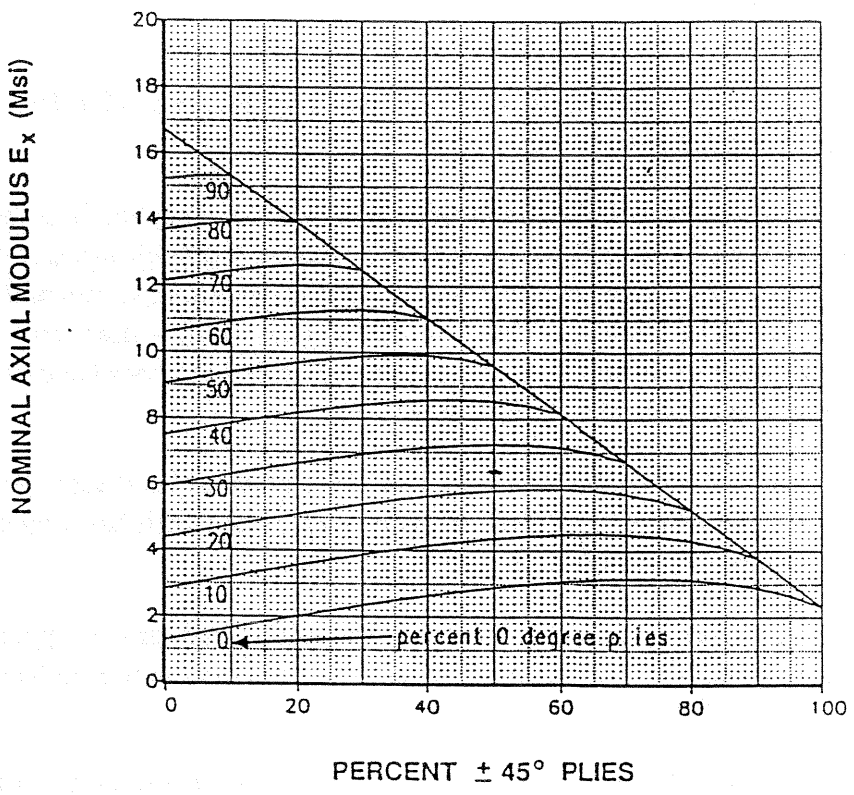


Figure 2.3.1-1 Nominal E_x Modulus

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 or 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

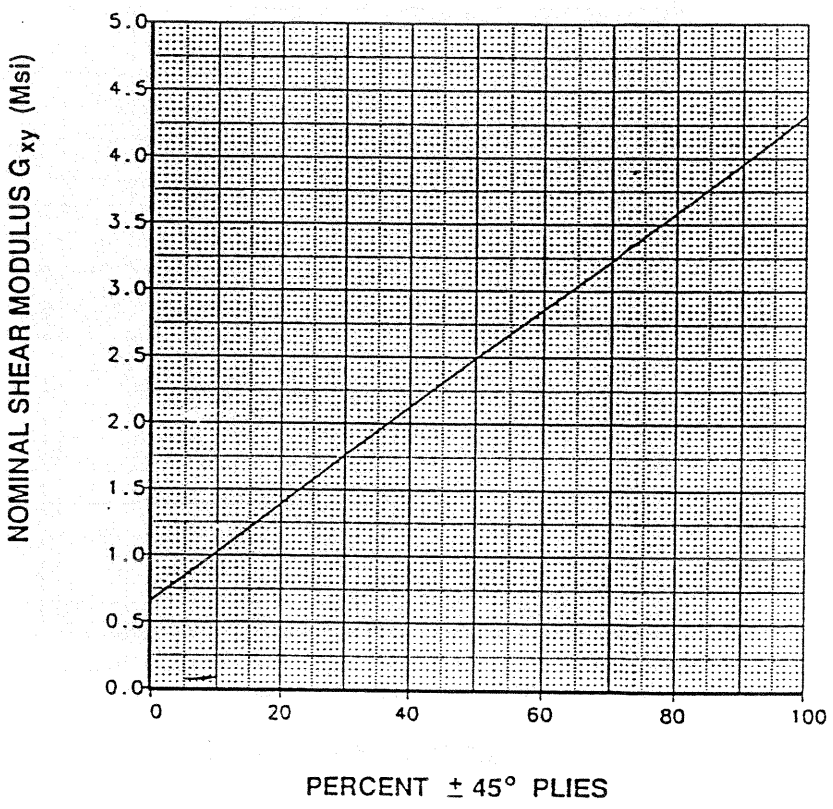


Figure 2.3.1-2 Nominal G_{xy} Modulus

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 or 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

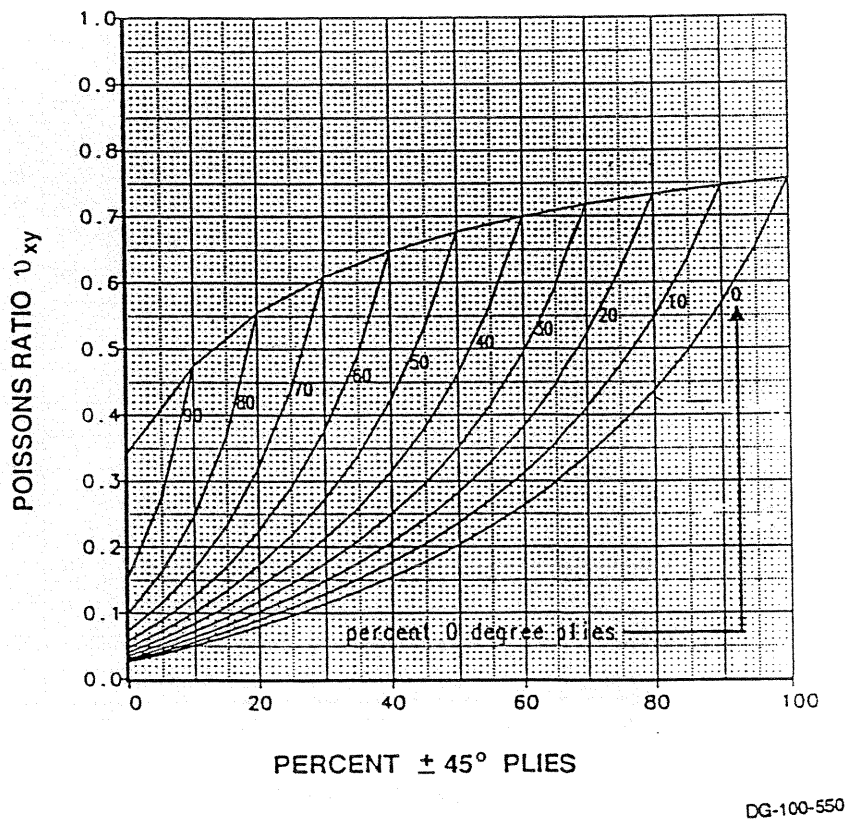


Figure 2.3.1-3 Nominal ν_{xy} Poisson's Ratio

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 or 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

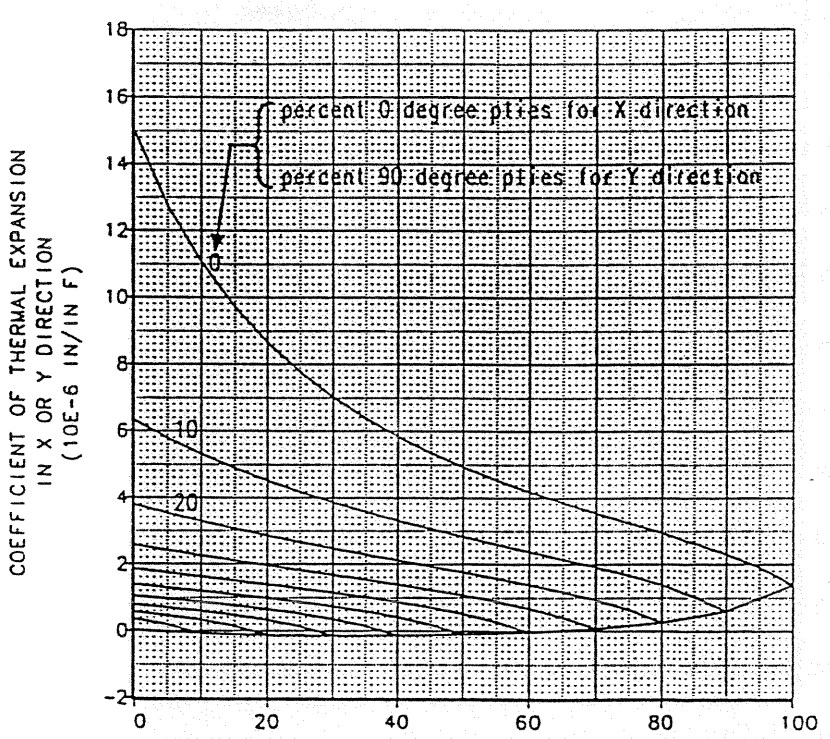
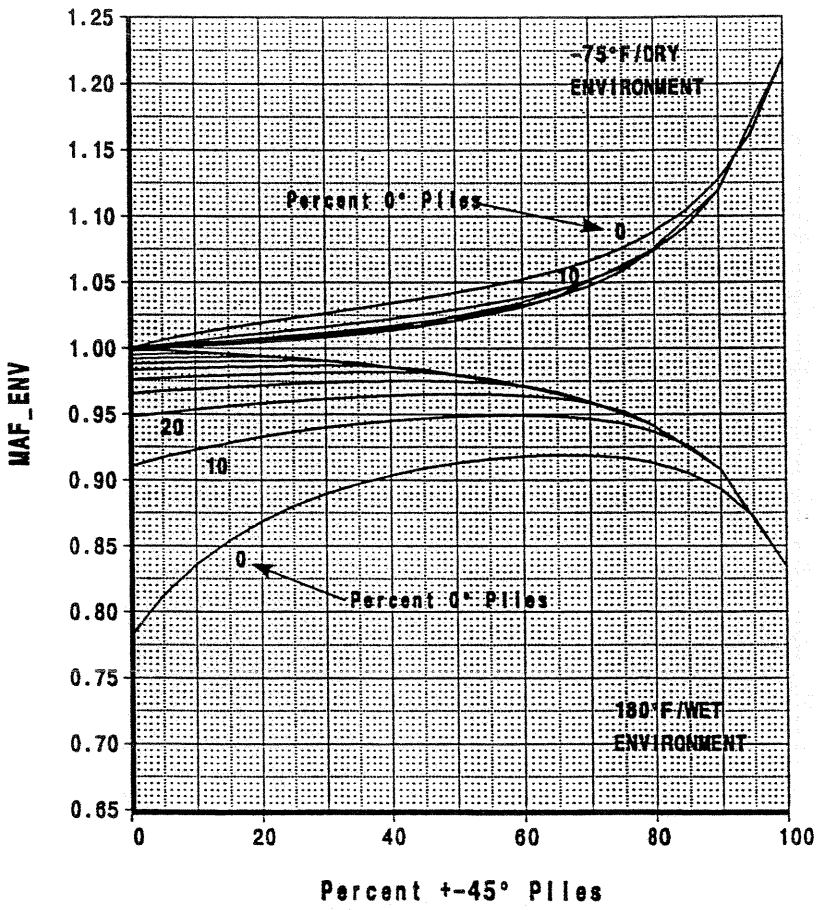


