2.7   BMS 8-79

2.7.1   BMS 8-79, Type 120 or Type 220, Class III, Grade 1

This specification applies to a low temperature cure, fire resistant, epoxy-resin-preimpregnated glass fabric to be used in structural reinforced solid glass laminates and glass laminate faced honeycomb sandwich parts using a single stage autoclave 250°F cure.

Type 120:   BMS 9-3, Type D, Style 120 Glass Fabric.
Type 220:   BMS 9-3, Type D, Style 220 Glass Fabric.

Reference: Coordination Sheet BY1HU-RAS-C91-102, "BMS 8-79 Design Values Supporting 777 Empennage Structure," 11/22/1991.
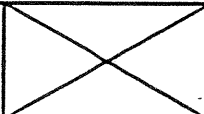
Contents:

Table 2.7.1-1   Ply Properties

Table 2.7.1-1 Ply Properties

TABLE 2.7.1-1	PLY PROPERTIES						

PREPREG MATERIAL SPECIFICATION: BMS 8-79, TYPE 120 or TYPE 220, CLASS III, GRADE I

RESIN CONTENT: 45 (% WT)

CURED PLY THICKNESS: .0045 (In)

PROCESS SPECIFICATION: BAC 5317, BAC 5574

PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		130° F	160° F
			DRY	WET	DRY	WET	WET	DRY
MODULUS ②	E_1 ①	msi	← 3.0 →					
	E_2 ①	msi	← 3.0 →					
	G_{12}	msi	0.48	0.48	0.48	0.42	0.33	0.31
	G_{13}	msi	0.48	0.48	0.48	0.42	0.33	0.31
	G_{23}	msi	0.48	0.48	0.48	0.42	0.33	0.31
POISSON'S RATIO	ν_{12}	- - - -	← .13 →					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	In/In ° F	5.5×10^{-6}		✕		5.5×10^{-6}	
	α_2	In/In ° F	5.5×10^{-6}				5.5×10^{-6}	
COEFFECIENTS OF LINEAR MOISTURE EXPANSION ④	β_1	In/In %M	N/A					
	β_2	In/In %M	N/A					
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.

DG-100-586

2.7.2   BMS 8-79, Type 1581 or 7781, Class III, Grade 1

This specification applies to a low temperature cure. fire resistant, epoxy resin preimpregnated glass fabric to be used in structural reinforced solid glass laminates and glass laminate faced honeycomb sandwich parts using a single stage autoclave 250°F cure.

Type 1581:   BMS 9-3, Type H-2, Style 181-150 Glass Fabric.
Type 7781:   BMS 9-3, Type H-3, Style 181-77 Glass Fabric

Reference: Coordination Sheet BY1HU-RAS-C91-102, "BMS 8-79   Design Values Supporting 777 Empennage Structure," 11/22/1991.
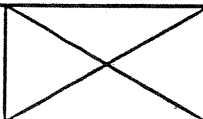
Contents:

Table 2.7.2-1   Ply Properties

THE BOEING COMPANY

Table 2.7.2-1 Ply Properties

TABLE 2.7.2-1	PLY PROPERTIES

PREPREG MATERIAL SPECIFICATION: BMS 8-79, TYPE 1581 or 7781, CLASS III, GRADE I,

RESIN CONTENT: 38 (% WT)

CURED PLY THICKNESS: .0095 (In)

PROCESS SPECIFICATION: BAC 5317, BAC 5574

PROPERTY		UNIT	ENVIRONMENTAL CONDITION					
			-75° F		70° F		130° F	160° F
			DRY	WET	DRY	WET	WET	DRY
MODULUS ②	E_1 ①	msi	3.5					
	E_2 ①	msi	3.5					
	G_{12}	msi	0.55	0.55	0.55	0.48	0.38	0.36
	G_{13}	msi	0.55	0.55	0.55	0.48	0.38	0.36
	G_{23}	msi	0.55	0.55	0.55	0.48	0.38	0.36
POISSON'S RATIO	ν_{12}	----	.11					
COEFFICIENTS OF LINEAR THERMAL EXPANSION ③	α_1	In/in ° F	5.5×10^{-6}		✕		5.5×10^{-6}	
	α_2	In/in ° F	5.5×10^{-6}				5.5×10^{-6}	
COEFFECIENTS OF LINEAR MOISTURE EXPANSION ④	β_1	In/in %M	N/A					
	β_2	In/in %M	N/A					
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.

DG-100-587

<div style="border:1px solid black; display:inline-block;">

BMS 8-79 FIBERGLASS
PRELIMINARY
DESIGN VALUES

</div>

TYPICAL PLY PROPERTIES

Numbers given are input values for a classical laminate plate theory (CLPT)
program used to generate tension, compression, or shear modulus and
Poisson's ratio curves.

PLY PROPERTIES at Room Temperature	Class III, Grade 1 TYPE 120	Class III, Grade 1 TYPE 1581/7781
AVERAGE MODULUS* (MSI)	3.0	3.5
SHEAR MODULUS (MSI)	0.48	0.55
POISSON'S RATIO	0.13	0.11

* Compression Modulus = Average Modulus

NOTE: Ply properties at various environmental conditions remain the same as
room temperature except shear modulus. Use the below graph to adjust shear
modulus for environmental conditions, input new value into CLPT, and generate
a new set of laminate property curves.

