Advanced General Aviation Transport Experiments

B – Basis Design Allowables for Epoxy – Based Prepreg

Newport Graphite Unitape G150 NASS / NCT321

AGATE-WP3.3-033051-096

July 2001

J. Tomblin, J. McKenna, Y. Ng, K. S. Raju
National Institute for Aviation Research
Wichita State University
Wichita, KS 67260-0093

TABLE OF CONTENTS

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

ν_{12}^{tu}	major Poisson's ratio, tension
$\mu\varepsilon$	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/Ep	carbon/epoxy
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
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
D2734-94	Void Content of Reinforced Plastics
D3171-90	Fiber Content of Resin – Matrix Composites by Matrix Digestion
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

PACUSA Lancair Document No: SX512110 Rev. A, Composite Fabrication of Epoxy Laminates and Assemblies

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 G150 NASS graphite 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[1]	RTD[2]	ETW[3]	ETD[4]
0^o (warp) Tension Strength	ASTM D3039-95	1x4	3x4	3x4	
0^o (warp) Tension Modulus, Strength and Poisson's Ratio	ASTM D3039-95	1x2	3x2	3x2	
90^o (fill) Tension Strength	ASTM D3039-95	1x4	3x4	3x4	3x6
90^o (fill) Tension Modulus and Strength	ASTM D3039-95	1x2	3x2	3x2	
0^o (warp) Compression Strength	SACMA SRM 1-94	1x6	3x6	3x6	3x6
0^o (warp) Compression Modulus	SACMA SRM 1-94	1x2	3x2	3x2	
90^o (fill) Compression Strength	SACMA SRM 1-94	1x6	3x6	3x6	
90^o (fill) Compression Modulus	SACMA SRM 1-94	1x2	3x2	3x2	
In-Plane Shear Strength	ASTM D5379-93	1x4	3x4	3x4	3x6
In-Plane Shear Modulus and Strength	ASTM D5379-93	1x2	3x2	3x2	
Short Beam Shear	ASTM D2344-89	1x6	3x6	3x6	3x6
Fiber Volume	ASTM D3171-90	One sample per panel			
Resin Volume	ASTM D3171-90	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 RM 18-94	61 dry, 6 wet			

Notes :

1 CTD: One prepreg lot of material tested (test temperature = -65 ± 5^o F, moisture content = as fabricated, soak time at –65 was 10 min.)

2 RTD: Three prepreg lots of material tested (test temperature = 70 ± 10^o F, moisture content = as fabricated)

3 ETW: Three prepreg lots of material tested (test temperature = 175 ± 5^o F, moisture content = equilibrium per section 1.5.2, soak time at 175 was 30-60 sec.)

4 ETD: Three prepreg lots of material tested (test temperature = 175 ± 5^o F, moisture content = as fabricated, soak time at 175 was 10 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 ± 5 % relative humidity and 145 ± 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 ± 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:

- Laminate Tensile Strength and Modulus
- Laminate 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:

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

where:

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

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.

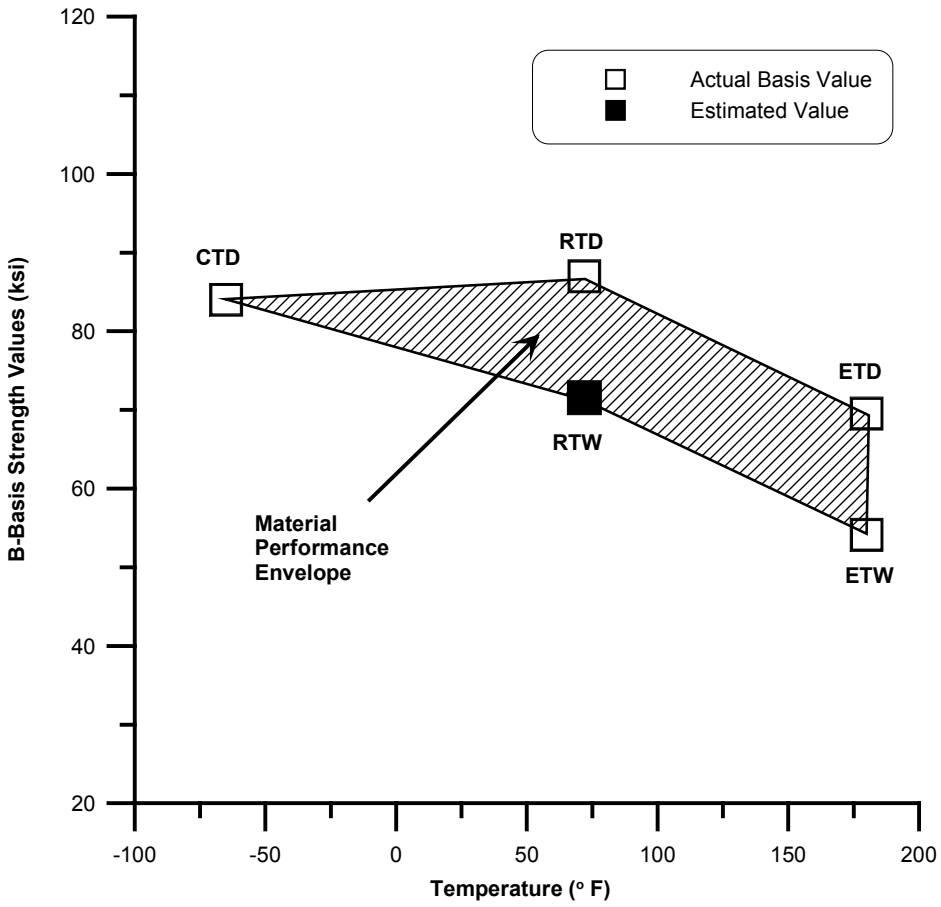


Figure 1.5.1 Material performance envelope.

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

ETD : B_{MOL} = 75.106 ksi

ETW : B_{MOL} = 59.746 ksi

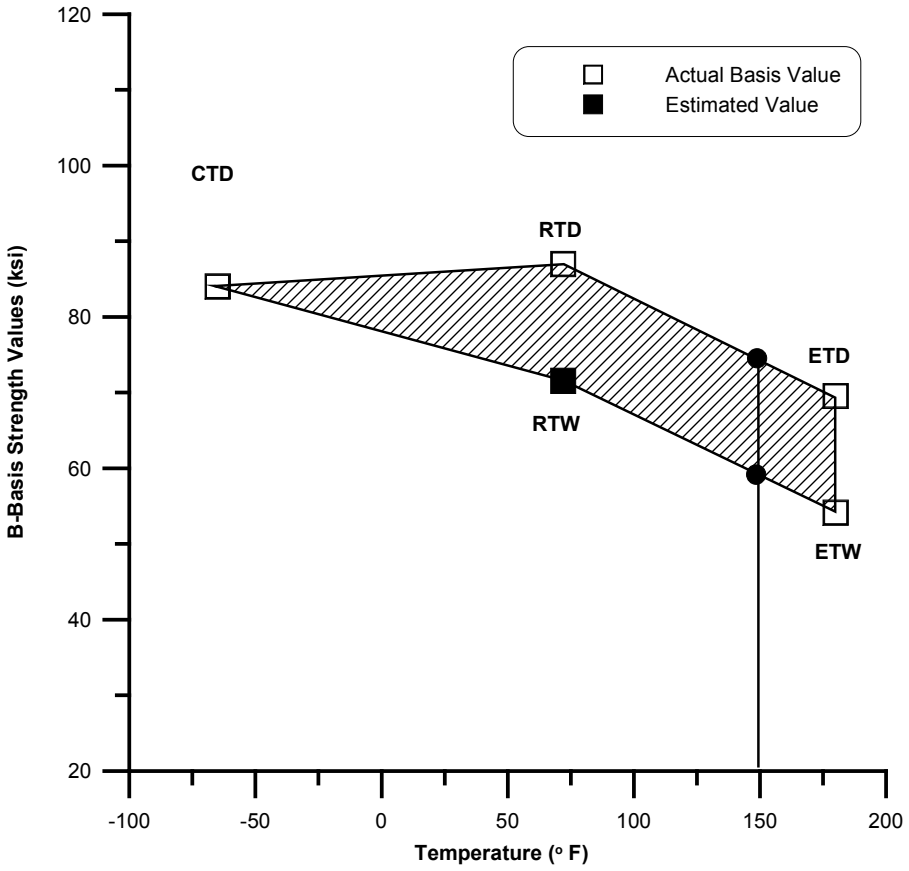


Figure 1.5.2 Example of 150° F interpolation for B-basis values.

2.0 NEWPORT G150/NCT 321 PREPREG PROPERTIES

2.1 Prepreg Documentation by Prepreg Lot

Prepreg Documentation	**Prepreg Manufacturer & Product ID: Newport NCT321-G150 (NASS)** **Impregnation Method: Hot Melt / Film on Paper**		
Prepreg Batch or Lot #	3825Y	3259X	3824Y
Batch # as labeled on specimens	1	2	3
Date of Manufacture	2/26/97	9/18/96	2/26/97
Expiration Date	9/4/97	3/19/97	9/4/97
Resin Content [%]	34.85%	35.87%	36.10%
Reinforcement Areal Weight & Test Method	150±5 g/m^2 NACTM 011		
Resin Flow & Test Conditions	12.6% 275°F/25 psi	11.8% 275°F/25 psi	12.2% 275°F/25 psi
Gel Time & Test Conditions	6min 20sec @ 275°F	5min 28sec @ 275°F	6min 20sec @ 275°F
Volatile Content	Not Tested (less than 0.5% typical)		
Reinforcement Documentation	**Fiber/Fabric Manufacturer & Product ID: HEXCEL NAS-S 12K** **Precursor Type:** Mitsubishi PAN 12K **Nominal Filament Count:** 12000 **Finish/Sizing Type and %:** sizing @ 0.7-1.3% **Nominal tow or yarn count/inch:** yield 0.798 g/m **Twist:** zero		
Fabric Batch or Lot #	1404-7E	1391-7A	1404-7E
Date of Manufacture	12/15/96	9/5/96	12/15/96
Average Fiber Density per Lot & Test Method	1.78 g/cm^3 ASTM D792		
Matrix Documentation	**Resin Manufacturer & Product ID: Newport NCT 321**		
Matrix Batch or Lot #	5046F	4727A	5046F
Date of Manufacture	2/19/97	9/17/96	2/19/97
Average Neat Resin Density by Lot & Test Method	1.20 g/cm^3 ASTM D792		

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 PAC USA Lancair SX512110 Rev. A, *Composite Fabrication of Epoxy Laminates and Assemblies*. All test specimens were cured per this specification by Pacific Aviation Composites. 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

- Uni-directional tape orientation angle shall be within ±2° of the specified orientation.
- At least two vacuum connections shall be used for any part larger than 4 square feet. For larger parts, at least one vacuum connection shall be provided for every 18 square feet of laminate surface.
- Allow the bagged assembly to stand for at least 15 minutes with an applied vacuum of at least 22” Hg. 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. If correction procedures are unsuccessful in eliminating the leak, the entire bag shall be re-bagged and the new bag shall be checked for leaks.

Oven Cure Procedure

- Install the bagged assembly in a cool oven (temperatures less than 100° F). Connect the calibrated thermocouples to the parts, allowing at least one thermocouple per part.
- Cure all prepreg parts as follows:

    1. Heat the part to 270±10° F at a rate of 1 to 6° F per minute based upon the part thermocouple reading. The part must reach 270±10° F in 60 to 180 minutes. At least 22” Hg vacuum shall be maintained throughout the heat up, hold, and cool down to 170° F.
    2. Hold at 270±10° F for 100±10 minutes. The hold period begins when the lowest part thermocouple reaches 260° F.
    3. When multiple parts are cured in the same oven load, the part thermocouple showing the slowest temperature heat-up rate in the load shall be used to determine the start of the 270° F hold period.

4. Cool the part to below 170°F at a rate not to exceed 10° F per minute as measured on the part thermocouple while maintaining full vacuum.

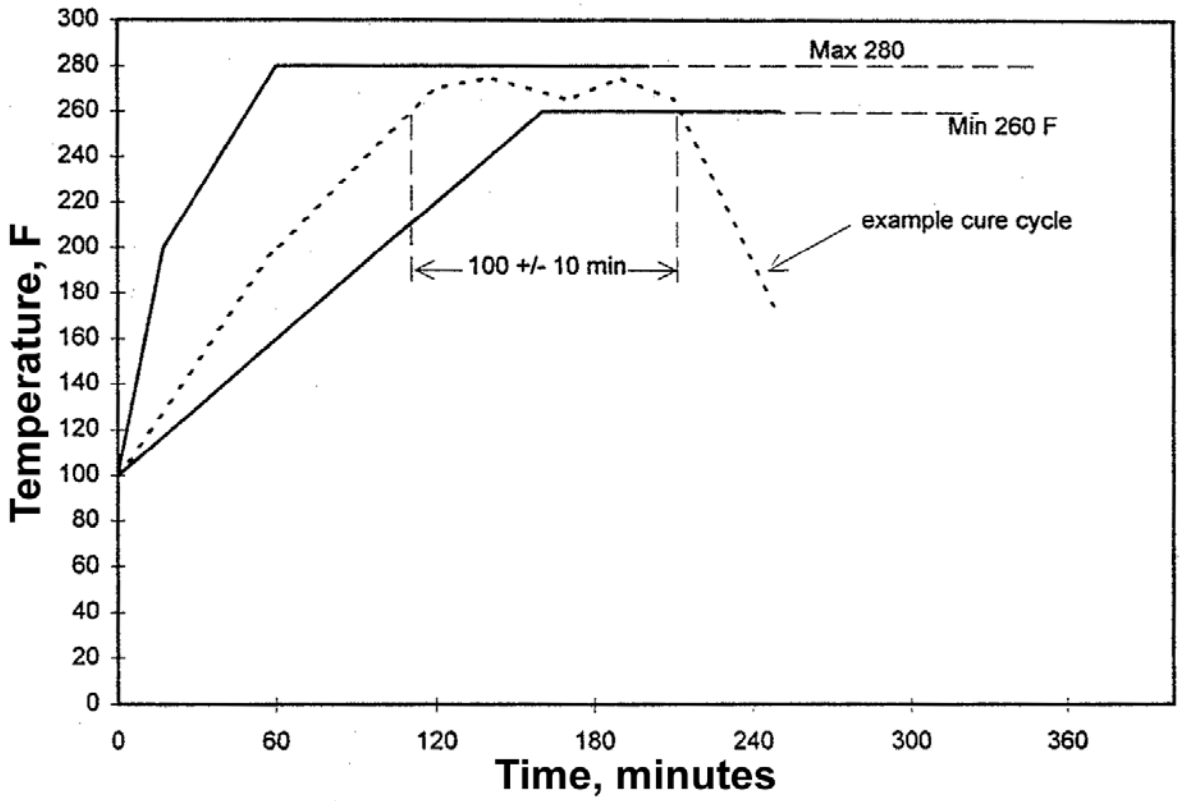


Figure 2.2: Sample prepreg cure cycle for NCT 321/G150 (NASS) unitape. Figure courtesy of Pacific Aviation Composites, USA LLC.

3.0 NEWPORT G150/NCT 321 LAMINATE PROPERTIES

3.1 Test Results

3.1.1 Summary

MATERIAL:	NCT 321/G150 (NASS) Unitape		**NCT 321/G150 Summary**
PREPREG:	Newport NCT 321/ G150 Unitape, 0.7%-1.3% sizing		
FIBER:	Hexcel NAS-S 12K	**RESIN:**	Newport NC321
T_g (dry): 250.5 °F	**T_g (wet):** 223.2 °F	**T_g METHOD:**	DMA (SRM 18-94)
PROCESSING:	Vacuum bag cure (22+ in. Hg.): 270 ± 10°F for 100 ± 10 min.		

Date of fiber manufacture	10/96-12/96	**Date of testing**	4/97 - 9/97
Date of resin manufacture	9/96 - 2/97	**Date of data submittal**	4/98
Date of prepreg manufacture	9/96 - 2/97	**Date of analysis**	4/97 - 9/97
Date of composite manufacture	3/97 - 4/97		

LAMINATE MECHANICAL PROPERTY SUMMARY
Data Reported as: Measured
(Normalized by CPT=0.006 in)

	CTD		RTD		ETD		ETW	
	B-Basis	Mean	B-Basis	Mean	B-Basis	Mean	B-Basis	Mean
F_1^{tu} (ksi)	252.33 (258.41)	282.25 (291.15)	251.40 (268.06)	282.82 (296.31)	---	---	233.93 (242.56)	257.70 (268.87)
E_1^t (Msi)	---	18.33 (18.99)	---	17.76 (18.64)	---	---	---	17.82 (18.55)
ν_{12}^{tu}	---	---	---	0.321	---	---	---	---
F_2^{tu} (ksi)	5.98	7.26	5.95	7.06	4.78	5.67	3.96	4.71
E_2^t (Msi)	---	1.34	---	1.17	---	---	---	0.85
F_1^{cu} (ksi)	157.40 (158.91)	193.40 (195.88)	139.20 (143.98)	165.80 (171.95)	128.81 (132.82)	153.28 (158.46)	97.31 (104.04)	116.03 (124.38)
E_1^c (Msi)	---	17.68 (16.99)	---	17.73 (17.87)	---	---	---	17.47 (17.68)
F_2^{cu} (ksi)	24.02	39.75	28.30	32.37	---	---	20.61	23.58
E_2^c (Msi)	---	1.64	---	1.63	---	---	---	1.14
F_{12}^{su} (ksi)	23.54	25.08	19.76	21.02	15.30	16.29	13.36	14.21
G_{12}^s (Msi)	---	0.65	---	0.55	---	---	---	0.48
F_{13}^{su**} (ksi)	---	---	12.59	13.12	---	---	---	---

** *Apparent* interlaminar shear strength

3.1.2 Individual Test Summaries

3.1.2.1 Tension, 1-axis

Tension, 1-axis
C/Ep
NCT 321/G150 (NASS) UNITAPE
$[0]_{10}$

Material: NCT 321/G150 (NASS) UNITAPE

Resin content: 34 - 39 wt.%
Fiber volume: 52 - 55 %
Ply thickness: 0.0059 - 0.0065 in.
Ply range: 10 ply

Comp. density: 1.48 - 1.49 g/cc
Void content: 0.5 - 3.3 %

Test method: D3039-95

Modulus calculation: linear fit from 1000 - 3000 με

Normalized by: 0.006 in. ply thickness

		CTD		RTD				ETW					
Test Temperature [°F]		-65		75				175					
Moisture Conditioning		dry		dry				equilibrium					
Equilibrium at T, RH		as fabricated		as fabricated				145 F, 85 %					
Source code		MDJXXXXB		MDJXXXXA				MDJXXXXC					
		Normalized	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
F_1^{tu} (ksi)	**Mean**	291.15	282.25	296.31	282.82			268.87	257.70				
	Minimum	251.01	242.52	263.96	254.83			232.76	230.46				
	Maximum	332.17	318.12	315.60	300.36			291.23	280.33				
	C.V.(%)	9.46	9.29	4.55	4.20			5.39	4.98				
	B-value	258.41	252.33	268.06	257.40			242.56	233.93				
	A-value	239.90	235.41	248.47	239.78			224.93	218.01				
	No. Specimens	6		24				18					
	No. Prepreg Lots	1		3				3					
E_1^t (Msi)	**Mean**	18.99	18.33	18.64	17.76			18.55	17.82				
	Minimum	16.92	16.47	18.37	17.28			17.99	17.42				
	Maximum	20.21	19.53	18.83	18.35			19.01	18.18				
	C.V.(%)	9.48	8.94	1.02	2.21			2.09	1.90				
	No. Specimens	3		6				6					
	No. Prepreg Lots	1		3				3					
ν_{12}^t	**Mean**			0.321									
	No. Specimens			3									
	No. Prepreg Lots			3									

3.1.2.2 Tension, 2-axis

Tension, 2-axis
C/Ep
NCT 321/G150 (NASS) UNITAPE
$[0]_{16}$

Material:	NCT 321/G150 (NASS) UNITAPE				
Resin content:	31 - 37 wt.%	**Comp. density:**	1.50 - 1.51 g/cc		
Fiber volume:	53 - 58 %	**Void content:**	0.8 - 2.8 %		
Ply thickness:	0.0060 - 0.0064 in.				
Ply range:	16 ply				
Test method:	D3039-95	**Modulus calculation:**	linear fit from 1000 - 3000 με		
Normalized by:	N/A				

		CTD		RTD		ETD		ETW					
Test Temperature [°F]		-65		75		175		175					
Moisture Conditioning		dry		dry		dry		equilibrium					
Equilibrium at T, RH		as fabricated		as fabricated		as fabricated		145 F, 85 %					
Source code		MDUXXXXB		MDUXXXXA		MDUXXXXE		MDUXXXXC					
		Normalized	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
F_2^{tu} (ksi)	**Mean**		7.26		7.07		5.67		4.71				
	Minimum		5.83		5.70		4.39		4.12				
	Maximum		8.49		7.90		6.39		5.14				
	C.V.(%)		13.60		7.92		11.05		6.31				
	B-value		5.98		5.95		4.78		3.96				
	A-value		5.22		5.20		4.18		3.46				
	No. Specimens	8		21		22		19					
	No. Prepreg Lots	1		3		3		3					
E_2^t (Msi)	**Mean**		1.34		1.17				0.85				
	Minimum		1.33		1.16				0.82				
	Maximum		1.34		1.19				0.86				
	C.V.(%)		0.63		1.11				2.43				
	No. Specimens	2		7				5					
	No. Prepreg Lots	1		3				3					

3.1.2.3 Compression, 1-axis

Compression,1-axis
C/Ep
NCT 321/G150 (NASS) UNITAPE
$[0]_8$,$[0]_{10}$

Material:	NCT 321/G150 (NASS) UNITAPE				
Resin content:	34 - 38 wt.%	**Comp. density:**	1.49 - 1.50 g/cc		
Fiber volume:	52 - 56 %	**Void content:**	0.5 - 2.1 %		
Ply thickness:	0.0057 - 0.0068 in.				
Ply range:	8 -10 plies				
Test method:	SRM 1-94, D695-91 (mod)	**Modulus calculation:**	linear fit from 1000 - 3000 με		
Normalized by:	0.006 in. ply thickness				

		CTD		RTD		ETD		ETW					
Test Temperature [°F]		-65		75		175		175					
Moisture Conditioning		dry		dry		dry		equilibrium					
Equilibrium at T, RH		as fabricated		as fabricated		as fabricated		145 F, 85 %					
Source code		MDKXXXXB		MDKXXXXA		MDKXXXXE		MDKXXXXC					
		Normalized	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
	Mean	195.88	193.40	171.95	165.80	158.46	153.28	124.38	116.03				
	Minimum	188.82	181.19	147.50	140.20	123.09	124.38	107.31	100.61				
	Maximum	208.63	211.94	201.02	188.28	197.74	190.78	150.64	145.34				
	C.V.(%)	3.69	5.74	7.80	7.40	12.21	11.25	9.05	9.96				
F_1^{cu} (ksi)	**B-value**	158.91	157.40	143.98	139.20	132.82	128.81	104.04	97.31				
	A-value	138.26	137.29	125.34	121.47	115.61	112.40	90.57	84.92				
	No. Specimens	6		19		20		18					
	No. Prepreg Lots	1		3		3		3					
	Mean	16.99	17.68	17.87	17.73			17.68	17.47				
	Minimum	16.57	17.49	17.01	16.73			17.13	17.26				
	Maximum	17.41	17.87	19.24	19.03			18.16	17.75				
E_1^c (Msi)	**C.V.(%)**	3.53	1.53	5.82	5.45			2.39	1.12				
	No. Specimens	2		6				6					
	No. Prepreg Lots	1		3				3					

3.1.2.4 Compression, 2-axis

Compression, 2-axis
C/Ep
NCT 321/G150 (NASS) UNITAPE
$[0]_8$

Material:	NCT 321/G150 (NASS) UNITAPE				
Resin content:	33 - 38 wt.%	**Comp. density:**	1.48 - 1.51 g/cc		
Fiber volume:	53 - 56 %	**Void content:**	0.3 - 3.4 %		
Ply thickness:	0.0058 - 0.0065 in.				
Ply range:	8 ply				
Test method:	SRM 1-94, D695-91 (mod)	**Modulus calculation:**	linear fit from 1000 - 3000 με		
Normalized by:	N/A				

		CTD		RTD				ETW					
Test Temperature [°F]		-65		75				175					
Moisture Conditioning		dry		dry				equilibrium					
Equilibrium at T, RH		as fabricated		as fabricated				145 F, 85 %					
Source code		MDWXXXXB		MDWXXXXA				MDWXXXXC					
		Normalized	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
F_2^{cu} (ksi)	**Mean**		39.75		32.37				23.58				
	Minimum		34.55		27.36				21.09				
	Maximum		43.02		35.81				26.43				
	C.V.(%)		7.21		7.97				6.25				
	B-value		34.02		28.30				20.61				
	A-value		30.76		25.56				18.61				
	No. Specimens	6		18				18					
	No. Prepreg Lots	1		3				3					
E_2^c (Msi)	**Mean**		1.64		1.63				1.14				
	Minimum		1.64		1.44				0.98				
	Maximum		1.64		1.75				1.27				
	C.V.(%)		N/A		7.22				10.55				
	No. Specimens	1		6				6					
	No. Prepreg Lots	1		3				3					

3.1.2.5 Shear, 12 axis

Shear, 12-axis
C/Ep
NCT 321/G150 (NASS) UNITAPE
$[0/90]_{5S}$

Material:	NCT 321/G150 (NASS) UNITAPE												
Resin content:	32 - 36 wt.%			**Comp. density:**	1.53 - 1.51 g/cc								
Fiber volume:	54 - 59 %			**Void content:**	0.5 - 0.9 %								
Ply thickness:	0.0056 - 0.0065 in.												
Ply range:	20 ply												
Test method:	D5379-93			**Modulus calculation:**	linear fit from 1000 - 6000 με								
Normalized by:	N/A												
		CTD		**RTD**		**ETD**		**ETW**					
Test Temperature [°F]		-65		75		175		175					
Moisture Conditioning		dry		dry		dry		equilibrium					
Equilibrium at T, RH		as fabricated		as fabricated		as fabricated		145 F, 85 %					
Source code		MDNXXXXB		MDNXXXXA		MDNXXXXE		MDNXXXXC					
		Normalized	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
	Mean		25.09		21.02		16.29		14.21				
	Minimum		24.85		19.22		14.85		13.28				
	Maximum		25.27		22.24		17.16		15.47				
	C.V.(%)		0.76		3.39		3.62		3.98				
F_{12}^{su} (ksi)	**B-value**		23.34		19.76		15.30		13.36				
	A-value		22.36		18.92		14.65		12.80				
	No. Specimens	6		19		18		20					
	No. Prepreg Lots	1		3		3		3					
	Mean		0.65		0.55				0.48				
	Minimum		0.64		0.47				0.41				
	Maximum		0.66		0.64				0.59				
G_{12}^{s} (Msi)	**C.V.(%)**		2.69		11.28				13.46				
	No. Specimens	2		7				6					
	No. Prepreg Lots	1		3				3					

3.1.2.6 Shear, 13 axis

Shear, 13-axis
C/Ep
NCT 321/G150 (NASS) UNITAPE
$[0]_{18}$

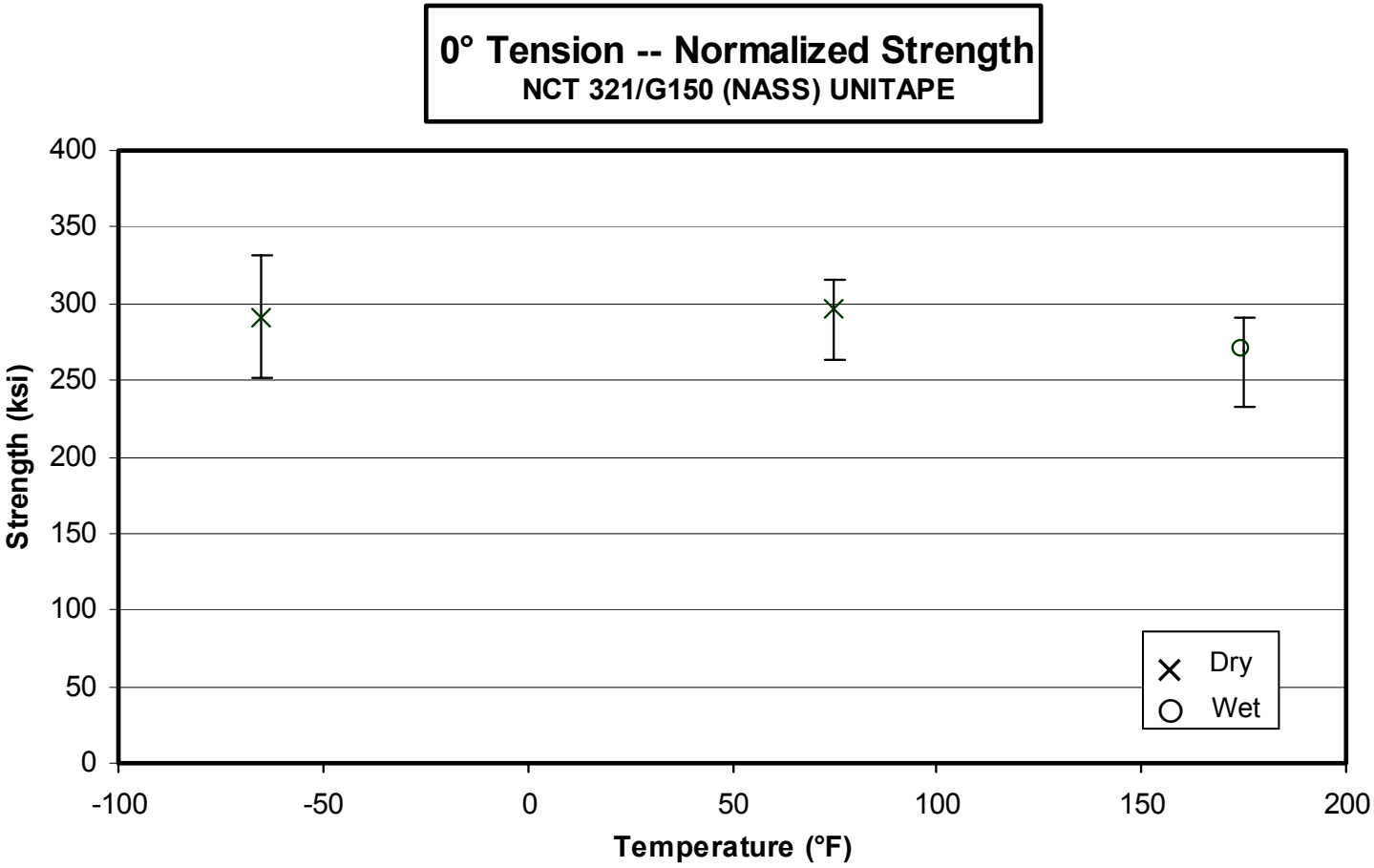
Material:	NCT 321/G150 (NASS) UNITAPE			
Resin content:	34 - 37 wt.%	**Comp. density:**	1.49 - 1.52 g/cc	
Fiber volume:	53 - 56 %	**Void content:**	0.7 - 1.7 %	
Ply thickness:	0.0058 - 0.0066 in.			
Ply range:	18 ply			
Test method:	D2344-89	**Modulus calculation:**	N/A	
Normalized by:	N/A			

		CTD		RTD		ETD		ETW					
Test Temperature [°F]				75									
Moisture Conditioning				dry									
Equilibrium at T, RH				as fabricated									
Source code				MDQXXXXA									
		Normalized	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**	**Normalized**	**Measured**
	Mean				13.12								
	Minimum				12.34								
	Maximum				13.70								
	C.V.(%)				2.20								
F_{13}^{su} (ksi)	**B-value**				12.59								
	A-value				12.21								
	No. Specimens			27									
	No. Prepreg Lots			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.

