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CHARACTERIZATION OF EA9396 EPOXY RESIN
FOR COMPOSITE REPAIR APPLICATIONS

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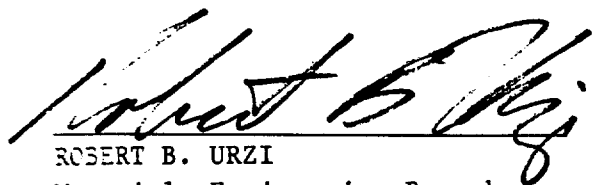
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13. ABSTRACT (Maximum 200 words) A program was completed to develop material property data for an epoxy resin system for aircraft repair applications. The epoxy resin was developed by Hysol and is designated EA9396. An extensive array of mechanical property data was generated for both glass and graphite reinforced laminates. Comparative properties of three resin lots were obtained. The effect of several processing and environmental variables on laminate properties was determined and the effect of long-term storage was established. All laminates prepared and tested during this program were cured with vacuum-bag pressure only. Mechanical tests were carried out at temperatures ranging from -65°F to 200°F on both dry and humidity-aged specimens. Processing variables that were studied included cure time and temperature, vacuum pressure level, resin impregnation procedure, alternate bagging schemes, alternate bleeder materials, and alternate resin/reinforcement ratios. Environmental variables that were studied included, in addition to humidity-aging, elevated temperature exposure and exposure to a high-intensity heat-pulse. <p style="text-align: right;">(Continued on attached page)</p>				
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Test results indicated that the neat EA9396 resin system absorbed about 9 percent water by weight during humidity aging and that its glass-transition temperature decreased from around 176°C (349°F) to around 107°C (225°F) as a result of moisture absorption for a 200°F/45-minute cure. Storage at temperatures ranging from 72°F to 120°F for up to 24 months had no adverse effect on achievable interlaminar shear strength. Pot/work life of the resin was only slightly shorter after 18 months than it was for fresh resin and exceeded 90 minutes at 72°F and 40 minutes at 100°F. Mechanical properties were very consistent from batch-to-batch. The absorption of moisture significantly lowered most mechanical properties, particularly with glass reinforcement.

14. SUBJECT TERMS (Concluded)

Epoxy	Tg	Glass
Two-Part	Bearing	Graphite
Repair	Dry	Elevated Temperature
Composite	Wet	Vacuum Bag
Wet Layup	Storage Life	Humidity Aging
Properties	Pot Life	Processing
Mechanical	Laminate	Temperature
Physical	Honeycomb	Pressure
Tensile	Sandwich	Thermal Flash
Compressive	Reinforcement	Cure
Shear		

PREFACE

This report covers the work performed during the period from November 1988 to May 1991 under Air Force Contract Nos. F33615-86-C-5031 and F33615-89-C-5643, Project 7381. The work was administered under the direction of the Systems Support Division of the Air Force Materials Directorate, Wright Laboratory, Wright-Patterson Air Force Base, Ohio. Mr. William Purcell (WL/MLSE) was the Program Project Engineer.

The Principal Investigator on this program was D. Robert Askins. The major portion of the laboratory work was conducted by Messrs. L. Dee Pike, Jr., Gary Andrews, and Don Byrge.

This report was submitted by the author in October 1991. The contractor's report number is UDR-TR-91-77.

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SECTION 1 INTRODUCTION

With the increased application of fiber-reinforced, resin-matrix composite materials in aircraft structure, the need for effective repair materials and procedures has led to a great deal of activity over the past 5-10 years. Some of this has focused on the development of equipment and procedures for repair while others have resulted in the development of new materials for use in repair.

Because of limitations in available equipment and the need for rapid turnaround in field repair scenarios, the techniques and materials used in repair differ from those employed in original construction. These considerations imposed a number of constraints on both the materials and procedures employed in this program. Some of these include, but are not limited to, the following:

- The material should have a long storage life at ambient temperatures ranging up to 120°F. This generally precludes the use of prepreg material and leads to two-part resin systems.
- The material should be curable at temperatures below the boiling point of water. This is desired so that any residual moisture absorbed in the substrate to which the repair is being applied does not catastrophically volatilize during cure and cause blistering, debonding, or excessive bondline porosity.
- The material should have a reasonably long pot life (approximately 1 hour) while being curable in a relatively short period (1 hour or less).
- The material should not lose a large proportion of its mechanical strength under hot/wet conditions.
- Only vacuum pressure will be available to provide compaction during cure.

An initial series of materials screening tests were carried out on several candidate materials that were identified by a review of vendor literature and direct vendor contact. The result of that screening test effort was a selection of one material for more comprehensive characterization. The investigation reported here dealt with the characterization of that material. The goal of this work was to develop a mechanical and physical property database for EA9396 glass and graphite fabricate laminates that would enable aircraft repairs to be designed using these materials.

SECTION 2 APPROACH

The materials used during this investigation are described in Section 2.1. Section 2.2 discusses and describes the mechanical and physical test methods that were employed and the experimental design that was followed. Section 2.3 discusses the processing procedures employed to fabricate both the baseline laminates, which represented the bulk of the panels, as well as those fabricated by procedures that varied from the baseline process.

2.1 MATERIALS

The principal material of interest in the investigation reported here was a wet-layup epoxy resin manufactured by Dexter-Hysol designated EA9396. This is an unfilled, low viscosity, two-part system. It was obtained in both gallon and quart kit forms directly from Dexter-Hysol. Three different batches of EA9396, produced in August, September and October of 1988, respectively, were supplied. The baseline property measurements (to be discussed in Section 2.2) employed all three of these resin batches in order to generate batch-to-batch comparisons. In addition to the baseline properties, many supplemental tests were also performed to assess the effects of various processing, reinforcement, and environmental variables on resulting properties. Batch-to-batch comparisons were not generated for these supplemental tests. Rather, these tests employed resin from only one of the three batches.

Laminate mechanical properties were generated for both glass and graphite fabric reinforced composite panels. The specific types of fabric used in these laminates are detailed in Table 1. Both of these were balanced 8-harness satin (8HS) style fabrics. The ply orientation of each laminate was such that the warp yarns of every ply ran in the same direction. Since 8HS fabric has a "top" side that consists of predominantly one yarn direction, and a "bottom" side that consists predominantly of the perpendicular yarn direction, the up/down orientation of the plies was reversed at the laminate midplane so that all plies above the midplane were oriented in the "up" direction while all plies below the midplane were oriented "down." In the data tables to follow in this report the "warp" direction is synonymous with the longitudinal or 0° direction, while the "fill" direction is synonymous with the transverse or 90° direction.

TABLE 1
GLASS AND GRAPHITE FABRIC REINFORCEMENT DESCRIPTION

Characteristic	Glass Fabric	Graphite Fabric
Fiber Type	E-Glass	Toray T300, 3K
Fiber Sizing	F-16 (Volan-A- type) 538 (Silane type)	UC 309 (epoxy compatible)
Weave Style	7781	W133 (8HS)
Fabric Width	190 cm (39.5 in)	197 cm (42 in)
Fabric Weight	295 gm/m ² (8.7 oz/yd ²)	366 gm/m ² (10.8 oz/yd ²)
Nominal Cured Ply Thickness	0.2 mm (0.008 in)	0.37 mm (0.0145 in)
Fiber Specific Gravity	2.54	1.78
Nominal Fiber Properties		
Tensile Strength	3445 MPa (500 Ksi)	3734 MPa (542 Ksi)
Young's Modulus	72 GPa (10.5 Msi)	235 GPa (34.1 Msi)
Elongation	4.8%	1.6%
Source	Hexcel (1) Burlington (2)	ICI Fiberite

(1) F-16 (Volan-A) sized fabric.

(2) 538 (Silane) sized fabric.

2.2 EXPERIMENTAL DESIGN

Seven different properties were measured on all three resin batches. These are referred to here as the baseline property measurements. Six of these seven were mechanical properties and the seventh was glass transition temperature. Table 2 lists the test matrix and test methods used for the baseline property measurements. This test matrix was repeated for both the glass and graphite fabric reinforcement and for each of the three resin batches. The glass transition tests were performed on unreinforced neat resin samples.

The baseline material properties derived from the test matrix presented in Table 2 provide a comprehensive database for repair design purposes. It incorporates the effects of different batches, reinforcement type, temperature, and dry-wet variables. The material properties generated from this test matrix represent the basic design needs.

In addition to the baseline properties listed in Table 2, numerous other supplemental tests were carried out to determine the effect of various processing and environmental variables on resulting properties. Only one batch of resin was used for these tests, and the results were compared to the baseline values, where appropriate, to assess the effect of the respective processing or environmental condition. Table 3 lists these supplemental, nonbaseline tests.

2.3 TEST METHODS

Nearly all of the testing conducted during this effort was performed in accordance with standard ASTM test procedures. The specific ASTM methods employed are listed in Tables 2 and 3 and are not discussed further here. The remainder of the tests were also performed in accordance with generally accepted laboratory procedures. Since, however, these are not as readily referenced as ASTM procedures, each of these non-ASTM procedures is briefly discussed in the following sections.

All specimens that were tested at other than room temperature in the dry condition were allowed to equilibrate for 20 minutes before loading was started. In order to minimize specimen dryout, testing of moisture conditioned specimens was started 4 minutes after the specimen was installed in the test fixture and the chamber door closed.

TABLE 2
 TEST MATRIX FOR BATCH-TO-BATCH COMPARISONS AND BASELINE
 MECHANICAL PROPERTY DATA

Property	Properties Measured(1)	Test Method	Replicates Per Batch at Each Test Condition Below					
			Dry		Wet (2)			
			-65°F	72°F	200°F	-65°F	72°F	200°F
Longitudinal (Warp) Tension	F _{tu} , ε _{ult} , E _t , ν ₁₂	ASTM D3039	0	5	0	0	5	0
Transverse (Fill) Tension	F _{tu} , ε _{ult} , E _t , ν ₁₂	ASTM D3039	5	5	5	5	5	5
Longitudinal (Warp) Compression	F _{cu} , ε _{ult} , E _c	ASTM D3410B	0	5	0	0	5	0
Transverse (Fill) Compression	F _{cu} , ε _{ult} , E _c	ASTM D3410B	5	5	5	5	5	5
45° Tension/ Inplane Shear	F _{ipsu} , E _t , G, ν ₁₂	ASTM D3518	5	5	5	5	5	5
Interlaminar Shear	F _{ils}	Four-Point Shear (3)	0	5	0	0	5	5
Glass Transition Temp.	T _g	DMA (4)		3 (5)			3 (5)	

- NOTES: (1) Poisson's ratio was only measured on two specimens from each set of five in the tensile tests.
 (2) Wet = tested at indicated test temperature after wet aging to saturation at 60°C (140°F)/100% R.H.
 (3) See Reference 1 and Section 2.3.1.
 (4) DMA = Dynamic Mechanical Analysis.
 (5) Glass Transition tests are not run at 22°C (72°F). The specimens are heated from 22°C (72°F) to above T_g at a constant heating rate.

TABLE 3

**SUMMARY OF SUPPLEMENTAL TESTS TO DETERMINE
 SPECIFIC MATERIALS PROPERTIES AND THE
 EFFECTS OF PROCESSING AND ENVIRONMENTAL
 VARIABLES ON PROPERTIES (1)**

<u>Variable of Concern</u>	<u>Type of Tests Conducted</u>	<u>Test Method</u>
Effect of Maximum Cure Temperature on Degree of Cure	DSC (2)	
Cure Time and Temperature	Interlaminar Shear	Four-Point Shear (5)
Cure Pressure	Laminate Physical Properties and Interlaminar Shear	ASTM D3171, D792, D2584, D2734, Four-Point Shear (5)
Bearing Strength	MIL-HDBK-17B Bearing Strength	MIL-HDBK-17B
Effect of 350°F Exposure	Interlaminar Shear	Four-Point Shear (5)
Effect of Resin Content	Interlaminar Shear and Compression	Four-Point Shear (5) ASTM D3410B
Effect of Storage Time and Temperature	Interlaminar Shear	Four-Point Shear (5)
	Viscosity	ASTM D2393
	Viscosity Curing Profile	Rheometrics RSA II
	DSC (2)	---
	FTIR (3)	---
	HPLC (4)	---
Effect of Temperature on Pot Life	Manual/Visual Assessment	N.A.
Effect of Adhesive Fillet Size on Honeycomb Sandwich	Flatwise Tension	ASTM D297

TABLE 3 (Concluded)

**SUMMARY OF SUPPLEMENTAL TESTS TO DETERMINE
 SPECIFIC MATERIALS PROPERTIES AND THE
 EFFECTS OF PROCESSING AND ENVIRONMENTAL
 VARIABLES ON PROPERTIES (1)**

<u>Variable of Concern</u>	<u>Type of Tests Conducted</u>	<u>Test Method</u>
Effect of Skin Processing Technique on Honeycomb Sandwich	Edgewise Compression	ASTM C364
Effect of Thermal Flash	Compression	ASTM D3410B
Effect of Alternate Impregnation and Bagging Schemes	Physical Properties	ASTM D792, D3171, D2584, D2734
Effect of A1100 Sizing on Wet-Strength Retention	Tension Inplane Shear Interlaminar Shear	ASTM D3039 ASTM D3518 Four-Point Shear (5)

NOTES:

- (1) Only one resin batch used for these tests.
- (2) Dynamic Scanning Calorimetry.
- (3) Fourier Transform Infrared Spectroscopy.
- (4) High Pressure Liquid Chromatography.
- (5) See Reference 1 and Section 2.3.1.

2.3.1 Interlaminar Shear

The most common test for interlaminar shear strength of composite laminates is the short beam shear (SBS) test of ASTM D2344. While this procedure calls for specimens 6.4 mm (0.25 inch) thick, most short beam shear tests on composite materials do not meet this requirement. The specimens are more commonly only around 3.2 mm (0.125 inch) or less thick. The typical result of such a test is that while a number for apparent interlaminar shear strength is generated, the failure mode is seldom interlaminar shear. An alternative test, referred to as Four-Point Shear (FPS), has been proposed and has been demonstrated as more likely to produce true and consistent interlaminar shear failure modes (Ref. 1). As a consequence of the advantages of the FPS test over the SBS test, the FPS test was used in this investigation to generate interlaminar shear data.

The FPS test is a modified version of the flexure test described in ASTM D790, Method II, Procedure B. In order to ensure an interlaminar failure mode, however, the support span is reduced to half the span used in flexural testing. Thus, the FPS tests carried out in this investigation were conducted at support span to specimen thickness ratios of 8 to 1 for the glass reinforced specimens and 16 to 1 for the graphite reinforced specimens.

2.3.2 Glass Transition Temperature

Glass transition temperature (T_g) can be determined by means of differential scanning calorimetry (DSC), thermomechanical analysis (TMA), and dynamic mechanical analysis (DMA). In DSC, the T_g is determined from the position of the shift in the baseline on a plot of heat release vs. temperature. The T_g values obtained with DSC are consistently lower (by 20-40°C) than those obtained with either TMA or DMA. In TMA, the T_g is determined from the location of change in slope of a plot of change in specimen length vs. temperature. The T_g values obtained from TMA are usually within 0-10°C of the value obtained with DMA. In DMA, the T_g is determined from the position of the peak in either the loss modulus (E'') vs. temperature curve or the $\tan \delta$ vs. temperature curve. The T_g values from the $\tan \delta$ curve are always higher than those from the loss modulus curve.

In this investigation the Tg values were determined on neat EA9396 cast resin samples by means of the loss modulus curve in a DMA test. The test was carried out at a heating rate of 0.5°C/min.

2.3.3 Bearing Strength

Although this test was not carried out in accordance with an ASTM standard, it was in accordance with the standard procedure for bearing strength presented in MIL-HDBK-17B (Ref. 2).

2.3.4 Viscosity

Viscosity of the uncured resin was measured in general accordance with ASTM Method D2393 using a Brookfield RVF Viscometer. All measurements were carried out at 22±2°C (72±4°F).