DRY: $CT = 0.962 + 2.59E\text{-}3*T - 2.77E\text{-}5*T^2$
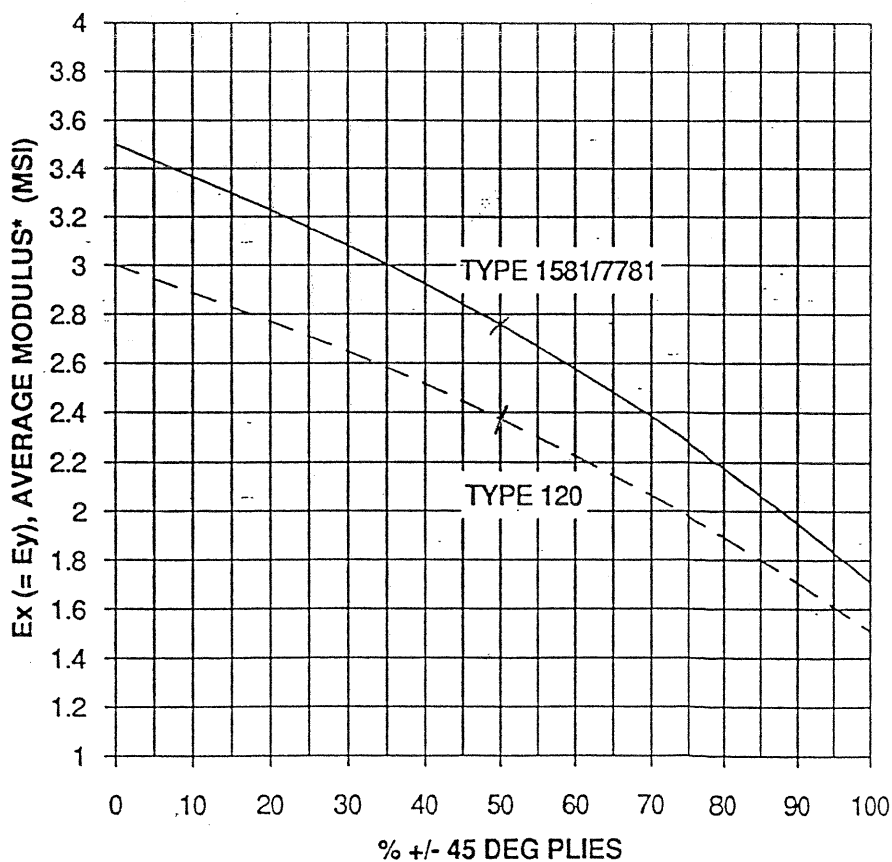
WET: $CT = 0.832 + 2.59E\text{-}3*T - 2.77E\text{-}5*T^2$
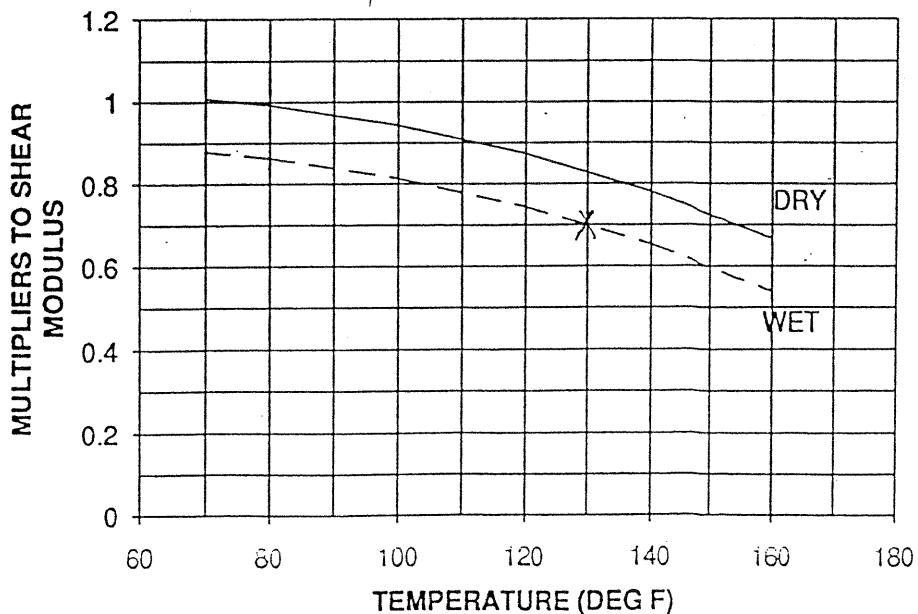
BMS 8-79 FIBERGLASS
PRELIMINARY
DESIGN VALUES

LAMINATE AVERAGE MODULUS
TYPICAL VALUES
CLASS III, GRADE 1, TYPE120 AND/OR 1581/7781
ROOM TEMPERATURE AMBIENT (RTA)

TYPE 120: $Ex = Ey = 3.00 - 1.11E\text{-}2^*(\%45'S) - 2.15E\text{-}5^*(\%45'S)^\wedge2 - 1.76E\text{-}7^*(\%45'S)^\wedge3$

TYPE 1581/7781: $Ex = Ey = 3.50 - 1.29E\text{-}2^*(\%45'S) - 2.87E\text{-}5^*(\%45'S)^\wedge2 - 2.12E\text{-}7^*(\%45'S)^\wedge3$