Figure 2.3.1-4 Nominal α_x Coefficient of Thermal Expansion

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



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

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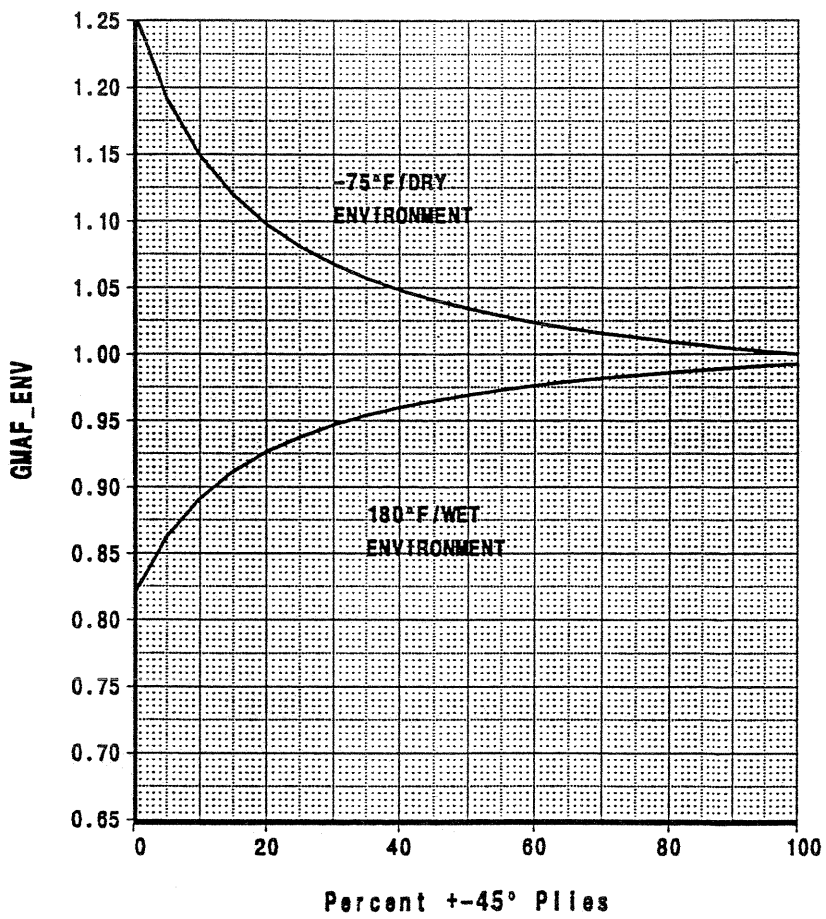
Figure 2.3.1-5 E_x Environmental Adjustment Factor

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



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

DG-100-553

Figure 2.3.1-6 G_{xy} Environmental Adjustment Factor

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 or 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

MAFT = 1.05

MAFC = 0.95

$$E_{1\ TENSION} = E_{1\ NOMINAL} \times MAFT$$

$$E_{1\ COMPRESSION} = E_{1\ NOMINAL} \times MAFC$$

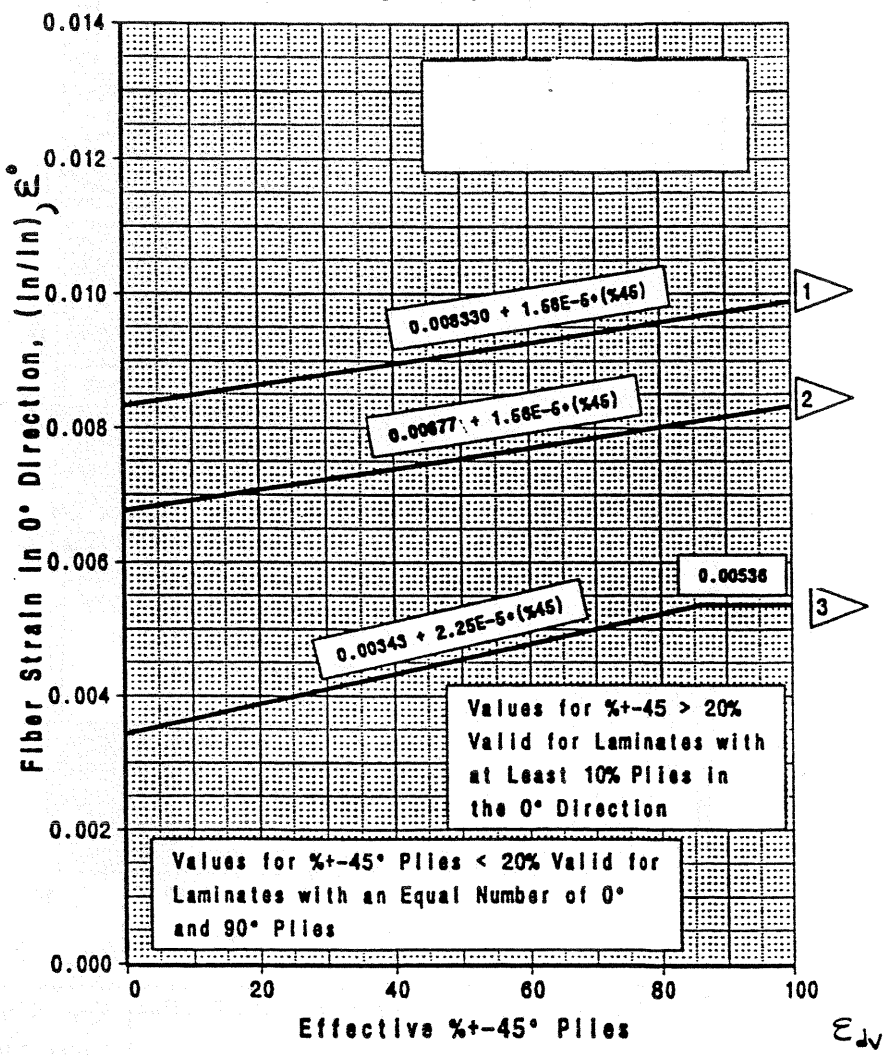
DG-100-554

Figure 2.3.1-7 E_x Tension/Compression Adjustment Factors

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317

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)



$\varepsilon_{dv} = \varepsilon^{\circ} \times K_{thick}$

1 Peak at Stress Concentration with Bending	For thickness correction see figure 2.3.1-15
2 Peak at: Bending or Stress Concentration Midplane	
3 Basic Cutoff at Midplane	Valid for all thicknesses

