



# Advanced General Aviation Transport Experiments

## B – Basis Design Allowables for Epoxy – Based Prepreg

### 3M S-Glass Unitape S2/SP381

***AGATE-WP3.3-033051-099***

**September 2001**

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## 1.0 INTRODUCTION

### 1.1 Scope

The Advanced General Aviation Transport Experiments (AGATE) consortium is an industry-university-government partnership initiated by NASA to create the technological basis for revitalization of the United States general aviation industry. It was founded in 1994 to develop affordable new technology as well as the industrial standards and certification methods for composite airframe, cockpit, flight systems and airspace infrastructure for Federal Aviation Regulations (FAR) Part 23 aircraft. The composite material properties contained within the document were generated under Work Package 3 : Integrated Design and Manufacturing Methods.

Although AGATE was focused towards the small general aviation aircraft (Part 23), the test methods and results contained in this document are consistent with MIL-HDBK-17-1E,2D,3E - Military Handbook for Polymer Matrix Composites. All material, specimens, fixtures and test results contained within this document were traceable and conformed by the Federal Aviation Administration (FAA) as part of the AGATE effort. It should be noted that before application of the basis values presented in this document to design, demonstration of the ability to consistently produce equivalent material properties as that evaluated during this program should be substantiated through an acceptable test program.

The test methods and results described in this document are intended to provide basic composite properties essential to most methods of analysis. These properties are considered to provide the initial base of the "building block" approach. Additional coupon level tests and subelement tests may be required to fully substantiate the full-scale design.

## 1.2 Symbols Used

$\nu_{12}^{tu}$	major Poisson's ratio, tension
$\mu\epsilon$	micro-strain
$E_1^c$	compressive modulus, longitudinal
$E_1^t$	tensile modulus, longitudinal
$E_2^c$	compressive modulus, transverse
$E_2^t$	tensile modulus, transverse
$F_{12}^{su}$	in – plane shear strength
$F_{13}^{su}$	apparent interlaminar shear strength
$F_1^{cu}$	compressive strength, longitudinal
$F_1^{tu}$	tensile strength, longitudinal
$F_2^{cu}$	compressive strength, transverse
$F_2^{tu}$	tensile strength, transverse
$G_{12}^s$	in – plane shear modulus

### Superscripts

c	compression
cu	compression ultimate
s	shear
su	shear ultimate
t	tension
tu	tension ultimate

### Subscripts

1	1 – axis; longitudinal (parallel to warp direction of reinforcement)
2	2 – axis; transverse (parallel to fill direction of reinforcement)
12	in – plane shear
13	interlaminar shear (apparent)

### 1.3 Acronyms and Definitions

A – Basis	95% lower confidence limit on the first population percentile
AGATE	Advanced General Aviation Transport Experiments
ASTM	American Society for Testing and Materials
B – Basis	95% lower confidence limit on the tenth population percentile
C. V.	coefficient of variation
CTD	cold temperature dry
CPT	cured ply thickness
DMA	dynamic mechanical analysis
dry	specimen tested with an “as fabricated” moisture content
ETD	elevated temperature dry
ETW	elevated temperature wet
FAR	Federal Aviation Regulations
FAW	fiber areal weight
GI/Ep	Glass-Epoxy
NASA	National Aeronautics and Space Administration
RTD	room temperature dry
SACMA	Suppliers of Advanced Composite Materials Association
SRM	SACMA Recommended Method
$T_g$	glass transition temperature
$t_{ply}$	cured ply thickness
wet	specimen tested with an equilibrium moisture content per section 1.5.2

## 1.4 References

### ASTM Standards

D3039-95	Tensile Properties of Polymer Matrix Composite Materials
D5379-93	Shear Properties of Composite Materials by the V-Notched Beam Method
D2344-89	Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short – Beam Method
D792-91	Density and Specific Gravity (Relative Density) of Plastics by Displacement
D2584-94	Ignition Loss of Cured Reinforced Plastics
D2734-94	Void Content of Reinforced Plastics
D695-91	Compressive Properties of Rigid Plastics

### SACMA Standards

SRM 1-94	Compressive Properties of Oriented Fiber-Resin Composites
SRM 8-94	Short Beam Shear Strength of Oriented Fiber-Resin Composites
SRM 18-94	Glass Transition Temperature ( $T_g$ ) Determination by DMA of Oriented Fiber-Resin Composites

### Other Documents

FAA Document DOT/FAA/AR-00/47: Material Qualification and Equivalency for Polymer Matrix Composite Material Systems, J.S. Tomblin, Y.C. Ng and K.S. Raju, 2001.

MIL-HDBK-17 1E, 2D, 3E – Military Handbook for Polymer Matrix Composites

Cirrus Design Corporation: Material Properties Test Plan, February 1997.

## 1.5 Methodology

### 1.5.1 Test Matrix

Testing was performed according to the test methods delineated in the test matrix, with modifications as referenced in the AGATE report, *Material Qualification and Equivalency for Polymer Matrix Composite Material Systems*. The test matrix for properties included in this document is listed on the next page, with the following notation cited in each column:

**# x #**

where the first # represents the required number of prepreg batches, defined as: Prepreg containing 3M S2 Glass fibers from one mill roll, impregnated with one batch of resin in one continuous manufacturing operation with traceability to all components. The second # represents the required number of replicates per prepreg batch. For example, “3 x 6” refers to three prepreg batches of material and six specimens per prepreg batch for a total requirement of 18 test specimens.

**Table 1.5.1: Test Matrix and Standards Used**

TEST	METHOD	NO. OF REPLICATES PER TEST CONDITION				
		CTD <sup>1</sup>	RTD <sup>2</sup>	ETW <sup>3</sup>	ETW <sup>4</sup>	ETD <sup>5</sup>
0° (warp) Tension Strength	ASTM D3039-95	1x3	5x8	5x8	3x4	3x4
0° (warp) Tension Modulus, Strength and Poisson's Ratio	ASTM D3039-95	1x3	5x3	5x3	3x2	3x2
90° (fill) Tension Strength	ASTM D3039-95	---	1x8	1x8	3x4	3x4
90° (fill) Tension Modulus and Strength	ASTM D3039-95	---	1x3	1x3	3x2	3x2
0° (warp) Compression Strength	SACMA SRM 1-94	1x6	5x11	5x11	3x6	3x6
0° (warp) Compression Modulus	SACMA SRM 1-94	---	1x11	1x11	3x2	3x2
90° (fill) Compression Strength	SACMA SRM 1-94	---	1x11	1x11	3x6	3x6
90° (fill) Compression Modulus	SACMA SRM 1-94	---	1x11	1x11	3x2	3x2
In-Plane Shear Strength	ASTM D5379-93	1x4	5x8	5x8	3x4	3x4
In-Plane Shear Modulus and Strength	ASTM D5379-93	1x2	5x3	5x3	3x2	3x2
Short Beam Shear	ASTM D2344-89	--	3x6	---	--	--
Fiber Volume	ASTM D2584-94	One sample per panel				
Resin Volume	ASTM D2584-94	One sample per panel				
Void Content	ASTM D2734-94	One sample per panel				
Cured Neat Resin Density	---	Supplied by manufacturer for material				
Glass Transition Temperature	SACMA SRM 18-94	1 x 5 dry, 1 x 5 wet				

**Notes :**

- 1 CTD: One prepreg lot of material tested (test temperature =  $-65 \pm 5^{\circ}$  F, moisture content = as fabricated, soak time at  $-65$  was 3 min.)
- 2 RTD: Three prepreg lots of material tested (test temperature =  $70 \pm 10^{\circ}$  F, moisture content = as fabricated)
- 3 ETW: Three prepreg lots of material tested (test temperature =  $150 \pm 5^{\circ}$  F, moisture content = equilibrium per section 1.5.2, soak time at 150 was 60 sec.)
- 4 ETW: Three prepreg lots of material tested (test temperature =  $180 \pm 5^{\circ}$  F, moisture content = as fabricated, soak time at 180 was 2-3 min.)
- 5 ETD: Three prepreg lots of material tested (test temperature =  $150 \pm 5^{\circ}$  F, moisture content = as fabricated, soak time at 150 was 2-3 min.)

## 1.5.2 Environmental Conditioning

All 'wet' conditioned samples were exposed to elevated temperature and humidity conditions to establish moisture saturation of the material. Specimens were exposed to  $85 \pm 5$  % relative humidity and  $145 \pm 5$  °F until an equilibrium moisture weight gain of traveler, or witness coupons (1" x 1" x specimen thickness) was achieved. ASTM D5229 and SACMA SRM 11 were used as guidelines for environmental conditioning and moisture absorption.

Effective moisture equilibrium was achieved when the average moisture content of the traveler specimen changed by less than 0.05% for two consecutive readings within a span of  $7 \pm 0.5$  days and was expressed by:

$$\frac{W_i - W_{i-1}}{W_b} < 0.0005$$

where  $W_i$  = weight at current time  
 $W_{i-1}$  = weight at previous time  
 $W_b$  = baseline weight prior to conditioning

It is common to see small fluctuations in an unfitted plot of the weight gain vs. time curve. There were no fluctuations that made significant errors in results or caused rejection in the moisture equilibrium criteria. Once the traveler coupons passed the criteria for two consecutive readings, the samples were removed from the environmental chamber and placed in a sealed bag with a moist paper or cotton towel for a maximum of 14 days until mechanical testing. Strain gauged specimens were removed from the controlled environment for a maximum of 2 hours for application of gages in ambient laboratory conditions.

## 1.5.3 Normalization Procedures

The normalization procedure attempts to reduce variability in fiber-dominated material properties by adjusting raw test values to a specified fiber volume content. Only the following properties were normalized:

- 0° (warp) Tensile Strength and Modulus
- 0° (warp) Compression Strength and Modulus

The normalization procedure was adopted from MIL-HDBK-17-1E, section 2.4.3.3. The procedure which was used to normalize the data is based on two primary assumptions:

- The relationship between fiber volume fraction and ultimate laminate strength is linear over the entire range of fiber/resin ratios. (It neglects the effects of resin starvation at high fiber contents.)
- Fiber volume is not commonly measured for each test sample, so this method accounts for the fiber volume variation between individual test specimens by utilizing a relationship between fiber volume fraction and laminate cured ply thickness. This relationship is virtually linear in the 0.45 to 0.65 fiber volume fraction range.

Additional information is detailed in FAA Document DOT/FAA/AR-00/47: Material Qualification and Equivalency for Polymer Matrix Composite Material Systems. For all normalized data contained in this document, the test values are normalized by cured ply thickness according to:

$$\text{Normalized Value} = \text{Test Value} \times \frac{CPT_{\text{specimen}}}{CPT_{\text{normalizing}}}$$

where:

$$CPT_{\text{specimen}} = \frac{\text{Average Sample Thickness}}{\# \text{ of plies}}$$

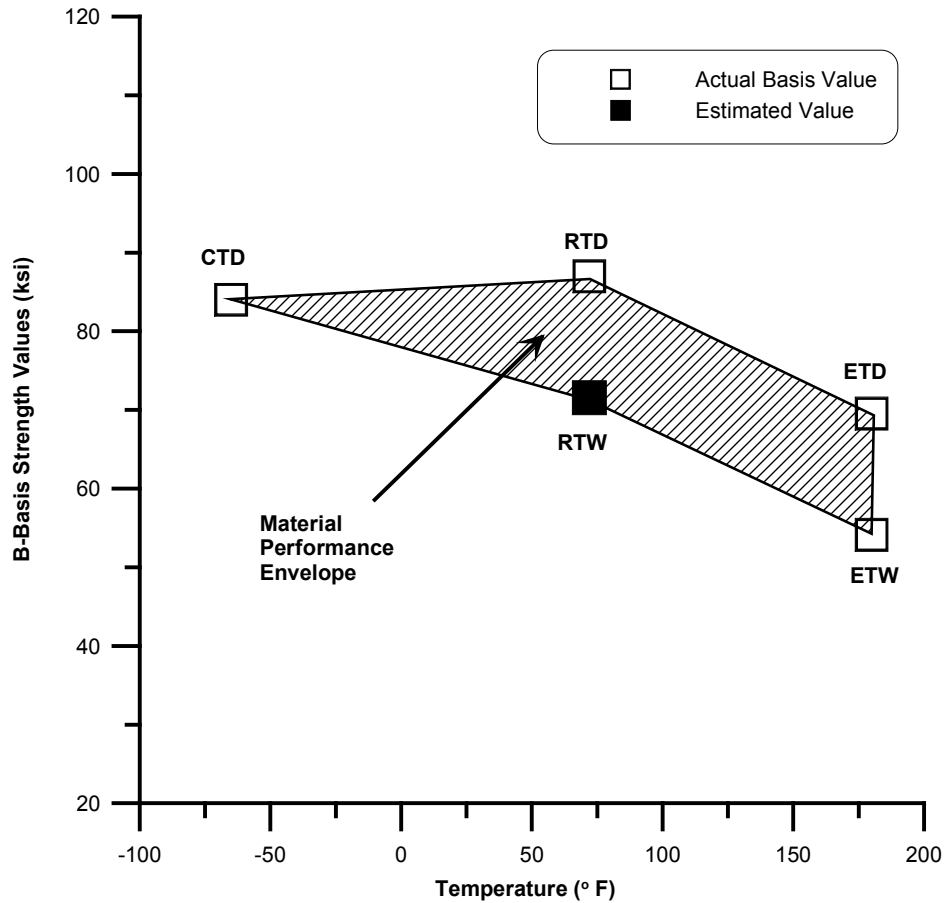
#### 1.5.4 Statistical Analysis

When compared to metallic materials, fiber reinforced composite materials exhibit a high degree of material property variability. This variability is due to many factors, including but not limited to: raw material and prepreg manufacture, material handling, part fabrication techniques, ply stacking sequence, environmental conditions, and testing techniques. This inherent variability drives up the cost of composite testing and tends to render smaller data sets than those produced for metallic materials. This necessitates the usage of statistical techniques for determining reasonable design allowables for composites.

The analyses and design allowable generation for both A and B basis values were performed using the procedure detailed in section 5.3 of FAA Document DOT/FAA/AR-00/47: Material Qualification and Equivalency for Polymer Matrix Composite Material Systems.

### 1.5.5 Material Performance Envelope and Interpolation

Using the B-basis numbers, a material performance envelope may be generated for the material system by plotting these values as a function of temperature. Figure 1.5.1 shows an example material performance envelope using B-basis values.



**Figure 1.5.1 Material performance envelope.**

Since each specific aircraft application of the qualified material may have different Material Operational Limits (MOL) than those tested in the material qualification (which is usually the upper limit), some applications may require a reduced MOL. In this case, simple linear interpolation may be used to obtain the corresponding basis values at the new application MOL.

This interpolation may be accomplished using the following simple relationships assuming  $T_{RTD} < T_{MOL} < T_{ETD}$  :

For the corresponding MOL “dry” basis value, the “interpolated” basis value using the qualification data is

$$B_{MOL} = B_{RTD} - \frac{(B_{RTD} - B_{ETD})(T_{RTD} - T_{MOL})}{(T_{RTD} - T_{ETD})}$$

where

- $B_{MOL}$  = new application basis value interpolated to  $T_{MOL}$
- $B_{RTD}$  = basis RTD strength value
- $B_{ETD}$  = basis ETD strength value
- $T_{RTD}$  = RTD test temperature
- $T_{ETD}$  = ETD test temperature
- $T_{MOL}$  = new application MOL temperature

For the corresponding MOL “wet” basis value, an estimated Room Temperature Wet (RTW) value must be calculated. This may be accomplished by the simple relation

$$B_{RTW} = B_{RTD} - (B_{ETD} - B_{ETW})$$

The “interpolated” wet basis value using the qualification data may then be obtained by

$$B_{MOL} = B_{RTW} - \frac{(B_{RTW} - B_{ETW})(T_{RTW} - T_{MOL})}{(T_{RTW} - T_{ETW})}$$

where:

- $B_{MOL}$  = new application basis value interpolated to  $T_{MOL}$
- $B_{RTW}$  = estimated basis RTW strength value
- $B_{ETW}$  = basis ETW strength value
- $T_{RTW}$  = RTW (i.e., RTD) test temperature
- $T_{ETW}$  = ETW test temperature
- $T_{MOL}$  = new application MOL temperature

These equations may also be used for interpolated mean strengths as well as A-basis values with the appropriate substitutions. It should be noted that because unforeseen material property drop-offs with respect to temperature and environment can occur, *extrapolation* to a higher MOL should not be attempted without additional testing and verification. In addition, the interpolation equations shown above are practical for materials obeying *typical* mechanical behavior. In most cases, some minimal amount of testing may also be required to verify the interpolated values.

### 1.5.5.1 Interpolation Example

This section provides an example of linear interpolations to a specific application environment less than the tested upper material limit used in qualification. Assuming a specific application environment of 150° F, Figure 1.5.2 depicts the linear interpolation of the B-basis design allowable to this environment. Using the above equations along with the nominal testing temperatures (see Table 1.5.1), the interpolated basis values at 150° F become

$$\text{ETD} : B_{\text{MOL}} = 75.106 \text{ ksi}$$

$$\text{ETW} : B_{\text{MOL}} = 59.746 \text{ ksi}$$

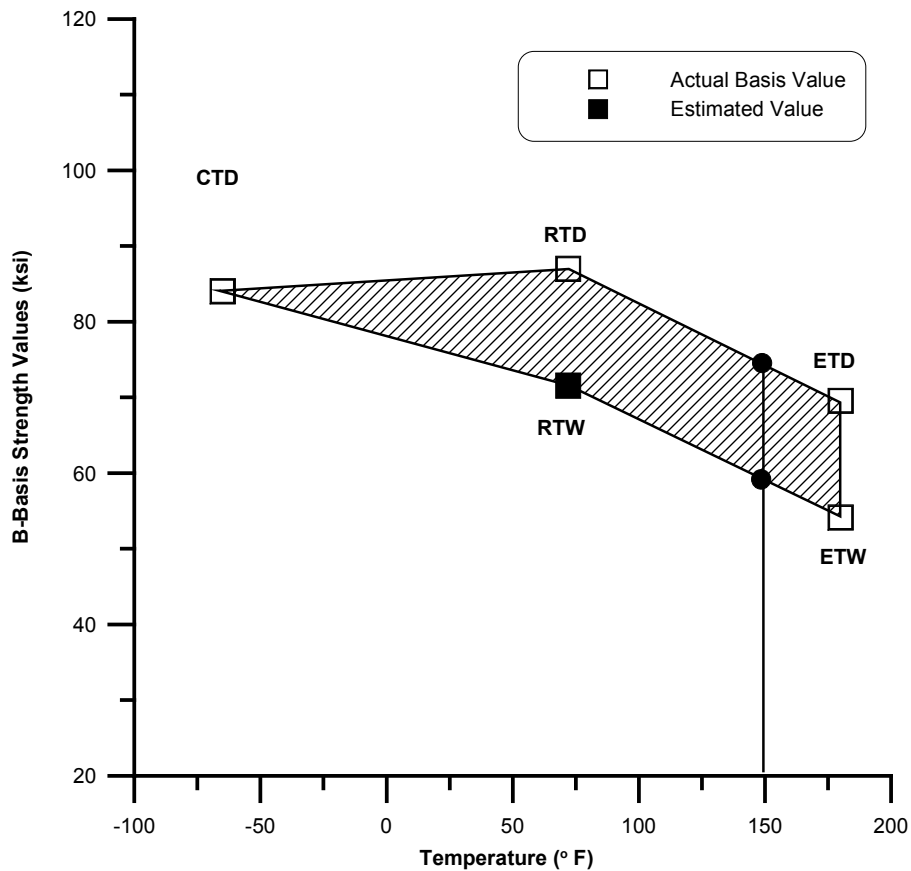


Figure 1.5.2 Example of 150° F interpolation for B-basis values.

## **2.0 3M S2 GLASS UNI / SP381 PREPREG PROPERTIES**

## 2.1 Prepreg Documentation by Prepreg Lot

Batch ID - AGATE	1	2	3	4	5	6	7	8
<b>Prepreg Documentation</b>	<b>Prepreg Manufacturer &amp; Product ID: 3M S2 uni / SP381</b> <b>Material Identification (weave, form, class, etc.): SP381 Uni S29 284FAW 33RC</b> <b>Impregnation Method: hot melt</b>							
Prepreg Batch or Lot #	22E7P	23E7P	24F7P	25F7P	26H7P	29L7P	27J7P	28L7P
Date of Manufacture	5/28/97	5/28/97	6/11/97	6/24/97	8/8/97	11/14/97	9/10/97	11/13/97
Expiration Date	5/28/97	5/28/98	6/11/98	6/24/98	8/8/98	11/14/98	9/10/98	11/13/98
Resin Content [%]	34.0	31.9	34.2	33.7	32.3	33.5	33.1	32.5
Reinforcement Areal Weight [gsm] & Test Method	286.7	287.2	286.1	284	292.6	291.5	286.7	291.8
Resin Flow [%] & Test Conditions	14.5	14.5	14.2	15.5	18.5	18	23.5	14.5
Gel Time [min] & Test Conditions	6.4	7.2	6.9	7.0	7.4	7.5	8.1	7.8
Volatile Content	N/A							
<b>Reinforcement Documentation</b>	<b>Fiber/Fabric Manufacturer &amp; Product ID:</b> <b>S2 glass uni Owens Corning S2</b> <b>Precursor Type: N/A</b> <b>Nominal Filament Count: 20 end – 204 filament/end</b> <b>Finish/Sizing Type and %: 449 ; 0.65 +/- 0.10%</b> <b>Nominal tow or yarn count/inch: 10.5 tows/in prepreg</b>							
Fabric Batch or Lot #	SE75030897	SE75030897	SE75030897	SE75030897	SE75030897	SE75090497	SE75030897	SE75090497
Date of Manufacture	3/8/97	3/8/97	3/8/97	3/8/97	3/8/97	9/4/97	3/8/97	9/4/97
Average Fiber Density & Test Method	Typical value = 2.49 g/cc Owens Corning Test Method N/A by lot							
<b>Matrix Documentation</b>	<b>Resin Manufacturer &amp; Product ID: 3M PM61216</b>							
Matrix Batch or Lot #	7218D7 7216D7	7217E7	7217D7	7217E7	7218G7	7222J7	7219J7	7219J7
Date of Manufacture	4/97	5/97	5/97	5/97	7/97	9/97	9/97	9/97
Average Neat Resin Density by Lot & Test Method	Typical value = 1.215 g/cc (ASTM D792) N/A by lot							

Note: A BGF style 106 surface veil was placed on each prepreg ply and was included in the layup of all panels

## 2.2 Process Specification

This specification does not address issues relating to safety, quality control, bagging material selection, bagging procedure, tool preparation, or equipment selection. Although these may affect overall part quality, it is the responsibility of the end user to develop procedures related to these issues in a manner that produces parts with high quality and consistency.

The following oven cure procedures are excerpts from Cirrus Design Corporation GEP0001 Rev. C specification, Manufacture of Glass-Fiber Prepreg Assemblies, 260°F Cure. All test specimens were cured per this specification by Cirrus Design Corporation. However, the effects of the upper and lower limits of vacuum, temperature, cure time, heat-up rate and hold temperature on the mechanical and thermal properties have not been investigated.

### Prior to Cure

- Unitape orientation angle shall be within  $\pm 3^\circ$  of the specified orientation.
- Before placing a bagged assembly in the oven, apply at least 22" Hg vacuum and check for bag leaks. Bag leaks greater than 3.0" Hg during 5 minutes shall be corrected.
- Debulk shall be performed every ten layers, or more frequently if required.

### Oven Cure Procedure

- The maximum air temperature of the oven prior to loading is 160°F. Connect the calibrated thermocouples to the parts, allowing at least one thermocouple per part. The temperature of the part must be 150°F or less before removing from the oven
- Cure all prepreg parts according to the following cure cycle chart.

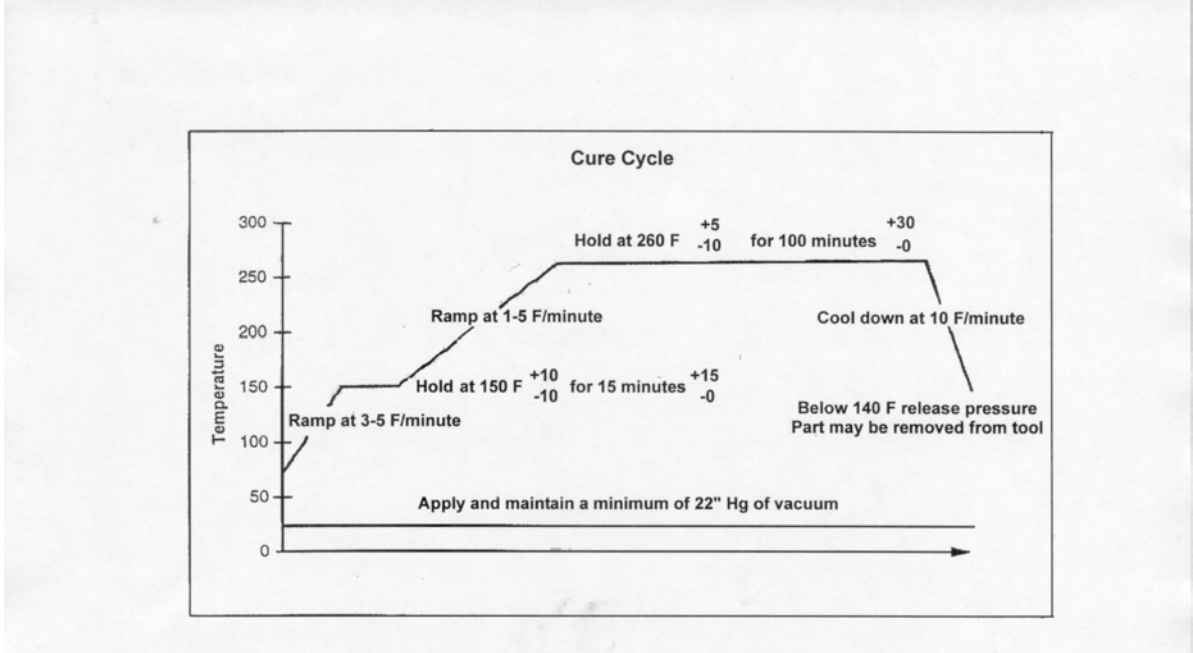


Figure 2.2: Sample prepreg cure cycle for SP381 / S2 unitape. Figure courtesy of Cirrus Design Corporation.

### **3.0 3M S2 GLASS UNI / SP381 LAMINA PROPERTIES**

### **3.1 Test Results**

### **3.1.1 Summary**

<b>MATERIAL:</b> SP381/ S2 Unitape <b>FIBER:</b> Owens Corning S2 <b>PREPREG:</b> 3M SP381/ S2 Unitape, 449 finish, 0.65± 0.10% sizing <b>Tg(dry):</b> 287.9°F <b>Tg (wet):</b> 240.6°F <b>Tg METHOD:</b> DMA (SRM 18-94)	<b>RESIN:</b> 3M SP381 <b>PROCESSING:</b> vacuum bag cure (22+ in Hg), 250-265F for 100-130min	<b>Date of fiber manufacture:</b> 3/97 – 9/97 <b>Date of resin manufacture:</b> 4/97 – 9/97 <b>Date of prepreg manufacture:</b> 5/97 – 11/97 <b>Date of composite manufacture:</b> 4/97-11/98 <b>Date of testing:</b> 8/97-9/98 <b>Date of analysis:</b> 6/97-9/98	<b>SP381/S2 Unitape Summary</b>
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**LAMINA MECHANICAL PROPERTY SUMMARY**

Data Reported as: Measured  
 (Normalized by CPT = 0.0094 in.)

	CTD (-65° F)		RTD			ETD (180° F)		ETW (150° F)			ETW (180° F)	
	B-Basis	Mean	A-Basis	B-Basis	Mean	B-Basis	Mean	A-Basis	B-Basis	Mean	B-Basis	Mean
<b>F<sub>1</sub><sup>tu</sup> (ksi)</b>	212.82 (209.52)	251.63 (250.16)	175.89 (170.16)	195.18 (190.10)	221.91 (217.73)	182.39 (176.95)	210.28 (205.69)	109.17 (105.88)	121.13 (118.28)	137.79 (135.54)	115.21 (110.00)	132.71 (127.74)
<b>E<sub>1</sub><sup>t</sup> (Msi)</b>	---	7.23 (7.08)	---	---	7.05 (6.91)	---	6.90 (6.73)	---	---	6.84 (6.72)	---	7.08 (6.84)
<b>ν<sub>12</sub><sup>tu</sup></b>	---	0.278	---	---	0.263	---	0.263	---	---	0.257	---	0.296
<b>F<sub>2</sub><sup>tu</sup> (ksi)</b>	---	---	6.61	7.22	8.20	7.67	8.65	6.59	7.20	8.18	6.39	7.21
<b>E<sub>2</sub><sup>t</sup> (Msi)</b>	---	---	---	---	1.97	---	1.75	---	---	1.43	---	1.24
<b>F<sub>1</sub><sup>cu</sup> (ksi)</b>	132.05 (131.72)	181.53 (179.87)	110.60 (110.31)	136.98 (135.88)	173.32 (171.11)	92.34 (90.87)	118.39 (115.91)	87.79 (88.86)	108.73 (109.46)	137.75 (138.01)	80.20 (78.73)	102.29 (99.92)
<b>E<sub>1</sub><sup>c</sup> (Msi)</b>	---	---	---	---	7.22 (7.01)	---	7.17 (6.87)	---	---	7.13 (6.95)	---	7.27 (6.90)
<b>F<sub>2</sub><sup>cu</sup> (ksi)</b>	---	---	32.90	35.53	39.78	27.22	30.25	22.27	24.06	26.93	21.51	23.95
<b>E<sub>2</sub><sup>c</sup> (Msi)</b>	---	---	---	---	2.61	---	2.08	---	---	2.14	---	2.10
<b>F<sub>12</sub><sup>su</sup> (ksi)</b>	22.15	24.65	16.56	17.65	19.17	13.64	14.94	12.12	12.92	14.03	10.84	11.87
<b>G<sub>12</sub><sup>s</sup> (Msi)</b>	---	0.62	---	---	0.59	---	0.54	---	---	0.54	---	0.38
<b>F<sub>13</sub><sup>su</sup> (ksi)</b>	---	---	7.52	8.49	9.85	---	---	---	---	---	---	---

\*\*Apparent interlaminar shear strength

### 3.1.2 Individual Test Summaries

Note: A BGF style 106 surface veil was placed on each prepreg ply prior to layup. However, this is not explicitly specified on the layup schedules on the following summary tables. Please keep in mind that the properties delineated in this document were obtained from testing laminates containing this surface veil. All normalized data was normalized by a cure ply thickness of 0.0094". This thickness includes both the ply and the veil.

### 3.1.2.1 Tension, 1-axis

<b>Material:</b> 3M SP381/ S2 Unitape  <b>Resin content:</b> 27 - 31 wt.% <b>Fiber volume:</b> 69 - 73 % <b>Ply thickness:</b> 0.0083 - 0.0096 in. <b>Ply range:</b> 6 ply  <b>Test method:</b> D3039-95  <b>Normalized by:</b> 0.0094 in. ply thickness							<b>Comp. density:</b> 1.80 - 1.92 g/cc <b>Void content:</b> 0.4 - 4.4 %		<b>Tension, 1-axis GI/Ep 3M SP381/ S2 Unitape [0]<sub>6</sub></b>				
<b>Modulus calculation:</b> linear fit from 1000 - 3000 $\mu\epsilon$													
		CTD		RTD		ETD		ETW		ETW			
<b>Test Temperature [°F]</b> <b>Moisture Conditioning</b> <b>Equilibrium at T, RH</b> <b>Source code</b>		-65 dry as fabricated LBJXXXXB		75 dry as fabricated LBJXXXXA		180 dry as fabricated LBJXXXXG		150 equilibrium 145 F, 85 % LBJXXXXC		180 equilibrium 145 F, 85 % LBJXXXXF			
		Normalized		Measured		Normalized		Measured		Normalized		Measured	
<b>F<sub>1</sub><sup>tu</sup> (ksi)</b>		<b>Mean</b>		250.16 251.63		217.73 221.91		205.69 210.28		135.54 137.79		127.74 132.71	
		<b>Minimum</b>		207.09 221.63		182.42 188.38		168.53 171.50		113.55 116.93		107.52 111.37	
		<b>Maximum</b>		278.48 278.32		240.12 237.80		226.85 232.03		154.51 154.65		145.97 150.14	
		<b>C.V.(%)</b>		10.86 8.57		6.91 6.65		9.35 9.72		9.12 8.42		7.93 7.67	
		<b>B-value</b>		209.52 212.82		190.09 195.18		176.95 182.39		118.28 121.13		110.00 115.21	
<b>A-value</b>		187.35 191.66		170.16 175.89		158.47 164.45		105.88 109.17		98.51 103.88			
<b>No. Specimens</b>		6		56		18		53		19			
<b>No. Prepreg Lots</b>		1		5		3		5		3			
<b>E<sub>1</sub><sup>t</sup> (Msi)</b>		<b>Mean</b>		7.08 7.23		6.91 7.05		6.73 6.90		6.72 6.84		6.84 7.08	
		<b>Minimum</b>		6.99 7.06		6.42 6.61		6.45 6.73		6.13 6.35		6.72 6.90	
		<b>Maximum</b>		7.20 7.48		7.15 7.46		6.86 7.06		6.99 7.14		6.94 7.39	
		<b>C.V.(%)</b>		1.52 3.03		2.84 3.42		2.23 1.86		3.34 3.03		1.13 2.44	
		<b>No. Specimens</b>		3		15		6		15		6	
<b>No. Batches</b>		1		5		3		5		3			
<b><math>\nu_{12}^t</math></b>		<b>Mean</b>		0.278		0.263		0.263		0.257		0.296	
		<b>No. Specimens</b>		3		15		6		12		6	
		<b>No. Prepreg Lots</b>		1		5		3		5		3	

### 3.1.2.2 Tension, 2-axis

Material: 3M SP381/ S2 Unitape		<b>Tension, 2-axis G/Ep 3M SP381/ S2 Unitape [0]<sub>9</sub></b>				
Resin content: 28 - 31 wt. %		Comp. density: 1.81 - 1.86 g/cc				
Fiber volume: 69 - 72 %		Void content: 2.0 - 4.7 %				
Ply thickness: 0.0092 - 0.0098 in.						
Ply range: 9 ply						
Test method: D3039-95		Modulus calculation: linear fit from 1000 - 3000 $\mu\epsilon$				
Normalized by: N/A						
		RTD	ETD	ETW	ETW	
Test Temperature [°F]		75	180	150	180	
Moisture Conditioning		dry	dry	equilibrium	equilibrium	
Equilibrium at T, RH		as fabricated	as fabricated	145 F, 85 %	145 F, 85 %	
Source code		LBUXXXA	LBUXXXG	LBUXXXC	LBUXXXF	
		Normalized	Measured	Normalized	Measured	
<b>F<sub>2</sub><sup>tu</sup> (ksi)</b>	Mean		8.20	8.65	8.18	7.21
	Minimum		6.47	7.30	7.21	6.60
	Maximum		9.03	9.53	8.80	7.59
	C.V.(%)		9.50	6.39	6.87	4.37
	B-value		7.22	7.67	7.20	6.39
	A-value		6.61	7.02	6.59	5.85
	No. Specimens		11	18	11	19
No. Prepreg Lots		1	3	1	3	
<b>E<sub>2</sub><sup>t</sup> (Msi)</b>	Mean		1.97	1.75	1.43	1.24
	Minimum		1.92	1.60	1.36	1.14
	Maximum		2.02	1.88	1.49	1.32
	C.V.(%)		2.60	5.20	4.63	6.47
	No. Specimens		3	6	3	6
	No. Prepreg Lots		1	3	1	3

### 3.1.2.3 Compression, 1-axis

<b>Compression, 1-axis GI/Ep 3M SP381/ S2 Unitape [0]<sub>6</sub></b>											
<b>Material:</b>	3M SP381/ S2 Unitape										
<b>Resin content:</b>	28 - 36 wt. %			<b>Comp. density:</b>	1.80 - 1.89 g/cc						
<b>Fiber volume:</b>	64 - 72 %			<b>Void content:</b>	0.0 - 4.7 %						
<b>Ply thickness:</b>	6 ply										
<b>Ply range:</b>	6 ply										
<b>Test method:</b>	D695-91 (mod)			<b>Modulus calculation:</b>	linear fit from 1000 - 3000 $\mu\epsilon$						
<b>Normalized by:</b>	0.0094 in. ply thickness										
	<b>CTD</b>		<b>RTD</b>		<b>ETD</b>		<b>ETW</b>		<b>ETW</b>		
<b>Test Temperature [°F]</b>	-65		75		180		150		180		
<b>Moisture Conditioning</b>	dry		dry		dry		equilibrium		equilibrium		
<b>Equilibrium at T, RH</b>	as fabricated		as fabricated		as fabricated		145 F, 85 %		145 F, 85 %		
<b>Source code</b>	LBKXXXXB		LBKXXXXA		LBKXXXXG		LBKXXXXC		LBKXXXXF		
	Normalized	Measured	Normalized	Measured	Normalized	Measured	Normalized	Measured	Normalized	Measured	
<b>F<sub>1</sub><sup>cu</sup> (ksi)</b>	<b>Mean</b>	179.87	181.53	171.11	173.32	115.91	118.39	138.01	137.75	99.92	102.29
	<b>Minimum</b>	155.69	152.18	132.52	130.09	95.14	98.37	88.44	84.25	41.39	41.59
	<b>Maximum</b>	217.85	217.08	224.35	219.58	135.46	138.91	167.04	171.30	123.68	127.00
	<b>C.V.(%)</b>	12.01	11.63	12.92	12.41	9.66	9.49	12.07	13.66	19.00	18.97
	<b>B-value</b>	131.72	132.05	135.88	136.98	90.87	92.34	109.46	108.73	78.73	80.20
	<b>A-value</b>	105.60	105.21	110.31	110.60	73.71	74.50	88.86	87.79	63.89	64.73
	<b>No. Specimens</b>	6		67		34		62		43	
<b>No. Prepreg Lots</b>	1		6		3		5		3		
<b>E<sub>1</sub><sup>c</sup> (Msi)</b>	<b>Mean</b>			7.01	7.22	6.87	7.17	6.95	7.13	6.90	7.27
	<b>Minimum</b>			6.70	6.90	6.05	6.19	6.82	6.92	6.53	6.87
	<b>Maximum</b>			7.32	7.46	7.19	7.60	7.11	7.35	7.43	7.60
	<b>C.V.(%)</b>			2.64	2.55	6.37	7.12	1.35	1.65	4.71	3.29
	<b>No. Specimens</b>			11		6		12		6	
	<b>No. Prepreg Lots</b>			1		3		1		3	