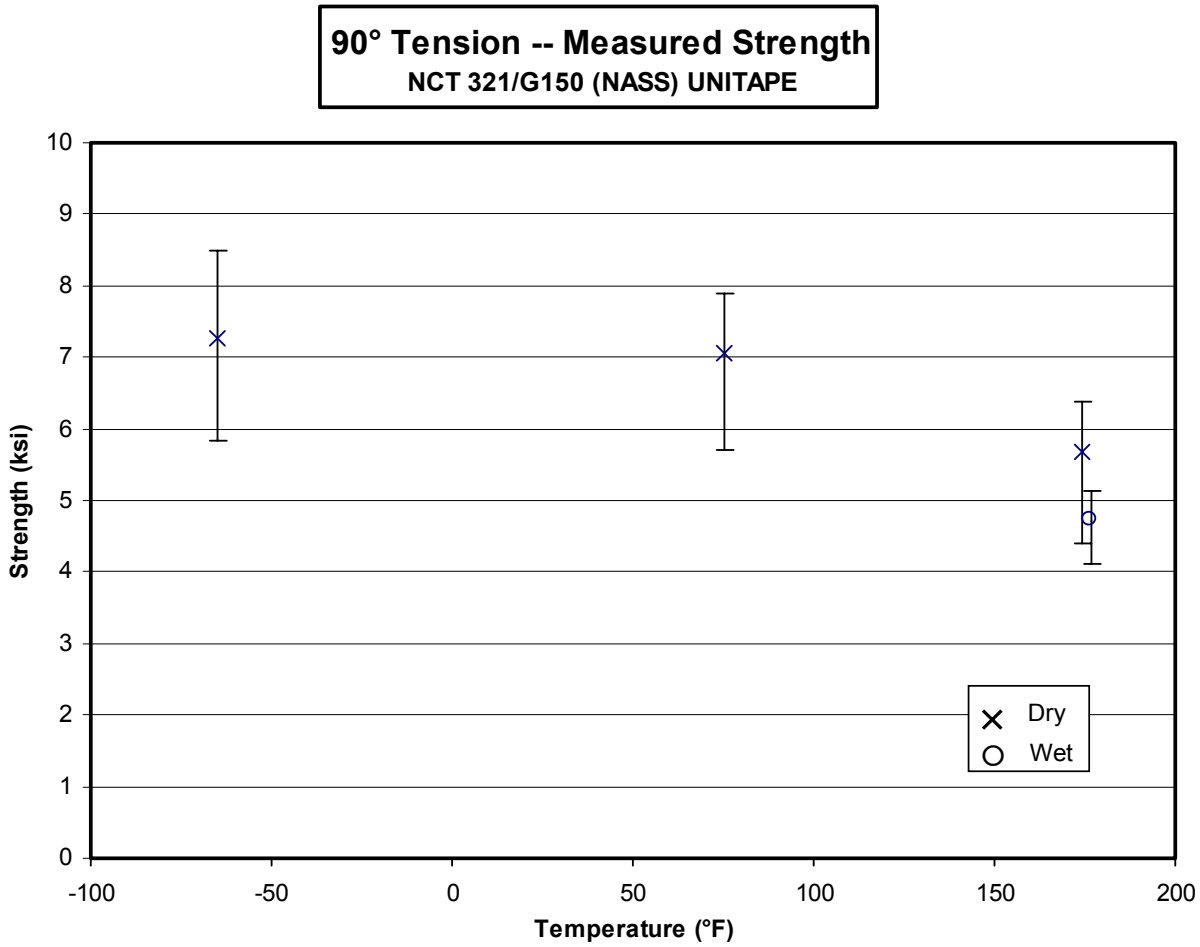
3.1.3 Individual Test Charts

3.1.3.1 Tension, 1-axis



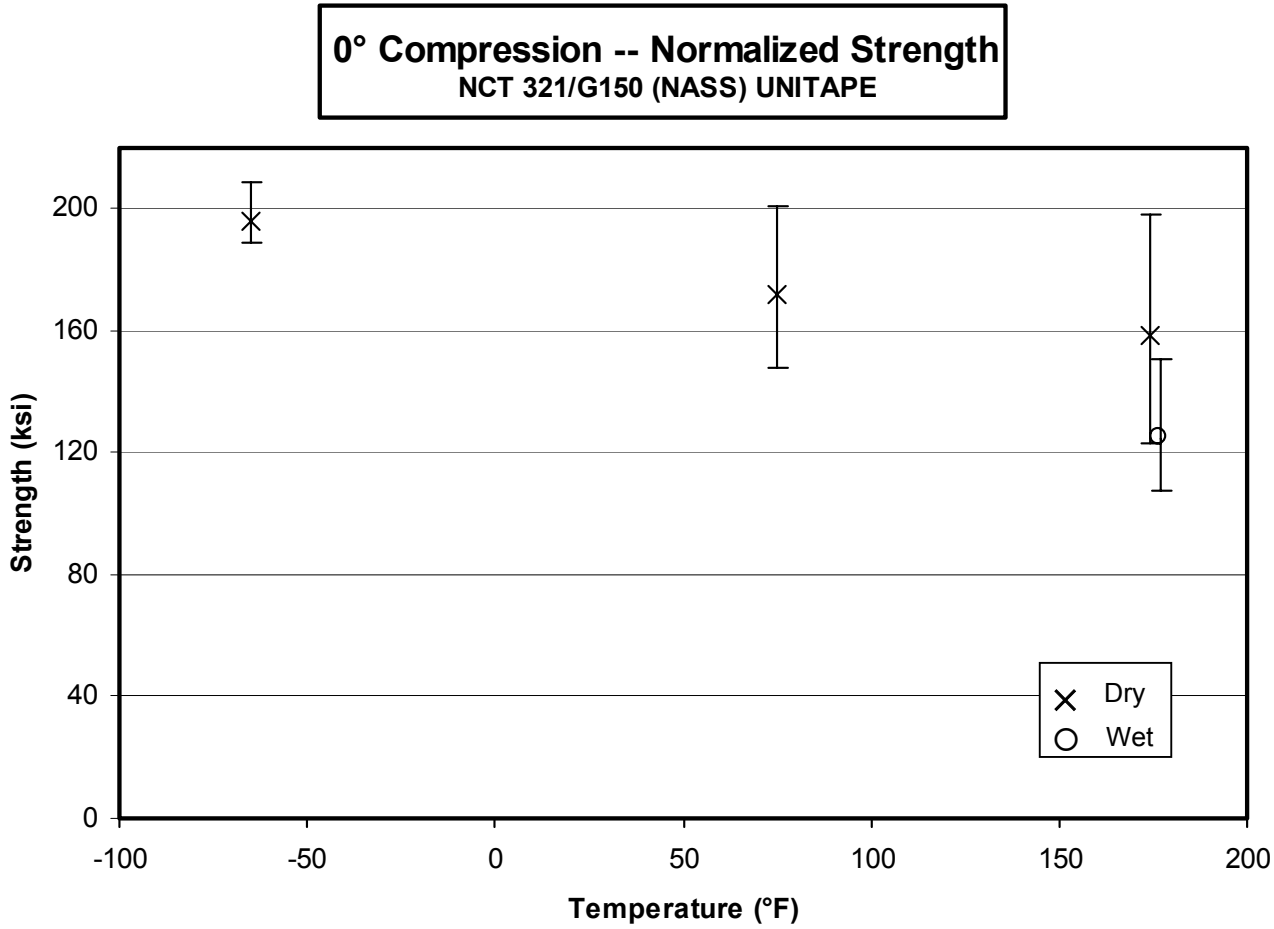
NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data.

3.1.3.2 Tension, 2-axis



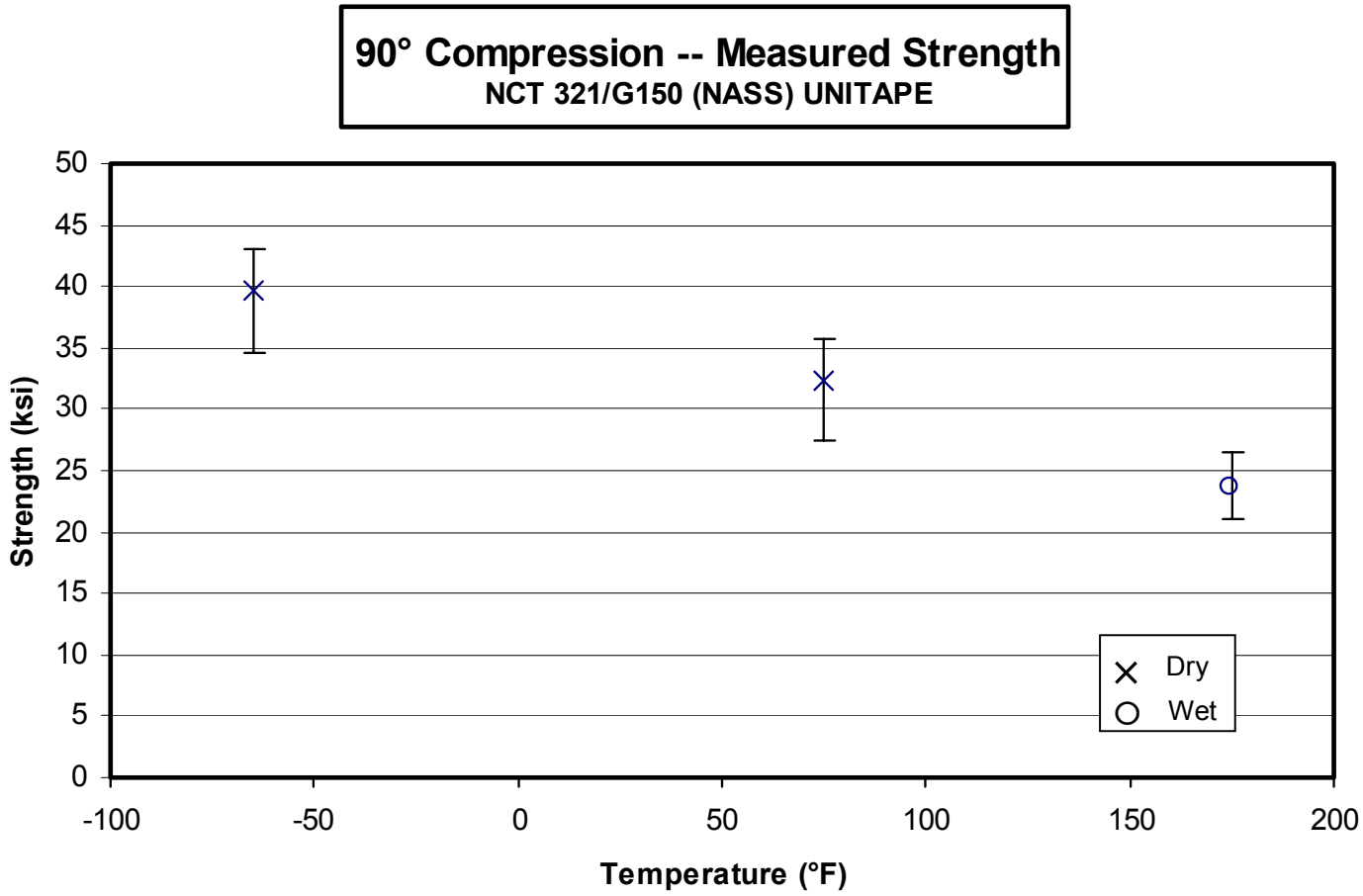
NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 175° dry and wet data has been staggered for clarity.

3.1.3.3 Compression, 1-axis



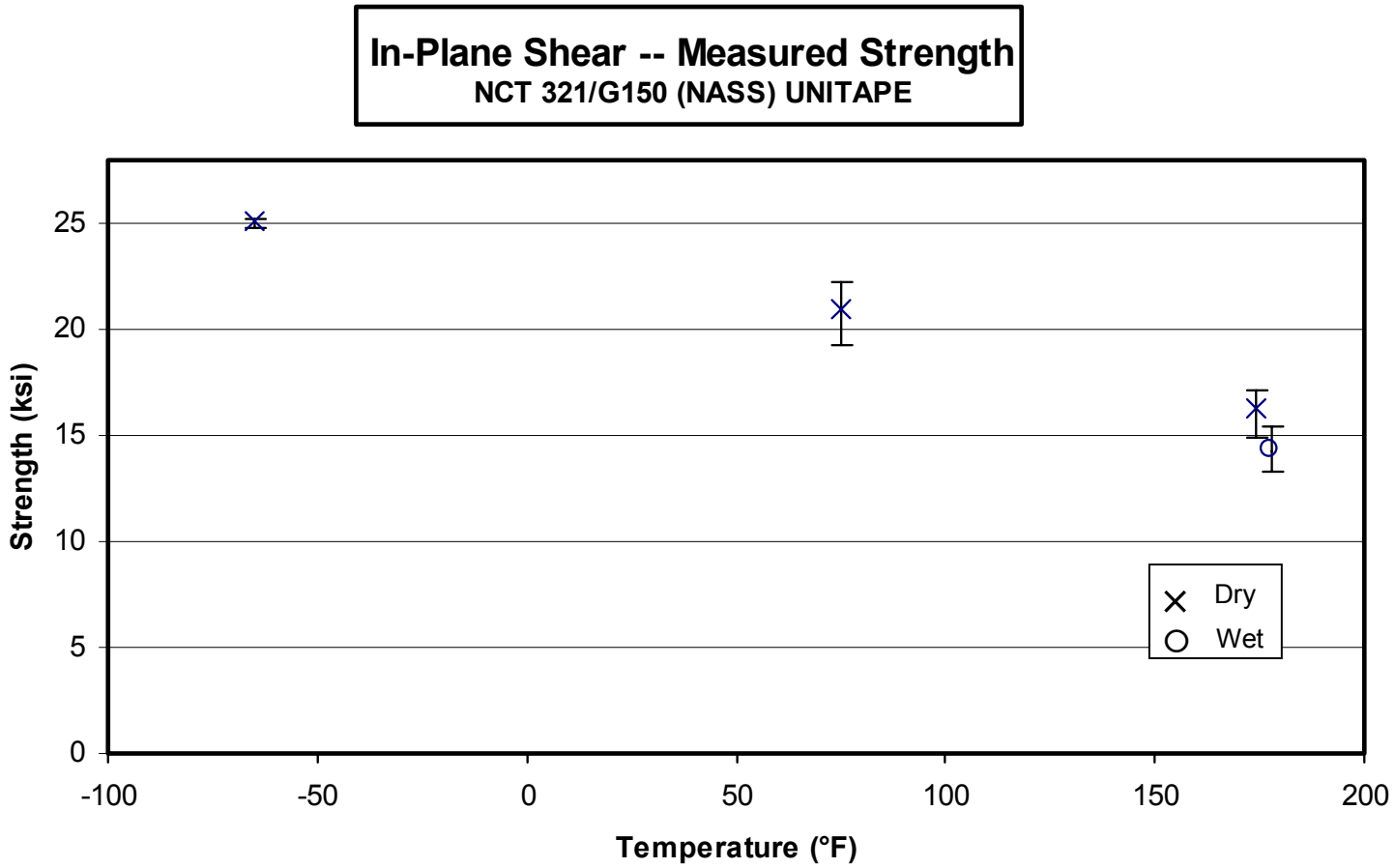
NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 175° dry and wet data has been staggered for clarity.

3.1.3.4 Compression, 2-axis



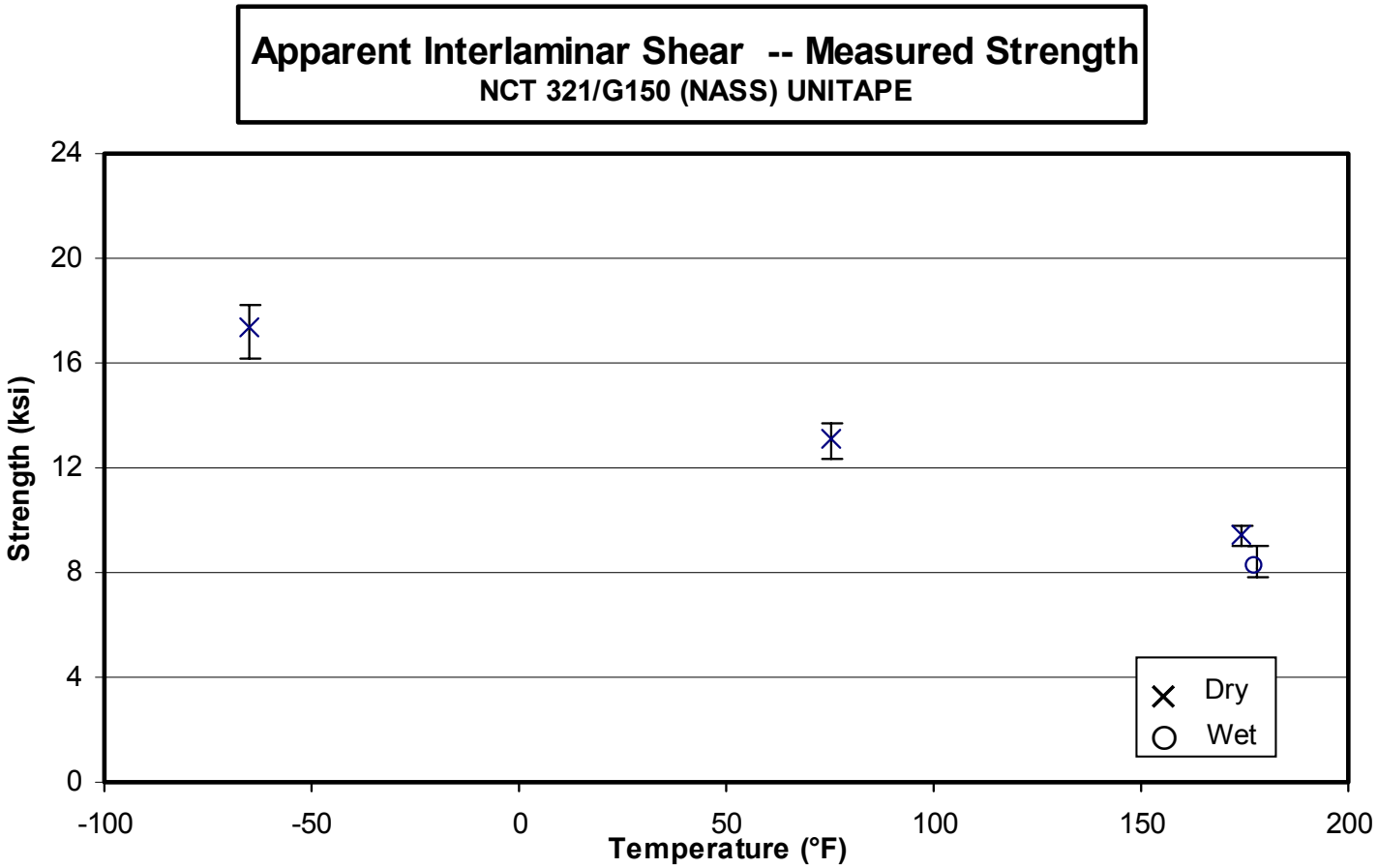
NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data.

3.1.3.5 Shear, 12 axis



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 175° dry and wet data has been staggered for clarity.

3.1.3.6 Shear, 13 axis



NOTE: The symbols represent the 'pooled' average of all tests, and the bars represent the upper and lower limit of the data. The 175° dry and wet data has been staggered for clarity.

3.1 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.

M D J 2 1 2 5 C

1st Character: Fabricator
'M' designates Lancair

2nd Character: Material System
'D' designates G150 NASS / NCT 321

3rd Character: Test Type
'J' designates 0° Tension Strength and Modulus, other test types will be clearly labeled at the top of each sheet

4th Character: Prepreg Batch ID
See Table 2.1 for Newport Batch ID / Sample Batch ID correlation.

5th Character: Panel Number
The panel(s) fabricated for a specific test method.

6th Character: Subpanel Number
The sub-panel(s) cut from each panel, with subpanel numbers labeled increasing from reference edge.

7th Character: Sample Number
The sample(s) cut from each subpanel, with sample numbers labeled increasing from reference edge.

8th Character: Test Condition
'A' --- RTD
'B' --- CTD
'C' --- ETW
'E' --- ETD
See Table 1.5.1 for condition parameters.

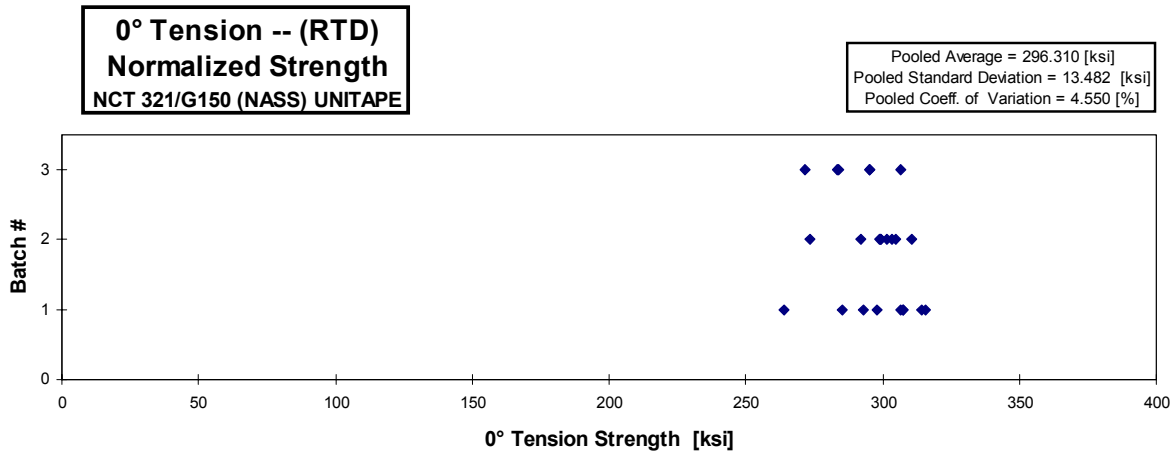
3.2.1 Raw Data Spreadsheets and Scatter Charts

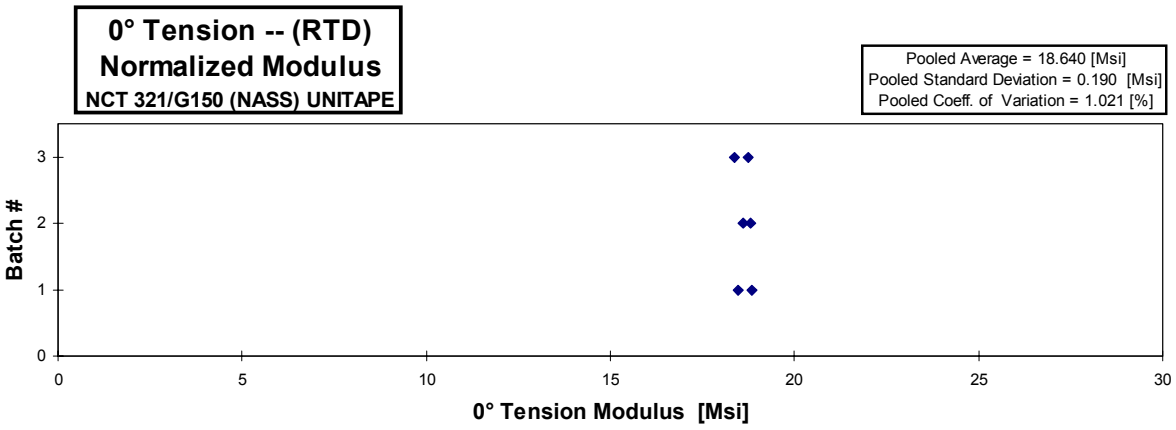
0° Tension -- (RTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

normalizing t_{ply} [in]: 0.0060

Specimen Number	Strength [ksi]	Modulus [Msi]	Poisson's Ratio	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]	$Strength_{norm}$ [ksi]	$Modulus_{norm}$ [Msi]
MDJ1111A	294.192	18.064	0.323	1	0.063	10	0.00625	306.613	18.827
MDJ1112A	295.850	17.780		1	0.062	10	0.00623	307.355	18.471
MDJ1113A	297.183			1	0.062	10	0.00621	307.419	
MDJ1114A	300.328			1	0.063	10	0.00631	315.595	
MDJ1115A	279.516			1	0.063	10	0.00629	293.026	
MDJ1116A	254.830			1	0.062	10	0.00622	263.961	
MDJ1117A	300.360			1	0.063	10	0.00628	314.210	
MDJ1118A	284.340			1	0.063	10	0.00628	297.767	
MDJ1119A	273.091			1	0.063	10	0.00626	285.077	
MDJ2111A	277.502	17.462	0.318	2	0.065	10	0.00647	299.163	18.825
MDJ2112A	271.285			2	0.065	10	0.00646	291.933	
MDJ2113A	277.500	17.277		2	0.065	10	0.00646	298.929	18.611
MDJ2114A	263.733			2	0.062	10	0.00623	273.623	
MDJ2115A	277.466			2	0.065	10	0.00648	299.432	
MDJ2116A	283.085			2	0.064	10	0.00640	301.800	
MDJ2117A	282.550			2	0.065	10	0.00647	304.762	
MDJ2118A	283.183			2	0.064	10	0.00643	303.399	
MDJ2119A	287.776			2	0.065	10	0.00648	310.879	
MDJ3111A	300.352	18.346	0.322	3	0.061	10	0.00613	306.777	18.738
MDJ3112A	283.458	17.644		3	0.062	10	0.00625	295.111	18.370
MDJ3113A	289.717			3	0.059	10	0.00587	283.440	
MDJ3114A	279.146			3	0.061	10	0.00611	284.032	
MDJ3115A	284.190			3	0.062	10	0.00624	295.321	
MDJ3116A	266.923			3	0.061	10	0.00611	271.817	

	Strength [ksi]	Modulus [Msi]	Poisson's Ratio	$Average_{norm}$	$Strength_{norm}$ [ksi]	$Modulus_{norm}$ [Msi]
Average	**282.815**	**17.762**	**0.321**	**0.00629**	**296.310**	**18.640**
Standard Dev.	**11.872**	**0.393**	**0.003**		**13.482**	**0.190**
Coeff. of Var. [%]	**4.198**	**2.211**	**0.890**		**4.550**	**1.021**
Min.	**254.830**	**17.277**	**0.318**	**0.0059**	**263.961**	**18.370**
Max.	**300.360**	**18.346**	**0.323**	**0.0065**	**315.595**	**18.827**
Number of Spec.	**24**	**6**	**3**		**24**	**6**



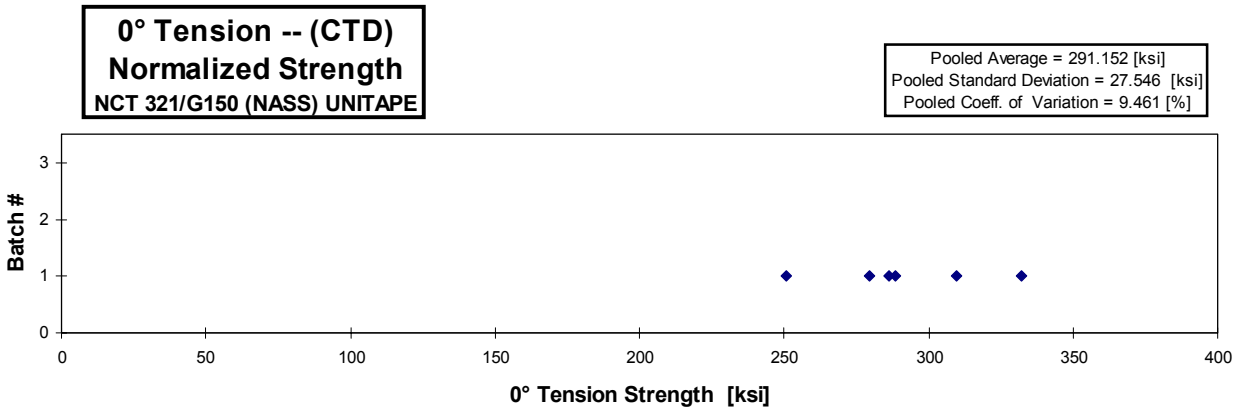


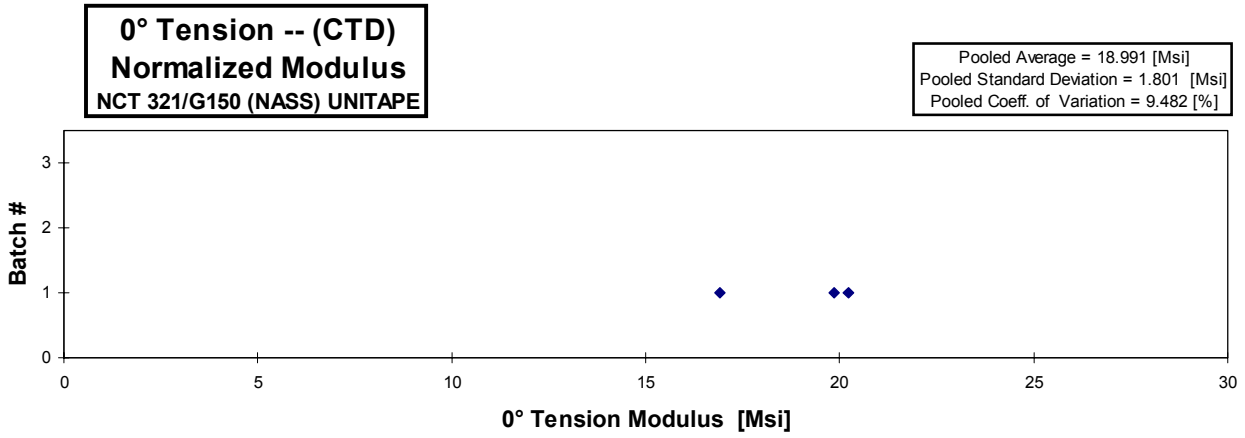
0° Tension -- (CTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

normalizing t_{ply} [in]: 0.0060

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]	$Strength_{norm}$ [ksi]	$Modulus_{norm}$ [Msi]
MDJ1121B	242.517		1	0.062	10	0.00621	251.005	
MDJ1122B	278.625		1	0.062	10	0.00616	286.209	
MDJ1123B	303.373		1	0.061	10	0.00612	309.441	
MDJ1126B	272.013	16.465	1	0.062	10	0.00617	279.569	16.923
MDJ1127B	318.116	19.004	1	0.063	10	0.00627	332.166	19.843
MDJ1128B	278.839	19.530	1	0.062	10	0.00621	288.521	20.208

Average	**282.247**	**18.333**	**$Average_{norm}$**	**0.00619**	**291.152**	**18.991**
Standard Dev.	**26.233**	**1.639**	**Standard $Dev._{norm}$**		**27.546**	**1.801**
Coeff. of Var. [%]	**9.294**	**8.939**	**Coeff. of $Var._{norm}$ [%]**		**9.461**	**9.482**
Min.	**242.517**	**16.465**	**Min.**	**0.0061**	**251.005**	**16.923**
Max.	**318.116**	**19.530**	**Max.**	**0.0063**	**332.166**	**20.208**
Number of Spec.	**6**	**3**	**Number of Spec.**		**6**	**3**



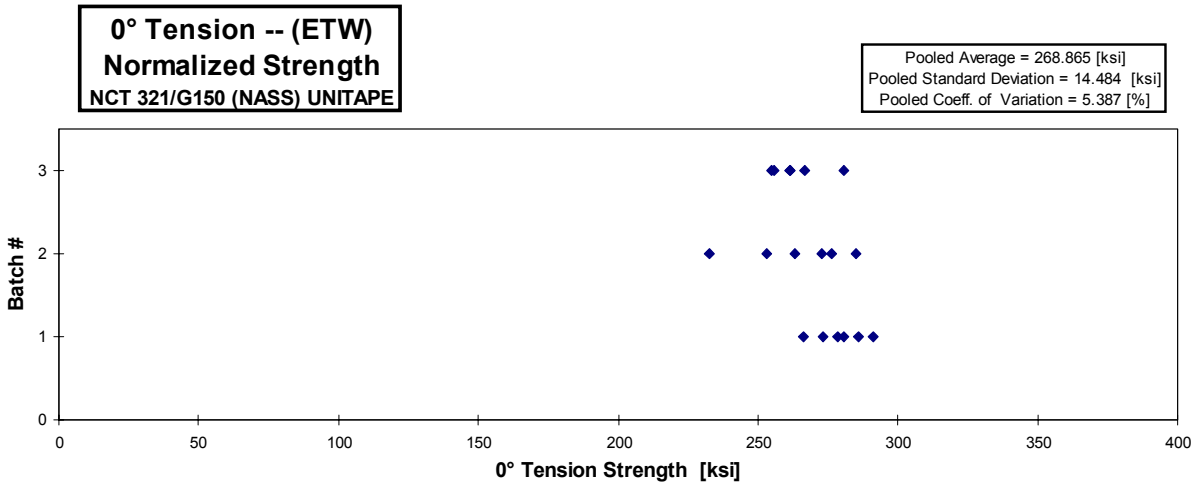


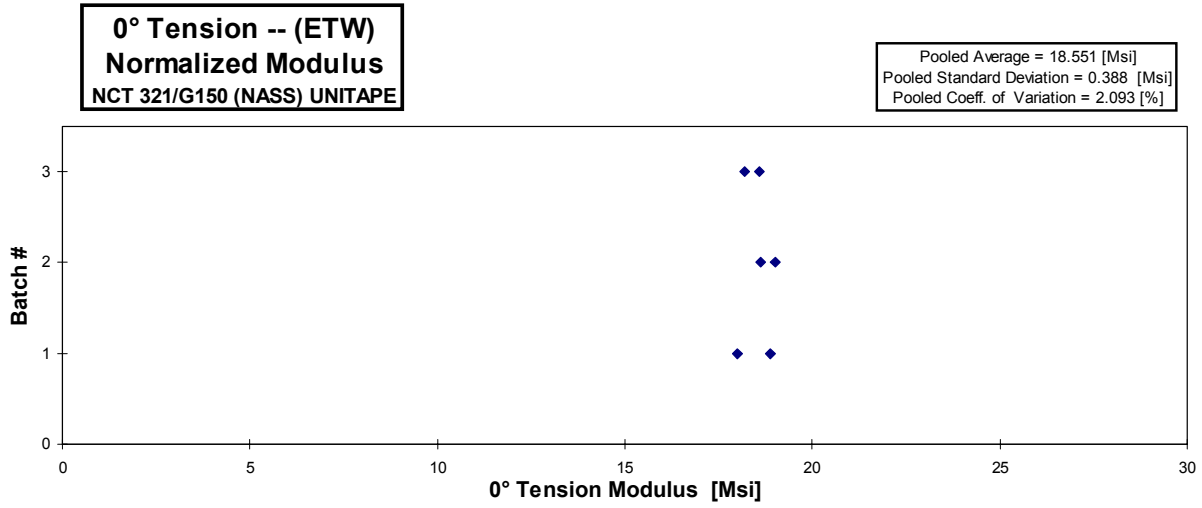
0° Tension -- (ETW)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

normalizing t_{ply} [in]: 0.0060

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]	$Strength_{norm}$ [ksi]	$Modulus_{norm}$ [Msi]
MDJ1111C	267.760	18.165	1	0.062	10	0.00624	278.396	18.886
MDJ1112C	265.600	17.943	1	0.060	10	0.00602	266.338	17.993
MDJ1113C	280.330		1	0.062	10	0.00623	291.232	
MDJ1114C	270.224		1	0.062	10	0.00623	280.582	
MDJ1115C	274.573		1	0.062	10	0.00624	285.708	
MDJ1116C	263.457		1	0.062	10	0.00622	273.117	
MDJ2121C	266.798	17.785	2	0.064	10	0.00641	285.104	19.005
MDJ2122C	246.324	17.431	2	0.064	10	0.00641	263.156	18.622
MDJ2123C	257.868		2	0.064	10	0.00643	276.205	
MDJ2124C	255.754		2	0.064	10	0.00640	272.804	
MDJ2125C	230.455		2	0.061	10	0.00606	232.759	
MDJ2126C	240.895		2	0.063	10	0.00630	253.007	
MDJ3121C	260.685	18.176	3	0.061	10	0.00614	266.623	18.590
MDJ3122C	250.241	17.420	3	0.063	10	0.00627	261.571	18.209
MDJ3123C	244.279		3	0.063	10	0.00627	255.068	
MDJ3124C	263.759		3	0.064	10	0.00638	280.537	
MDJ3125C	250.440		3	0.063	10	0.00627	261.570	
MDJ3126C	249.086		3	0.062	10	0.00616	255.797	