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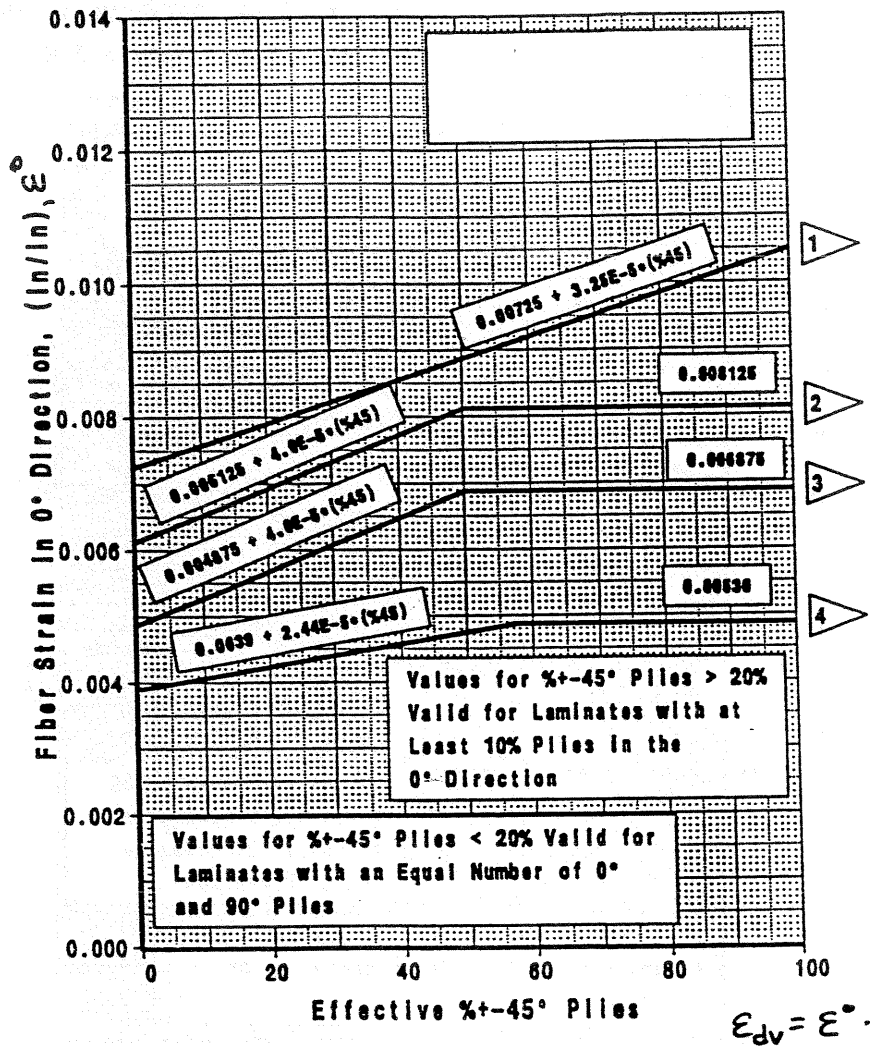
Figure 2.3.1-8 Tension Design Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317

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)



$\varepsilon_{dv} = \varepsilon^{\circ} \cdot K_{thick}$

1	Peak at Stress Concentration with Bending	For thickness correction see Figure 2.3.1-15
2	Peak at Stress Concentration Midplane	
3	Peak Bending	
4	Basic Cutoff at Midplane	Valid for all thicknesses

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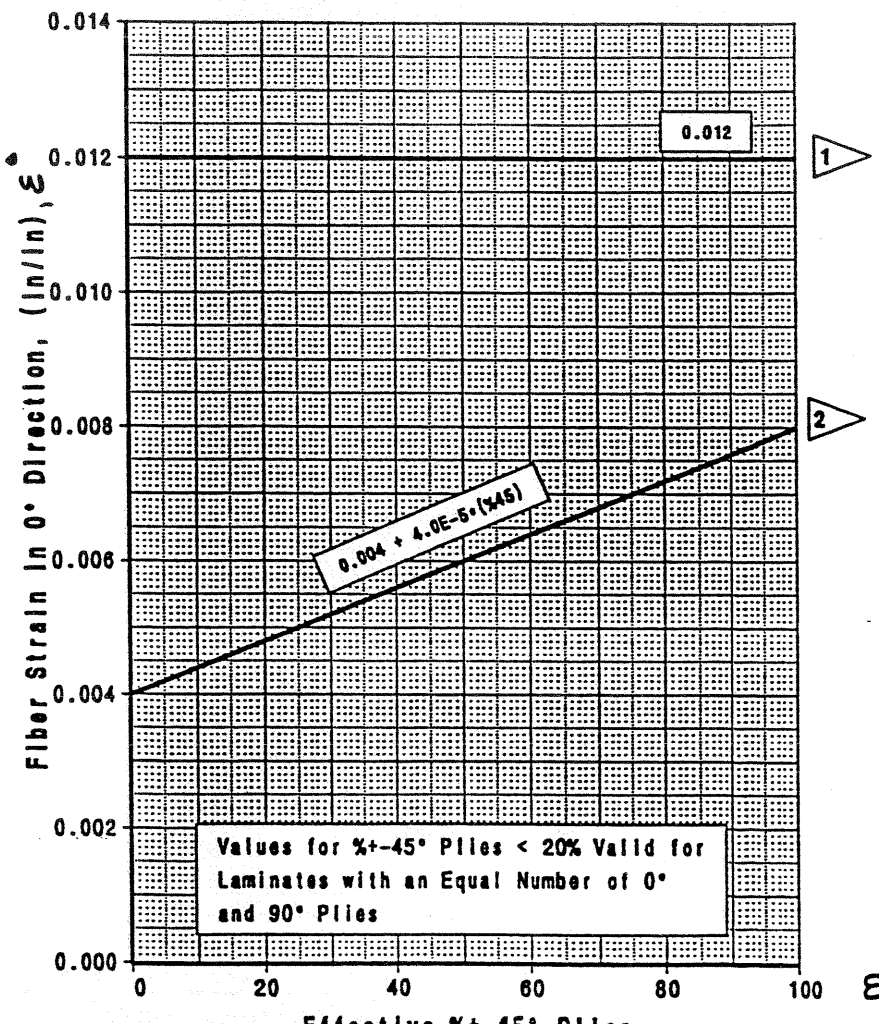
Figure 2.3.1-9 Compression Design Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317

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)



$\varepsilon_{dv} = \varepsilon^{\circ} \cdot K_{thick}$

		For thickness correction see:
1	Unnotched	Figure 2.3.1-15
2	Open-Hole, Filled-Hole, 0.25" Dia, w/d=6.0	Figure 11.4-38

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Figure 2.3.1-10 Tension Typical Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317

70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES

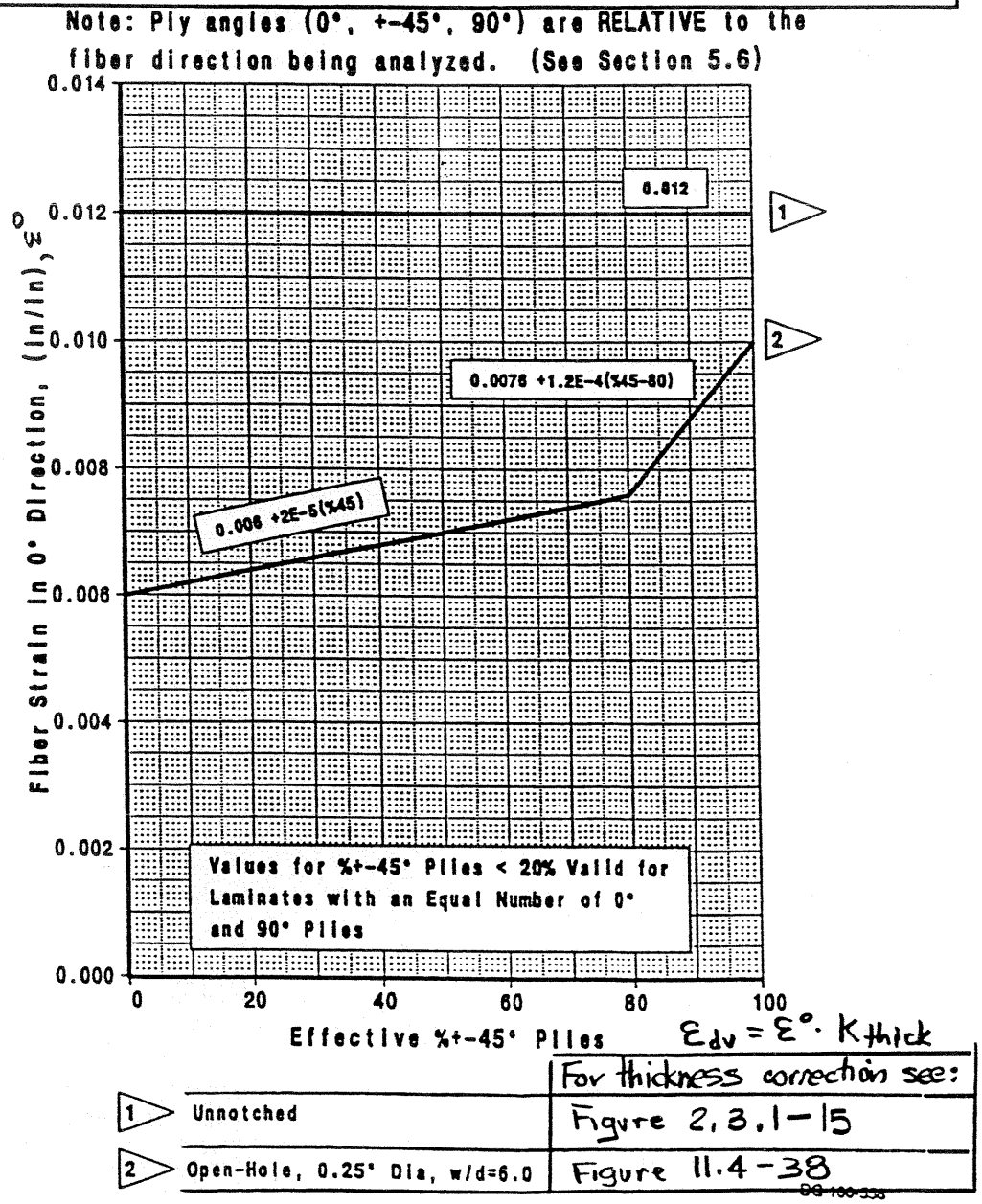

Figure 2.3.1-11 Compression Typical Values -70°F

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

Lamina Shear Design Values

	Lamina Shear Strain
Unnotched	0.020
Open-Hole	0.015

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.