### 3.1.2.4 Compression, 2-axis

<b>Compression, 2-axis G/Ep 3M SP381/ S2 Unitape [0]<sub>6</sub></b>											
<b>Material:</b> 3M SP381/ S2 Unitape		<b>Resin content:</b> 28 - 29 wt. %		<b>Fiber volume:</b> 71 - 72 %		<b>Ply thickness:</b> 0.0087 - 0.0099 in.		<b>Ply range:</b> 6 ply			
<b>Test method:</b> D695-91 (mod)		<b>Comp. density:</b> 1.83 - 1.87 g/cc		<b>Void content:</b> 2.2 - 3.4 %		<b>Modulus calculation:</b> linear fit from 1000 - 3000 $\mu\epsilon$					
<b>Normalized by:</b> N/A											
		<b>RTD</b>		<b>ETD</b>		<b>ETW</b>		<b>ETW</b>			
<b>Test Temperature [°F]</b>		75		180		150		180			
<b>Moisture Conditioning</b>		dry		dry		equilibrium		equilibrium			
<b>Equilibrium at T, RH</b>		as fabricated		as fabricated		145 F, 85 %		145 F, 85 %			
<b>Source code</b>		LBWXXXXA		LBWXXXXG		LBWXXXXC		LBWXXXXF			
		Normalized	Measured	Normalized	Measured	Normalized	Measured	Normalized	Measured		
<b>F<sub>2</sub><sup>cu</sup> (ksi)</b>		<b>Mean</b>		39.78		30.25		26.93		23.95	
		<b>Minimum</b>		37.59		26.75		24.07		19.79	
		<b>Maximum</b>		41.53		33.75		28.85		25.26	
		<b>C.V.(%)</b>		3.20		7.90		4.70		5.02	
		<b>B-value</b>		35.53		27.22		24.06		21.51	
		<b>A-value</b>		32.90		25.18		22.27		19.91	
		<b>No. Specimens</b>		11		20		11		17	
<b>No. Prepreg Lots</b>		1		3		1		3			
<b>E<sub>2</sub><sup>c</sup> (Msi)</b>		<b>Mean</b>		2.61		2.08		2.14		2.10	
		<b>Minimum</b>		2.52		1.90		2.06		1.86	
		<b>Maximum</b>		2.74		2.26		2.39		2.27	
		<b>C.V.(%)</b>		2.63		6.34		4.15		7.90	
		<b>No. Specimens</b>		11		6		11		6	
		<b>No. Prepreg Lots</b>		1		3		1		3	

### 3.1.2.5 Shear, 12 axis

<b>Material:</b> 3M SP381/ S2 Unitape  <b>Resin content:</b> 28 - 30 wt.% <b>Fiber volume:</b> 70 - 72 % <b>Ply thickness:</b> 0.0087 - 0.0099 in. <b>Ply range:</b> 17 ply  <b>Test method:</b> D5379-93  <b>Normalized by:</b> N/A							<b>Comp. density:</b> 1.83 - 1.92 g/cc <b>Void content:</b> 0.0 - 3.3 %		<b>Shear, 12-axis GI/Ep 3M SP381/ S2 Unitape [(0/90)<sub>4</sub>/0/(90/0)<sub>4</sub>]</b>		
<b>Modulus calculation:</b> linear fit from 1000 - 6000 $\mu\epsilon$											
		<b>CTD</b>	<b>RTD</b>	<b>ETD</b>	<b>ETW</b>	<b>ETW</b>					
<b>Test Temperature [°F]</b>		-65	75	180	150	180					
<b>Moisture Conditioning</b>		dry	dry	dry	equilibrium	equilibrium					
<b>Equilibrium at T, RH</b>		as fabricated	as fabricated	as fabricated	145 F, 85 %	145 F, 85 %					
<b>Source code</b>		LBNXXXXB	LBNXXXXA	LBNXXXXG	LBNXXXXC	LBNXXXXF					
		Normalized	Measured	Normalized	Measured	Normalized					
		Measured	Measured	Measured	Measured	Measured					
<b>Mean</b>		24.65	19.17	14.94	14.03	11.87					
<b>Minimum</b>		23.57	18.12	13.73	11.64	10.93					
<b>Maximum</b>		25.39	20.15	16.72	15.50	12.36					
<b>C.V.(%)</b>		2.70	2.64	4.98	7.36	3.17					
<b>F<sub>12</sub><sup>su</sup> (ksi)</b>		22.15	17.65	13.64	12.92	10.84					
<b>A-value</b>		20.79	16.56	12.80	12.12	10.18					
<b>No. Specimens</b>		6	56	18	56	18					
<b>No. Prepreg Lots</b>		1	5	3	5	3					
<b>Mean</b>		0.62	0.59	0.54	0.54	0.38					
<b>Minimum</b>		0.58	0.49	0.46	0.41	0.31					
<b>Maximum</b>		0.66	0.71	0.64	0.63	0.41					
<b>C.V.(%)</b>		9.43	10.41	12.11	9.61	9.50					
<b>G<sub>12</sub><sup>s</sup> (Msi)</b>		2	15	6	15	6					
<b>No. Prepreg Lots</b>		1	5	3	5	3					

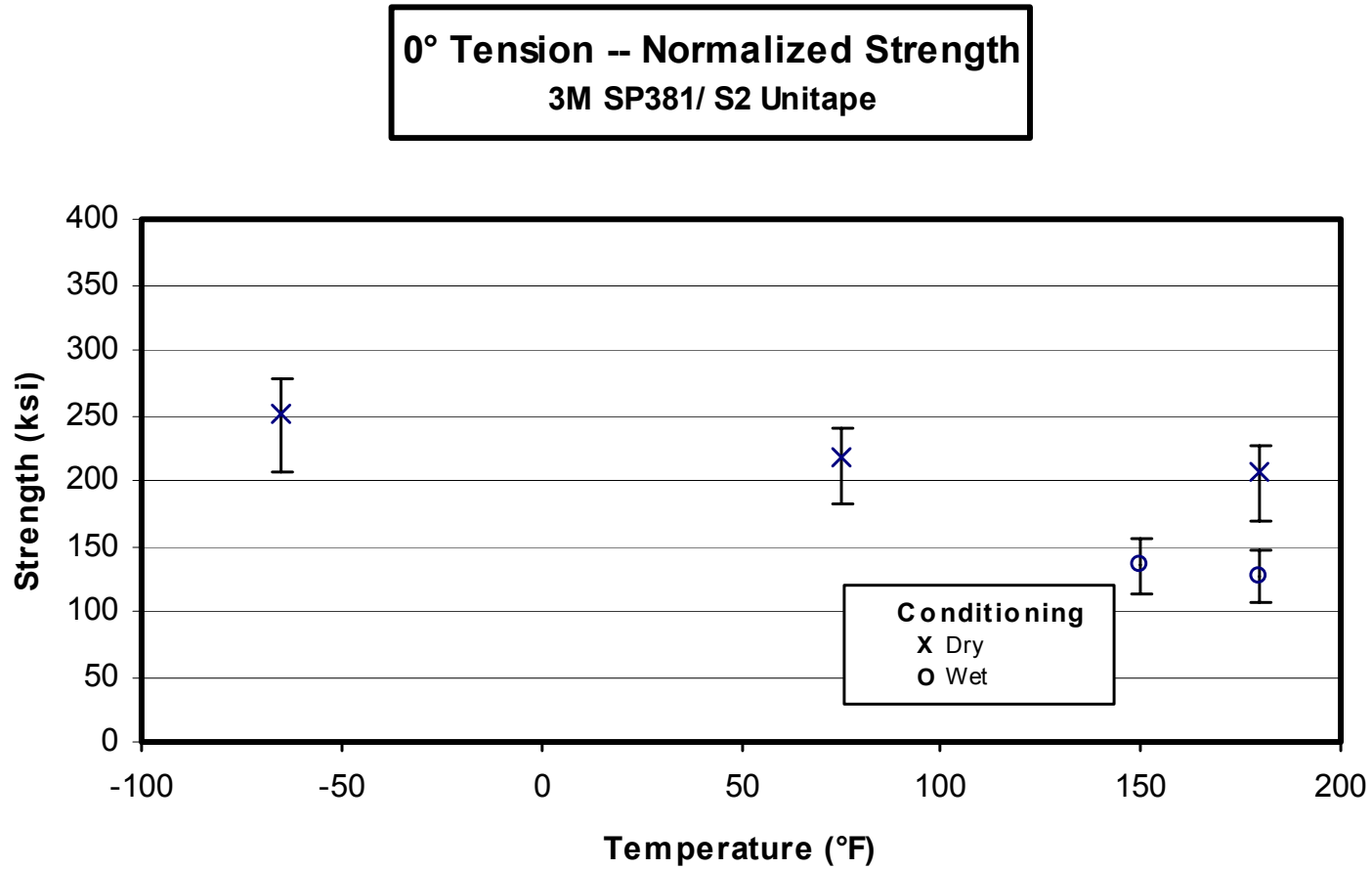
### 3.1.2.6 Shear, 13 axis

<b>Material:</b> 3M SP381/ S2 Unitape <b>Resin content:</b> 27 - 28 wt.% <b>Fiber volume:</b> 72 - 73 % <b>Ply thickness:</b> 0.0088 - 0.0099 in. <b>Ply range:</b> 16 ply <b>Test method:</b> D2344-89 <b>Normalized by:</b> N/A						<b>Comp. density:</b> 1.87 - 1.93 g/cc <b>Void content:</b> 0.2 - 2.1 %		<b>Shear, 13-axis                  GI/Ep                  3M SP381/ S2 Unitape                  [0]<sub>16</sub></b>			
						<b>Modulus calculation:</b>		N/A			
<b>RTD</b>											
<b>Test Temperature [°F]</b>			75								
<b>Moisture Conditioning Equilibrium at T, RH</b>			dry as fabricated								
<b>Source code</b>			LBQXXXXA								
		Normalized	Measured	Normalized	Measured	Normalized	Measured	Normalized	Measured	Normalized	Measured
<b>Mean</b>				9.85							
<b>Minimum</b>				8.28							
<b>Maximum</b>				10.96							
<b>C.V.(%)</b>				7.32							
<b>F<sub>13</sub><sup>su</sup> (ksi)</b>				8.49							
<b>B-value</b>				7.52							
<b>A-value</b>											
<b>No. Specimens</b>				23							
<b>No. Prepreg Lots</b>				3							

NOTES: These values represent the apparent interlaminar shear properties and are to be used for quality control purposes only. Do not use these values for interlaminar shear strength design values.

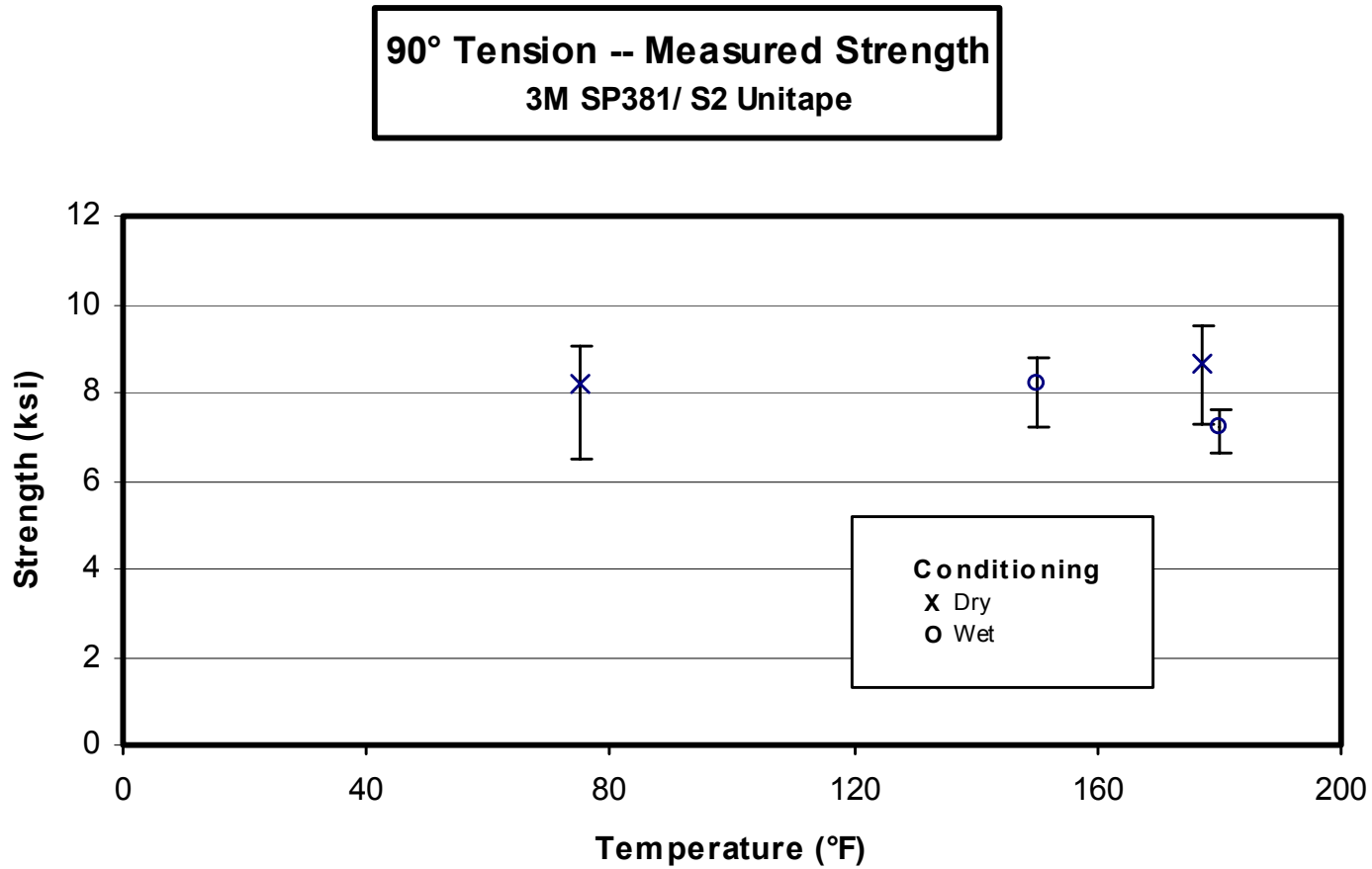
### **3.1.3 Individual Test Charts**

### 3.1.3.1 Tension, 1-axis



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 180° dry and wet data have been staggered for clarity.

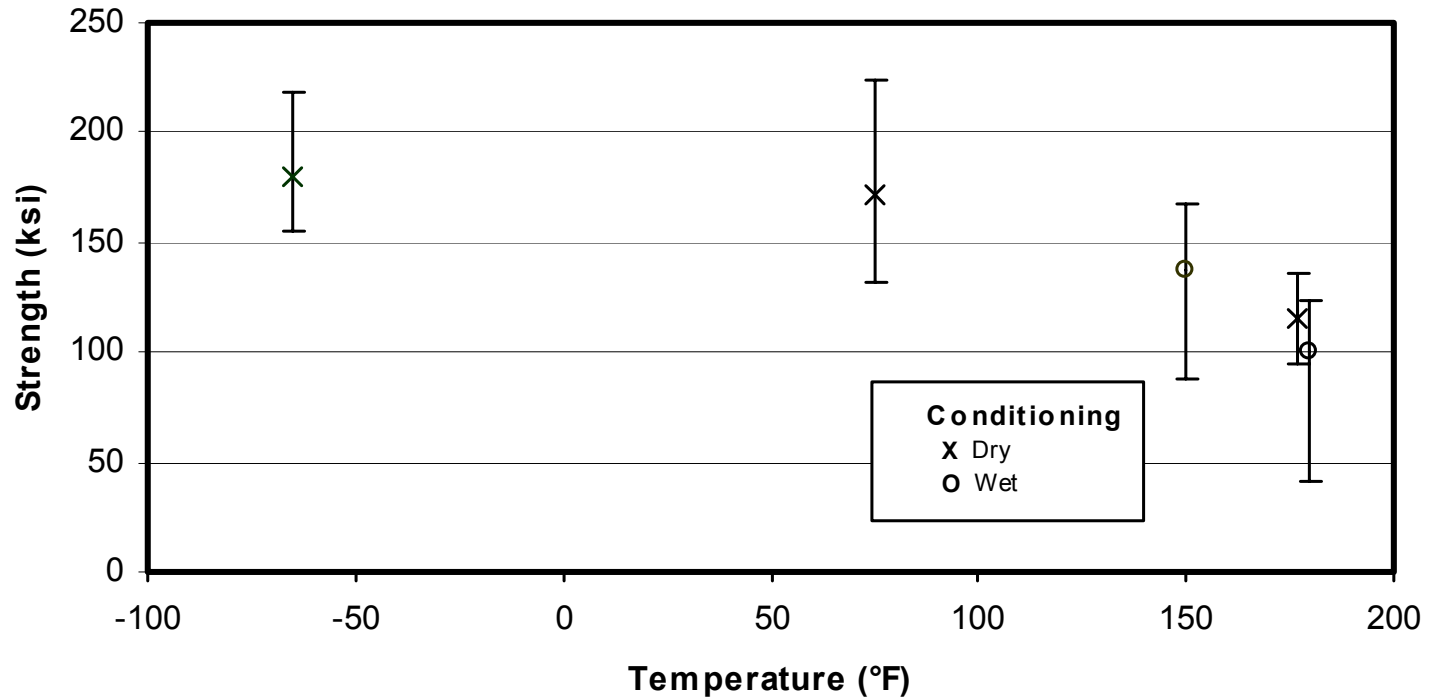
### 3.1.3.2 Tension, 2-axis



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 180° dry and wet data have been staggered for clarity.

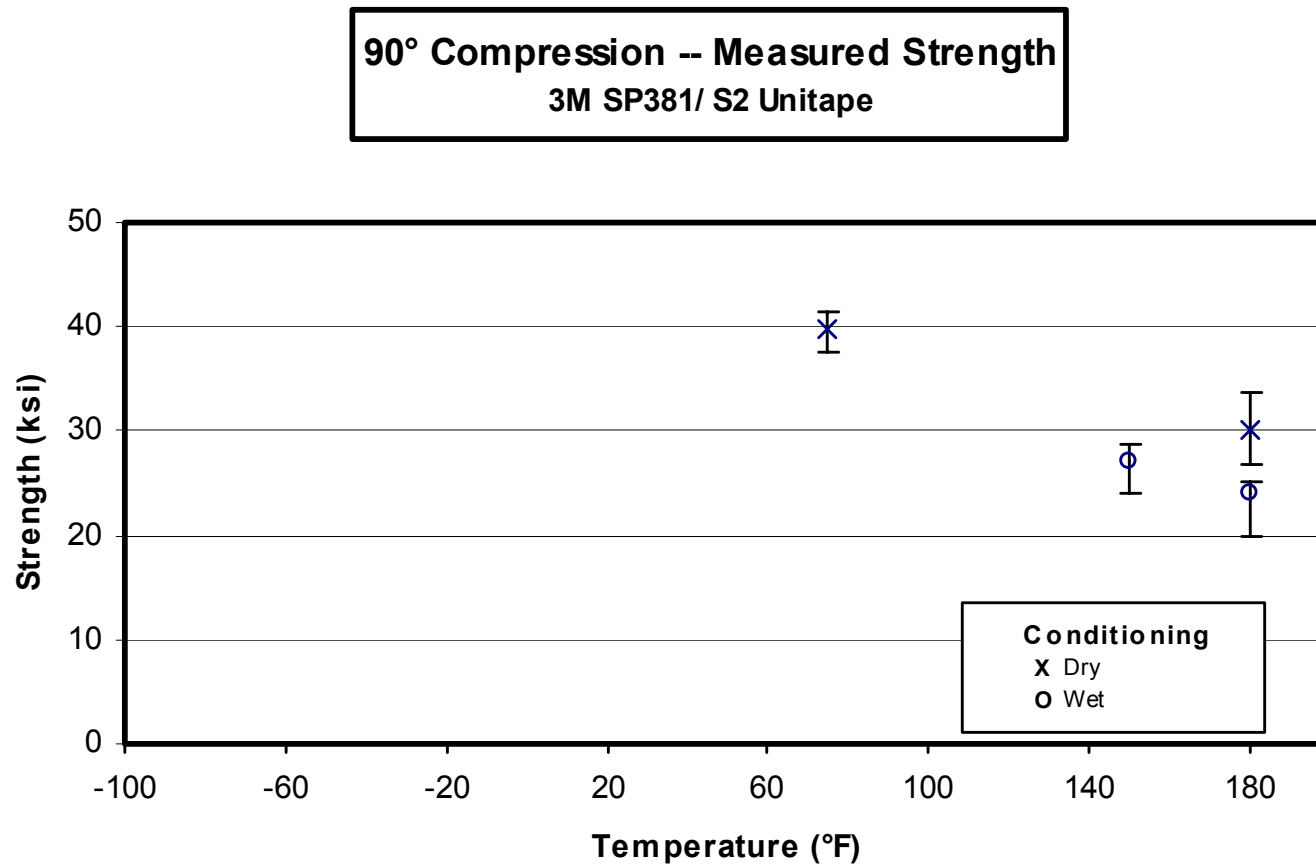
### 3.1.3.3 Compression, 1-axis

**0° Compression -- Normalized Strength  
3M SP381/ S2 Unitape**



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 180° dry and wet data have been staggered for clarity.

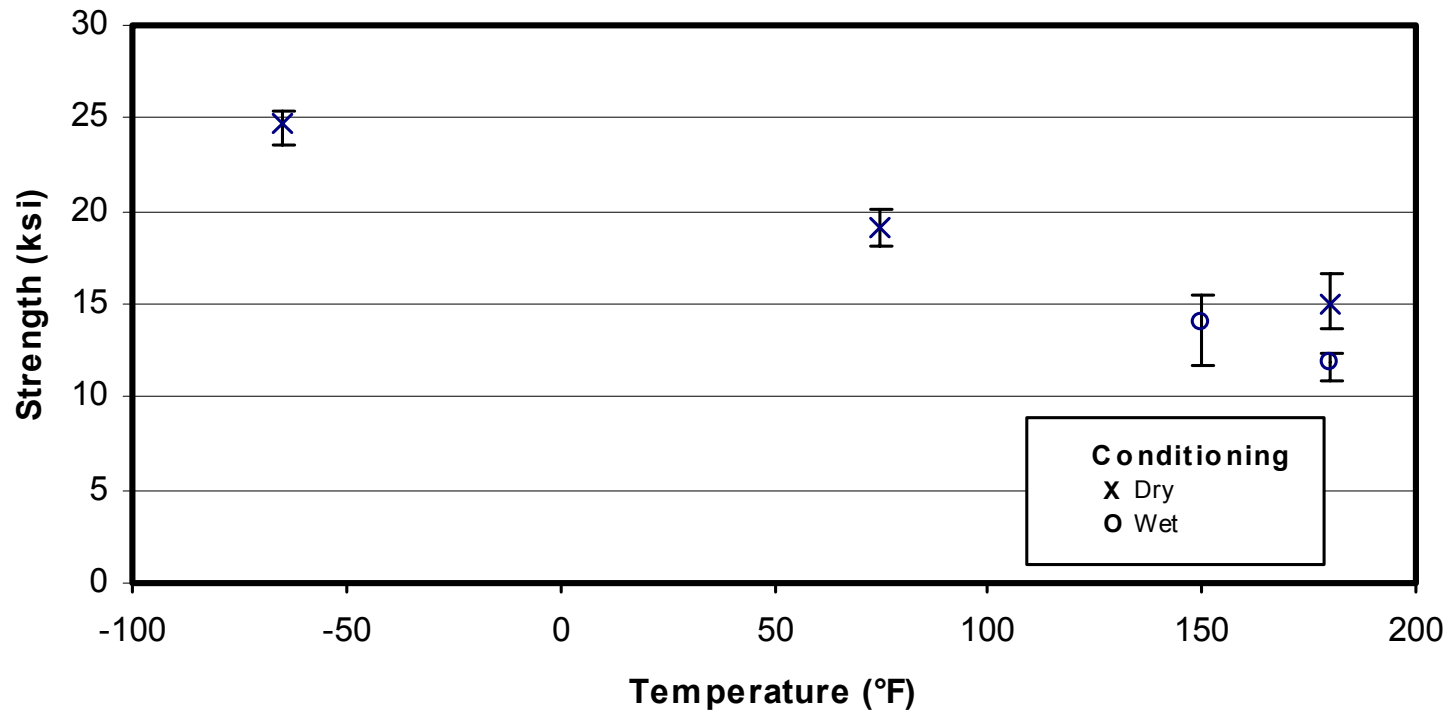
### 3.1.3.4 Compression, 2-axis



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 180° dry and wet data have been staggered for clarity.

### 3.1.3.5 Shear, 12 axis

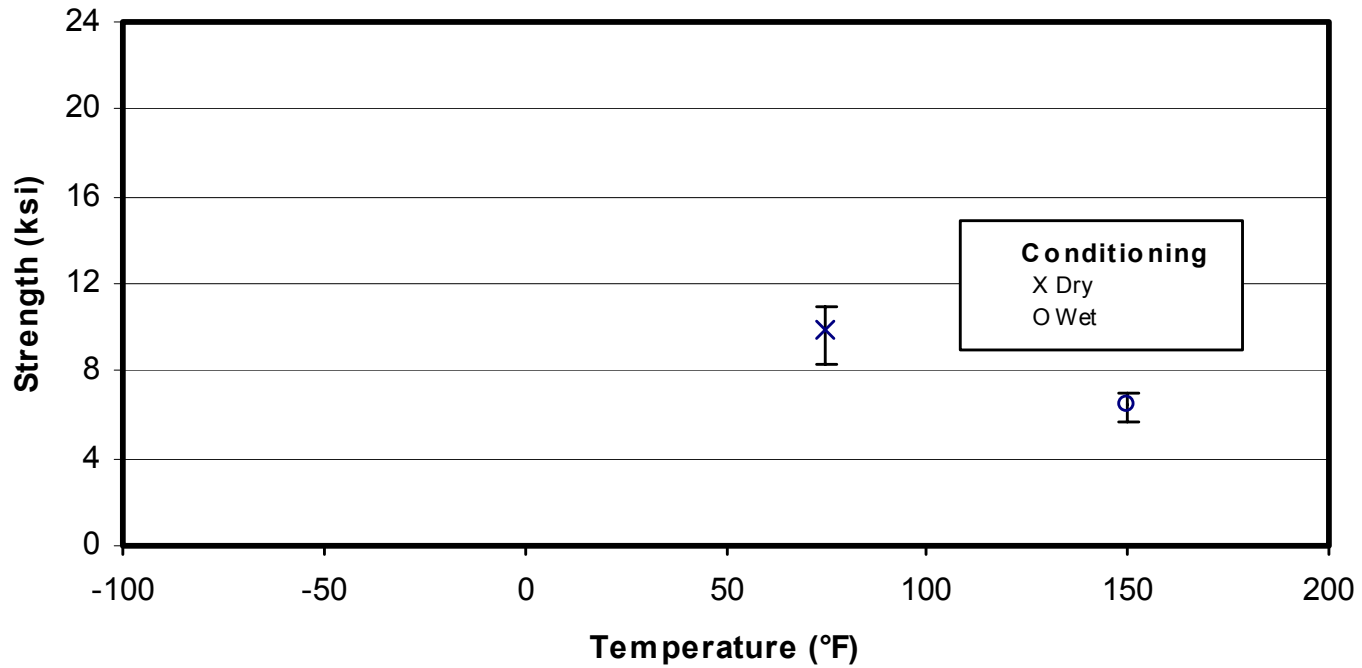
**In-Plane Shear -- Measured Strength  
3M SP381/ S2 Unitape**



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 180° dry and wet data have been staggered for clarity.

### 3.1.3.6 Shear, 13 axis

#### Apparent Interlaminar Shear -- Measured Strength 3M SP381/ S2 Unitape



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data.

## 3.2 Raw Data

### Specimen Naming Convention

Test coupons were identified using an eight-digit specimen code, with the significance of each digit delineated below. A representative sample ID is shown for reference purposes.

**L B J 2 1 2 5 F**

1<sup>st</sup> Character: Fabricator

'L' designates Cirrus

2<sup>nd</sup> Character: Material System

'B' designates S2 / SP381

3<sup>rd</sup> Character: Test Type

'J' designates 0° Tension  
Strength and Modulus, other  
test types will be clearly labeled  
at the top of each sheet

4<sup>th</sup> Character: Prepreg Batch ID

See Table 2.1 for 3M Batch ID /  
Sample Batch ID correlation.

5<sup>th</sup> Character: Panel Number

The panel(s) fabricated for a specific test method.

6<sup>th</sup> Character: Subpanel Number

The sub-panel(s) cut from each panel, with subpanel  
numbers labeled increasing from reference edge.

7<sup>th</sup> Character: Sample Number

The sample(s) cut from each subpanel, with sample  
numbers labeled increasing from reference edge.

8<sup>th</sup> Character: Test Condition

'A' --- RTD

'B' --- CTD

'C' --- ETW, 150°F

'F' --- ETW, 180°F

'G' --- ETD, 180°F

See Table 1.5.1 for condition parameters.

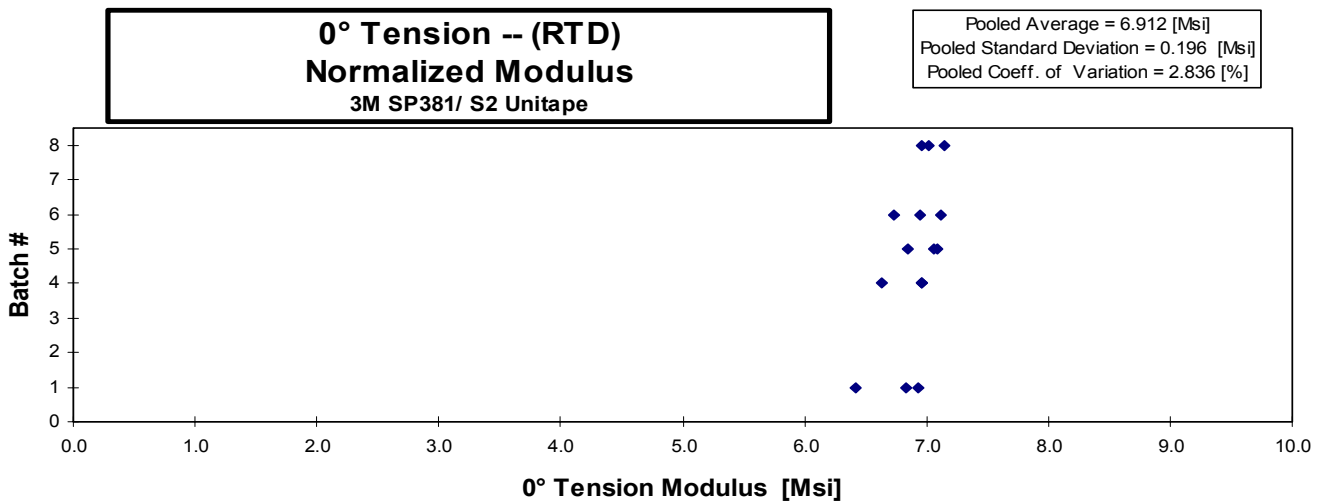
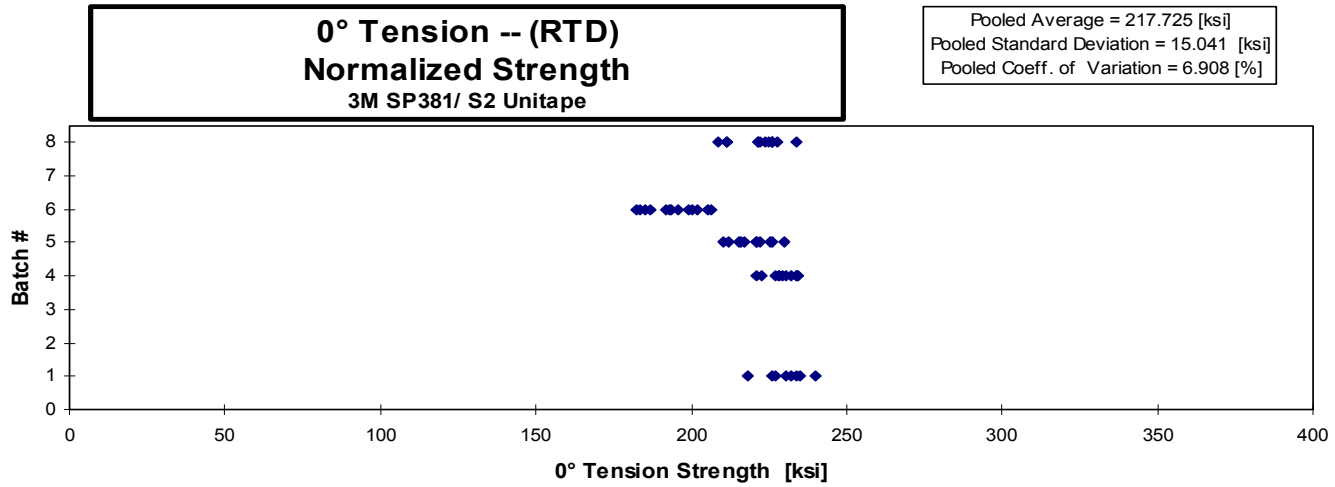
### **3.2.1 Raw Data Spreadsheets and Scatter Charts**

**0° Tension -- (RTD)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

normalizing t<sub>ply</sub>  
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Poisson's Ratio	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]
LBJ1311A	1	229.576	6.903	0.272	0.056	6	0.00931	227.269	6.834
LBJ1312A	1	223.666	6.868	0.252	0.057	6	0.00949	225.914	6.937
LBJ1313A	1	233.939	6.873	0.264	0.053	6	0.00878	218.385	6.416
LBJ1413A	1	234.035			0.057	6	0.00943	234.795	
LBJ1415A	1	233.685			0.056	6	0.00940	233.616	
LBJ1416A	1	227.371			0.057	6	0.00953	230.395	
LBJ1417A	1	237.798			0.057	6	0.00949	240.117	
LBJ1418A	1	235.257			0.056	6	0.00927	231.920	
LBJ4211A	4	224.178	7.014	0.242	0.056	6	0.00934	222.655	6.966
LBJ4212A	4	228.260	6.609	0.306	0.057	6	0.00944	229.272	6.639
LBJ4213A	4	229.428	6.882	0.259	0.057	6	0.00952	232.276	6.968
LBJ4214A	4	227.739			0.058	6	0.00964	233.662	
LBJ4215A	4	236.591			0.056	6	0.00930	234.074	
LBJ4216A	4	232.367			0.057	6	0.00948	234.221	
LBJ4217A	4	223.958			0.057	6	0.00957	228.061	
LBJ4218A	4	226.121			0.057	6	0.00950	228.527	
LBJ4219A	4	227.092			0.057	6	0.00954	230.447	
LBJ421AA	4	217.914			0.057	6	0.00954	221.133	
LBJ421BA	4	235.601			0.054	6	0.00907	227.316	
LBJ5311A	5	235.071	7.345	0.254	0.054	6	0.00904	226.180	7.067
LBJ5312A	5	222.354	7.321	0.272	0.055	6	0.00909	215.126	7.083
LBJ5313A	5	221.139	7.013	0.253	0.055	6	0.00919	216.107	6.853
LBJ5314A	5	218.341			0.054	6	0.00906	210.469	
LBJ5315A	5	221.320			0.055	6	0.00922	217.069	
LBJ5316A	5	226.384			0.053	6	0.00880	211.867	
LBJ5317A	5	231.329			0.055	6	0.00916	225.519	
LBJ5318A	5	235.426			0.055	6	0.00919	230.139	
LBJ5319A	5	229.022			0.054	6	0.00908	221.171	
LBJ531AA	5	225.738			0.055	6	0.00920	220.935	
LBJ531BA	5	228.843			0.055	6	0.00913	222.351	
LBJ6211A	6	204.964			0.057	6	0.00943	205.510	
LBJ6212A	6	199.183	7.084	0.270	0.057	6	0.00944	200.124	7.118
LBJ6213A	6	204.880	7.047	0.266	0.056	6	0.00927	202.034	6.949
LBJ6214A	6	193.992	6.804	0.264	0.056	6	0.00929	191.814	6.728
LBJ6215A	6	198.742			0.055	6	0.00915	193.515	
LBJ6216A	6	211.460			0.055	6	0.00918	206.586	
LBJ6217A	6	197.365			0.056	6	0.00933	195.965	
LBJ6218A	6	189.888			0.055	6	0.00909	183.660	
LBJ6219A	6	193.060			0.054	6	0.00903	185.358	
LBJ621AA	6	192.481			0.057	6	0.00943	193.050	
LBJ621BA	6	188.385			0.056	6	0.00932	186.826	
LBJ621CA	6	200.682			0.051	6	0.00854	182.416	
LBJ621DA	6	195.285			0.057	6	0.00958	198.979	
LBJ8311A	8	236.757	7.365	0.272	0.054	6	0.00896	225.772	7.024
LBJ8312A	8	235.944	7.455	0.258	0.054	6	0.00901	226.183	7.147
LBJ8313A	8	235.415	7.185	0.251	0.055	6	0.00910	227.972	6.957
LBJ8314A	8	232.801			0.054	6	0.00898	222.276	
LBJ8315A	8	229.284			0.052	6	0.00868	211.667	
LBJ8316A	8	231.711			0.054	6	0.00899	221.577	
LBJ8317A	8	234.443			0.054	6	0.00897	223.704	
LBJ8318A	8	235.980			0.056	6	0.00932	233.888	
LBJ8319A	8	215.038			0.055	6	0.00924	211.416	
LBJ831AA	8	226.237			0.055	6	0.00921	221.691	
LBJ831BA	8	234.463			0.054	6	0.00903	225.109	
LBJ831CA	8	232.880			0.055	6	0.00912	225.860	
LBJ831DA	8	216.146			0.054	6	0.00908	208.673	

<b>Average</b>	<b>221.911</b>	<b>7.051</b>	<b>0.263</b>	<b>Average<sub>norm</sub></b>	<b>0.00922</b>	<b>217.725</b>	<b>6.912</b>
<b>Standard Dev.</b>	<b>14.763</b>	<b>0.241</b>	<b>0.015</b>	<b>Standard Dev.<sub>norm</sub></b>		<b>15.041</b>	<b>0.196</b>
<b>Coeff. of Var. [%]</b>	<b>6.653</b>	<b>3.422</b>	<b>5.671</b>	<b>Coeff. of Var. [%]<sub>norm</sub></b>		<b>6.908</b>	<b>2.836</b>
<b>Min.</b>	<b>188.385</b>	<b>6.609</b>	<b>0.242</b>	<b>Min.</b>	<b>0.0085</b>	<b>182.416</b>	<b>6.416</b>
<b>Max.</b>	<b>237.798</b>	<b>7.455</b>	<b>0.306</b>	<b>Max.</b>	<b>0.0096</b>	<b>240.117</b>	<b>7.147</b>
<b>Number of Spec.</b>	<b>56</b>	<b>15</b>	<b>15</b>	<b>Number of Spec.</b>		<b>56</b>	<b>15</b>



**0° Tension -- (CTD)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

normalizing  $t_{ply}$   
 [in]

0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Poisson's Ratio	Avg. Specimen Thickn. [in]	# Plies in Laminate
LBJ1411B	1	221.629	7.476	0.319	0.053	6
LBJ1412B	1	230.565	7.159	0.274	0.056	6
LBJ1413B	1	254.917	7.055	0.242	0.058	6
LBJ1414B	1	278.320			0.056	6
LBJ1415B	1	266.290			0.057	6
LBJ1416B	1	258.060			0.057	6

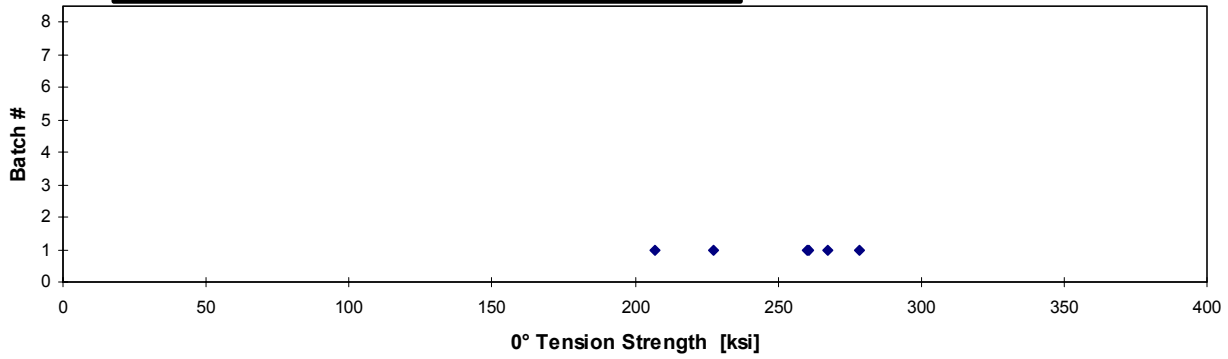
Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]
0.00878	207.089	6.985
0.00926	227.226	7.055
0.00959	260.040	7.197
0.00941	278.485	
0.00944	267.470	
0.00949	260.653	