2.3.5 Viscosity Curing Profile

A viscosity curing profile is a continuous measure of polymer viscosity during polymerization (cure). While the procedure can be carried out for any time-temperature history, it is usually performed by heating the test sample at a constant rate until cure is complete. This procedure was used for this investigation. Resin samples were tested in a Rheometrics Solids Analyzer (RSA II) at a heating rate of 1°C/minute and a frequency of 1 Hz. The sample was contained in a parallel plate configuration and both dynamic (η') and loss (η'') viscosities were continuously recorded throughout the test. The dynamic viscosity (η') was used as an indication of the resin viscosity behavior.

2.3.6 Differential Scanning Calorimetry (DSC)

A DSC test measures the heat released by a test sample as its temperature is raised. As the sample undergoes polymerization, the heat released during the polymerization process is reflected as the area under the hump of the heat release vs. temperature curve. If a sample is only partially polymerized, only part of the heat of polymerization will be released and the area under the curve will be correspondingly reduced. Thus, the heat release during a DSC test can be used as a measure of degree of cure.

The DSC tests carried out in this investigation were performed on a DuPont 9900 instrument in accordance with generally accepted thermal analysis techniques. Sample sizes were 5 mg.

2.3.7 Fourier Transform Infrared (FTIR) Spectroscopy

FTIR spectroscopy is a widely use and standard analytical procedure that can be used to identify the presence or absence of different chemical groups. FTIR analysis in this study were performed with a Nicolet 200XD Transform Infrared Spectrometer. These tests were performed on uncured resin samples after various periods of storage to determine whether chemical changes occurred. The resin sample was simply spread onto a salt crystal for mounting in the spectrometer.

2.3.8 High Pressure Liquid Chromatography (HPLC)

HPLC is also a widely used and generally well standardized procedure that separates multicomponent formulations into their constituent parts. The separation occurs because different components have different transit times through chromatography columns. These differences arise because of differences in molecular size and relative attraction to the column packing material.

In this program, samples were prepared for HPLC analysis by dissolving in dioxane to a concentration of 1% by weight and filtering through a 0.5-micron PTFE filter to remove insolubles. The gradient profile used during the HPLC test is listed below. The flow rate during analysis was 0.5 ml/minute.

<u>Time (minutes)</u>	<u>% Water</u>	<u>% Dioxane</u>
1	50	50
10	50	50
40	30	70
50	30	70

The analyses were carried out on a Hewlett-Packard Model 1090 instrument with a reverse phase C-18 ZORBOX ODS column (250 x 4.6 mm) and a UV detector.

2.4 PROCESSING PROCEDURES

The "Standard" laminate processing procedure is described in detail in Appendix A, and the various "non-Standard" procedures are described in Appendix B.

We must note that this effort was not to develop or use the precise repair processing procedure that might be used in actual on-aircraft repair with these materials. Rather, a laboratory procedure was employed that was both convenient and that produced laminate quality comparable to what would be expected in repair scenarios.

All of the laminates prepared during this investigation were prepared by wet-layup hand-impregnation procedures. Most of the laminates were prepared in the same manner, by what will be referred to as the "Standard" procedure. This includes all of the baseline laminates (Table 2) and many of the supplemental laminates (Table 3). The processing procedures used for the remainder of the supplemental laminates (Table 3) differed from the "Standard" procedure in a variety of ways, depending on the particular variable being investigated. Examples of such differences include a difference in cure temperature, cure pressure, resin/reinforcement ratio, bagging scheme, or ply impregnation procedure. A detailed step-by-step description of the "standard" procedure is presented in Appendix A, along with the rationale for certain of the procedural details.

The amount of resin used to impregnate the reinforcing fabric was about 50% more than the amount remaining in the laminate after cure, with the excess bled out the top of the ply stack. The quantity of resin used to impregnate the reinforcing fabric was determined as a ratio to the amount of reinforcement being impregnated. In the case of the laminates used in this program, the resin was not apportioned equally to each ply of reinforcement. Rather, every other ply was impregnated. This approach was adopted for two reasons. First, it considerably shortened the time required to complete the wet-layup, thereby eliminating potential pot life problems. Secondly, it permitted much more resin to be distributed onto and worked into a ply. This made it much easier to uniformly spread and impregnate a ply. The alternating dry plies were laid atop each wet impregnated ply and manually tamped down so that in short order it was uniformly wetted by resin from the preceding plies. The laminates were cured in an air circulating oven for 45 minutes at 93°C (200°F) under vacuum pressure. The vacuum level applied to the vacuum bag was typically ~635 mm (25 inches) Hg.

SECTION 3 DISCUSSION OF RESULTS

As would be surmised from the tests outlined in Table 2, a very substantial quantity of mechanical property data was generated during this program. The majority of these data represent baseline tensile, compressive, inplane and interlaminar shear properties that were determined on three different resin batches. In addition to these baseline data, additional data, as outlined in Table 3, were generated on only a single resin batch for a variety of different properties and processing or environmental exposure variations.

The following sections (3.1 through 3.12) discuss these various test results item by item. In these sections, all the data presented in either tabular or graphical form represent average values. Individual specimen data are presented in Appendices C-Q.

3.1 LAMINATE PHYSICAL PROPERTIES

The physical properties of nearly every laminate fabricated during this program were determined. These included specific gravity (D792), cured ply thickness, fiber content, resin content, and void content (D2734). In the case of the glass reinforced laminates, the fiber and resin contents were determined with an ignition loss procedure (D2584), while in the case of the graphite reinforced laminates, an acid digestion procedure (D3171, procedure A) was used. Table 4 presents a summary of the laminate physical property data for all the laminates prepared with the baseline fabrication procedure. Appendix C presents individual panel data. The physical properties of laminates fabricated by procedures that deviated from the baseline processing procedure may have been different or equivalent to those listed in Table 4. depending on the nature of the processing deviation. These will be noted as appropriate in the following sections.

It is apparent from the data in Table 4 that the laminate quality produced by the standard baseline processing procedure described in Appendix A was very consistent. While the void contents of these laminates was consistently in the vicinity of 5% by volume, it must be remembered that this was for a vacuum bag cure. While no mechanical property data were generated in this program on autoclave cured laminates, some were prepared in this manner for another project and were essentially void free as a result of the positive pressure during cure instead of vacuum pressure.

TABLE 4
 PHYSICAL PROPERTIES SUMMARY FOR LAMINATES PREPARED WITH
 BASELINE PROCESSING PROCEDURE (1)

Type of Laminate	Specific Gravity		Ply Thickness (10 ⁻³ inch)		Fiber Content (% by vol)		Resin Content (% by wt.)		Void Content (% by vol.)	
	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.
T300-W133(Gr)/EA9396 (2)	1.48	0.01	15.1	0.3	55.8	1.0	33.9	1.3	4.7	0.8
"E" - 7781(GI)/EA9396 (2)	1.91	0.03	8.5	0.2	55.0	1.5	26.6	1.4	5.0	1.1

(1) The baseline processing procedure is detailed in Appendix A.

(2) Values based on 23 baseline laminates.

3.2 BATCH-TO-BATCH MECHANICAL PROPERTY COMPARISONS

The following four subsections present and discuss the results from the batch-to-batch mechanical property comparisons in tension, compression, inplane shear, and interlaminar shear. Table 2 listed the test matrices for these tests and indicated the data that was obtained. All of the laminates used for these tests were prepared in accordance with the standard processing procedures described in Appendix A. The data from these tests are considered as the "baseline" properties and are so referred to in later sections and tables of this report.

3.2.1 Tension

Tension tests were carried out in both the longitudinal (warp) and transverse (fill) directions for both reinforcements (graphite and glass fabric) and all three resin batches. Tables 5-10 summarize the tensile data from the baseline tests. While it is evident from the data in these tables that there are no appreciable differences evident between the three batches of resin, the effect of temperature and moisture are very apparent.

3.2.2 Compression

Compression tests were carried out in both the longitudinal (warp) and transverse (fill) directions for both reinforcements (graphite and glass fabric) and all three resin batches. Tables 11-16 summarize the compression data from the baseline tests. As with the tensile data, it is evident that there are no appreciable differences evident between the three batches of resin.

3.2.3 Inplane Shear

Inplane shear tests were carried out on both reinforcements (graphite and glass fabric) and all three resin batches. Tables 17-20 summarize the inplane shear data from the baseline tests. As with the tensile and compression data, no appreciable batch-to-batch differences are evident in the inplane shear data.

3.2.4 Interlaminar Shear

Interlaminar shear tests were carried out on both reinforcements (graphite and glass fabric) and all three resin batches. Interlaminar shear tests, however, were not performed for as many of the test conditions as was the case for tension, compression,

TABLE 5
 BASELINE LONGITUDINAL (WARP) TENSILE PROPERTIES OF
 GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10 ⁶ psi)		
22°C (72°F), DRY	1 - Avg. Std. Dev.	356.7 16.6	24.82 0.58	51,740 2,140	3.600 0.084	17,481 973	0.121 ---
	2 - Avg. Std. Dev.	368.5 23.5	25.37 0.61	53,440 3,410	3.680 0.088	18,512 2,039	0.110 ---
	3 - Avg. Std. Dev.	345.4 5.2	24.70 0.56	50,090 750	3.583 0.081	17,238 559	0.114 ---
22°C (72°F), WET (2)	1 - Avg. Std. Dev.	113.1 5.6	21.94 0.66	16,400 810	3.182 0.095	5,283 438	0.073(3) 0.012
	2 - Avg. Std. Dev.	106.3 9.2	22.57 0.46	15,420 1,330	3.273 0.067	4,795 484	0.092 ---
	3 - Avg. Std. Dev.	119.5 6.7	23.70 0.42	17,330 970	3.437 0.061	5,213 328	0.092 ---

- NOTES:
1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
 2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
 3. Average of three specimens.

TABLE 6
BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10 ⁶ psi)		
-54°C (-65°F) DRY	1 - Avg. Std. Dev.	526.4 19.9	29.25 0.30	76,350 2,890	4.243 0.043	23,133+(2) 3,304	0.153 ---
	2 - Avg. Std. Dev.	476.8 69.2	28.99 1.81	69,150 10,040	4.205 0.263	18,159+(2) 4,975	0.155(3) 0.22
	3 - Avg. Std. Dev.	484.8 7.6	28.36 0.83	70,320 1,100	4.113 0.120	20,419+(2) 6,511	0.155 ---
22°C (72°F), DRY	1 - Avg. Std. Dev.	367.8 32.8	27.04 1.33	53,340 4,750	3.922 0.193	17,052 1,489	0.124 ---
	2 - Avg. Std. Dev.	368.1 16.8	24.42 0.67	53,390 2,430	3.542 0.097	18,450 1,324	0.128 ---
	3 - Avg. Std. Dev.	386.7 14.2	24.44 0.70	56,080 2,060	3.545 0.102	20,766+(2) 2,945	0.130 ---
93°C (200°F) DRY	1 - Avg. Std. Dev.	321.0 18.3	24.46 0.68	46,550 2,660	3.547 0.099	15,198 824	0.116 ---
	2 - Avg. Std. Dev.	312.2 12.6	24.24 0.68	45,280 1,830	3.515 0.099	14,895 551	0.095 ---
	3 - Avg. Std. Dev.	301.9 29.2	24.25 0.80	43,790 4,230	3.517 0.116	13,005+(2) 2,268	0.094 ---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. Where + sign follows an average value, strain gage failed before specimen fracture on one or more specimens.
3. Average of three specimens.

TABLE 7
BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10 ⁶ psi)		
-54°C (-65°F) WET	1 - Avg.	134.7	26.75	19,530	3.880	5,549	0.143
	Std. Dev.	19.2	0.54	2,780	0.078	1,037	---
	2 - Avg.	156.6	25.95	22,720	3.764	6,829	0.117
	Std. Dev.	15.4	1.42	2,230	0.206	460	---
	3 - Avg.	147.5	26.03	21,390	3.775	6,349	0.145
	Std. Dev.	14.7	0.66	2,130	0.095	656	---
22°C (72°F), WET	1 - Avg.	129.3	22.49	18,750	3.262	6,063	0.097
	Std. Dev.	7.3	0.62	1,060	0.090	322	---
	2 - Avg.	112.7	22.07	16,350	3.201(3)	5,292(3)	0.016
	Std. Dev.	4.4	0.78	640	0.113	226	---
	3 - Avg.	120.9	22.01	17,530	3.192	5,773	0.086
	Std. Dev.	10.9	0.23	1,580	0.033	483	---
93°C (200°F) WET	1 - Avg.	93.8	19.80	13,610	2.872	4,625	0.048
	Std. Dev.	4.0	0.38	580	0.055	148	---
	2 - Avg.	93.2	22.32	13,520	3.237	4,298	0.101
	Std. Dev.	9.1	2.83	1,320	0.411	710	---
	3 - Avg.	93.1	20.08	13,500	2.912	4,486	0.087
	Std. Dev.	7.2	2.65	1,040	0.385	430	---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of three specimens.

TABLE 8
BASELINE LONGITUDINAL (WARP) TENSILE PROPERTIES OF
GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10 ⁶ psi)		
22°C (72°F), DRY	1 - Avg.	567.4	57.78	82,300	8,380	8,911	0.053
	Std. Dev.	32.5	2.60	4,710	0.377	568	---
	2 - Avg.	561.0	56.43	81,370	8,184	7,507	0.053(3)
	Std. Dev.	29.7	2.39	4,310	0.346	835	0.013
22°C (72°F), WET (2)	3 - Avg.	539.4	59.03	78,230	8,562	7,060	0.073
	Std. Dev.	44.1	2.83	6,400	0.410	1,020	---
	1 - Avg.	597.6	62.40	86,670	9,050	9,618	0.029
	Std. Dev.	40.2	1.46	5,830	0.212	603	---
	2 - Avg.	562.3	59.58	81,560	8,642	9,277	0.041
	Std. Dev.	34.2	1.62	4,960	0.235	472	---
	3 - Avg.	596.3	60.52	86,480	8,777	9,831	0.041
	Std. Dev.	23.2	1.94	3,370	0.282	365	---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Average of three specimens.

TABLE 9
BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10 ⁶ psi)		
-54°C (-65°F) DRY	1 - Avg. Std. Dev.	642.5 30.8	62.79 0.30	93,190 4,460	9.107 0.043	10,239 395	0.060(2) 0.008
	2 - Avg. Std. Dev.	619.4 66.8	63.63 4.62	89,830 9,690	9.229 0.670	9,283 530	0.048 ---
	3 - Avg. Std. Dev.	611.4 20.1	65.77 1.94	88,680 2,910	9.540 0.281	9,208 428	0.053 ---
22°C (72°F), DRY	1 - Avg. Std. Dev.	663.8 26.0	57.07 1.78	96,280 3,770	8.278 0.258	11,157 493	0.048(2) 0.001
	2 - Avg. Std. Dev.	687.1 12.7	60.60 1.37	99,660(2) 1,840	8.790(2) 0.199	11,228(2) 355	0.063(2) 0.009
	3 - Avg. Std. Dev.	619.1 10.9	61.96 0.23	89,800(3) 1,580	8.987(3) 0.033	9,431(3) 1,136	0.044(4) ---
93°C (200°F) DRY	1 - Avg. Std. Dev.	455.3 37.3	57.23 2.67	66,030 5,410	8.301 0.387	7,827 785	0.037 ---
	2 - Avg. Std. Dev.	539.0 70.5	59.27 2.92	78,170 10,230	8.596 0.424	8,940 992	0.053 ---
	3 - Avg. Std. Dev.	567.1 36.8	62.30 0.90	82,250 5,340	9.038 0.130	8,993 494	0.082 ---

NOTES:

1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
2. Average of three specimens.
3. Average of four specimens.
4. Single specimen.