DG-100-559

Figure 2.3.1-12 Lamina Shear Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317

70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES

Environment	Strain Adjustment Factors (1)		
	Tension	Compression	Shear
-75F/Dry	0.90	1.20	1.20
70F/Ambient	1.00	1.00	1.00
70F/Wet	1.00	0.95	0.95
130F/Wet	0.95	0.87	0.87
160F/Wet	0.93	0.83	0.83
180F/Wet	0.91	0.80	0.80

(1) Strain factors apply to both unnotched and notched laminate strains

DG-100-560

Figure 2.3.1-13 Strength Environmental Adjustment Factors

	Design Value	Typical
Tension	10.0 Ksi	12.0 Ksi
Compression	10.0 Ksi	12.0 Ksi

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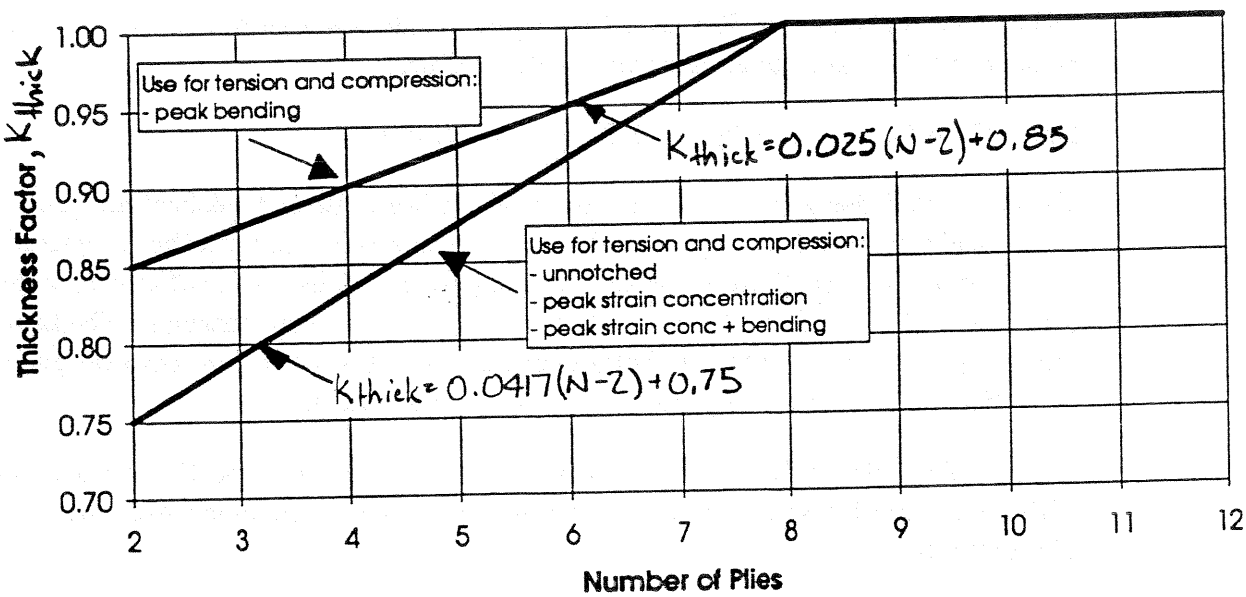
Figure 2.3.1-14 Tape Transverse Typical & Design Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE II, CLASS 1 OR 3, GRADE 190
Resin Content:	38 (% WT)
Process Specification:	BAC 5317
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



(Factor multipied with baseline strain values)

Figure 2.3.1-15 Laminate/Facesheet Thickness Correction Factors

Guidelines for Usage of Moduli and Strength Design Values

Ply Properties - Table 2.3.2-1

The room temperature (70°F) / dry condition values shown in this table 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 2.3.2-7) 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.

Modulus Plots - Figures 2.3.2-2 through 2.3.2-7.

These curves were calculated using laminated plate theory from the values given in Table 2.3.2-1 and from the tension and compression E1 values shown on Figure 2.3.2-7. 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.

Basic Cutoff Strains - Figures 2.3.2-8 and 2.3.2-9

The basic cutoff design value strains are used for laminate or facesheet mid-plane strain checks and are intended to apply to all areas of the structure, with the exception of peak strains at point of localized concentrations (see below). The basic cutoff values apply at a distance of 0.50 inch from the laminate edge at the strain concentraion. The basic cutoff strains apply as strain cutoffs in bolted joint areas of the structure, however geometry correction factors are not applied to the basic cutoff values.--

The mid-plane strength margin of safety analysis procedure in Section 5.6.3 should be used with the basic cutoff strain values. Use the open hole lamina shear strain design value in Figure 2.3.2-12.

The basic cutoff tension strain is the same as the filled hole tension strain (Section 11.4). The corresponding typical tension strain values are the typical filled hole tension strains in Section 11.4.

The basic cutoff compression strains are intended to reflect the lower of a open hole compression strain (refer to Section 11.4) and a compression after impact (barely visible) strain. The corresponding typical compression strain values are the typical open hole compression strains in Section 11.4. The open hole strains represent a 0.25 inch diameter, width/diameter = 5.0, and no countersink configuration.

Peak Bending Strains - Figures 2.3.2-8 and 2.3.2-9

The peak bending design value strains are used for laminate or facesheet bending strain checks. They apply to the same areas as the basic cutoff strains. The bending strength margin of safety analysis procedure in Section 5.6.3 should be used with peak bending strain values. Use the unnotched lamina shear strain design value in Figure 2.3.2-12.

The peak bending strains are based on flexure tests of open and filled hole laminate coupons.

The corresponding tension typical strain value is the unnotched tension typical in Figure 2.3.2-8. The corresponding compression typical strain value is the filled hole compression typical in Section 11.4.

Peak Stress Concentration and Peak Stress Concentration with Bending Strains - Figures 2.3.2-8 and 2.3.2-9

The peak stress concentration and peak stress concentration with bending design value strains are used for laminate or facesheet strain checks at the laminate free edge at a strain concentration. These values correspond to the basic cutoff strains and peak bending strains which are used for locations 0.50 inches away from the laminate free edge. Margins of safety are calculated using applied strains from a detailed analysis (usually a finite element model) and the procedures in Sections 5.6.4.

The peak stress concentration strains are derived from element level tests which contained in-plane strain concentrations. The peak stress concentration with bending strains are derived from unnotched, undamaged coupon test results.

The corresponding tension typical strain value is the unnotched tension typical in Figure 2.3.2-8. The corresponding compression typical strain value is the unnotched compression typical in Figure 2.3.2-9.

Unnotched Tension and Compression Typical Strains - Figures 2.3.2-8 and 2.3.2-9

These typical strain values are based on unnotched, undamaged coupon test results. The values may be used for test correlation analyses. The margin of safety analysis procedure in Section 5.6.3 should be used with the unnotched strain values.

2.3.2 BMS 8-256, Type IV, Class 2, Style 3K-70-PW

This specification applies to non-self adhesive, controlled flow, 350°F cure epoxy resin impregnated BMS 9-8 Type I carbon fiber (average modulus range 32 to 35 msi) woven fabric.

Type IV: 40 percent by weight resin content.
Class 2: Woven Fabric Prepreg

Contents:

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Table 2.3.2-1 Ply Properties

TABLE 2.3.2-1		PLY PROPERTIES						
PREPREG MATERIAL SPECIFICATION:		BMS 8-256, TYPE IV, CLASS 2 STYLE 3K-70-PW						
RESIN CONTENT:		40 (% WT)						
CURED PLY THICKNESS:		.0085 (In)						
DENSITY:		0.055 lb/in^3						
PROCESS SPECIFICATION:		BAC 5317-4						
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		180° F ⑤	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	8.10					
	E_2 ①	msi	8.10					
	G_{12}	msi	0.88	(0.88)	0.70	(0.62)	(0.53)	0.45
	G_{13}	msi	0.88	(0.88)	0.70	(0.62)	(0.53)	0.45
	G_{23}	msi	0.88	(0.88)	0.70	(0.62)	(0.53)	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	220×10^{-6}					
	β_2	In/In %M	220×10^{-6}					
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.

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.

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

⑥ Values In ( ) are estimates.