* Compression Modulus = Average Modulus

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┌─────────────────────────┐
│   BMS 8-79 FIBERGLASS   │
│      PRELIMINARY        │
│     DESIGN VALUES       │
└─────────────────────────┘
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LAMINATE SHEAR MODULUS
TYPICAL VALUES
CLASS III, GRADE 1, TYPE120 AND/OR 1581/7781
ROOM TEMPERATURE AMBIENT (RTA)

TYPE 120: $Gxy = 0.48 + 8.47E\text{-}3*(\%45'S) + 2.53E\text{-}7*(\%45'S)^\wedge 2 - 2.05E\text{-}9*(\%45'S)^\wedge 3$

TYPE 1581/7781: $Gxy = 0.55 + 1.03E\text{-}2*(\%45'S) - 1.90E\text{-}7*(\%45'S)^\wedge 2 + 1.29E\text{-}9*(\%45'S)^\wedge 3$

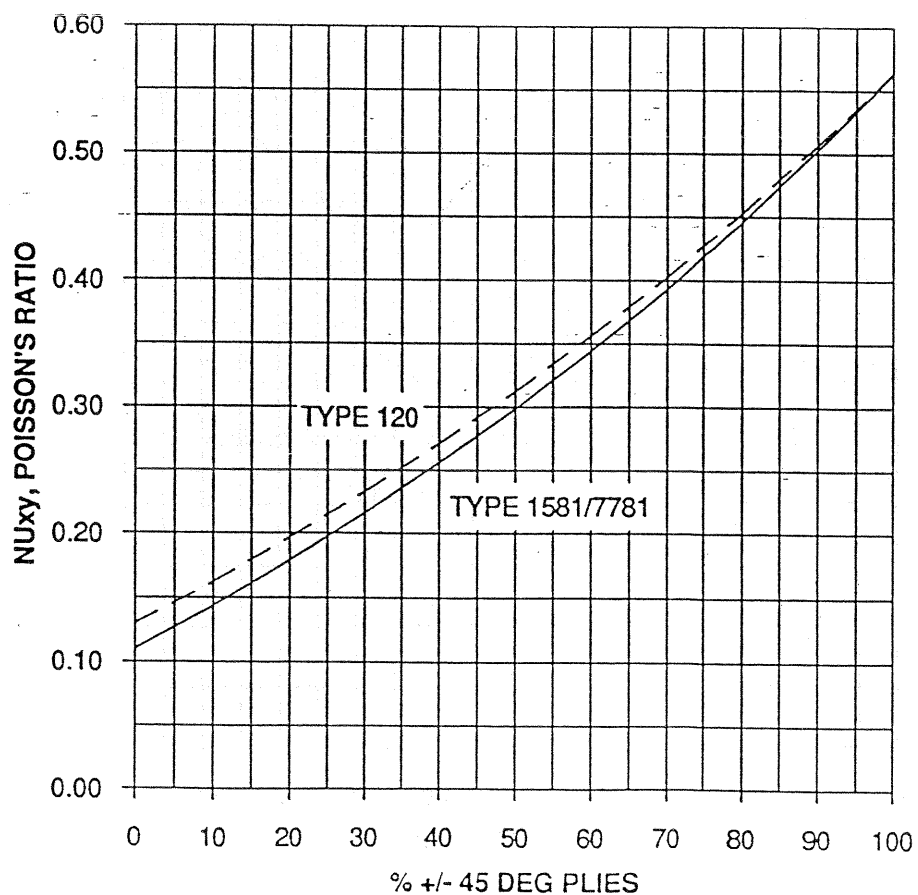<div style="border: 1px solid black; text-align: center;">
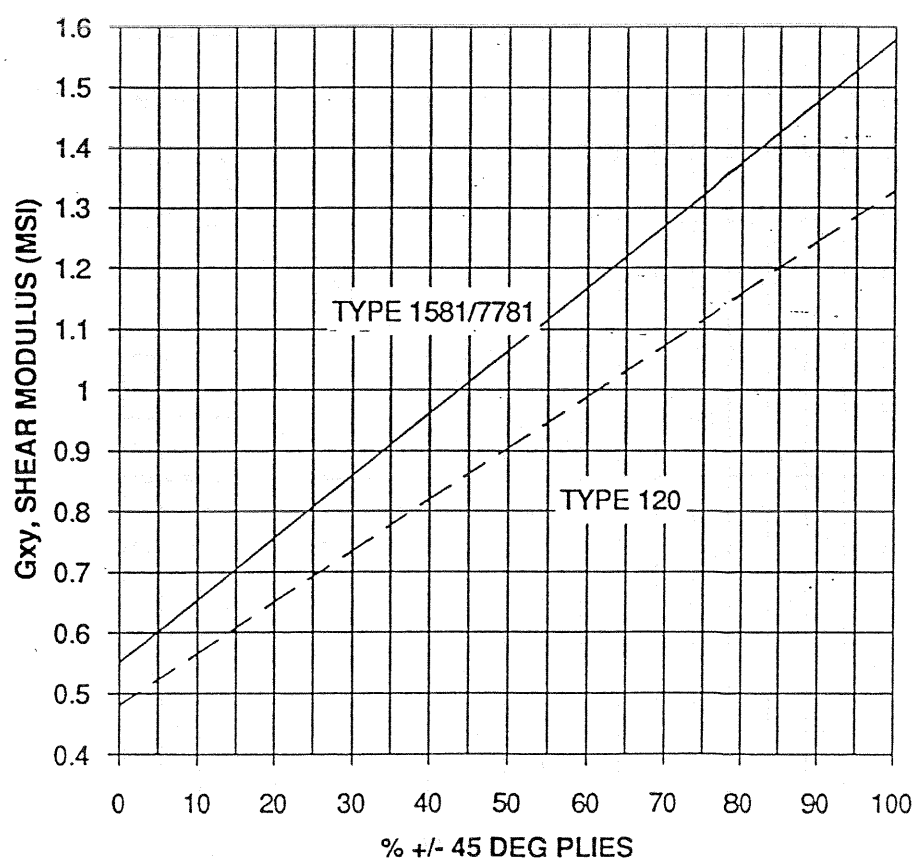
BMS 8-79 FIBERGLASS
PRELIMINARY
DESIGN VALUES