<b>Average</b>	<b>251.630</b>	<b>7.230</b>	<b>0.278</b>
<b>Standard Dev.</b>	<b>21.556</b>	<b>0.219</b>	<b>0.039</b>
<b>Coeff. of Var. [%]</b>	<b>8.566</b>	<b>3.032</b>	<b>13.933</b>
<b>Min.</b>	<b>221.629</b>	<b>7.055</b>	<b>0.242</b>
<b>Max.</b>	<b>278.320</b>	<b>7.476</b>	<b>0.319</b>
<b>Number of Spec.</b>	<b>6</b>	<b>3</b>	<b>3</b>

<b>Average<sub>norm</sub></b>	<b>0.00933</b>	<b>250.160</b>	<b>7.079</b>
<b>Standard Dev.<sub>norm</sub></b>		<b>27.169</b>	<b>0.108</b>
<b>Coeff. of Var. [%]<sub>norm</sub></b>		<b>10.861</b>	<b>1.523</b>
<b>Min.</b>	<b>0.0088</b>	<b>207.089</b>	<b>6.985</b>
<b>Max.</b>	<b>0.0096</b>	<b>278.485</b>	<b>7.197</b>
<b>Number of Spec.</b>		<b>6</b>	<b>3</b>

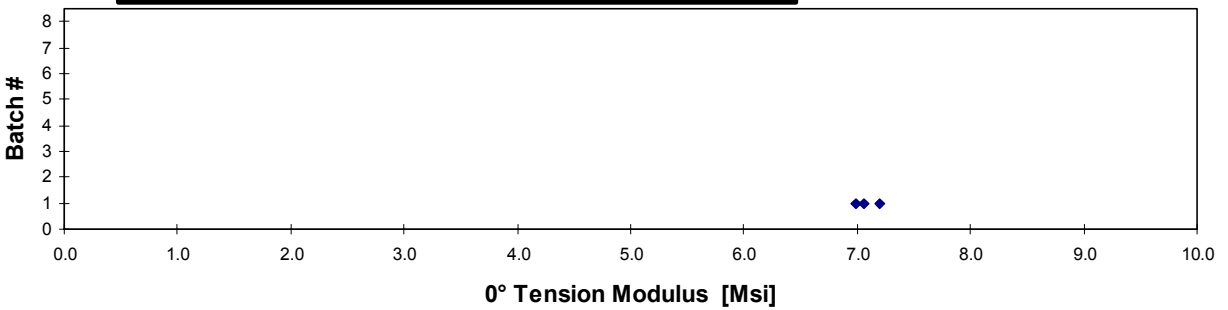
**0° Tension -- (CTD)  
Normalized Strength  
3M SP381/ S2 Unitape**

Pooled Average = 250.160 [ksi]  
Pooled Standard Deviation = 27.169 [ksi]  
Pooled Coeff. of Variation = 10.861 [%]



**0° Tension -- (CTD)  
Normalized Modulus  
3M SP381/ S2 Unitape**

Pooled Average = 7.079 [Msi]  
Pooled Standard Deviation = 0.108 [Msi]  
Pooled Coeff. of Variation = 1.523 [%]



**0° Tension -- (ETW - 150°)**  
**Strength & Modulus**  
 3M SP381/ S2 Unitape

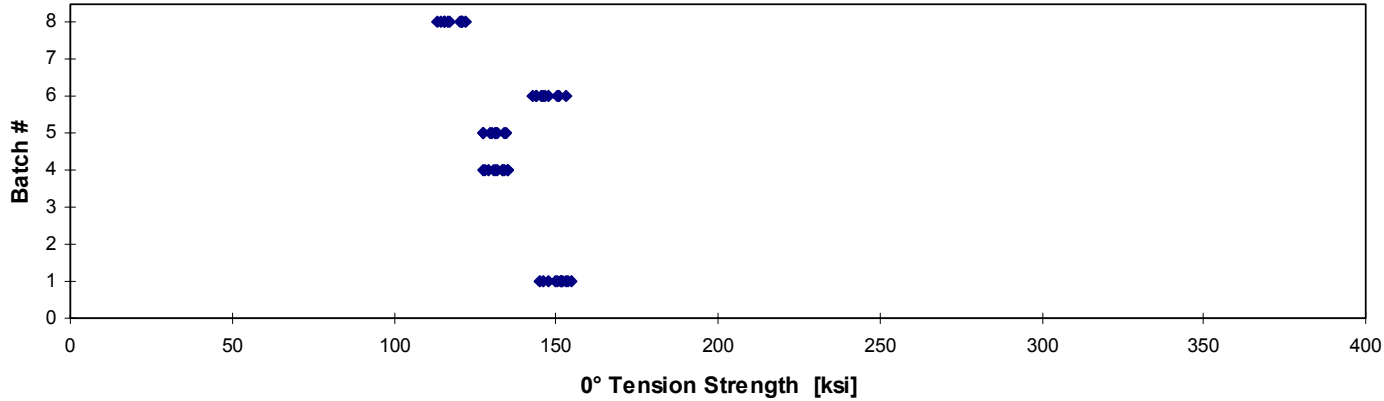
normalizing  $t_{ply}$   
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Poisson's Ratio	Avg. Specimen Thicken. [in]	# Plies in Laminate	Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]
LBJ1111C	1	144.429			0.057	6	0.00944	145.112	
LBJ1112C	1	149.787			0.057	6	0.00951	151.557	
LBJ1113C	1	154.651			0.056	6	0.00932	153.326	
LBJ1114C	1	153.555			0.056	6	0.00927	151.377	
LBJ1115C	1	152.313			0.057	6	0.00948	153.663	
LBJ1116C	1	148.281	6.897		0.057	6	0.00951	150.034	6.979
LBJ1117C	1	153.906	6.631		0.056	6	0.00929	152.041	6.551
LBJ1118C	1	146.903	6.849		0.056	6	0.00934	145.904	6.802
LBJ1119C	1	146.036			0.057	6	0.00951	147.806	
LBJ111AC	1	152.481			0.057	6	0.00953	154.509	
LBJ111BC	1	151.433			0.056	6	0.00932	150.180	
LBJ4111C	4	136.154	6.748	0.251	0.055	6	0.00920	133.257	6.604
LBJ4112C	4	131.768	6.726	0.240	0.057	6	0.00942	132.002	6.738
LBJ4113C	4	131.498	6.707	0.270	0.058	6	0.00964	134.918	6.882
LBJ4114C	4	135.133			0.054	6	0.00899	129.223	
LBJ4115C	4	137.135			0.055	6	0.00916	133.609	
LBJ4116C	4	134.491			0.056	6	0.00935	133.815	
LBJ4117C	4	132.658			0.057	6	0.00958	135.206	
LBJ4118C	4	132.138			0.056	6	0.00931	130.928	
LBJ4119C	4	131.953			0.056	6	0.00938	131.602	
LBJ411AC	4	129.049			0.056	6	0.00928	127.371	
LBJ411BC	4	126.242			0.057	6	0.00954	128.182	
LBJ5211C	5	137.640			0.054	6	0.00902	132.027	
LBJ5212C	5	139.285	6.970	0.256	0.053	6	0.00878	130.065	6.509
LBJ5213C	5	131.392	6.766	0.281	0.055	6	0.00911	127.315	6.556
LBJ5215C	5	133.736			0.055	6	0.00923	131.325	
LBJ5216C	5	134.501			0.055	6	0.00919	131.520	
LBJ5217C	5	140.556			0.054	6	0.00898	134.284	
LBJ5218C	5	135.060			0.055	6	0.00914	131.388	
LBJ5219C	5	130.104	6.982	0.237	0.055	6	0.00921	127.490	6.841
LBJ521AC	5	138.865			0.055	6	0.00913	134.843	
LBJ521BC	5	134.367			0.055	6	0.00909	129.960	
LBJ6111C	6	143.949	6.746	0.268	0.056	6	0.00939	143.779	6.738
LBJ6112C	6	147.983	6.932	0.232	0.056	6	0.00936	147.414	6.906
LBJ6113C	6	151.548	6.347	0.218	0.054	6	0.00908	146.398	6.131
LBJ6114C	6	154.410			0.056	6	0.00932	153.132	
LBJ6115C	6	151.707			0.054	6	0.00901	145.386	
LBJ6116C	6	145.052			0.056	6	0.00926	142.952	
LBJ6117C	6	152.091			0.056	6	0.00928	150.158	
LBJ6119C	6	149.782			0.055	6	0.00916	145.976	
LBJ611AC	6	153.972			0.055	6	0.00922	151.060	
LBJ611BC	6	147.519			0.055	6	0.00917	143.858	
LBJ8211C	8	116.929	7.141	0.313	0.055	6	0.00921	114.510	6.994
LBJ8212C	8	124.099	7.036	0.259	0.055	6	0.00916	120.945	6.857
LBJ8213C	8	128.792	7.130	0.258	0.053	6	0.00890	121.904	6.749
LBJ8214C	8	120.395			0.055	6	0.00910	116.589	
LBJ8215C	8	117.826			0.055	6	0.00920	115.319	
LBJ8216C	8	120.776			0.056	6	0.00936	120.205	
LBJ8217C	8	127.091			0.054	6	0.00896	121.119	
LBJ8218C	8	120.046			0.053	6	0.00889	113.554	
LBJ821AC	8	118.389			0.056	6	0.00929	117.059	
LBJ821BC	8	122.998			0.056	6	0.00926	121.108	
LBJ821CC	8	120.078			0.054	6	0.00904	115.465	

<b>Average</b>	<b>137.791</b>	<b>6.841</b>	<b>0.257</b>	<b>Average<sub>norm</sub></b>	<b>0.00924</b>	<b>135.542</b>	<b>6.722</b>
<b>Standard Dev.</b>	<b>11.604</b>	<b>0.207</b>	<b>0.025</b>	<b>Standard Dev.<sub>norm</sub></b>		<b>12.364</b>	<b>0.224</b>
<b>Coeff. of Var. [%]</b>	<b>8.422</b>	<b>3.033</b>	<b>9.750</b>	<b>Coeff. of Var. [%]<sub>norm</sub></b>		<b>9.122</b>	<b>3.337</b>
<b>Min.</b>	<b>116.929</b>	<b>6.347</b>	<b>0.218</b>	<b>Min.</b>	<b>0.00888</b>	<b>113.554</b>	<b>6.131</b>
<b>Max.</b>	<b>154.651</b>	<b>7.141</b>	<b>0.313</b>	<b>Max.</b>	<b>0.0096</b>	<b>154.509</b>	<b>6.994</b>
<b>Number of Spec.</b>	<b>53</b>	<b>15</b>	<b>12</b>	<b>Number of Spec.</b>		<b>53</b>	<b>15</b>

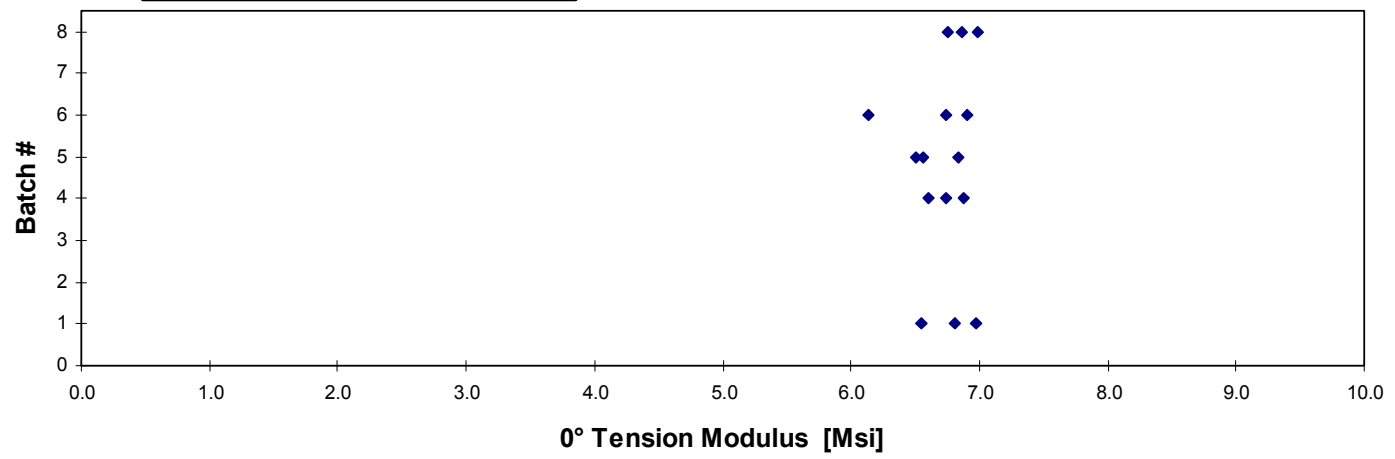
**0° Tension -- (ETW - 150°)**  
**Normalized Strength**  
3M SP381/ S2 Unitape

Pooled Average = 135.542 [ksi]  
Pooled Standard Deviation = 12.364 [ksi]  
Pooled Coeff. of Variation = 9.122 [%]



**0° Tension -- (ETW - 150°)**  
**Normalized Modulus**  
3M SP381/ S2 Unitape

Pooled Average = 6.722 [Msi]  
Pooled Standard Deviation = 0.224 [Msi]  
Pooled Coeff. of Variation = 3.337 [%]



**0° Tension -- (ETW - 180°)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

normalizing  $t_{ply}$   
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Poisson's Ratio	Avg. Specimen Thickn. [in]	# Plies in Laminate
LBJ2111F	2	142.166			0.056	6
LBJ2118F	2	145.067	7.388	0.371	0.052	6
LBJ2119F	2	138.124			0.056	6
LBJ211AF	2	137.331			0.055	6
LBJ211BF	2	142.103			0.053	6
LBJ211CF	2	139.812			0.054	6
LBJ211DF	2	150.141	7.101	0.302	0.055	6
LBJ3115F	3	135.857	6.903	0.269	0.055	6
LBJ3118F	3	133.272	6.995	0.248	0.056	6
LBJ311CF	3	132.236			0.055	6
LBJ311DF	3	132.790			0.050	6
LBJ311FF	3	130.008			0.055	6
LBJ3215F	3	136.388			0.055	6
LBJ7111F	7	122.270	7.129	0.298	0.054	6
LBJ7112F	7	111.372	6.964	0.287	0.054	6
LBJ7113F	7	119.477			0.054	6
LBJ7114F	7	120.942			0.055	6
LBJ7115F	7	117.986			0.055	6
LBJ7216F	7	134.139			0.053	6

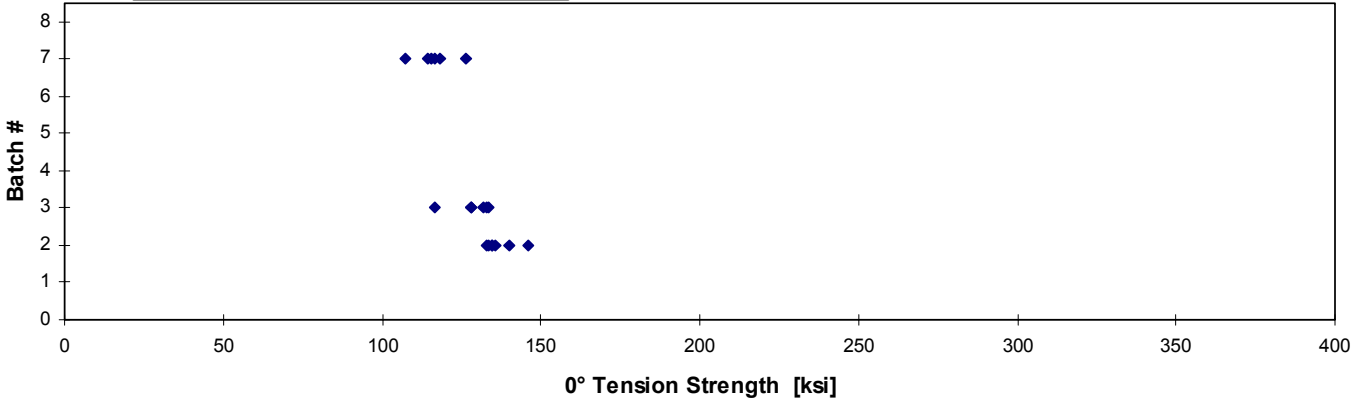
Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]
0.00926	140.023	
0.00871	134.393	6.844
0.00925	135.920	
0.00913	133.395	
0.00879	132.907	
0.00904	134.441	
0.00914	145.970	6.904
0.00925	133.649	6.791
0.00932	132.130	6.935
0.00909	127.859	
0.00826	116.701	
0.00924	127.857	
0.00916	132.962	
0.00899	116.887	6.815
0.00908	107.521	6.723
0.00902	114.675	
0.00918	118.119	
0.00919	115.302	
0.00885	126.291	

**Average** 132.710 7.080 0.296  
**Standard Dev.** 10.174 0.173 0.042  
**Coeff. of Var. [%]** 7.667 2.444 14.213  
**Min.** 111.372 6.903 0.248  
**Max.** 150.141 7.388 0.371  
**Number of Spec.** 19 6 6

**Average<sub>norm</sub>** 0.00905 127.737 6.835  
**Standard Dev.<sub>norm</sub>** 10.132 0.077  
**Coeff. of Var. [%]<sub>norm</sub>** 7.932 1.129  
**Min.** 0.0083 107.521 6.723  
**Max.** 0.0093 145.970 6.935  
**Number of Spec.** 19 6

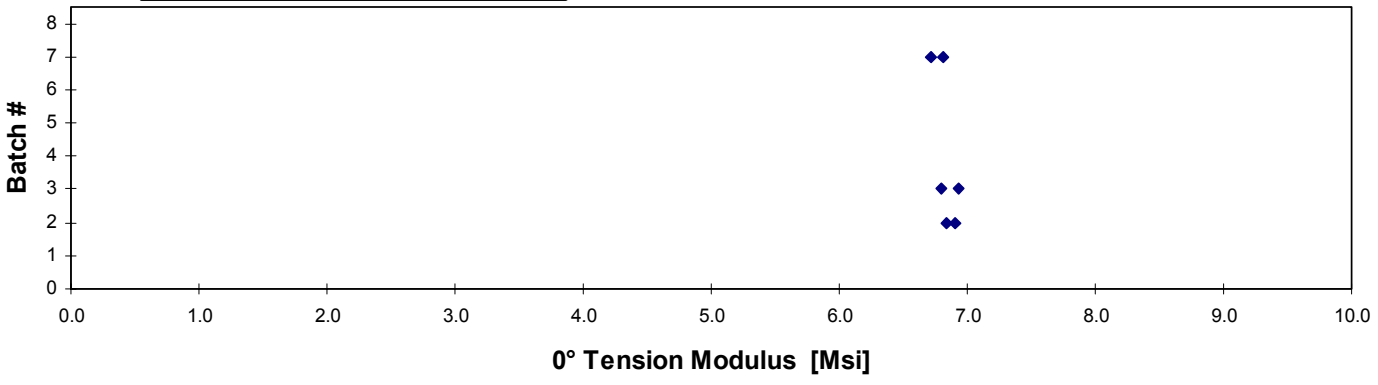
**0° Tension -- (ETW - 180°)**  
**Normalized Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 127.737 [ksi]  
 Pooled Standard Deviation = 10.132 [ksi]  
 Pooled Coeff. of Variation = 7.932 [%]



**0° Tension -- (ETW - 180°)**  
**Normalized Modulus**  
 3M SP381/ S2 Unitape

Pooled Average = 6.835 [Msi]  
 Pooled Standard Deviation = 0.077 [Msi]  
 Pooled Coeff. of Variation = 1.129 [%]



**0° Tension -- (ETD - 180°)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

normalizing  $t_{ply}$   
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Poisson's Ratio	Avg. Specimen Thickn. [in]	# Plies in Laminate
LBJ2121G	2	223.037	7.057	0.280	0.054	6
LBJ2124G	2	222.641			0.055	6
LBJ2125G	2	213.601			0.056	6
LBJ2126G	2	232.033	7.033	0.261	0.055	6
LBJ2127G	2	229.287			0.056	6
LBJ2128G	2	224.205			0.055	6
LBJ3113G	3	206.114	6.728	0.251	0.054	6
LBJ3114G	3	215.301	6.887	0.268	0.056	6
LBJ311GG	3	211.929			0.056	6
LBJ3210G	3	230.208			0.054	6
LBJ3214G	3	215.226			0.055	6
LBJ3216G	3	228.233			0.055	6
LBJ7116G	7	172.194	6.887	0.270	0.055	6
LBJ7117G	7	171.502	6.799	0.246	0.056	6
LBJ7118G	7	177.098			0.056	6
LBJ7119G	7	181.233			0.056	6
LBJ7212G	7	217.492			0.054	6
LBJ7213G	7	213.649			0.055	6

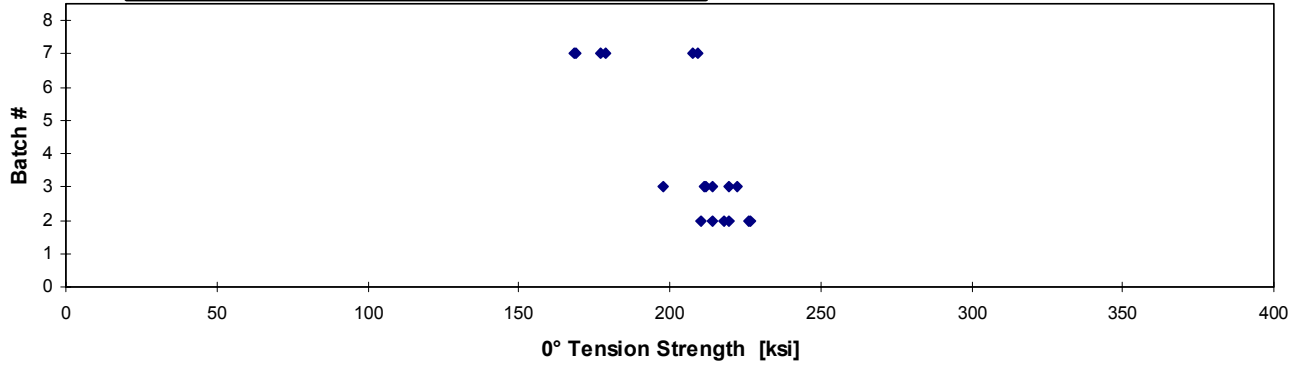
Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]
0.00902	214.008	6.771
0.00921	218.035	
0.00926	210.382	
0.00917	226.274	6.858
0.00930	226.847	
0.00921	219.567	
0.00901	197.647	6.452
0.00936	214.347	6.857
0.00940	211.992	
0.00896	219.391	
0.00923	211.410	
0.00915	222.163	
0.00920	168.531	6.741
0.00927	169.070	6.703
0.00939	176.889	
0.00926	178.609	
0.00906	209.523	
0.00914	207.714	

**Average**                    **210.277**        **6.898**        **0.263**  
**Standard Dev.**            **20.446**        **0.128**        **0.013**  
**Coeff. of Var. [%]**        **9.723**         **1.858**        **4.828**  
**Min.**                        **171.502**       **6.728**        **0.246**  
**Max.**                        **232.033**       **7.057**        **0.280**  
**Number of Spec.**            **18**             **6**             **6**

**Average<sub>norm</sub>**    **0.00920**        **205.689**        **6.730**  
**Standard Dev.<sub>norm</sub>**        **19.223**         **0.150**  
**Coeff. of Var. [%]<sub>norm</sub>**    **9.346**         **2.227**  
**Min.**                        **0.0090**        **168.531**        **6.452**  
**Max.**                        **0.0094**        **226.847**        **6.858**  
**Number of Spec.**            **18**             **6**

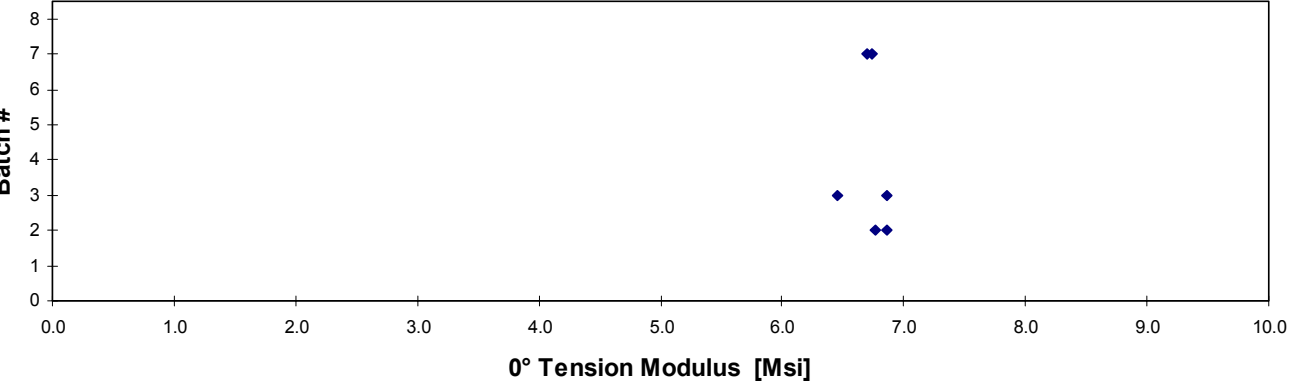
**0° Tension -- (ETD - 180°)**  
**Normalized Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 205.689 [ksi]  
 Pooled Standard Deviation = 19.223 [ksi]  
 Pooled Coeff. of Variation = 9.346 [%]



**0° Tension -- (ETD - 180°)**  
**Normalized Modulus**  
 3M SP381/ S2 Unitape

Pooled Average = 6.730 [Msi]  
 Pooled Standard Deviation = 0.150 [Msi]  
 Pooled Coeff. of Variation = 2.227 [%]



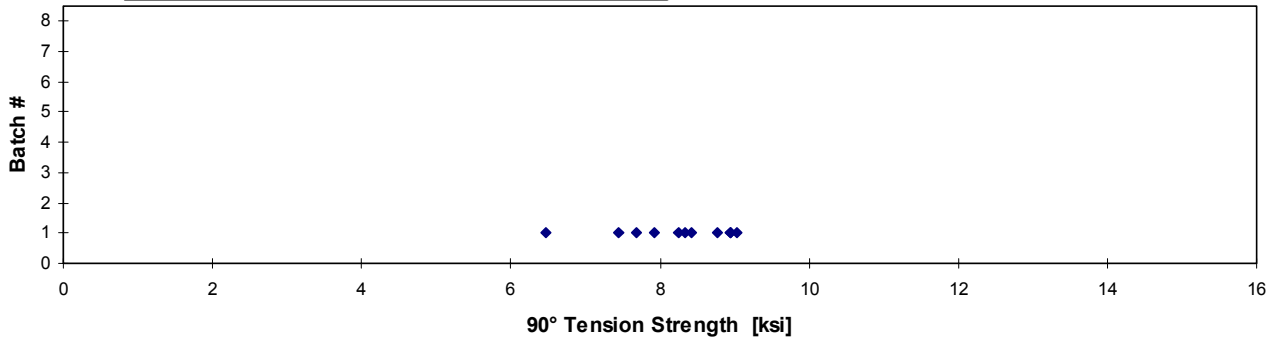
<b>90° Tension -- (RTD)</b> <b>Strength &amp; Modulus</b> <b>3M SP381/ S2 Unitape</b>
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Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. $t_{ply}$ [in]
LBU1411A	1	8.942	2.019	0.087	9	0.00967
LBU1413A	1	9.029	1.970	0.088	9	0.00972
LBU1414A	1	7.457	1.917	0.087	9	0.00969
LBU1415A	1	8.421		0.086	9	0.00956
LBU1416A	1	8.253		0.087	9	0.00971
LBU1417A	1	7.929		0.088	9	0.00975
LBU1418A	1	8.777		0.087	9	0.00962
LBU1511A	1	6.473		0.085	9	0.00943
LBU1512A	1	7.675		0.084	9	0.00930
LBU1513A	1	8.347		0.085	9	0.00946
LBU1515A	1	8.935		0.085	9	0.00943

<b>Average</b>	<b>8.203</b>	<b>1.969</b>	<b>0.0096</b>
<b>Standard Dev.</b>	<b>0.779</b>	<b>0.051</b>	
<b>Coeff. of Var. [%]</b>	<b>9.495</b>	<b>2.600</b>	
<b>Min.</b>	<b>6.473</b>	<b>1.917</b>	<b>Min. 0.0093</b>
<b>Max.</b>	<b>9.029</b>	<b>2.019</b>	<b>Max. 0.0098</b>
<b>Number of Spec.</b>	<b>11</b>	<b>3</b>	

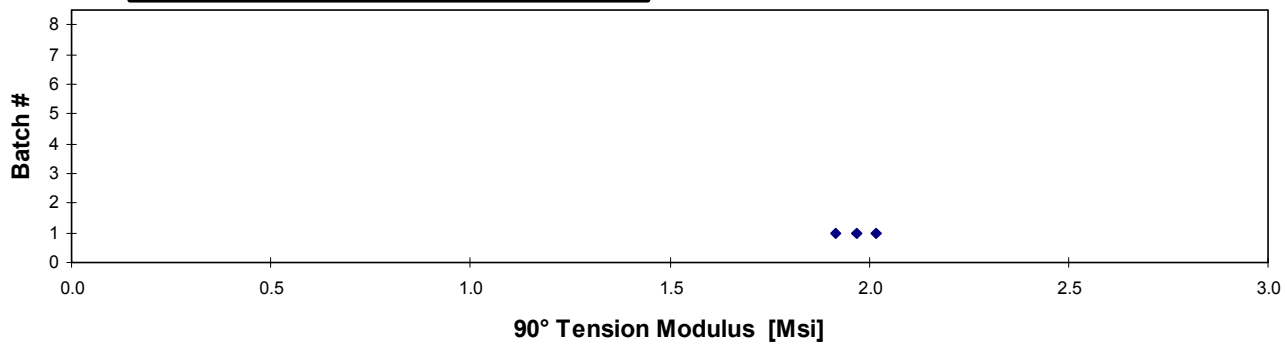
**90° Tension -- (RTD)**  
**Measured Strength**  
3M SP381/ S2 Unitape

Pooled Average = 8.203 [ksi]  
Pooled Standard Deviation = 0.779 [ksi]  
Pooled Coeff. of Variation = 9.495 [%]



**90° Tension -- (RTD)**  
**Measured Modulus**  
3M SP381/ S2 Unitape

Pooled Average = 1.969 [Msi]  
Pooled Standard Deviation = 0.051 [Msi]  
Pooled Coeff. of Variation = 2.600 [%]



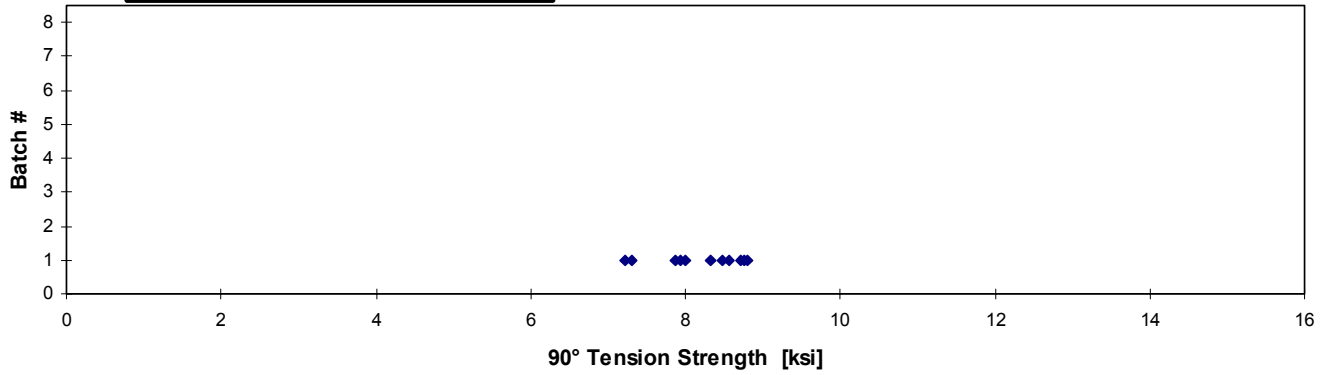
**90° Tension -- (ETW - 150°)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBU1211C	1	7.305		0.088	9	0.00975
LBU1212C	1	8.006	1.424	0.086	9	0.00959
LBU1214C	1	7.938		0.085	9	0.00941
LBU1215C	1	7.869		0.088	9	0.00979
LBU1216C	1	7.211		0.087	9	0.00965
LBU1313C	1	8.726	1.492	0.085	9	0.00947
LBU1314C	1	8.766	1.360	0.085	9	0.00947
LBU1315C	1	8.332		0.085	9	0.00942
LBU1316C	1	8.468		0.086	9	0.00952
LBU1317C	1	8.557		0.084	9	0.00932
LBU1318C	1	8.796		0.085	9	0.00943

<b>Average</b>	<b>8.179</b>	<b>1.425</b>	<b>Average</b>	<b>0.0095</b>
<b>Standard Dev.</b>	<b>0.562</b>	<b>0.066</b>		
<b>Coeff. of Var. [%]</b>	<b>6.871</b>	<b>4.632</b>		
<b>Min.</b>	<b>7.211</b>	<b>1.360</b>	<b>Min.</b>	<b>0.0093</b>
<b>Max.</b>	<b>8.796</b>	<b>1.492</b>	<b>Max.</b>	<b>0.0098</b>
<b>Number of Spec.</b>	<b>11</b>	<b>3</b>		

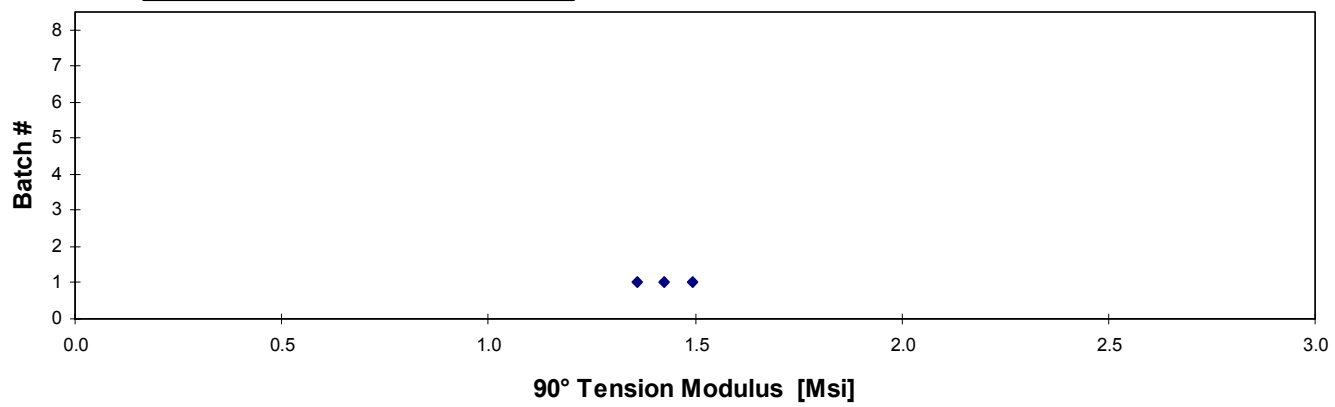
**90° Tension -- (ETW - 150°)**  
**Measured Strength**  
3M SP381/ S2 Unitape

Pooled Average = 8.179 [ksi]  
Pooled Standard Deviation = 0.562 [ksi]  
Pooled Coeff. of Variation = 6.871 [%]



**90° Tension -- (ETW - 150°)**  
**Measured Modulus**  
3M SP381/ S2 Unitape

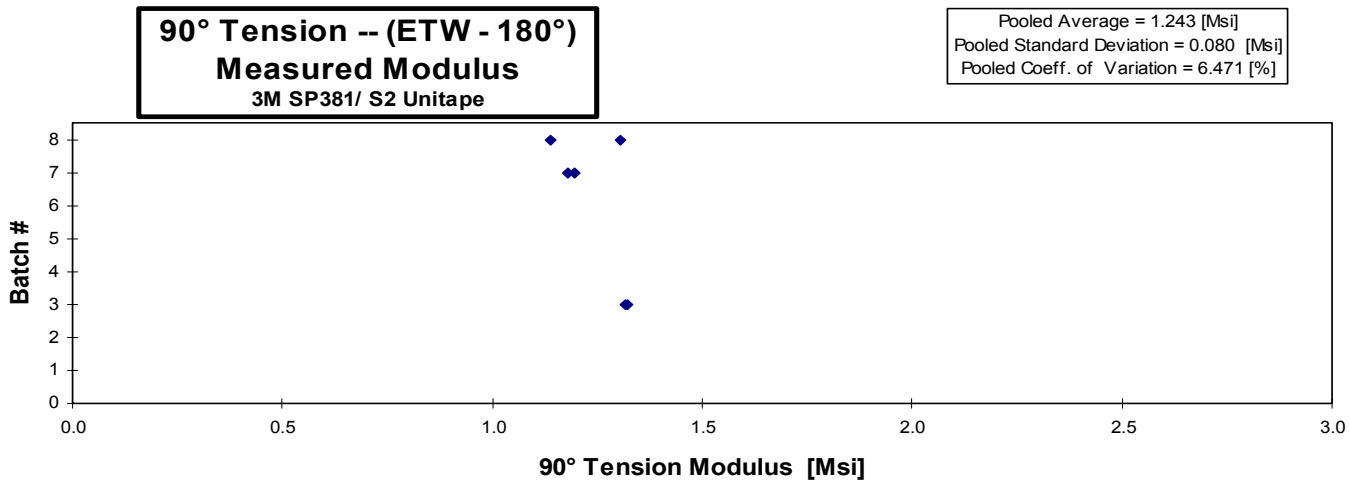
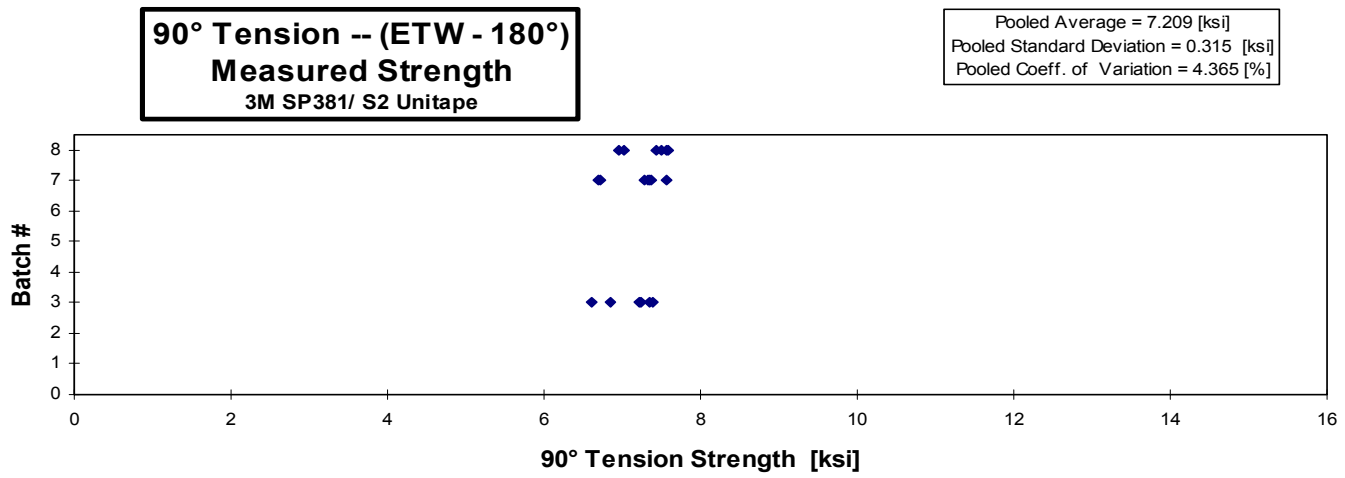
Pooled Average = 1.425 [Msi]  
Pooled Standard Deviation = 0.066 [Msi]  
Pooled Coeff. of Variation = 4.632 [%]