Average	**257.696**	**17.820**	**$Average_{norm}$**	**0.00626**	**268.865**	**18.551**
Standard Dev.	**12.832**	**0.338**	**$Standard\ Dev._{norm}$**		**14.484**	**0.388**
Coeff. of Var. [%]	**4.980**	**1.900**	**$Coeff.\ of\ Var.\ [\%]_{norm}$**		**5.387**	**2.093**
Min.	**230.455**	**17.420**	**Min.**	**0.0060**	**232.759**	**17.993**
Max.	**280.330**	**18.176**	**Max.**	**0.0064**	**291.232**	**19.005**
Number of Spec.	**18**	**6**	**Number of Spec.**		**18**	**6**

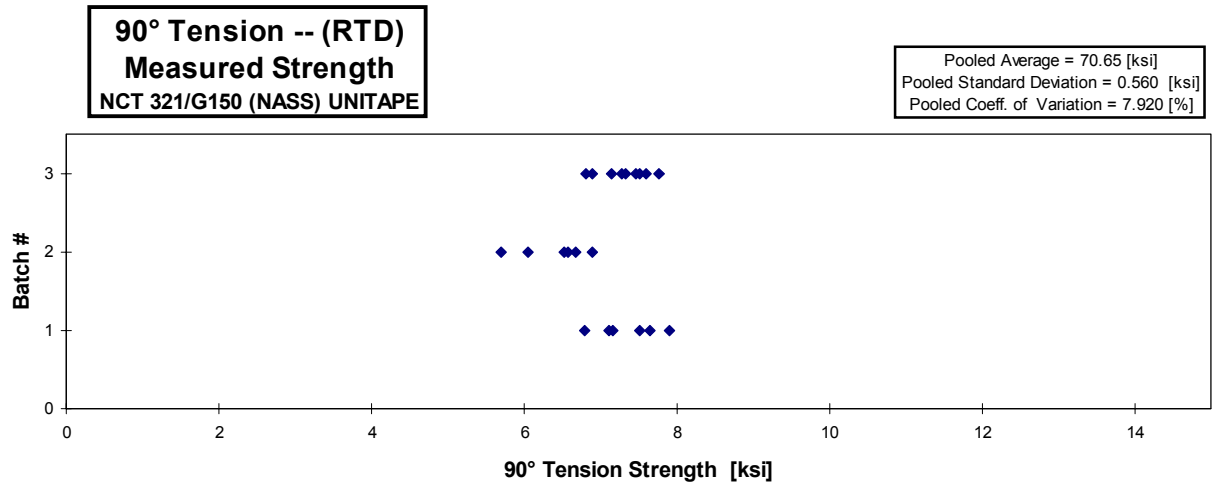


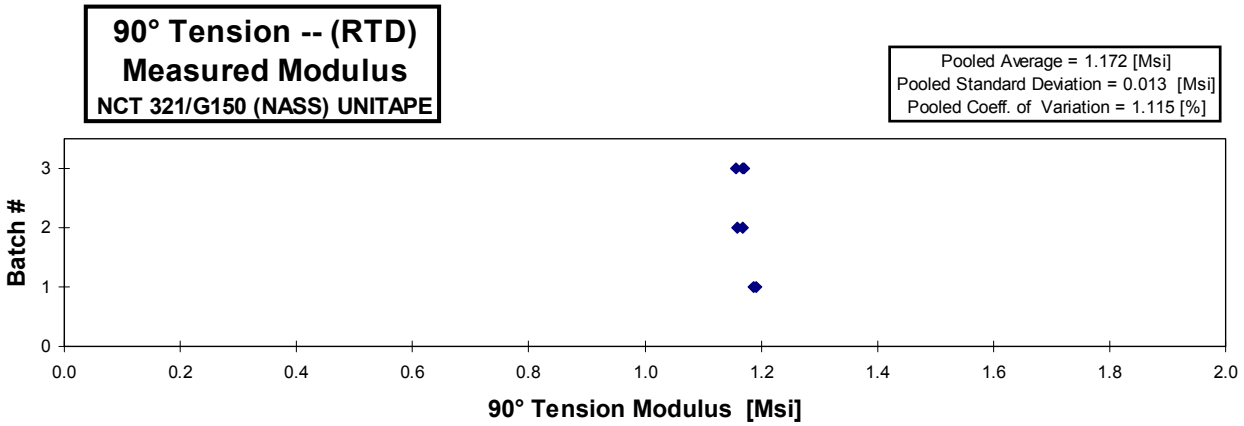


90° Tension -- (RTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDU1411A	7.512		1	0.098	16	0.0061
MDU1412A	7.899		1	0.097	16	0.0061
MDU1413A	7.164		1	0.097	16	0.0061
MDU1414A	7.109		1	0.097	16	0.0061
MDU1418A	6.790	1.187	1	0.097	16	0.0061
MDU1419A	7.653	1.192	1	0.097	16	0.0060
MDU2311A	6.571	1.170	2	0.101	16	0.0063
MDU2312A	6.900	1.160	2	0.101	16	0.0063
MDU2313A	5.703		2	0.101	16	0.0063
MDU2315A	6.670		2	0.101	16	0.0063
MDU2317A	6.530		2	0.101	16	0.0063
MDU2318A	6.055		2	0.101	16	0.0063
MDU3111A	7.338		3	0.098	16	0.0061
MDU3112A	6.819		3	0.099	16	0.0062
MDU3113A	7.458		3	0.099	16	0.0062
MDU3114A	7.142		3	0.098	16	0.0062
MDU3115A	6.890		3	0.098	16	0.0061
MDU3116A	7.593	1.157	3	0.099	16	0.0062
MDU3117A	7.285	1.170	3	0.099	16	0.0062
MDU3118A	7.761	1.168	3	0.098	16	0.0061
MDU3119A	7.518		3	0.098	16	0.0062

Average	**7.065**	**1.172**		
Standard Dev.	**0.560**	**0.013**		
Coeff. of Var. [%]	**7.920**	**1.115**		
Min.	**5.703**	**1.157**	**Min.**	**0.0060**
Max.	**7.899**	**1.192**	**Max.**	**0.0063**
Number of Spec.	**21**	**7**		

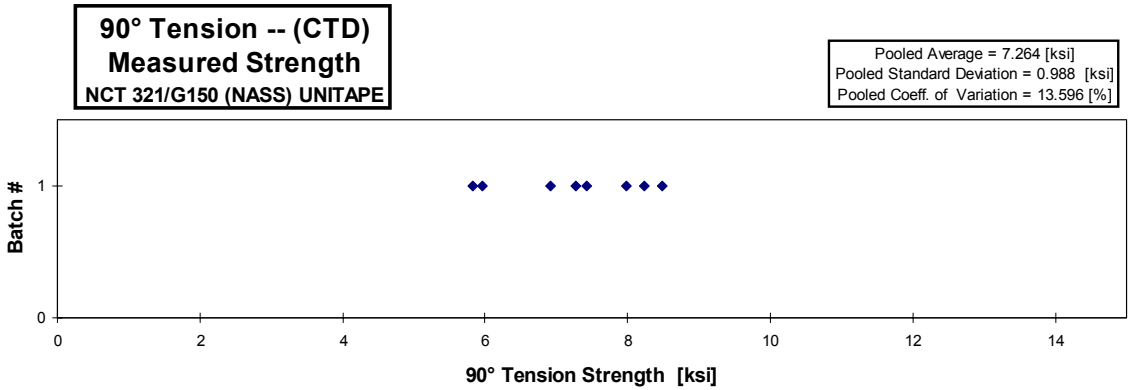


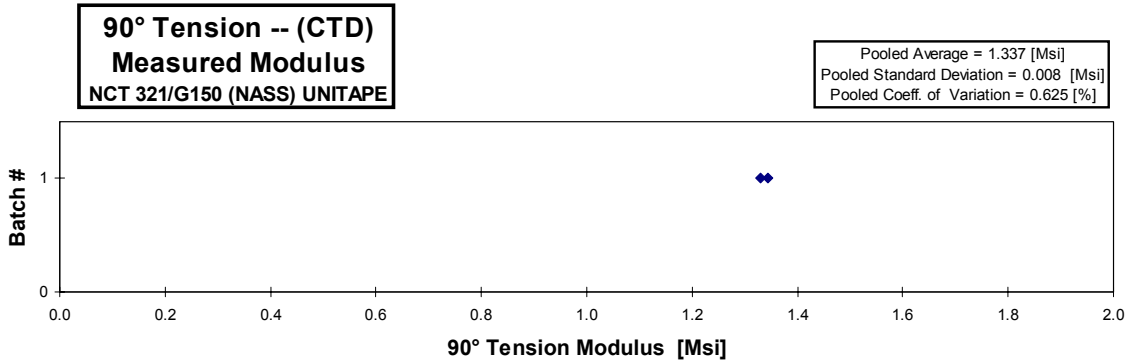


90° Tension -- (CTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDU1111B	5.966		1	0.098	16	0.0061
MDU1112B	8.485		1	0.098	16	0.0061
MDU1113B	6.925		1	0.098	16	0.0061
MDU1114B	7.975		1	0.098	16	0.0061
MDU1115B	7.425		1	0.098	16	0.0061
MDU1116B	7.271		1	0.098	16	0.0061
MDU1117B	8.236	1.331	1	0.098	16	0.0061
MDU1118B	5.828	1.343	1	0.098	16	0.0061

Average	**7.264**	**1.337**		
Standard Dev.	**0.988**	**0.008**		
Coeff. of Var. [%]	**13.596**	**0.625**		
Min.	**5.828**	**1.331**	**Min.**	**0.0061**
Max.	**8.485**	**1.343**	**Max.**	**0.0061**
Number of Spec.	**8**	**2**		

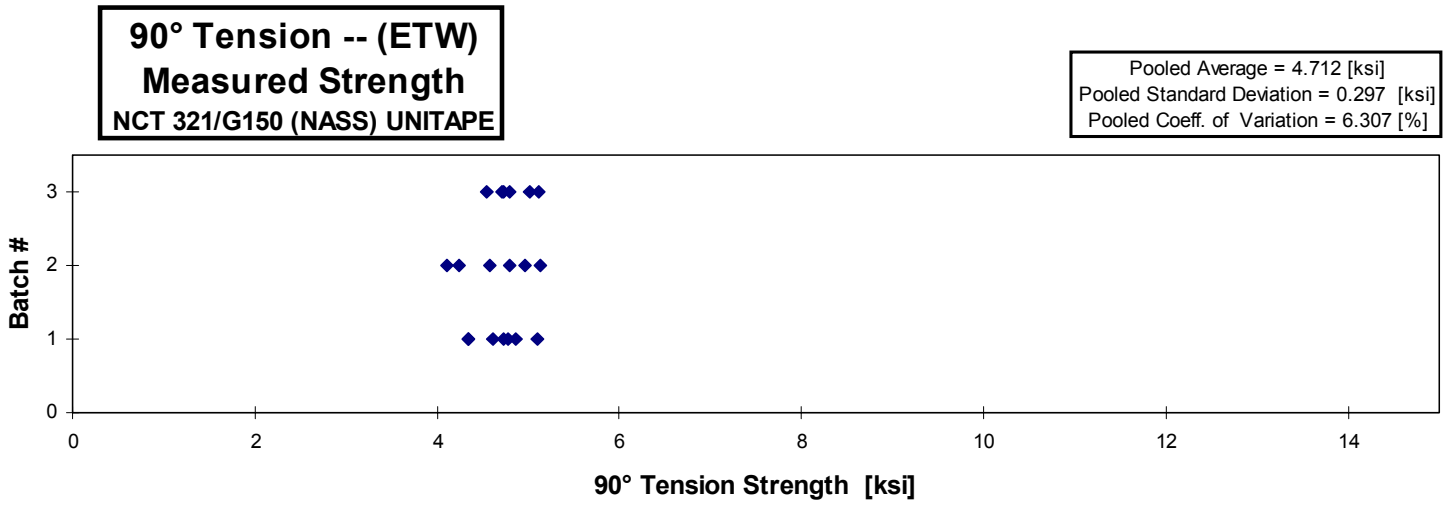


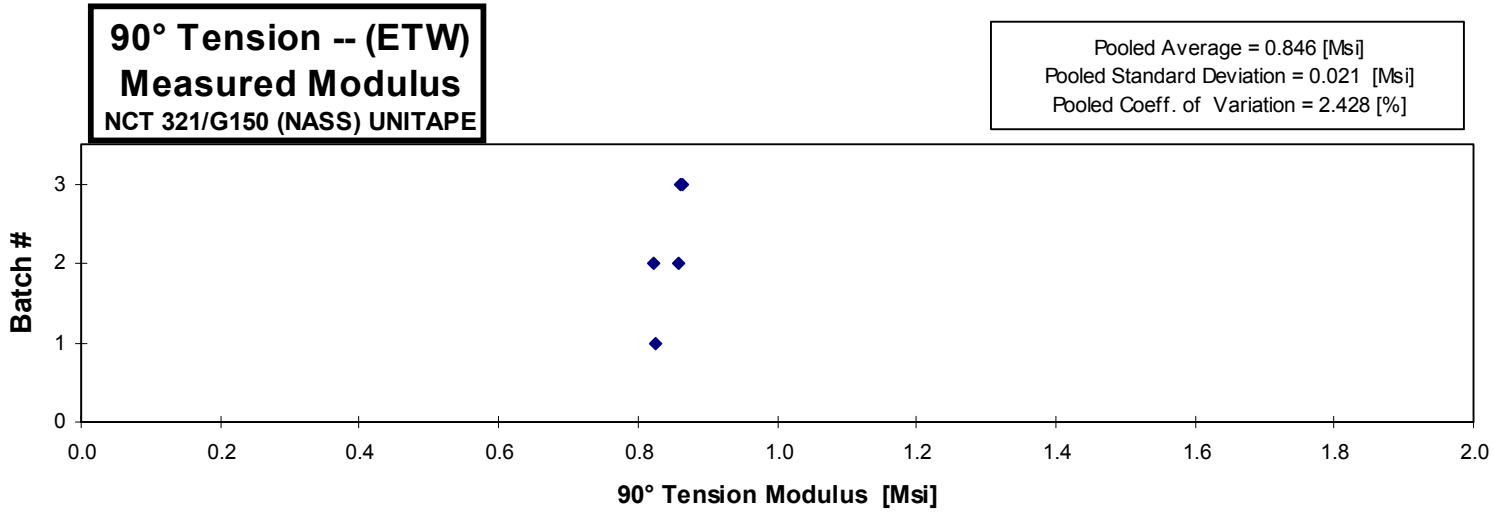


90° Tension -- (ETW)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDU1312C	4.608		1	0.097	16	0.0061
MDU1313C	4.778		1	0.097	16	0.0061
MDU1314C	4.734		1	0.097	16	0.0061
MDU1315C	5.101		1	0.097	16	0.0061
MDU1316C	4.337		1	0.097	16	0.0061
MDU1318C	4.866		1	0.097	16	0.0061
MDU1319C	4.345	0.824	1	0.097	16	0.0061
MDU2111C	4.960		2	0.102	16	0.0063
MDU2112C	4.795	0.859	2	0.101	16	0.0063
MDU2113C	4.245		2	0.101	16	0.0063
MDU2114C	5.137		2	0.101	16	0.0063
MDU2115C	4.116		2	0.101	16	0.0063
MDU2118C	4.582	0.822	2	0.102	16	0.0064
MDU3211C	5.010	0.863	3	0.098	16	0.0061
MDU3212C	5.115	0.861	3	0.098	16	0.0061
MDU3213C	4.792		3	0.098	16	0.0061
MDU3214C	4.553		3	0.098	16	0.0061
MDU3215C	4.738		3	0.098	16	0.0061
MDU3216C	4.715		3	0.098	16	0.0061

Average	**4.712**	**0.846**		
Standard Dev.	**0.297**	**0.021**		
Coeff. of Var. [%]	**6.307**	**2.428**		
Min.	**4.116**	**0.822**	**Min.**	**0.0061**
Max.	**5.137**	**0.863**	**Max.**	**0.0064**
Number of Spec.	**19**	**5**		





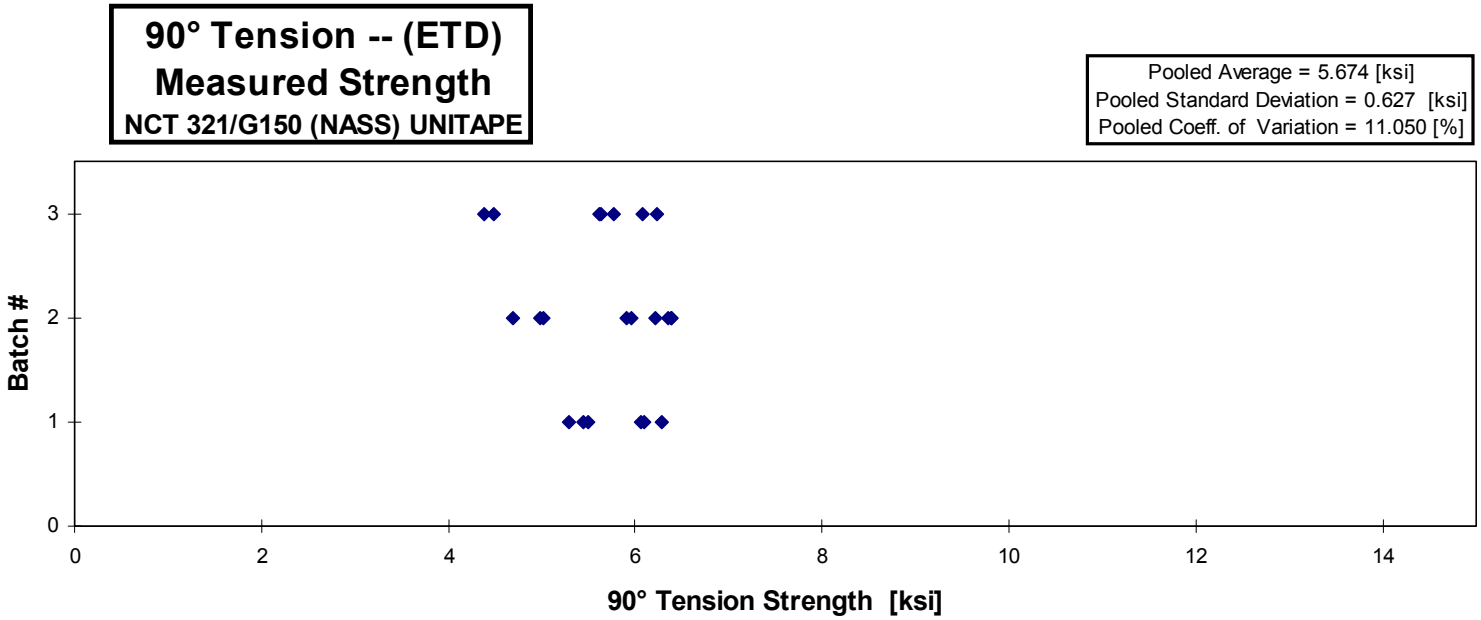
90° Tension -- (ETD) Strength

NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDU1211E	5.445	1	0.098	16	0.0061
MDU1212E	6.287	1	0.097	16	0.0061
MDU1213E	6.054	1	0.098	16	0.0061
MDU1214E	5.494	1	0.098	16	0.0061
MDU1215E	5.288	1	0.097	16	0.0061
MDU1216E	6.101	1	0.097	16	0.0061
MDU2411E	6.221	2	0.129	**	**
MDU2412E	6.360	2	0.128	**	**
MDU2413E	6.382	2	0.127	**	**
MDU2414E	4.987	2	0.127	**	**
MDU2415E	5.901	2	0.127	**	**
MDU2416E	6.387	2	0.127	**	**
MDU2417E	4.699	2	0.127	**	**
MDU2418E	5.023	2	0.127	**	**
MDU2419E	5.964	2	0.127	**	**
MDU3311E	5.619	3	0.098	16	0.0062
MDU3312E	6.237	3	0.099	16	0.0062
MDU3313E	6.084	3	0.098	16	0.0062
MDU3314E	5.777	3	0.099	16	0.0062
MDU3315E	4.485	3	0.098	16	0.0061
MDU3316E	4.392	3	0.098	16	0.0061
MDU3317E	5.642	3	0.098	16	0.0061

**Not Reported

Average	**5.674**		
Standard Dev.	**0.627**		
Coeff. of Var. [%]	**11.050**		
Min.	**4.392**	**Min.**	**0.0061**
Max.	**6.387**	**Max.**	**0.0062**
Number of Spec.	**22**		

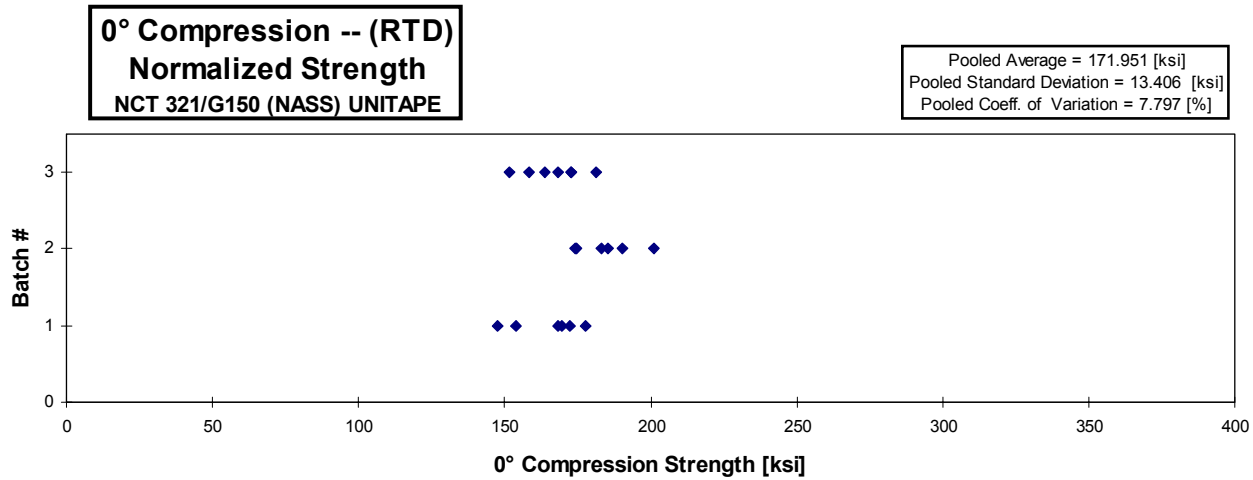


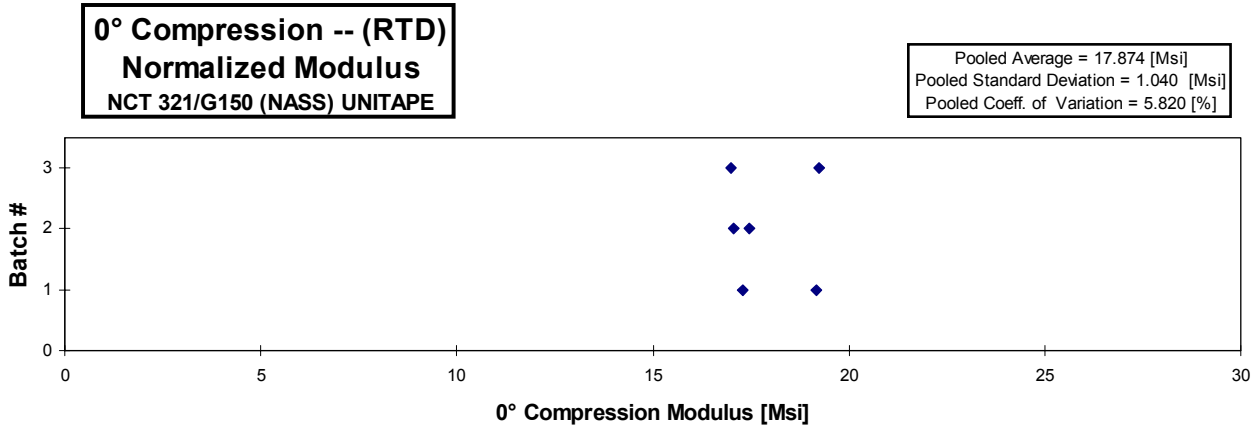
0° Compression -- (RTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

normalizing t_{ply} [in]: 0.0060

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]	$Strength_{norm}$ [ksi]	$Modulus_{norm}$ [Msi]
MDK1411A	162.695		1	0.050	8	0.00625	169.474	
MDK1412A	163.125		1	0.051	8	0.00634	172.471	
MDK1414A	163.154		1	0.050	8	0.00619	168.253	
MDK1415A	140.198		1	0.051	8	0.00631	147.500	
MDK1416A	170.500		1	0.050	8	0.00625	177.604	
MDK1417A	146.222		1	0.051	8	0.00631	153.838	
MDL1221A		17.580	1	0.047	8	0.00590		17.296
MDL1222A		19.030	1	0.048	8	0.00604		19.159
MDK2121A	180.861		2	0.051	8	0.00631	190.281	
MDK2122A	188.275		2	0.051	8	0.00641	201.023	
MDK2123A	178.052		2	0.050	8	0.00625	185.471	
MDK2124A	167.531		2	0.050	8	0.00625	174.512	
MDK2126A	173.403		2	0.051	8	0.00634	183.338	
MDK2127A	167.319		2	0.050	8	0.00625	174.290	
MDL2211A		16.857	2	0.061	10	0.00608		17.068
MDL2212A		17.398	2	0.060	10	0.00603		17.470
MDK3323A	168.333		3	0.049	8	0.00616	172.717	
MDK3327A	180.305		3	0.048	8	0.00603	181.244	
MDK3221A	161.403		3	0.049	8	0.00609	163.925	
MDK3222A	165.517		3	0.049	8	0.00609	168.103	
MDK3223A	155.368		3	0.049	8	0.00613	158.605	
MDK3224A	147.930		3	0.049	8	0.00616	151.782	
MDK3225A	169.986		3	0.049	8	0.00609	172.642	
MDL3112A		16.731	3	0.061	10	0.00610		17.010
MDL3114A		18.771	3	0.062	10	0.00615		19.240

Average	**165.799**	**17.728**	**$Average_{norm}$**	**0.00618**	**171.951**	**17.874**
Standard Dev.	**12.274**	**0.966**	**$Standard\ Dev._{norm}$**		**13.406**	**1.040**
Coeff. of Var. [%]	**7.403**	**5.449**	**$Coeff.\ of\ Var.\ [\%]_{norm}$**		**7.797**	**5.820**
Min.	**140.198**	**16.731**	**Min.**	**0.0059**	**147.500**	**17.010**
Max.	**188.275**	**19.030**	**Max.**	**0.0064**	**201.023**	**19.240**
Number of Spec.	**19**	**6**	**Number of Spec.**		**19**	**6**



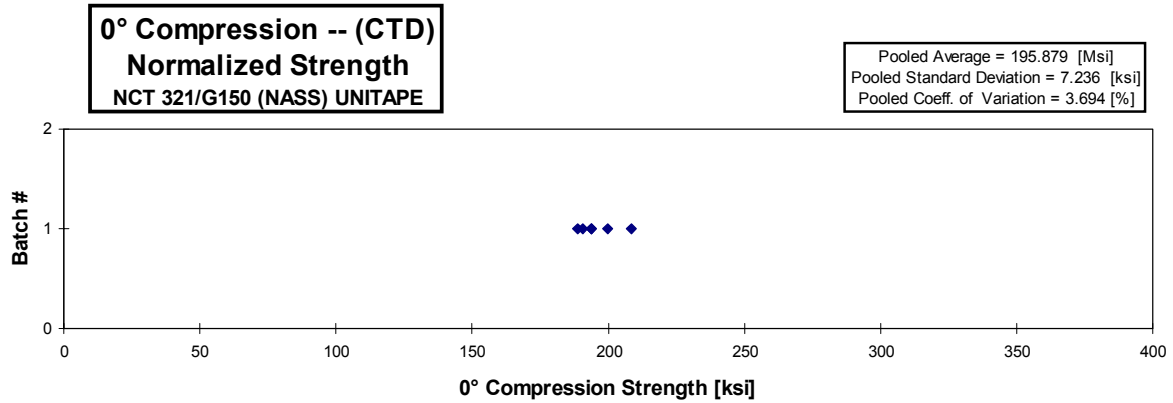


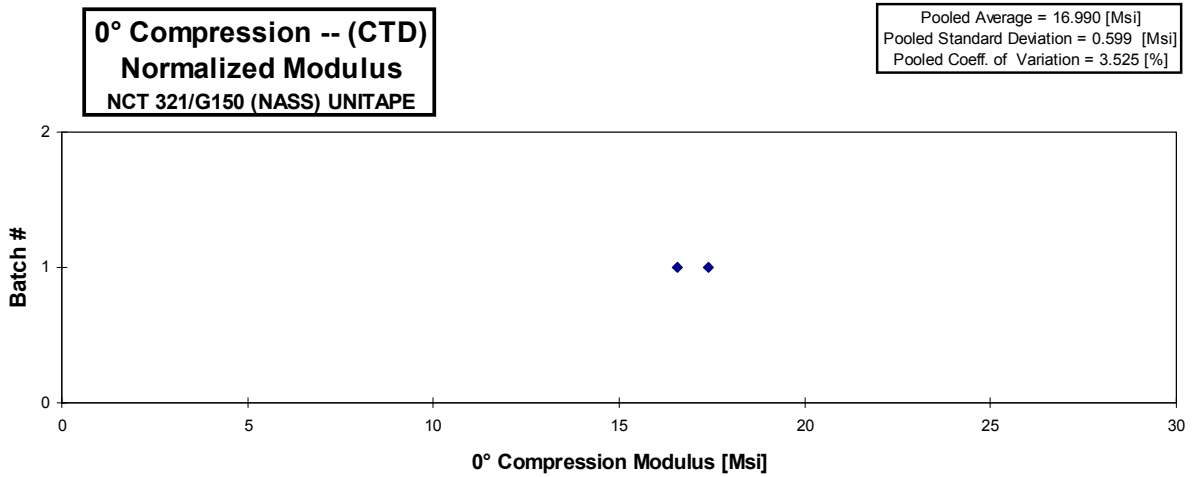
0° Compression -- (CTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

normalizing t_{ply} [in]: 0.0060

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]	$Strength_{norm}$ [ksi]	$Modulus_{norm}$ [Msi]
MDK1311B	193.910		1	0.048	8	0.00600	193.910	
MDK1312B	211.937		1	0.047	8	0.00591	208.626	
MDK1313B	199.548		1	0.048	8	0.00600	199.548	
MDK1314B	187.839		1	0.048	8	0.00603	188.817	
MDK1411B	185.990		1	0.050	8	0.00625	193.740	
MDK1412B	181.194		1	0.051	8	0.00631	190.631	
MDL1222B		17.487	1	0.045	8	0.00568		16.567
MDL1223B		17.870	1	0.047	8	0.00585		17.414

Average	**193.403**	**17.678**	**$Average_{norm}$**	**0.00600**	**195.879**	**16.990**
Standard Dev.	**11.104**	**0.271**	**$Standard\ Dev._{norm}$**		**7.236**	**0.599**
Coeff. of Var. [%]	**5.741**	**1.533**	**$Coeff.\ of\ Var.\ [\%]_{norm}$**		**3.694**	**3.525**
Min.	**181.194**	**17.487**	**Min.**	**0.0057**	**188.817**	**16.567**
Max.	**211.937**	**17.870**	**Max.**	**0.0063**	**208.626**	**17.414**
Number of Spec.	**6**	**2**	**Number of Spec.**		**6**	**2**