</div>

LAMINATE POISSON'S RATIO
TYPICAL VALUES
CLASS III, GRADE 1, TYPE120 AND/OR 1581/7781
ROOM TEMPERATURE AMBIENT (RTA)

TYPE 120: $NUxy = 0.13 + 3.15E\text{-}3*(\%45'S) + 7.79E\text{-}6*(\%45'S)^2 + 4.10E\text{-}8*(\%45'S)^3$

TYPE 1581/7781: $NUxy = 0.11 + 3.27E\text{-}3*(\%45'S) + 7.23E\text{-}6*(\%45'S)^2 + 5.41E\text{-}8*(\%45'S)^3$
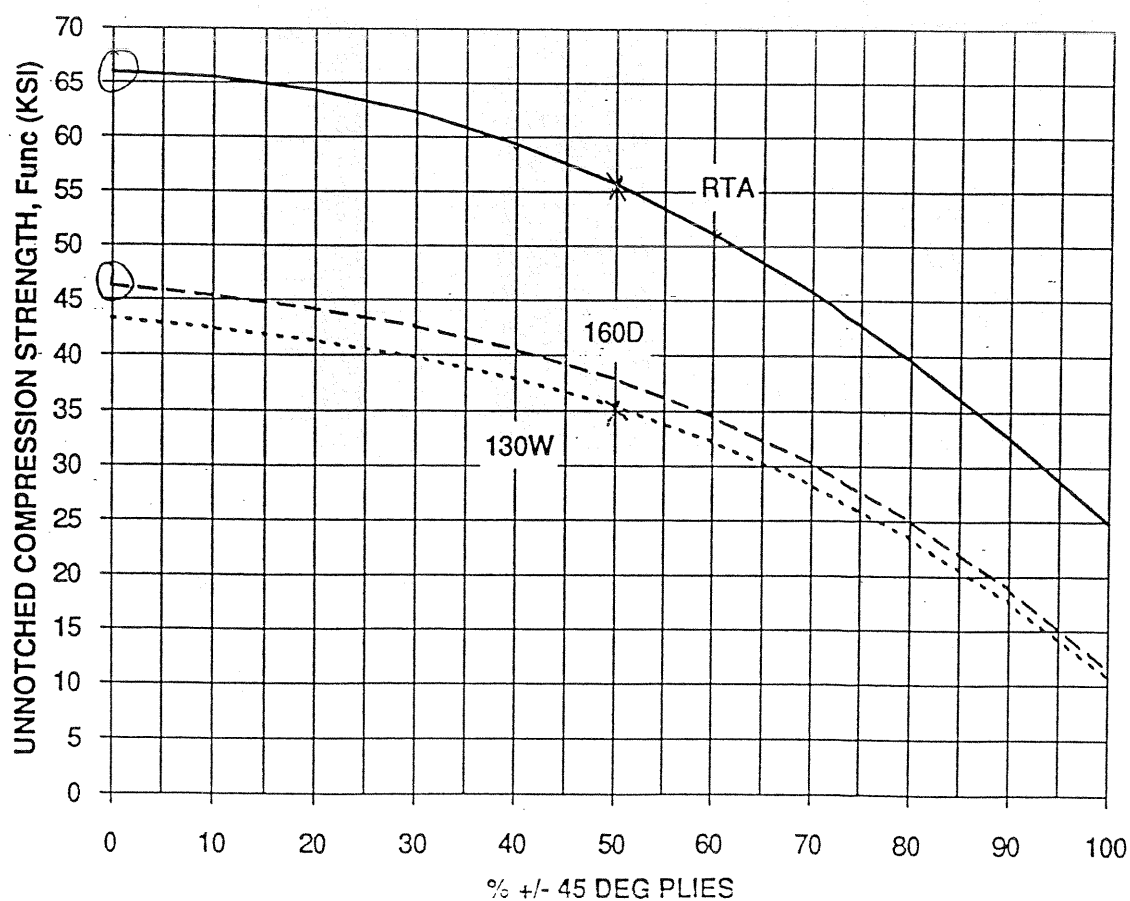
BMS 8-79 FIBERGLASS PRELIMINARY DESIGN VALUES