<b>90° Tension -- (ETW - 180°)</b> <b>Strength &amp; Modulus</b> <b>3M SP381/ S2 Unitape</b>
--

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBU3113F	3	6.603	1.321	0.083	9	0.00925
LBU3114F	3	7.210	1.318	0.082	9	0.00915
LBU3115F	3	7.384		0.083	9	0.00927
LBU3116F	3	7.342		0.085	9	0.00943
LBU3117F	3	7.231		0.085	9	0.00944
LBU3211F	3	6.845		0.084	9	0.00935
LBU7211F	7	6.688	1.194	0.084	9	0.00930
LBU7212F	7	7.366		0.084	9	0.00935
LBU7214F	7	7.286		0.083	9	0.00923
LBU7215F	7	7.575		0.083	9	0.00924
LBU7216F	7	7.346		0.085	9	0.00940
LBU7217F	7	7.324		0.085	9	0.00946
LBU7218F	7	6.708	1.182	0.085	9	0.00944
LBU8111F	8	6.949	1.140	0.083	9	0.00923
LBU8112F	8	7.587	1.305	0.083	9	0.00928
LBU8113F	8	7.507		0.084	9	0.00938
LBU8114F	8	7.566		0.083	9	0.00927
LBU8115F	8	7.432		0.084	9	0.00934
LBU8216F	8	7.013		0.083	9	0.00927

<b>Average</b>	<b>7.209</b>	<b>1.243</b>	<b>0.0093</b>
<b>Standard Dev.</b>	<b>0.315</b>	<b>0.080</b>	
<b>Coeff. of Var. [%]</b>	<b>4.365</b>	<b>6.471</b>	
<b>Min.</b>	<b>6.603</b>	<b>1.140</b>	<b>Min. 0.0092</b>
<b>Max.</b>	<b>7.587</b>	<b>1.321</b>	<b>Max. 0.0095</b>



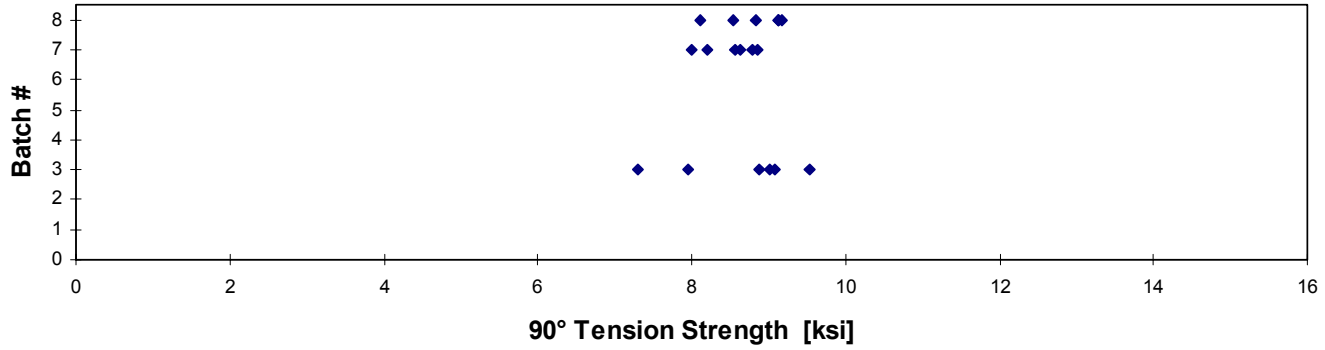
<b>90° Tension -- (ETD - 180°)</b> <b>Strength &amp; Modulus</b> <b>3M SP381/ S2 Unitape</b>
--

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBU3111G	3	8.882	1.748	0.084	9	0.00933
LBU3112G	3	9.013		0.084	9	0.00937
LBU3118G	3	9.525	1.729	0.084	9	0.00938
LBU3119G	3	9.089		0.083	9	0.00928
LBU3212G	3	7.299		0.084	9	0.00933
LBU3213G	3	7.963		0.086	9	0.00950
LBU7111G	7	7.995	1.739	0.083	9	0.00927
LBU7112G	7	8.567	1.597	0.084	9	0.00930
LBU7113G	7	8.639		0.084	9	0.00934
LBU7114G	7	8.852		0.084	9	0.00931
LBU7115G	7	8.201		0.084	9	0.00933
LBU7116G	7	8.789		0.084	9	0.00932
LBU8116G	8	9.169	1.879	0.084	9	0.00930
LBU8117G	8	8.827	1.782	0.083	9	0.00921
LBU8118G	8	9.135		0.083	9	0.00926
LBU8212G	8	8.123		0.083	9	0.00922
LBU8213G	8	8.544		0.083	9	0.00926
LBU8214G	8	9.132		0.083	9	0.00925

<b>Average</b>	<b>8.652</b>	<b>1.746</b>	<b>0.0093</b>
<b>Standard Dev.</b>	<b>0.553</b>	<b>0.091</b>	
<b>Coeff. of Var. [%]</b>	<b>6.391</b>	<b>5.204</b>	
<b>Min.</b>	<b>7.299</b>	<b>1.597</b>	<b>Min. 0.0092</b>
<b>Max.</b>	<b>9.525</b>	<b>1.879</b>	<b>Max. 0.0095</b>
<b>Number of Spec.</b>	<b>18</b>	<b>6</b>	

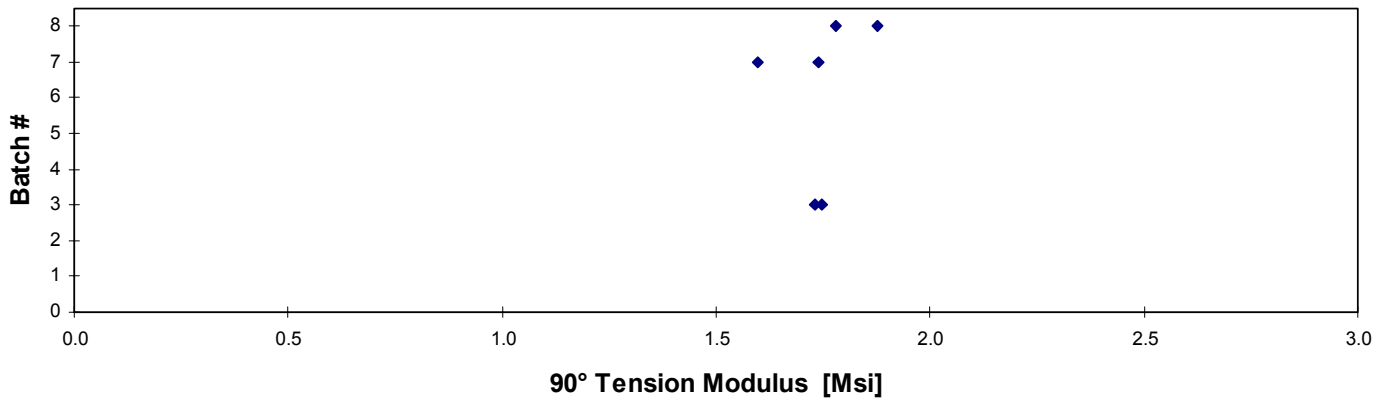
**90° Tension -- (ETD - 180°)**  
**Measured Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 8.652 [ksi]  
 Pooled Standard Deviation = 0.553 [ksi]  
 Pooled Coeff. of Variation = 6.391 [%]



**90° Tension -- (ETD - 180°)**  
**Measured Modulus**  
 3M SP381/ S2 Unitape

Pooled Average = 1.746 [Msi]  
 Pooled Standard Deviation = 0.091 [Msi]  
 Pooled Coeff. of Variation = 5.204 [%]



**0° Compression -- (RTD)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

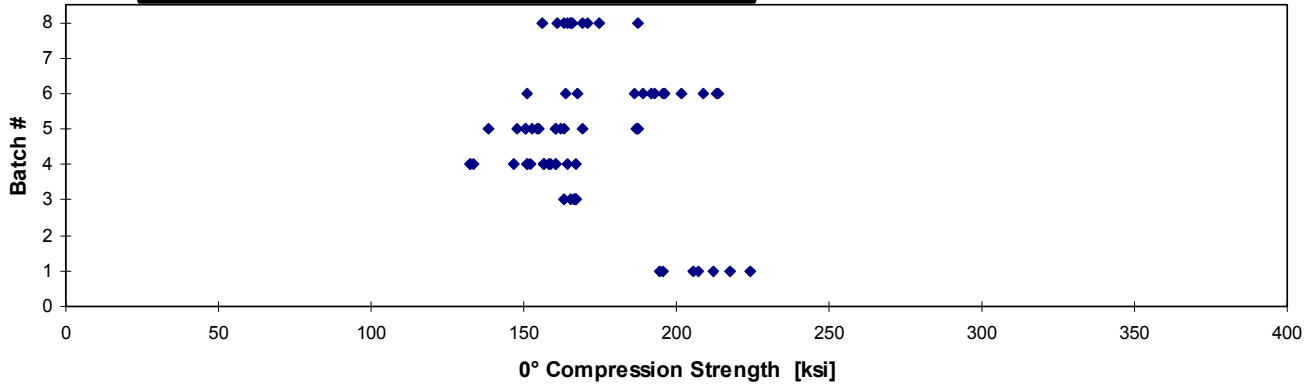
normalizing t<sub>ply</sub>  
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]
LBK1221A	1	206.534		0.057	6	0.00943	207.083	
LBK1222A	1	211.616		0.055	6	0.00913	205.425	
LBK1224A	1	219.579		0.058	6	0.00960	224.348	
LBK1225A	1	190.795		0.058	6	0.00963	195.362	
LBK1226A	1	181.947		0.060	6	0.01005	194.610	
LBK1227A	1	208.428		0.057	6	0.00955	211.847	
LBK1229A	1	211.728		0.058	6	0.00967	217.734	
LBL1121A	1		7.006	0.056	6	0.00927		6.907
LBL1122A	1		7.081	0.054	6	0.00904		6.811
LBL1123A	1		7.227	0.055	6	0.00918		7.058
LBL1124A	1		6.899	0.056	6	0.00938		6.886
LBL1125A	1		7.283	0.052	6	0.00865		6.699
LBL1126A	1		7.089	0.056	6	0.00928		6.995
LBL1127A	1		7.299	0.055	6	0.00922		7.156
LBL1128A	1		7.420	0.056	6	0.00928		7.321
LBL1129A	1		7.434	0.054	6	0.00895		7.075
LBL1131A	1		7.458	0.055	6	0.00913		7.243
LBL1132A	1		7.192	0.055	6	0.00912		6.978
LBK3322A	3	169.427		0.054	6	0.00907	163.419	
LBK3325A	3	169.620		0.056	6	0.00925	166.989	
LBK3328A	3	166.453		0.056	6	0.00933	165.272	
LBK3129A	3	169.697		0.055	6	0.00923	166.613	
LBK312AA	3	167.273		0.056	6	0.00938	166.902	
LBK4314A	4	160.685		0.056	6	0.00929	158.833	
LBK4315A	4	167.306		0.055	6	0.00923	164.265	
LBK4317A	4	157.927		0.056	6	0.00933	156.737	
LBK431AA	4	156.153		0.055	6	0.00916	152.139	
LBK4322A	4	133.828		0.056	6	0.00931	132.523	
LBK4324A	4	152.696		0.058	6	0.00963	156.351	
LBK4327A	4	159.262		0.057	6	0.00948	160.603	
LBK4328A	4	146.372		0.058	6	0.00972	151.303	
LBK432BA	4	130.615		0.058	6	0.00960	133.394	
LBK4411A	4	130.093		0.057	6	0.00958	132.515	
LBK4412A	4	143.828		0.058	6	0.00959	146.697	
LBK4413A	4	166.223		0.057	6	0.00944	166.886	
LBK4415A	4	149.845		0.057	6	0.00948	151.040	
LBK4416A	4	155.390		0.057	6	0.00956	158.007	
LBK4417A	4	162.549		0.056	6	0.00926	160.171	
LBK4418A	4	158.143		0.056	6	0.00931	156.600	
LBK5323A	5	184.450		0.057	6	0.00952	186.821	
LBK5324A	5	184.676		0.057	6	0.00954	187.459	
LBK5325A	5	185.841		0.057	6	0.00948	187.488	
LBK5523A	5	162.519		0.056	6	0.00927	160.213	
LBK5528A	5	159.890		0.055	6	0.00911	154.981	
LBK5521A	5	168.537		0.055	6	0.00910	163.233	
LBK5525A	5	167.188		0.054	6	0.00902	160.444	
LBK5527A	5	160.535		0.054	6	0.00903	154.202	
LBK5531A	5	185.425		0.056	6	0.00925	182.944	
LBK5533A	5	152.418		0.055	6	0.00913	147.959	
LBK5534A	5	173.509		0.055	6	0.00917	169.261	
LBK5535A	5	156.198		0.054	6	0.00907	150.659	
LBK5536A	5	143.469		0.054	6	0.00906	138.318	
LBK5537A	5	167.930		0.054	6	0.00907	161.975	
LBK5538A	5	154.522		0.055	6	0.00916	150.549	
LBK6211A	6	192.688		0.056	6	0.00935	191.663	
LBK6212A	6	190.280		0.056	6	0.00933	188.846	
LBK6213A	6	216.359		0.056	6	0.00930	213.961	
LBK6214A	6	210.963		0.056	6	0.00931	208.905	
LBK6215A	6	190.068		0.055	6	0.00921	186.193	
LBK6216A	6	196.207		0.056	6	0.00938	195.685	
LBK6217A	6	201.476		0.056	6	0.00940	201.387	
LBK6218A	6	214.158		0.056	6	0.00936	213.208	
LBK6219A	6	202.232		0.055	6	0.00912	196.137	
LBK621AA	6	201.313		0.054	6	0.00902	193.104	
LBK6224A	6	163.160		0.057	6	0.00943	163.666	
LBK6227A	6	160.813		0.053	6	0.00884	151.190	
LBK6228A	6	170.295		0.055	6	0.00924	167.427	
LBK8322A	8	170.442		0.053	6	0.00889	161.149	
LBK8324A	8	173.795		0.054	6	0.00894	165.321	
LBK8325A	8	198.301		0.053	6	0.00887	187.138	
LBK8327A	8	169.746		0.055	6	0.00918	165.683	
LBK8328A	8	176.678		0.056	6	0.00928	174.486	
LBK8329A	8	174.633		0.055	6	0.00921	171.149	
LBK8411A	8	170.249		0.055	6	0.00914	165.571	
LBK8412A	8	163.850		0.054	6	0.00894	155.861	
LBK8416A	8	172.563		0.053	6	0.00888	163.001	
LBK8418A	8	178.608		0.054	6	0.00892	169.504	
LBK8419A	8	172.293		0.054	6	0.00895	164.122	

Average	173.318	7.217	Average <sub>norm</sub>	0.00926	171.112	7.012
Standard Dev.	21.503	0.184	Standard Dev. <sub>norm</sub>		22.099	0.185
Coeff. of Var. [%]	12.407	2.551	Coeff. of Var. [%] <sub>norm</sub>		12.915	2.639
Min.	130.093	6.899	Min.	0.0086	132.515	6.699
Max.	219.579	7.458	Max.	0.0101	224.348	7.321
Number of Spec.	67	11	Number of Spec.		67	11

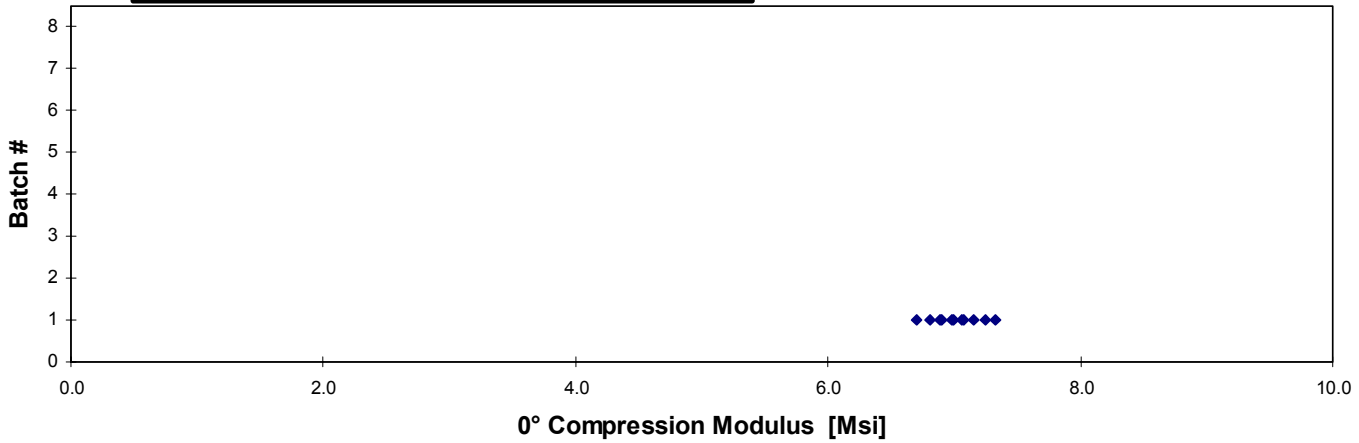
**0° Compression -- (RTD)  
Normalized Strength  
3M SP381/ S2 Unitape**

Pooled Average = 171.112 [ksi]  
Pooled Standard Deviation = 22.099 [ksi]  
Pooled Coeff. of Variation = 12.915 [%]



**0° Compression -- (RTD)  
Normalized Modulus  
3M SP381/ S2 Unitape**

Pooled Average = 7.012 [Msi]  
Pooled Standard Deviation = 0.185 [Msi]  
Pooled Coeff. of Variation = 2.639 [%]



**0° Compression -- (CTD)  
 Strength  
 3M SP381/ S2 Unitape**

normalizing  $t_{ply}$   
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Avg. Specimen Thickn. [in]	# Plies in Laminate
LBK6313B	1	182.393	0.057	6
LBK6318B	1	217.084	0.057	6
LBK6231B	1	176.002	0.053	6
LBK6239B	1	174.888	0.055	6
LBK6136B	1	152.180	0.058	6
LBK6139B	1	186.642	0.056	6

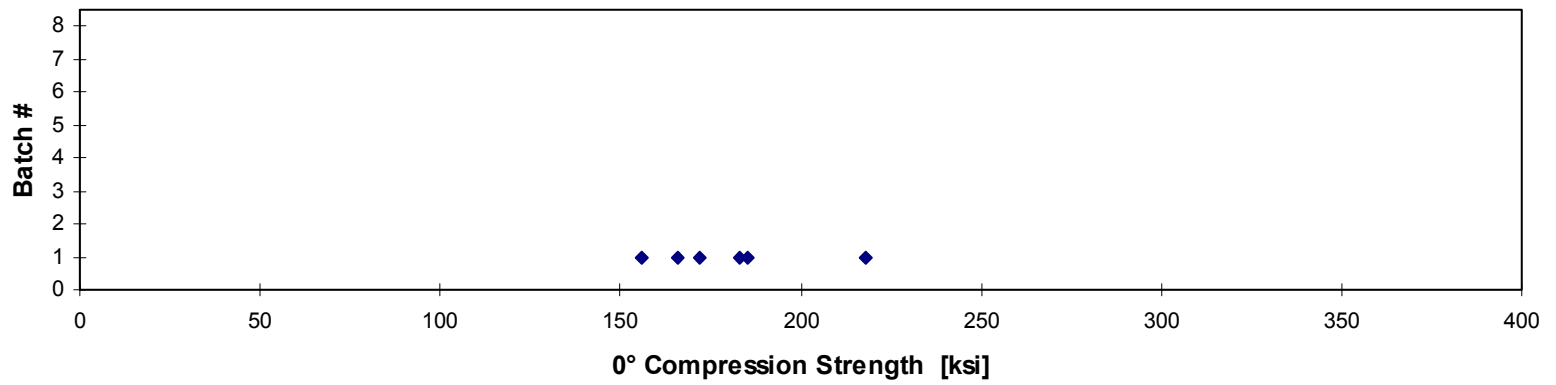
Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]
0.00943	182.959
0.00943	217.854
0.00885	165.626
0.00924	171.865
0.00962	155.688
0.00933	185.236

**Average** 181.531  
**Standard Dev.** 21.105  
**Coeff. of Var. [%]** 11.626  
**Min.** 152.180  
**Max.** 217.084  
**Number of Spec.** 6

**Average<sub>norm</sub>** 0.00932  
**Standard Dev.<sub>norm</sub>** 179.871  
**Coeff. of Var. [%]<sub>norm</sub>** 21.600  
**Min.** 12.009  
**Max.** 155.688  
**Number of Spec.** 217.854  
 6

**0° Compression -- (CTD)  
Normalized Strength  
3M SP381/ S2 Unitape**

Pooled Average = 179.871 [ksi]  
Pooled Standard Deviation = 21.600 [ksi]  
Pooled Coeff. of Variation = 12.009 [%]



**0° Compression -- (ETW - 150°)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

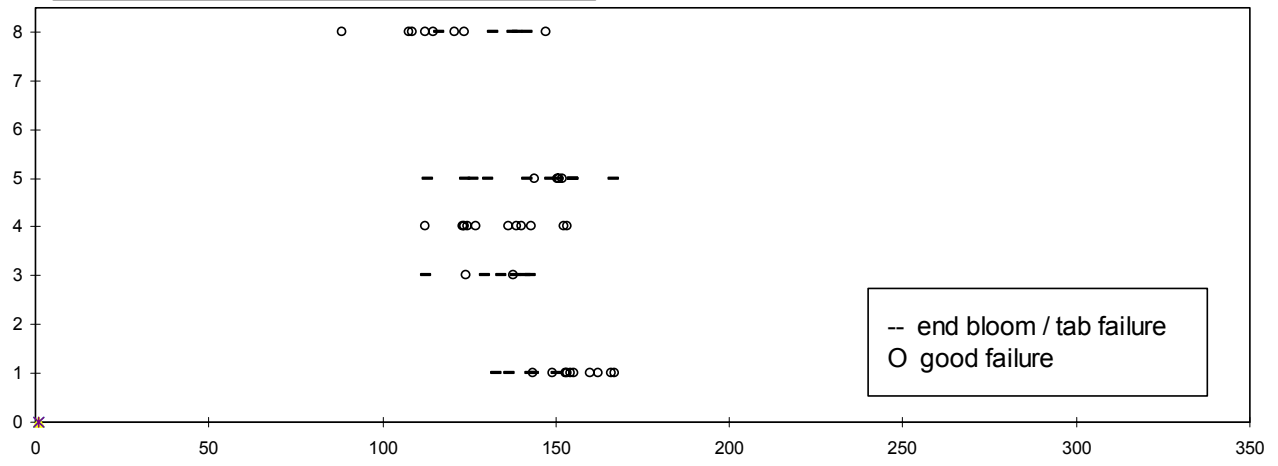
normalizing  $t_{ply}$   
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]	Failure Mode
LBK1111C	1	170.359		0.055	6	0.00922	167.037		good failure
LBK1112C	1	131.374		0.057	6	0.00949	132.655		tab failure
LBK1113C	1	158.194		0.055	6	0.00922	155.108		good failure
LBK1114C	1	154.231		0.055	6	0.00914	149.992		tab failure
LBK1115C	1	152.824		0.053	6	0.00875	142.324		tab failure
LBK1116C	1	142.880		0.054	6	0.00898	136.484		tab failure
LBK1117C	1	149.025		0.054	6	0.00906	143.608		tab failure
LBK1131C	1	163.947		0.056	6	0.00931	162.348		good failure
LBK1132C	1	159.163		0.055	6	0.00911	154.224		good failure
LBK1133C	1	153.047		0.055	6	0.00917	149.248		good failure
LBK1134C	1	160.616		0.056	6	0.00935	159.762		good failure
LBK1135C	1	155.614		0.056	6	0.00926	153.337		good failure
LBK1136C	1	171.300		0.055	6	0.00910	165.909		good failure
LBK1138C	1	147.400		0.055	6	0.00916	143.675		good failure
LBK1139C	1	155.565		0.055	6	0.00924	152.875		good failure
LBL1111C	1		7.164	0.054	6	0.00908		6.916	
LBL1112C	1		7.271	0.054	6	0.00907		7.016	
LBL1114C	1		7.355	0.055	6	0.00909		7.114	
LBL1115C	1		7.109	0.055	6	0.00910		6.879	
LBL1116C	1		7.175	0.055	6	0.00909		6.940	
LBL1117C	1		7.068	0.055	6	0.00920		6.920	
LBL1118C	1		7.129	0.056	6	0.00928		7.034	
LBL1119C	1		6.923	0.056	6	0.00929		6.840	
LBL111AC	1		7.095	0.055	6	0.00922		6.960	
LBL1121C	1		6.980	0.055	6	0.00922		6.844	
LBL1122C	1		7.119	0.054	6	0.00901		6.822	
LBL1123C	1		7.214	0.055	6	0.00920		7.057	
LBK3121C	3	129.802		0.056	6	0.00938	129.515		end bloom
LBK3122C	3	137.343		0.057	6	0.00944	137.891		good failure
LBK3123C	3	138.434		0.056	6	0.00940	138.434		end bloom
LBK3124C	3	126.601		0.055	6	0.00920	123.964		good failure
LBK3125C	3	136.648		0.055	6	0.00922	134.044		end bloom
LBK3126C	3	140.323		0.057	6	0.00954	142.376		end bloom
LBK3127C	3	139.740		0.057	6	0.00950	141.288		end bloom
LBK3128C	3	114.070		0.056	6	0.00928	112.603		end bloom
LBK4111C	4	138.473		0.057	6	0.00952	140.191		good failure
LBK4112C	4	120.335		0.058	6	0.00974	124.709		good failure
LBK4113C	4	141.640		0.057	6	0.00950	143.210		good failure
LBK4114C	4	118.021		0.059	6	0.00982	123.253		good failure
LBK4115C	4	112.750		0.056	6	0.00938	112.500		good failure
LBK4116C	4	135.989		0.057	6	0.00943	136.351		good failure
LBK4117C	4	138.677		0.056	6	0.00941	138.862		good failure
LBK4118C	4	124.875		0.057	6	0.00957	127.089		good failure
LBK4119C	4	120.231		0.058	6	0.00967	123.695		good failure
LBK411AC	4	146.649		0.059	6	0.00984	153.539		good failure
LBK411BC	4	141.257		0.061	6	0.01013	152.215		good failure
LBK5111C	5	166.184		0.053	6	0.00876	154.840		end bloom
LBK5112C	5	155.299		0.055	6	0.00915	151.100		good failure
LBK5113C	5	166.222		0.057	6	0.00942	166.516		end bloom
LBK5114C	5	151.265		0.057	6	0.00944	151.868		good failure
LBK5121C	5	145.740		0.056	6	0.00928	143.931		good failure
LBK5122C	5	161.864		0.054	6	0.00899	154.761		end bloom
LBK5123C	5	142.907		0.056	6	0.00933	141.830		end bloom
LBK5124C	5	151.265		0.055	6	0.00920	148.047		end bloom
LBK5125C	5	151.162		0.056	6	0.00937	150.626		good failure
LBK5126C	5	149.408		0.057	6	0.00948	150.732		end bloom
LBK5127C	5	155.194		0.056	6	0.00938	154.851		end bloom
LBK5132C	5	129.104		0.055	6	0.00919	126.243		end bloom-thin tabs
LBK5133C	5	113.337		0.056	6	0.00938	113.136		end bloom-thin tabs
LBK5134C	5	126.869		0.055	6	0.00918	123.889		end bloom-thin tabs
LBK5135C	5	129.911		0.057	6	0.00944	130.429		end bloom-thin tabs
LBK8121C	8	108.275		0.060	6	0.00996	114.754		good failure
LBK8122C	8	117.592		0.058	6	0.00967	120.980		good failure
LBK8123C	8	138.973		0.060	6	0.00996	147.227		good failure
LBK8124C	8	110.424		0.058	6	0.00959	112.627		good failure
LBK8125C	8	118.857		0.059	6	0.00978	123.651		good failure
LBK8126C	8	102.707		0.059	6	0.00986	107.715		good failure
LBK8127C	8	84.253		0.059	6	0.00987	88.436		good failure
LBK8128C	8	132.869		0.060	6	0.01000	141.409		end bloom
LBK8129C	8	104.462		0.059	6	0.00979	108.769		good failure
LBK812AC	8	128.306		0.060	6	0.01006	137.349		end bloom
LBK8131C	8	110.395		0.059	6	0.00990	116.267		end bloom
LBK8132C	8	127.529		0.058	6	0.00970	131.543		end bloom
LBK8133C	8	132.728		0.059	6	0.00982	138.612		end bloom

Average	137.750	7.133	Average <sub>norm</sub>	0.00939	138.007	6.945
Standard Dev.	18.816	0.117	Standard Dev. <sub>norm</sub>		16.655	0.094
Coeff. of Var. [%]	13.660	1.646	Coeff. of Var. [%] <sub>norm</sub>		12.069	1.348
Min.	84.253	6.923	Min.	0.0088	88.436	6.822
Max.	171.300	7.355	Max.	0.0101	167.037	7.114
Number of Spec.	62	12	Number of Spec.		62	12

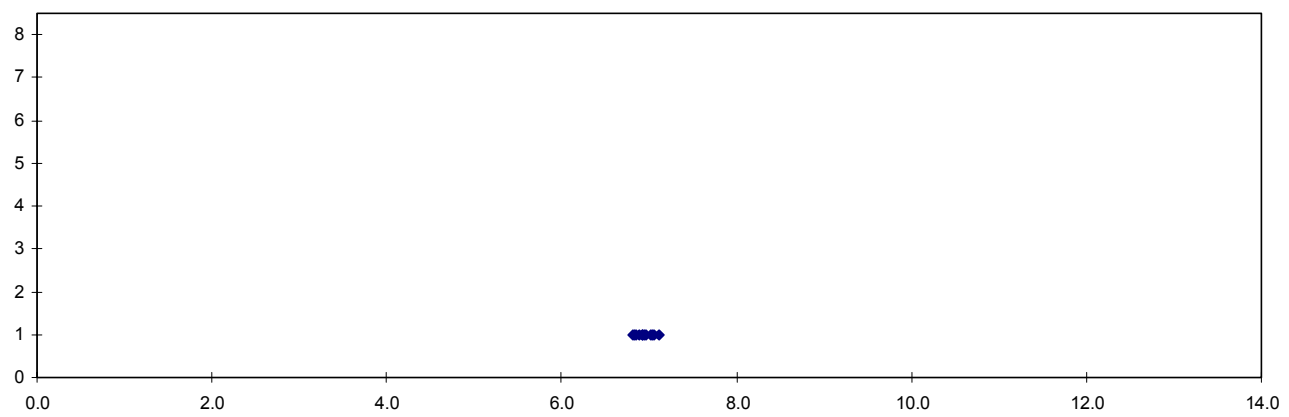
**0° Compression -- (ETW - 150°)**  
**Normalized Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 138.007 [Msi]  
 Pooled Standard Deviation = 16.655 [Msi]  
 Pooled Coeff. of Variation = 12.069 [%]



**0° Compression -- (ETW - 150°)**  
**Normalized Modulus**  
 3M SP381/ S2 Unitape

Pooled Average = 6.945 [Msi]  
 Pooled Standard Deviation = 0.094 [Msi]  
 Pooled Coeff. of Variation = 1.348 [%]



**0° Compression -- (ETW - 180°)**  
**Strength & Modulus**  
 3M SP381/ S2 Unitape

normalizing  $t_{ply}$   
 [in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thicken. [in]	# Plies in Laminate
LBK2121F	2	106.453		0.055	6
LBK2122F	2	104.432		0.055	6
LBK2123F	2	97.640		0.055	6
LBK2124F	2	89.513		0.055	6
LBK2125F	2	84.445		0.054	6
LBK2126F	2	73.138		0.056	6
LBK2127F	2	91.054		0.055	6
LBK2128F	2	69.070		0.055	6
LBK2311F	2	102.114		0.054	6
LBK2312F	2	114.412		0.054	6
LBK2313F	2	108.864		0.054	6
LBK2314F	2	118.517		0.055	6
LBK2315F	2	106.021		0.055	6
LBK23X1F	2	115.659		0.054	6
LBK23X3F	2	102.808		0.054	6
LBK23X4F	2	67.764		0.055	6
LBK23X5F	2	112.743		0.055	6
LBL2134F	2		7.255	0.053	6
LBL2135F	2		7.220	0.055	6
LBK6321F	6	108.142		0.054	6
LBK6322F	6	105.682		0.055	6
LBK6323F	6	106.218		0.054	6
LBK6324F	6	109.482		0.054	6
LBK6325F	6	121.663		0.056	6
LBK6326F	6	108.263		0.055	6
LBK6327F	6	105.842		0.055	6
LBK6331F	6	117.759		0.056	6
LBK6332F	6	119.224		0.055	6
LBK6333F	6	122.060		0.056	6
LBK6334F	6	121.975		0.056	6
LBK6335F	6	116.677		0.055	6
LBK6336F	6	116.150		0.056	6
LBK6337F	6	107.847		0.054	6
LBK6338F	6	112.927		0.056	6
LBK6339F	6	119.689		0.056	6
LBK633AF	6	115.791		0.056	6
LBK633BF	6	127.001		0.055	6
LBL3138F	3		7.373	0.050	6
LBL313BF	3		7.600	0.055	6
LBK7111F	7	111.303		0.056	6
LBK7112F	7	74.665		0.056	6
LBK7113F	7	86.737		0.057	6
LBK7114F	7	55.568		0.056	6
LBK7115F	7	41.591		0.056	6
LBK7116F	7	85.850		0.056	6
LBK7117F	7	92.282		0.056	6
LBK7119F	7	123.601		0.056	6
LBL713AF	7		6.865	0.054	6
LBL713CF	7		7.287	0.054	6

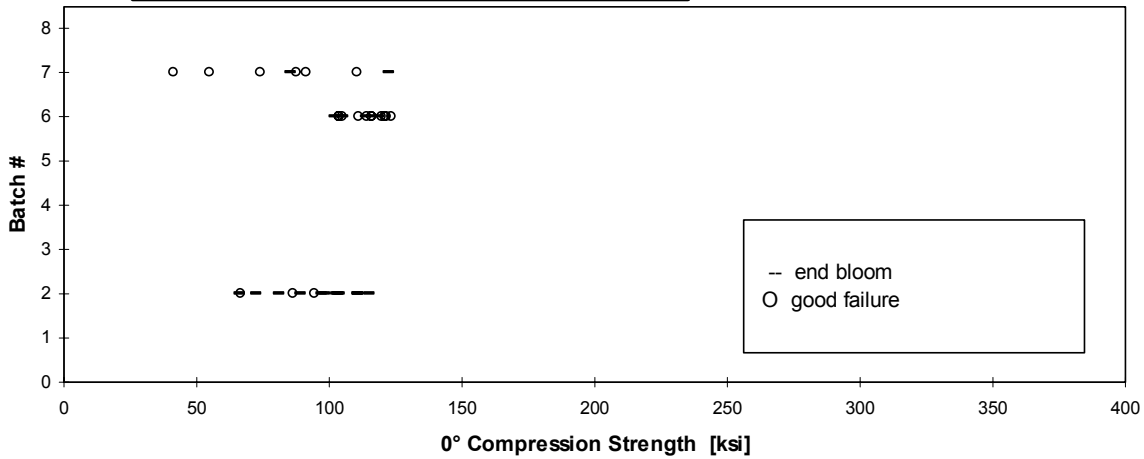
Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]	Failure Mode
0.00916	103.763		end bloom
0.00923	102.580		end bloom
0.00911	94.654		
0.00910	86.616		
0.00902	81.039		end bloom
0.00925	71.970		end bloom
0.00920	89.076		end bloom
0.00910	66.835		
0.00895	97.181		end bloom
0.00905	110.203		end bloom
0.00892	103.266		end bloom
0.00909	114.629		end bloom
0.00915	103.154		end bloom
0.00898	110.481		end bloom
0.00898	98.206		end bloom
0.00914	65.902		end bloom
0.00919	110.244		end bloom
0.00889		6.860	
0.00916		7.037	
0.00904	103.971		
0.00923	103.808		end bloom
0.00903	102.075		end bloom
0.00902	105.017		end bloom
0.00940	121.609		
0.00912	105.000		
0.00922	103.825		end bloom
0.00928	116.193		end bloom
0.00914	115.948		
0.00930	120.707		
0.00925	120.028		
0.00915	113.625		end bloom
0.00940	116.150		
0.00902	103.496		
0.00927	111.376		
0.00931	118.522		end bloom
0.00928	114.354		
0.00915	123.680		
0.00833		6.530	
0.00920		7.435	
0.00935	110.760		
0.00931	73.970		
0.00950	87.660		
0.00929	54.903		
0.00935	41.388		
0.00934	85.279		end bloom
0.00928	91.096		
0.00931	122.450		end bloom
0.00905		6.613	
0.00897		6.954	

**Average** 102.294 7.267  
**Standard Dev.** 19.402 0.239  
**Coeff. of Var. [%]** 18.967 3.293  
**Min.** 41.591 6.865  
**Max.** 127.001 7.600  
**Number of Spec.** 43 6

**Average<sub>norm</sub>** 0.00915 99.923 6.905  
**Standard Dev.<sub>norm</sub>** 18.990 0.325  
**Coeff. of Var. [%]<sub>norm</sub>** 19.004 4.711  
**Min.** 41.388 6.530  
**Max.** 123.680 7.435  
**Number of Spec.** 43 6

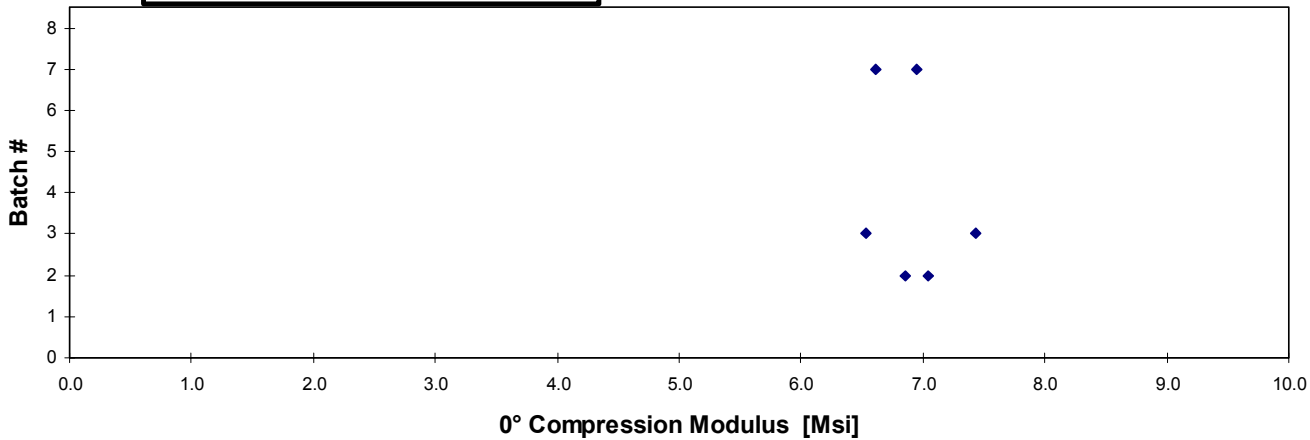
**0° Compression -- (ETW - 180°)**  
**Normalized Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 99.923 [Msi]  
 Pooled Standard Deviation = 18.990 [Msi]  
 Pooled Coeff. of Variation = 19.004 [%]



**0° Compression -- (ETW - 180°)**  
**Normalized Modulus**

Pooled Average = 6.905 [Msi]  
 Pooled Standard Deviation = 0.325 [Msi]  
 Pooled Coeff. of Variation = 4.711 [%]