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Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

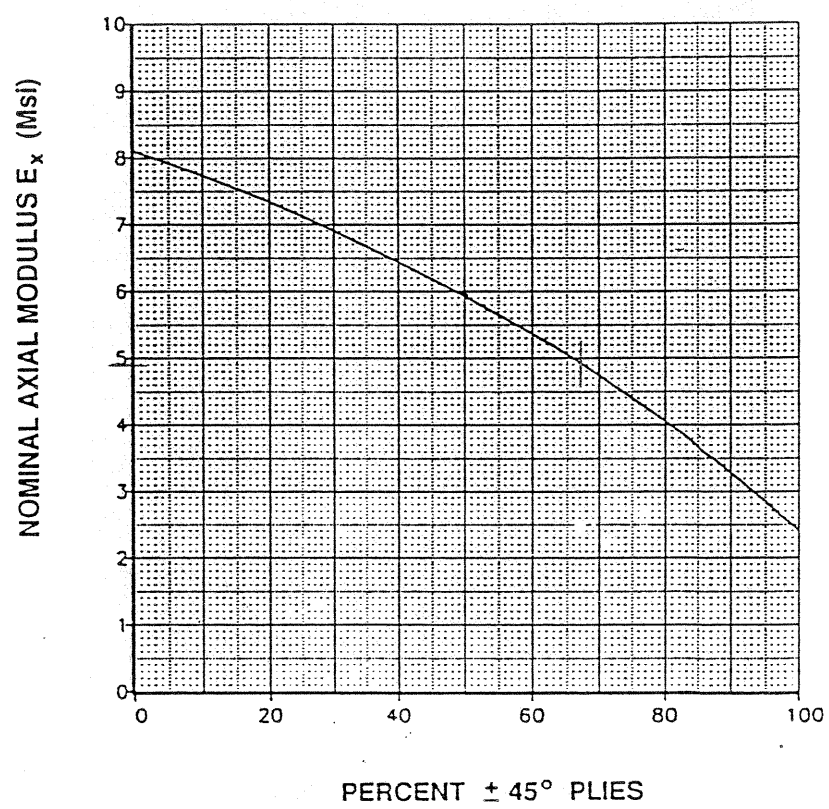


Figure 2.3.2-1 Nominal E_x Modulus

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

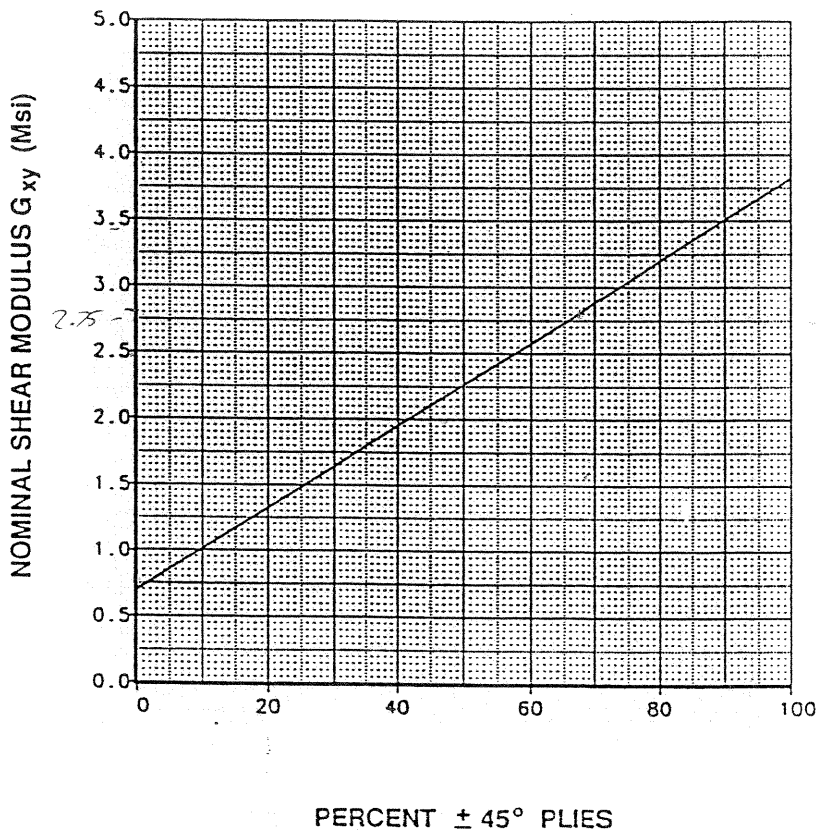


Figure 2.3.2-2 Nominal G_{xy} Modulus

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

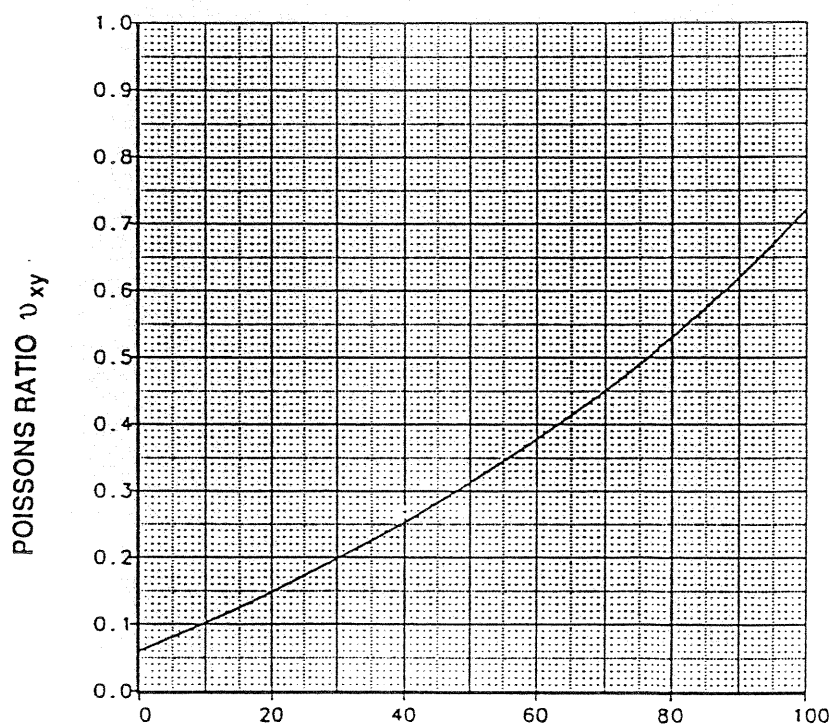


Figure 2.3.2-3 Nominal ν_{xy} Poisson's Ratio

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

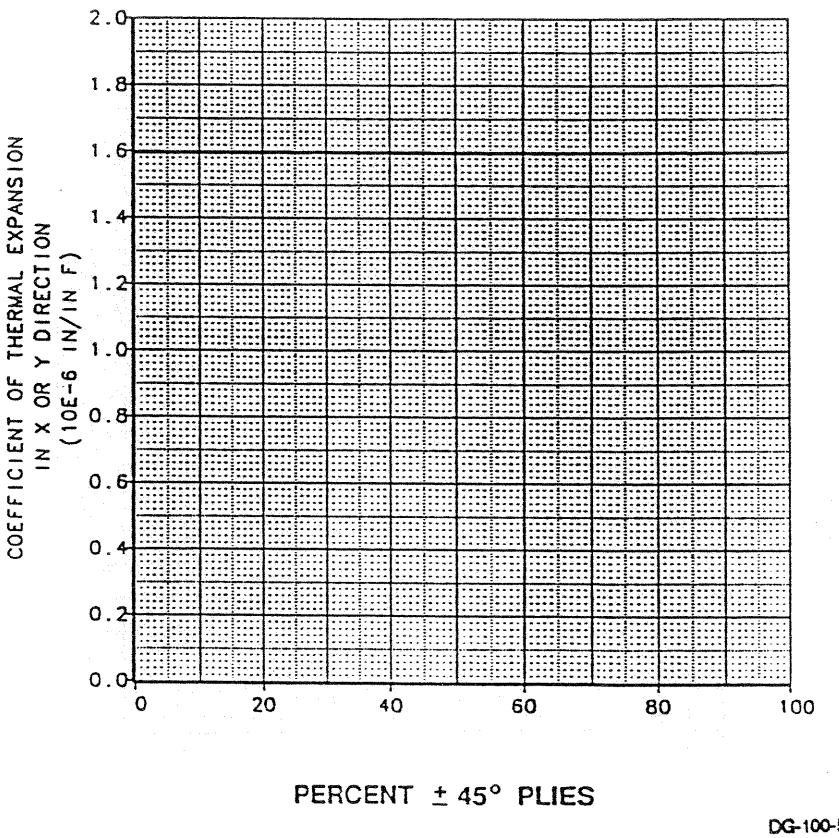
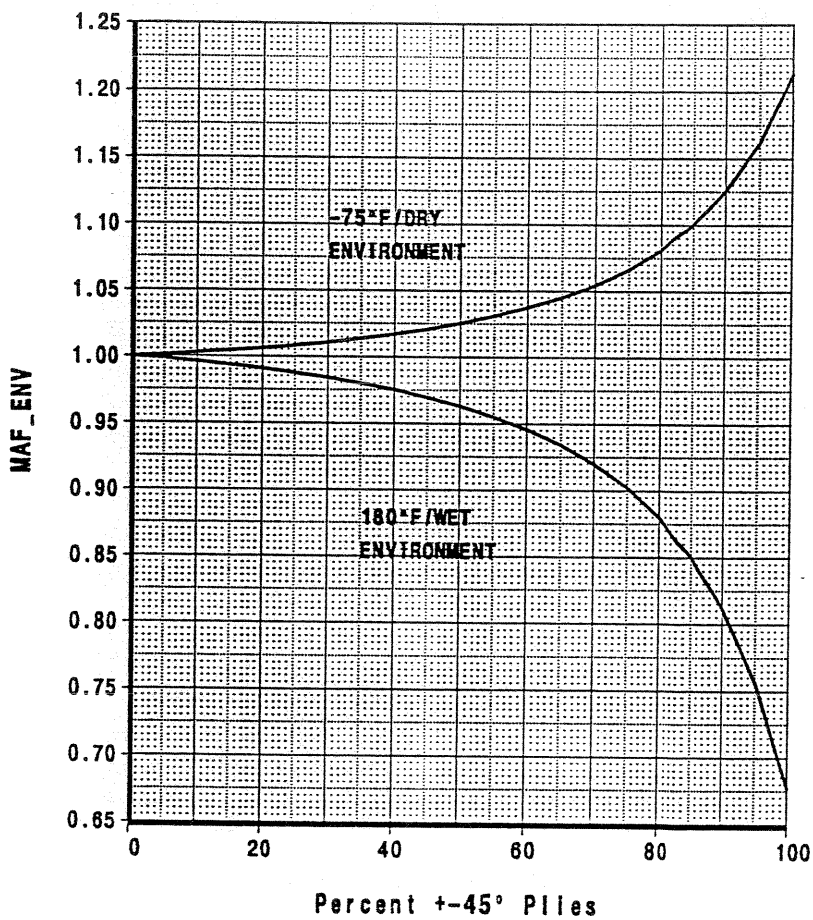