UNNOTCHED COMPRESSION STRENGTH
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 120 AND/OR 1581/7781

ROOM TEMP/AMBIENT: $Func = 65.96 - 4.11E\text{-}3*(\%45\text{'s})^2$

130 deg F/ WET: $Func = 43.27 - 7.85E\text{-}2*(\%45\text{'s}) - 6.77E\text{-}4*(\%45\text{'s})^2 - 1.80E\text{-}5*(\%45\text{'s})^3$

160 deg F/DRY: $Func = 46.28 - 8.39E\text{-}2*(\%45\text{'s}) - 7.24E\text{-}4*(\%45\text{'s})^2 - 1.93E\text{-}5*(\%45\text{'s})^3$

BMS 8-79 FIBERGLASS
PRELIMINARY
DESIGN VALUES

OPEN HOLE COMPRESSION
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781

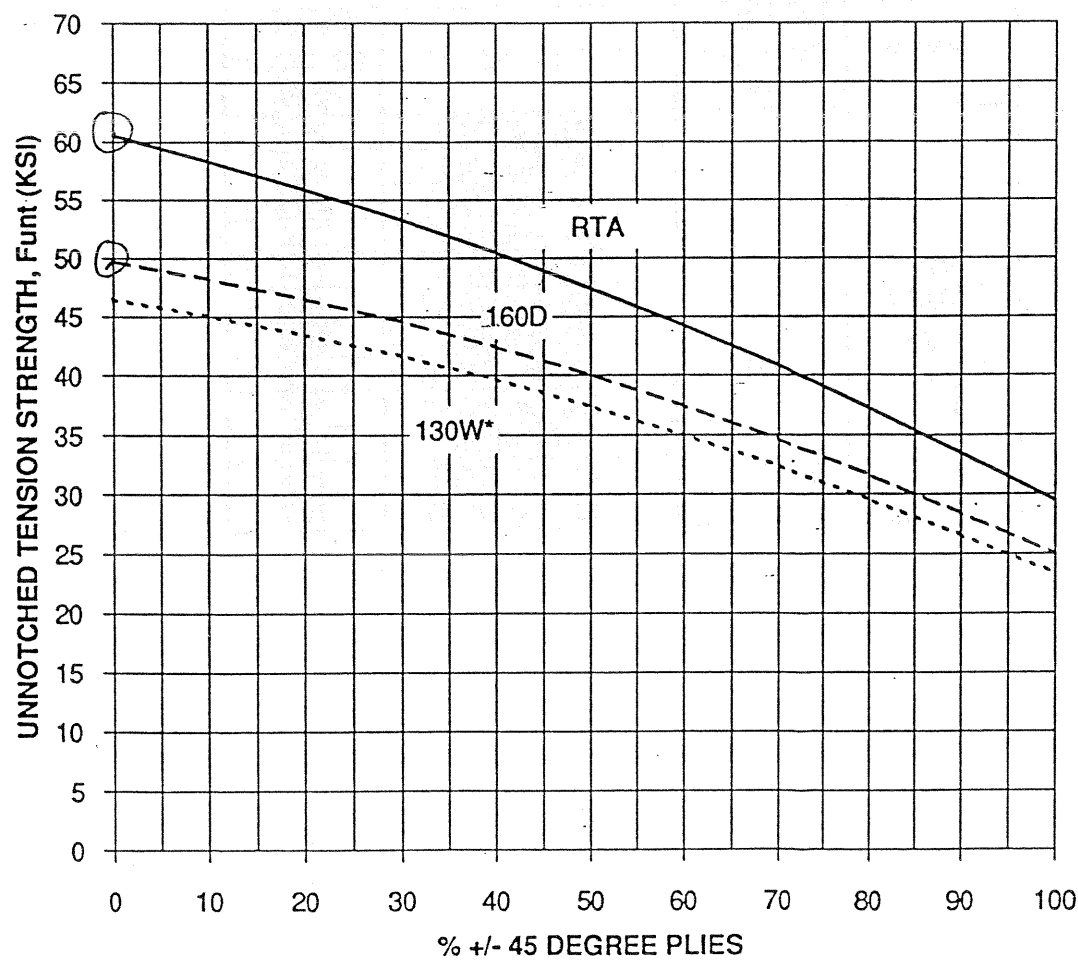| LAYUP	HOLE DIAMETER (IN)	ENVIRONMENT	B-BASIS ESTIMATE (KSI)
ALL LAYUPS	1/4"	RT/AMBIENT	30.3
		130 deg F/WET	22
		160 deg F/DRY	23.3
	1/4" CSK	RT/AMBIENT	24.6
		130 deg F/WET	15.5
		160 deg F/DRY	16.7
	3/16"	RT/AMBIENT	34.6
		130 deg F/WET	24.5
		160 deg F/DRY	25.8
	3/16" CSK	RT/AMBIENT	28.4
		130 deg F/WET	17.9
		160 deg F/DRY	19.3

How Much Data ?