**0° Compression -- (ETD - 180°)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

normalizing  $t_{ply}$

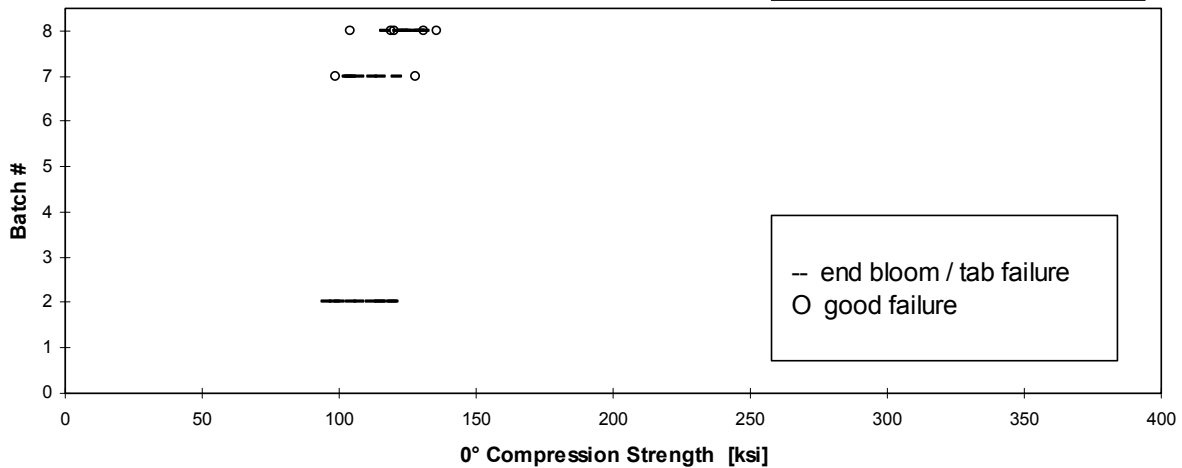
[in]  
 0.0094

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thicken. [in]	# Plies in Laminate	Avg. $t_{ply}$ [in]	Strength <sub>norm</sub> [ksi]	Modulus <sub>norm</sub> [Msi]	Failure Mode
LBK2317G	2	114.070		0.055	6	0.00918	111.391		end bloom
LBK2318G	2	103.558		0.054	6	0.00908	99.978		end bloom
LBK2319G	2	98.368		0.055	6	0.00909	95.141		end bloom
LBK231AG	2	102.720		0.054	6	0.00900	98.394		end bloom
LBK231BG	2	111.151		0.055	6	0.00908	107.406		end bloom
LBK23X6G	2	120.748		0.054	6	0.00896	115.128		end bloom
LBK23X7G	2	123.315		0.054	6	0.00907	118.942		end bloom
LBK23X8G	2	110.155		0.053	6	0.00887	103.954		end bloom
LBK23X9G	2	117.750		0.055	6	0.00918	114.931		end bloom
LBK23XAG	2	122.984		0.055	6	0.00913	119.386		end bloom
LBL2138G	2		7.318	0.055	6	0.00909		7.075	
LBL2139G	2		7.598	0.053	6	0.00889		7.187	
LBK8212G	8	122.400		0.056	6	0.00932	121.315		end bloom
LBK8213G	8	117.022		0.056	6	0.00938	116.763		end bloom
LBK8214G	8	108.420		0.054	6	0.00905	104.432		
LBK8215G	8	126.038		0.055	6	0.00919	123.189		end bloom
LBK8216G	8	121.418		0.055	6	0.00921	118.996		
LBK8217G	8	127.576		0.055	6	0.00918	124.578		end bloom
LBK8219G	8	137.572		0.054	6	0.00894	130.803		end bloom
LBK8232G	8	133.757		0.055	6	0.00922	131.208		
LBK8233G	8	130.034		0.056	6	0.00935	129.285		end bloom
LBK8234G	8	118.806		0.057	6	0.00952	120.280		
LBK8235G	8	125.343		0.056	6	0.00925	123.343		end bloom
LBK8236G	8	138.911		0.055	6	0.00917	135.462		
LBK8237G	8	128.821		0.055	6	0.00916	125.566		end bloom
LBK8238G	8	131.928		0.055	6	0.00922	129.355		end bloom
LBK8239G	8	130.108		0.056	6	0.00938	129.877		end bloom
LBL3131G	3		6.190	0.055	6	0.00918		6.047	
LBL3135G	3		7.325	0.054	6	0.00905		7.053	
LBK7121G	7	128.128		0.056	6	0.00938	127.844		
LBK7122G	7	122.668		0.056	6	0.00927	120.983		end bloom
LBK7123G	7	113.859		0.055	6	0.00922	111.639		end bloom
LBK7124G	7	116.572		0.056	6	0.00928	115.022		end bloom
LBK7125G	7	105.120		0.056	6	0.00926	103.536		end bloom
LBK7126G	7	103.014		0.056	6	0.00937	102.695		end bloom
LBK7127G	7	98.385		0.057	6	0.00942	98.560		
LBK7128G	7	107.192		0.056	6	0.00940	107.192		end bloom
LBK7129G	7	107.192		0.055	6	0.00915	104.293		end bloom
LBL7131G	7		7.486	0.054	6	0.00898		7.148	
LBL7132G	7		7.073	0.053	6	0.00891		6.703	

<b>Average</b>	<b>118.385</b>	<b>7.165</b>	<b>Average<sub>norm</sub></b>	<b>0.00917</b>	<b>115.908</b>	<b>6.869</b>
<b>Standard Dev.</b>	<b>11.235</b>	<b>0.510</b>	<b>Standard Dev.<sub>norm</sub></b>		<b>11.197</b>	<b>0.438</b>
<b>Coeff. of Var. [%]</b>	<b>9.490</b>	<b>7.115</b>	<b>Coeff. of Var. [%]<sub>norm</sub></b>		<b>9.660</b>	<b>6.373</b>
<b>Min.</b>	<b>98.368</b>	<b>6.190</b>	<b>Min.</b>		<b>95.141</b>	<b>6.047</b>
<b>Max.</b>	<b>138.911</b>	<b>7.598</b>	<b>Max.</b>		<b>135.462</b>	<b>7.187</b>
<b>Number of Spec.</b>	<b>34</b>	<b>6</b>	<b>Number of Spec.</b>		<b>34</b>	<b>6</b>

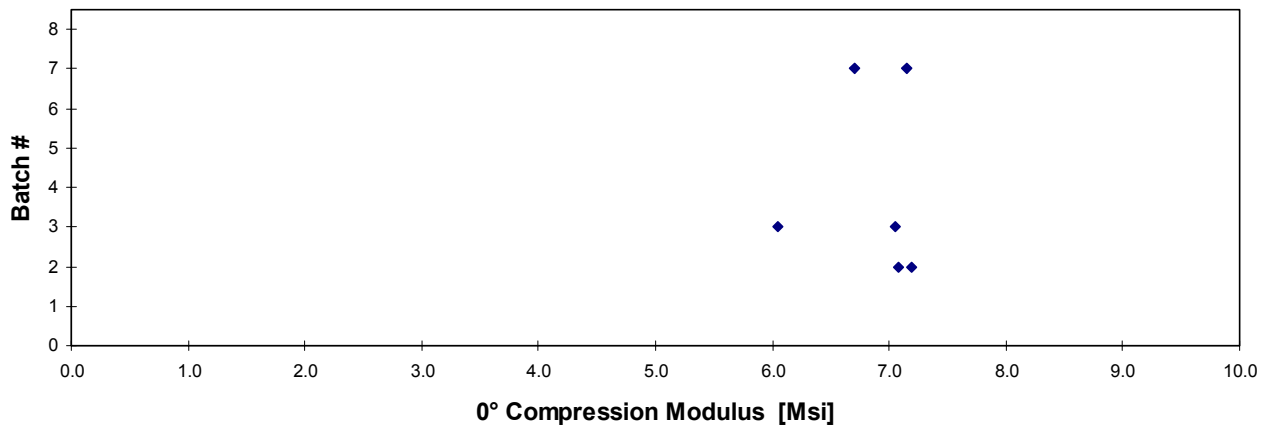
**0° Compression -- (ETD - 180°)**  
**Normalized Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 115.908 [Msi]  
 Pooled Standard Deviation = 11.197 [Msi]  
 Pooled Coeff. of Variation = 9.660 [%]



**0° Compression -- (ETD - 180°)**  
**Normalized Modulus**  
 3M SP381/ S2 Unitape

Pooled Average = 6.869 [Msi]  
 Pooled Standard Deviation = 0.438 [Msi]  
 Pooled Coeff. of Variation = 6.373 [%]



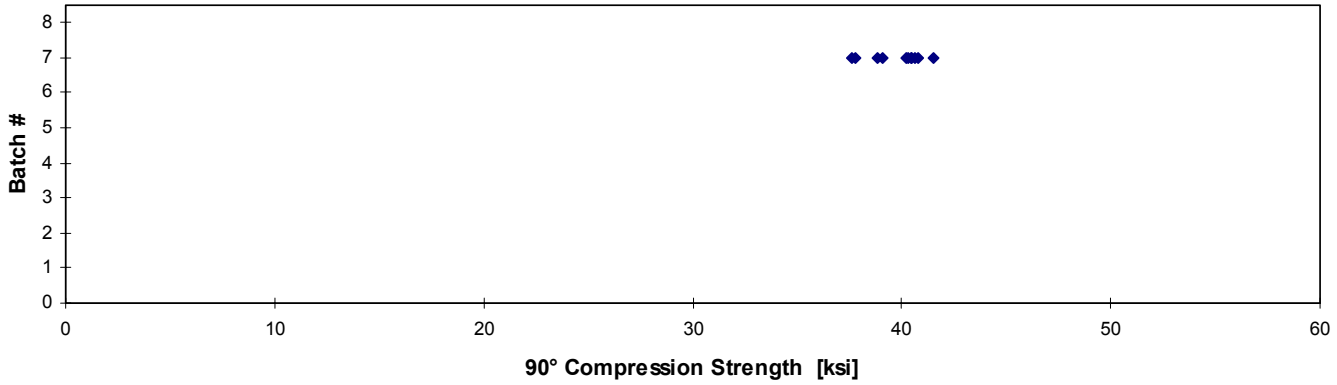
**90° Compression -- (RTD)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thckn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBW7311A	7	40.798		0.056	6	0.00926
LBW7312A	7	40.231		0.056	6	0.00933
LBW7313A	7	37.590		0.056	6	0.00931
LBW7314A	7	37.781		0.055	6	0.00923
LBW7315A	7	40.615		0.056	6	0.00933
LBW7317A	7	38.861		0.055	6	0.00923
LBW7318A	7	39.060		0.056	6	0.00934
LBW7319A	7	40.428		0.056	6	0.00930
LBW731AA	7	41.533		0.055	6	0.00923
LBW731BA	7	40.425		0.056	6	0.00929
LBW731CA	7	40.275		0.056	6	0.00930
LBZ1211A	1		2.597	0.056	6	0.00928
LBZ1213A	1		2.744	0.055	6	0.00910
LBZ1214A	1		2.655	0.055	6	0.00917
LBZ1215A	1		2.624	0.055	6	0.00922
LBZ1216A	1		2.521	0.055	6	0.00917
LBZ1217A	1		2.599	0.054	6	0.00908
LBZ1218A	1		2.683	0.055	6	0.00909
LBZ1311A	1		2.639	0.054	6	0.00893
LBZ1312A	1		2.537	0.056	6	0.00925
LBZ1313A	1		2.565	0.054	6	0.00898
LBZ1314A	1		2.538	0.054	6	0.00895

<b>Average</b>	<b>39.781</b>	<b>2.609</b>	<b>Average</b>	<b>0.0092</b>
<b>Standard Dev.</b>	<b>1.275</b>	<b>0.069</b>		
<b>Coeff. of Var. [%]</b>	<b>3.204</b>	<b>2.631</b>		
<b>Min.</b>	<b>37.590</b>	<b>2.521</b>	<b>Min.</b>	<b>0.0089</b>
<b>Max.</b>	<b>41.533</b>	<b>2.744</b>	<b>Max.</b>	<b>0.0093</b>

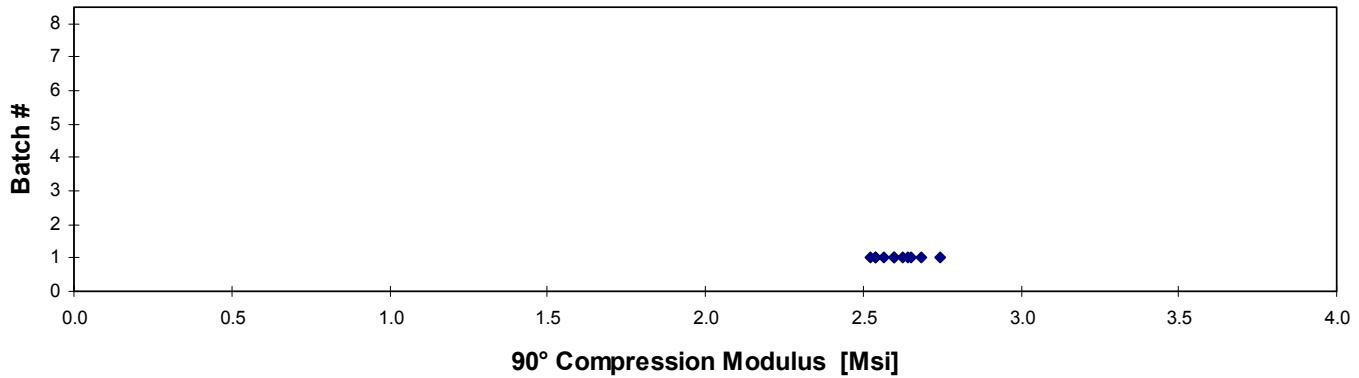
**90° Compression -- (RTD)  
Measured Strength  
3M SP381/ S2 Unitape**

Pooled Average = 39.781 [ksi]  
Pooled Standard Deviation = 1.275 [ksi]  
Pooled Coeff. of Variation = 3.204 [%]



**90° Compression -- (RTD)  
Measured Modulus  
3M SP381/ S2 Unitape**

Pooled Average = 2.609 [Msi]  
Pooled Standard Deviation = 0.069 [Msi]  
Pooled Coeff. of Variation = 2.631 [%]



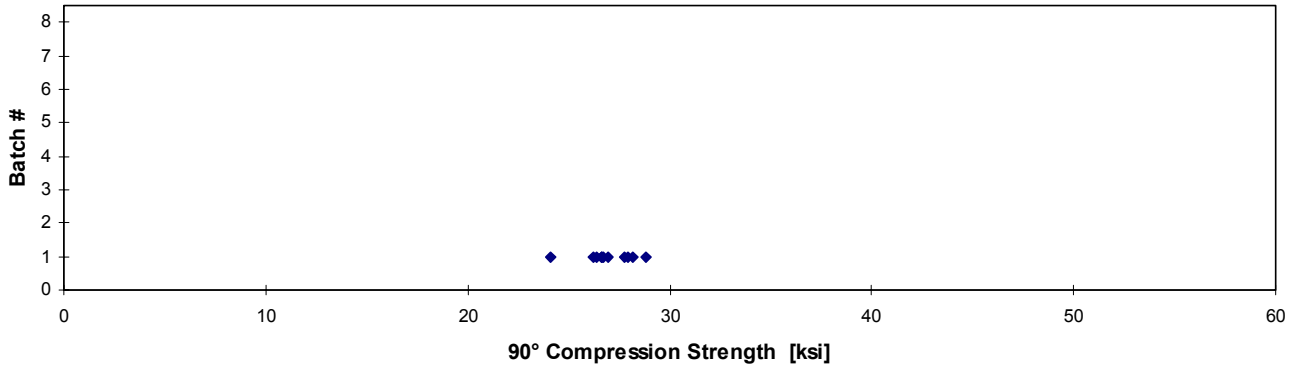
<b>90° Compression -- (ETW - 150°)</b> <b>Strength &amp; Modulus</b> <b>3M SP381/ S2 Unitape</b>
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Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBW1221C	1	28.853		0.056	6	0.00929
LBW1222C	1	26.682		0.056	6	0.00925
LBW1223C	1	26.255		0.056	6	0.00931
LBW1224C	1	27.740		0.056	6	0.00930
LBW1225C	1	27.937		0.056	6	0.00930
LBW1226C	1	26.657		0.055	6	0.00923
LBW1227C	1	26.371		0.056	6	0.00925
LBW1228C	1	28.136		0.055	6	0.00921
LBW1229C	1	26.639		0.056	6	0.00928
LBW122AC	1	26.949		0.056	6	0.00940
LBW1321C	1	24.066		0.055	6	0.00912
LBZ1111C	1		2.144	0.053	6	0.00886
LBZ1112C	1		2.159	0.054	6	0.00900
LBZ1113C	1		2.059	0.054	6	0.00899
LBZ1114C	1		2.101	0.053	6	0.00888
LBZ1115C	1		2.390	0.052	6	0.00875
LBZ1116C	1		2.139	0.054	6	0.00908
LBZ1117C	1		2.081	0.053	6	0.00890
LBZ1119C	1		2.130	0.054	6	0.00894
LBZ111BC	1		2.107	0.054	6	0.00893
LBZ111CC	1		2.088	0.054	6	0.00894
LBZ1211C	1		2.172	0.054	6	0.00898

<b>Average</b>	<b>26.935</b>	<b>2.143</b>	<b>Average</b>	<b>0.0091</b>
<b>Standard Dev.</b>	<b>1.266</b>	<b>0.089</b>		
<b>Coeff. of Var. [%]</b>	<b>4.699</b>	<b>4.150</b>		
<b>Min.</b>	<b>24.066</b>	<b>2.059</b>	<b>Min.</b>	<b>0.0087</b>
<b>Max.</b>	<b>28.853</b>	<b>2.390</b>	<b>Max.</b>	<b>0.0094</b>
<b>Number of Spec.</b>	<b>11</b>	<b>11</b>		

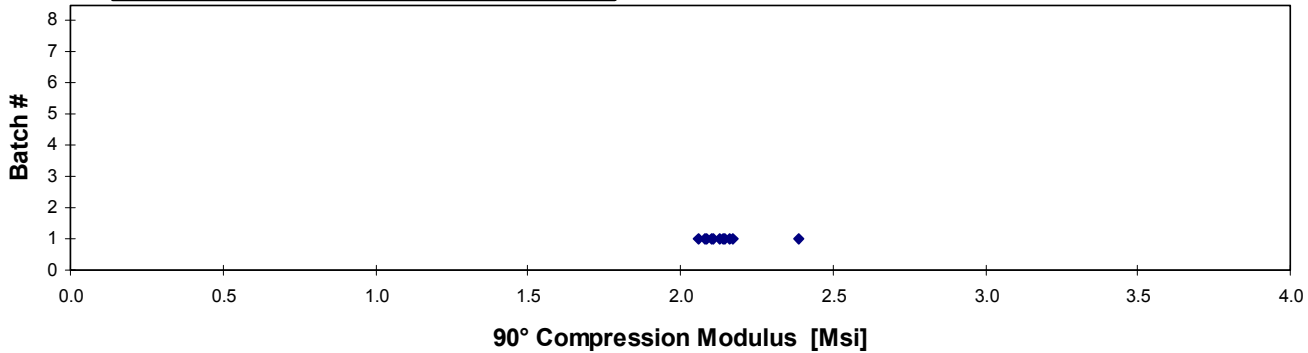
**90° Compression -- (ETW - 150°)**  
**Measured Strength**  
3M SP381/ S2 Unitape

Pooled Average = 26.935 [ksi]  
Pooled Standard Deviation = 1.266 [ksi]  
Pooled Coeff. of Variation = 4.699 [%]



**90° Compression -- (ETW - 150°)**  
**Measured Modulus**  
3M SP381/ S2 Unitape

Pooled Average = 2.143 [Msi]  
Pooled Standard Deviation = 0.089 [Msi]  
Pooled Coeff. of Variation = 4.150 [%]



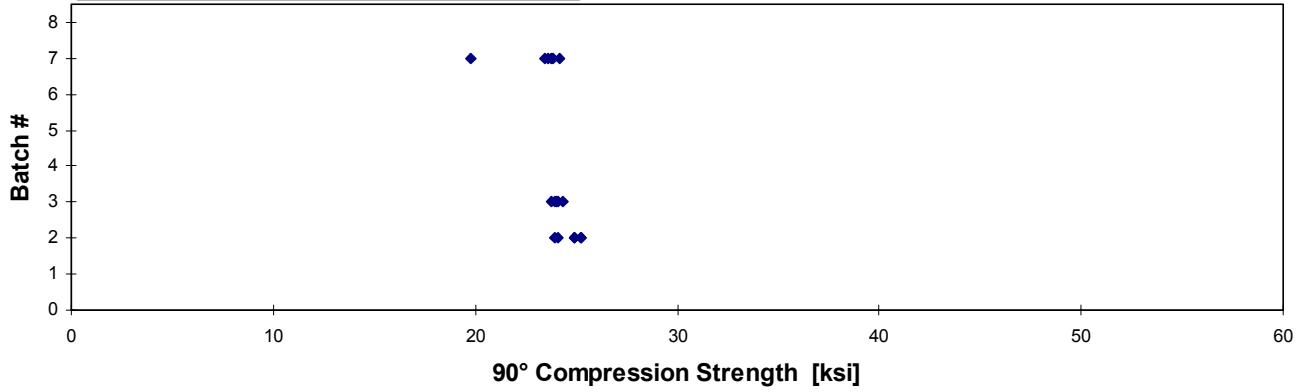
**90° Compression -- (ETW - 180°)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBW2221F	2	25.264		0.054	6	0.00904
LBW2222F	2	24.920		0.054	6	0.00905
LBW2223F	2	25.199		0.054	6	0.00903
LBW2224F	2	24.911		0.055	6	0.00912
LBW2225F	2	24.089		0.055	6	0.00912
LBW2226F	2	23.943		0.055	6	0.00913
LBZ2231F	2		2.257	0.054	6	0.00901
LBZ2235F	2		2.005	0.054	6	0.00895
LBW3211F	3	24.075		0.056	6	0.00926
LBW3212F	3	23.915		0.056	6	0.00935
LBW3214F	3	23.812		0.058	6	0.00968
LBW3215F	3	24.311		0.058	6	0.00968
LBW3216F	3	24.015		0.059	6	0.00978
LBZ3231F	3		2.275	0.054	6	0.00894
LBZ3234F	3		2.205	0.054	6	0.00896
LBW7211F	7	23.735		0.056	6	0.00938
LBW7212F	7	19.787		0.056	6	0.00937
LBW7213F	7	23.452		0.057	6	0.00943
LBW7214F	7	23.865		0.057	6	0.00955
LBW7215F	7	24.186		0.058	6	0.00960
LBW7216F	7	23.625		0.057	6	0.00954
LBZ7321F	7		2.030	0.055	6	0.00913
LBZ7322F	7		1.858	0.055	6	0.00921

<b>Average</b>	<b>23.947</b>	<b>2.105</b>		<b>0.0093</b>
<b>Standard Dev.</b>	<b>1.202</b>	<b>0.166</b>		
<b>Coeff. of Var. [%]</b>	<b>5.021</b>	<b>7.896</b>		
<b>Min.</b>	<b>19.787</b>	<b>1.858</b>	<b>Min.</b>	<b>0.0089</b>
<b>Max.</b>	<b>25.264</b>	<b>2.275</b>	<b>Max.</b>	<b>0.0098</b>
<b>Number of Spec.</b>	<b>17</b>	<b>6</b>		

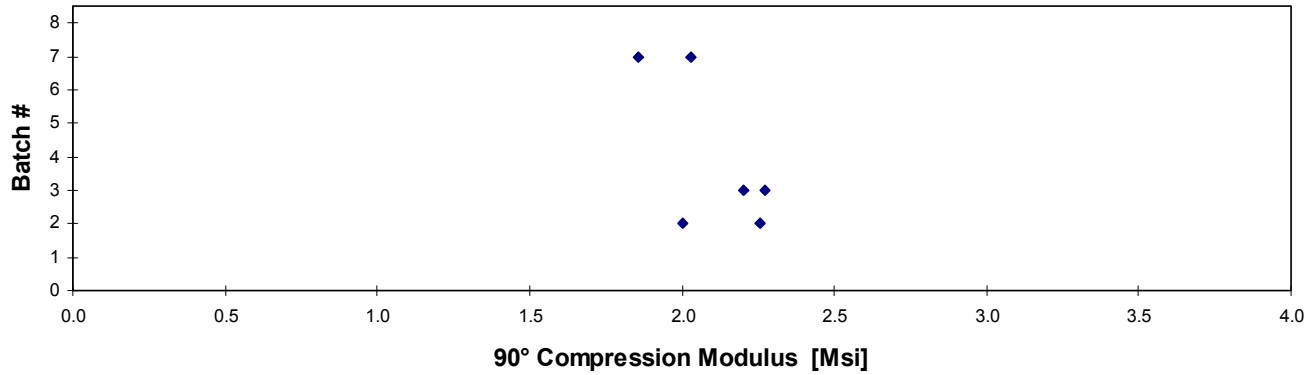
**90° Compression -- (ETW - 180°)**  
**Measured Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 23.947 [ksi]  
 Pooled Standard Deviation = 1.202 [ksi]  
 Pooled Coeff. of Variation = 5.021 [%]



**90° Compression -- (ETW - 180°)**  
**Measured Modulus**  
 3M SP381/ S2 Unitape

Pooled Average = 2.105 [Msi]  
 Pooled Standard Deviation = 0.166 [Msi]  
 Pooled Coeff. of Variation = 7.896 [%]



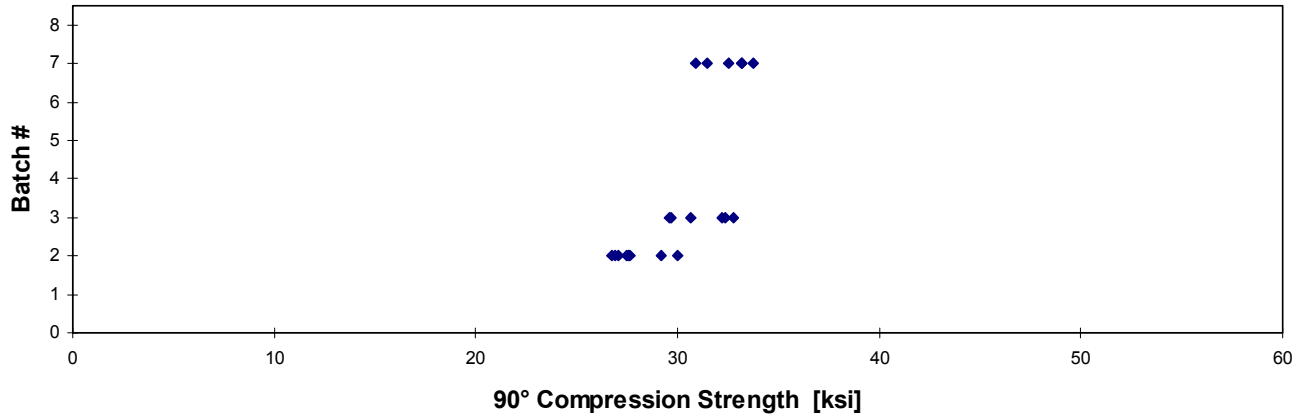
**90° Compression -- (ETD - 180°)**  
**Strength & Modulus**  
 3M SP381/ S2 Unitape

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBW2211G	2	29.214		0.054	6	0.00900
LBW2212G	2	26.926		0.054	6	0.00900
LBW2213G	2	27.075		0.054	6	0.00900
LBW2214G	2	27.551		0.054	6	0.00902
LBW2215G	2	27.443		0.054	6	0.00903
LBW2216G	2	27.629		0.055	6	0.00916
LBW2217G	2	30.031		0.055	6	0.00918
LBW2218G	2	26.751		0.055	6	0.00914
LBZ2232G	2		1.970	0.054	6	0.00900
LBZ2233G	2		2.108	0.054	6	0.00893
LBW3221G	3	30.676		0.056	6	0.00929
LBW3222G	3	29.678		0.060	6	0.00993
LBW3223G	3	29.620		0.058	6	0.00958
LBW3224G	3	32.369		0.056	6	0.00940
LBW3226G	3	32.219		0.058	6	0.00963
LBW3227G	3	32.758		0.056	6	0.00934
LBZ3237G	3		2.087	0.053	6	0.00880
LBZ323BG	3		1.895	0.054	6	0.00895
LBW7221G	7	33.164		0.055	6	0.00919
LBW7222G	7	30.907		0.056	6	0.00932
LBW7223G	7	33.745		0.055	6	0.00923
LBW7224G	7	33.216		0.056	6	0.00928
LBW7225G	7	32.490		0.056	6	0.00938
LBW7226G	7	31.447		0.056	6	0.00925
LBZ7312G	7		2.170	0.054	6	0.00900
LBZ7313G	7		2.258	0.054	6	0.00901

<b>Average</b>	<b>30.245</b>	<b>2.081</b>	<b>0.0092</b>
Standard Dev.	2.390	0.132	
Coeff. of Var. [%]	7.901	6.336	
Min.	26.751	1.895	Min. 0.0088
Max.	33.745	2.258	Max. 0.0099
Number of Spec.	20	6	

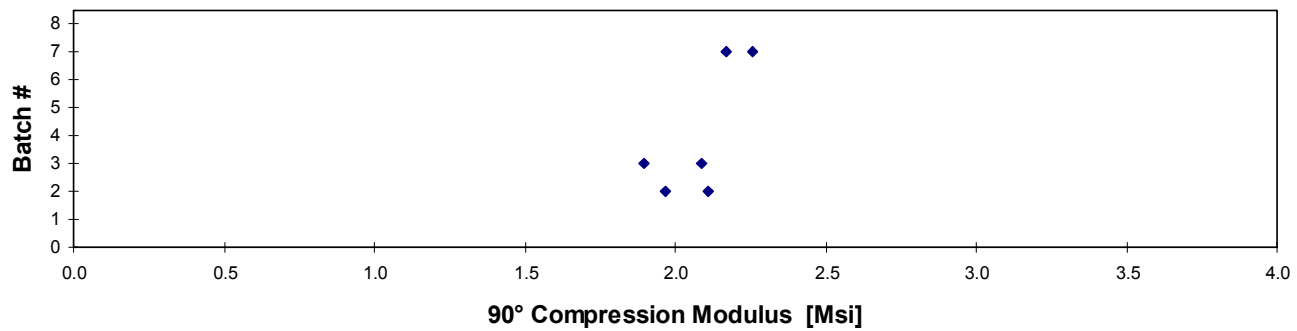
**90° Compression -- (ETD - 180°)**  
**Measured Strength**  
3M SP381/ S2 Unitape

Pooled Average = 30.245 [ksi]  
Pooled Standard Deviation = 2.390 [ksi]  
Pooled Coeff. of Variation = 7.901 [%]



**90° Compression -- (ETD - 180°)**  
**Measured Modulus**  
3M SP381/ S2 Unitape

Pooled Average = 2.081 [Msi]  
Pooled Standard Deviation = 0.132 [Msi]  
Pooled Coeff. of Variation = 6.336 [%]



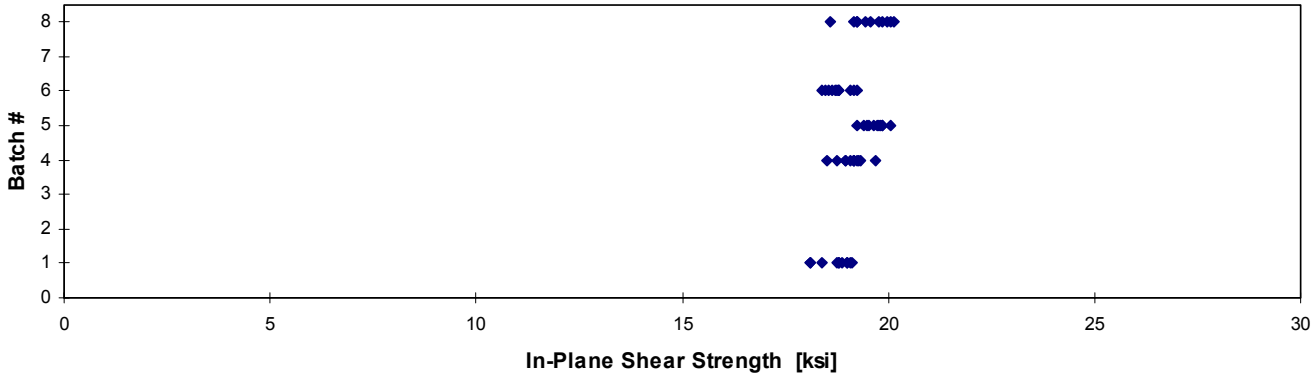
<b>In-Plane Shear -- (RTD)</b>
<b>Strength &amp; Modulus</b>
<b>3M SP381/ S2 Unitape</b>

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBN1121A	1	18.118	0.530	0.167	17	0.00984
LBN1122A	1	18.883	0.619	0.163	17	0.00959
LBN1131A	1	18.739	0.560	0.166	17	0.00975
LBN1132A	1	19.105		0.166	17	0.00975
LBN1133A	1	18.117		0.165	17	0.00971
LBN1134A	1	18.992		0.161	17	0.00946
LBN1135A	1	18.982		0.166	17	0.00978
LBN1136A	1	18.399		0.166	17	0.00978
LBN1137A	1	19.069		0.166	17	0.00975
LBN1138A	1	18.792		0.166	17	0.00977
LBN1139A	1	18.784		0.156	17	0.00916
LBN4211A	4	19.152		0.159	17	0.00937
LBN4212A	4	19.146		0.158	17	0.00930
LBN4213A	4	19.063	0.586	0.156	17	0.00915
LBN4214A	4	19.671	0.512	0.160	17	0.00944
LBN4215A	4	19.311	0.493	0.161	17	0.00947
LBN4216A	4	18.942		0.162	17	0.00951
LBN4217A	4	19.142		0.162	17	0.00952
LBN4218A	4	19.241		0.162	17	0.00951
LBN4219A	4	19.293		0.160	17	0.00941
LBN421AA	4	18.760		0.162	17	0.00951
LBN4131A	4	18.946		0.158	17	0.00930
LBN4132A	4	18.519		0.162	17	0.00955
LBN5111A	5	20.074	0.523	0.159	17	0.00937
LBN5112A	5	19.424	0.594	0.152	17	0.00896
LBN5113A	5	19.854	0.636	0.159	17	0.00935
LBN5114A	5	19.499		0.159	17	0.00938
LBN5115A	5	19.532		0.160	17	0.00942
LBN5116A	5	19.749		0.156	17	0.00919
LBN5117A	5	19.765		0.159	17	0.00935
LBN5118A	5	19.823		0.159	17	0.00937
LBN5121A	5	19.848		0.156	17	0.00919
LBN5122A	5	19.230		0.161	17	0.00948
LBN5123A	5	19.643		0.160	17	0.00941
LBN6123A	6	19.226	0.707	0.164	17	0.00965
LBN6124A	6	19.073	0.673	0.163	17	0.00956
LBN6125A	6	19.154		0.164	17	0.00963
LBN6126A	6	18.701		0.164	17	0.00963
LBN6127A	6	18.772		0.163	17	0.00959
LBN6211A	6	18.375		0.151	17	0.00891
LBN6212A	6	18.813		0.159	17	0.00937
LBN6213A	6	18.488	0.620	0.161	17	0.00944
LBN6214A	6	18.555		0.160	17	0.00943
LBN6215A	6	18.799		0.161	17	0.00945
LBN6216A	6	18.635		0.157	17	0.00922
LBN8121A	8	19.245	0.556	0.160	17	0.00939
LBN8122A	8	18.602	0.591	0.162	17	0.00951
LBN8123A	8	19.160	0.639	0.162	17	0.00952
LBN8124A	8	19.574		0.161	17	0.00946
LBN8125A	8	19.245		0.154	17	0.00907
LBN8126A	8	19.782		0.161	17	0.00947
LBN8127A	8	20.147		0.161	17	0.00949
LBN8131A	8	19.848		0.161	17	0.00949
LBN8132A	8	19.990		0.154	17	0.00905
LBN8133A	8	19.461		0.162	17	0.00952
LBN8134A	8	20.061		0.162	17	0.00952

<b>Average</b>	<b>19.166</b>	<b>0.589</b>	<b>Average</b>	<b>0.0094</b>
<b>Standard Dev.</b>	<b>0.506</b>	<b>0.061</b>		
<b>Coeff. of Var. [%]</b>	<b>2.641</b>	<b>10.406</b>		
<b>Min.</b>	<b>18.117</b>	<b>0.493</b>	<b>Min.</b>	<b>0.0089</b>
<b>Max.</b>	<b>20.147</b>	<b>0.707</b>	<b>Max.</b>	<b>0.0098</b>
<b>Number of Spec.</b>	<b>56</b>	<b>15</b>		

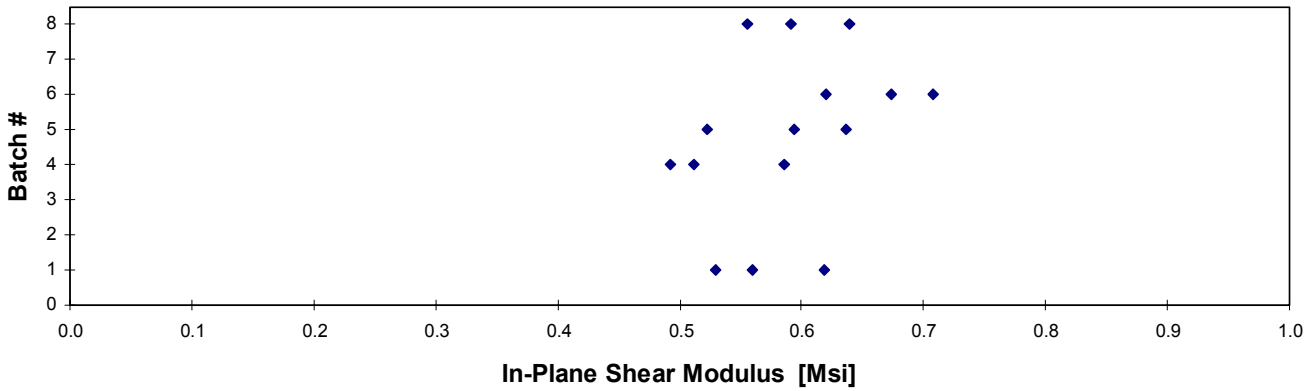
**In-Plane Shear -- (RTD)  
 Measured Strength  
 3M SP381/ S2 Unitape**

Pooled Average = 19.166 [ksi]  
 Pooled Standard Deviation = 0.506 [ksi]  
 Pooled Coeff. of Variation = 2.641 [%]



**In-Plane Shear -- (RTD)  
 Measured Modulus  
 3M SP381/ S2 Unitape**

Pooled Average = 0.589 [Msi]  
 Pooled Standard Deviation = 0.061 [Msi]  
 Pooled Coeff. of Variation = 10.406 [%]



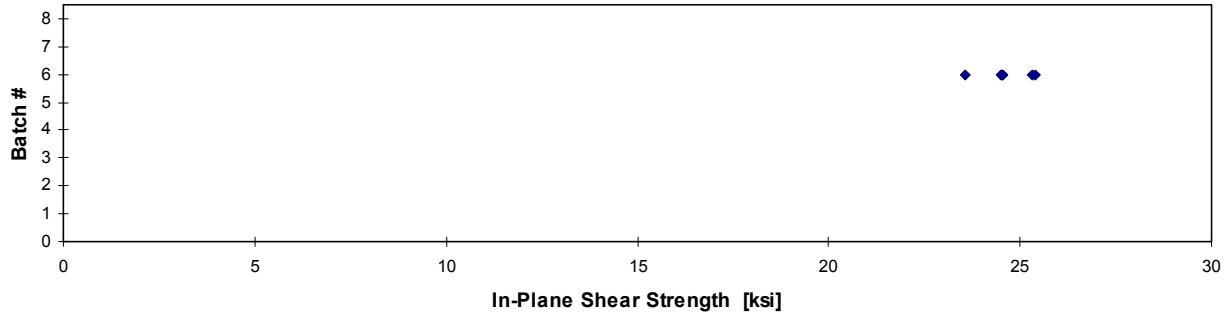
**In-Plane Shear -- (CTD)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. $t_{ply}$ [in]
LBN6131B	6	25.387	0.664	0.162	17	0.00954
LBN6132B	6	24.555	0.581	0.162	17	0.00955
LBN6133B	6	24.541		0.165	17	0.00968
LBN6134B	6	24.492		0.164	17	0.00962
LBN6135B	6	25.329		0.163	17	0.00958
LBN6136B	6	23.574		0.154	17	0.00906