TABLE 10
BASELINE TRANSVERSE (FILL) TENSILE PROPERTIES OF
GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)	Poisson's Ratio
		Ultimate Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strength (psi)	Tensile Modulus (10 ⁶ psi)		
-54°C(-65°F) WET	1 - Avg.	671.3	64.70	97,370	9.384	9,760	0.046
	Std. Dev.	30.0	2.54	4,350	0.369	1,540	---
	2 - Avg.	650.7	65.57	94,380	9.510	9,662	0.046
	Std. Dev.	58.8	1.05	8,530	0.153	1,017	---
	3 - Avg.	677.2	66.60	98,220	9.659	10,058	0.068
	Std. Dev.	50.2	3.28	7,280	0.475	459	---
22°C (72°F), WET	1 - Avg.	572.2	59.48	82,990	8.627	9,526	0.037
	Std. Dev.	72.5	1.81	10,520	0.262	972	---
	2 - Avg.	619.6	60.63	89,860	8.794	10,264	0.046
	Std. Dev.	48.8	4.04	7,080	0.586	872	---
	3 - Avg.	619.1	60.54	89,790	8.780	10,286	0.056
	Std. Dev.	38.7	1.36	5,620	0.197	657	---
93°C (200°F) WET	1 - Avg.	448.2	54.85	65,010	7.956	7,058	0.034(3)
	Std. Dev.	41.2	4.85	5,980	0.703	2,348	0.018
	2 - Avg.	434.9	55.72	63,080	8.082	8,164	0.049(4)
	Std. Dev.	16.1	4.83	2,340	0.701	1,556	0.010
	3 - Avg.	445.8	54.63	64,660(5)	7.923(5)	6,979(5)	0.067(3)
	Std. Dev.	28.7	4.02	4,160	0.583	1,308	0.018

- NOTES:**
1. All average values represent five specimens except Poisson's ratio, which only represents two specimens unless otherwise noted.
 2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
 3. Average of three specimens.
 4. Average of four specimens.
 5. Average of five specimens.

TABLE 11
BASELINE LONGITUDINAL (WARP) COMPRESSIVE PROPERTIES
OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10 ⁶ psi)	
22°C (72°F), DRY	1 - Avg.	336.5	25.06	48,800	3.635	15,086
	Std. Dev.	25.8	2.30	3,740	0.334	2,573
	2 - Avg.	343.4	25.68	49,800	3.724	13,359
	Std. Dev.	23.7	1.36	3,440	0.197	1,198
	3 - Avg.	346.9	25.45	50,310	3.691	15,600
	Std. Dev.	9.9	0.83	1,430	0.120	926
22°C (72°F), WET (2)	1 - Avg.	163.9	21.17	23,770	3.070	8,540
	Std. Dev.	27.4	2.05	3,970	0.298	1,300
	3 - Avg.	175.5	23.57	25,450	3.419	7,742
	Std. Dev.	13.0	2.41	1,880	0.350	1,864
	2 - Avg.	95.6	95.56	13,860	3.049	5,229
	Std. Dev.	11.4	1.39	1,660	0.202	896

NOTES:

1. All average values represent five specimens.
2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
3. Tested at incorrect temperature. Should have been tested at 22°C (72°F).

TABLE 12
 BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
 OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10 ⁶ psi)	
-54°C (-65°F), DRY	1 - Avg. Std. Dev.	442.2 32.1	27.67 0.68	64,140 4,650	4.013 0.099	17,511 1,604
	2 - Avg. Std. Dev.	397.0 9.8	28.87 2.39	57,580 1,420	4.187 0.346	14,622 953
	3 - Avg. Std. Dev.	480.9 26.2	29.99 0.63	69,750 3,800	4.350 0.092	18,121 1,761
22°C (72°F), DRY	1 - Avg. Std. Dev.	287.4 23.6	26.12 0.95	41,690 3,420	3.788 0.138	11,670 2,118
	2 - Avg. Std. Dev.	269.4 20.8	24.75 1.34	39,080 3,020	3.590 0.195	11,725 2,050
	3 - Avg. Std. Dev.	287.9 18.3	24.80 2.41	41,760 2,660	3.597 0.349	12,246 3,323
93°C (200°F), DRY	1 - Avg. Std. Dev.	192.7(2) ---	23.93(2) ---	27,950(2) ---	3.471(2) ---	9,240(2) ---
	2 - Avg. Std. Dev.	172.6 11.1	23.12 1.91	25,040 1,610	3.353 0.277	7,450 1,077
	3 - Avg. Std. Dev.	230.5 16.5	24.97 1.56	33,430 2,390	3.622 0.226	9,625 1,876

NOTES:
 1. All average values represent five specimens unless otherwise noted.
 2. Average of two specimens.

TABLE 13
BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
OF GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10 ⁶ psi)	
-54°C (-65°F), WET	1 - Avg. Std. Dev.	319.5 29.6	28.38 1.06	46,340 4,300	4.116 0.154	12,196 1,686
	2 - Avg. Std. Dev.	297.8 27.1	26.75 2.36	43,190 3,930	3.881 0.342	11,330 1,090
	3 - Avg. Std. Dev.	344.7 24.8	29.14 1.48	49,990 3,600	4.227 0.215	13,633 1,424
22°C (72°F), WET	1 - Avg. Std. Dev.	147.8 16.8	22.82 0.40	21,440 2,430	3.310 0.058	7,384 1,929
	3 - Avg. Std. Dev.	177.1 12.7	24.93 3.72	25,680 1,840	3.616 0.539	8,214 815
	1 - Avg. Std. Dev.	95.5 7.6	22.31 2.23	13,850 1,100	3.236 0.323	4,493 521
93°C (200°F), WET	2 - Avg. Std. Dev.	91.4 11.7	19.33 2.73	13,260 1,700	2.803 0.396	4,809 1,335
	2 - Avg.(4) Std. Dev.(4)	88.3 6.9	14.35 2.12	12,800 680	3.060 0.308	4,156 836
	3 - Avg. Std. Dev.	119.8 7.0	22.57 4.21	17,370(3) 1,020	3.273(3) 0.610	4,727(3) 1,459

- NOTES:**
1. All average values represent five specimens unless otherwise noted.
 2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
 3. Average of four specimens.
 4. Tested inadvertently at 93°C (200°F) WET condition. Should have been tested at 22°C (72°F) WET condition.

TABLE 14
 BASELINE LONGITUDINAL (WARP) COMPRESSIVE PROPERTIES
 OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition (2)	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10 ⁶ psi)	
22°C (72°F), DRY	1 - Avg.	456.9(3)	52.88(3)	66,270(3)	7.670(3)	9,627(3)
	Std. Dev.	65.3	7.99	9,470	1.159	2,860
	2 - Avg.	496.8	60.23	72,060	8.735	8,062
	Std. Dev.	33.2	7.83	4,810	1.135	1,534
	3 - Avg.	481.8(4)	57.18(4)	69,880(4)	8.290(4)	9,532+(4,5)
	Std. Dev.	21.0	11.79	3,050	1.711	3,334
22°C (72°F), WET (2)	1 - Avg.	396.5	51.71	57,510	7.502	8,313
	Std. Dev.	61.4	4.07	8,910	0.590	2,664
	2 - Avg.	369.9	54.87	53,650	7.958	7,397
	Std. Dev.	20.8	8.27	3,010	1.200	1,794
	3 - Avg.	347.6	52.78	50,410	7.655	7,807
	Std. Dev.	14.8	9.39	2,150	1.362	2,045

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F), 100% R.H. until saturated.
3. Average of three specimens.
4. Average of four specimens.
5. Where + sign follows an average value, strain gage failed before specimen fracture on one or more specimens.

TABLE 15
BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10 ⁶ psi)	
-54°C (-65°F), DRY	1 - Avg. Std. Dev.	592.5 32.7	69.49(2) 7.78	85,930 4,740	9.499(2) 1.128	9,993(2) 1,680
	2 - Avg. Std. Dev.	531.0 41.6	56.09(2) 3.26	77,010 6,030	8.135(2) 0.473	11,615(2) 2,264
	3 - Avg. Std. Dev.	596.5 43.7	54.38 2.96	86,520 6,340	7.887 0.429	13,047 888
22°C (72°F), DRY	1 - Avg. Std. Dev.	414.2 32.3	51.51 6.83	60,080 4,680	7.471 0.990	7,919 872
	2 - Avg. Std. Dev.	410.1(2) 37.3	57.38(2) 5.08	59,480(2) 5,410	8.322(2) 0.737	8,148(2) 1,714
	3 - Avg. Std. Dev.	434.6 20.8	54.34 4.72	63,030 3,010	7.882 0.685	8,698 3,423
93°C (200°F), DRY	1 - Avg. Std. Dev.	300.2 10.7	55.93 5.24	43,540 1,550	8.112 0.760	5,342 1,055
	2 - Avg. Std. Dev.	257.1 16.5	56.29 9.18	37,290 2,400	8.164 1.331	4,511 980
	3 - Avg. Std. Dev.	279.1 11.3	52.22 1.88	40,480 1,640	7.574 0.273	6,217 853

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. Average of four specimens.

TABLE 16
 BASELINE TRANSVERSE (FILL) COMPRESSIVE PROPERTIES
 OF GRAPHITE REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition	Resin Batch No.	SI Units		U.S. Units		Ultimate Strain (10 ⁻⁶)
		Ultimate Strength (MPa)	Compressive Modulus (GPa)	Ultimate Strength (psi)	Compressive Modulus (10 ⁶ psi)	
-54°C (-65°F), WET	1 - Avg. Std. Dev.	544.1 34.1	63.28 4.64	78,920 4,950	9.179 0.673	10,090 2,806
	2 - Avg. Std. Dev.	514.1 31.5	59.32 1.42	74,560 4,570	8.604 0.206	10,476 1,383
	3 - Avg. Std. Dev.	534.3 51.4	59.32 3.14	77,500 7,460	8.604 0.456	9,337 2,256
22°C (72°F), WET	1 - Avg. Std. Dev.	365.8 32.3	61.49 1.91	53,060 4,680	8.918 0.277	5,893 848
	2 - Avg. Std. Dev.	338.3 12.1	53.43 7.74	49,070 1,760	7.749 1.123	7,366 3,156
	3 - Avg. Std. Dev.	344.6 32.3	55.50 3.55	49,980 4,690	8.049 0.515	6,754 1,256
93°C (200°F), WET	1 - Avg. Std. Dev.	168.0(3) 21.9	66.89(3) 5.58	24,370(3) 3,170	9.701(3) 0.810	2,485(3) 421
	2 - Avg. Std. Dev.	190.4 33.9	56.16 4.72	27,610 4,910	8.146 0.685	3,783 1,064
	3 - Avg. Std. Dev.	222.3(3) 23.4	58.57(3) 6.29	32,240(3) 3,400	8.495(3) 0.912	3,950(3) 704

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. WET = wet aged at 60°C (140°F), 100% R.H. until saturated.
3. Average of four specimens.

TABLE 17
 BASELINE IN-PLANE SHEAR PROPERTIES OF GLASS
 REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			±45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	+45° Tens. Modulus (GPa)	In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (10 ⁶ psi)	+45° Tens. Modulus (10 ⁶ psi)	
-54°C (-65°F), DRY	1 - Avg. Std.Dev.	114.9(2) 19.4	7.39 0.83	20.95 2.23	16,670(2) 2,820	1.072(2) 0.120	3.038(2) 0.323	0.418(2) 0.033
	2 - Avg. Std.Dev.	118.3(3) 15.9	6.93(3) 0.75	19.71(3) 2.48	17,160(3) 2,300	1.005(3) 0.109	2.858(3) 0.360	0.420(3) 0.036
	3 - Avg. Std.Dev.	115.6 16.0	7.01 0.68	19.62 2.45	16,770 2,320	1.016 0.098	2.845 0.356	0.397 0.043
22°C (72°F), DRY	1 - Avg. Std.Dev.	78.2(2) 9.9	5.94(2) 0.38	17.25(2) 1.21	11,340(2) 1,430	0.861(2) 0.055	2.502(2) 0.176	0.449(2) 0.029
	2 - Avg. Std.Dev.	80.7(4) 4.5	4.99(4) 0.46	14.28(4) 1.40	11,710(4) 813	0.723(4) 0.066	2.071(4) 0.203	0.433(4) 0.079
	3 - Avg. Std.Dev.	76.9 7.2	4.91 0.32	13.86 1.14	11,150 1,050	0.712 0.047	2.010 0.166	0.411 0.037
93°C (200°F) DRY	1 - Avg. Std.Dev.	48.7(2) 9.2	3.08(2) 0.54	10.23(2) 1.50	7,060(2) 1,330	0.446(2) 0.079	1.484(2) 0.217	0.676(2) 0.087
	2 - Avg. Std.Dev.	47.9(2) 5.4	3.09(2) 0.24	9.73(2) 0.80	6,940(2) 790	0.448(2) 0.035	1.411(2) 0.116	0.577(2) 0.091
	3 - Avg. Std.Dev.	51.2 9.5	3.38 0.37	11.01 1.17	7,420 1,380	0.490 0.054	1.597 0.169	0.631 0.047

NOTES:

1. All average values represent five specimens unless otherwise noted.
2. Average of seven specimens.
3. Average of six specimens.
4. Average of eleven specimens.

TABLE 18
BASELINE IN-PLANE SHEAR PROPERTIES OF GLASS
REINFORCED E-7781/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			+45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	+45° Tens. Modulus (GPa)	In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (10 ⁶ psi)	+45° Tens. Modulus (10 ⁶ psi)	
-54°C (-65°F), WET	1 - Avg. Std.Dev.	60.3(3) 9.5	6.41(3) 0.24	18.91(3) 0.79	8,740(3) 1,380	0.930(3) 0.035	2.743(3) 0.115	0.476(3) 0.051
	2 - Avg. Std.Dev.	57.7 7.3	5.30 0.68	15.89 1.14	8,370 1,060	0.769 0.099	2.305 0.166	0.508 0.096
	3 - Avg. Std.Dev.	57.3 6.0	6.01 0.64	18.01 1.83	8,310 870	0.873 0.093	2.612 0.266	0.498 0.022
22°C (72°F), WET	1 - Avg. Std.Dev.	37.0(3) 5.1	3.30(3) 0.34	10.60(3) 1.09	5,370(3) 740	0.479(3) 0.050	1.537(3) 0.158	0.610(3) 0.121
	2 - Avg. Std.Dev.	37.9 2.8	3.04 0.66	9.63 1.32	5,490 400	0.441 0.096	1.396 0.192	0.608 0.150
	3 - Avg. Std.Dev.	39.1 5.4	3.84 0.52	12.77 1.68	5,670 790	0.557 0.076	1.852 0.244	0.672 0.172
93°C (200°F) WET	1 - Avg. Std.Dev.	18.7(4) 3.3	1.61(4) 0.42	5.58(4) 0.84	2,710(4) 480	0.234(4) 0.061	0.809(4) 0.122	0.775(4) 0.237
	2 - Avg. Std.Dev.	19.3 0.9	1.34 0.28	4.87 0.86	2,800 130	0.194 0.041	0.706 0.125	0.840 0.217
	3 - Avg. Std.Dev.	18.6 2.6	2.08 0.72	7.52 2.23	2,700 370	0.301 0.104	1.091 0.323	0.835 0.120

NOTES:
 1. All average values represent five specimens unless otherwise noted.
 2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
 3. Average of eight specimens.
 4. Average of seven specimens.