3/16   34.6   28.4

1/4   30.3   24.6

BMS 8-79 FIBERGLASS
PRELIMINARY
DESIGN VALUES

UNNOTCHED TENSION STRENGTH
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781

ROOM TEMP/AMBIENT: $F_{unt} = 60.52 - 2.13\text{E-}1*(\%45\text{'s}) - 9.69\text{E-}4*(\%45\text{'s})^2$

130 deg F/WET: $F_{unt} = 46.45 - 1.31\text{E-}1*(\%45\text{'s}) - 1.01\text{E-}3*(\%45\text{'s})^2$

160 deg F/DRY: $F_{unt} = 49.73 - 1.40\text{E-}1*(\%45\text{'s}) - 1.08\text{E-}3*(\%45\text{'s})^2$

* 130 deg/WET curve based on expected behavoir of material

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┌─────────────────────┐
│  BMS 8-79 FIBERGLASS │
│     PRELIMINARY      │
│   DESIGN VALUES      │
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FILLED HOLE TENSION
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781

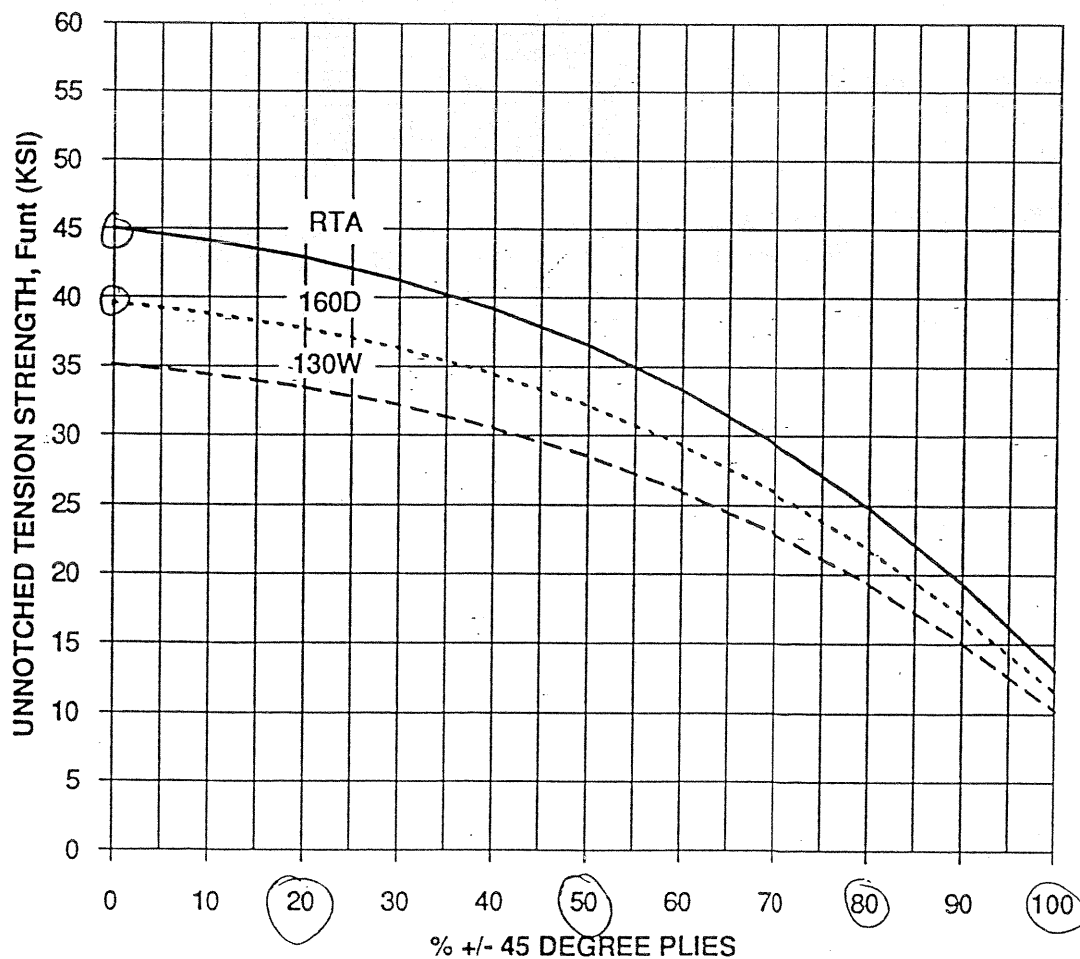| LAYUP	FASTENER DIAMETER (IN)	ENVIRONMENT	B-BASIS ESTIMATE (KSI)
ALL LAYUPS	1/4"	RT/AMBIENT	28.7
		130 deg F/WET	22.7
		160 deg F/DRY	24.1
	1/4" CSK	RT/AMBIENT	22.0
		130 deg F/WET	17.4
		160 deg F/DRY	18.5
	3/16"	RT/AMBIENT	30.6
		130 deg F/WET	24.2
		160 deg F/DRY	25.7
	3/16" CSK	RT/AMBIENT	23.5
		130 deg F/WET	18.6
		160 deg F/DRY	19.7

BMS 8-79 FIBERGLASS PRELIMINARY DESIGN VALUES

UNNOTCHED TENSION STRENGTH
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 120

ROOM TEMP/AMBIENT: $Funt = 45.00 - 7.43E\text{-}2*(\%45\text{'s}) - 1.35E\text{-}3*(\%45\text{'s})^2 - 1.10E\text{-}5*(\%45\text{'s})^3$

130 deg F/WET: $Funt = 34.10 - 5.80E\text{-}2*(\%45\text{'s}) - 1.05E\text{-}3*(\%45\text{'s})^2 - 8.58E\text{-}6*(\%45\text{'s})^3$

160 deg F/DRY: $Funt = 39.60 - 6.54E\text{-}2*(\%45\text{'s}) - 1.19E\text{-}3*(\%45\text{'s})^2 - 9.68E\text{-}6*(\%45\text{'s})^3$

low ?