Figure 2.3.2-4 Nominal α_x Coefficient of Thermal Expansion

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

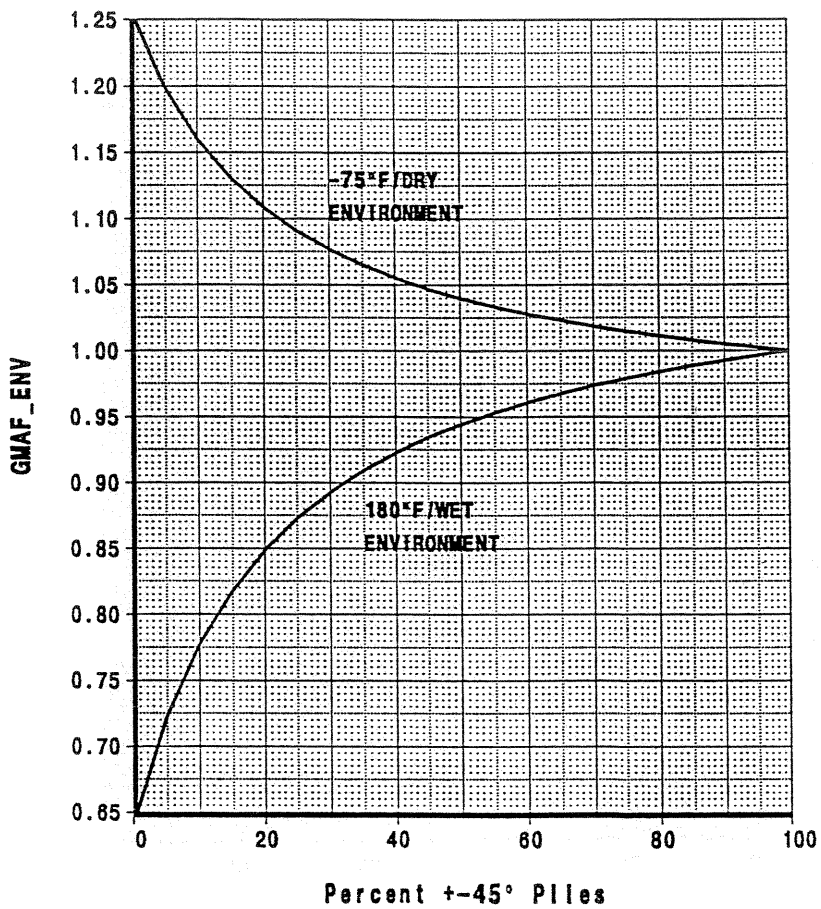


$$E_{x_{ENVIRONMENT}} = E_{x_{NOMINAL}} \times MAF\_ENV$$

DG-100-566

Figure 2.3.2-5 E_x Environmental Adjustment Factors

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



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

DG-100-567

Figure 2.3.2-6 G_{xy} Environmental Adjustment Factors

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70° F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

MAFT = 1.05

MAFC = 0.95

$$E_{1\ TENSION} = E_{1\ NOMINAL} \times MAFT$$

$$E_{1\ COMPRESSION} = E_{1\ NOMINAL} \times MAFC$$

$$E_{2\ TENSION} = E_{2\ NOMINAL} \times MAFT$$

$$E_{2\ COMPRESSION} = E_{2\ NOMINAL} \times MAFC$$

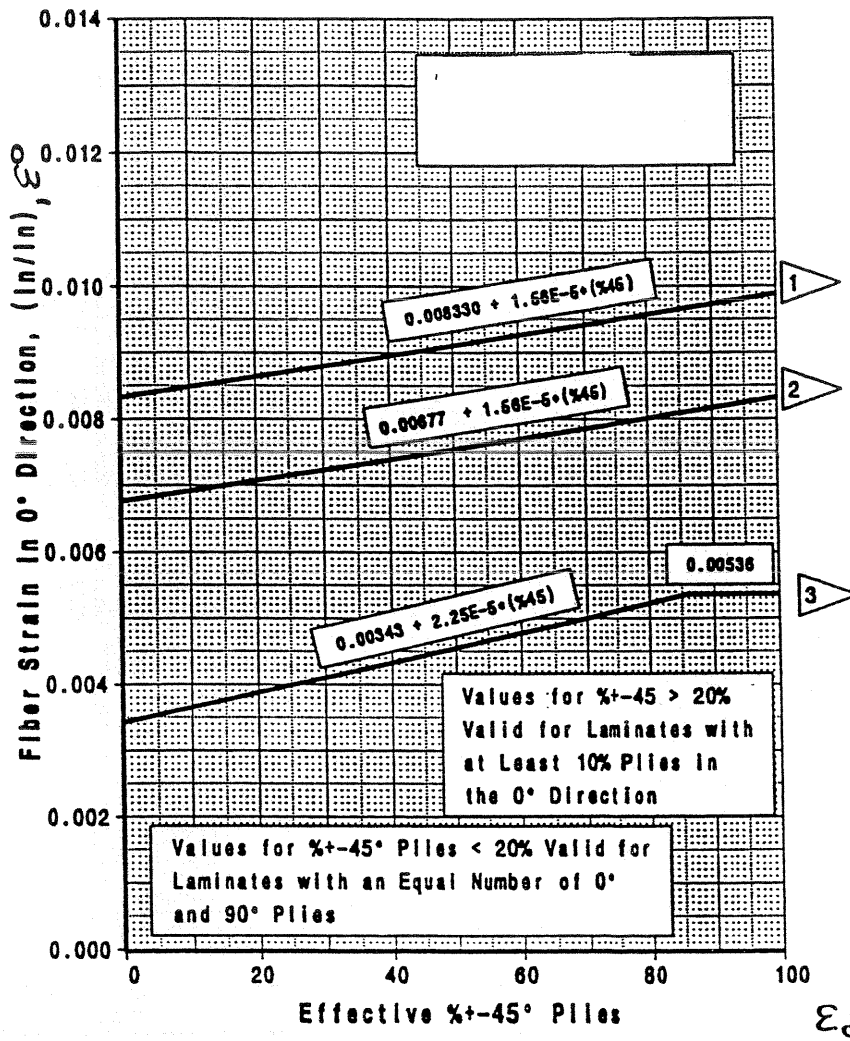
DG-100-568

Figure 2.3.2-7 E_x Tension/Compression Adjustment Factors

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4

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)



$\varepsilon_{dv} = \varepsilon^{\circ} \cdot K_{thick}$

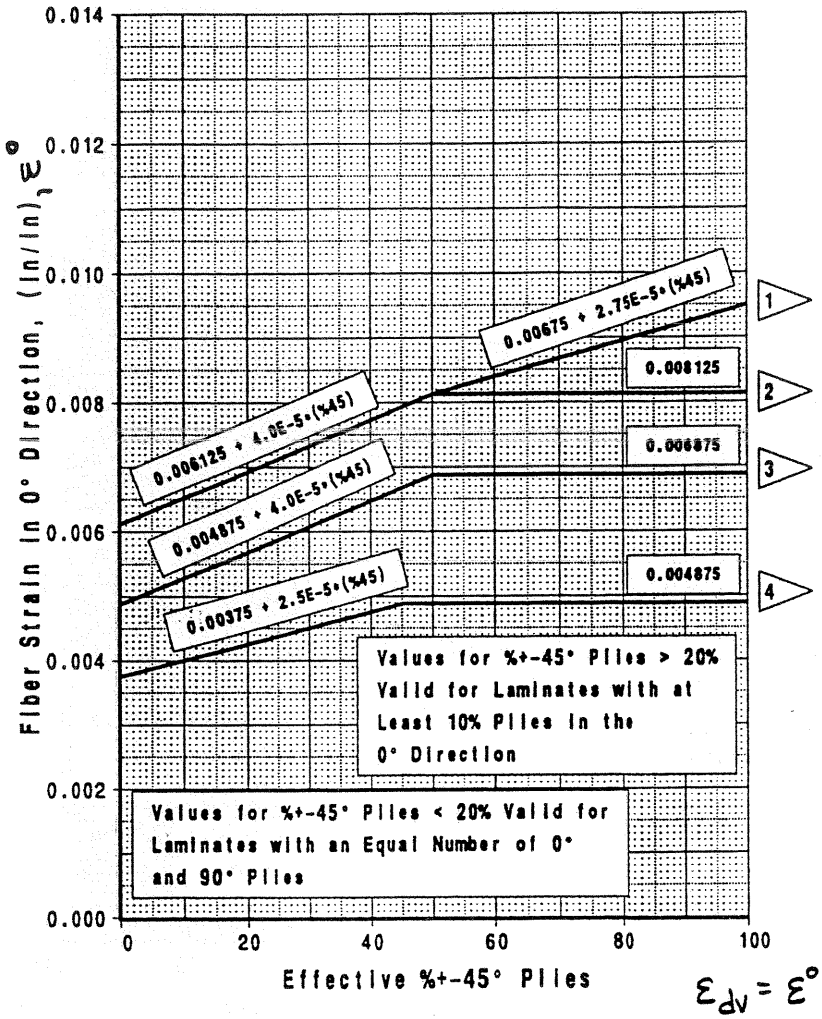
1 Peak at Stress Concentration with Bending	For thickness correction see Figure 2.3.2-14
2 Peak at: Bending or Stress Concentration Midplane	
3 Basic Cutoff at Midplane	Valid for all thicknesses