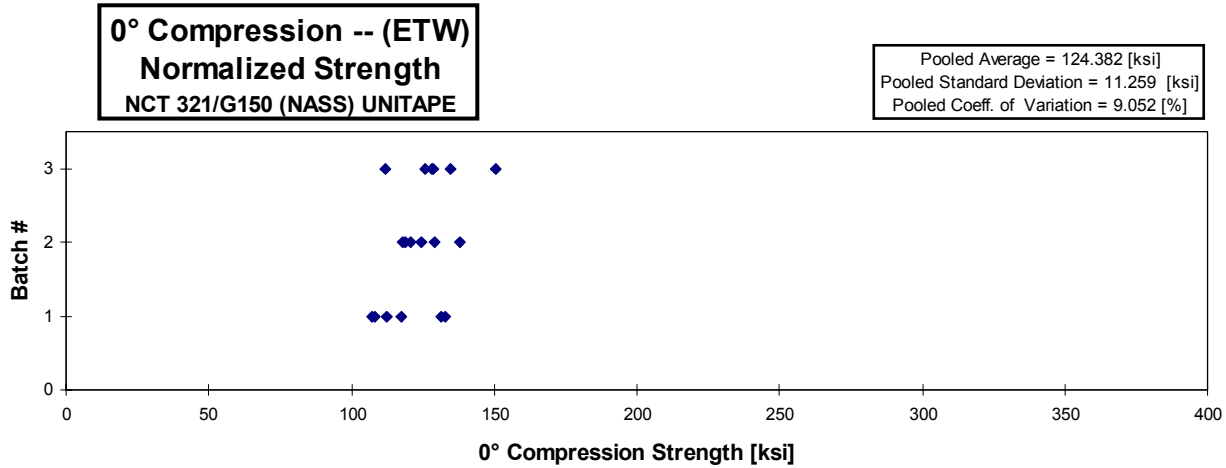


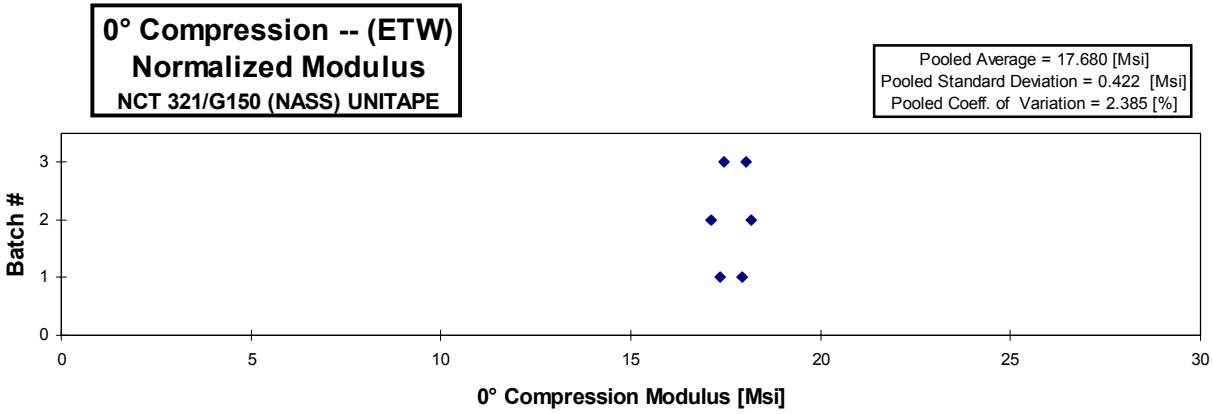
0° Compression -- (ETW)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

normalizing t_{ply} [in]: 0.0060

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]	$Strength_{norm}$ [ksi]	$Modulus_{norm}$ [Msi]
MDK1211C	124.634		1	0.064	10	0.00640	132.943	
MDK1212C	111.628		1	0.063	10	0.00633	117.674	
MDK1213C	108.126		1	0.062	10	0.00623	112.181	
MDK1214C	101.131		1	0.064	10	0.00643	108.295	
MDK1215C	124.253		1	0.064	10	0.00635	131.502	
MDK1216C	100.607		1	0.064	10	0.00640	107.314	
MDL1211C		17.754	1	0.049	8	0.00606		17.939
MDL1213C		17.265	1	0.048	8	0.00603		17.355
MDK2111C	109.718		2	0.052	8	0.00650	118.861	
MDK2112C	109.291		2	0.053	8	0.00663	120.675	
MDK2115C	113.323		2	0.055	8	0.00684	129.259	
MDK2116C	123.997		2	0.054	8	0.00669	138.205	
MDK2117C	105.722		2	0.054	8	0.00669	117.836	
MDK2118C	111.475		2	0.054	8	0.00669	124.248	
MDL2211C		17.347	2	0.059	10	0.00593		17.130
MDL2212C		17.574	2	0.062	10	0.00620		18.159
MDK3311C	121.150		3	0.051	8	0.00634	128.091	
MDK3312C	123.512		3	0.050	8	0.00625	128.658	
MDK3313C	119.549		3	0.051	8	0.00631	125.775	
MDK3314C	130.664		3	0.050	8	0.00619	134.747	
MDK3315C	104.353		3	0.052	8	0.00644	111.963	
MDK3316C	145.343		3	0.050	8	0.00622	150.642	
MDL3111C		17.603	3	0.062	10	0.00615		18.043
MDL3112C		17.308	3	0.061	10	0.00605		17.452

Average	**116.026**	**17.475**	**$Average_{norm}$**	**0.00635**	**124.382**	**17.680**
Standard Dev.	**11.557**	**0.196**	**Standard $Dev._{norm}$**		**11.259**	**0.422**
Coeff. of Var. [%]	**9.961**	**1.123**	**Coeff. of Var. $[\%]_{norm}$**		**9.052**	**2.385**
Min.	**100.607**	**17.265**	**Min.**	**0.0059**	**107.314**	**17.130**
Max.	**145.343**	**17.754**	**Max.**	**0.0068**	**150.642**	**18.159**
Number of Spec.	**18**	**6**	**Number of Spec.**		**18**	**6**





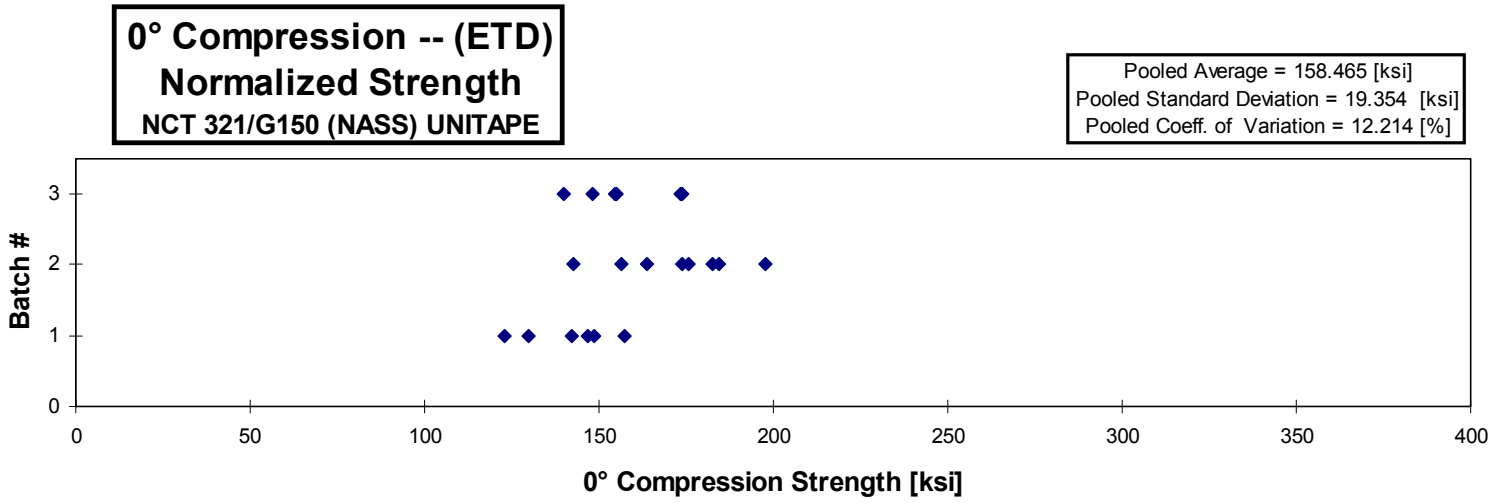
0° Compression -- (ETD) Strength

NCT 321/G150 (NASS) UNITAPE

normalizing t_{ply} [in]: 0.0060

Specimen Number	Strength [ksi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]	$Strength_{norm}$ [ksi]
MDK1321E	145.268	1	0.047	8	0.00588	142.241
MDK1322E	131.715	1	0.047	8	0.00591	129.657
MDK1323E	146.601	1	0.048	8	0.00600	146.601
MDK1324E	150.166	1	0.048	8	0.00594	148.602
MDK1325E	124.380	1	0.048	8	0.00594	123.085
MDK1327E	157.525	1	0.048	8	0.00600	157.525
MDK2511E	135.390	2	0.051	8	0.00631	142.442
MDK2512E	155.608	2	0.051	8	0.00631	163.712
MDK2513E	150.796	2	0.050	8	0.00622	156.294
MDK2514E	164.373	2	0.051	8	0.00634	173.790
MDK2515E	168.717	2	0.050	8	0.00625	175.747
MDK2517E	175.958	2	0.050	8	0.00622	182.373
MDK2518E	177.893	2	0.050	8	0.00622	184.379
MDK2519E	190.781	2	0.050	8	0.00622	197.736
MDK3212E	130.592	3	0.052	8	0.00644	140.114
MDK3214E	147.584	3	0.051	8	0.00631	155.271
MDK3216E	162.672	3	0.051	8	0.00641	173.687
MDK3217E	164.024	3	0.051	8	0.00634	173.421
MDK3218E	139.374	3	0.051	8	0.00638	148.084
MDK3223E	146.161	3	0.051	8	0.00634	154.535

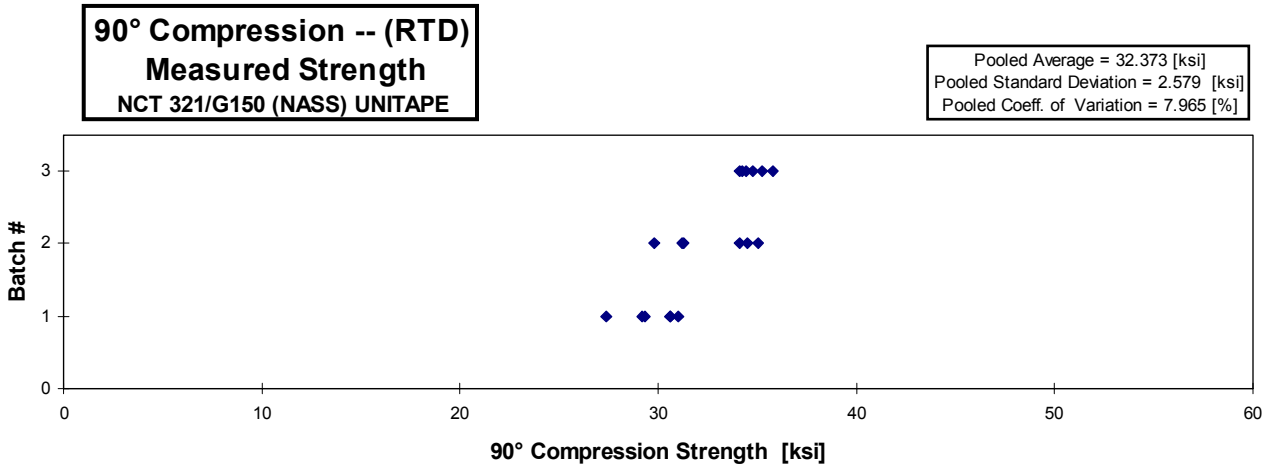
Average	**153.279**	**$Average_{norm}$**	**0.00620**	**158.465**
Standard Dev.	**17.246**	**$Standard\ Dev._{norm}$**		**19.354**
Coeff. of Var. [%]	**11.251**	**$Coeff.\ of\ Var.\ [\%]_{norm}$**		**12.214**
Min.	**124.380**	**Min.**	**0.0059**	**123.085**
Max.	**190.781**	**Max.**	**0.0064**	**197.736**
Number of Spec.	**20**	**Number of Spec.**		**20**

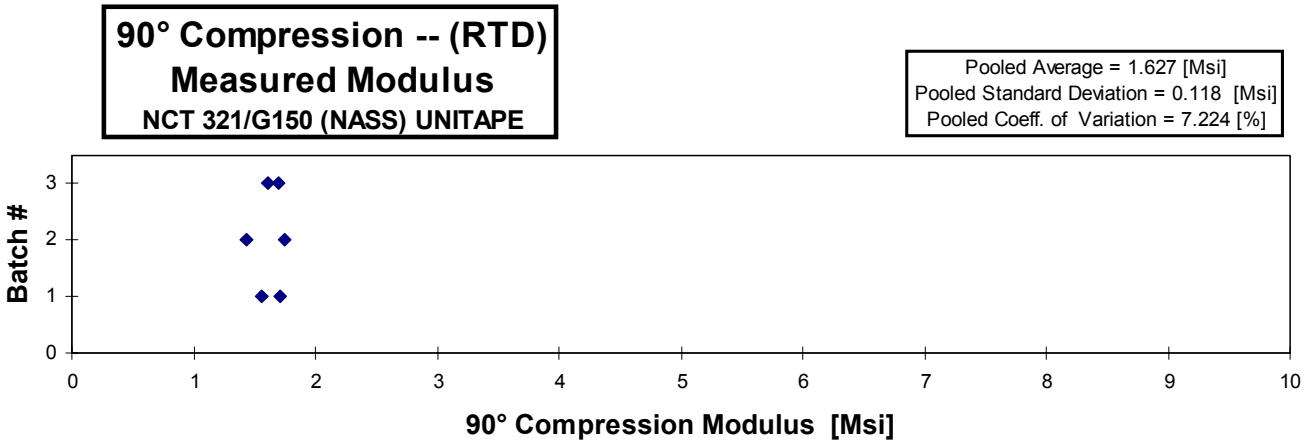


90° Compression -- (RTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDW1211A	27.359		1	0.049	8	0.0062
MDW1212A	29.349		1	0.049	8	0.0061
MDW1213A	30.592		1	0.048	8	0.0060
MDW1214A	30.613		1	0.049	8	0.0062
MDW1215A	29.185		1	0.049	8	0.0061
MDW1217A	31.006		1	0.048	8	0.0059
MDZ1111A		1.717	1	0.050	8	0.0062
MDZ1112A		1.558	1	0.050	8	0.0062
MDW2211A	31.284		2	0.050	8	0.0063
MDW2214A	29.810		2	0.050	8	0.0062
MDW2215A	31.215		2	0.049	8	0.0062
MDW2217A	34.126		2	0.050	8	0.0062
MDW2218A	35.059		2	0.047	8	0.0058
MDW2219A	34.540		2	0.050	8	0.0063
MDZ2111A		1.747	2	0.052	8	0.0065
MDZ2112A		1.437	2	0.051	8	0.0064
MDW3221A	34.778		3	0.050	8	0.0062
MDW3222A	35.221		3	0.051	8	0.0063
MDW3223A	34.247		3	0.050	8	0.0063
MDW3224A	34.120		3	0.051	8	0.0063
MDW3225A	35.805		3	0.050	8	0.0063
MDW3226A	34.408		3	0.050	8	0.0063
MDZ3114A		1.700	3	0.050	8	0.0062
MDZ3115A		1.606	3	0.050	8	0.0063

Average	**32.373**	**1.627**		
Standard Dev.	**2.579**	**0.118**		
Coeff. of Var. [%]	**7.965**	**7.224**		
Min.	**27.359**	**1.437**	**Min.**	**0.0058**
Max.	**35.805**	**1.747**	**Max.**	**0.0065**
Number of Spec.	**18**	**6**		

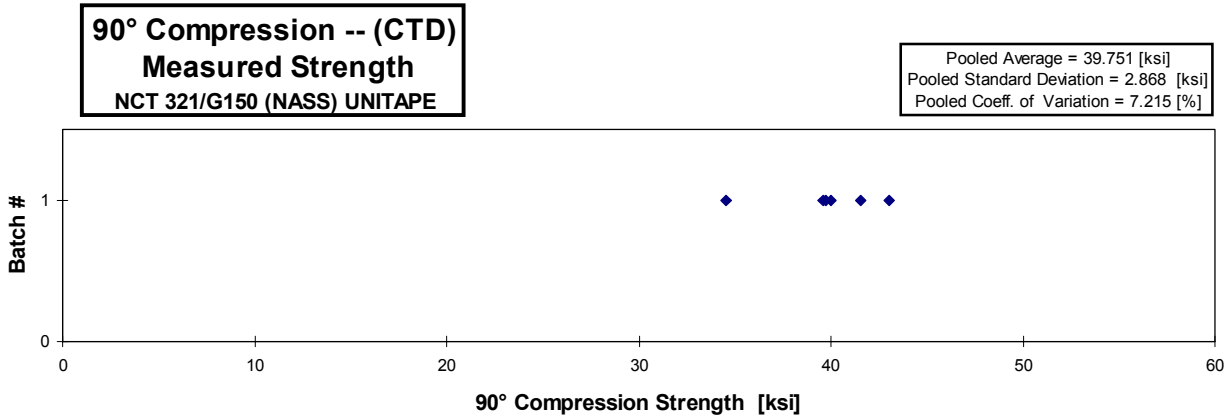


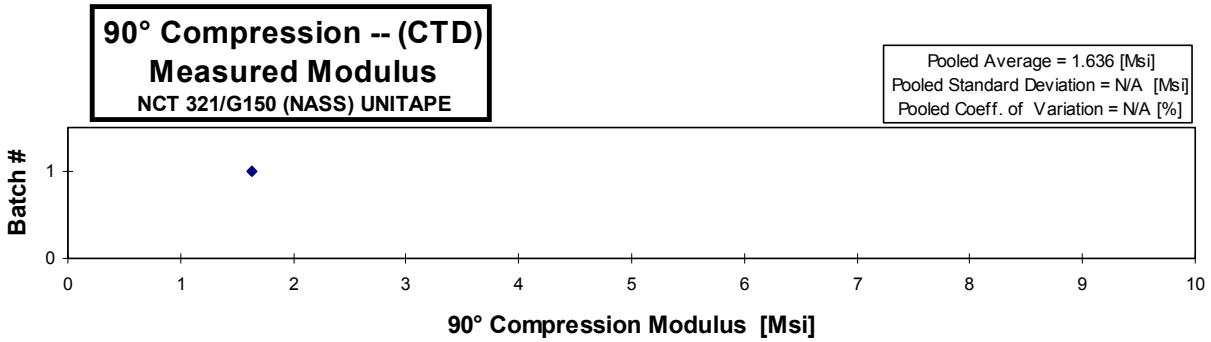


90° Compression -- (CTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDW1121B	39.759		1	0.047	8	0.0059
MDW2113B	34.549		1	0.048	8	0.0060
MDW1125B	41.574		1	0.048	8	0.0060
MDW1126B	43.015		1	0.049	8	0.0061
MDW1127B	40.012		1	0.048	8	0.0060
MDW1128B	39.596		1	0.048	8	0.0060
MDZ1111B		***	1	0.050	8	0.0062
MDZ1112B		1.636	1	0.049	8	0.0062

Average	**39.751**	**1.636**		
Standard Dev.	**2.868**	***		
Coeff. of Var. [%]	**7.215**	***		
Min.	**34.549**	**1.636**	**Min.**	**0.0059**
Max.	**43.015**	**1.636**	**Max.**	**0.0062**
Number of Spec.	**6**	**1**		

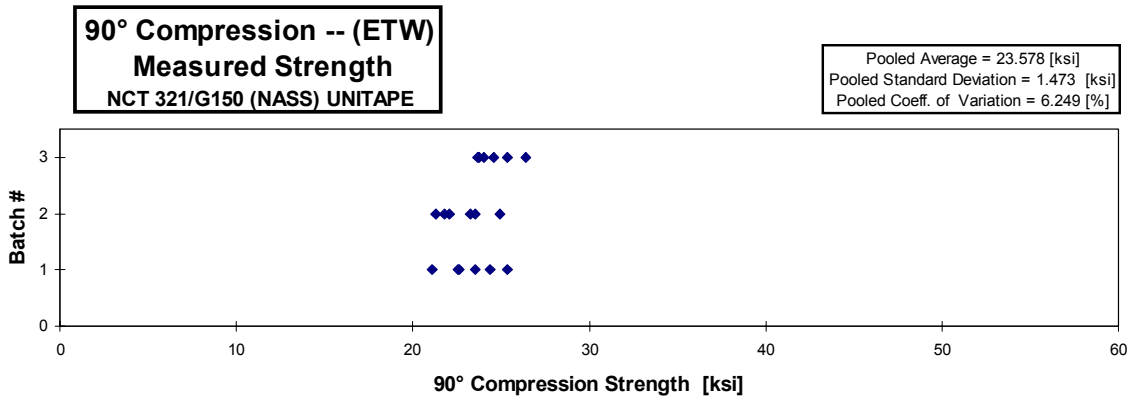


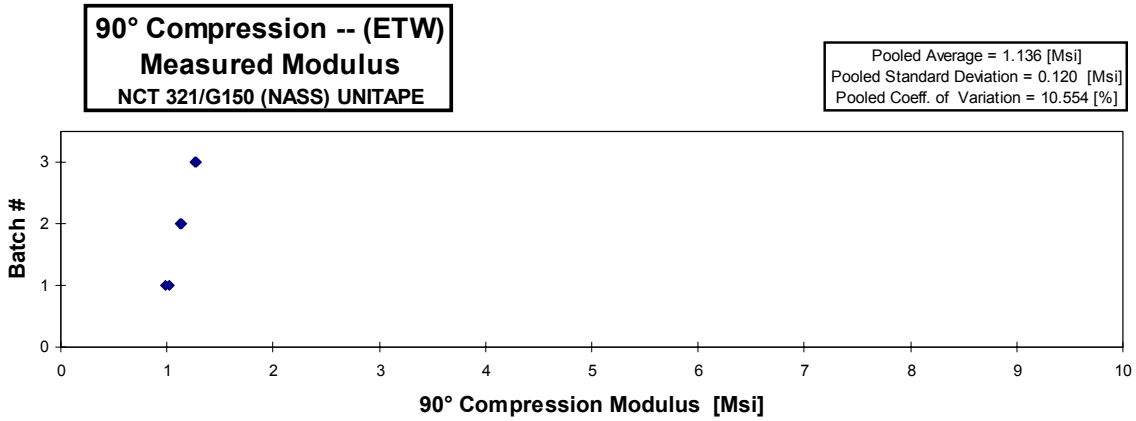


90° Compression -- (ETW)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDW1111C	21.094		1	0.047	8	0.0059
MDW1112C	22.563		1	0.048	8	0.0059
MDW1113C	22.638		1	0.048	8	0.0060
MDW1114C	24.400		1	0.048	8	0.0060
MDW1115C	23.528		1	0.048	8	0.0060
MDW1116C	25.372		1	0.048	8	0.0059
MDZ1111C		1.024	1	0.051	8	0.0063
MDZ1112C		0.984	1	0.050	8	0.0062
MDW2111C	21.792		2	0.052	8	0.0065
MDW2112C	21.338		2	0.052	8	0.0065
MDW2113C	22.087		2	0.050	8	0.0063
MDW2114C	23.565		2	0.051	8	0.0064
MDW2115C	24.918		2	0.051	8	0.0064
MDW2116C	23.261		2	0.050	8	0.0063
MDZ2111C		1.139	2	0.052	8	0.0065
MDZ2112C		1.126	2	0.052	8	0.0065
MDW3121C	26.429		3	0.049	8	0.0061
MDW3122C	24.007		3	0.049	8	0.0061
MDW3123C	23.741		3	0.049	8	0.0061
MDW3124C	25.366		3	0.049	8	0.0061
MDW3125C	24.599		3	0.048	8	0.0060
MDW3126C	23.699		3	0.048	8	0.0060
MDZ3111C		1.272	3	0.048	8	0.0060
MDZ3113C		1.269	3	0.048	8	0.0060

Average	**23.578**	**1.136**		
Standard Dev.	**1.473**	**0.120**		
Coeff. of Var. [%]	**6.249**	**10.554**		
Min.	**21.094**	**0.984**	**Min.**	**0.0059**
Max.	**26.429**	**1.272**	**Max.**	**0.0065**
Number of Spec.	**18**	**6**		

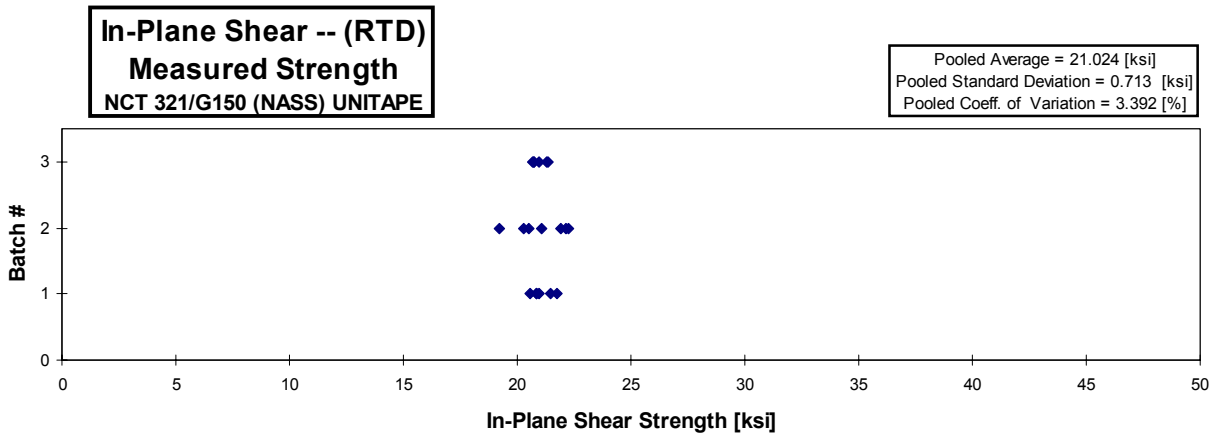


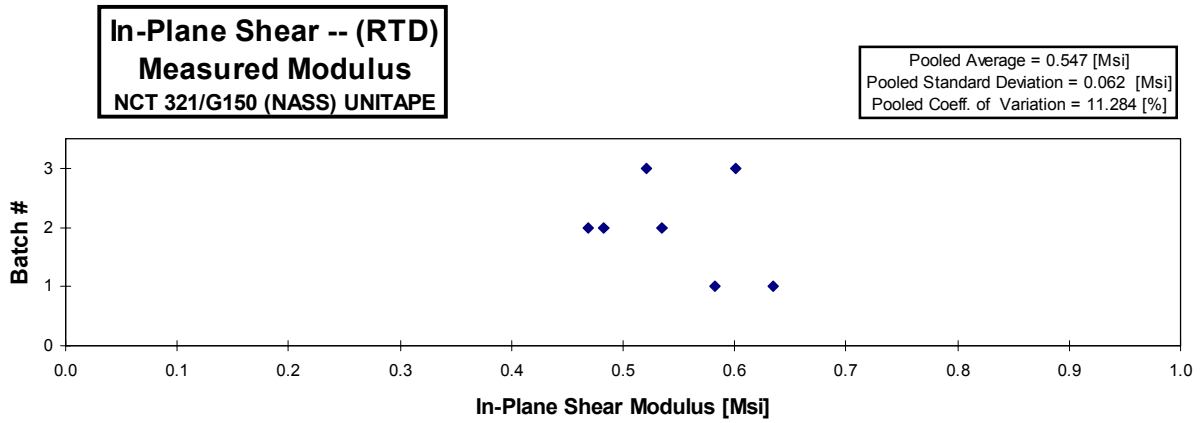


In-Plane Shear -- (RTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDN1111A	21.454		1	0.121	20	0.0061
MDN1112A	20.570		1	0.122	20	0.0061
MDN1113A	20.832		1	0.122	20	0.0061
MDN1114A	20.830		1	0.122	20	0.0061
MDN1115A	20.930	0.582	1	0.122	20	0.0061
MDN1116A	21.761	0.635	1	0.114	20	0.0057
MDN2112A	21.057	0.535	2	0.128	20	0.0064
MDN2113A	19.220		2	0.128	20	0.0064
MDN2114A	21.926		2	0.129	20	0.0065
MDN2115A	20.262		2	0.128	20	0.0064
MDN2116A	20.491		2	0.130	20	0.0065
MDN2131A	22.141	0.483	2	0.127	20	0.0063
MDN2132A	22.236	0.469	2	0.127	20	0.0063
MDN3131A	20.682		3	0.123	20	0.0061
MDN3132A	21.362		3	0.123	20	0.0062
MDN3133A	20.708		3	0.122	20	0.0061
MDN3134A	20.753		3	0.122	20	0.0061
MDN3135A	21.294	0.601	3	0.123	20	0.0061
MDN3136A	20.944	0.520	3	0.122	20	0.0061

Average	**21.024**	**0.547**		
Standard Dev.	**0.713**	**0.062**		
Coeff. of Var. [%]	**3.392**	**11.284**		
Min.	**19.220**	**0.469**	**Min.**	**0.0057**
Max.	**22.236**	**0.635**	**Max.**	**0.0065**
Number of Spec.	**19**	**7**		

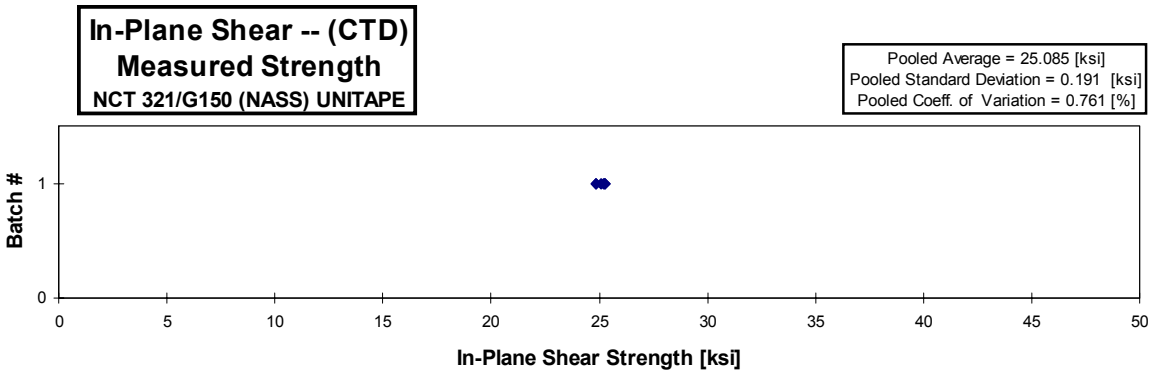


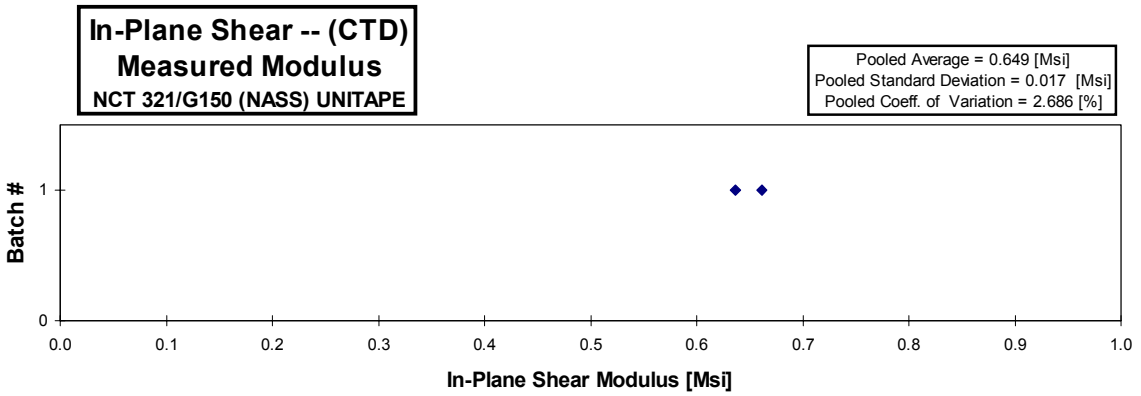


In-Plane Shear -- (CTD)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDN1111B	24.850		1	0.122	20	0.0061
MDN1112B	25.080	0.661	1	0.121	20	0.0061
MDN1113B	25.267	0.637	1	0.122	20	0.0061
MDN1114B	25.269		1	0.122	20	0.0061
MDN1125B	24.861		1	0.122	20	0.0061
MDN1126B	25.183		1	0.122	20	0.0061

Average	**25.085**	**0.649**		
Standard Dev.	**0.191**	**0.017**		
Coeff. of Var. [%]	**0.761**	**2.686**		
Min.	**24.850**	**0.637**	**Min.**	**0.0061**
Max.	**25.269**	**0.661**	**Max.**	**0.0061**
Number of Spec.	**6**	**2**		

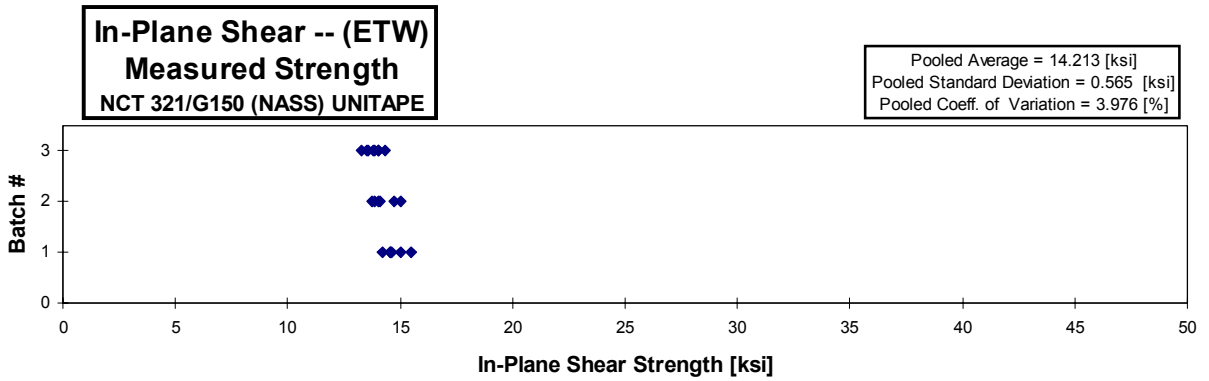


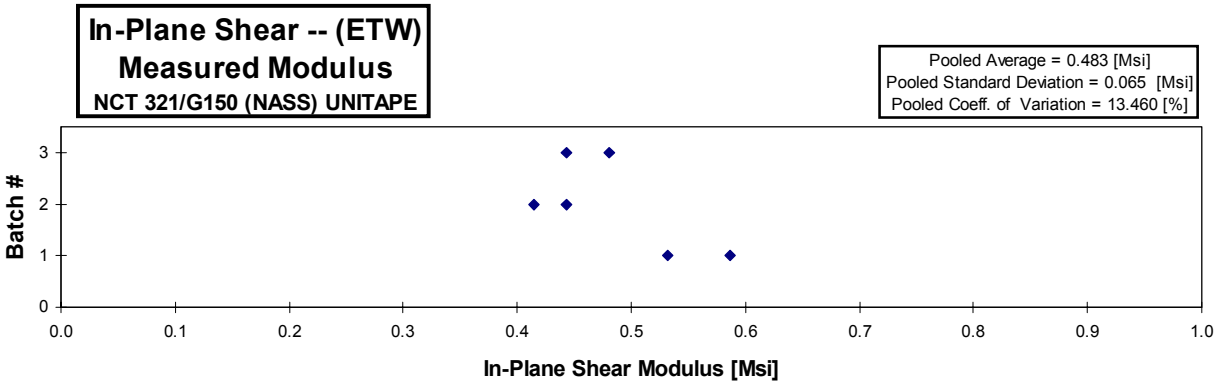


In-Plane Shear -- (ETW)
Strength & Modulus
NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Modulus [Msi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDN1131C	15.019	0.587	1	0.122	20	0.0061
MDN1132C	15.468	0.532	1	0.123	20	0.0061
MDN1133C	14.586		1	0.122	20	0.0061
MDN1134C	14.612		1	0.113	20	0.0056
MDN1135C	14.187		1	0.122	20	0.0061
MDN1136C	14.579		1	0.122	20	0.0061
MDN2111C	14.072	0.443	2	0.127	20	0.0063
MDN2121C	13.874	0.415	2	0.128	20	0.0064
MDN2122C	14.015		2	0.131	20	0.0065
MDN2123C	14.718		2	0.129	20	0.0065
MDN2124C	13.745		2	0.129	20	0.0065
MDN2125C	14.995		2	0.131	20	0.0065
MDN3111C	14.041		3	0.122	20	0.0061
MDN3112C	13.279		3	0.122	20	0.0061
MDN3113C	14.014		3	0.122	20	0.0061
MDN3114C	14.312	0.481	3	0.123	20	0.0061
MDN3115C	13.786		3	0.123	20	0.0061
MDN3131C	13.597	0.443	3	0.122	20	0.0061
MDN3133C	13.491		3	0.123	20	0.0062
MDN3134C	13.873		3	0.122	20	0.0061