TABLE 19
 BASELINE IN-PLANE SHEAR PROPERTIES OF GRAPHITE
 REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			+45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	+45° Tens. Modulus (GPa)	In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (10 ⁶ psi)	+45° Tens. Modulus (10 ⁶ psi)	
-54°C(-65°F), DRY	1 - Avg. Std.Dev.	125.1 16.8	5.50 0.67	18.91 2.00	18,140 2,440	0.797 0.097	2.742 0.290	0.723 0.052
	2 - Avg. Std.Dev.	120.5 8.8	5.79 0.53	19.38 1.85	17,480 1,270	0.839 0.077	2.811 0.269	0.674 0.037
	3 - Avg. Std.Dev.	134.8 4.3	5.86 0.34	20.31 1.61	19,550 620	0.850 0.050	2.945 0.233	0.731 0.056
22°C (72°F), DRY	1 - Avg. Std.Dev.	89.3 9.8	3.99 0.57	14.30 2.13	12,950 1,420	0.579 0.083	2.074 0.309	0.791 0.060
	2 - Avg. Std.Dev.	81.9 3.4	4.28 0.44	14.67 0.96	11,880 500	0.621 0.064	2.128 0.140	0.721 0.087
	3 - Avg. Std.Dev.	93.9 8.5	4.43 0.32	15.25 1.43	13,620 1,230	0.642 0.047	2.211 0.208	0.724 0.147
93°C (200°F) DRY	1 - Avg. Std.Dev.	53.5 7.4	2.62 0.21	9.92 0.84	7,760 1,080	0.380 0.031	1.439 0.122	0.894 0.053
	2 - Avg. Std.Dev.	52.6 3.7	3.18 0.68	11.34 1.93	7,630 540	0.461 0.098	1.645 0.280	0.799 0.093
	3 - Avg. Std.Dev.	55.6 4.1	2.74 0.24	10.12 1.13	8,060 600	0.398 0.035	1.468 0.164	0.840 0.081

NOTES: 1. All average values represent five specimens unless otherwise noted.

TABLE 20
BASELINE IN-PLANE SHEAR PROPERTIES OF GRAPHITE
REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL (1)

Test Condition(2)	Resin Batch No.	SI Units			U.S. Units			+45° Poisson's Ratio
		In-Plane Shear Str. (MPa)	In-Plane Shear Mod. (GPa)	+45° Tens. Modulus (GPa)	In-Plane Shear Str. (10 ⁶ psi)	In-Plane Shear Mod. (10 ⁶ psi)	+45° Tens. Modulus (10 ⁶ psi)	
-54°C(-65°F), WET	1 - Avg. Std.Dev.	112.4 17.4	5.96 0.19	19.98 1.60	16,300 2,520	0.865 0.028	2.897 0.232	0.673 0.093
	2 - Avg. Std.Dev.	116.1 10.6	6.37 0.82	21.26 2.85	16,830 1,540	0.924 0.119	3.083 0.414	0.669 0.052
	3 - Avg. Std.Dev.	119.2 14.8	4.89 0.43	17.52 1.79	17,280 2,140	0.709 0.063	2.541 0.260	0.791 0.070
22°C (72°F), WET	1 - Avg. Std.Dev.	68.7 9.3	3.39 0.31	11.74 1.10	9,970 1,350	0.492 0.045	1.702 0.159	0.729 0.083
	2 - Avg. Std.Dev.	70.5 9.4	4.21 0.89	14.92 3.12	10,230 1,370	0.610 0.129	2.163 0.453	0.779 0.128
	3 - Avg. Std.Dev.	77.1 6.7	3.61 0.41	13.46 1.29	11,180 970	0.524 0.060	1.952 0.187	0.869 0.108
93°C (200°F) WET	1 - Avg. Std.Dev.	31.2 4.3	1.70 0.41	5.97 1.42	4,520 630	0.247 0.059	0.866 0.206	0.755 0.124
	2 - Avg. Std.Dev.	30.8 3.5	1.85 0.86	6.82 2.83	4,470 500	0.268 0.124	0.989 0.410	0.873 0.186
	3 - Avg. Std.Dev.	30.9 3.3	1.57 0.28	6.59 0.83	4,480 480	0.228 0.040	0.956 0.120	1.074 0.142

NOTES:
 1. All average values represent five specimens unless otherwise noted.
 2. WET = wet aged at 60°C (140°F)/100% R.H. until saturated.

and inplane shear. Table 21 summarizes the interlaminar shear data from the baseline tests. Again, all three resin batches produced very similar property levels.

3.3 GLASS TRANSITION TEMPERATURE

As noted in Section 2.3.2 and Table 2, Tg measurements were carried out on neat resin samples for both dry and wet conditions by means of a DMA test. Figure 1 illustrates a typical DMA test result, and the Tg value determined from the analysis is indicated in the figure. Table 22 summarizes the Tg data from the baseline tests. It is apparent from the data in Table 22 that the batch-to-batch Tg values are in excellent agreement and also that absorbed moisture significantly reduces the Tg of EA9396.

An additional Tg test was performed on a neat EA9396 resin sample that was cured at a lower temperature and for a shorter time than the standard cure condition. This value is also listed in Table 22 for comparison. The reduced Tg value for this shorter, lower temperature cure suggests that cure is incomplete and this corroborates the results from the cure studies that are discussed in Sections 3.5.1 and 3.5.2.

3.4 BEARING STRENGTH

Bearing strength tests were performed on only one of the three resin batches. All of the laminates used for bearing strength tests were prepared and cured in accordance with the standard baseline processing procedures, detailed in Appendix A. Bearing strength tests were carried out on both reinforcements (graphite and glass fabric) and in both the wet and dry condition although only at room temperature. Table 23 summarizes the bearing test data. It is evident from these data that absorbed moisture significantly reduces bearing strength.

3.5 EFFECT OF NONBASELINE CURE/PROCESSING CONDITIONS

The baseline cure condition used in this program was a vacuum bag cure at 93°C (200°F) for 45 minutes. Alternative conditions that were used included curing at both lower and higher temperatures, lower and higher cure vacuum levels than the baseline 635 mm (25 in) Hg, and cure times other than 45 minutes. Laminates processed at these alternative conditions were tested for interlaminar shear strength to assess the effect of the alternative cure. In addition, a number of differential scanning calorimetry (DSC) measurements were made for different cure temperatures and cure histories.

TABLE 21
 BASELINE INTERLAMINAR SHEAR PROPERTIES OF
 EA9396 COMPOSITE LAMINATES

Reinforcement Type	Resin Batch Number	Test Condition(3)	SI Units		U.S. Units		Weight Gain During Aging (%)
			Interlaminar Shear Strength (1,2) (MPa) Avg. Std. Dev.	Interlaminar Shear Strength (1,2) (psi) Avg. Std. Dev.	Interlaminar Shear Strength (1,2) (psi) Avg. Std. Dev.	Interlaminar Shear Strength (1,2) (psi) Avg. Std. Dev.	
"E"-7781 Glass	1	22°C(72°F) Dry	40.03	1.68	5806	244	N.A.
	2	22°C(72°F) Dry	38.27	1.22	5551	177	N.A.
	3	22°C(72°F) Dry	37.97	1.64	5507	238	N.A.
	1	22°C(72°F) Wet	18.66	0.37	2706	53	2.32
	2	22°C(72°F) Wet	20.74	0.85	3008	124	2.10
	3	22°C(72°F) Wet	22.17	0.35	3216	51	2.09
	1	93°C(200°F) Wet	9.25	0.50	1342	73	2.24
	2	93°C(200°F) Wet	13.25	0.57	1922	82	2.09
	3	93°C(200°F) Wet	12.93	0.52	1875	75	2.11
T300-W133 Graphite	1	22°C(72°F) Dry	39.06	2.78	5665	403	N.A.
	2	22°C(72°F) Dry	39.82	4.55	5776	660	N.A.
	3	22°C(72°F) Dry	38.94	2.35	5648	341	N.A.
	1	22°C(72°F) Wet	32.74	15.82	4748	409	2.19
	2	22°C(72°F) Wet	32.63	6.96	4733	180	2.32
	3	22°C(72°F) Wet	31.78	4.14	4609	107	2.24
	1	93°C(200°F) Wet	14.21	1.19	2061	173	2.22
	2	93°C(200°F) Wet	15.51	0.48	2250	69	2.32
	3	93°C(200°F) Wet	18.73	0.97	2716	140	2.24

- NOTES:
- Four-point shear. Graphite tests at 16:1 span-thickness ratio, Glass tests at 8:1.
 - Warp direction of fabric is running in length direction of specimens.
 - WET = wet aged at 60°C (140°F)/95-100% R.H. until saturated.

Sample : EA 9396 2-2 DRY
Size : 22.70 x 13.30 x 1.85 mm
Method : DMA-STEP 2°
Comment: STEP 2°C

File : E:RUN1883.01
Operator: GALASKA
Run Date: 06/13/89 16:05

DMA

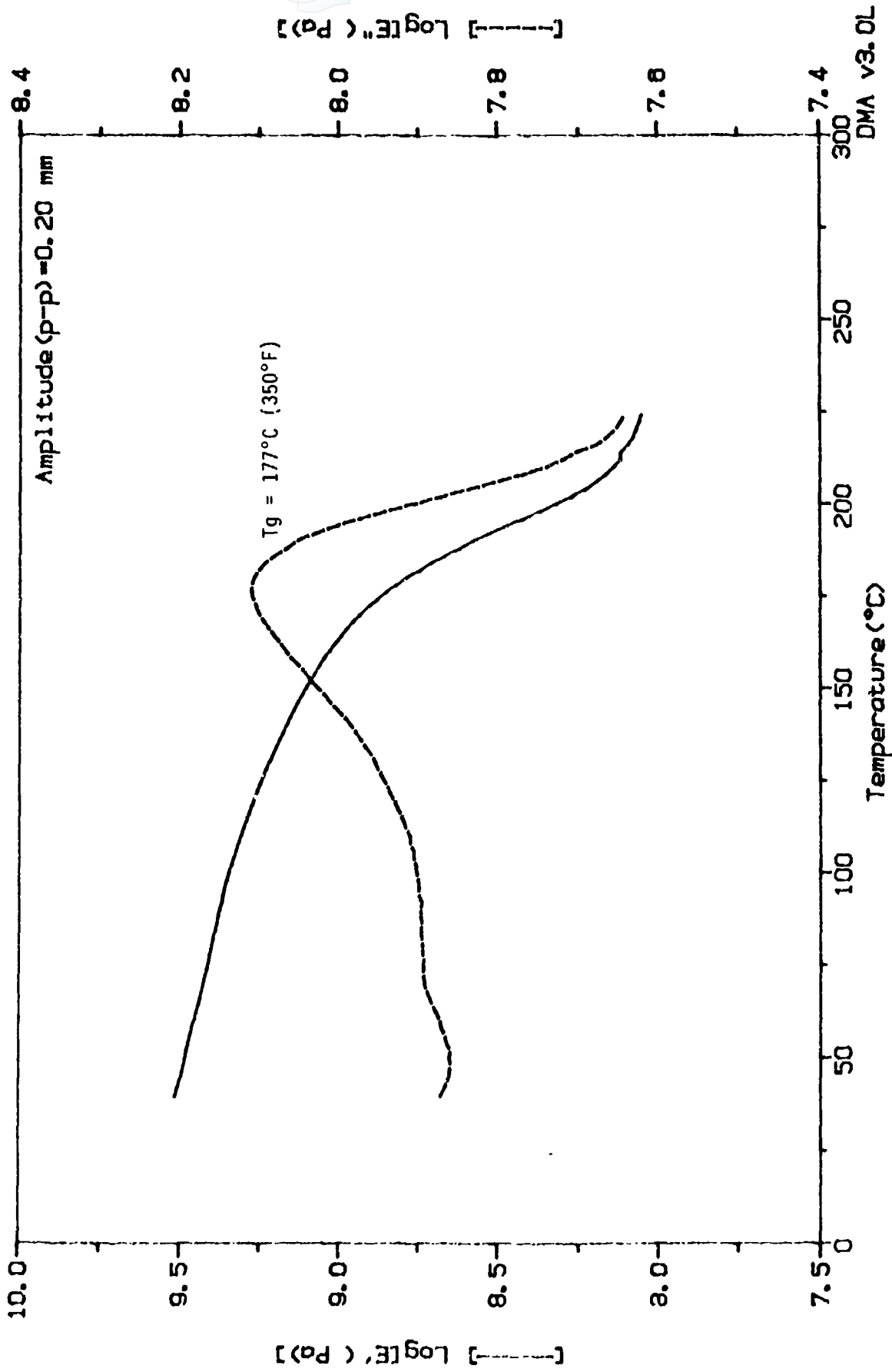


Figure 1. Typical DMA Cure With Tg Value.

TABLE 22

GLASS TRANSITION TEMPERATURE OF EA9396
NEAT RESIN CASTINGS (1)

Resin Batch Number	Test Condition	Tg (2)		Weight Gain During Aging (%)
		(°C)	(°F)	
1 - Avg.	Dry	175	347	N.A.
2 - Avg.	Dry	176	349	N.A.
3 - Avg.	Dry	177	350	N.A.
1 - Avg.	Wet (3)	106	223	9.1
2 - Avg.	Wet (3)	108	226	8.7
3 - Avg.	Wet (3)	107	225	8.8
NA (4)	Dry	149	300	N.A.

- (1) Castings cured 45 minutes at 93°C (200°F) unless otherwise noted.
- (2) Listed values represent averages of three test samples from each resin batch.
- (3) Wet = Aging at 60°C (140°F), 95-100% R.H. until saturated.
- (4) Casting cured 30 minutes at 82°C (180°F).

TABLE 23

ROOM TEMPERATURE BEARING STRENGTH OF EA9396
COMPOSITE MATERIAL

Reinforcement	Aging Condition	Bearing Strength @	
		4% Elong. (ksi)	Max. Bearing Strength (ksi)
E-7781 Glass	None(dry)	42.4	54.9
	Wet (1)	21.6	35.1
T300-W133 Graphite	None (dry)	58.3	71.3
	Wet (1)	33.7	89.0

- (1) Wet aged at 60°C (140°F), 95-100% RH until saturated.

3.5.1 Effect of Cure Temperature on Degree of Cure by DSC

Both isothermal and dynamic DSC measurements were made on neat uncured EA9396 resin samples. Table 24 summarizes the data obtained from these tests. Figure 2 illustrates typical dynamic and isothermal DSC test scans. Heat released as a result of the polymerization (or cure) reaction causes the plotted curve to rise above the baseline. The area under this curve corresponds to the total heat released during the curing reaction. In the two curves illustrated in Figure 2, the total heat released was 535.1 J/gm for the case of the dynamic scan and 479.3 J/gm for the case of the isothermal scan. The higher heat release value for the dynamic test implies that the sample was more completely cured during this test than in the isothermal test. This is a logical result since the sample was heated to a substantially higher maximum temperature in the dynamic test (>200°C (>392°F)) than in the isothermal test (82°C (180°F)).

In the case of the isothermal tests, a second DSC test, carried out in the dynamic mode at 2°C/minute, was performed on each sample to determine residual exotherm. Figure 3 illustrates a dynamic DSC test result from which residual exotherm, or heat release during postcure, was obtained.

The first two tests listed in Table 24, dynamic tests at 10°C/minute and 1°C/minute, respectively, were performed to establish the total exotherm (total heat release during cure) of the EA9396 resin and to determine whether heating rate caused significant differences in exotherm. From these tests, it appears that between 535 and 574 J/gm are released by EA9396 when it is completely cured. Following these tests, four isothermal tests were carried out over the temperature range of 66-107°C (150-225°F).