<b>Average</b>	<b>24.646</b>	<b>0.622</b>	<b>Average</b>	<b>0.0095</b>
<b>Standard Dev.</b>	<b>0.664</b>	<b>0.059</b>		
<b>Coeff. of Var. [%]</b>	<b>2.696</b>	<b>9.426</b>		
<b>Min.</b>	<b>23.574</b>	<b>0.581</b>	<b>Min.</b>	<b>0.0091</b>
<b>Max.</b>	<b>25.387</b>	<b>0.664</b>	<b>Max.</b>	<b>0.0097</b>
<b>Number of Spec.</b>	<b>6</b>	<b>2</b>		

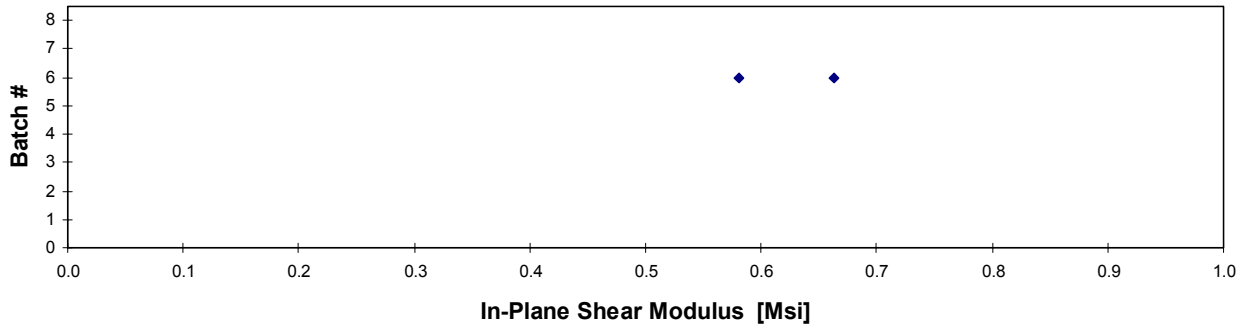
**In-Plane Shear -- (CTD)  
Measured Strength  
3M SP381/ S2 Unitape**

Pooled Average = 24.646 [ksi]  
Pooled Standard Deviation = 0.664 [ksi]  
Pooled Coeff. of Variation = 2.696 [%]



**In-Plane Shear -- (CTD)  
Measured Modulus  
3M SP381/ S2 Unitape**

Pooled Average = 0.622 [Msi]  
Pooled Standard Deviation = 0.059 [Msi]  
Pooled Coeff. of Variation = 9.426 [%]



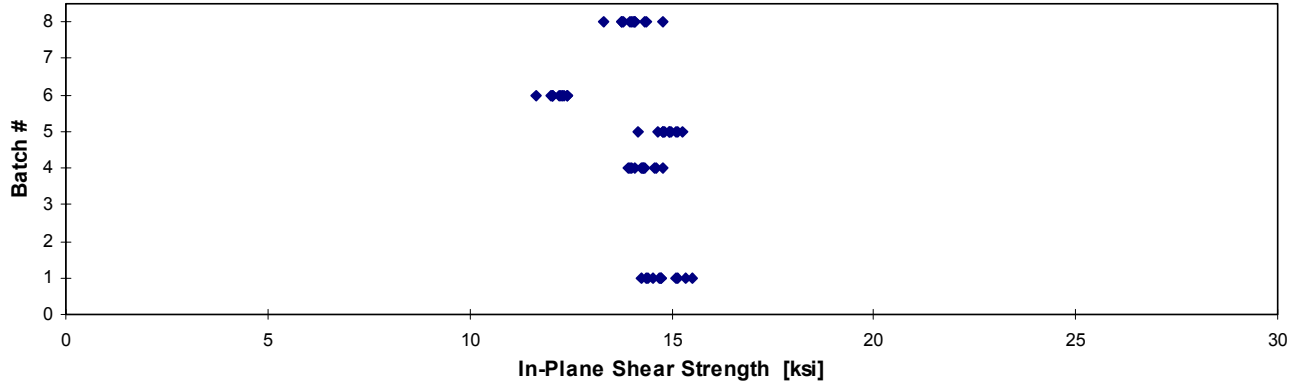
<b>In-Plane Shear -- (ETW - 150°)</b> <b>Strength &amp; Modulus</b> <b>3M SP381/ S2 Unitape</b>
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Specimen Number	Batch Number	Strength [ksj]	Modulus [Msi]	Avg. Specimen Thckn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBN1111C	1	15.345	0.577	0.165	17	0.00972
LBN1112C	1	14.413	0.534	0.166	17	0.00979
LBN1113C	1	14.738	0.527	0.168	17	0.00985
LBN1114C	1	14.746		0.161	17	0.00948
LBN1116C	1	15.497		0.167	17	0.00981
LBN1117C	1	15.132		0.167	17	0.00983
LBN1118C	1	15.098		0.167	17	0.00984
LBN1119C	1	14.712		0.167	17	0.00985
LBN1121C	1	14.377		0.168	17	0.00986
LBN1122C	1	14.527		0.167	17	0.00985
LBN1123C	1	14.265		0.157	17	0.00922
LBN4111C	4	13.965	0.542	0.151	17	0.00886
LBN4112C	4	14.608	0.581	0.161	17	0.00946
LBN4113C	4	13.910	0.501	0.160	17	0.00941
LBN4114C	4	14.088		0.156	17	0.00920
LBN4115C	4	14.300		0.158	17	0.00930
LBN4116C	4	13.985		0.159	17	0.00938
LBN4117C	4	14.238		0.161	17	0.00944
LBN4118C	4	14.320		0.161	17	0.00946
LBN4119C	4	14.271		0.160	17	0.00942
LBN411AC	4	14.765		0.161	17	0.00944
LBN4121C	4	14.555		0.162	17	0.00953
LBN5111C	5	14.991	0.590	0.159	17	0.00936
LBN5112C	5	15.084	0.413	0.159	17	0.00936
LBN5121C	5	15.279	0.539	0.159	17	0.00935
LBN5122C	5	14.922		0.160	17	0.00941
LBN5123C	5	14.663		0.160	17	0.00942
LBN5124C	5	14.762		0.160	17	0.00943
LBN5211C	5	14.929		0.158	17	0.00930
LBN5212C	5	14.836		0.158	17	0.00930
LBN5213C	5	14.183		0.147	17	0.00866
LBN5214C	5	14.760		0.158	17	0.00931
LBN5215C	5	15.158		0.158	17	0.00932
LBN6111C	6	12.067	0.515	0.163	17	0.00959
LBN6112C	6	12.020		0.163	17	0.00961
LBN6113C	6	11.644	0.517	0.163	17	0.00959
LBN6114C	6	12.227		0.159	17	0.00937
LBN6115C	6	12.062		0.152	17	0.00895
LBN6116C	6	12.058		0.163	17	0.00958
LBN6117C	6	12.313		0.162	17	0.00952
LBN6118C	6	12.256		0.161	17	0.00950
LBN6119C	6	12.314		0.163	17	0.00960
LBN611AC	6	12.420		0.163	17	0.00961
LBN6121C	6	12.409	0.489	0.164	17	0.00962
LBN8111C	8	13.327	0.591	0.154	17	0.00908
LBN8112C	8	13.772		0.162	17	0.00952
LBN8113C	8	13.793	0.549	0.161	17	0.00945
LBN8114C	8	13.771		0.160	17	0.00939
LBN8115C	8	14.014		0.158	17	0.00930
LBN8116C	8	14.389		0.159	17	0.00935
LBN8117C	8	14.781		0.162	17	0.00951
LBN8118C	8	14.069		0.160	17	0.00941
LBN8119C	8	14.325		0.162	17	0.00951
LBN811AC	8	14.070		0.162	17	0.00951
LBN8121C	8	14.041		0.159	17	0.00936
LBN8123C	8	13.979	0.629	0.163	17	0.00958

<b>Average</b>	<b>14.028</b>	<b>0.540</b>	<b>Average</b>	<b>0.0095</b>
<b>Standard Dev.</b>	<b>1.033</b>	<b>0.052</b>		
<b>Coeff. of Var. [%]</b>	<b>7.362</b>	<b>9.611</b>		
<b>Min.</b>	<b>11.644</b>	<b>0.413</b>	<b>Min.</b>	<b>0.0087</b>
<b>Max.</b>	<b>15.497</b>	<b>0.629</b>	<b>Max.</b>	<b>0.0099</b>
<b>Number of Spec.</b>	<b>56</b>	<b>15</b>		

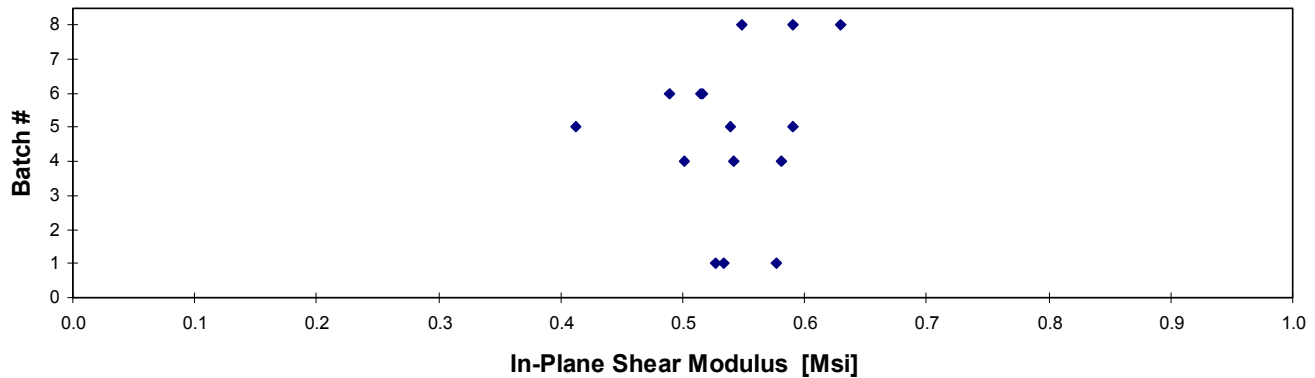
**In-Plane Shear -- (ETW - 150°)**  
**Measured Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 14.028 [ksi]  
 Pooled Standard Deviation = 1.033 [ksi]  
 Pooled Coeff. of Variation = 7.362 [%]



**In-Plane Shear -- (ETW - 150°)**  
**Measured Modulus**  
 3M SP381/ S2 Unitape

Pooled Average = 0.540 [Msi]  
 Pooled Standard Deviation = 0.052 [Msi]  
 Pooled Coeff. of Variation = 9.611 [%]



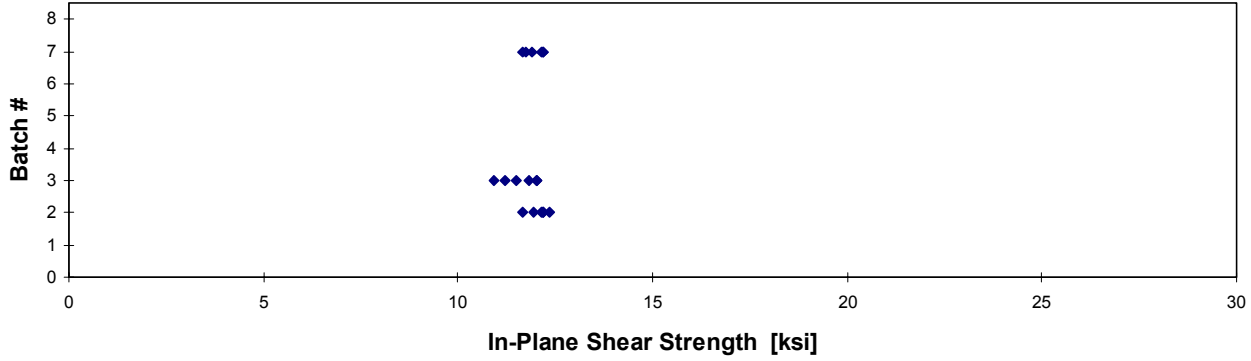
**In-Plane Shear -- (ETW - 180°)  
 Strength & Modulus  
 3M SP381/ S2 Unitape**

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBN2111F	2	11.665	0.388	0.158	17	0.00927
LBN2112F	2	12.358	0.394	0.158	17	0.00929
LBN2113F	2	12.177		0.158	17	0.00928
LBN2114F	2	11.923		0.157	17	0.00921
LBN2115F	2	12.144		0.157	17	0.00926
LBN2116F	2	12.190		0.155	17	0.00914
LBN3111F	3	10.929	0.311	0.163	17	0.00958
LBN3112F	3	12.033	0.385	0.161	17	0.00949
LBN3113F	3	12.024		0.162	17	0.00952
LBN3114F	3	11.825		0.159	17	0.00938
LBN3115F	3	11.191		0.161	17	0.00944
LBN3116F	3	11.477		0.158	17	0.00930
LBN7111F	7	12.127	0.412	0.162	17	0.00955
LBN7112F	7	11.673	0.403	0.161	17	0.00947
LBN7113F	7	12.182		0.162	17	0.00952
LBN7114F	7	11.902		0.162	17	0.00953
LBN7115F	7	11.756		0.156	17	0.00915
LBN7116F	7	12.172		0.162	17	0.00956

<b>Average</b>	<b>11.875</b>	<b>0.382</b>	<b>0.0094</b>
<b>Standard Dev.</b>	<b>0.377</b>	<b>0.036</b>	
<b>Coeff. of Var. [%]</b>	<b>3.174</b>	<b>9.497</b>	
<b>Min.</b>	<b>10.929</b>	<b>0.311</b>	<b>Min. 0.0091</b>
<b>Max.</b>	<b>12.358</b>	<b>0.412</b>	<b>Max. 0.0096</b>
<b>Number of Spec.</b>	<b>18</b>	<b>6</b>	

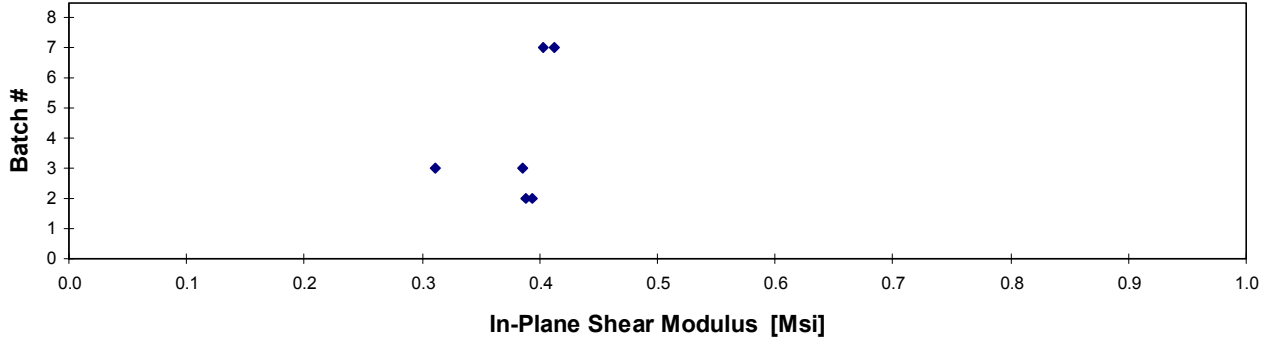
**In-Plane Shear -- (ETW - 180°)**  
**Measured Strength**  
 3M SP381/ S2 Unitape

Pooled Average = 11.875 [ksi]  
 Pooled Standard Deviation = 0.377 [ksi]  
 Pooled Coeff. of Variation = 3.174 [%]



**In-Plane Shear -- (ETW - 180°)**  
**Measured Modulus**  
 3M SP381/ S2 Unitape

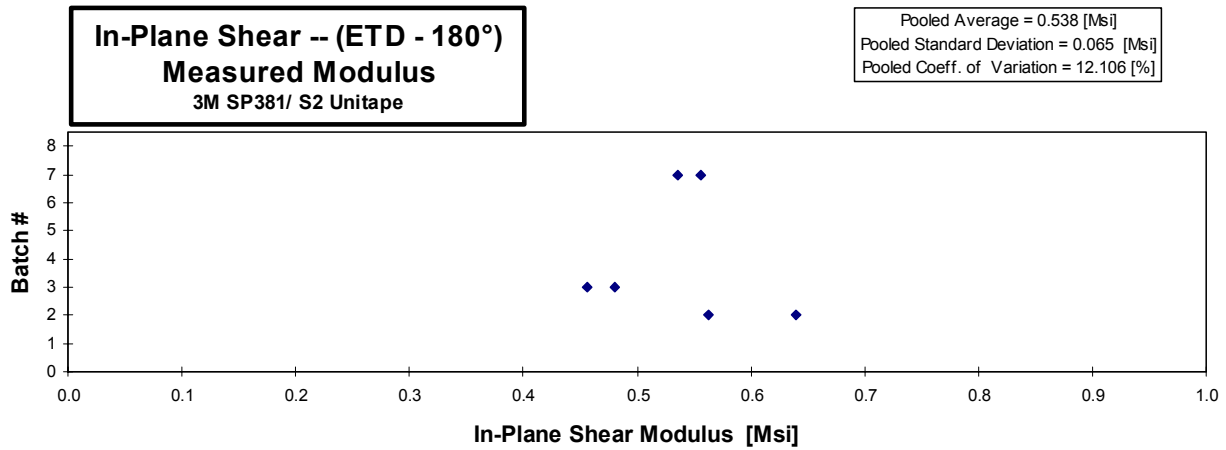
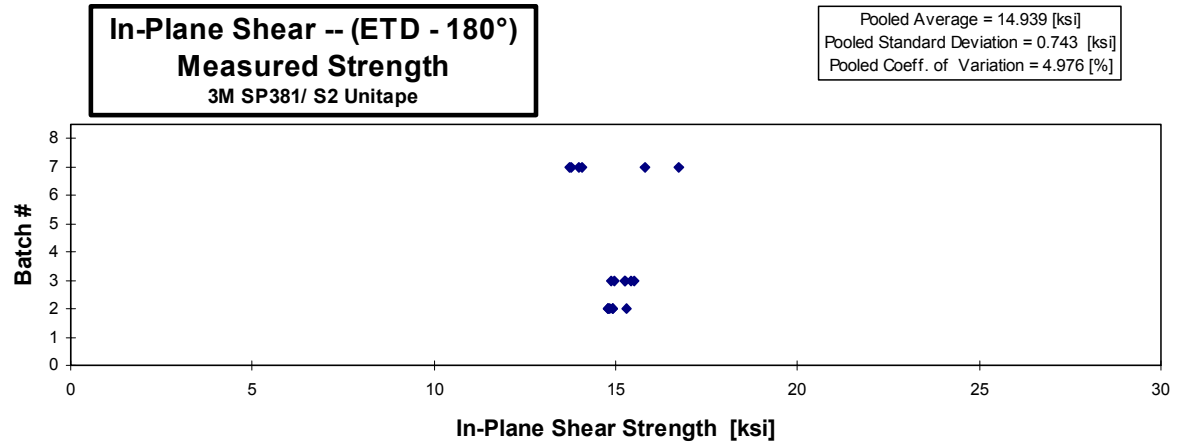
Pooled Average = 0.382 [Msi]  
 Pooled Standard Deviation = 0.036 [Msi]  
 Pooled Coeff. of Variation = 9.497 [%]



<b>In-Plane Shear -- (ETD - 180°)</b> <b>Strength &amp; Modulus</b> <b>3M SP381/ S2 Unitape</b>
---

Specimen Number	Batch Number	Strength [ksi]	Modulus [Msi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t <sub>ply</sub> [in]
LBN2121G	2	14.771	0.640	0.160	17	0.00942
LBN2122G	2	14.921	0.562	0.159	17	0.00937
LBN2123G	2	14.773		0.160	17	0.00940
LBN2124G	2	14.849		0.159	17	0.00938
LBN2125G	2	15.316		0.158	17	0.00928
LBN2126G	2	14.912		0.156	17	0.00916
LBN3121G	3	15.260	0.456	0.166	17	0.00975
LBN3122G	3	15.434	0.481	0.166	17	0.00975
LBN3123G	3	14.866		0.161	17	0.00947
LBN3124G	3	15.495		0.164	17	0.00963
LBN3125G	3	15.257		0.163	17	0.00957
LBN3126G	3	14.962		0.164	17	0.00967
LBN7121G	7	15.807	0.556	0.163	17	0.00961
LBN7122G	7	16.722	0.535	0.165	17	0.00970
LBN7123G	7	13.726		0.161	17	0.00949
LBN7124G	7	13.767		0.163	17	0.00961
LBN7125G	7	13.986		0.163	17	0.00957
LBN7126G	7	14.081		0.163	17	0.00958

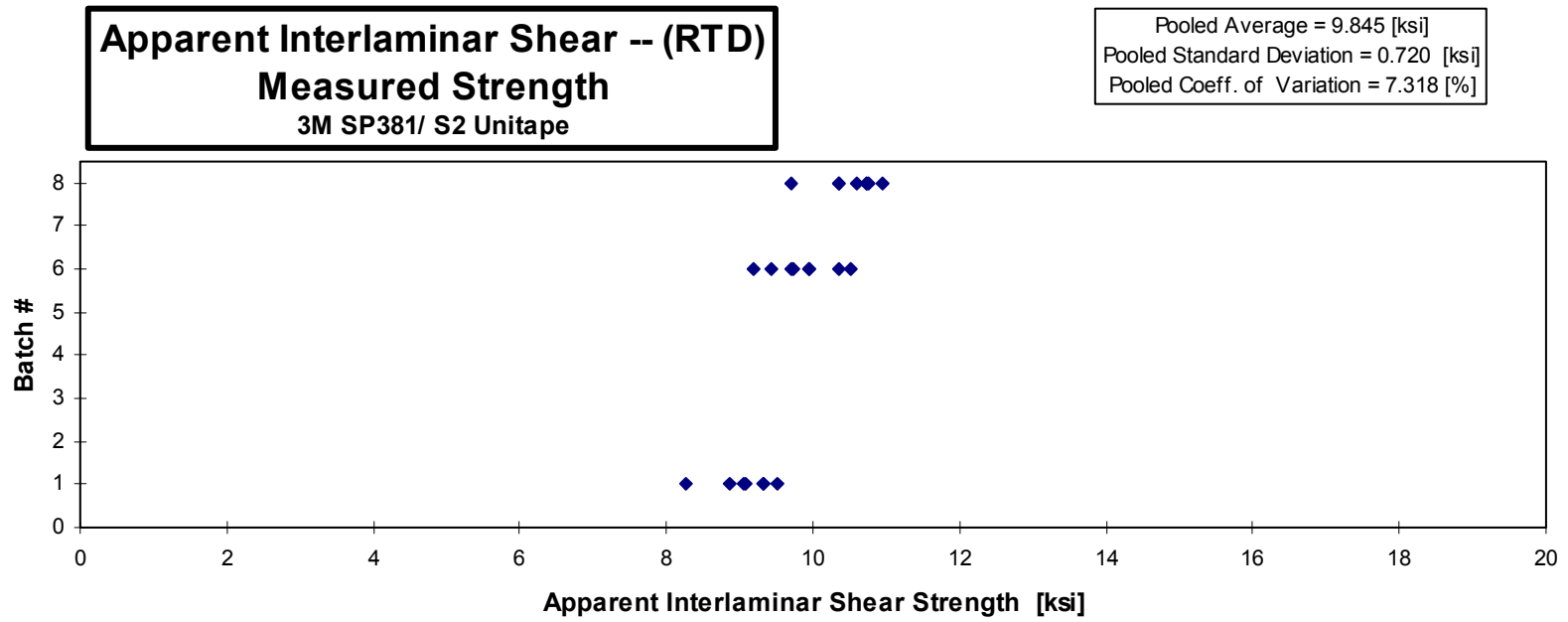
<b>Average</b>	<b>14.939</b>	<b>0.538</b>	<b>0.0095</b>
<b>Standard Dev.</b>	<b>0.743</b>	<b>0.065</b>	
<b>Coeff. of Var. [%]</b>	<b>4.976</b>	<b>12.106</b>	
<b>Min.</b>	<b>13.726</b>	<b>0.456</b>	<b>Min. 0.0092</b>
<b>Max.</b>	<b>16.722</b>	<b>0.640</b>	<b>Max. 0.0098</b>
<b>Number of Spec.</b>	<b>18</b>	<b>6</b>	



**Apparent Interlaminar Shear -- (RTD)  
 Strength  
 3M SP381/ S2 Unitape**

Specimen Number	Batch Number	Strength [ksi]	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. $t_{ply}$ [in]
LBQ1111A	1	9.318	0.158	16	0.00988
LBQ1112A	1	9.087	0.155	16	0.00971
LBQ1113A	1	9.501	0.158	16	0.00985
LBQ1115A	1	9.329	0.157	16	0.00982
LBQ1116A	1	8.856	0.158	16	0.00988
LBQ1117A	1	9.060	0.157	16	0.00979
LBQ1118A	1	8.278	0.153	16	0.00954
LBQ6111A	6	9.181	0.155	16	0.00968
LBQ6112A	6	9.428	0.152	16	0.00952
LBQ6113A	6	10.520	0.153	16	0.00955
LBQ6114A	6	9.741	0.154	16	0.00963
LBQ6115A	6	9.949	0.153	16	0.00957
LBQ6116A	6	10.365	0.155	16	0.00972
LBQ6117A	6	9.703	0.153	16	0.00958
LBQ6118A	6	9.947	0.153	16	0.00956
LBQ8111A	8	10.604	0.150	16	0.00937
LBQ8112A	8	10.956	0.142	16	0.00890
LBQ8113A	8	10.732	0.151	16	0.00946
LBQ8114A	8	10.755	0.147	16	0.00919
LBQ8115A	8	10.349	0.150	16	0.00938
LBQ8116A	8	9.701	0.141	16	0.00881
LBQ8117A	8	10.731	0.151	16	0.00941
LBQ8118A	8	10.347	0.150	16	0.00939

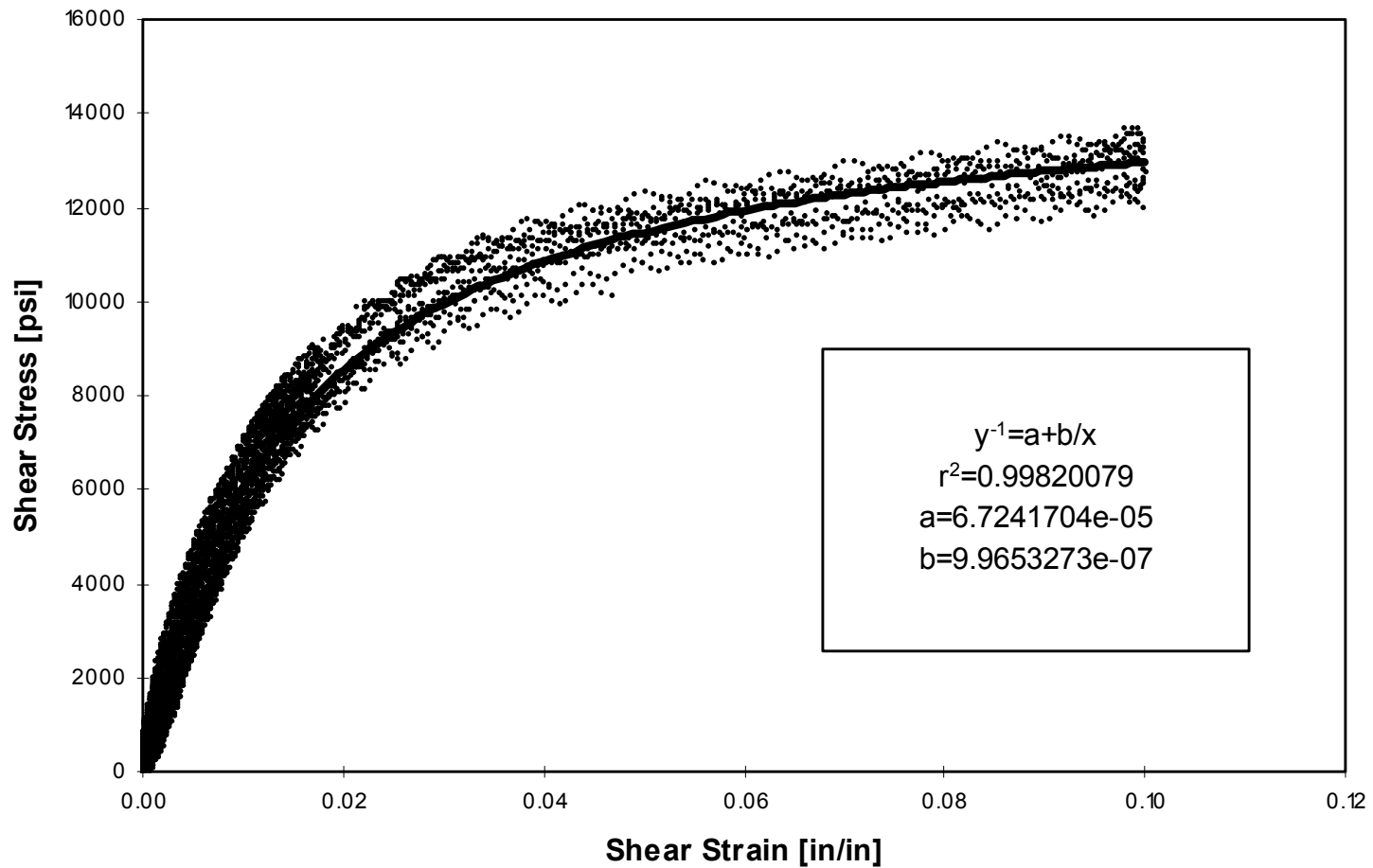
<b>Average</b>	<b>9.845</b>	<b>Average</b>	<b>0.0095</b>
<b>Standard Dev.</b>	<b>0.720</b>		
<b>Coeff. of Var. [%]</b>	<b>7.318</b>		
<b>Min.</b>	<b>8.278</b>	<b>Min.</b>	<b>0.0088</b>
<b>Max.</b>	<b>10.956</b>	<b>Max.</b>	<b>0.0099</b>
<b>Number of Spec.</b>	<b>23</b>		



### **3.2.3 Representative Shear Stress-Strain Curve**

The following stress-strain curve is representative of the S2 uni / SP381 prepreg system. The tension and compression stress-strain curves are not presented in graphical form. If strain design allowables from these tests are required, simple one-dimensional linear stress-strain relationships may be used to obtain corresponding strain design values. This process should approximate tensile and compressive strain behavior relatively well but may produce extremely conservative strain values in shear due to the nonlinear behavior. A more realistic approach for shear strain design allowables is to use a maximum strain value of 5% (reference MIL-HDBK-17-1E, section 5.7.6). If a nonlinear analysis of the material's shear behavior is required, the curve-fit of the shear stress-strain curve may be used. The representative shear stress-strain curve was obtained by taking the average of all the sample shear curves and determining the best-fit line through the data. The actual data points also presented on the chart to demonstrate material variability.

### Shear Stress vs. Shear Strain, RTD



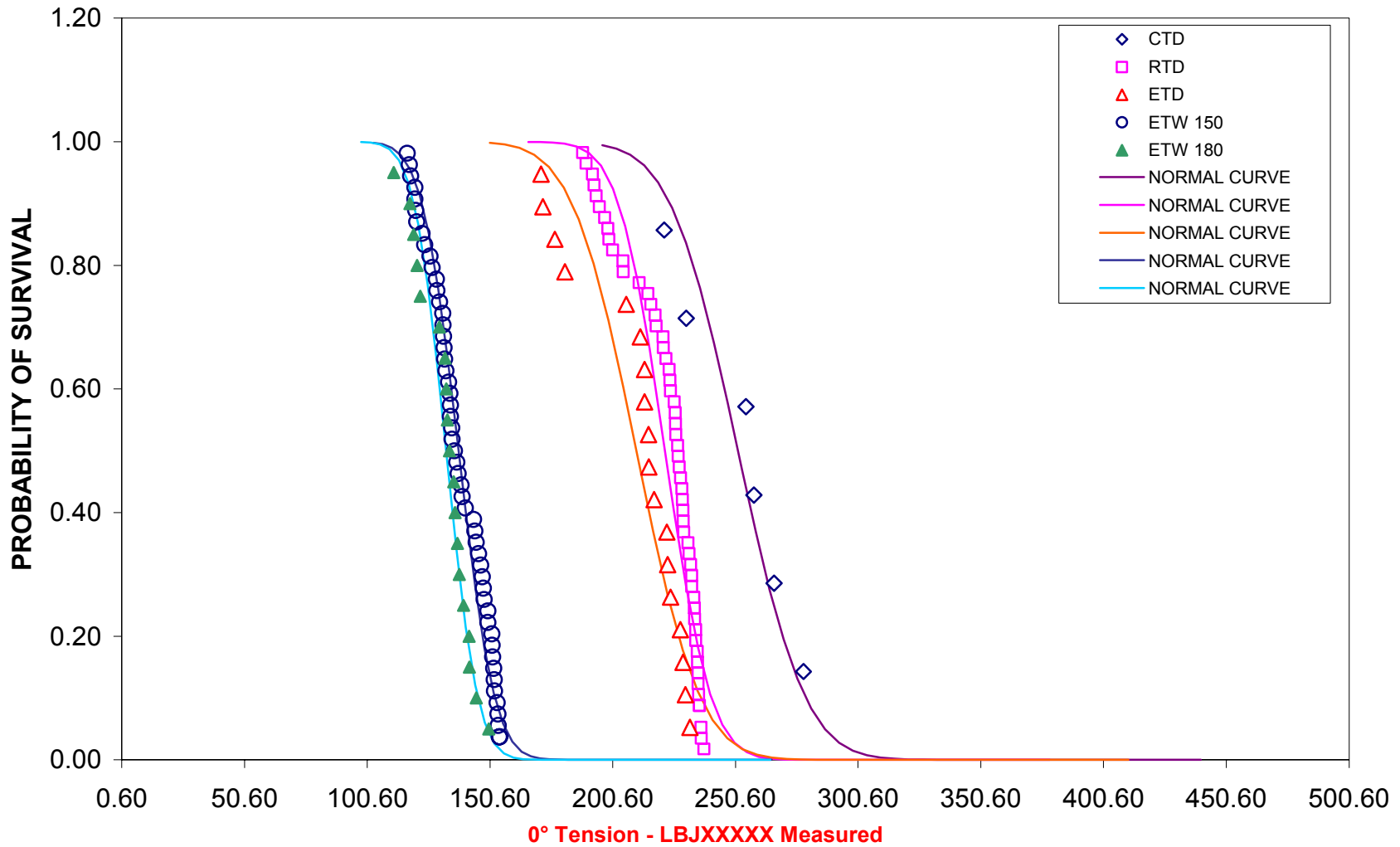
Representative shear stress-strain curve for S2 uni / SP381, tested at room temperature ambient condition.