DG-100-503

Figure 2.3.2-8 Tension Design Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
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)



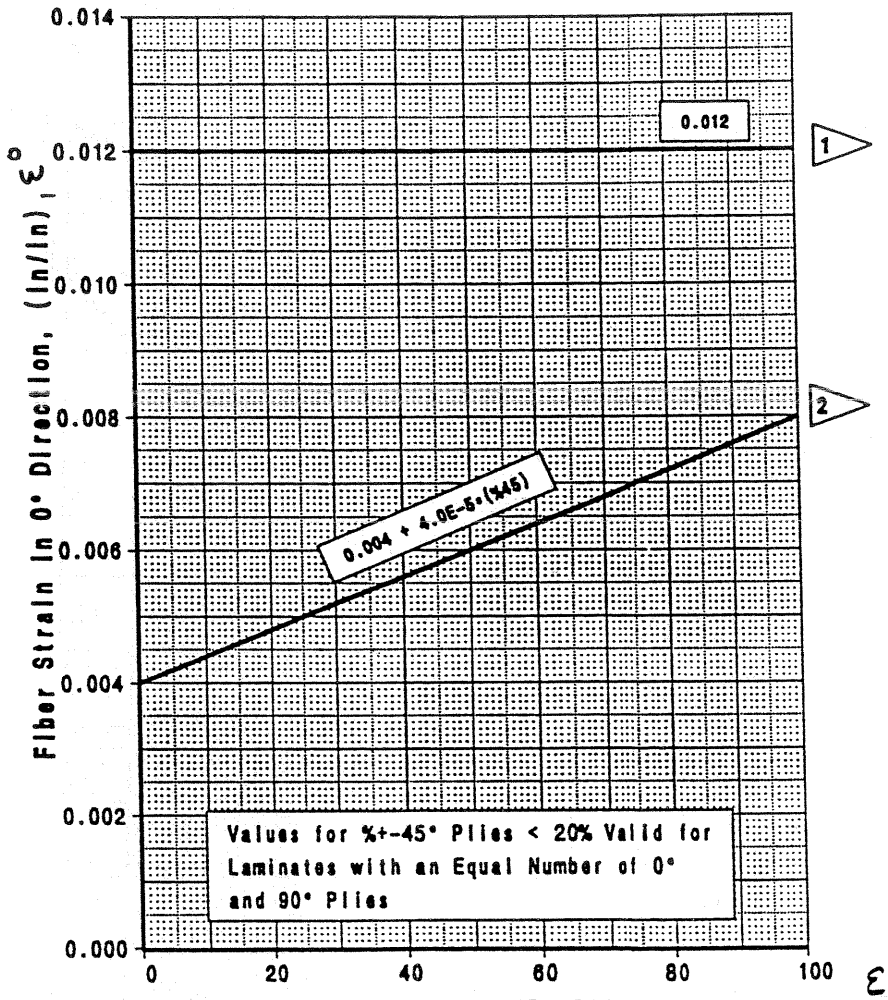
$\varepsilon_{dv} = \varepsilon^{\circ} \cdot K_{thick}$

1 Peak at Stress Concentration with Bending	For thickness correction see Figure 2.3.2-14
2 Peak at Stress Concentration Midplane	
3 Peak Bending	
4 Basic Cutoff at Midplane	Valid for all thicknesses

Figure 2.3.2-9 Compression Design Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
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)



$\varepsilon_{dv} = \varepsilon^{\circ} \cdot K_{thick}$

		For thickness correction see:
1	Unnotched	Figure 2.3.2-14
2	Open-Hole, Filled-Hole, 0.25" Dia, w/d=6.0	Figure 11.4-38

DG-100-571

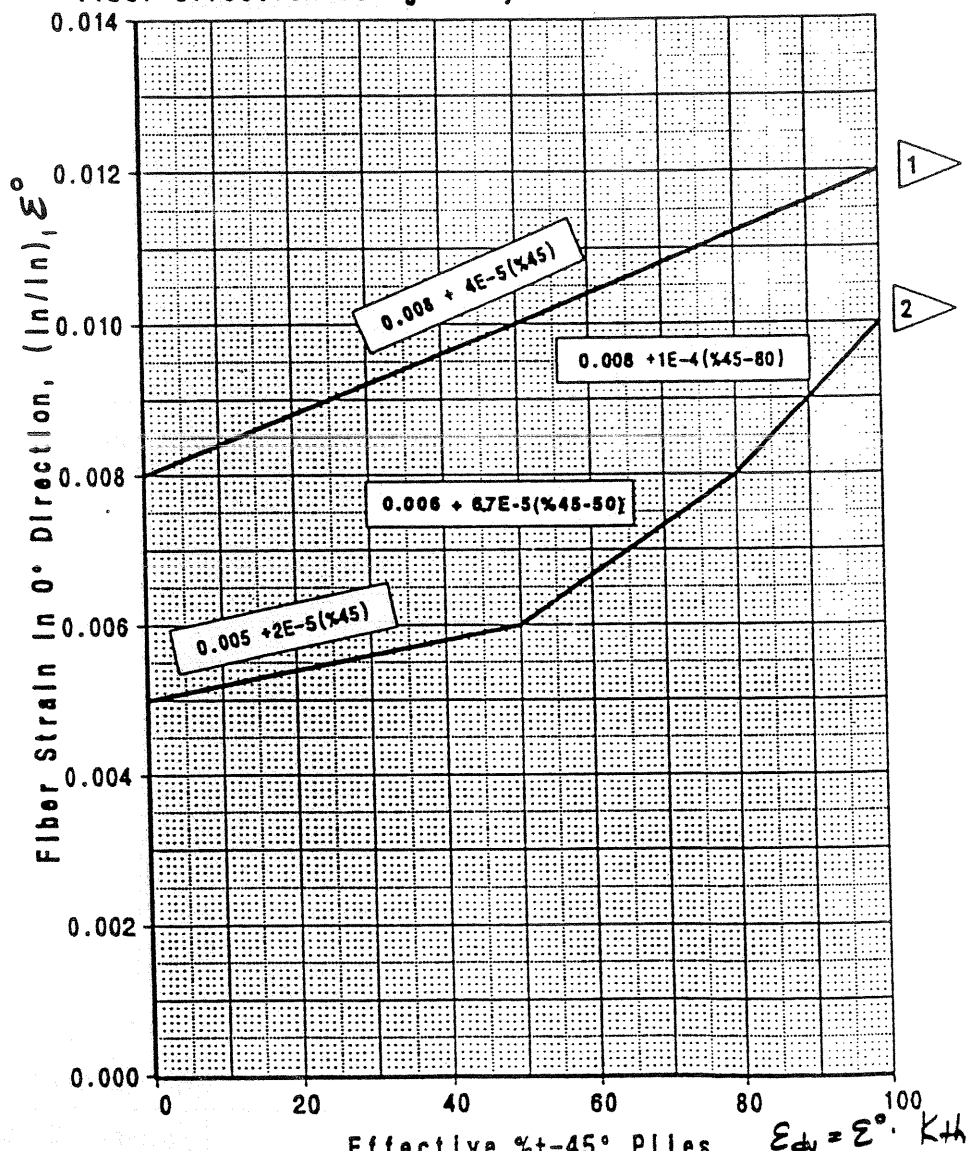
Figure 2.3.2-10 Tension Typical Values - 70°F

THE BOEING COMPANY

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4

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)



		For thickness correction see:
1	Unnotched	Figure 2.3.2-14
2	Open-Hole, 0.25" Dia, w/d=6.0	Figure 11.4-38

Figure 2.3.2-11 Compression Typical Values - 70°F DG-100-572

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

Lamina Shear Design Values

	Lamina Shear Strain
Unnotched	0.020
Open-Hole	0.015

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.