It is evident from the isothermal data that as the cure temperature increases, the degree of cure, as measured by the heat release, increases and the residual exotherm (or remaining cure that can be achieved) diminishes. Examination of the residual exotherm DSC curves are particularly interesting in that they demonstrate that the remainder of the cure still to be accomplished after the initial cure, does not begin until the temperature is considerably higher than the temperature at which the initial cure occurred. This is evident by comparing the curves in Figures 2b and 3. The data in Table 24 show that the postcure initiation temperature becomes progressively higher as the initial cure temperature is increased. Another point of interest from the data for the four isothermal tests in the center of Table 24 is that the sum of the heat released during

TABLE 24
 EFFECT OF TEMPERATURE ON CURE EXOTHERM BEHAVIOR
 OF EA9396 NEAT RESIN

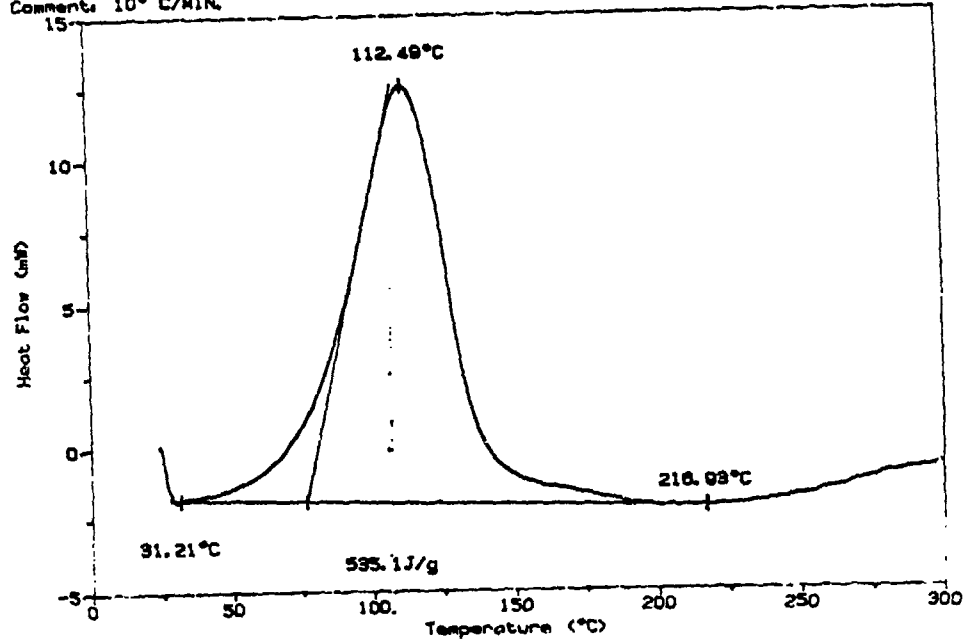
DSC Run Type	Heating Rate (°C/min)	Cure(Hold) Temperature (°C) [°F]	Time to Complete Cure at Hold Temp. (min.) (1)	Heat Release During Cure (J/gm)	Cure State (%) (2)	Heat Release During Postcure (J/gm)(3)	Temperature at Which Postcure Initiates (°C) [°F]	Total Heat Release (J/gm)
Dynamic	10	-- (4)	--	535	100%	--	--	535
Dynamic	1	-- (4)	--	574	100%	--	--	574
Isothermal	2	(66)[150]	~75	450	83%	94	(100)[212]	544
Isothermal	2	(82)[180]	~40	479	89%	57	(110)[230]	536
Isothermal	2	(93)[200]	~30	486	91%	46	(120)[248]	532
Isothermal	2	(107)[225]	~10	496	95%	27	(130)[266]	522
Isothermal	2	(82)[180]	~41	519	89%	60(5)	(107)[225]	579
Dynamic	10	-- (4)	--	--	68(est)(6)	170	(69)[156]	535(est)(6)

- (1) Time after reaching hold temperature.
- (2) Heat released during cure ÷ total heat release.
- (3) All values in this column determined in a dynamic, 2°C/min, DSC test.
- (4) Temperature increased throughout cure until no further heat release evident. Test typically terminated in 225-300°C range.
- (5) After the 82°C isothermal cure, the sample was held at 22°C for 7 days before the residual heat (of postcure) was measured in a dynamic DSC test.
- (6) Sample cured at 22°C for 7 days before residual heat (or postcure) was measured in a dynamic DSC test. Assumed a total heat release of 535 J/gm (equal to first test listed in table). Heat release during 7 day, 22°C cure assumed equal to 535 J/gm minus heat release during postcure.

Sample: EA 9396
 Size: 6.7940 mg

DSC

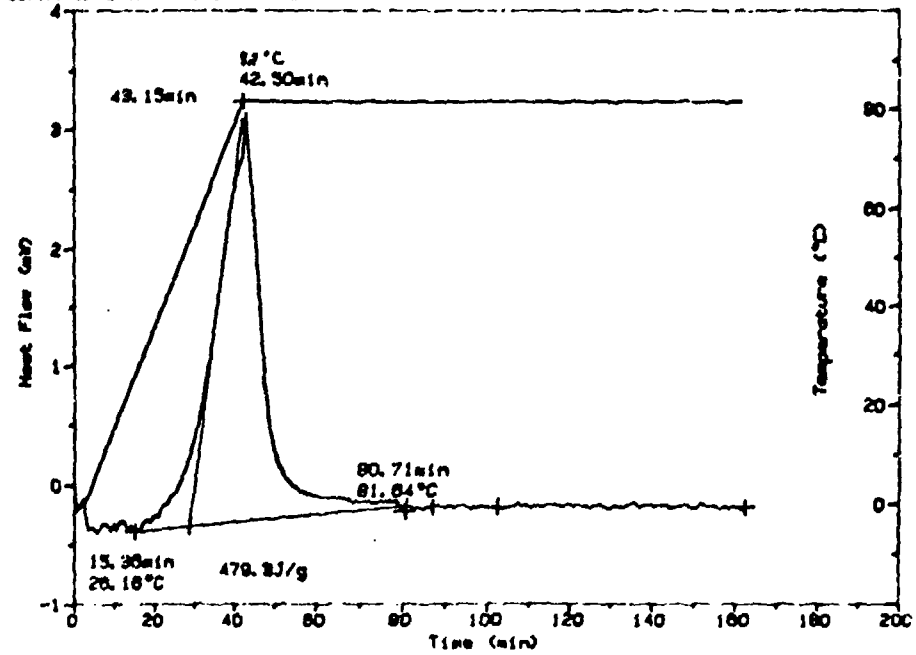
Comments: 10° C/MIN.



(a) Dynamic DSC Heat Release Test for Curing of EA9396.

Sample: EA 9396
 Size: 5.8700 mg
 Method: DSC-150 @ 82°C
 Comments: 2°C/min-150 @ 82°C

DSC



(b) Isothermal DSC Heat Release Test for Curing of EA9396 at 82°C (180°F).

Figure 2. Typical Dynamic and Isothermal Heat Release Test Results for Curing of EA9396.

DSC

Sample: EA 9396
Size: 5.8700 mg

Comment: 10°C/min AFTER ISO @ 82°C

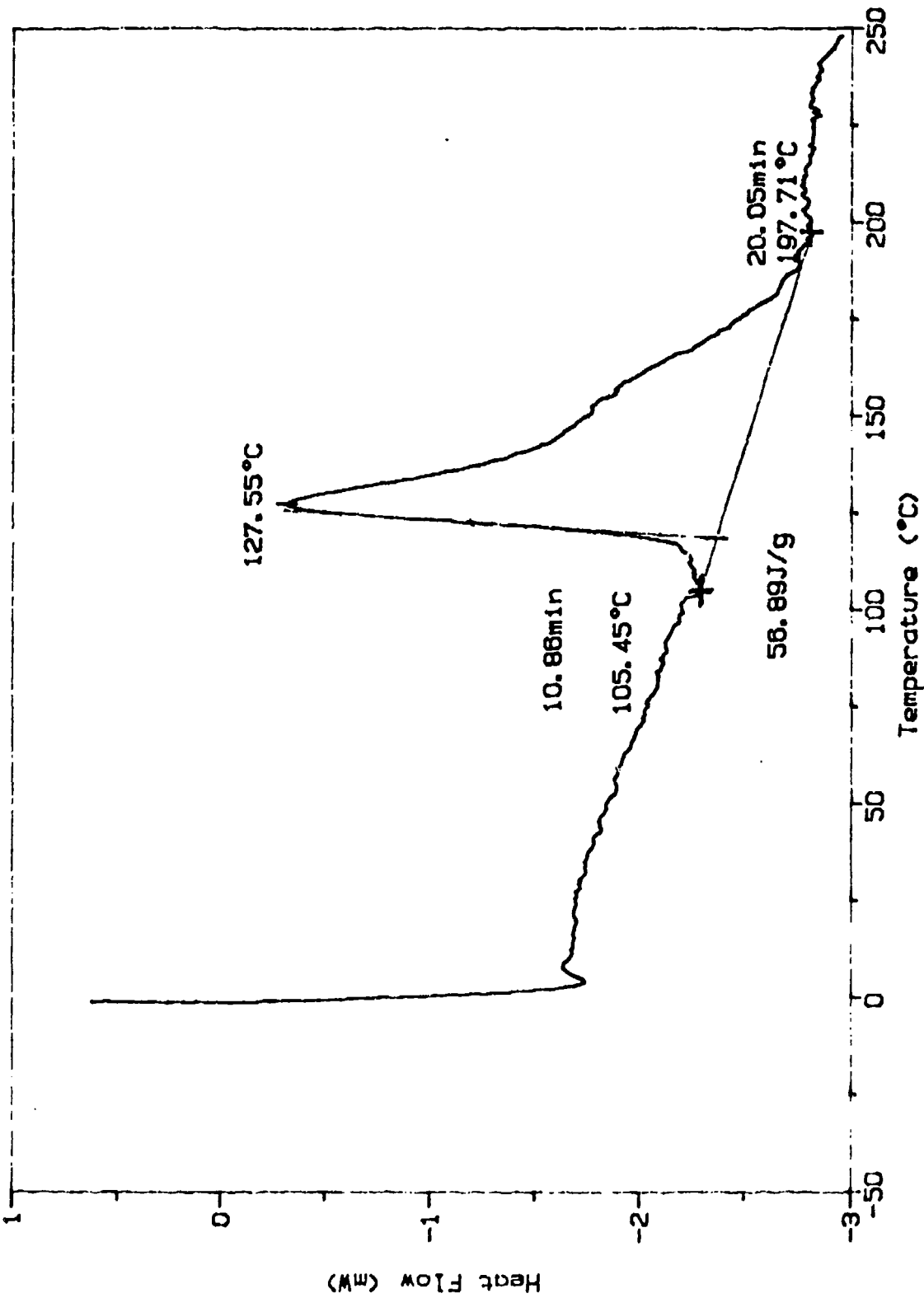


Figure 3. Dynamic DSC Residual Heat Release Test for Postcuring of EA9396 After Isothermal Cure at 82°C (180°F).

the cure and postcure ranges between 522 and 544 J/gm. These total heat release values are in excellent agreement with the total heat release values determined previously for the two dynamic tests.

The last two DSC tests that were conducted were aimed at determining:

- (a) whether an 82°C (180°F) cure, followed by a 7-day postcure at room temperature, would produce full cure, and
- (b) how much cure could be achieved in a 7-day cure at room temperature.

In the former instance, one would expect a dynamic residual exotherm test that was delayed 7 days after the initial 82°C (180°F) isothermal cure, to exhibit no additional heat release if cure had proceeded to completion during the intervening week at room temperature. In the latter case, the amount of residual exotherm remaining would provide a measure of how complete the cure was in the initial 7-day room temperature cure.

Note from the data in Table 24 that after an 82°C (180°F) cure, an additional 7 days at room temperature did not appear to produce any additional cure since only an additional 60 J/gm of exotherm was measured after the 7-day period.

The 7-day room temperature cure appeared to produce only about 68% of full cure since an additional 170 J/gm of exotherm was measured in a dynamic DSC test after the 7-day room temperature cure. This is consistent with the pattern observed in the other isothermal cure tests.

Based on these measurements, the baseline cure schedule of 45 minutes at 93°C (200°F) would appear to produce approximately 90% of the full cure in so far as heat release is concerned. Thus one would expect that extended subsequent exposure to temperatures above this level would drive the material to more complete cure. These results are consistent with the T_g data discussed in Section 3.3, in which a shorter, lower temperature cure produced a lower T_g than the standard cure, implying a lower degree of cure.

3.5.2 Effect of Cure Time and Temperature on Interlaminar Shear Strength

Graphite fabric reinforced laminates were impregnated and cured at various combinations of time and temperature and then tested for interlaminar shear strength. Table 25 presented the data obtained from these tests.

It is evident that for all of the cures carried out at 80°C (175°F) or higher, the room temperature dry shear strength is basically equivalent while it falls off somewhat for the reduced temperature cure. There appears to be a slight loss of wet shear strength levels for reduced cure temperatures but so long as the cure temperature remains at 80°C (175°F) or above, the loss is not much more than about 10%. The room temperature cure, on the other hand, results in a wet room temperature shear strength that is nearly 25% below that produced by the higher temperature cures.

3.5.3 Effect of Cure Vacuum Pressure on Interlaminar Shear Strength

Glass fabric reinforced laminates were impregnated and cured at the standard baseline cure condition of 45 minutes at 93°C (200°F) but at vacuum pressure levels both above and below the nominal 635 mm (25 in) Hg used with the baseline laminates. These laminates were then tested for interlaminar shear strength. Table 26 presents these test results, as well as the physical properties for each of these laminates. The physical property data show several logical trends. Specific gravity increases and ply thickness decreases with increasing cure vacuum level. The shear strength behavior appears to be independent of vacuum level until the vacuum level falls below 625 mm (25 in) Hg. At lower vacuum levels than this, the shear strength is noticeably lower. This may be, in part, a result of the fact that the void contents of the laminates cured under the reduced vacuum levels are higher than the normal 5% that occurs in the laminates cured under 635 mm (25 in) Hg vacuum.

3.6 RESIN POT/WORK LIFE

Two different types of pot-life or work-life tests were carried out. The purpose of the first was to determine the time available before a freshly mixed resin batch advanced to gel. The purpose of the second was to determine the time available before an impregnated layup advanced so far that it was no longer workable.

In the first test, two 200-gram samples of EA9396 were mixed and placed in 22°C (72°F) and 38°C (100°F) environments while pot-life observations were recorded.

TABLE 25
EFFECT OF CURE TEMPERATURE ON INTERLAMINAR
SHEAR STRENGTH OF GRAPHITE REINFORCED
EA9396 LAMINATES

Cure Condition	Interlaminar Shear Strength (psi) (2)		
	22°C (72°F), Dry	22°C (72°F), Wet (4)	93°C (200°F), Wet (4)
45 min. at 107°C (225°F)	6120	4540	---
45 min. at 93°C (200°F) (3)	5700	4700	2340
30 min. at 93°C (200°F)	6220	4430	2270
30 min. at 82°C (180°F)	6230	4340	1900
45 min. at 79.5°C (175°F)	5640	4020	---
7 days at 22°C (72°F) plus additional 3 mos. dry storage or wet aging	5010	3410	---

- (1) All cures were under nominally full vacuum pressure ~ 25 in. Hg).
- (2) Four-point shear test procedure.
- (3) This represents the baseline cure schedule used throughout the program.
- (4) Wet aged at 60°C (140°F), 95-100% R.H. till saturated.
- (5) Laminate under compacting vacuum bag pressure only during first few hours of 22°C (72°F) cure. Remaining 164 hrs. of cure at 22°C (72°F) under ambient conditions.

TABLE 26
 EFFECT OF CURE PRESSURE ON LAMINATE PHYSICAL CHARACTERISTICS
 AND INTERLAMINAR SHEAR STRENGTH

Cure Vacuum Level (in. Hg)	Specific Gravity	Resin Content (% wt.)	Fiber Content (% vol.)	Void Content (% vol.)	Ply Thickness (mil)	Interlaminar Shear Strength (psi) (1)
10	1.87	28.6	52.6	5.4	8.5	4640
16	1.88	25.6	55.0	7.1	8.3	5170
23	1.91	24.4	56.6	6.7	8.0	4630
25 (2)	1.91	26.6	55.2	5.1	8.0	5700
27	1.94	26.2	56.1	3.9	7.8	5940

(1) Tests conducted at 72°F on dry specimens.
 (2) Baseline laminates.

These pot-life measurements were repeated on samples from the same batch of resin after 20 months of storage at 4°C (40°F). Table 27 presents the results of these tests.

In the second test, two 12-ply graphite fabric reinforced laminates were impregnated with freshly mixed EA9396 resin and then placed in 22°C (72°F) to 38°C (100°F) environments while observations were recorded on the state of the matrix resin. Table 28 presents the results of these tests.