### **3.3 Statistical Results**

### **3.3.1 Plot by Condition**

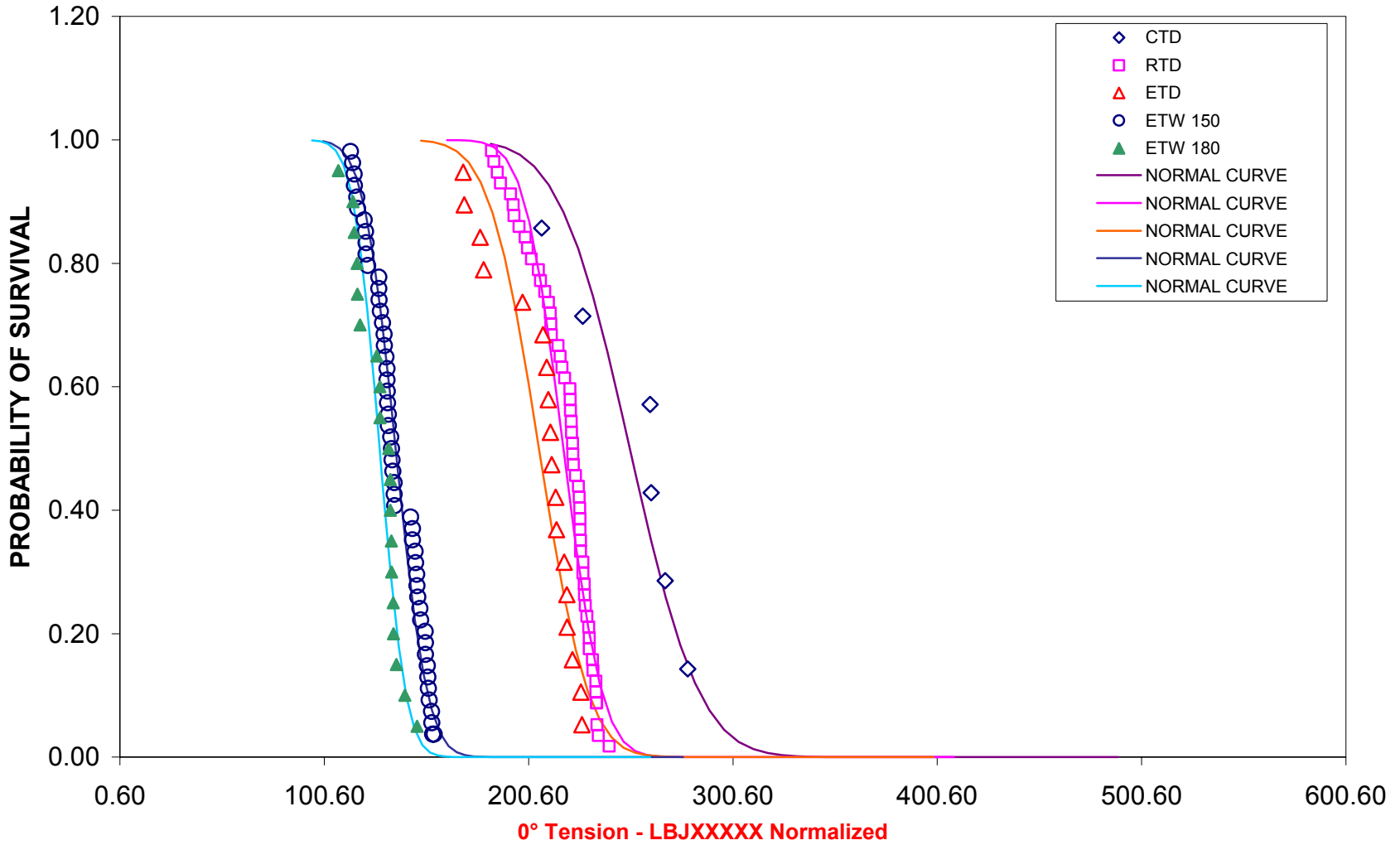
## DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

**3M SP381/ S2 Unitape  
 Cirrus**



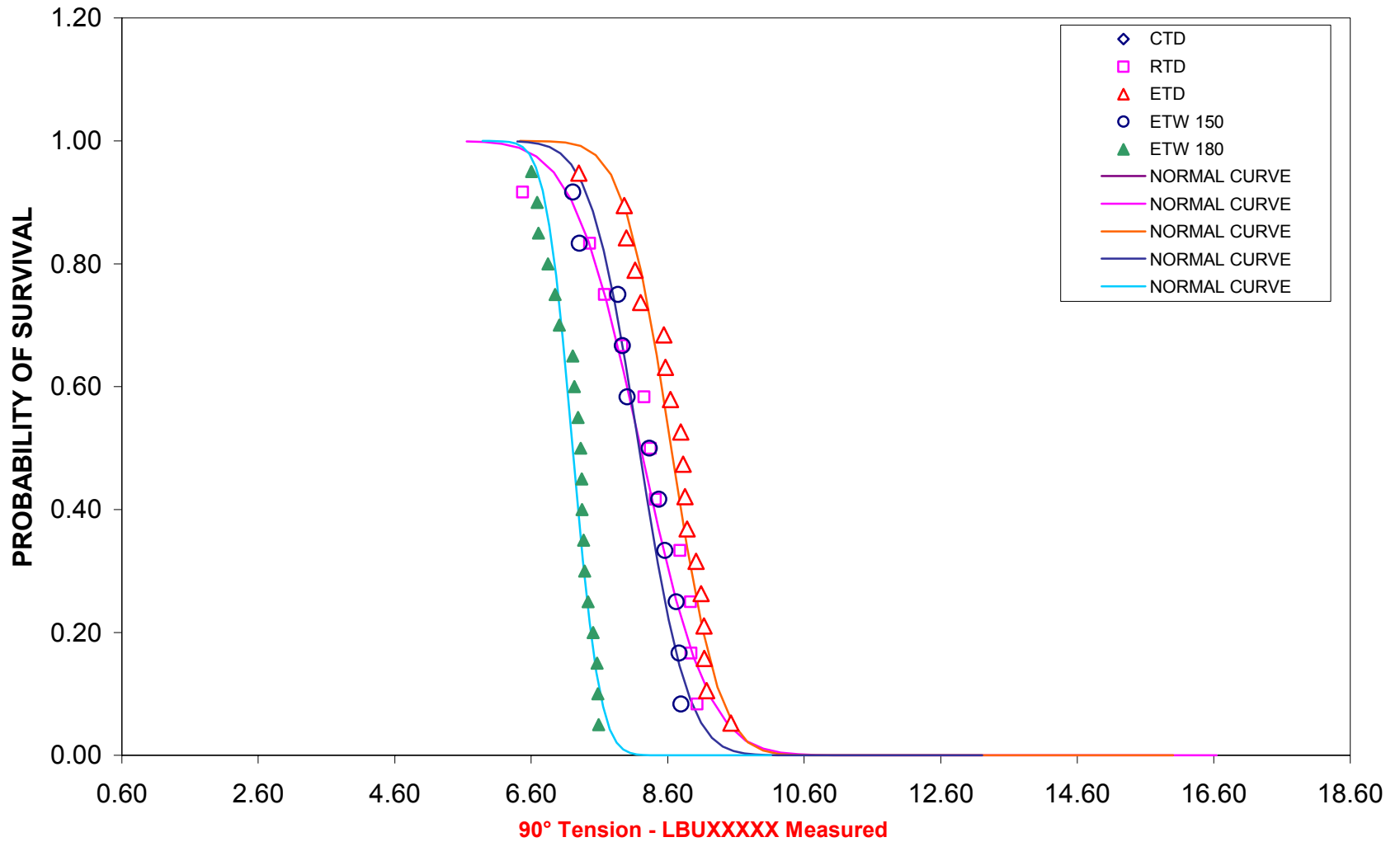
## DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

**3M SP381/ S2 Unitape  
 Cirrus**



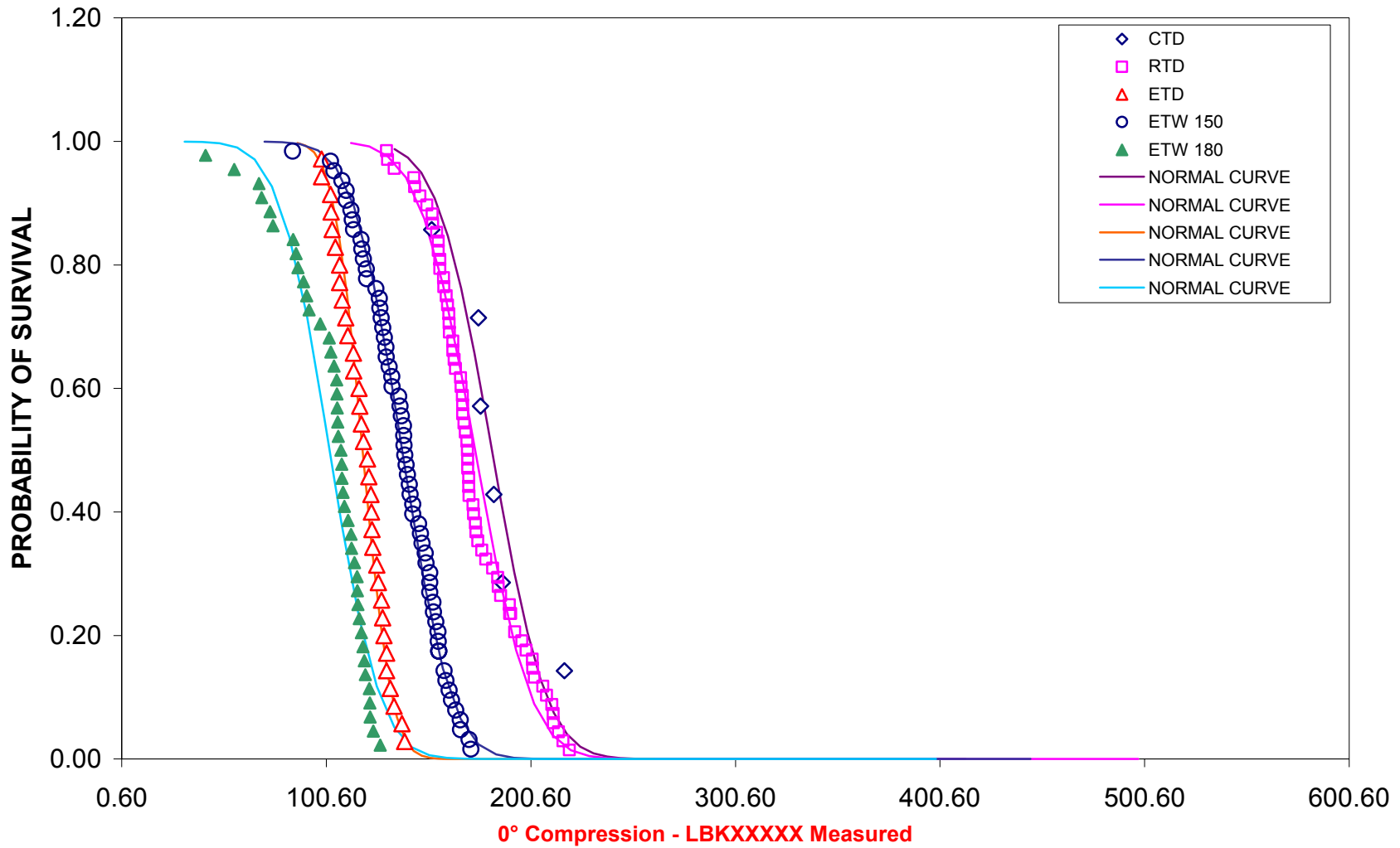
## DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

**3M SP381/ S2 Unitape  
 Cirrus**



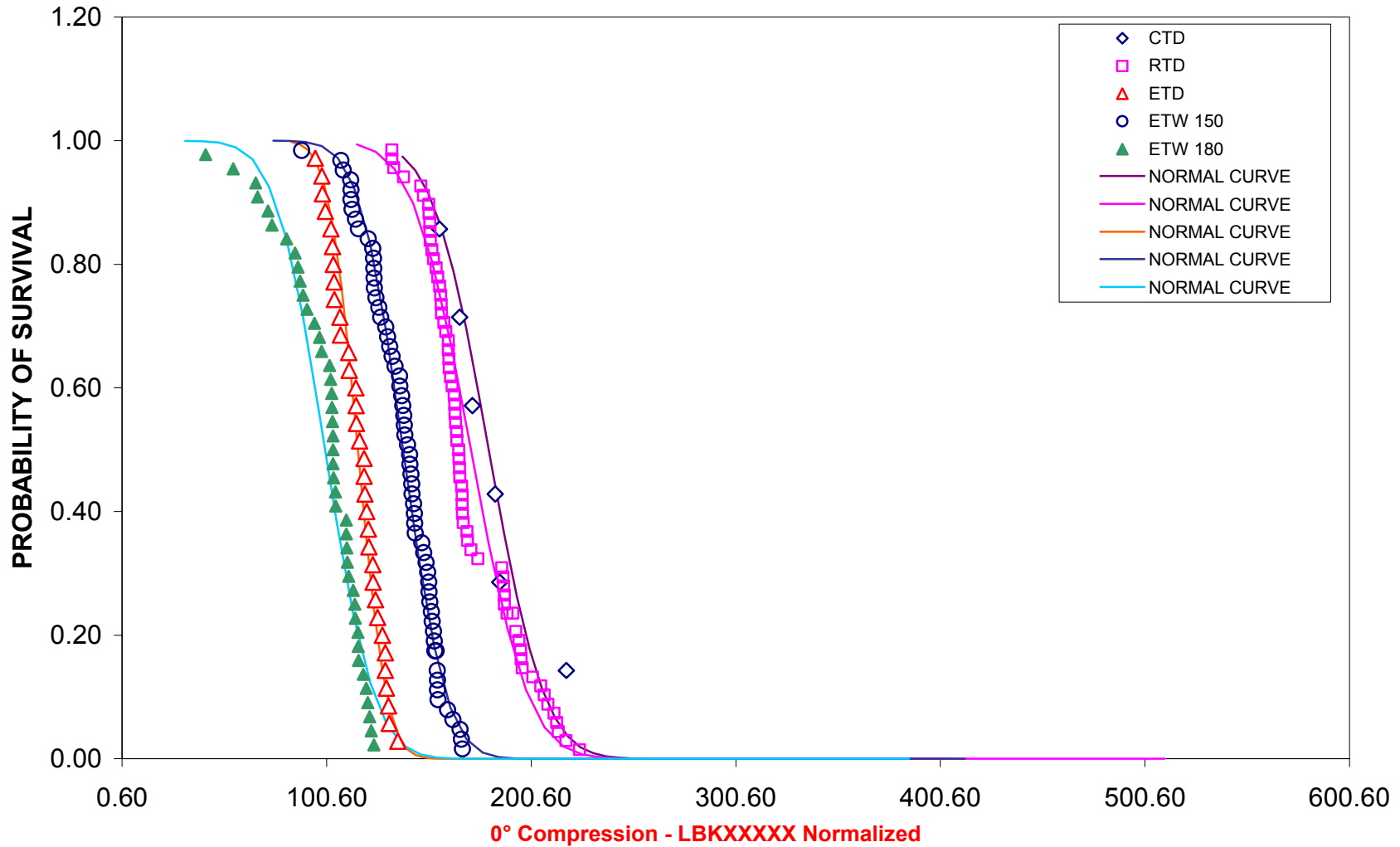
### DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

**3M SP381/ S2 Unitape  
Cirrus**



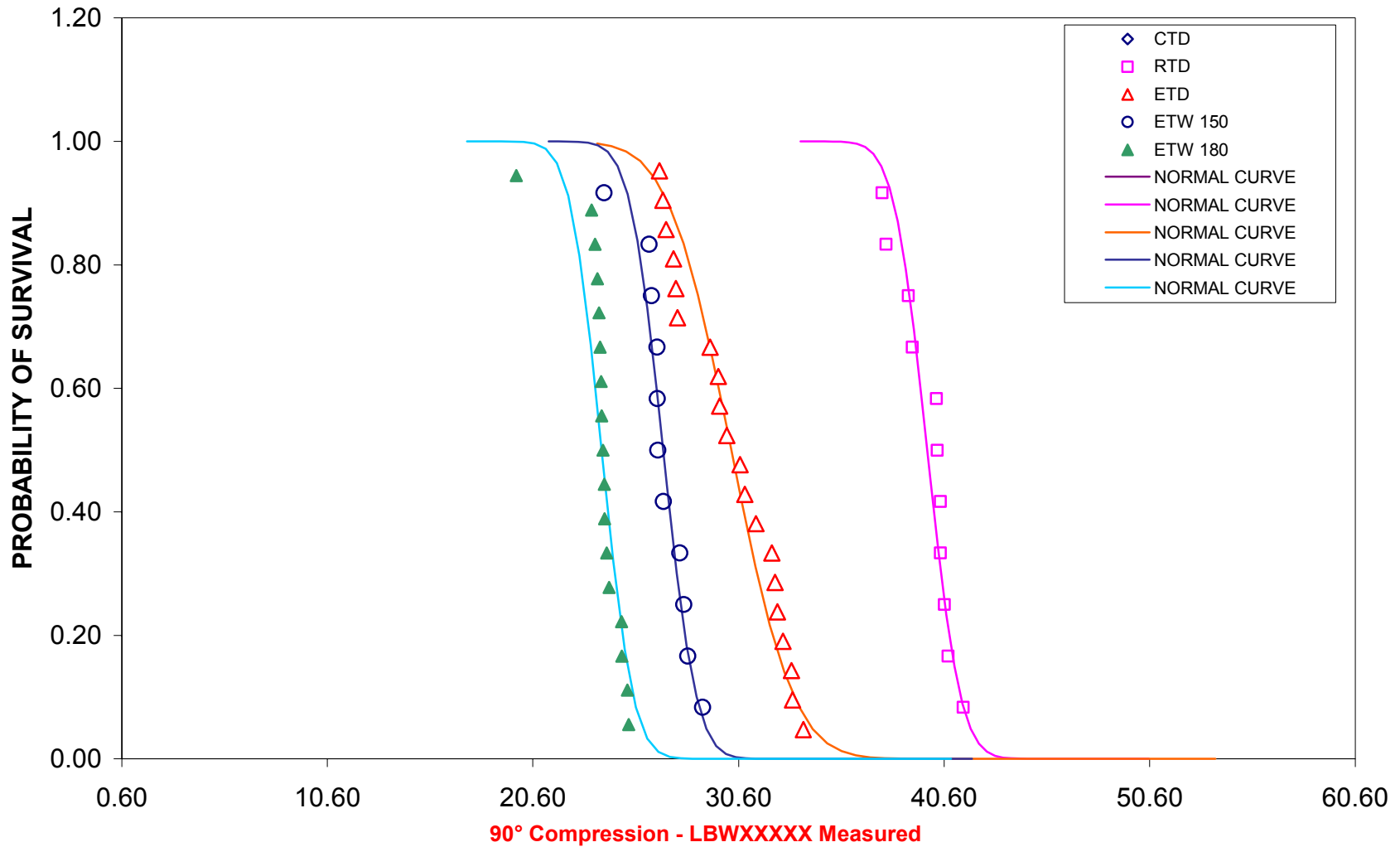
## DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

3M SP381/ S2 Unitape  
Cirrus



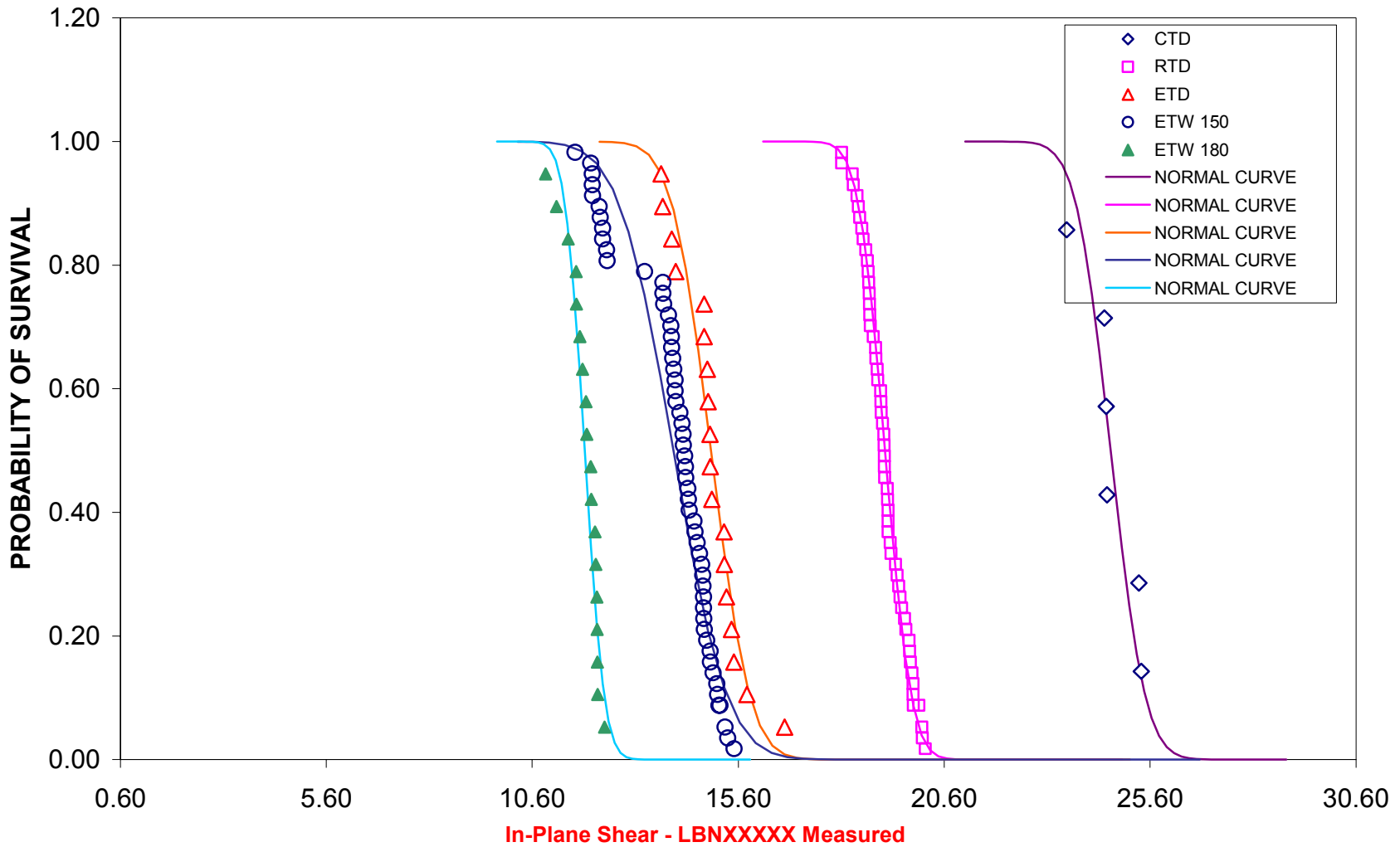
## DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

**3M SP381/ S2 Unitape  
 Cirrus**



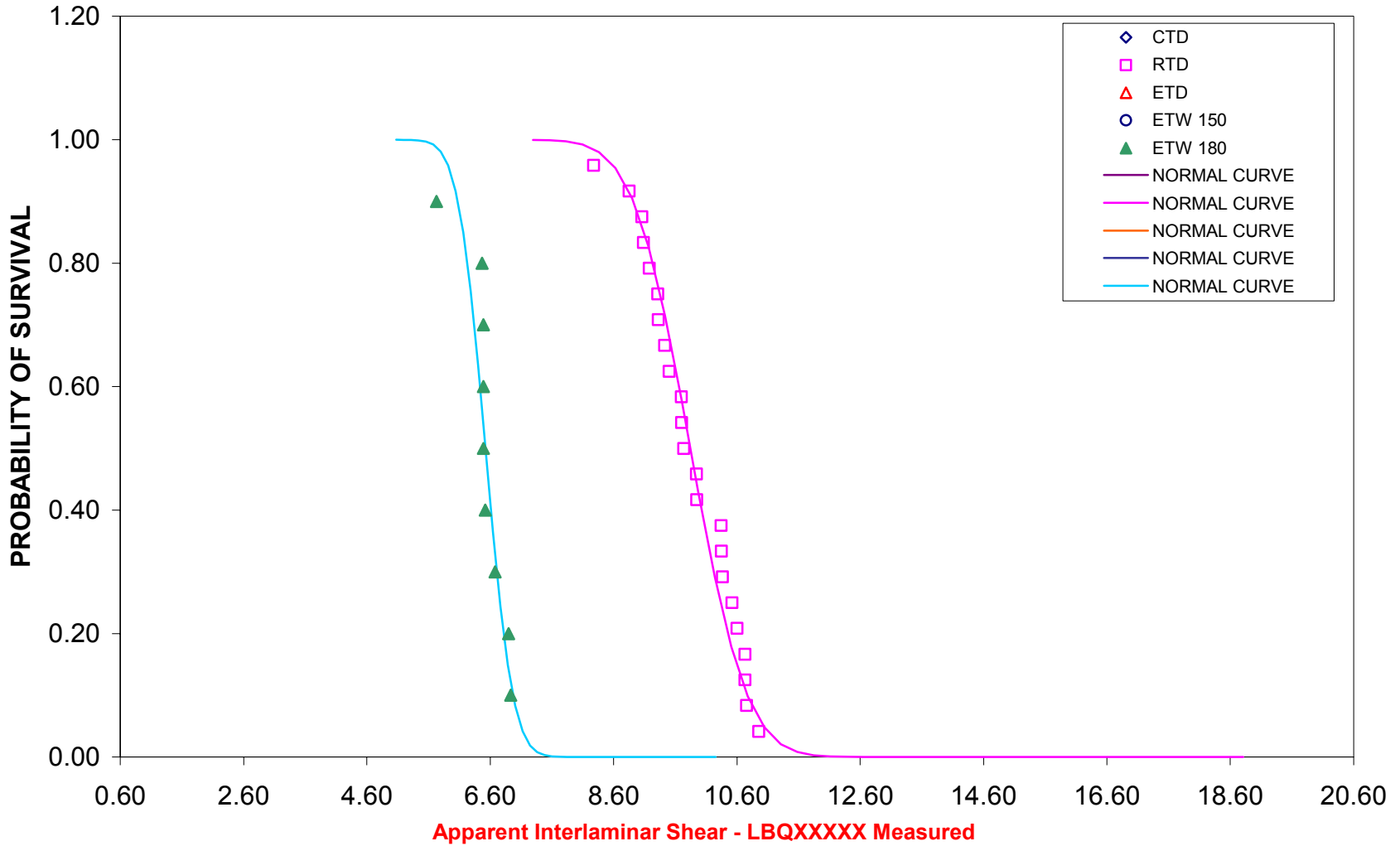
### DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