DG-100-573

Figure 2.3.2-12 Lamina Shear Values - 70°F

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	

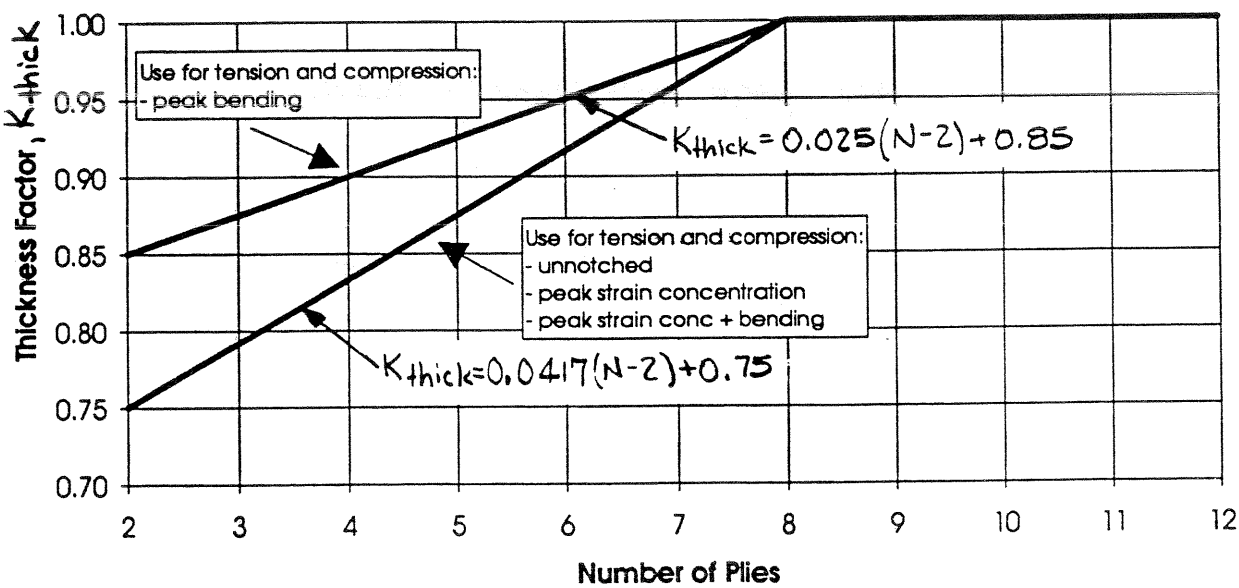
Environment	Strain Adjustment Factors (1)		
	Tension	Compression	Shear
-75F/Dry	0.90	1.20	1.20
70F/Ambient	1.00	1.00	1.00
70F/Wet	1.00	0.95	0.95
130F/Wet	0.95	0.87	0.87
160F/Wet	0.93	0.83	0.83
180F/Wet	0.91	0.80	0.80

(1) Strain factors apply to both unnotched and notched laminate strains

DG-100-574

Figure 2.3.2-13 Strength Environmental Adjustment Factors

Prepreg Material Specification:	BMS 8-256, TYPE IV, CLASS 2, STYLE 3K-70-PW
Resin Content:	40 (% WT)
Process Specification:	BAC 5317-4
70°F/DRY ENVIRONMENT, (0/±45/90) LAMINATES	



(Factor multiplied with baseline strain values)

Figure 2.3.2-14 Laminate/Facesheet Thickness Correction Factor.

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2.4 BMS 8-294

2.4.1 BMS 8-294, Form 3, Type I, Class 3, Grade 190

This specification applies to a 350°F cure epoxy resin impregnated BMS 9-9 Type II carbon fiber (average modulus range 38 to 42 msi) unidirectional tape.

Type I: 35 percent by weight resin content.
Class 3: Unidirectional prepreg tape for use with automated tape laying equipment.

Reference: D510-20056-1, "A-6 Analysis Methods and Allowables", 1/31/1986.

Contents:

Table 2.4.1-1 Ply Properties

TABLE 2.4.1-1		PLY PROPERTIES						
PREPREG MATERIAL SPECIFICATION: BMS 8-294, FORM 3, TYPE I, CLASS 3, GRADE 190,								
RESIN CONTENT: 35 (% WT)								
CURED PLY THICKNESS: .0074 (In)								
DENSITY: 0.056 lb/in^3								
PROCESS SPECIFICATION:								
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		160° F	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	21.0					
	E_2	msi			1.35			
	G_{12}	msi			.95			
	G_{13}	msi						
	G_{23}	msi						
POISSON'S RATIO	ν_{12}	----	0.33					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F						
	α_2	in/in ° F						
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 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-100-575

2.5 BMS 8-297

2.5.1 BMS 8-297, Type III, Class 1, Grade 90, 145 or 190

This specification applies to a 350°F cure epoxy resin impregnated BMS 9-8 Type I carbon fiber unidirectional tape.

Type III: 37 percent by weight resin content.
Class 1: Unidirectional prepreg tape.

Reference: D581-12004-1, "Advanced Composite Design Handbook", Boeing Military Airplanes, (B2 Program), 12/23/1988.

Contents:

Table 2.5.1-1 Ply Properties

TABLE 2.5.1-1		PLY PROPERTIES							
PREPREG MATERIAL SPECIFICATION: BMS 8-297, TYPE III, CLASS 1, GRADE 95, 145 OR 190 RESIN CONTENT: 37 (% WT) CURED PLY THICKNESS: .0039 (in) Grade 95 .0059 (in) Grade 145 .0078 (in) Grade 190 PROCESS SPECIFICATION: BAC 5597									
PROPERTY		UNIT	ENVIRONMENTAL CONDITION						
			-75° F		70° F		180° F		
			DRY	WET	DRY	WET	DRY	WET	
MODULUS ②	E_1 ①	msi	← 17.1 →						
	E_2 ①	msi	1.28		1.28			1.28	
	G_{12}	msi	.83		.60			.54	
	G_{13}	msi	.83		.60			.54	
	G_{23}	msi	.83		.60			.54	
POISSON'S RATIO	ν_{12}	----	← .34 →						
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F			X				
	α_2	in/in ° F							
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. $E_1^T = 18.0$, $E_1^C = 16.2$.

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-100-576

2.5.2 BMS 8-297, Type III, Class 2, Style 3K-135-8H

This specification applies to a 350°F cure epoxy resin impregnated BMS 9-8 Type I carbon fiber woven fabric.

Type III: 37 percent by weight resin content.
Class 2: Woven Fabric Prepreg.

Reference: D581-12004-1, "Advanced Composite Design Handbook", Boeing Military Airplanes, (B2 Program), 12/23/1988.

Contents:

Table 2.5.2-1 Ply Properties

TABLE 2.5.2-1		PLY PROPERTIES						
PREPREG MATERIAL SPECIFICATION:		BMS 8-297, TYPE III, CLASS 2, STYLE 3K-135-8H						
RESIN CONTENT:		37 (% WT)						
CURED PLY THICKNESS:		.015 (in)						
PROCESS SPECIFICATION:		BAC 5597						
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		180° F	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	9.2					
	E_2	msi	9.2					
	G_{12}	msi	.87		.70			.46
	G_{13}	msi	.87		.70			.46
	G_{23}	msi	.87		.70			.46
POISSON'S RATIO	ν_{12}	----	.06					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F			X			
	α_2	in/in ° F						
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. $E_1^T = 9.7$, $E_1^C = 8.7$.

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-100-577

2.5.3 BMS 8-297, Type IV, Class 2, Style 3K-70-PW

This specification applies to a 350°F cure epoxy resin impregnated BMS 9-8 Type I carbon fiber woven fabric.

Type IV: 40 percent by weight resin content.
Class 2: Woven Fabric Prepreg.

Reference: D581-12004-1, "Advanced Composite Design Handbook", Boeing Military Airplanes, (B2 Program), 12/23/1988.

Contents:

Table 2.5.3-1 Ply Properties

TABLE 2.5.3-1	PLY PROPERTIES
PREPREG MATERIAL SPECIFICATION:	BMS 8-297, TYPE IV, CLASS 2, STYLE 3K-70-PW
RESIN CONTENT:	40 (% WT)
CURED PLY THICKNESS:	.0083 (in)
PROCESS SPECIFICATION:	BAC 5597

PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		180° F	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	8.3					
	E_2	msi	8.3					
	G_{12}	msi	.87		.70			.46
	G_{13}	msi	.87		.70			.46
	G_{23}	msi	.87		.70			.46
POISSON'S RATIO	ν_{12}	----	.06					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F						
	α_2	in/in ° F						
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. $E_1^T = 8.7$, $E_1^C = 7.9$.

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-100-578

2.5.4 BMS 8-297, Type III, Class 2, Style 3K-70-PW

This specification applies to a 350°F cure epoxy resin impregnated BMS 9-8 Type I carbon fiber woven fabric.

Type III: 37 percent by weight resin content.
Class 2: Woven Fabric Prepreg.

Reference: D581-12004-1, "Advanced Composite Design Handbook", Boeing Military Airplanes, (B2 Program), 12/23/1988.

Contents:

Table 2.5.4-1 Ply Properties

TABLE 2.5.4-1		PLY PROPERTIES						
PREPREG MATERIAL SPECIFICATION:		BMS 8-297, TYPE III, CLASS 2, STYLE 3K-70-PW						
RESIN CONTENT:		37 (% WT)						
CURED PLY THICKNESS:		.0078 (in)						
PROCESS SPECIFICATION:		BAC 5597						
PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		180° F	
			DRY	WET	DRY	WET	DRY	WET
MODULUS ②	E_1 ①	msi	← 8.8 →					
	E_2	msi	← 8.8 →					
	G_{12}	msi	.87		.70			.46
	G_{13}	msi	.87		.70			.46
	G_{23}	msi	.87		.70			.46
POISSON'S RATIO	ν_{12}	----	← .06 →					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	in/in ° F			X			
	α_2	in/in ° F						
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. $E_1^T = 9.2$, $E_1^C = 8.4$.

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-100-579