It is apparent from the data in Tables 27 and 28 that the pot/work life is markedly shortened by increasing the temperature from 22°C (72°F) to 38°C (100°F). In addition, the effect of long-term storage is to reduce the available pot life and especially to shorten the time between first noticeable exotherm and final kick-over. In spite of the shortened pot-life or work-life available after extended storage for the conditions examined, the available time is still probably sufficient to permit most repairs to be satisfactorily completed.

3.7 EFFECT OF STORAGE TIME AND TEMPERATURE

The purpose of these tests was to determine how the processability of the material changed and whether good mechanical property levels could still be achieved after extended resin storage at ambient and elevated temperature. The tests listed in Table 3 were periodically conducted over a 30-month storage period. Samples of both parts A and B of a single batch of the EA9396 resin system were placed in storage at room temperature, 38°C (100°F) and 49°C (120°F). The samples were stored in the cans they were received in from the vendor.

The HPLC, FTIR, DSC and Rheometrics viscosity profile measurements failed to reveal any significant changes in the resin system as a result of 24 months storage at any of the three storage temperatures. Figure 4 presents HPLC spectra for part A of the EA9396 system in the freshly received condition (~3 months after manufacture) and after 18 months of storage at 49°C (120°F), respectively. Both spectra were generated using the same test parameters. It is evident that no significant difference appears. The HPLC spectra for 24 months at all three storage temperatures indicated equivalent behavior. Since no components are present in Part B of the EA9396 system that produce significant features in an HPLC spectra, this test was not performed on Part B.

TABLE 27
POT LIFE OBSERVATIONS FOR 200-GRAM BATCH OF EA9396 (1)

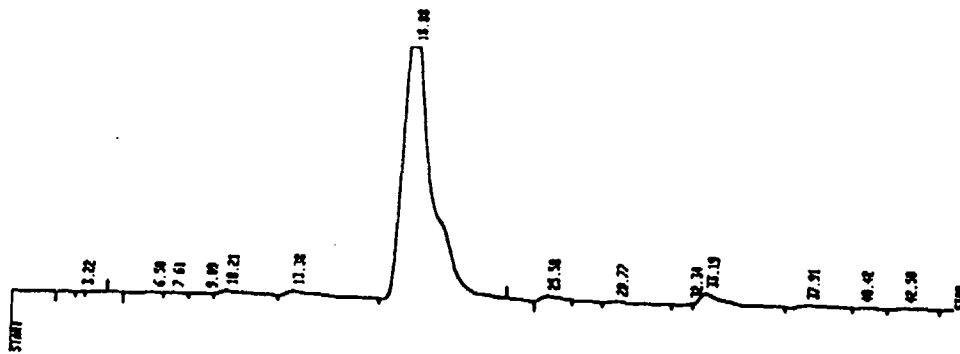
Storage Condition	Test Temperature	Time to First Notice of Exotherm (min. after mixing)	Time to Boil/Gel (2) (min. after mixing)
Freshly Received	22°C (72°F)	105	112/113
	39°C (100°F)	40	60/61
20 months at	22°C (72°F)	90	92/94
	38°C (100°F)	40	42/43

- (1) Times listed were measured from completion of mixing.
- (2) At the first times indicated, the two samples were so hot that they were bubbling and smoking. Gel followed within a minute of this.

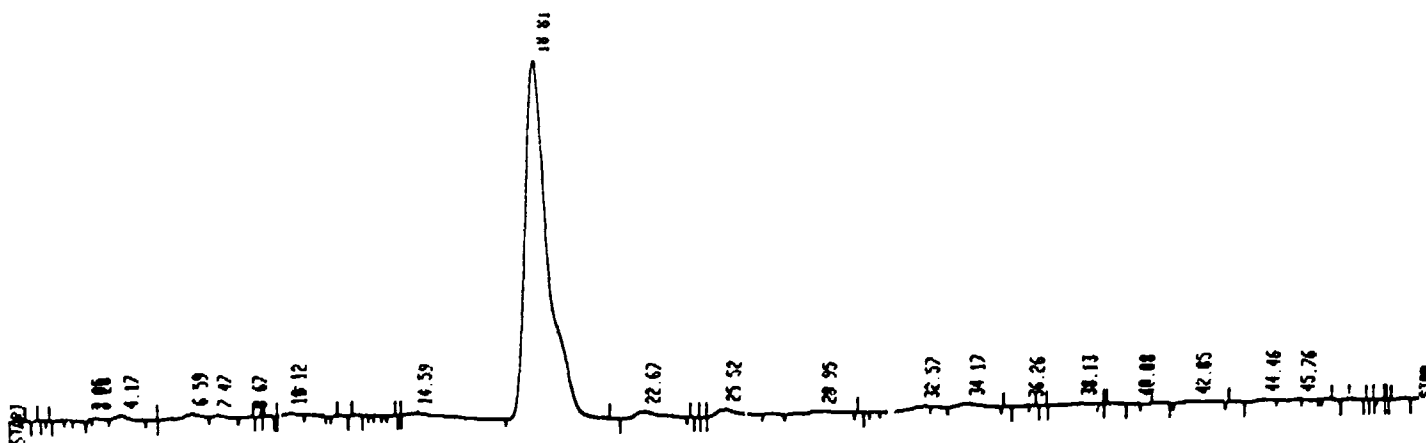
TABLE 28
**WORK LIFE OBSERVATIONS OF 12-PLY GRAPHITE LAMINATE
 IMPREGNATED WITH EA9396 A/B RESIN (1)**

Temperature Environment	Maximum Midplane Temp. (2)	Time to Become Tacky (min) (3)	Time to Lose Tack (min) (4)	Time at Which Surface is no Longer Indentable (min) (5)
22°C (72°F)	29°C (84°F)	~60	210	240
38°C (100°F)	47°C (116°F)	~50	100	100

- (1) Times listed were measured from completion of laminate impregnation. Impregnation required approximately 15 minutes after completion of mixing.
- (2) Midplane temperature recorded with imbedded thermocouple.
- (3) Subjective judgement of when resin changes from thick syrupy state to a sticky, nonliquid state.
- (4) Subjective judgement.
- (5) Unable to make an impression on surface of laminate with a wooden tongue depressor and hand pressure.



(a) Fresh Resin.



(b) Resin Aged for Eighteen Months at 49°C (120°F).

Test Parameters: Resin dissolved in dioxane
 Flow rate: 1 ml/min
 Gradient Profile

Time (minutes)	% Water	% Dioxane
0	50	50
10	50	50
40	30	70
50	30	70

Figure 4. HPLC Spectra of EA9396, Part A.

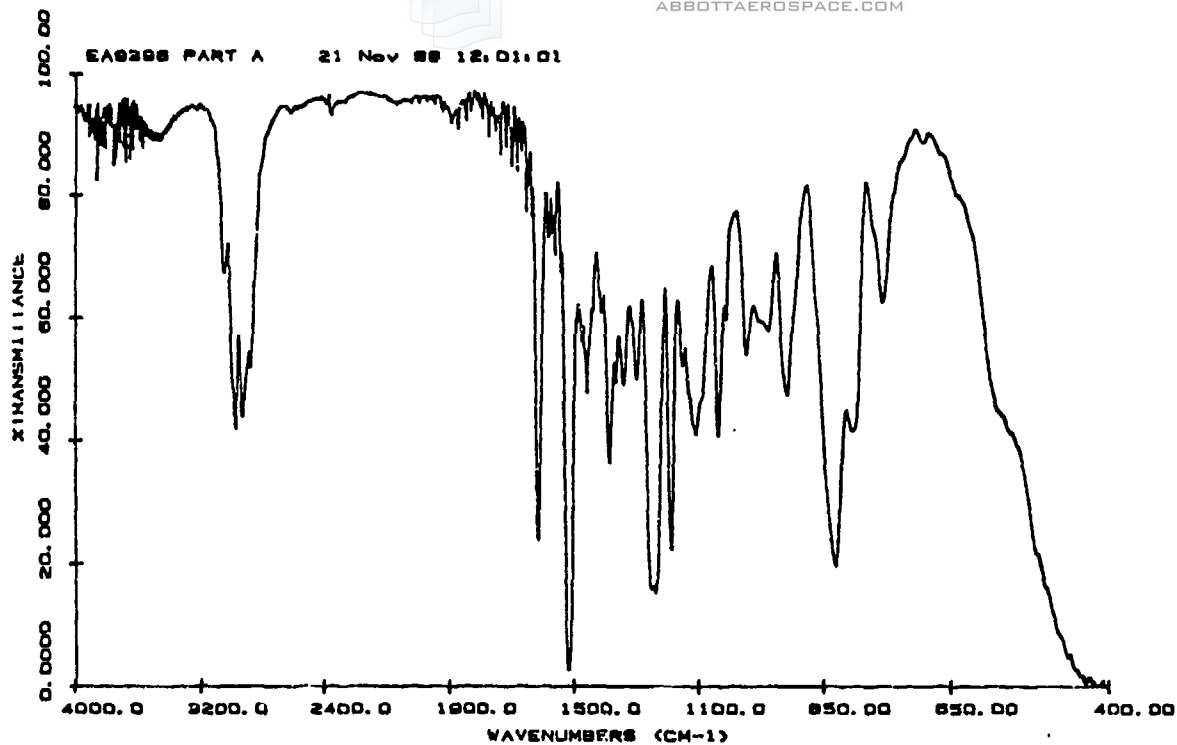
Figures 5 and 6 present FTIR spectra for both parts A and B in the fresh condition and after 24 months storage at 49°C (120°F). No significant changes between the fresh and 24-month aged material is apparent for either parts A or B.

Figure 7 presents a Rheometrics cure profile for fresh EA9396 material. Similar curves were obtained every 6 months for up to 24 months at each of the three storage temperatures. Table 29 lists key information extracted from each of these cure profiles. It is evident from the data in Table 29 that no changes are apparent as storage time increases.

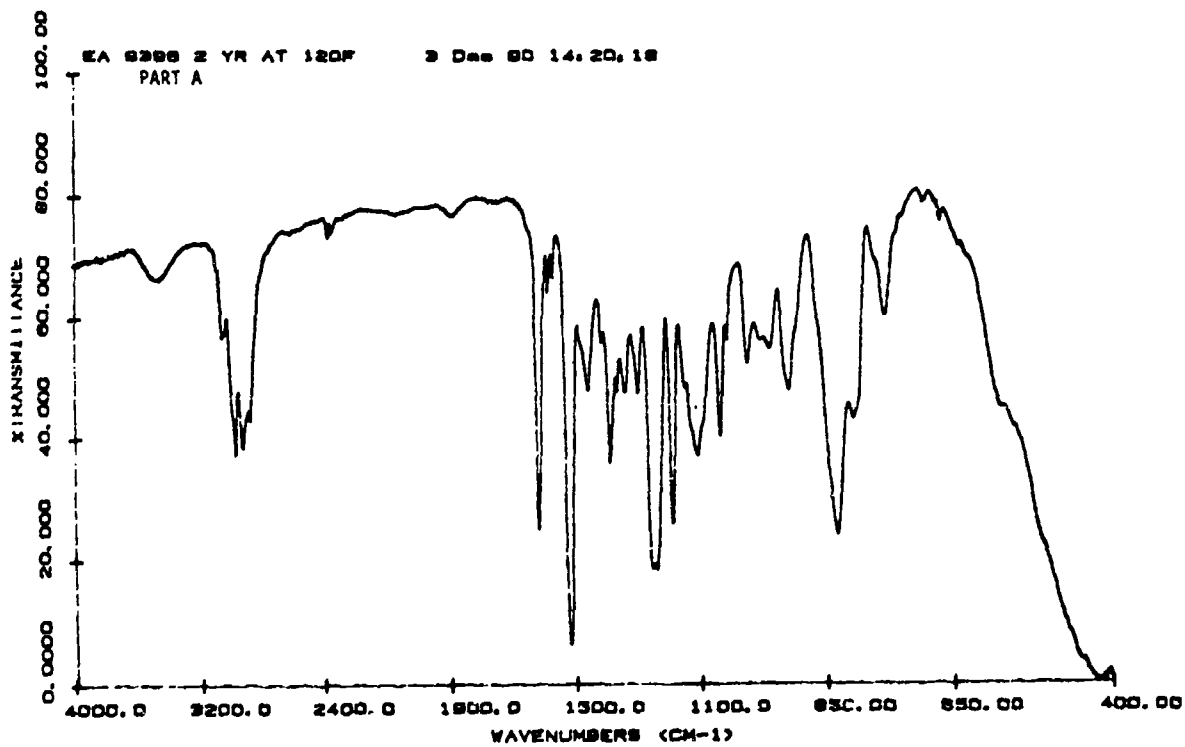
Figure 8 presents a DSC curve for fresh EA9396 material. Additional curves were generated every 6 months for up to 24 months at each of the three storage temperatures. Table 30 lists key information extracted from each of these DSC tests. As with the data from the cure profiles, no significant changes are apparent in the data of Table 30 as storage time increases.

The room temperature viscosity of parts A and B was also measured, using a Brookfield viscometer, as storage time increased. While the viscosity of the unmixed part B did not change during storage, part A did. Table 31 lists these changes. It is evident that at the 49°C (120°F) storage temperature viscosity starts to increase markedly after 12 months. After 30 months storage at 49°C (120°F), part A had become much too viscous to use at room temperature for wet layup impregnation of a laminate. After 36 months at 38°C (100°F), the viscosity of part A was still low enough to be processible by wet layup impregnation although the material was starting to show a marked viscosity increase. At the 22°C (72°F) storage condition, the resin was still usable after over four years.

In addition to the tests discussed above, the EA9396 resin samples that were in storage at the three different temperatures were also used to prepare graphite fabric reinforced laminates for interlaminar shear testing after various storage intervals. The interlaminar shear properties achievable from stored resin was not degraded at all so long as the viscosity remained low enough to permit wet layup impregnation of the reinforcement. In fact, it appears that an increased interlaminar shear strength is possible over time. Table 32 presents these data.

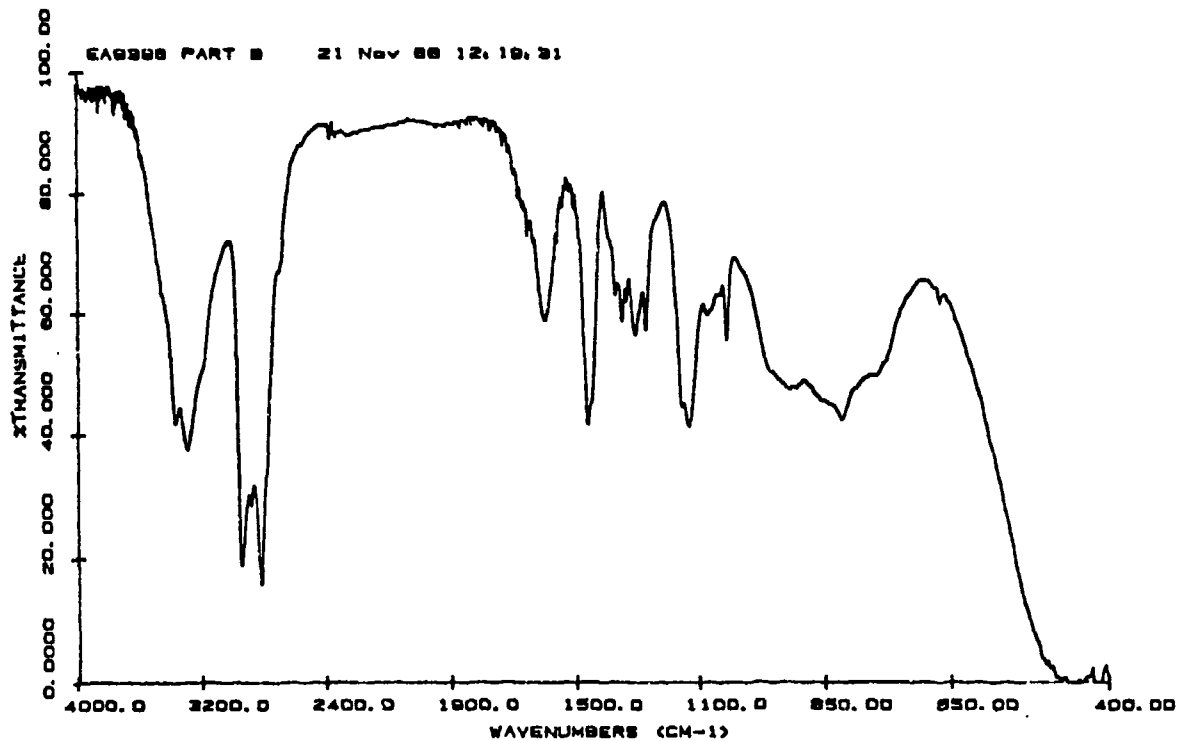


(a) Fresh Resin.