Average	**14.213**	**0.483**		
Standard Dev.	**0.565**	**0.065**		
Coeff. of Var. [%]	**3.976**	**13.460**		
Min.	**13.279**	**0.415**	**Min.**	**0.0056**
Max.	**15.468**	**0.587**	**Max.**	**0.0065**
Number of Spec.	**20**	**6**		



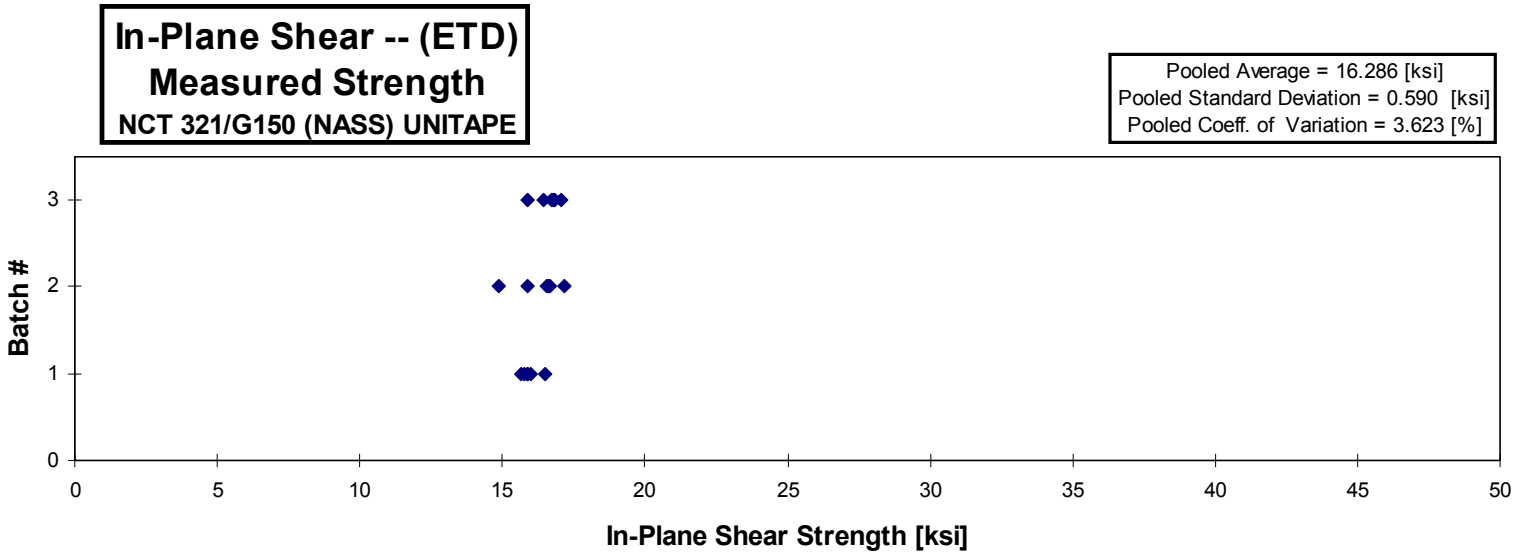


In-Plane Shear -- (ETD) Strength

NCT 321/G150 (NASS) UNITAPE

Specimen Number	Strength [ksi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDN1121E	15.906	1	0.123	20	0.0061
MDN1122E	16.016	1	0.122	20	0.0061
MDN1123E	15.861	1	0.121	20	0.0061
MDN1124E	15.795	1	0.122	20	0.0061
MDN1125E	16.522	1	0.114	20	0.0057
MDN1126E	15.634	1	0.122	20	0.0061
MDN2131E	17.162	2	0.119	20	0.0060
MDN2132E	15.904	2	0.129	20	0.0065
MDN2133E	14.853	2	0.130	20	0.0065
MDN2134E	16.602	2	0.128	20	0.0064
MDN2135E	16.542	2	0.128	20	0.0064
MDN2136E	16.664	2	0.128	20	0.0064
MDN3121E	16.839	3	0.122	20	0.0061
MDN3122E	16.710	3	0.122	20	0.0061
MDN3123E	16.460	3	0.122	20	0.0061
MDN3124E	17.046	3	0.122	20	0.0061
MDN3125E	15.856	3	0.123	20	0.0061
MDN3126E	16.782	3	0.122	20	0.0061

Average	**16.286**		
Standard Dev.	**0.590**		
Coeff. of Var. [%]	**3.623**		
Min.	**14.853**	**Min.**	**0.0057**
Max.	**17.162**	**Max.**	**0.0065**
Number of Spec.	**18**		

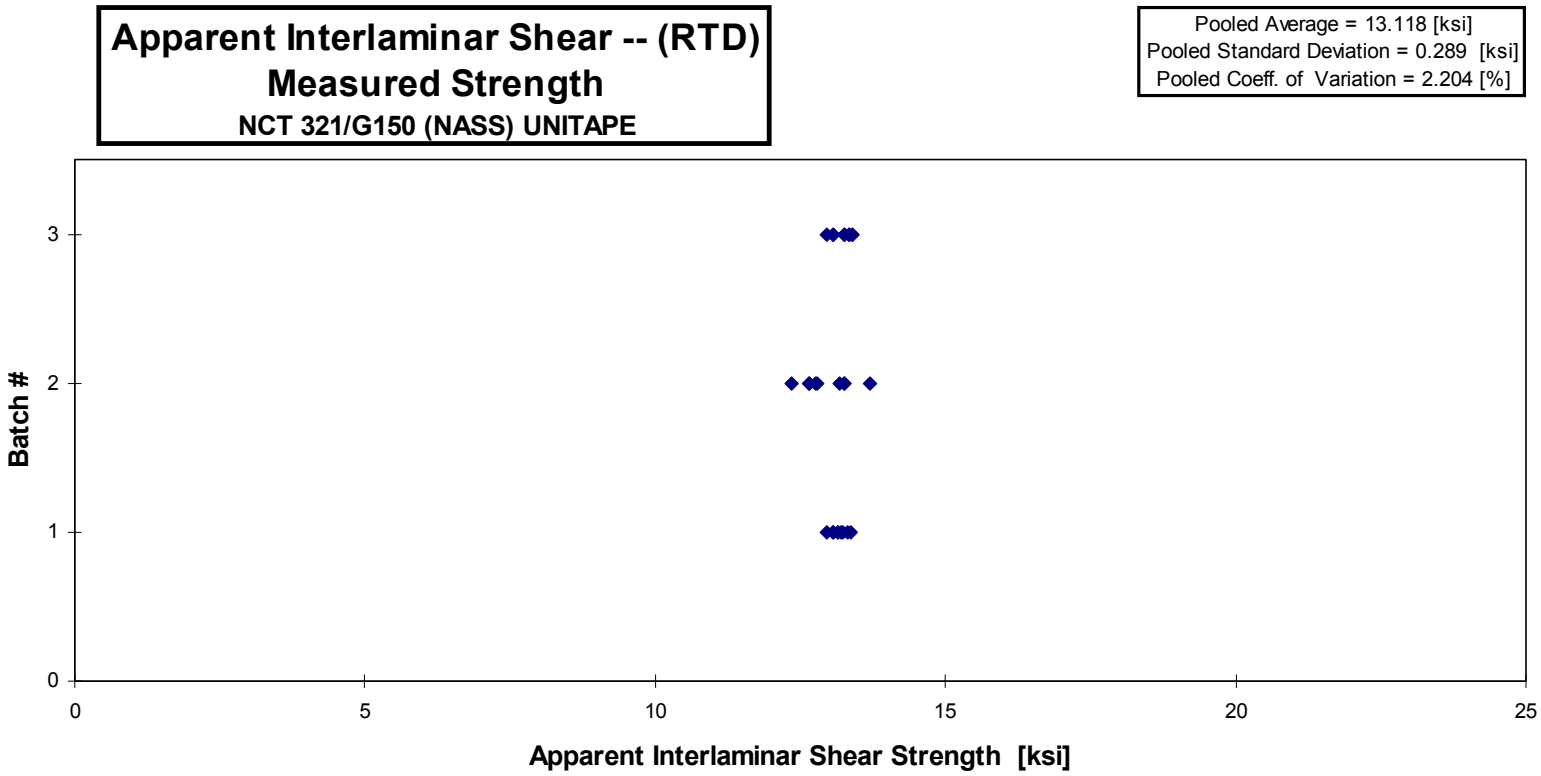


Apparent Interlaminar Shear -- (RTD) Strength

NCT 321/G150 (NASS) UNITAPE

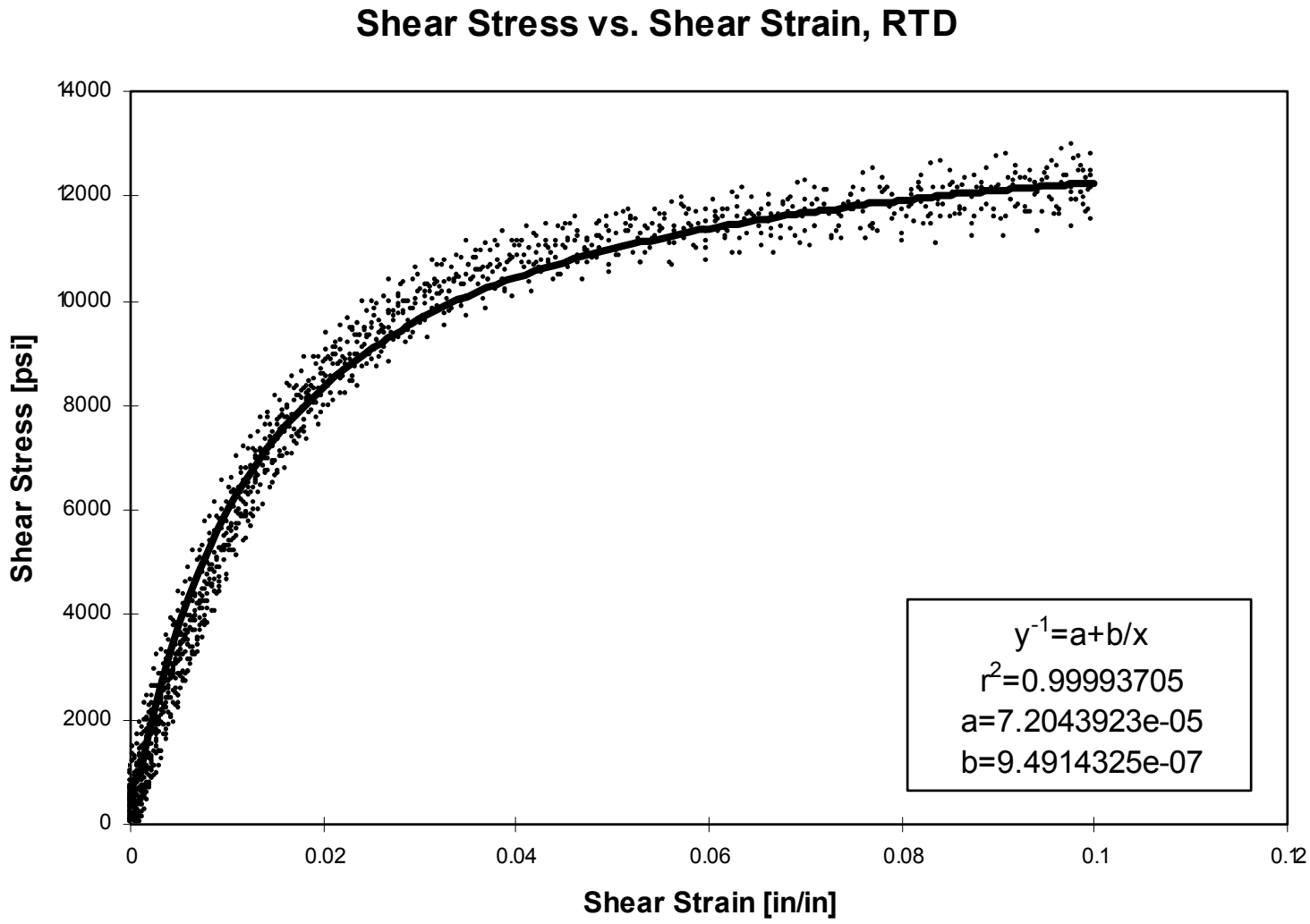
Specimen Number	Strength [ksi]	Batch Number	Avg. Specimen Thickn. [in]	# Plies in Laminate	Avg. t_{ply} [in]
MDQ1111A	13.203	1	0.111	18	0.0061
MDQ1112A	13.324	1	0.111	18	0.0062
MDQ1113A	13.381	1	0.110	18	0.0061
MDQ1114A	12.962	1	0.111	18	0.0062
MDQ1115A	13.146	1	0.107	18	0.0059
MDQ1116A	13.243	1	0.109	18	0.0061
MDQ1117A	13.155	1	0.109	18	0.0060
MDQ1118A	13.075	1	0.111	18	0.0062
MDQ1119A	13.068	1	0.111	18	0.0061
MDQ2111A	13.260	2	0.117	18	0.0065
MDQ2112A	12.766	2	0.116	18	0.0064
MDQ2113A	12.339	2	0.116	18	0.0064
MDQ2114A	13.698	2	0.117	18	0.0065
MDQ2115A	12.648	2	0.116	18	0.0064
MDQ2116A	12.779	2	0.116	18	0.0065
MDQ2117A	12.639	2	0.116	18	0.0064
MDQ2118A	13.179	2	0.116	18	0.0064
MDQ2119A	13.271	2	0.117	18	0.0065
MDQ3111A	13.342	3	0.112	18	0.0062
MDQ3112A	13.055	3	0.111	18	0.0062
MDQ3113A	13.399	3	0.111	18	0.0062
MDQ3114A	13.053	3	0.112	18	0.0062
MDQ3115A	13.260	3	0.111	18	0.0062
MDQ3116A	13.249	3	0.111	18	0.0062
MDQ3117A	12.963	3	0.113	18	0.0063
MDQ3118A	13.403	3	0.112	18	0.0062
MDQ3119A	13.338	3	0.111	18	0.0062

Average	**13.118**		
Standard Dev.	**0.289**		
Coeff. of Var. [%]	**2.204**		
Min.	**12.339**	**Min.**	**0.0059**
Max.	**13.698**	**Max.**	**0.0065**
Number of Spec.	**27**		



3.2.2 Representative Shear Stress-Strain Curve

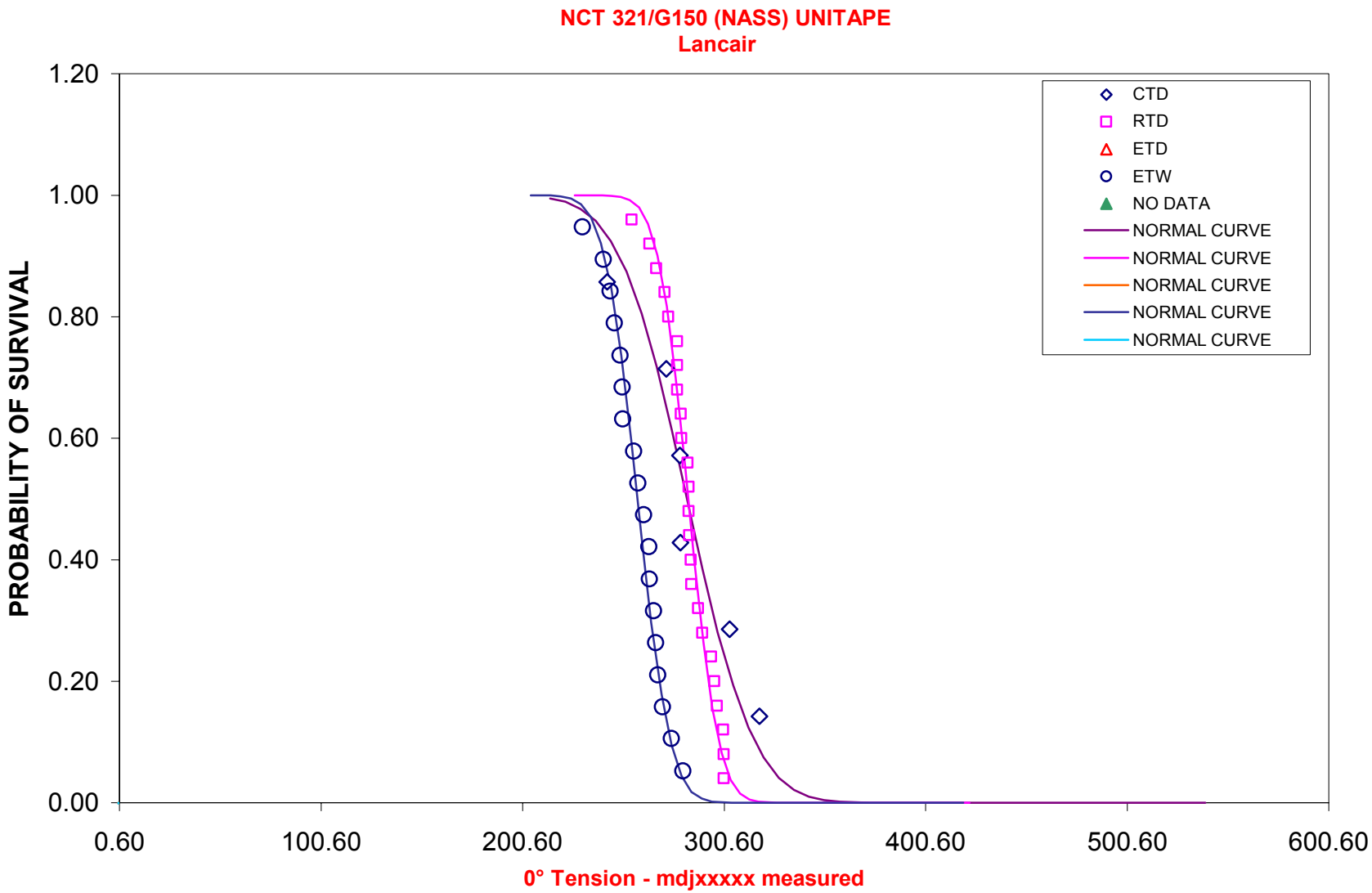
The following stress-strain curve is representative of the G150 NASS / NCT 321 prepreg system. The tension and compression stress-strain curves are not presented in graphical form. If strain design allowables from these tests are required, simple one-dimensional linear stress-strain relationships may 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.



3.3 Statistical Results

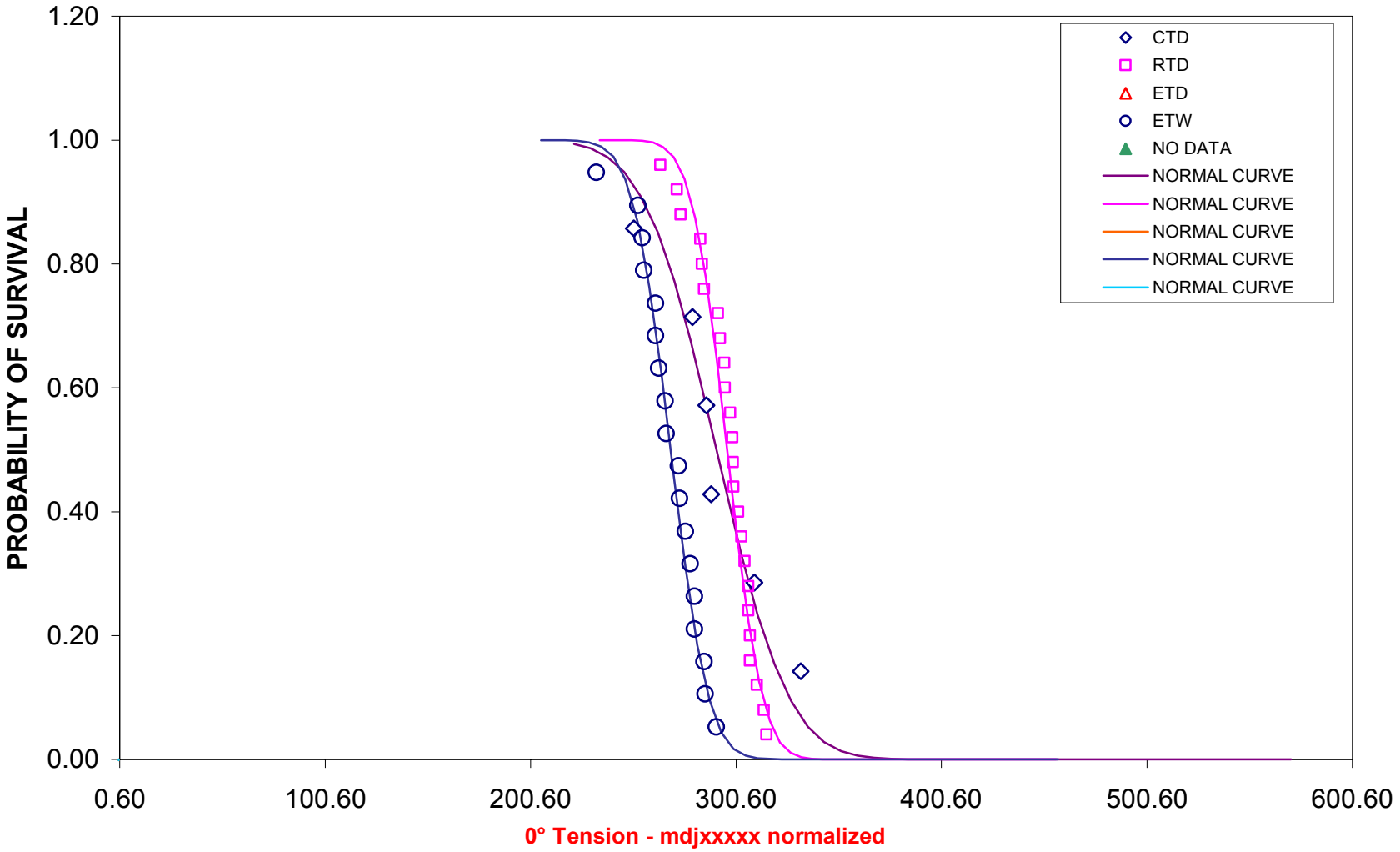
3.3.1 Plot by Condition

DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS



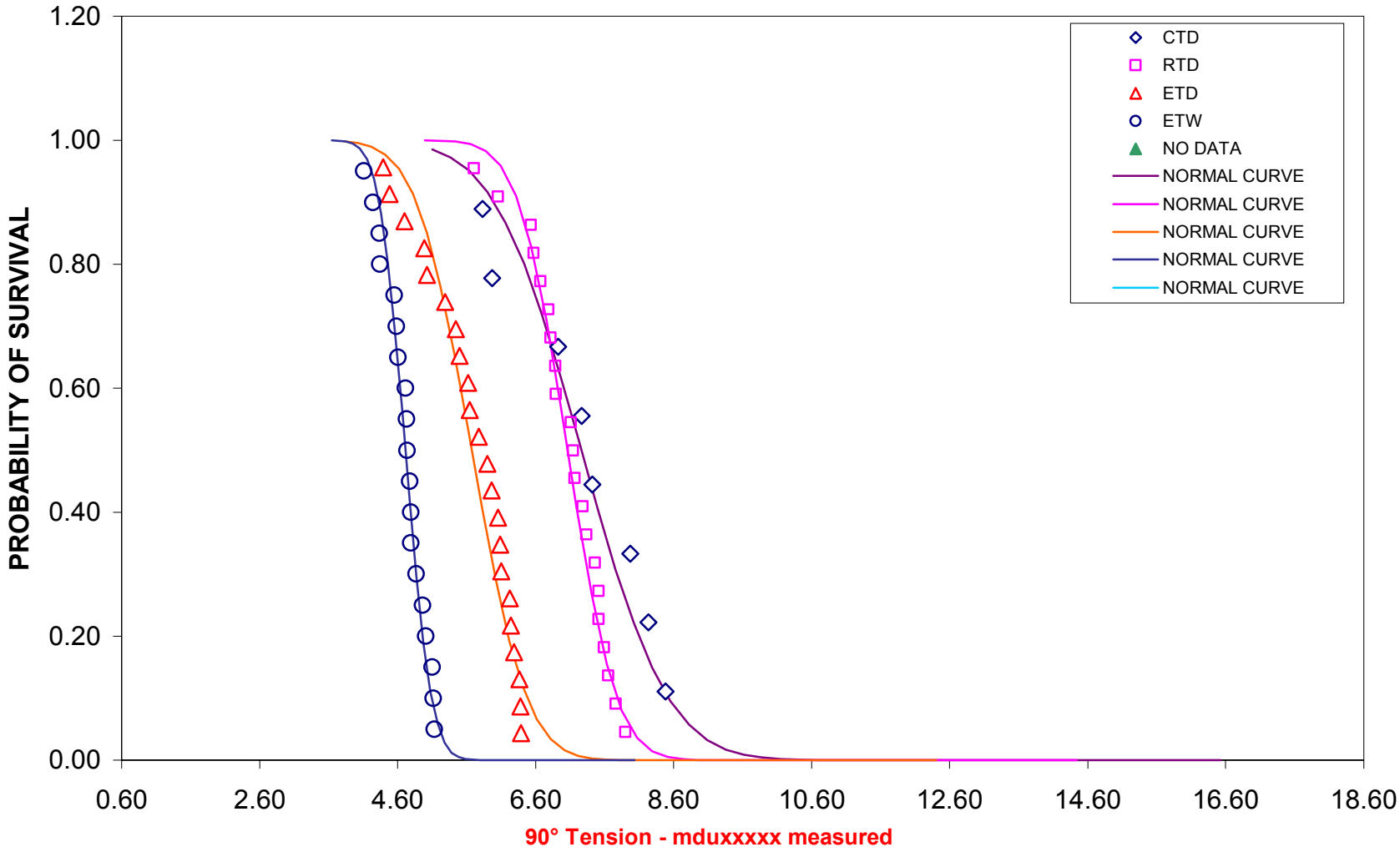
DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

NCT 321/G150 (NASS) UNITAPE
Lancair



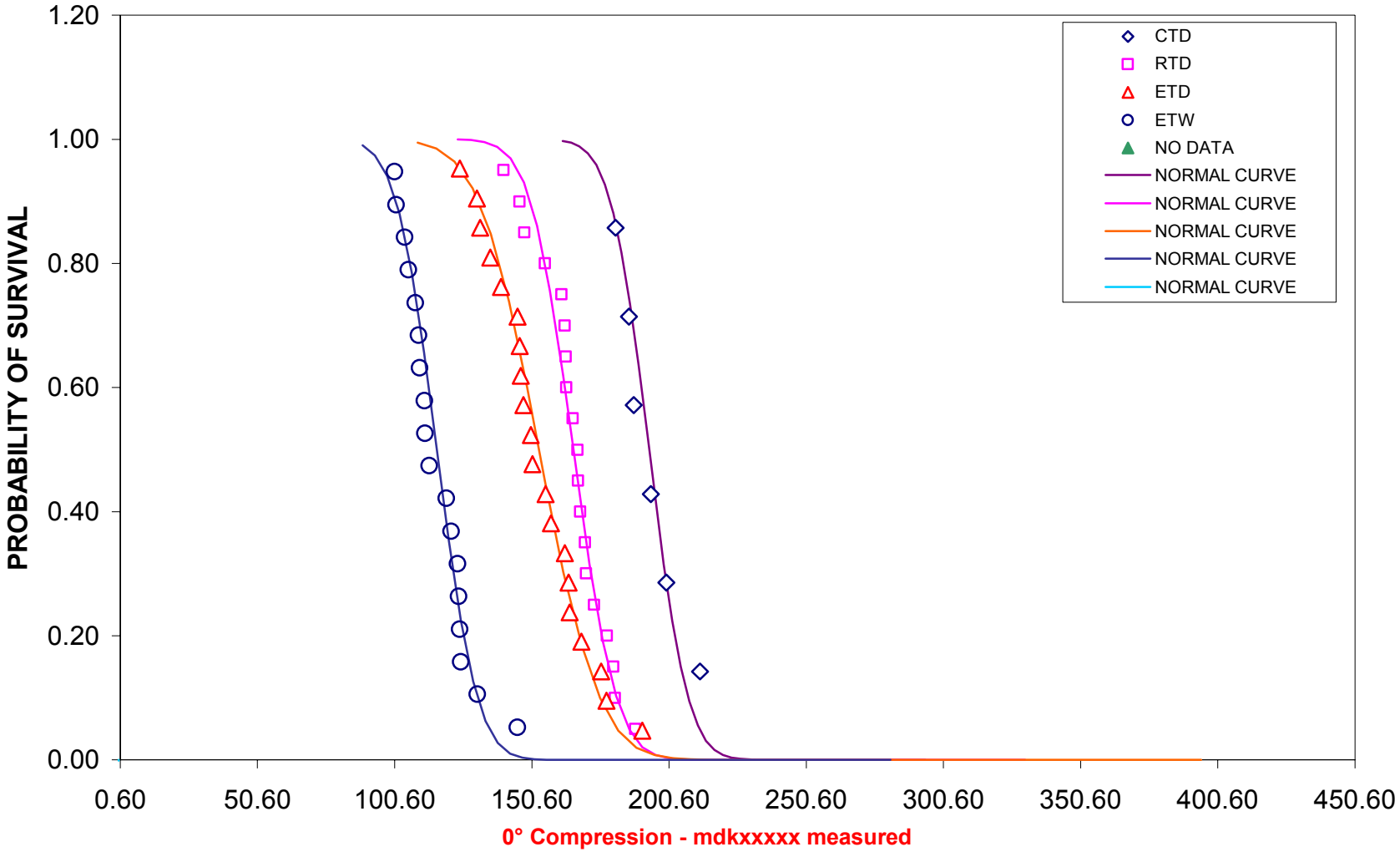
DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