**3M SP381/ S2 Unitape  
Cirrus**



## DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

**3M SP381/ S2 Unitape  
 Cirrus**



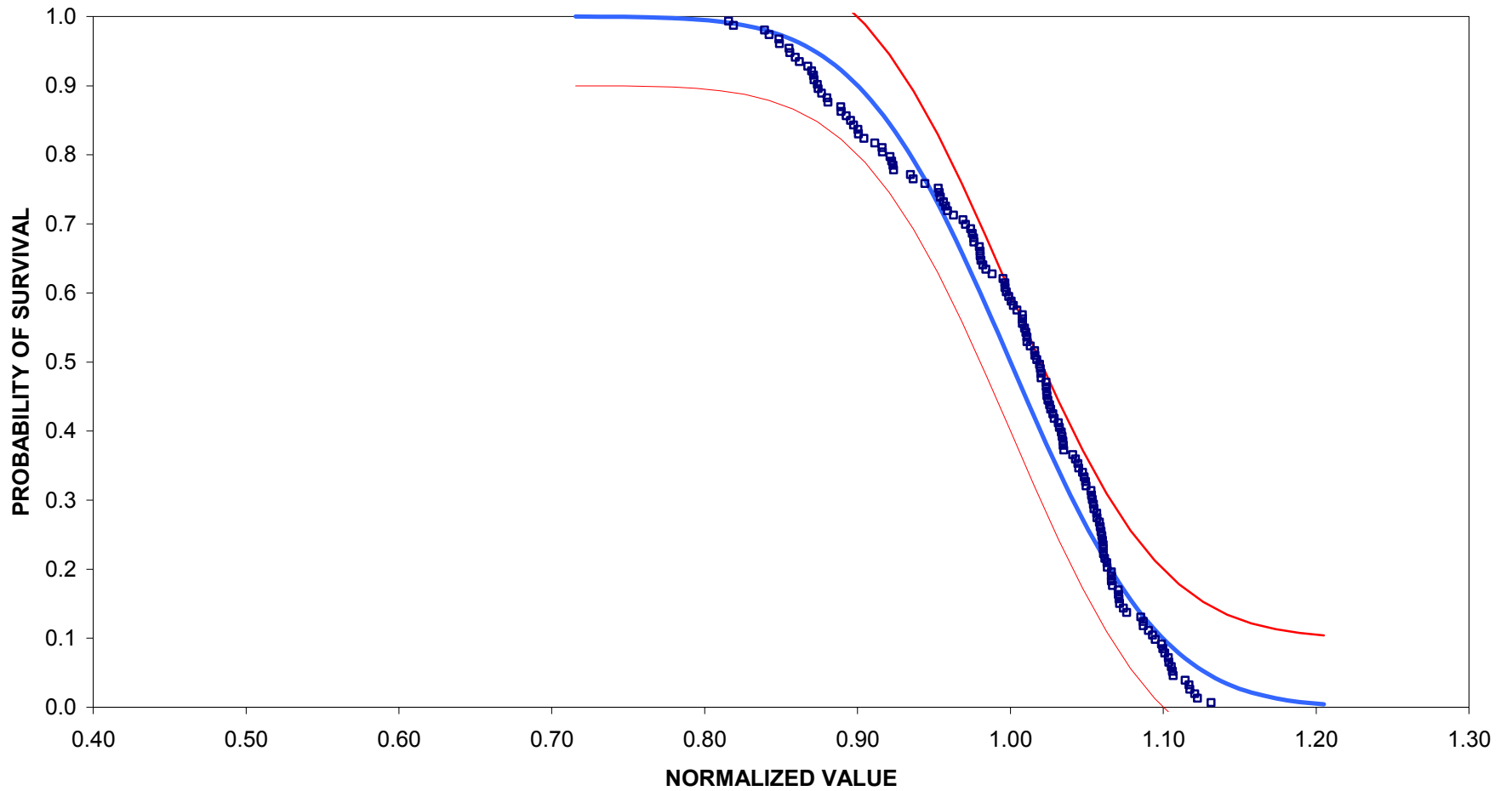
### **3.3.2 Plot of Pooled Data**

### DISTRIBUTION OF POOLED DATA

**3M SP381/ S2 Unitape**

**Cirrus**

**0° Tension - LBJXXXXX Measured**

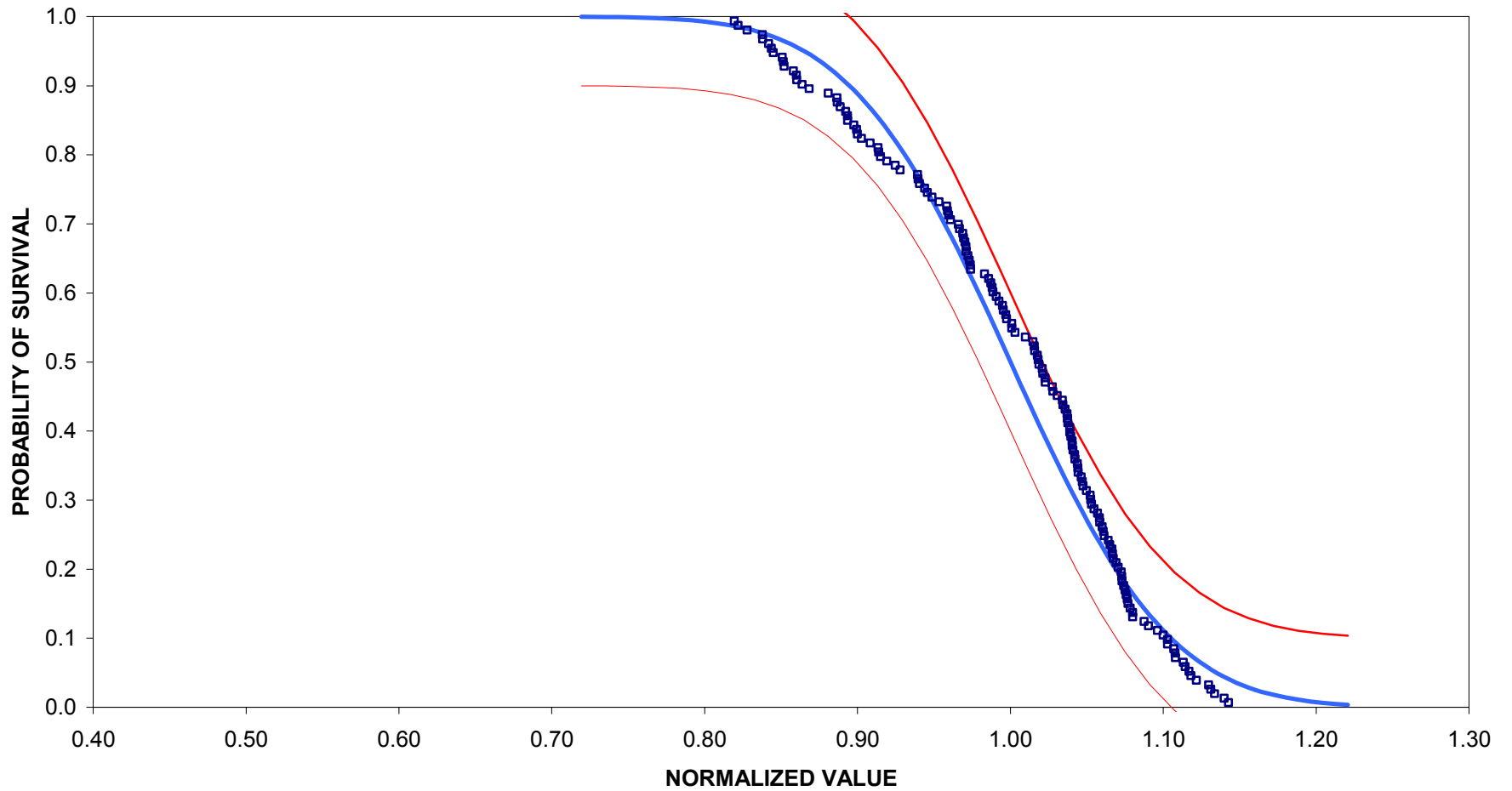


### DISTRIBUTION OF POOLED DATA

**3M SP381/ S2 Unitape**

**Cirrus**

**0° Tension - LBJXXXXX Normalized**

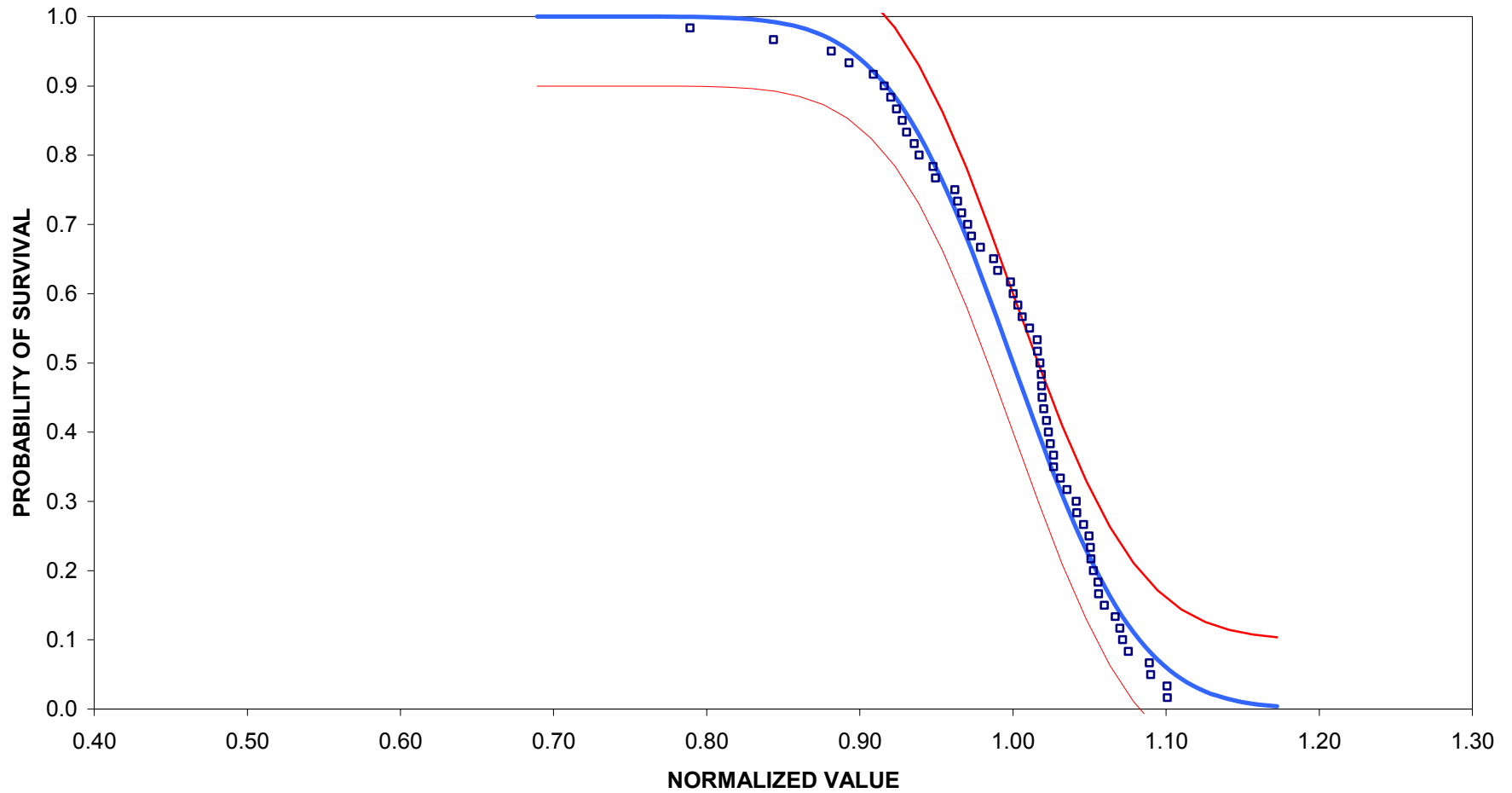


### DISTRIBUTION OF POOLED DATA

**3M SP381/ S2 Unitape**

**Cirrus**

**90° Tension - LBUXXXX Measured**

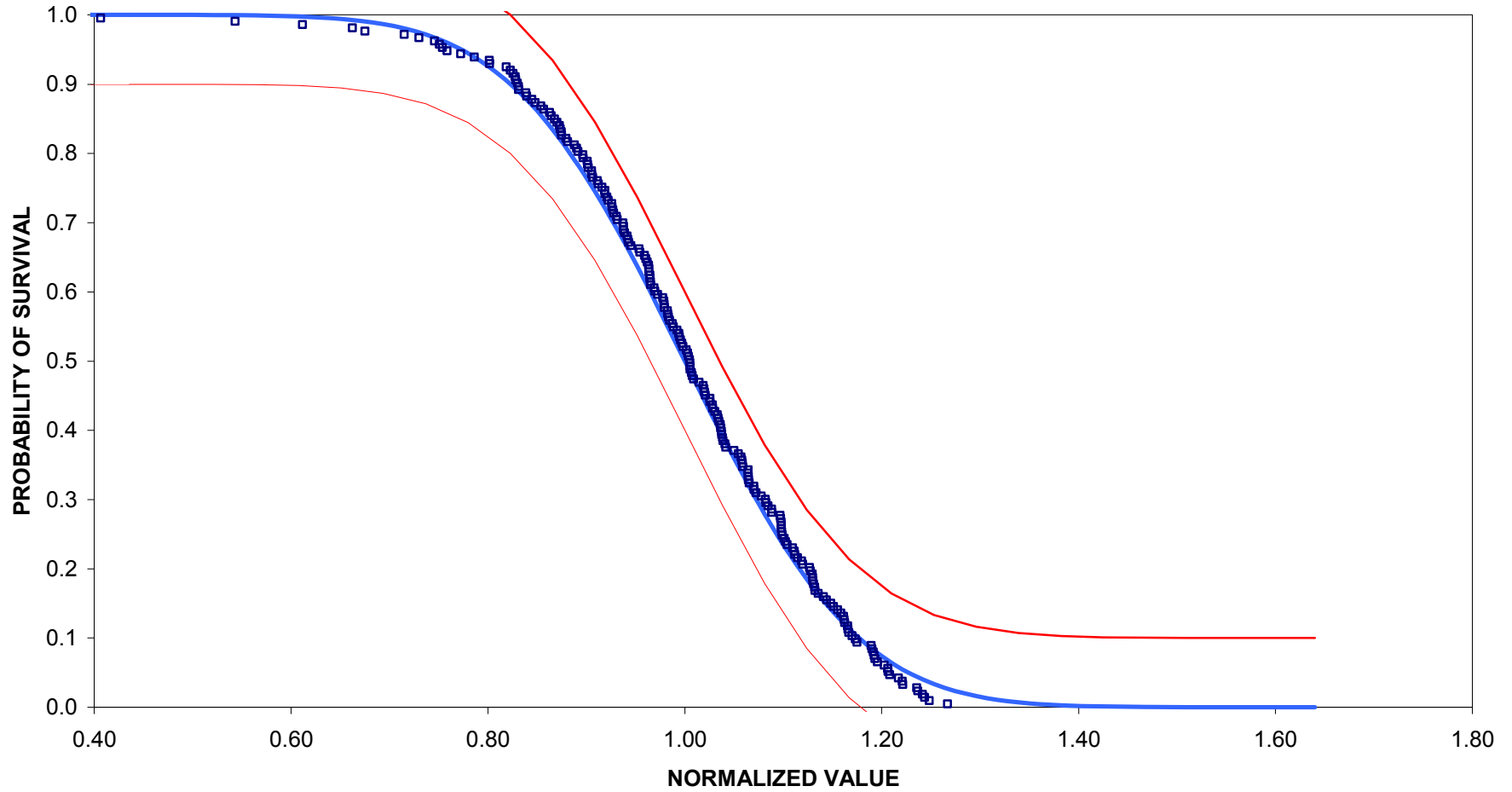


### DISTRIBUTION OF POOLED DATA

3M SP381/ S2 Unitape

Cirrus

0° Compression - LBKXXXXX Measured

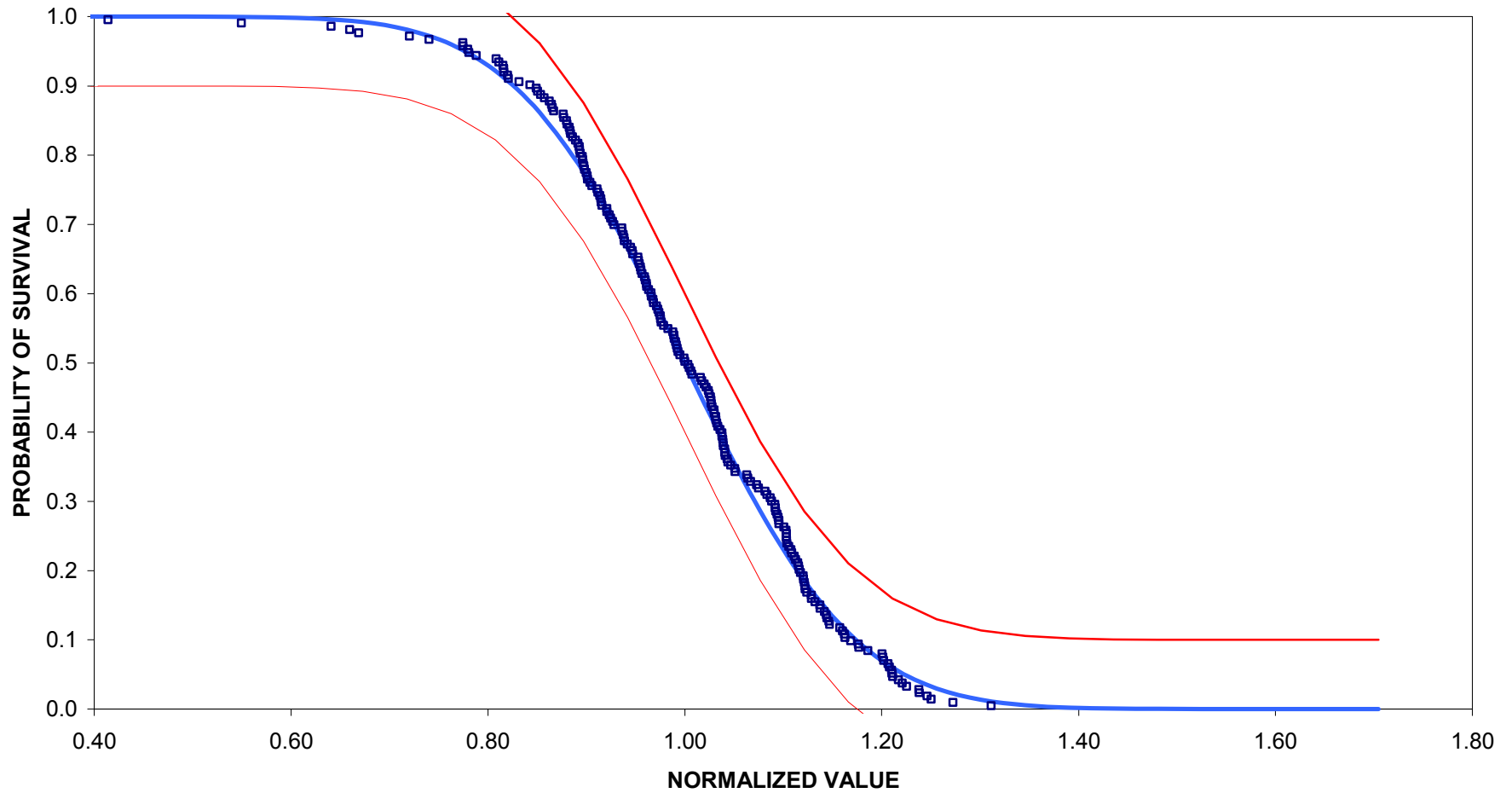


### DISTRIBUTION OF POOLED DATA

3M SP381/ S2 Unitape

Cirrus

0° Compression - LBKXXXXX Normalized

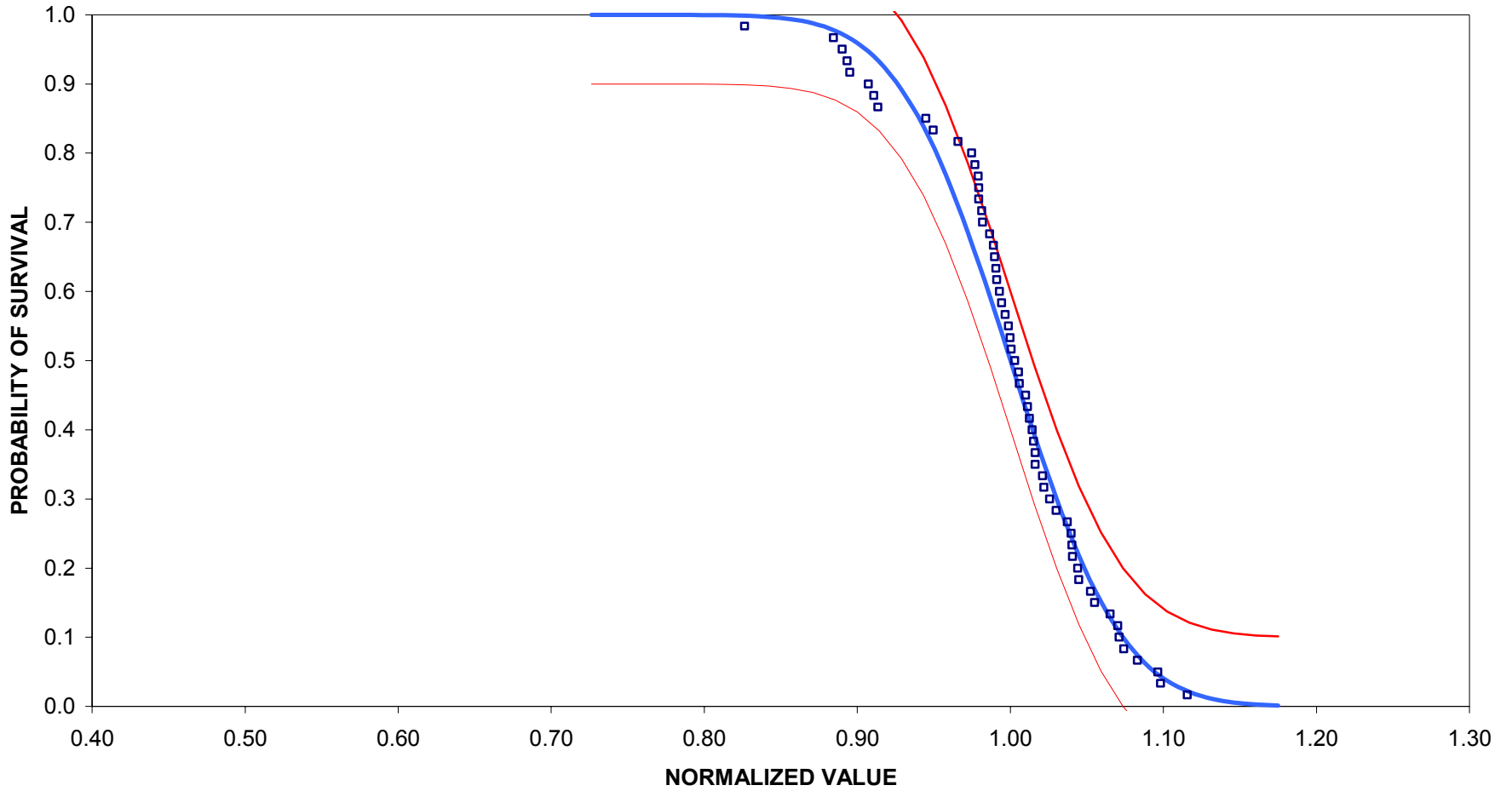


### DISTRIBUTION OF POOLED DATA

**3M SP381/ S2 Unitape**

**Cirrus**

**90° Compression - LBWXXXXX Measured**

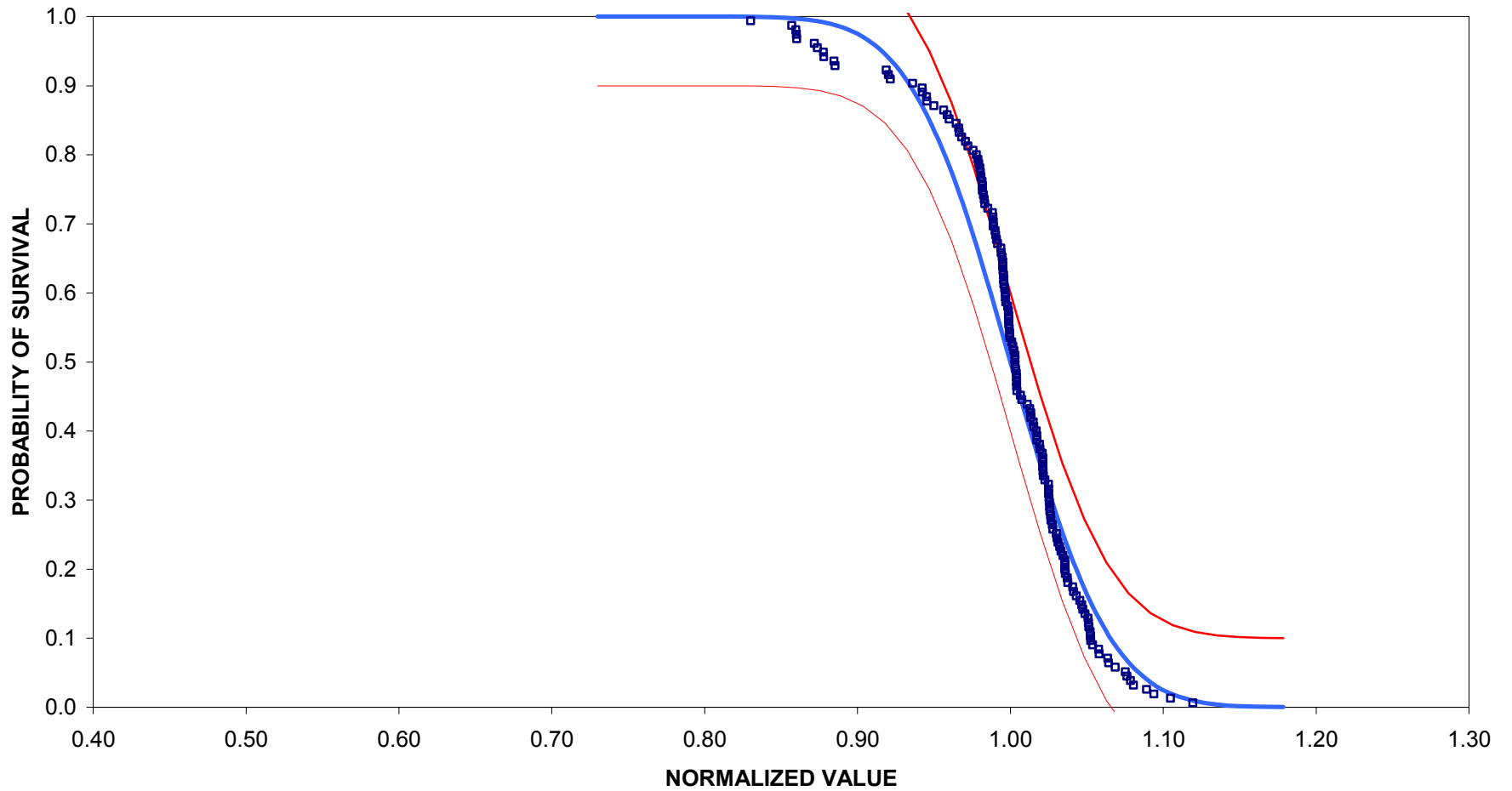


### DISTRIBUTION OF POOLED DATA

**3M SP381/ S2 Unitape**

**Cirrus**

**In-Plane Shear - LBNXXXXX Measured**

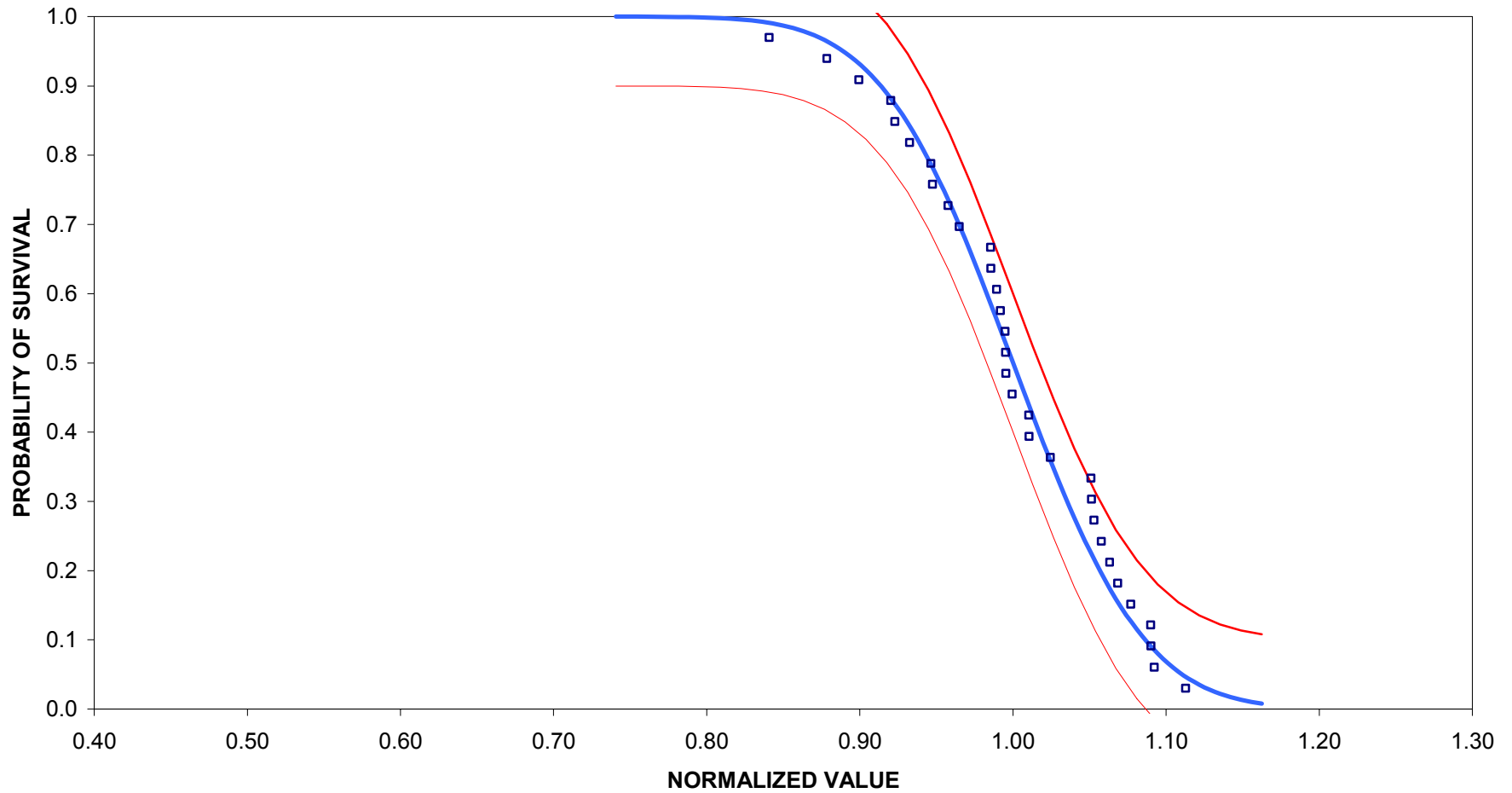


### DISTRIBUTION OF POOLED DATA

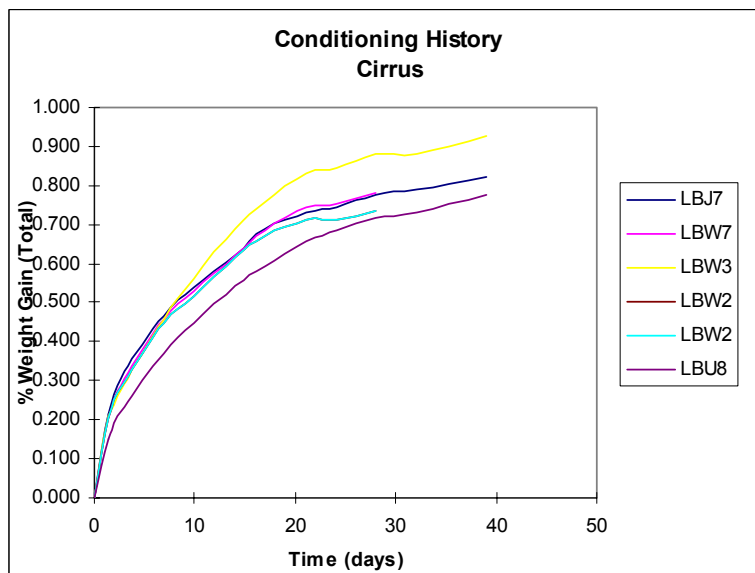
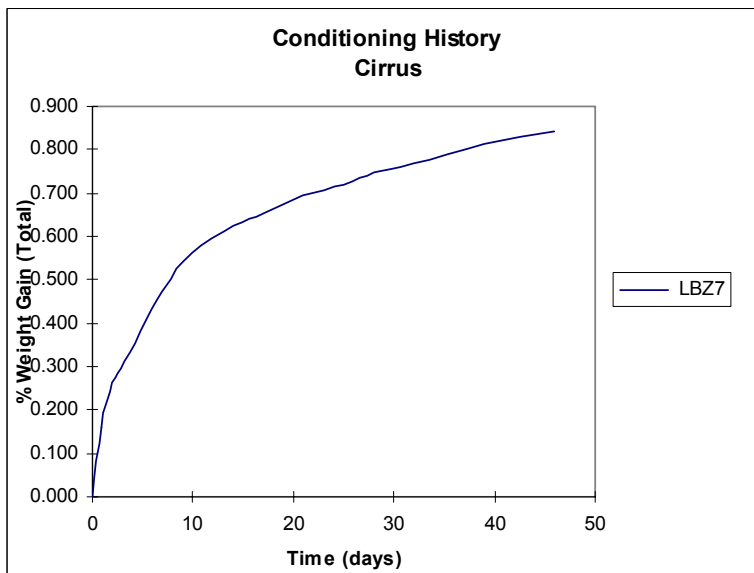
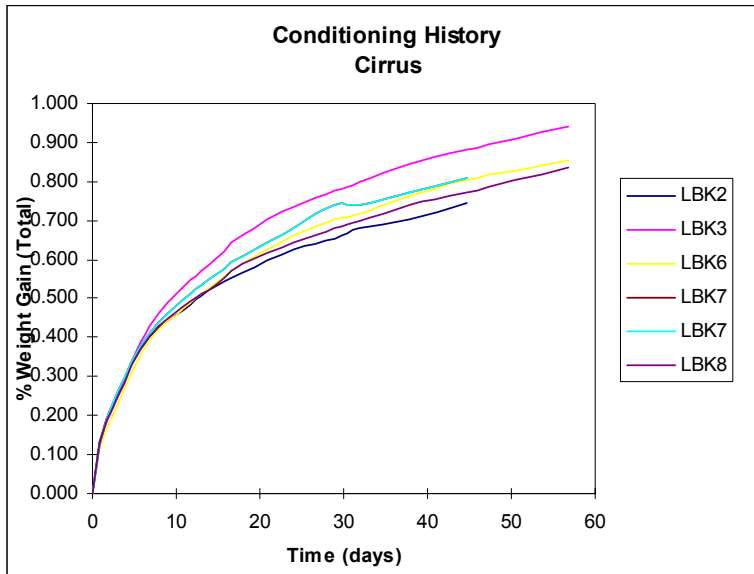
**3M SP381/ S2 Unitape**

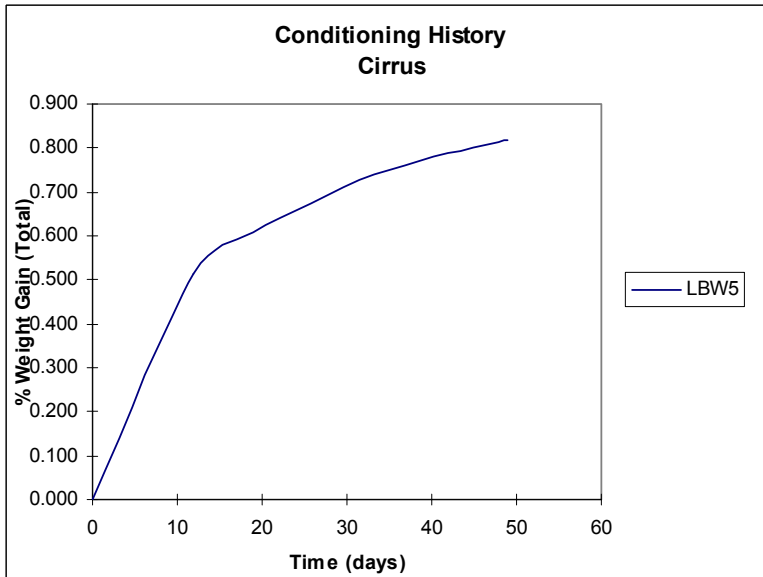
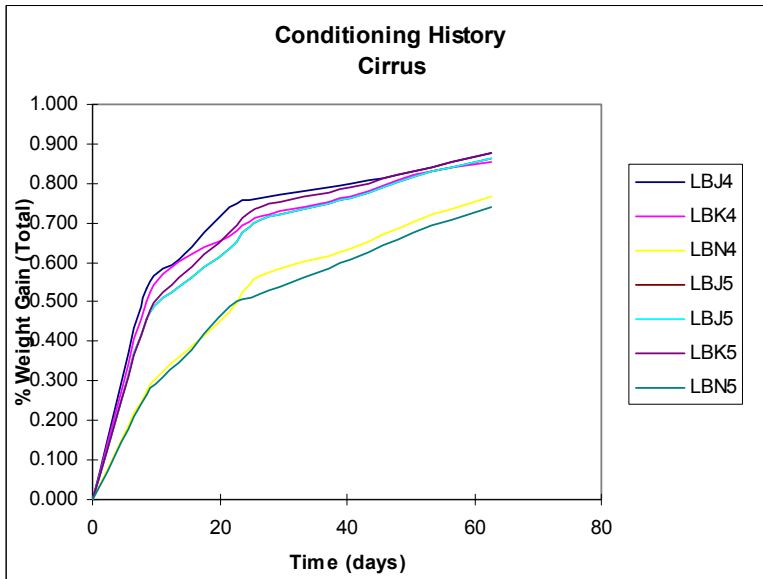
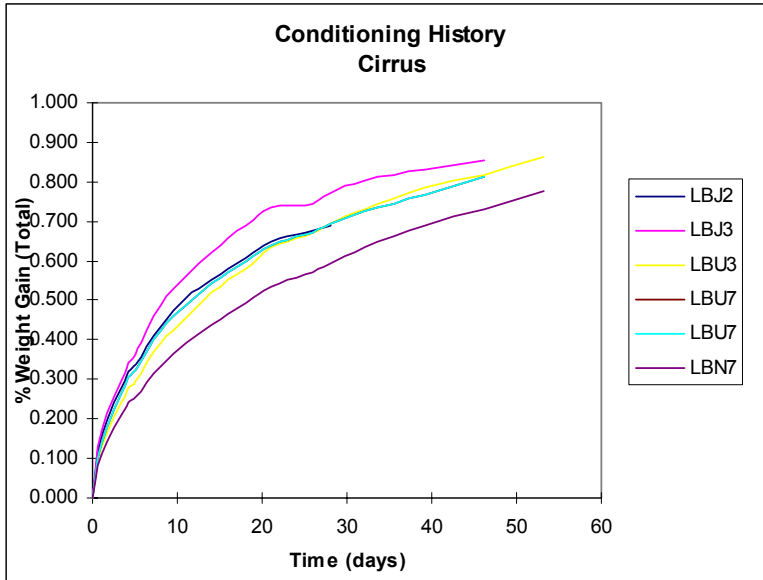
**Cirrus**

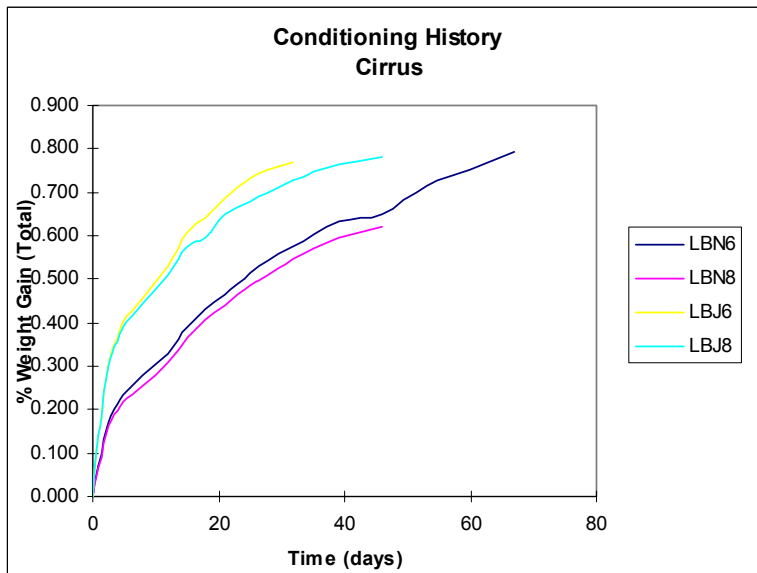
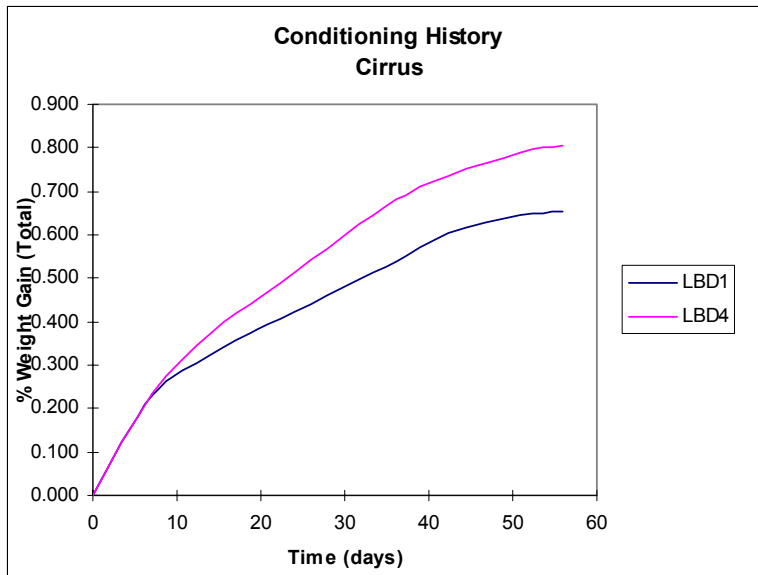
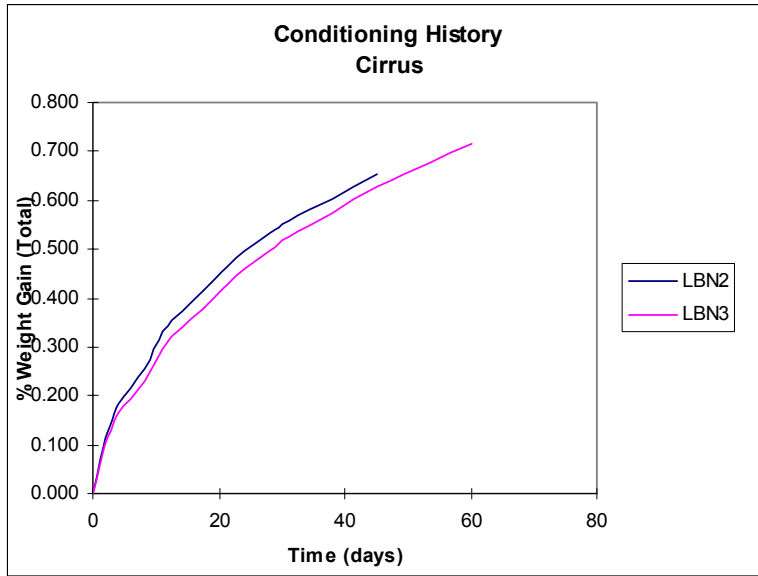
**Apparent Interlaminar Shear - LBQXXXXX Measured**

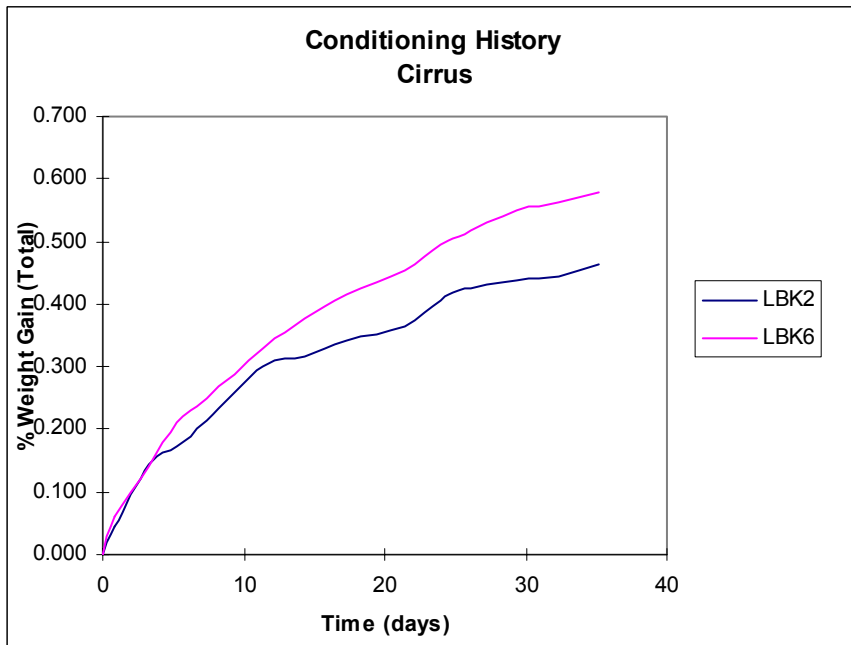
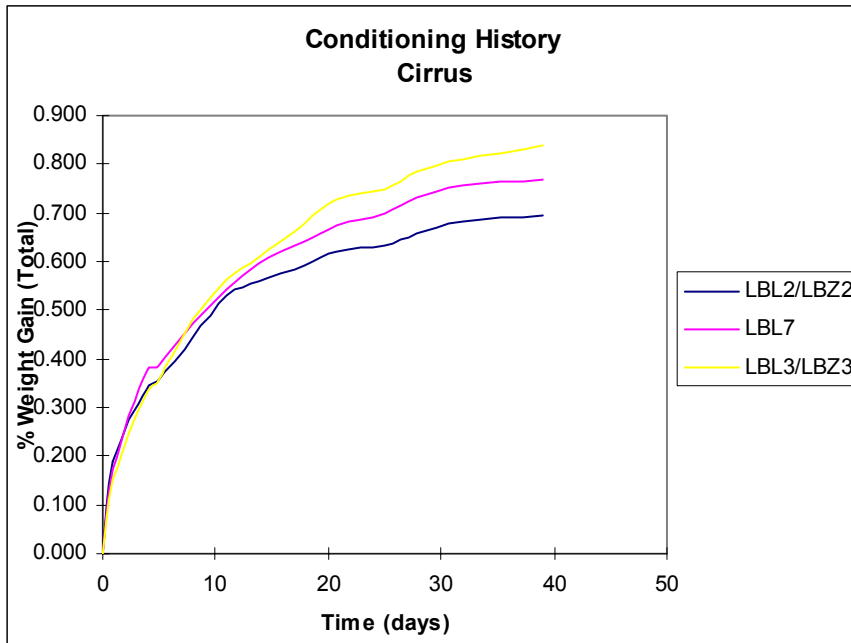


### **3.4 Moisture Conditioning History Charts**







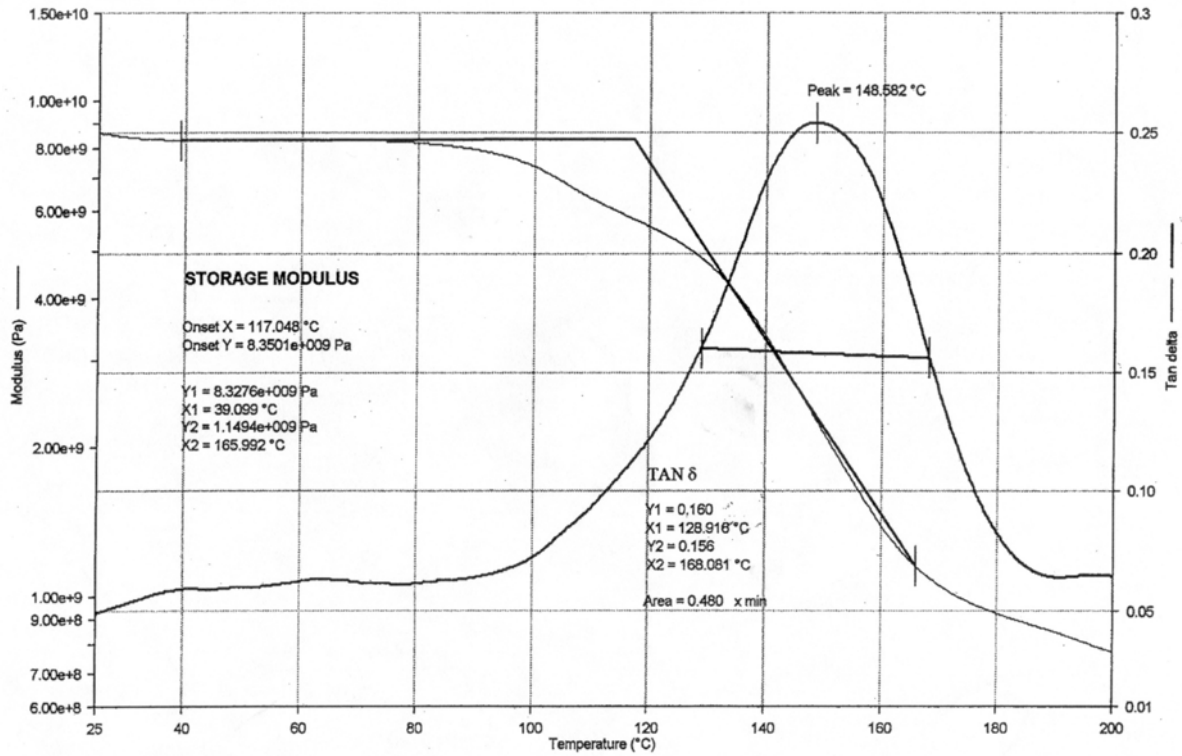


### **3.5 Physical Test Results**

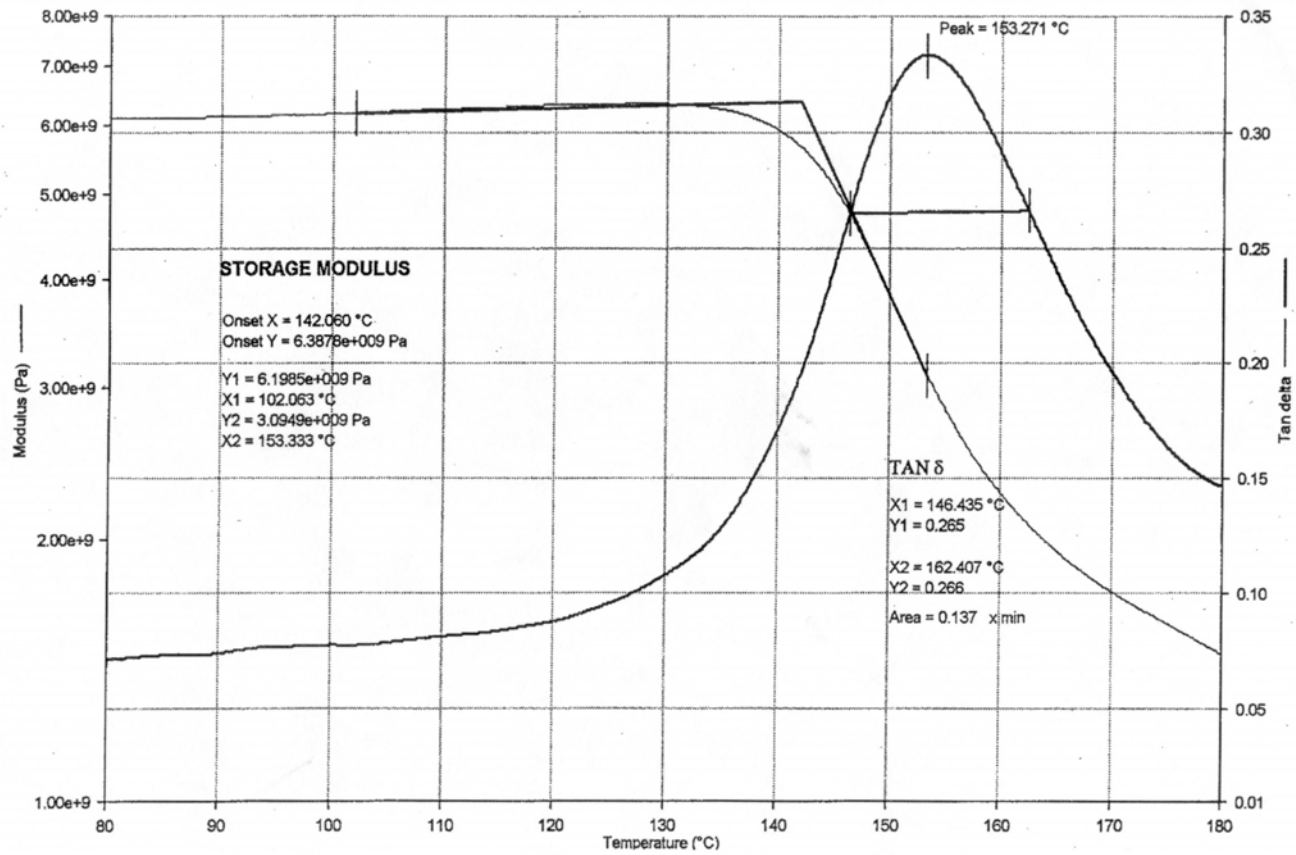
### Physical Test Summary 3M SP381/ S2 Unitape

	Composite Density [g/cc]	Resin Content [wt%]	Fiber Volume [vol%]	Void Content [vol%]
<b>0° Tension (LBJXXXXX)</b>				
No. of Specimens	13	13	13	13
Mean	1.857	29.174	53.473	1.982
Standard Deviation	0.043	1.150	1.973	1.653
<b>90° Tension (LBUXXXXXX)</b>				
No. of Specimens	6	6	6	6
Mean	1.832	29.205	52.726	3.253
Standard Deviation	0.021	1.361	1.516	0.843
<b>0° Compression (LBKXXXXX)</b>				
No. of Specimens	14	14	14	14
Mean	1.857	29.863	52.954	1.610
Standard Deviation	0.027	1.930	1.807	1.449
<b>90° Compression (LBWXXXXX)</b>				
No. of Specimens	3	3	3	3
Mean	1.848	28.840	53.449	2.699
Standard Deviation	0.017	0.594	0.884	0.611
<b>In-Plane Shear (LBNXXXXX)</b>				
No. of Specimens	10	10	10	10
Mean	1.872	29.130	53.928	1.203
Standard Deviation	0.026	0.738	1.188	1.102
<b>Interlaminar Shear (LBQXXXXX)</b>				
No. of Specimens	3	3	3	3
Mean	1.895	27.786	55.640	1.030
Standard Deviation	0.029	0.791	1.420	0.953
<b>Overall No. of Specimens</b>				
<b>Overall Mean</b>	<b>1.859</b>	<b>29.260</b>	<b>53.457</b>	<b>1.858</b>
<b>Overall Std. Deviation</b>	<b>0.033</b>	<b>1.391</b>	<b>1.721</b>	<b>1.431</b>

<b>DMA Results -- Onset Storage Modulus</b>					
DRY			WET		
<b>As Fabricated</b>			<b>Moisture Equilibrium at 85% RH</b>		
<b>Sample #</b>	<b>Tg [°C]</b>	<b>Tg [°F]</b>	<b>Sample #</b>	<b>Tg [°C]</b>	<b>Tg [°F]</b>
LBD1-A	142.06	287.71	LBD2-C	121.12	250.02
LBD3-A	141.33	286.39	LBD3-C	108.18	226.72
LBD4-A	141.98	287.57	LBD7-C	117.13	242.84
LBD7-A	141.42	286.55	LBD8-C	117.05	242.69
LBD8-A	143.97	291.14			
		<b>Average [°F]</b>			<b>287.87</b>
		<b>Standard Dev. [°F]</b>			<b>1.92</b>
		<b>Coeff. Of Var. [%]</b>			<b>0.67</b>
		<b>Average [°F]</b>			<b>240.57</b>
		<b>Standard Dev. [°F]</b>			<b>9.85</b>
		<b>Coeff. Of Var. [%]</b>			<b>4.09</b>



Representative DMA curve for S2 uni / SP381, 'saturated' condition.



Representative DMA curve for S2 uni / SP381, 'as fabricated' condition.

## **4.0 TESTING AND REPORTING COMMENTS**

Conformity data is documented and archived as part of the Cirrus certification program.  
FAA project No. TC1425CH-A.