Chart: UNNOTCHED TENSION STRENGTH, Funt (KSI) vs % +/- 45 DEGREE PLIES, with curves labeled RTA, 160D, 130W.

| BMS 8-79 FIBERGLASS |
| PRELIMINARY |
| DESIGN VALUES |

SINGLE SHEAR JOINT STRENGTH* ~ APPARENT BEARING STRONGH ($\frac{P}{DX}$)
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781

LAYUP**	FASTENER CONFIGURATION (ALL 3/16" DIA)	ENVIRONMENT	B-BASIS ESTIMATE (KSI)
25/50/25	100 deg TENSION w/ 1/4" GROMMET	RT/AMBIENT	74.3
		130 deg F/WET	58.1
		160 deg F/WET	52.7
		160 deg F/DRY	65.0
25/50/25	100 deg SHEAR	RT/AMBIENT	79.2
		130 deg F/WET	64.4
		160 deg F/WET	60.9
		160 deg F/DRY	63.5

* Test Conditions: Edge Stabilized, e/D = 2.5, w/D = 5.0, Thickness = 0.114"
Strap Material: 7075-T73 Aluminum, Thickness = 0.125"

** Layup: (%0's, %45's, %90's)
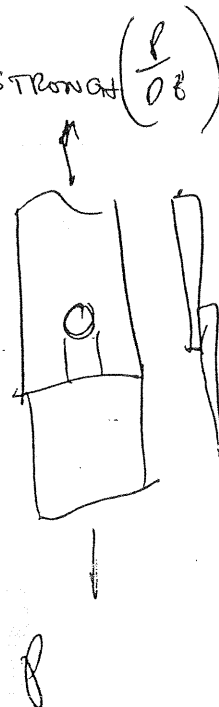
BMS 8-79 FIBERGLASS PRELIMINARY DESIGN VALUES

FASTENER PULL THROUGH
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781

LAYUP*	THICKNESS (IN)	FASTENER CONFIGURATION (ALL 3/16" DIA)	ENVIRONMENT	B-BASIS ESTIMATE (LBS)
25/50/25	0.114	100 deg TENSION w/ 1/4" GROMMET	RT/AMBIENT	923
25/50/25	0.114	100 deg SHEAR	RT/AMBIENT	808
10/80/10	0.095	100 deg SHEAR	RT/AMBIENT	542

* Layup: (%0's, %45's, %90's)

INTERLAMINAR SHEAR
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781

LAYUP*	THICKNESS (IN)	ENVIRONMENT	B-BASIS ESTIMATE (KSI)
50/0/50	0.114	-75 deg F/DRY	9.12
		RT/AMBIENT	6.38
		160 deg F/DRY	4.76

* Layup: (%0's, %45's, %90's)

BMS 8-79 FIBERGLASS
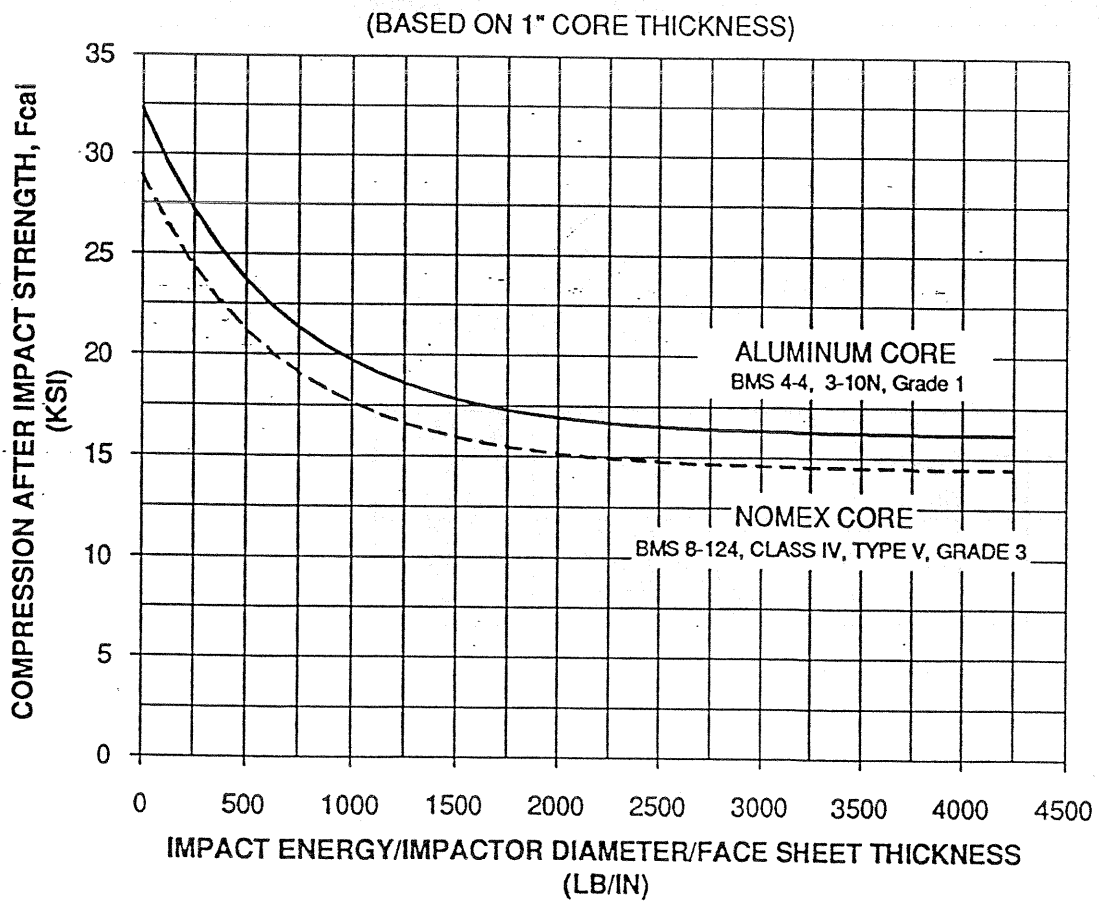## PRELIMINARY
DESIGN VALUES