NCT 321/G150 (NASS) UNITAPE
Lancair

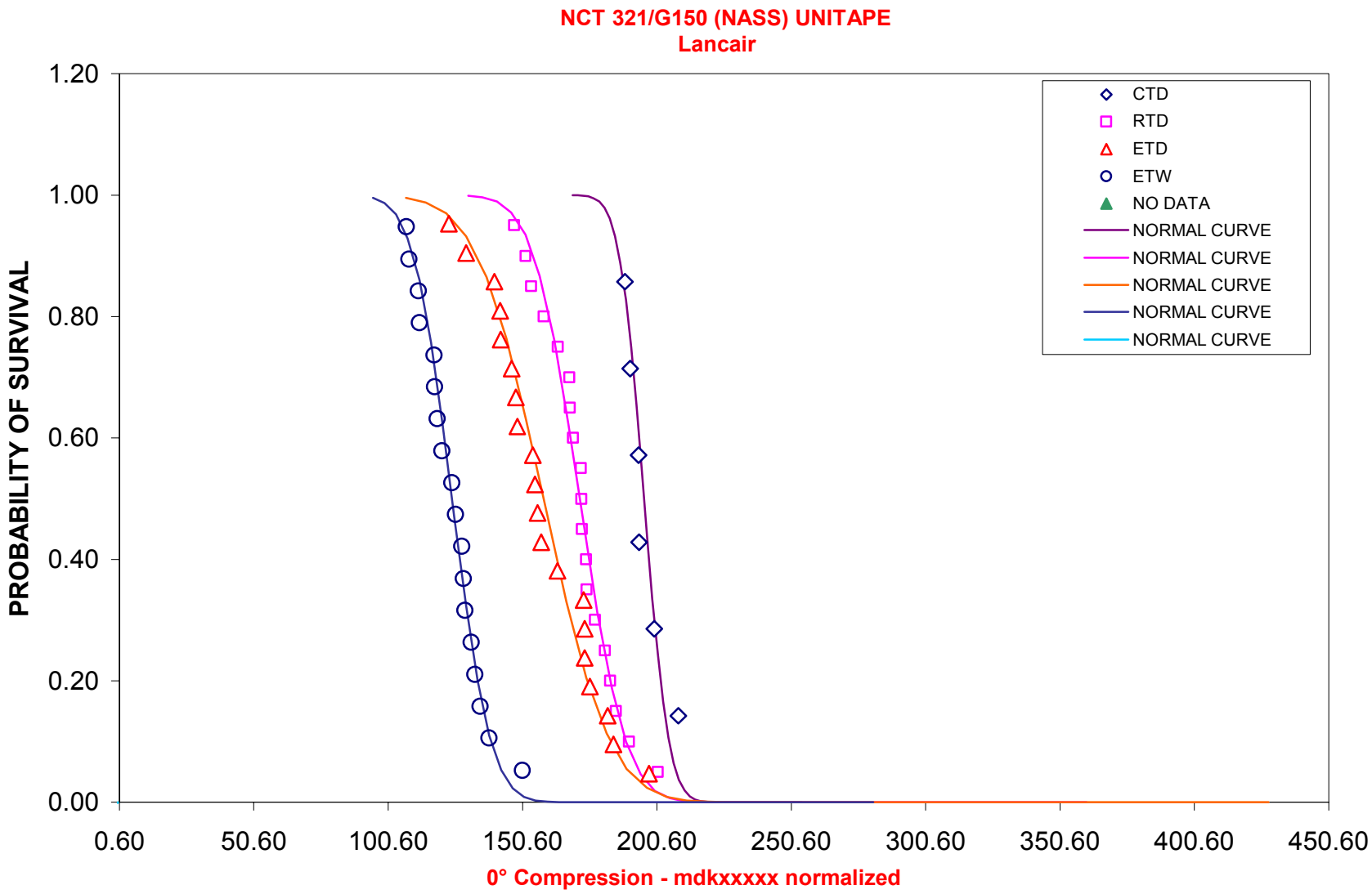


DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

NCT 321/G150 (NASS) UNITAPE
Lancair

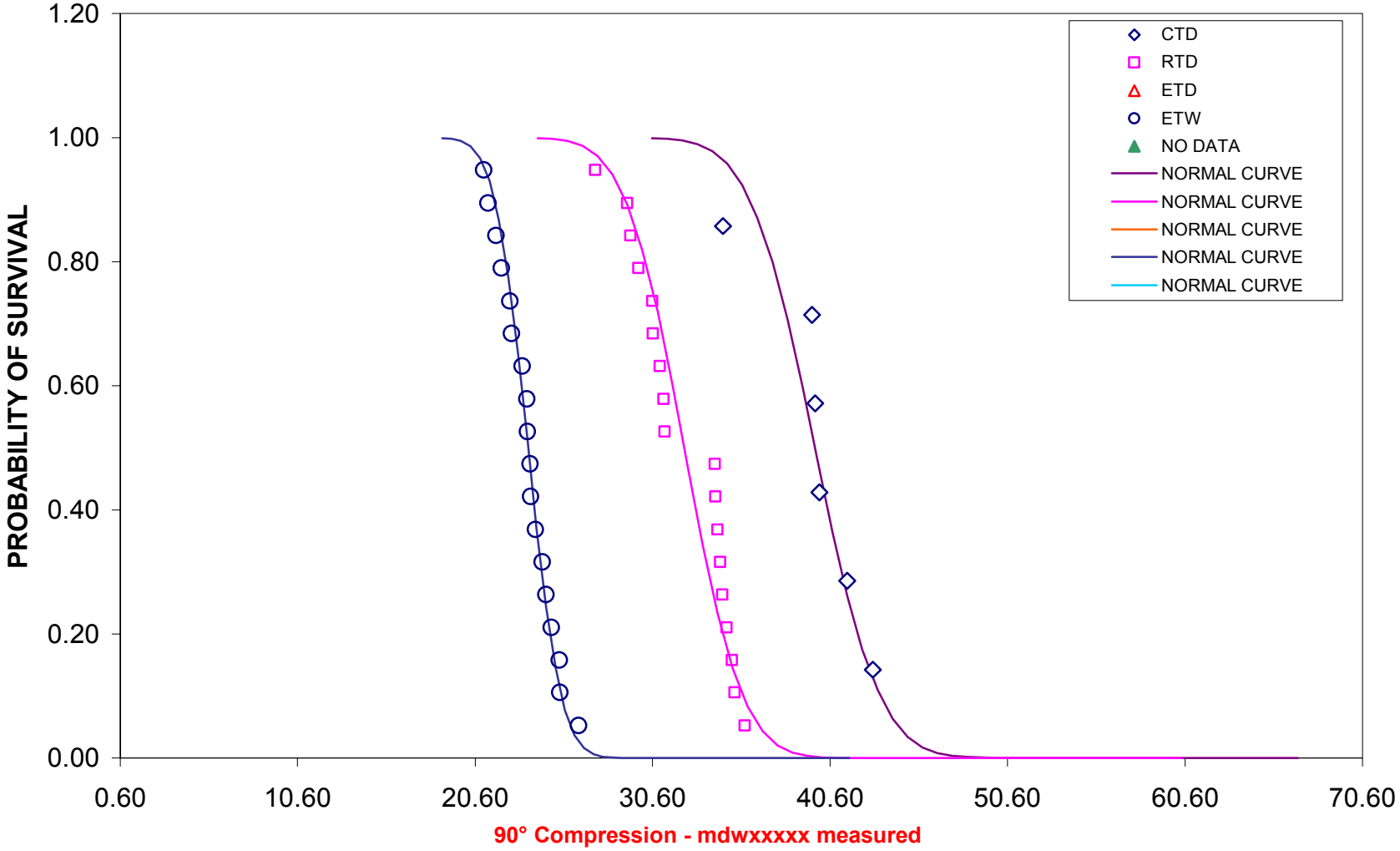


DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS



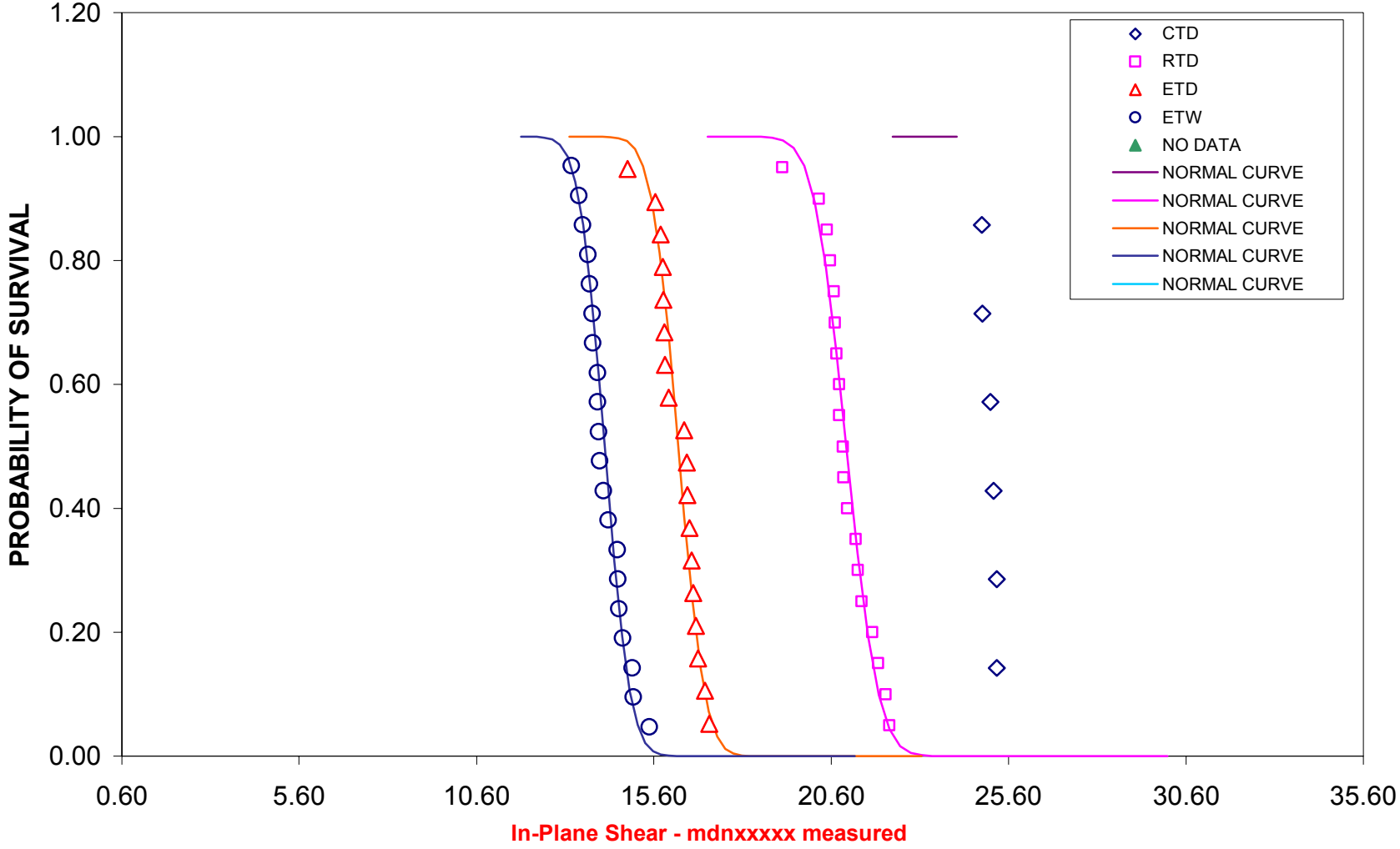
DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

NCT 321/G150 (NASS) UNITAPE
Lancair



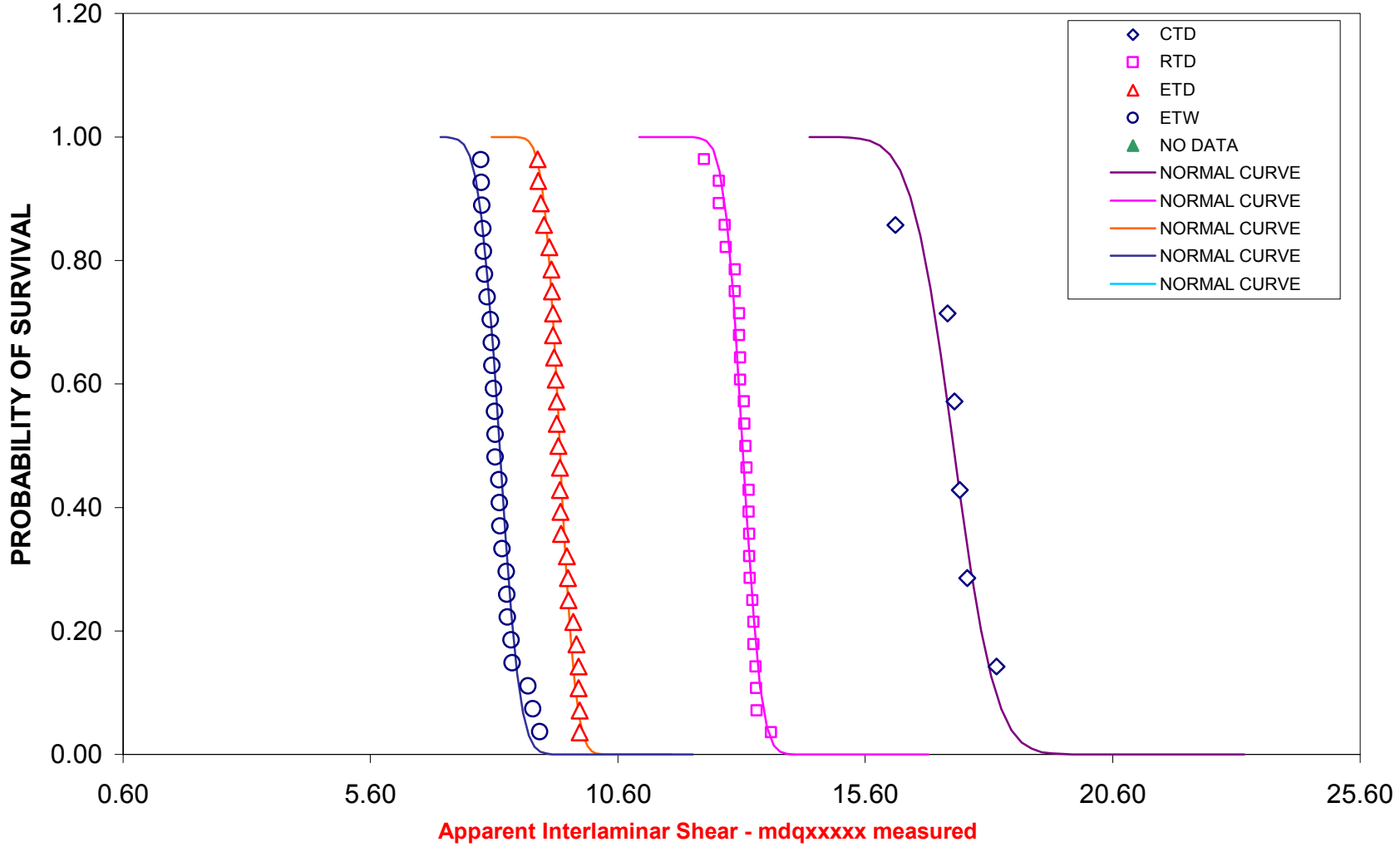
DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