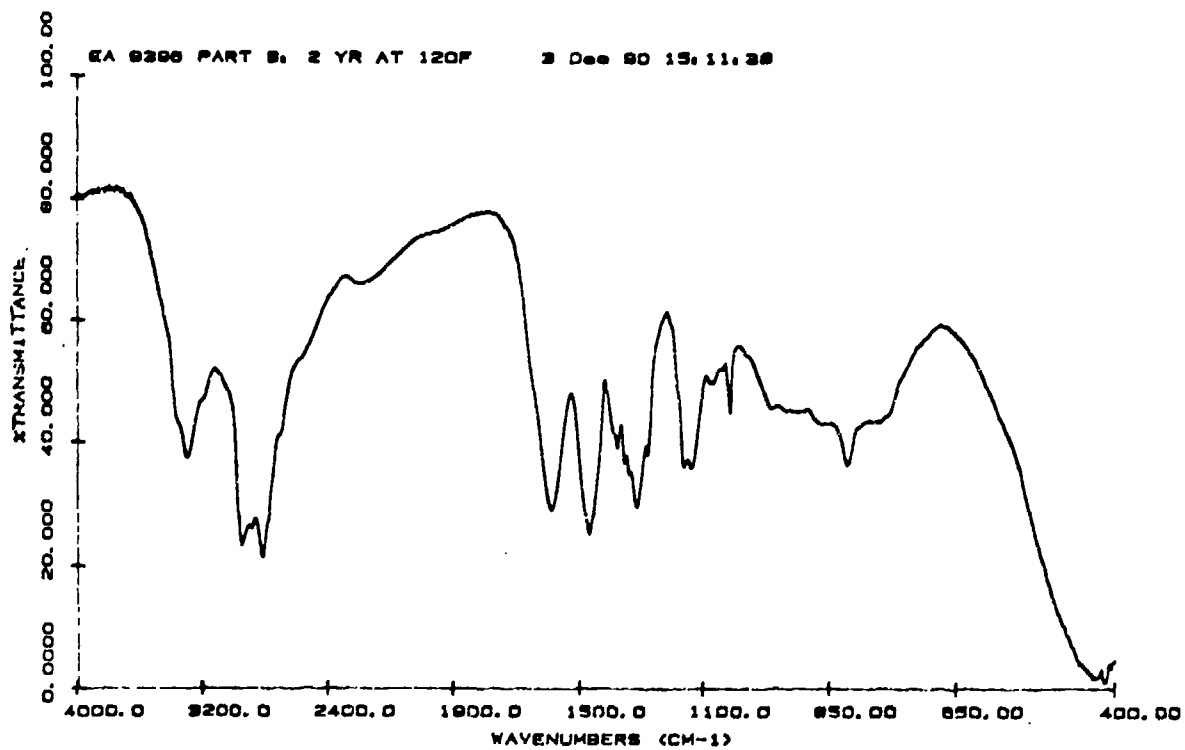


(b) Resin Aged for Two Years at 49°C (120°F).

Figure 5. FTIR Spectra of EA9396, Part A.



(a) Fresh Resin.



(b) Resin Aged For Two Years at 49 C (120°F).

Figure 6. FTIR Spectra of EA9396, Part B.

Initial testing of EA9396.

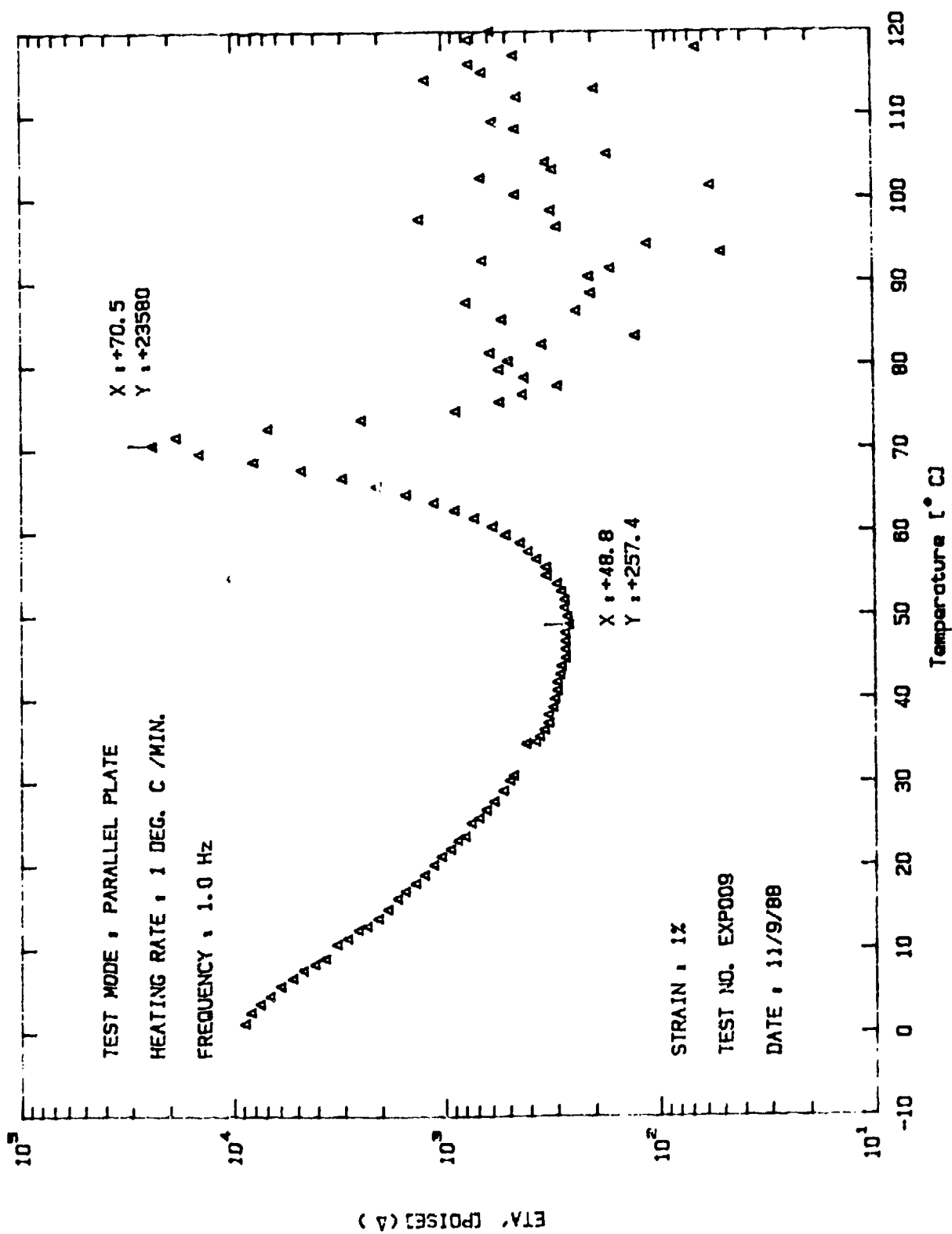


Figure 7. Rheometrics Viscosity Cure Profile for Fresh EA9396 Resin.

TABLE 29
EFFECT OF LONG-TERM STORAGE AT ELEVATED TEMPERATURE ON
THE CURING VISCOSITY PROFILE CHARACTERISTICS OF EA9396

Storage Conditions	Temperature at Minimum Viscosity	Minimum Viscosity (poise)	Gel Temperature (°C)
Initial	49	~257	70.5
1 month at 38°C (100°F)	51	~150	71.6
1 month at 49°C (120°F)	47	~150	71.9
3 months at 22°C (72°F)	50	~40	73.3
6 months at 22°C (72°F)	48	~110	66.8
6 months at 38°C (100°F)	45	~110	65.9
6 months at 49°C (120°F)	44	~200	67.8
12 months at 22°C (72°F)	67	~149	71.9
12 months at 38°C (100°F)	66	~46	72.6
12 months at 49°C (120°F)	64	~64	71.4
18 months at 22°C (72°F)	49	~54	70.5
18 months at 38°C (100°F)	47	~54	68.4
18 months at 49°C (120°F)	47	~127	68.4
24 months at 22°C (72°F)	47	~60	71.6
24 months at 38°C (100°F)	50	~60	71.6
24 months at 49°C (120°F)	51	~120	70.5

NOTE: Test conducted on Rheometrics Solids Analyzer using a heating rate of 1°C (34°F)/minute.

Sample: EA 9398
Size: 5.2460 mg
Comments: 10°C/min

DSC

File: DSC0334.01
Operator: GALASKA
Run Date: 12/19/88 13:50

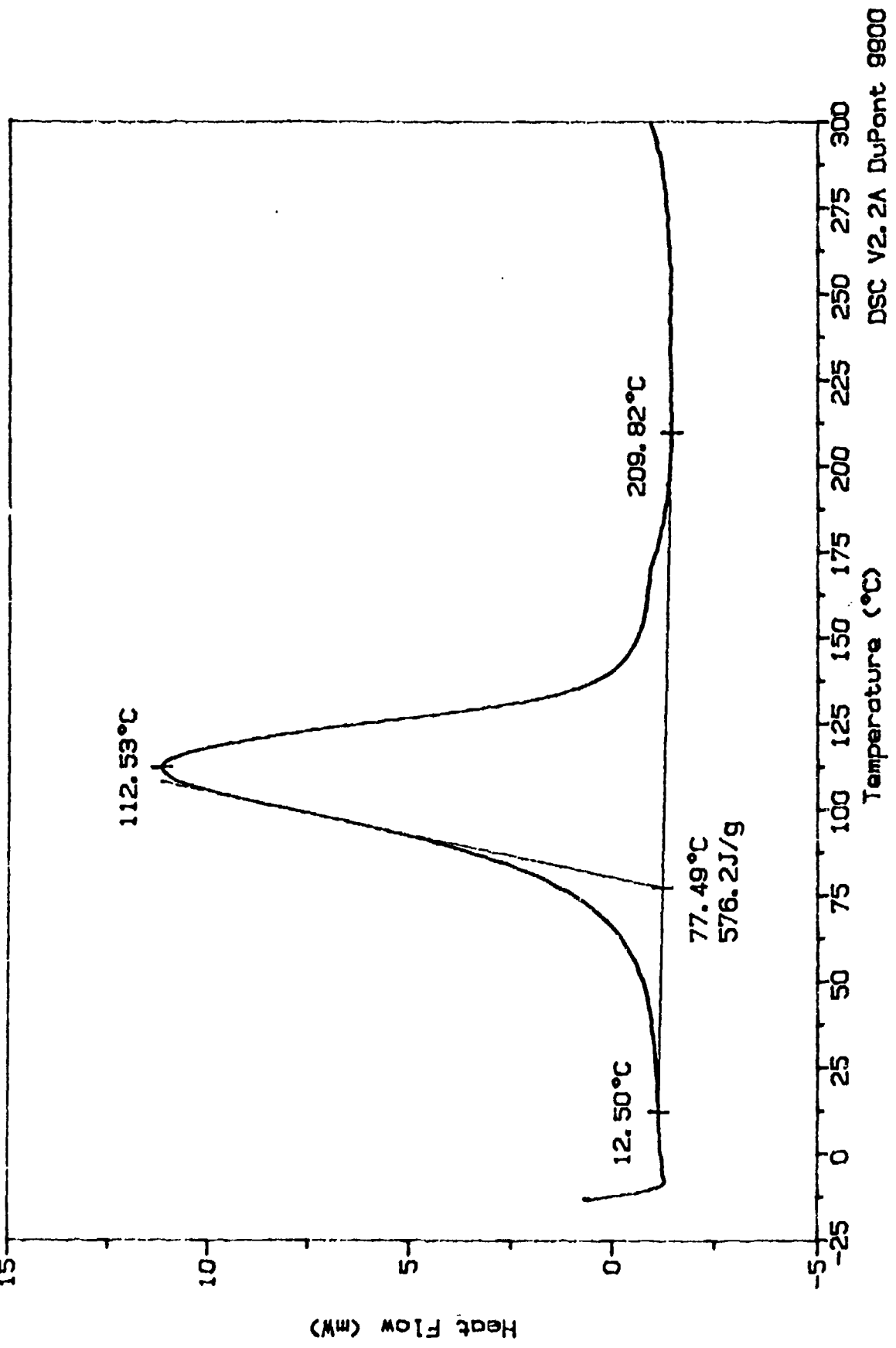


Figure 8. Heat Release Test Results for Fresh EA9396 Resin.

TABLE 30
EFFECT OF LONG-TERM STORAGE AT ELEVATED TEMPERATURE ON
THE CALORIMETRIC CURE CHARACTERISTICS OF EA9396

Storage Conditions	Temperature at Reaction Peak (°C)	Total Heat of Cure (J/gm)
Initial	112.5	576.2
1 month at 38°C (100°F)	115.2	588.8
1 month at 49°C (120°F)	114.6	576.4
3 months at 22°C (72°F)	115.0	572.9
6 months at 22°C (72°F)	108.9	633.8
6 months at 38°C (100°F)	110.9	593.5
6 months at 49°C (120°F)	111.8	624.6
12 months at 22°C (72°F)	112.8	613.4
12 months at 38°C (100°F)	114.3	589.5
12 months at 49°C (120°F)	112.6	601.6
18 months at 22°C (72°F)	107.2	615.4
18 months at 38°C (100°F)	111.5	564.6
18 months at 49°C (120°F)	112.8	586.8
24 months at 22°C (72°F)	114.1	599.6
24 months at 38°C (100°F)	115.1	575.6
24 months at 49°C (120°F)	114.1	560.6

NOTE: Dynamic DSC test at heating rate of 10°C/minute under nitrogen.

TABLE 31
EFFECT OF LONG-TERM STORAGE AT ELEVATED
TEMPERATURE ON THE VISCOSITY OF EA9396, PART A

Storage Temperature	Storage Time (1) (months)	Brookfield Viscosity of Part A	
		(Pa-s)	(Poise)
22°C (72°F)	Initial	84	840
	3	92	920
	6	72	720
	12	72	720
	18	112	1,120
	24	82	820
	30	78	780
	36	80	800
	43	100	1,000
	50	100	1,000
	38°C (100°F)	1	84
7		84	840
12		96	960
18		108	1,080
24		84	840
30		234	2,340
36		460	4,600
43		>2,000	>20,000(2)
50		---	(3)
49°C (120°F)	1	88	880
	7	88	880
	12	100	1,000
	18	263	2,630
	21	344	3,440
	24	650	6,500
	30	>2,000	>20,000(2)

NOTES:

1. Months after receipt of resin. Resin was manufactured three months before receipt.
2. Material no longer processible into laminates.
3. Hard crust on surface.