SANDWICH, COMPRESSION AFTER IMPACT STRENGTH
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781
ROOM TEMPERATURE AMBIENT (RTA)

ALUMINUM CORE (WITH or WITHOUT ADHESIVE): $F_{cai} = 16.1*(1 + EXP(-.0015*X))$

NOMEX CORE: $F_{cai} = 14.4*(1+EXP(-.0015*X))$

X-AXIS = IMPACT ENERGY/IMPACTOR DIAMETER/FACE SHEET THICKNESS

130 deg F/ WET and/or 160 deg F/DRY: MULTIPLY RTA STRENGTH BY 0.85

(BASED ON 1" CORE THICKNESS)

Y-axis: COMPRESSION AFTER IMPACT STRENGTH, F_{cai} (KSI)

ALUMINUM CORE
BMS 4-4, 3-10N, Grade 1

NOMEX CORE
BMS 8-124, CLASS IV, TYPE V, GRADE 3

X-axis: IMPACT ENERGY/IMPACTOR DIAMETER/FACE SHEET THICKNESS (LB/IN)

NOTE: For aluminum core, visible damage occurs at very low impact levels when compared to nomex core.

BMS 8-79 FIBERGLASS PRELIMINARY DESIGN VALUES

ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 1581/7781 FACESHEETS

SANDWICH, SHORT BEAM SHEAR
(Based on Core 1" Thick)

CORE	ENVIRONMENT	B-BASIS ESTIMATE (psi)
NOMEX BMS 8-124, Class IV, Type V, Grade 3	RT/AMBIENT	120
	160 deg F/DRY	116
ALUMINUM* BMS 4-4, 3-10N, Grade 1	RT/AMBIENT	147
	160 deg F/DRY	130

*Applicable with or without Adhesive

SANDWICH, FLATWISE COMPRESSION
(Based on Core 1" Thick)

CORE	ENVIRONMENT	B-BASIS ESTIMATE (psi)
NOMEX BMS 8-124, Class IV, TypeV, Grade 3	RT/AMBIENT	290
	160 deg F/DRY	284
ALUMINUM* BMS 4-4, 3-10N, Grade 1	RT/AMBIENT	237
	160 deg F/DRY	230

* Applicable with or without Adhesive

SANDWICH, FLATWISE TENSION
(Based on Core 1" Thick)

CORE	ENVIRONMENT	B-BASIS ESTIMATE (psi)
NOMEX BMS 8-124, Class IV, TypeV, Grade 3	RT/AMBIENT	305
	160 deg F/DRY	302
ALUMINUM* BMS 4-4, 3-10N, Grade 1	RT/AMBIENT	640
	160 deg F/DRY	588

*Applicable with or without Adhesive

BMS 8-79 FIBERGLASS
PRELIMINARY
DESIGN VALUES

SANDWICH FACESHEET
COMPRESSION STRENGTH
ESTIMATED B-BASIS DESIGN VALUES
CLASS III, GRADE 1, TYPE 120 AND/OR 1581/7781

LAYUP*	# OF FACESHEET PLIES	ENVIRONMENT	B-BASIS ESTIMATE (KSI)
30/40/30	5	RT/AMBIENT	29.60
		130 deg F/WET	23.10
		160 deg F/DRY	23.70
20/60/20	5	RT/AMBIENT	24.50
		130 deg F/WET	19.10
		160 deg F/DRY	19.60

* Layup: (%0's, %45's, %90's)

SANDWICH FACESHEET
TENSION STRENGTH
ESTIMATED B-BASIS DESIGN VALUES

LAYUP*	# OF FACESHEET PLIES	ENVIRONMENT	B-BASIS ESTIMATE (KSI) CLASS III, GRADE 1	
			TYPE 120	TYPE 1581/7780
30/40/30	5	RT/AMBIENT	31.70	38.04
		130 deg F/WET	24.40	29.28
		160 deg F/DRY	27.90	33.48
20/60/20	5	RT/AMBIENT	29.90	35.88
		130 deg F/WET	23.00	27.60
		160 deg F/DRY	26.30	31.56

* Layup: (%0's, %45's, %90's)