NCT 321/G150 (NASS) UNITAPE
Lancair



DISTRIBUTION OF GROUPED DATA FOR DIFFERENT TEST CONDITIONS

NCT 321/G150 (NASS) UNITAPE
Lancair



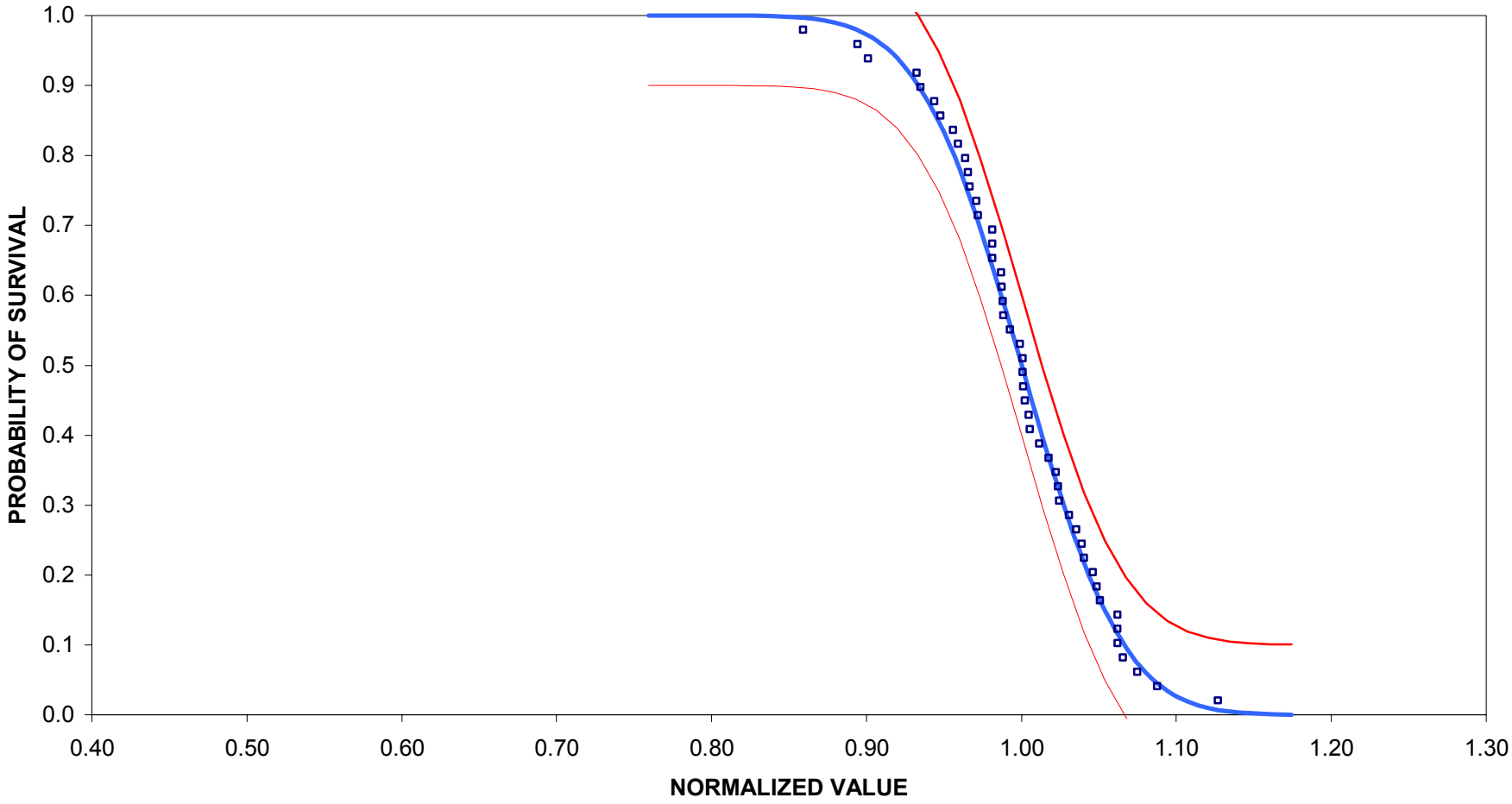
3.3.2 Plot of Pooled Data

DISTRIBUTION OF POOLED DATA

NCT 321/G150 (NASS) UNITAPE

Lancair

0° Tension - mdjxxxxx measured

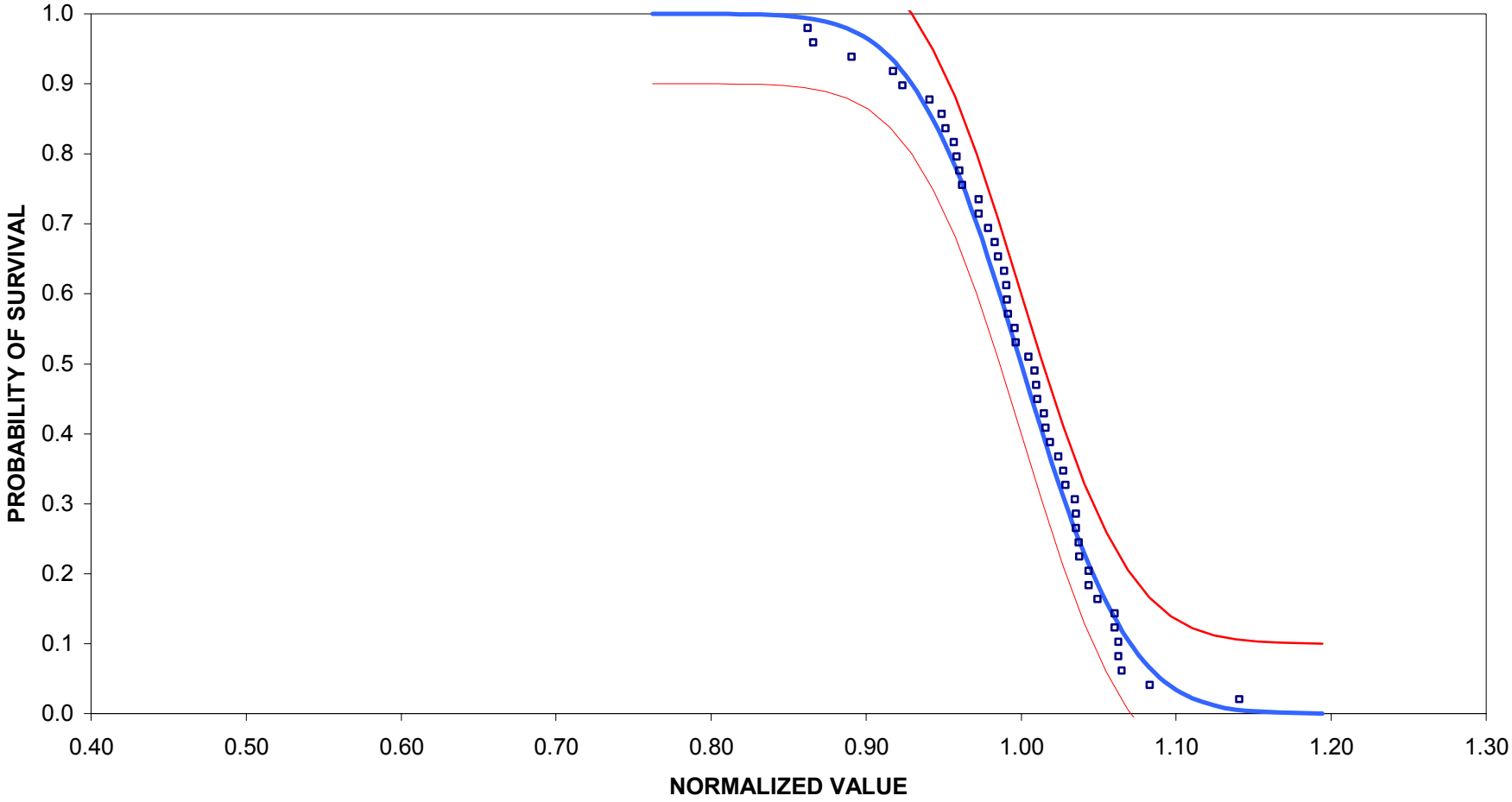


DISTRIBUTION OF POOLED DATA

NCT 321/G150 (NASS) UNITAPE

Lancair

0° Tension - mdjxxxxx normalized

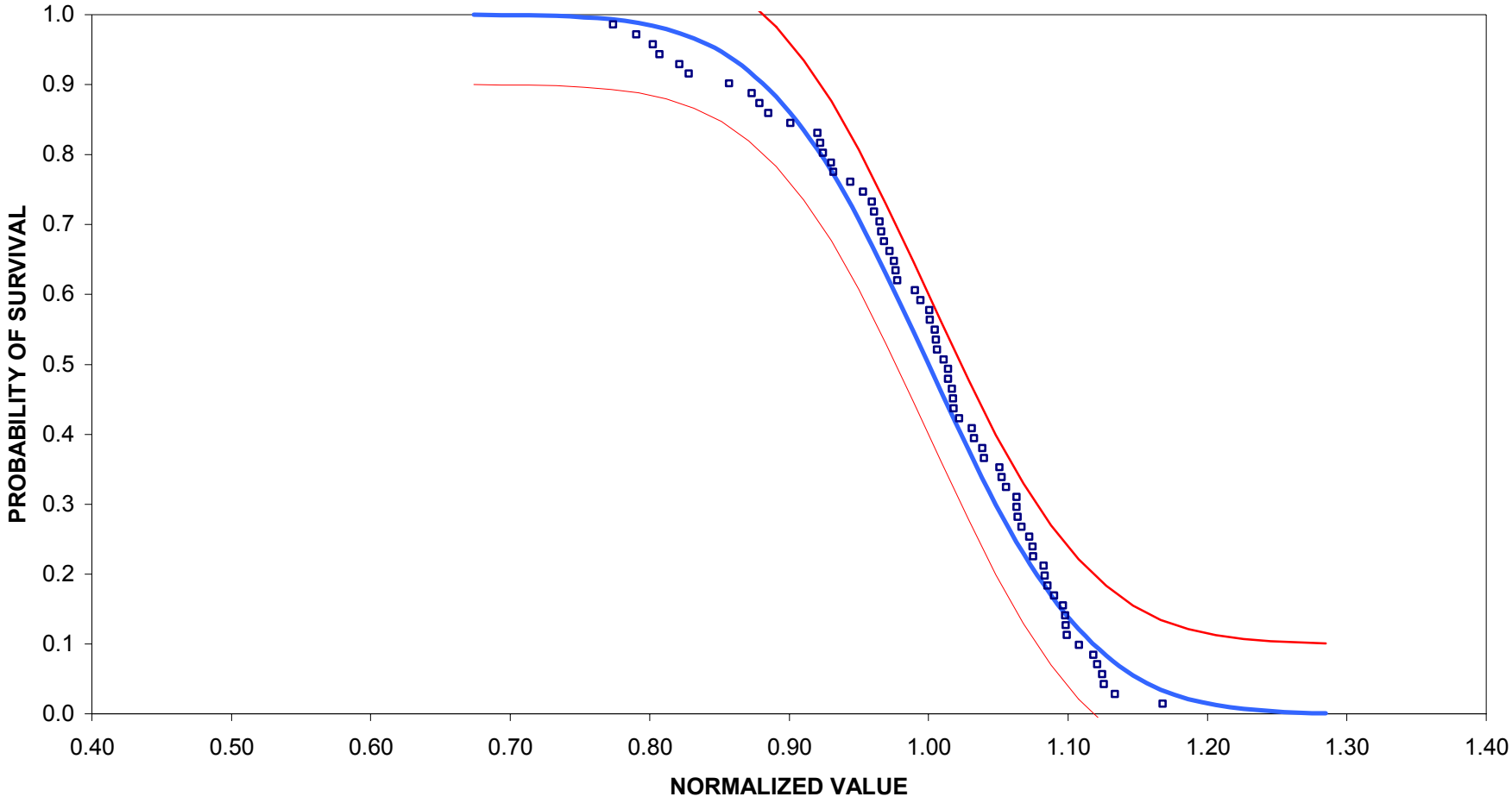


DISTRIBUTION OF POOLED DATA

NCT 321/G150 (NASS) UNITAPE

Lancair

90° Tension - mduxxxxx measured

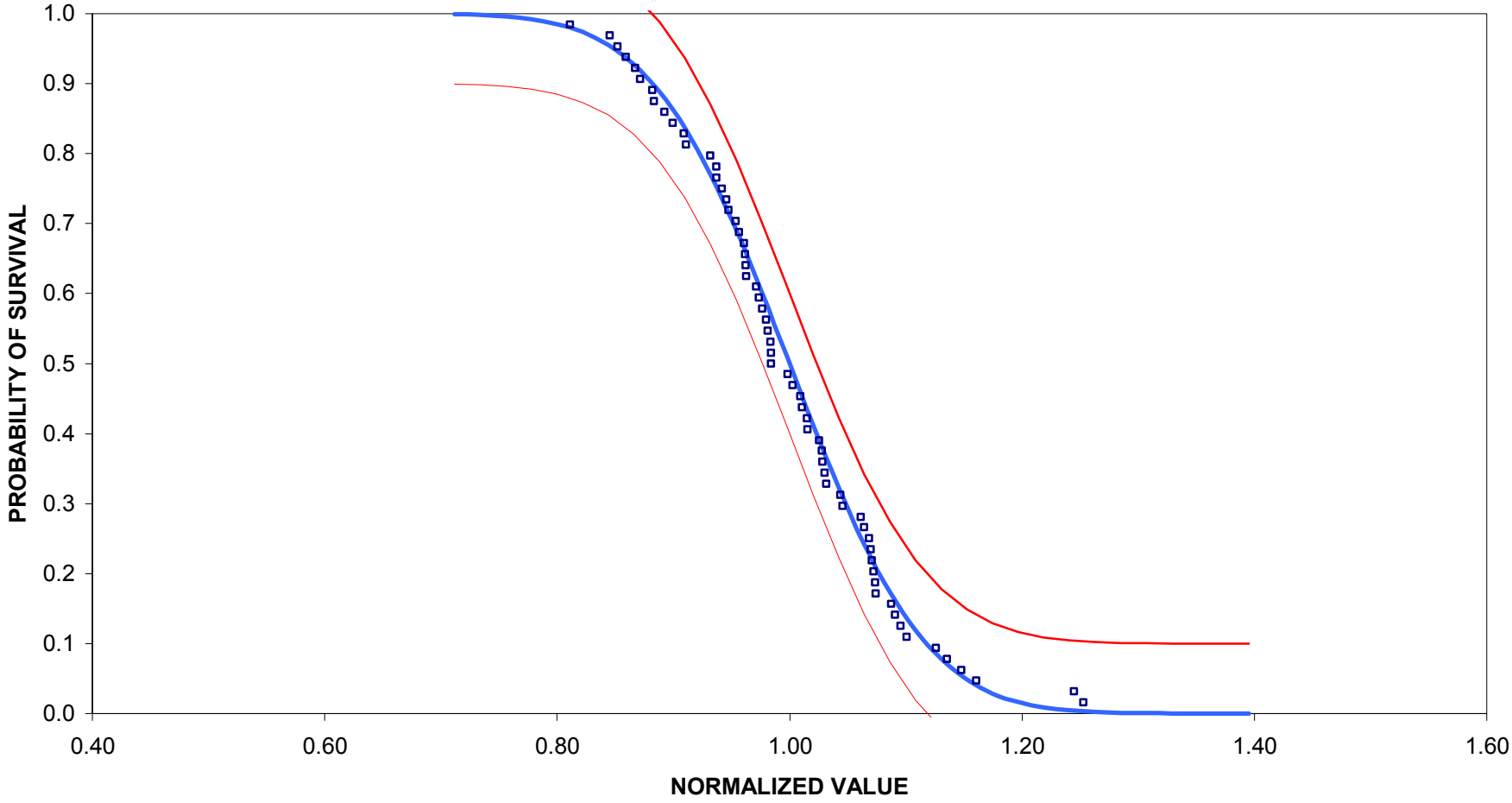


DISTRIBUTION OF POOLED DATA

NCT 321/G150 (NASS) UNITAPE

Lancair

0° Compression - mdkxxxxx measured

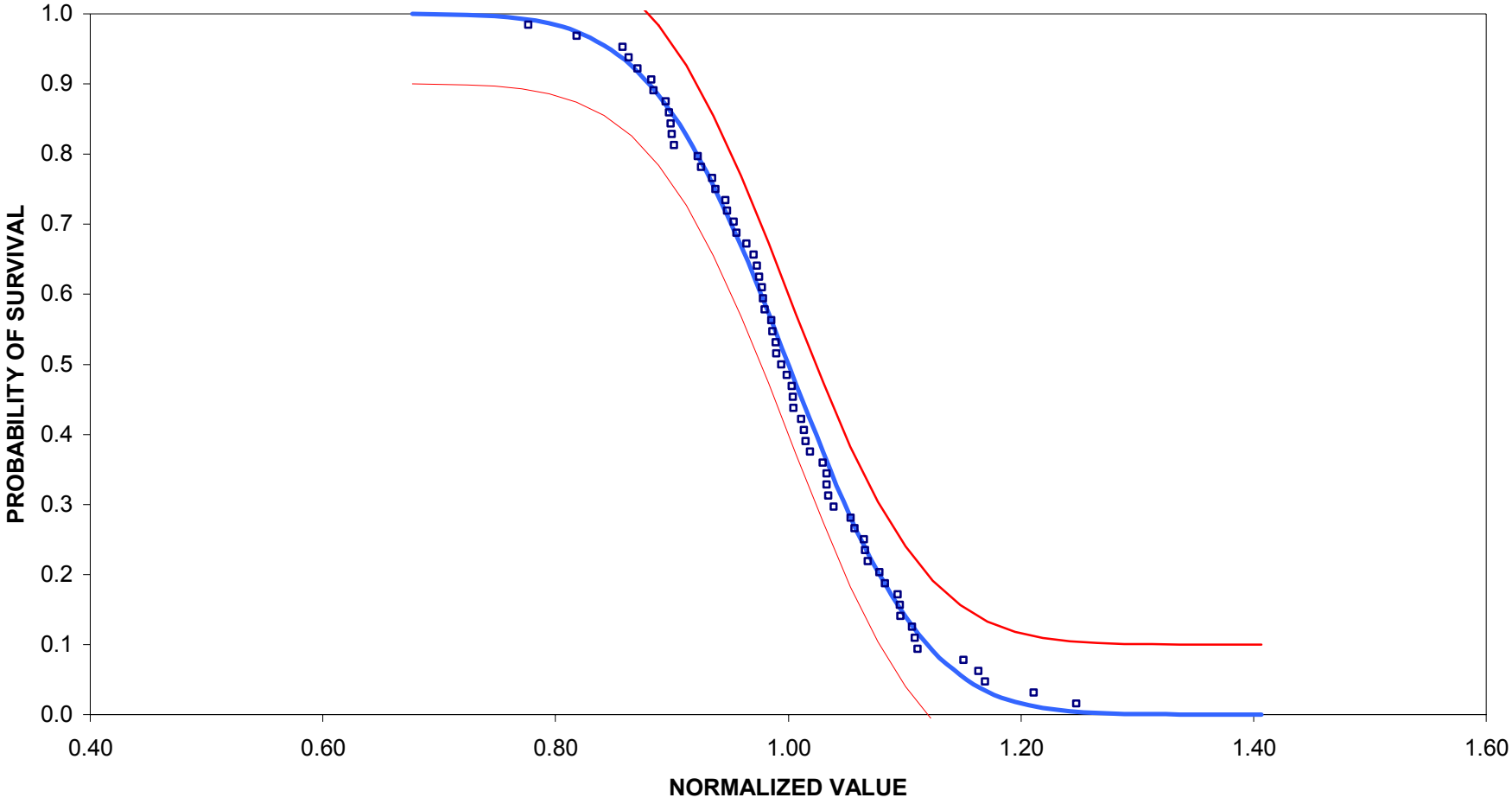


DISTRIBUTION OF POOLED DATA

NCT 321/G150 (NASS) UNITAPE

Lancair

0° Compression - mdkxxxxx normalized

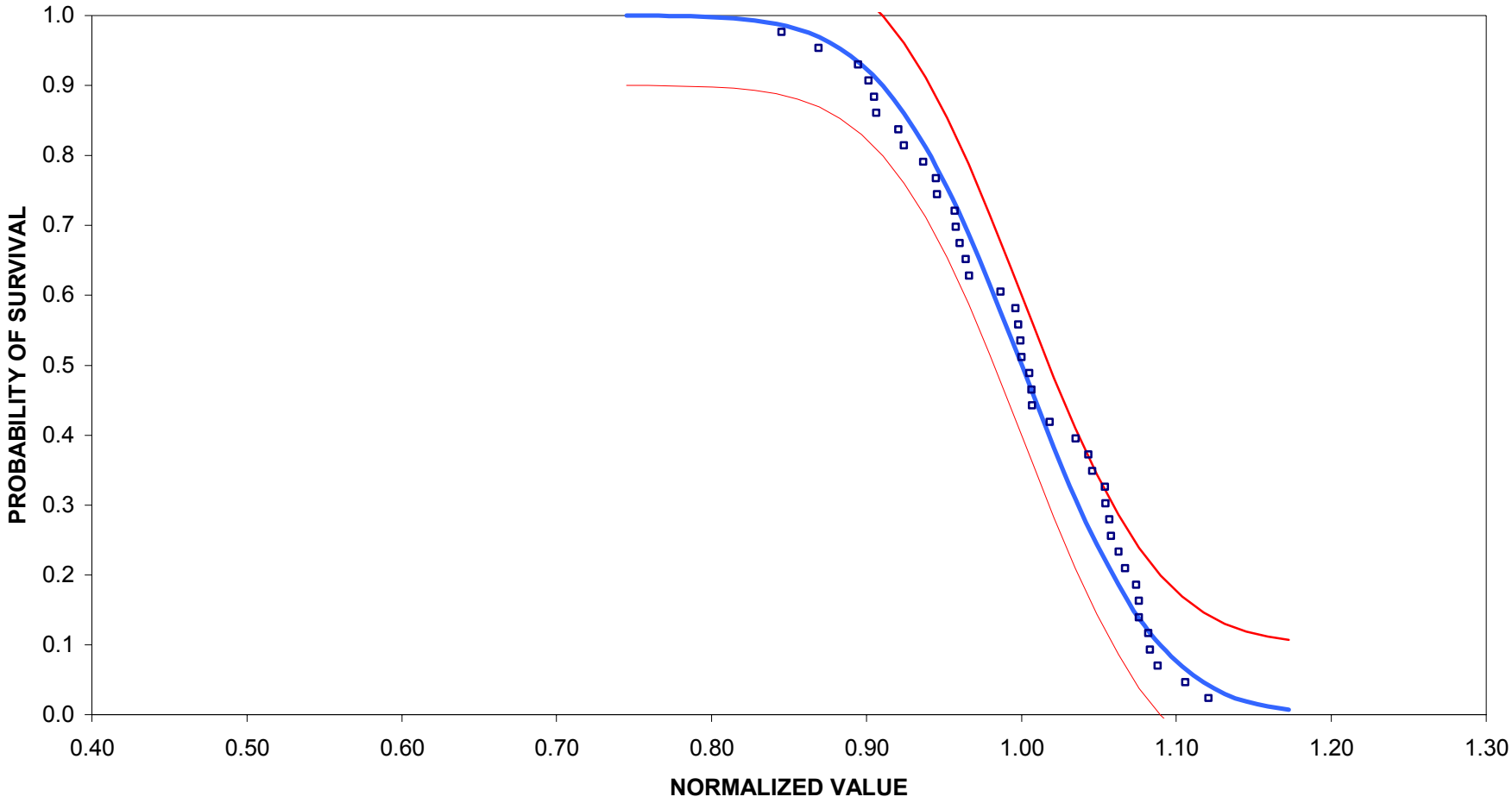


DISTRIBUTION OF POOLED DATA

NCT 321/G150 (NASS) UNITAPE

Lancair

90° Compression - mdwxxxxx measured

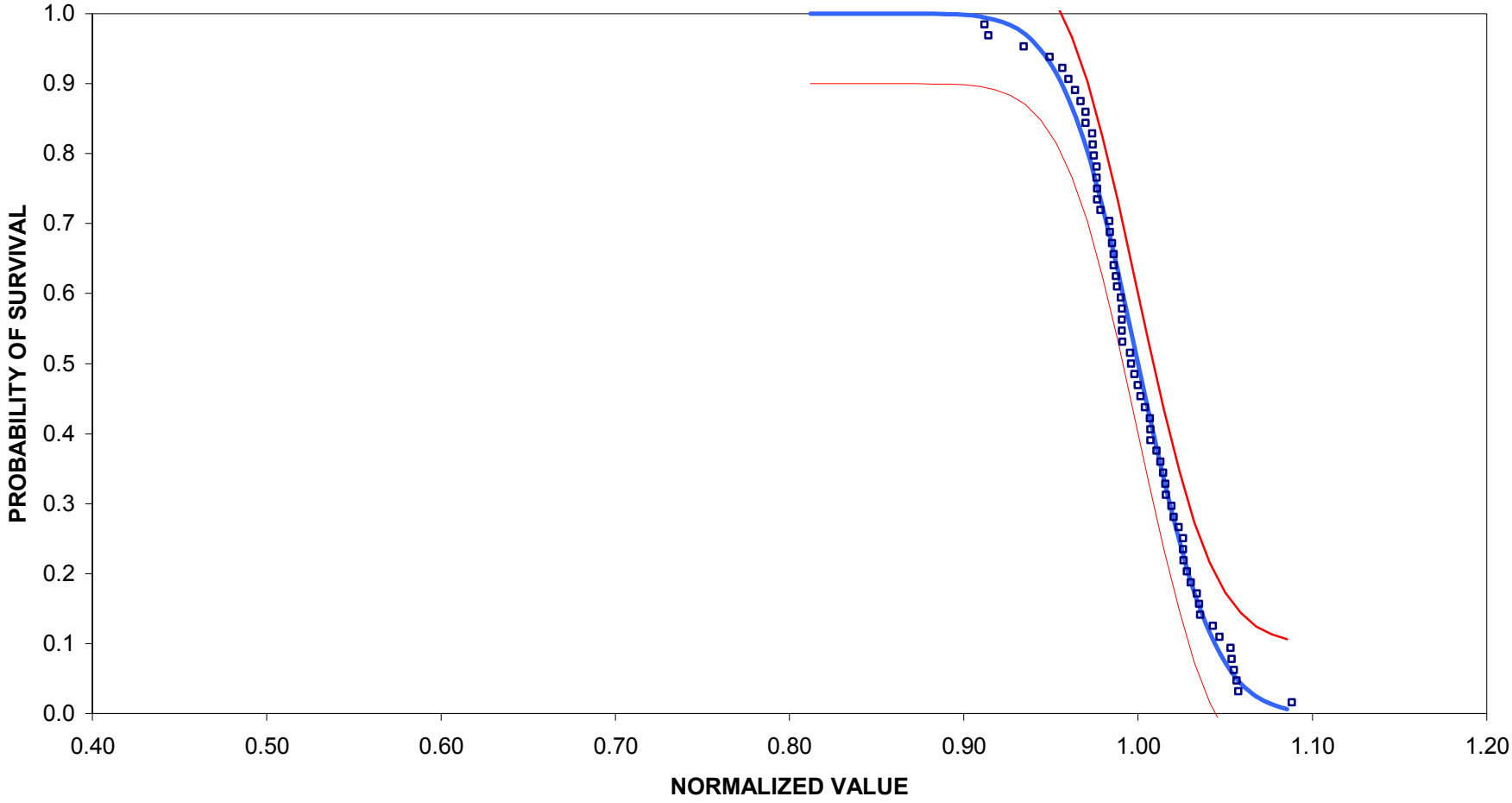


DISTRIBUTION OF POOLED DATA

NCT 321/G150 (NASS) UNITAPE

Lancair

In-Plane Shear - mdnxxxxx measured

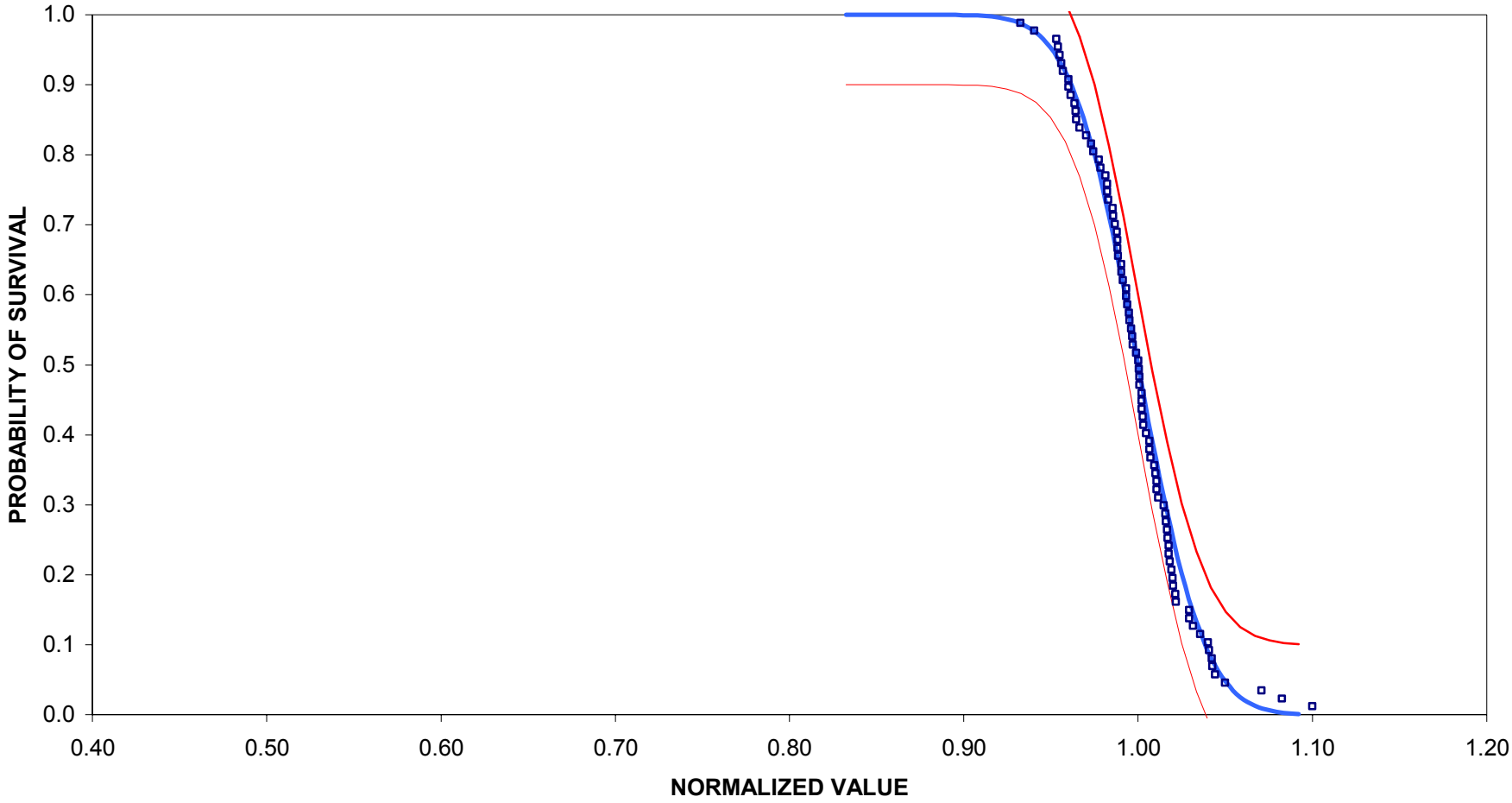


DISTRIBUTION OF POOLED DATA

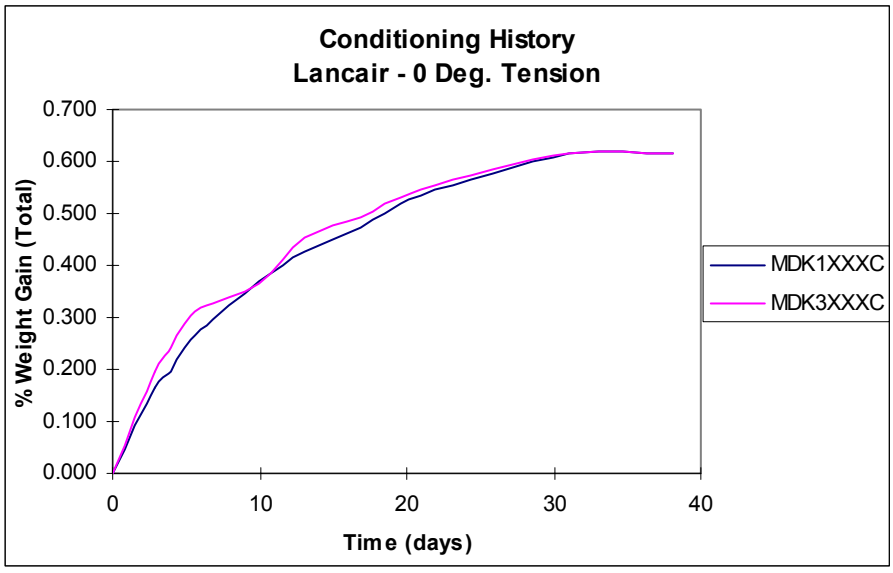
NCT 321/G150 (NASS) UNITAPE

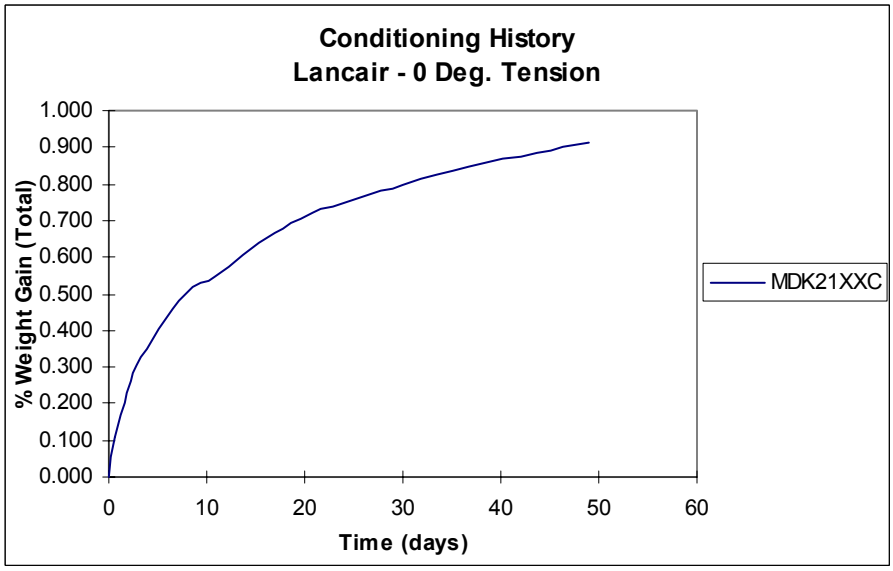
Lancair

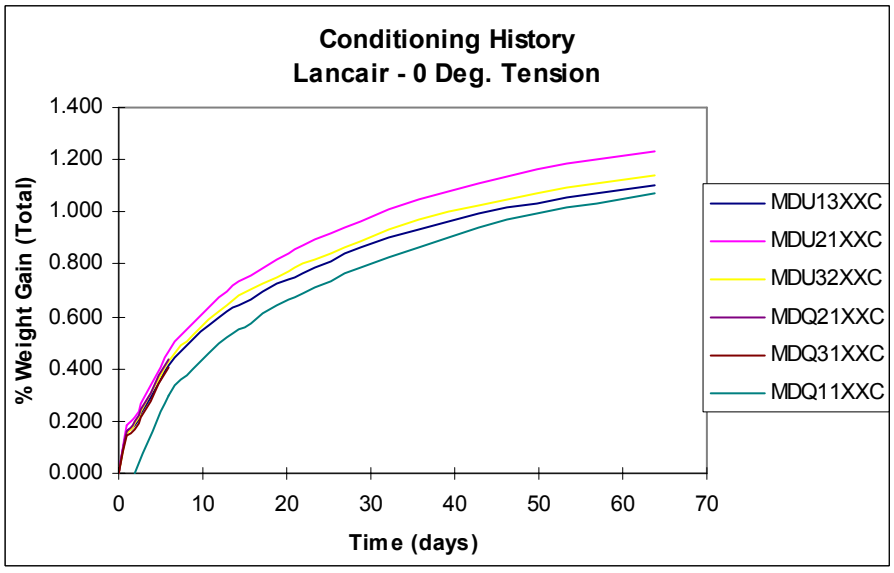
Apparent Interlaminar Shear - mdqxxxxx measured

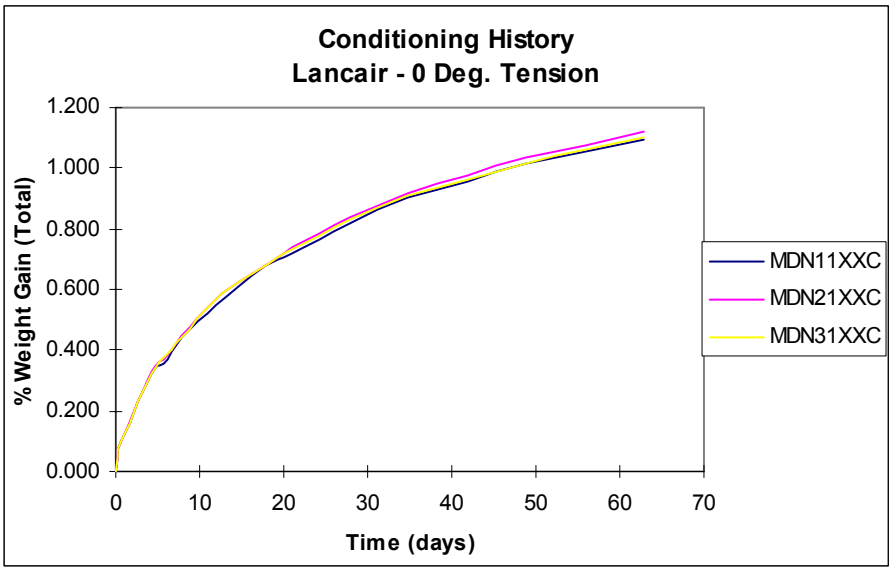


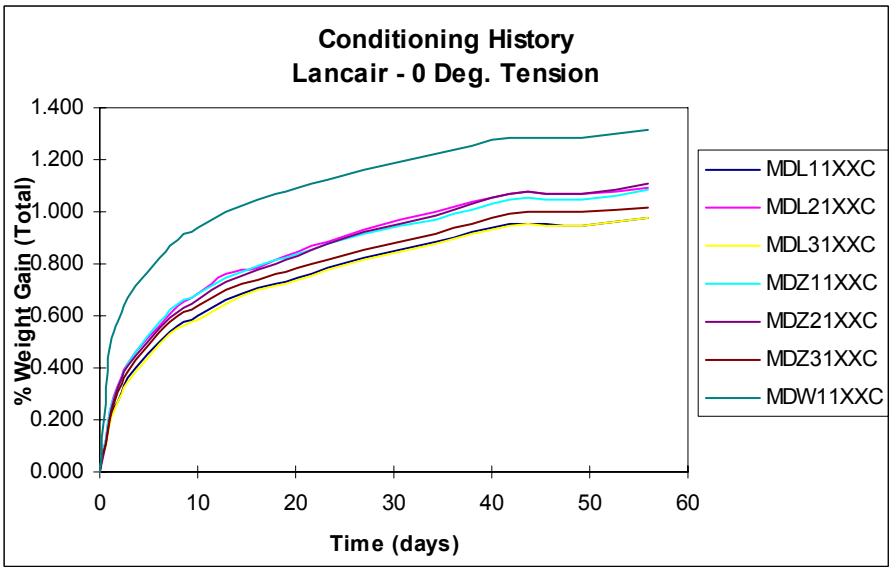
3.4 Moisture Conditioning History Charts

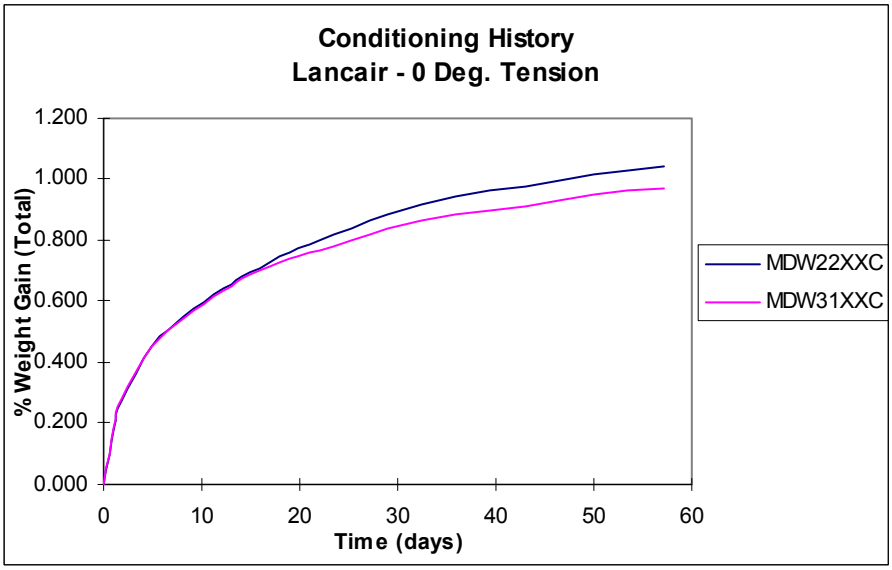


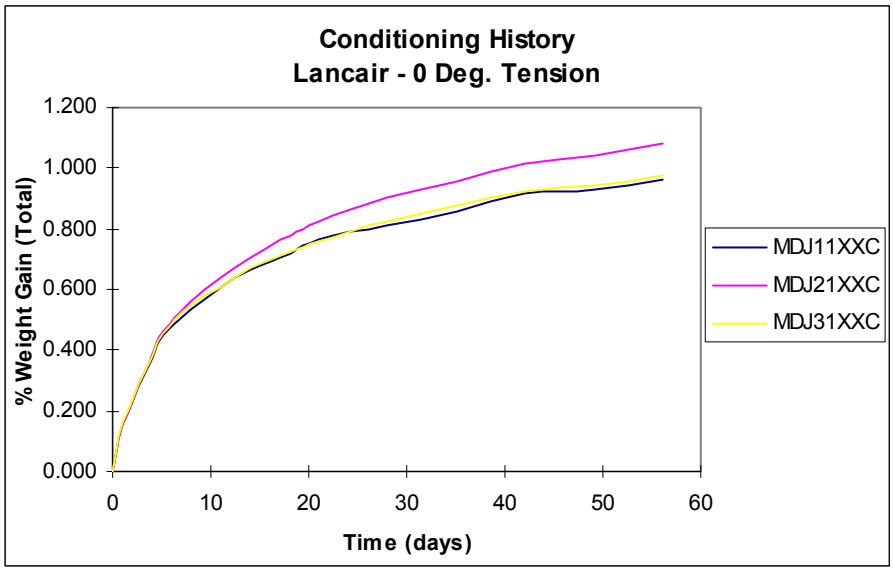










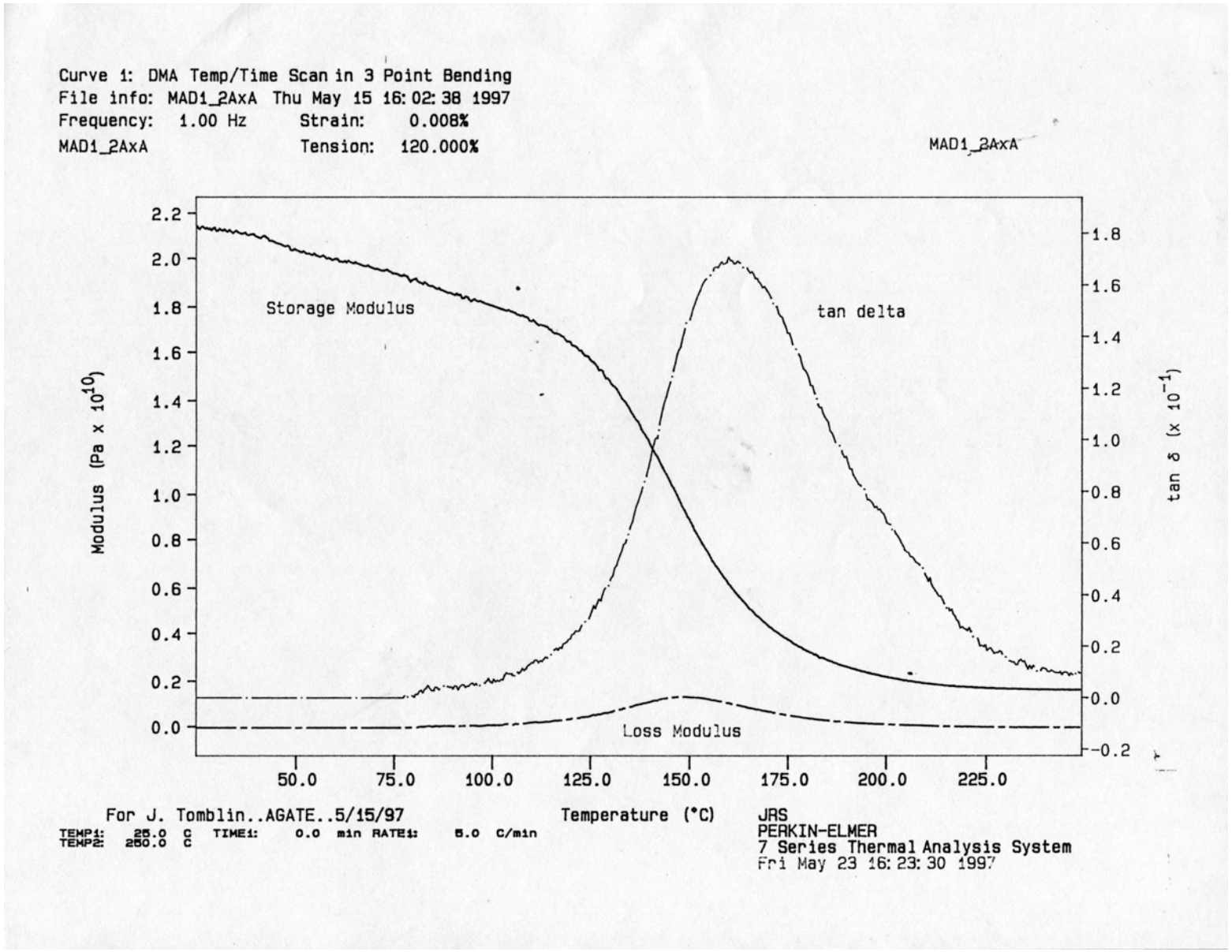


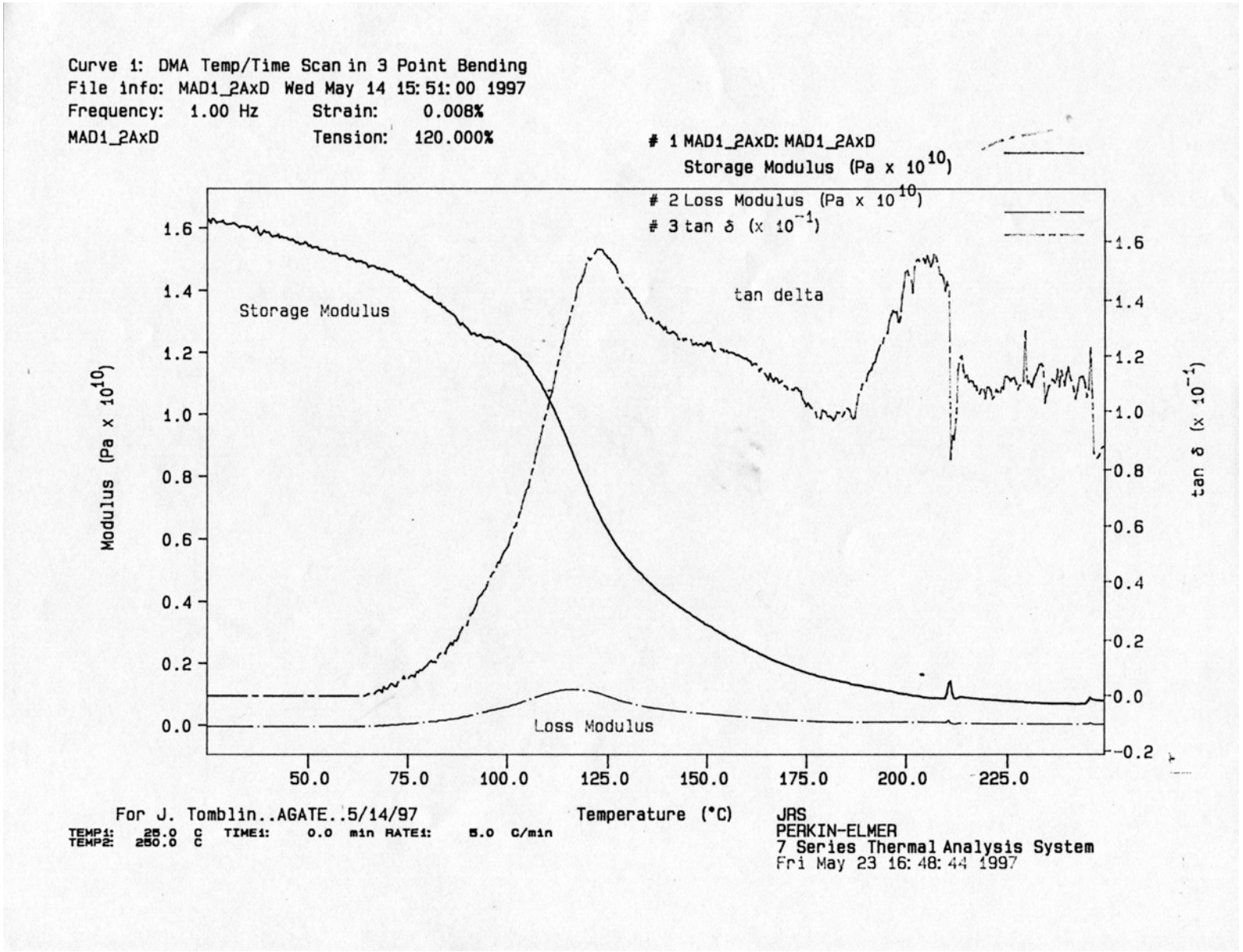
3.5 DMA Results

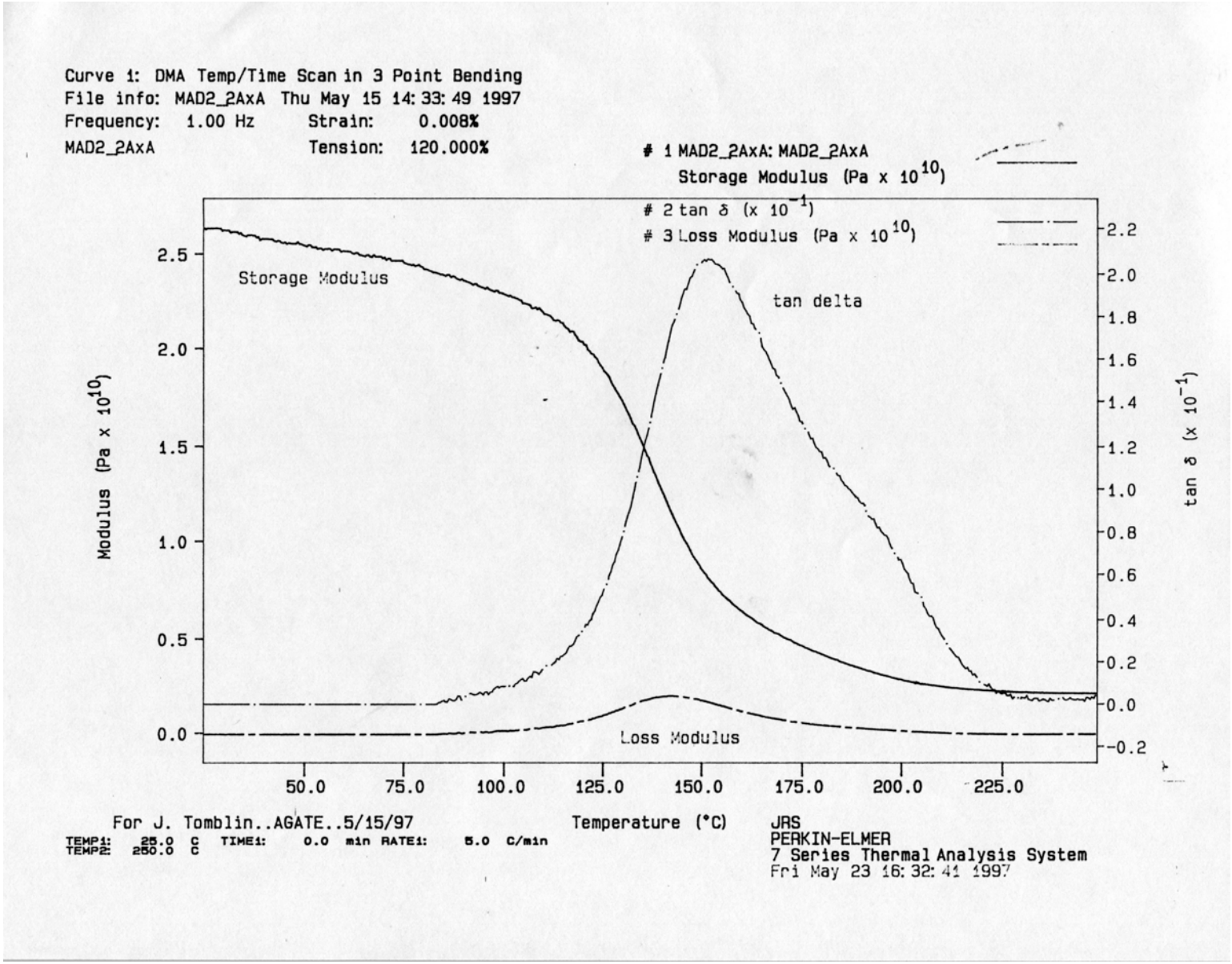
DMA Results

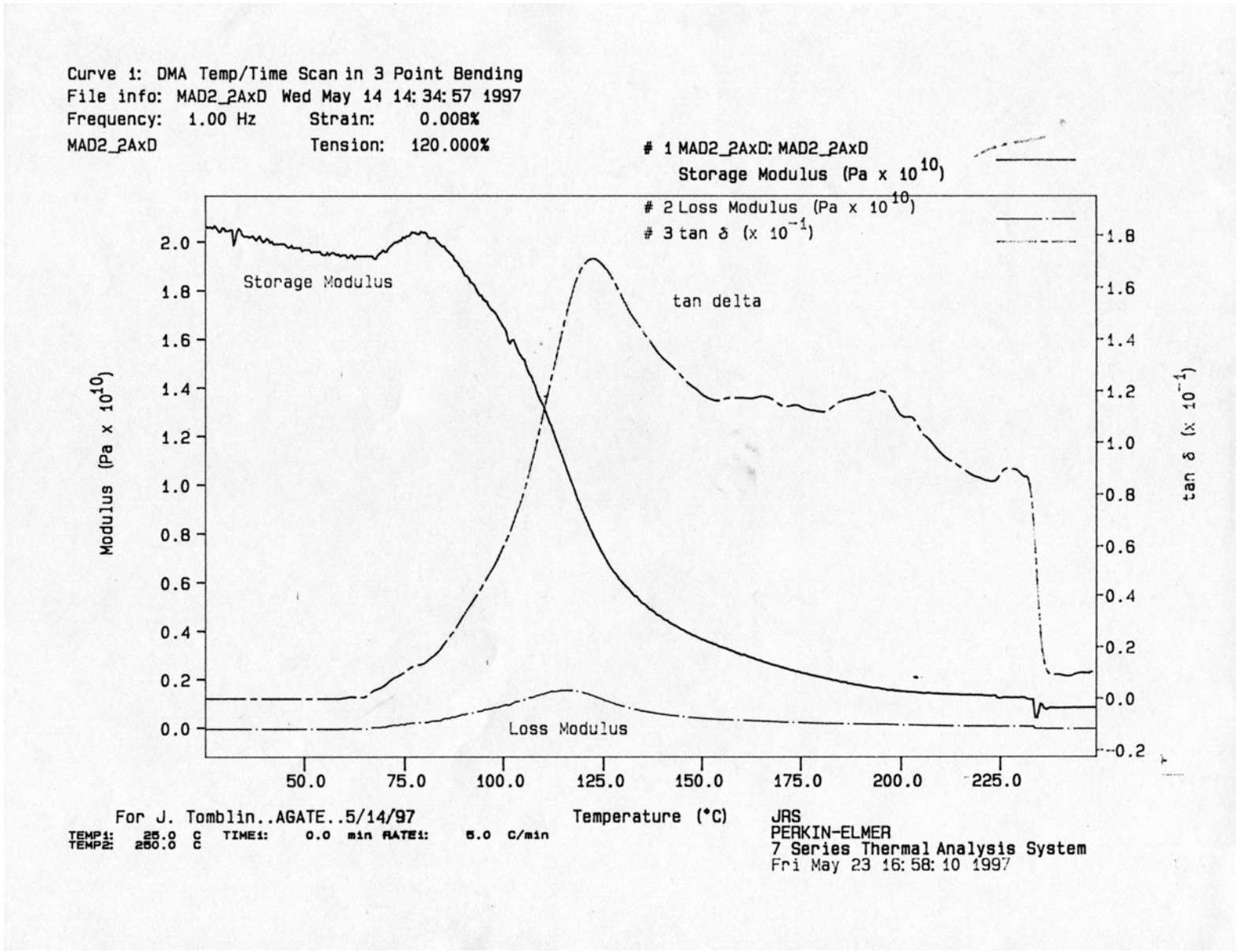
Sample	Tg Onset of Storage Modulus (°C)	Tg Maxima of Loss Modulus (°C)	Tg Maxima of Tan δ (°C)
1 wet	105.8	117.6	124.7
2 wet	107.2	116.2	122.8
3 wet	100.7	111.6	118.7
4 wet	108.7	126.5	135.5
5 wet	110.4	127.0	136.7
6 wet	104.0	126.0	134.8
Average wet	*106.2*	*120.8*	*128.9*

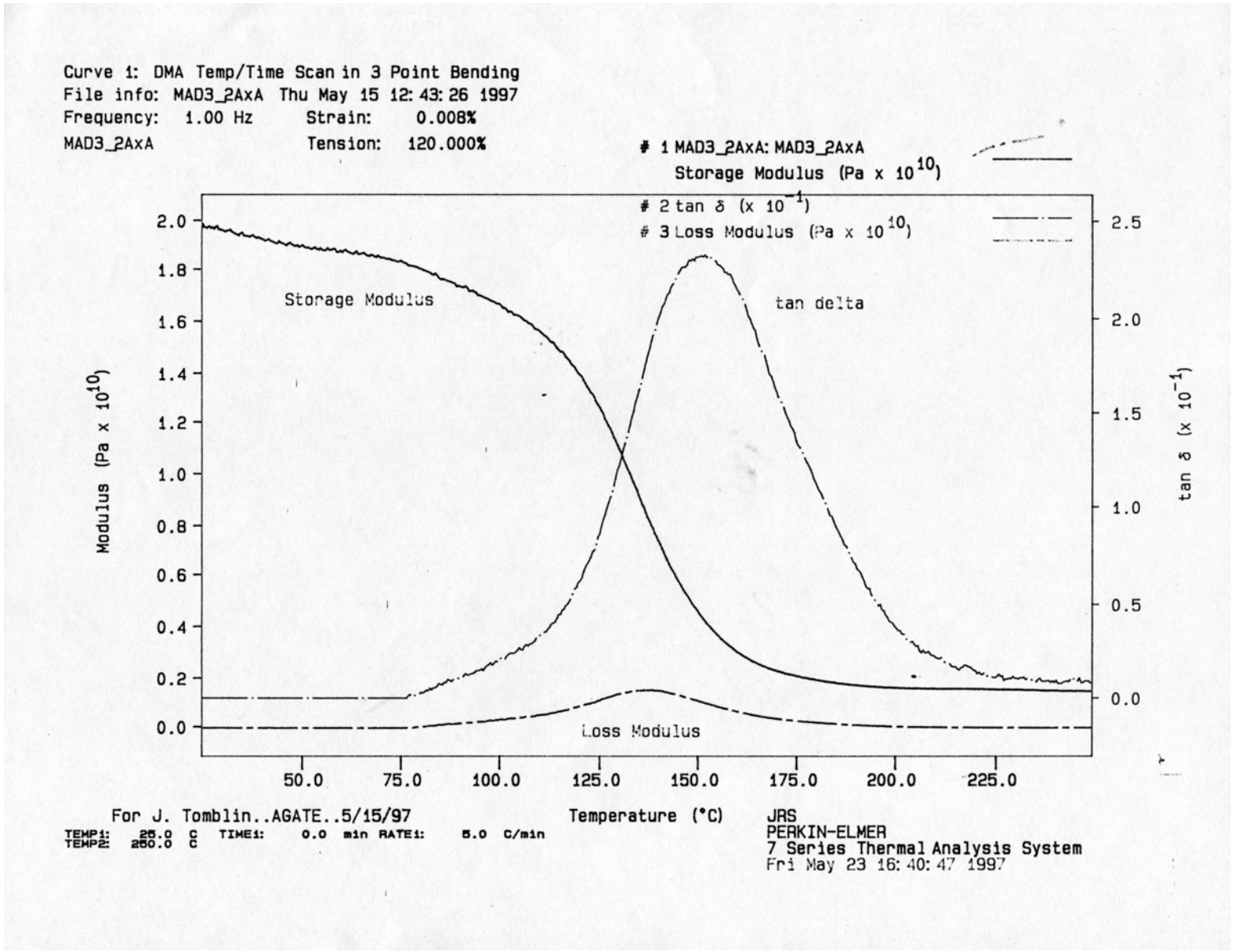
Sample	Tg Onset of Storage Modulus (°C)	Tg Maxima of Loss Modulus (°C)	Tg Maxima of Tan δ (°C)
1 dry	126.4	149.1	160.0
2 dry	135.5	142.4	151.6
3 dry	118.6	138.6	151.8
4 dry	114.5	145.0	162.0
5 dry	109.4	154.4	169.2
6 dry	124.0	156.1	168.6
Average dry	*121.4*	*147.6*	*160.5*

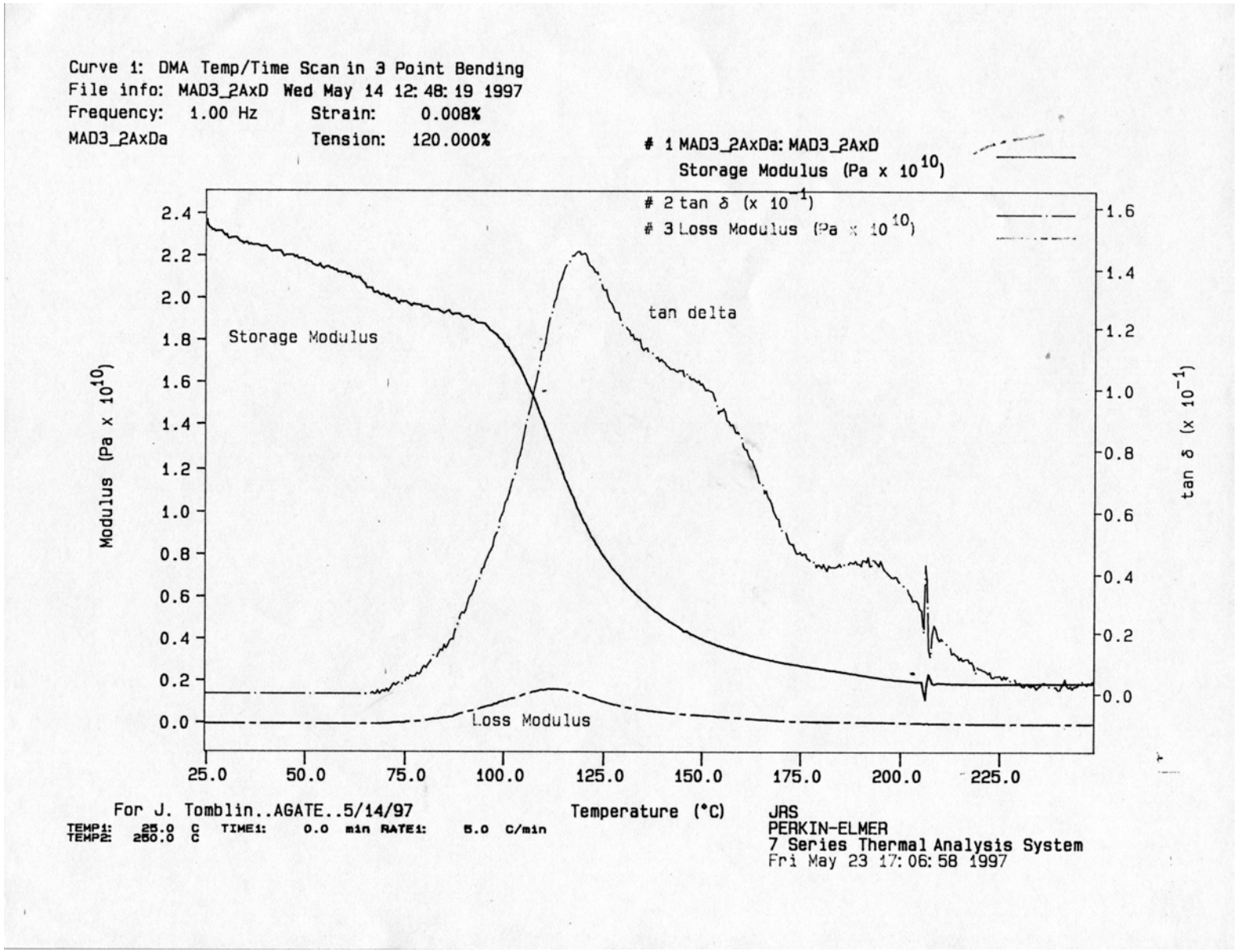


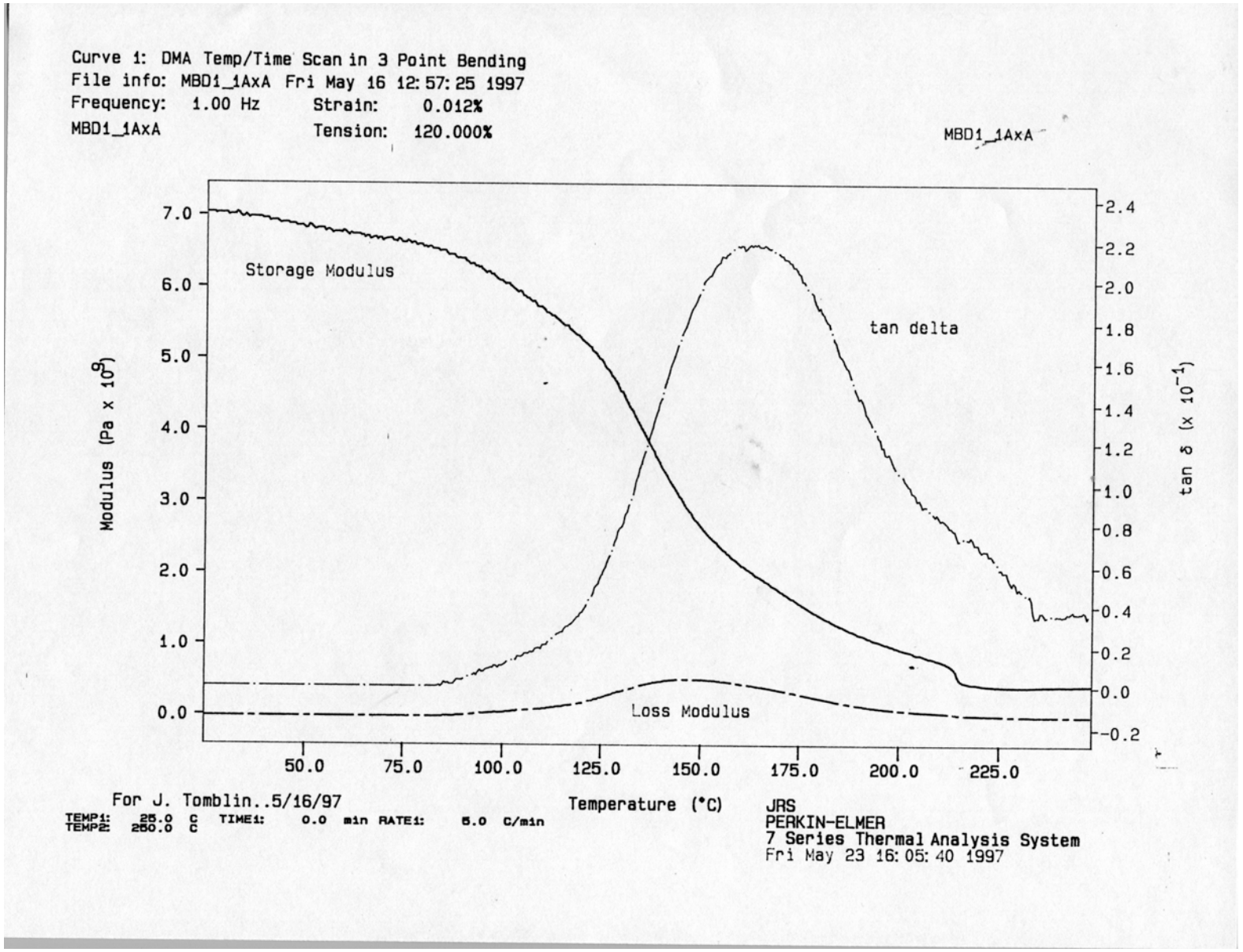


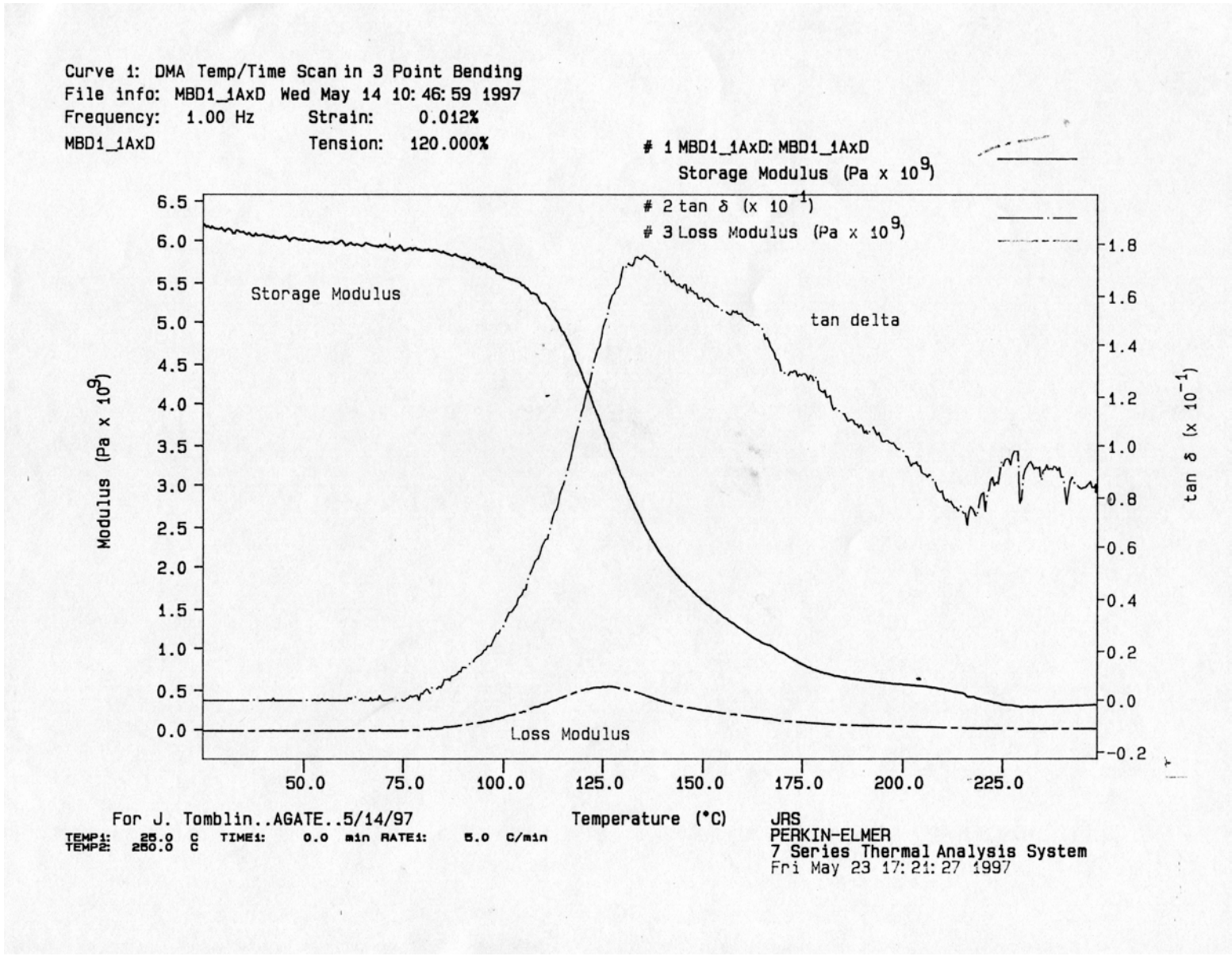


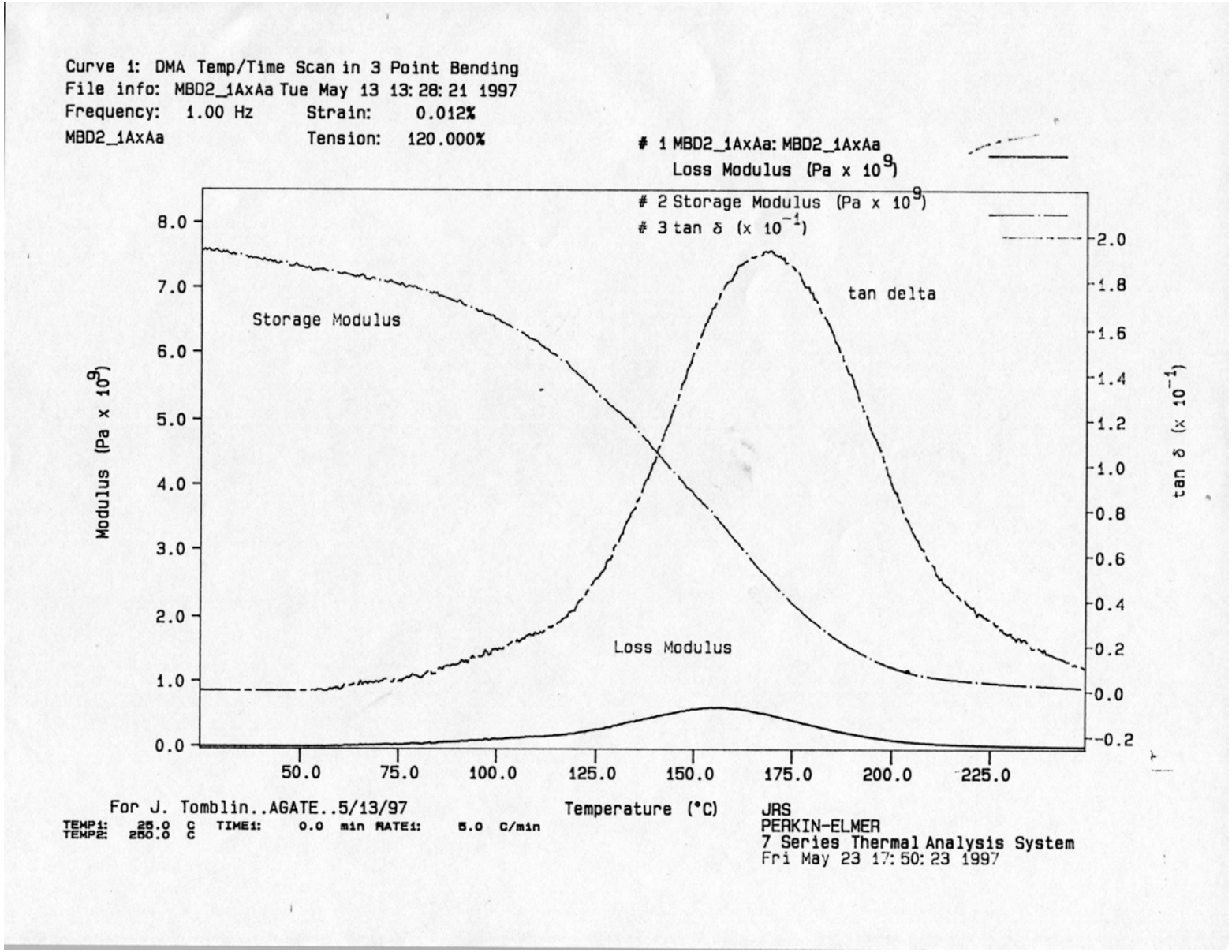


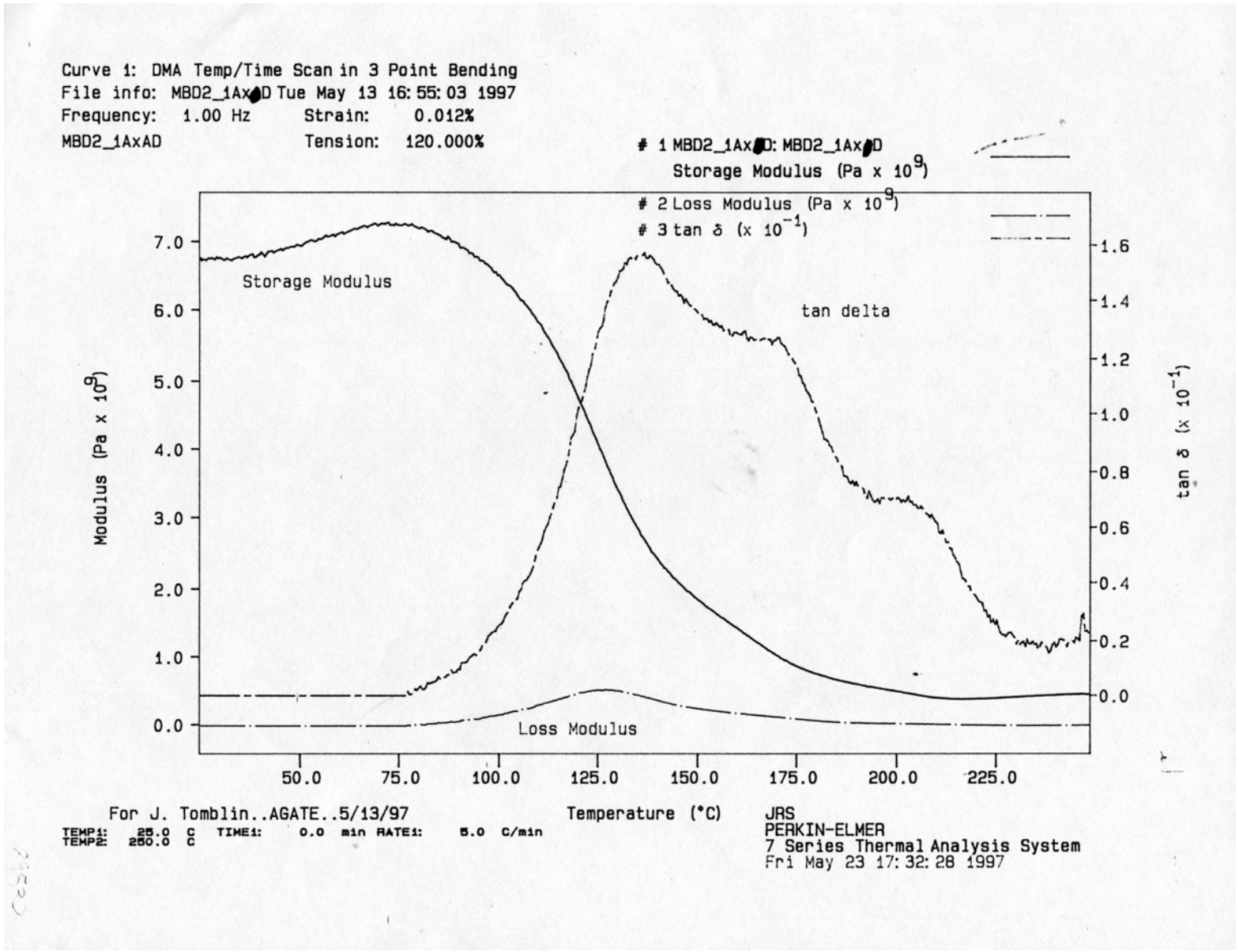


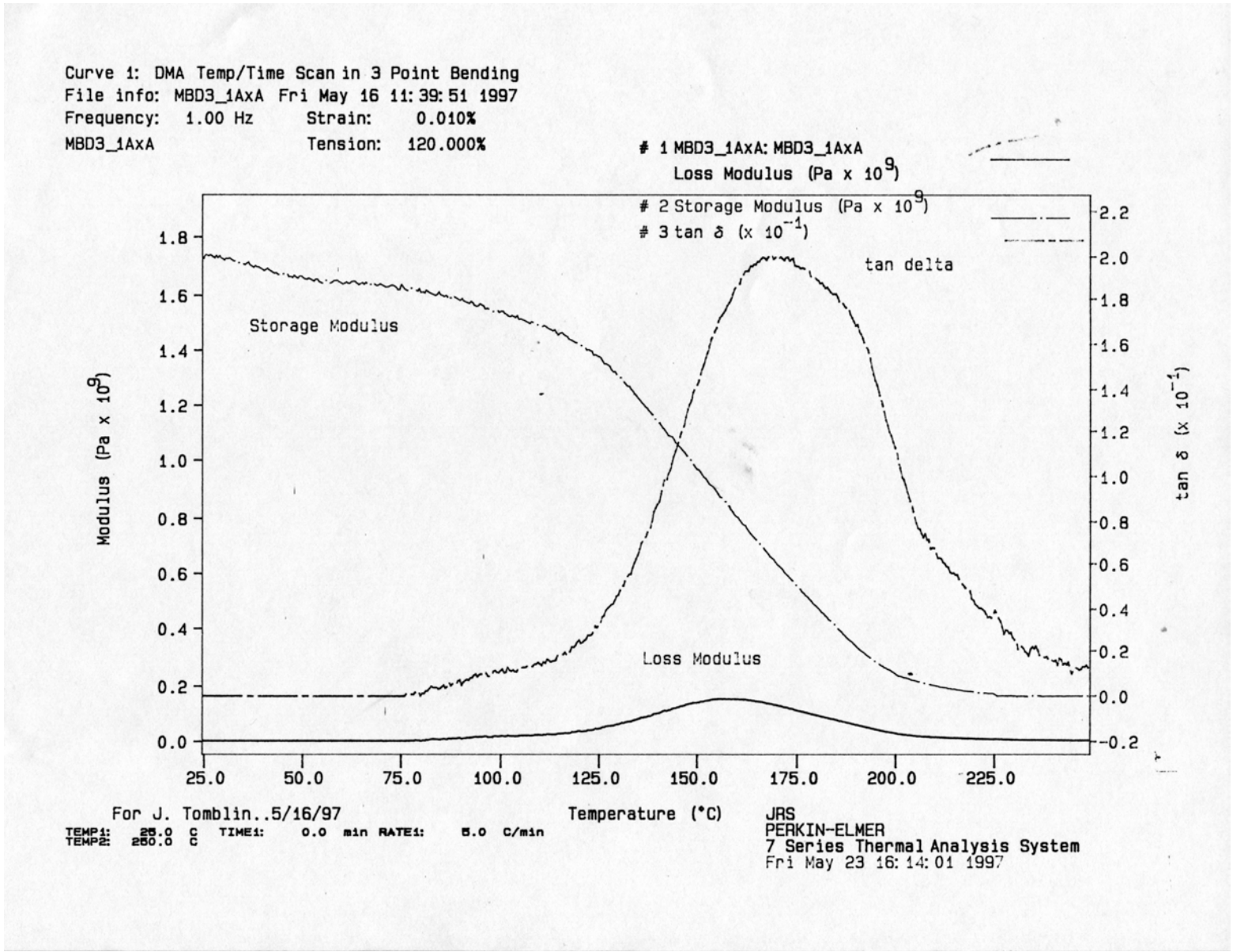


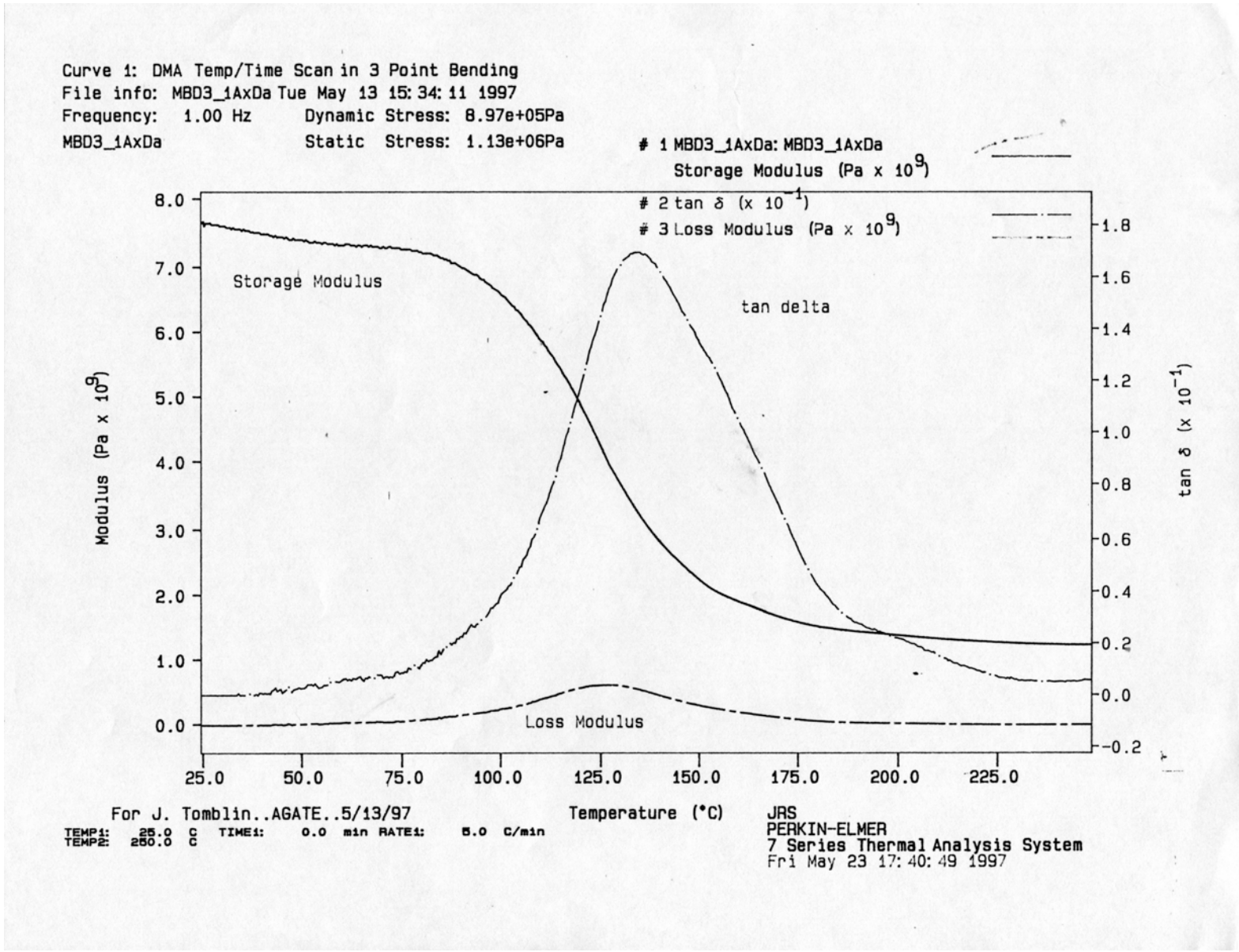












4.0 TESTING AND REPORTING COMMENTS

Conformity data is documented and archived as part of the Lancair certification program. FAA project No. TC 1616SE-A.