TABLE 32
EFFECT OF LONG-TERM STORAGE AT ELEVATED TEMPERATURE
ON ACHIEVABLE INTERLAMINAR SHEAR STRENGTH OF GRAPHITE-
REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL

Storage Temp.	Storage Time (2) (months)	Interlaminar Shear Strength (3)				Wt. Gain During Wet Aging(%) (4)
		DRY		WET (4)		
		(MPa)	(psi)	(MPa)	(psi)	
22°C (72°F)	Initial	37.56	5447	25.91	3758	3.91
	3	38.27	5515	31.46	4563	1.56 (5)
	6	42.60	6178	30.40	4409	2.68
	12	36.94	5357	29.95	4344	2.59
	18	42.21	6122	31.88	4624	2.65
	24	46.28	6712	32.00	4641	2.63
	43	45.59	6612	33.86	4910	2.86
	50	43.76	6347	---	---	---
38°C (100°F)	1	42.52	6166	32.82	4759	2.70
	6	42.77	6202	32.31	4686	2.61
	12	43.72	6341	32.77	4752	2.54
	18	44.32	6427	35.80	5192	2.65
	24	40.48	5871	28.05	4068	2.80
	43	45.59	6612	33.48	4856	3.02
49°C (120°F)	1	39.29	5698	29.83	4326	2.90
	6	42.88	6218	29.29	4247	2.79
	12	42.52	6167	26.08	3782	4.25
	18	46.41	6731	35.65	5170	2.65
	24	43.15	6257	31.59	4581	2.83

NOTES:

1. EA9396 Parts A and B stored at temperature listed for time listed before resin was mixed and laminate prepared.
2. From date of receipt. Resin was manufactured 3 months before receipt.
3. All tests were conducted at 22°C (72°F). Dry values represent average of three specimens, wet values represent average of two specimens.
4. WET = specimens immersed in water at 60°C (140°F) until saturated before being tested unless otherwise noted.
5. Immersed in water at 22°C (72°F) until saturated before being tested.

In summary, it appears that the EA9396 resin system is very tolerant of long-term storage. It is still useable after 24 months storage at 49°C (120°F) and after over 50 months storage at a temperature of 22°C (72°F).

3.8 EFFECT OF FIBER CONTENT

Since field or depot repairs may be subject to greater inconsistency in control of processing parameters than was the case in a laboratory environment, several laminates were prepared with deliberately lower fiber contents than the baseline laminates. These were then tested for both interlaminar shear and compressive properties. Both glass and graphite fabric reinforced laminates were prepared with fiber contents ranging from the standard 55% by volume down to as low as 34% by volume. The low fiber content laminates were all cured by the same "standard cure cycle", described in step (m) of Appendix A, that was used for the baseline laminates. The differences in fiber content were achieved by changing the bleeder ply/laminate ply ratio used during cure and/or the ratio of resin to reinforcement used during impregnation (see Table A.2 in Appendix A). Two attempts were made to obtain higher than normal fiber content laminates. In one case, the bleeder ratio was increased by 50% and the resin ratio reduced by 5% from the standard. In the other case, the bleeder ratio was not changed but the resin ratio was reduced by 27% from the standard. In each case, the resulting laminate exhibited practically identical physical characteristics (fiber content, void content) to the baseline laminates. This implies that one is not likely to obtain much higher fiber contents than that exhibited by the baseline laminates regardless of processing variations encountered in the field. The same should not be said with regard to void content since it is likely that some processing variations would affect porosity. Reduced fiber contents, on the other hand, were achieved by simultaneously reducing the bleeder ratio and raising the resin ratio during impregnation. In the extreme cases, in which the lowest fiber contents were achieved, the bleeder was eliminated entirely while the resin ratio used during impregnation was increased to 150% and 180% of the standard ratio for graphite and glass reinforced laminates, respectively. Interlaminar shear and compression specimens were machined and tested from these reduced fiber content laminates. The data from these tests are presented in Tables 33 and 34.

Examination of the data in Table 33 reveals several points. First, it appears that the interlaminar shear strength is influenced by both fiber and void content. In the case of the glass reinforced laminates, the two lowest shear strengths were produced by laminates that had significantly lower fiber content and significantly higher void content

TABLE 33
 EFFECT OF RESIN/FIBER CONTENT ON INTERLAMINAR SHEAR
 STRENGTH OF EA9396 COMPOSITE LAMINATES

Panel Number	Reinforcement Fabric	Laminate Physical Properties					Interlaminar Shear Strength (1)		
		Resin Content (% wt)	Fiber Content (% vol)	Void Content (% vol)	Specific Gravity	22°C(72°F), Dry		22°C(72°F), Wet(2)	
						Number Replicates	Shear Strength MPa(psi)	Number Replicates	Shear Strength MPa(psi)
GL-31	E-7781, Glass	26.2	55.4	5.0	1.94	3	36.5(5290)	2	21.4(3110)
GL-30	"	26.7	54.3	6.1	1.89	3	38.2(5540)	2	21.9(3180)
GL-13R(3)	"	26.5	54.0	6.9	1.87	5	40.1(5810)	5	18.7(2710)
GL-33	"	28.4	52.3	6.4	1.86	3	37.8(5490)	2	20.5(2970)
GL-10	"	35.2	45.6	4.7	1.79	4	37.9(5500)	---	---
GL-54	"	43.6	35.8	8.8	1.62	3	33.2(4810)	---	---
GL-53	"	45.6	33.9	9.3	1.59	2	34.7(5030)	---	---
GR-51	T300-W133, Graphite	32.5	55.8	6.5	1.47	3	40.5(5870)	2	29.5(4280)
GR-52	"	33.6	54.7	6.4	1.47	3	40.4(5860)	2	32.7(4740)
GR-17(3)	"	35.6	54.6	4.0	1.48	5	39.1(5670)	5	32.7(4750)
GR-53	"	39.0	50.1	4.9	1.46	3	43.6(6320)	2	34.2(4960)
GR-54	"	39.0	49.8	4.7	1.47	3	43.8(6350)	2	35.3(5120)
GR-84	"	45.6	42.3	7.5	1.39	3	31.4(4550) (4)	---	---
GR-79	"	48.8	40.5	5.5	1.41	3	33.5(4860) (4)	---	---

- NOTES:
 (1) Four-point shear. Graphite tests at 16:1 span-thickness ratio, glass tests at 8:1 unless otherwise noted.
 (2) Wet = wet aged at 60°C (140°F), 95-100% R.H. until saturation.
 (3) Baseline panel data.
 (4) Tests carried out at 12:1 span-thickness ratio.

TABLE 34
EFFECT OF RESIN/FIBER CONTENT ON 22°C (72°F), DRY
COMPRESSIVE PROPERTIES OF EA9396 LAMINATES

Panel Number	Reinforcement Fabric	Laminate Physical Properties				Laminate Mechanical Properties(1)			
		Resin Content (% wt)	Fiber Content (% vol)	Void Content (% vol)	Specific Gravity	Number Replicates	Ultimate Compr. Strength MPa (10 ³ psi)	Initial Modulus GPa (10 ⁶ psi)	Ult. Strain (10 ⁻⁶ in/in)
GL-53	E-7781, Glass	45.6	33.9	9.3	1.59	6	238(34.52)	17.0(2.5)	14,070
GL-54	"	43.6	35.8	8.8	1.62	6	254(36.85)	18.7(2.7)	15,560
GL-7,8(2)	"	28.1	53.7	4.4	1.90	5	287(41.69)	26.1(3.8)	11,670
GL-9(2)	"	27.6	53.8	5.0	1.84	5	269(39.08)	24.7(3.6)	11,730
GL-10R(2)	"	30.4	51.2	4.0	1.87	5	288(41.80)	24.8(3.6)	12,250
GR-79	T300-W133, Graphite	48.8	40.5	5.5	1.41	6	309(44.87)	37.3(5.4)	9,030
GR-84	"	45.6	42.3	7.5	1.39	---	298(43.18)	37.6(5.4)	8,020
GR-13,14(2)	"	35.9	54.6	3.6	1.48	5	414(60.08)	51.5(7.5)	7,920
GR-15(2)	"	34.7	55.5	4.3	1.48	5	410(59.50)	57.4(8.3)	8,150
GR-16(2)	"	34.9	54.9	4.8	1.47	5	435(63.03)	54.3(7.9)	8,700

NOTES:
 (1) All tests conducted at 22°C (72°F), dry condition in fill direction of fabric reinforcement.
 (2) Baseline panel data.

than the other five laminates. In the case of the graphite reinforced laminates, the two laminates with the lowest fiber content exhibited significantly lower shear strengths than the other five laminates. Similar behavior is observed in the case of the compressive properties, presented in Table 34. For both the glass and graphite reinforced laminates, the compressive strength is lowest for the laminates with low fiber content and high void content.

In summary, the shear and compression data in Tables 33 and 34 indicate that laminate strength is reduced with decreasing fiber content and increasing void content. For example, in Tables 33 and 34, panel numbers GL-53 and GL-54 had the lowest fiber contents and the highest void contents and also produced the lowest strengths. Similarly, panel GR-79 had the lowest fiber content and an intermediate void content and produced the second lowest strengths, while panel GR-84 had the second lowest fiber content and the highest void content and produced the lowest strengths. It also appears that the laminates that were deliberately prepared with low fiber contents generally had higher void contents than baseline laminates. This indicates that low fiber content (resin-rich) laminates should be avoided if optimum properties are desired.

3.9 ALTERNATE IMPREGNATION AND BAGGING SCHEMES

Appendix A describes the rationale behind the individual steps in the "standard processing procedure." This procedure was selected for use in the laboratory because it was convenient and because it produced laminate quality consistent with what would be expected in repair scenarios using a vacuum bag cure. A number of laminates were prepared during the program, however, by procedures that differed from the standard procedures. These differences were in the areas of ply impregnation procedures, bleeder material used, and bagging scheme employed. Each of the activities undertaken in these respective subject areas are discussed in the following sections.

3.9.1 Alternate Ply Impregnation Procedure

It was recognized that repair technicians working in the field might elect to employ different processing procedures than were used here. In order to anticipate what these different procedures might be, and to determine their effects on resulting laminate quality, two variations from the standard ply impregnation procedure were investigated.

In the first, the resin was applied to every ply instead of every other ply as in the standard procedure. In the second, a lower ratio of resin to reinforcement was employed during the impregnation steps than in the standard procedure. Each of these variant procedures is described in detail in Appendix B but a brief summary of each is presented in the following paragraphs.

The first variant impregnation procedure involved applying resin to every reinforcement ply during the wet layup procedure instead of every other ply. The reason for doing this was to determine whether laminate quality (specifically, void content) would be adversely affected. Since only half as much resin was available to be applied and worked into each ply, it was thought that resin distribution might be less uniform and that more voids due to air entrapment might result. As in the "standard procedure," the total amount of resin used during impregnation represented a 50% excess over what was desired in the final laminate. The same amount was applied to every ply, including the first and last, as opposed to the resin distribution approach described in steps (e)-(j) of Appendix A. Other than this, all other steps were identical to those described in Appendix A.

The physical properties of specimens cut from this panel are presented in Table 35. Table 35 shows that while this laminate had a slightly higher void content than the baseline laminates made with the standard processing procedure (Table 4), the difference was within the range of the standard deviation of the baseline panels. The other physical properties are also very nearly equivalent to those exhibited by the baseline panels.

The second variant impregnation procedure involved using a smaller quantity of resin during impregnation of the reinforcement plies than the amount computed in step (c) of Appendix A. The reason for doing this was to determine whether equivalent laminate quality (specifically void content) could be achieved without bleeding excess resin out of the wet layup stack. Instead of the 50% excess used in the standard procedure, the amount used for this laminate represented 0% excess (nominally net resin content). Thus, the resin/reinforcement ratio employed for this laminate was only 0.370 gm resin/gm reinforcement instead of the 0.555 gms listed in Table A.2. The other difference was that since no excess resin was used, no bleeder plies were used during cure. Other than these two variations, all other steps were identical to those described in Appendix A.

TABLE 35
 PHYSICAL PROPERTIES SUMMARY OF LAMINATES
 PREPARED WITH VARIANT PROCESSING PROCEDURES

Type of Laminate	Processing Variation	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
E-7781 (GI)/EA 9396	Every ply impregnated	1.87	0.21	8.1	52.6	28.4	5.9
E-7781 (GI)/EA 9396	Net resin used during impregnation and no bleeding	1.85	0.20	7.9	50.3	30.8	4.8

The physical properties of specimens cut from this panel are presented in Table 35. It is evident from these data that void content was not adversely affected by this alternative processing procedure. It does appear, however, that the panel was somewhat more resin-rich than the baseline panels made with bleeder plies during cure. This is probably because the amount of resin used was only nominally net resin content, not precisely net resin content.

Based on these two variations in resin impregnation procedures, it appears that essentially equivalent laminate quality can be achieved with a variety of procedures.

3.9.2 Alternative Bleeder Materials

All of the baseline laminates prepared during this program, as well as nearly all the other laminates prepared in accordance with the "Standard Laminate Processing Procedure," were bagged according to Figure A.1 using Mochburg CW 1850 bleeder, which had an area weight of 71 gm/m². It was empirically determined that this bleeder material typically absorbed about three times its own weight of EA9396 resin during a cure cycle when used in the ply ratios listed in Table A.2. This was used as bleeder material only because it was readily available and because of prior experience with it. It was recognized, however, that in field repair scenarios, this particular bleeder material might not be available. Several laminates were, therefore, prepared using the same fabric material as bleeder as was used for reinforcement in the wet layup, specifically, the E-7781 glass and T300-W133 graphite fabrics described in Table 1. The absorptivity of these materials as bleeder was characterized, and the physical properties of the laminates made using them were determined to demonstrate equivalence to the baseline laminates made using the standard processing procedure. The procedure used to determine bleeder material absorptivity is described in Appendix R. Table 36 summarizes the results obtained for the laminates made with the glass and graphite fabric as bleeder material. Other than the bleeder material, these laminates were prepared in accordance with the standard procedure described in Appendix A.

3.9.3 Alternative Bagging Schemes

The standard laminate bagging scheme, illustrated in Figure A.1, was employed for the large majority of the laminates prepared in this program. Two alternative bagging schemes were investigated, however, in an effort to see if the void

TABLE 36
 PHYSICAL PROPERTIES SUMMARY FOR LAMINATES
 PREPARED WITH ALTERNATIVE BLEEDER MATERIAL

Type of Laminate	Bleeder Material	Bleeder Area Density (gm/m ²)	Bleeder/Laminate Ply Ratio	Bleeder Absorptivity(1) gm/gm (gm/m ²)	Specific Gravity	Laminate Physical Properties (2)				
						Ply Thickness mm (10 ⁻³ inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)	
E7781(GI)/EA9396	E-7781 Glass	295	3/16	0.41 (122)	1.84	0.20 (7.8)	50.0	30.7	5.6	
E7781(GI)/EA9396	E-7781 Glass	295	2/8	0.50 (148)	1.85	0.21 (8.2)	49.5	31.6	4.5	
E7781(GI)/EA9396	E-7781 Glass	295	3/8	0.41 (122)	1.89	0.23 (8.9)	52.5	29.2	4.2	
E7781(GI)/EA9396	CW1850	71	2/8	3.0 (213)	1.91	0.20 (8.0)	55.2	26.6	5.1	
T300-W133 (Gr)/EA9396	T300-W133 Graphite	366	3/12	0.54 (198)	1.48	0.37 (14.4)	55.4	33.1	5.8	
T300-W133 (Gr)/EA9396	T300-W133 Graphite	366	3/8	0.47 (172)	1.49	0.39 (15.4)	53.5	36.0	4.5	
T300-W133 (Gr)/EA9396	CW1850	71	5/12	3.0 (213)	1.48	0.36 (14.3)	55.8	33.6	4.9	

(1) Grams resin absorbed per gram or per square meter of bleeder material.
 (2) All laminates cured 45 minutes at 93°C (200°F) under vacuum bag pressure.

content could be reduced by means readily available to technicians carrying out field repairs.

The first variant was to perforate the normally nonporous barrier between the bleeder material and the breather material. The rationale for this was that this perforation permits the vacuum, when it is applied, to draw air out of the bleeder instead of forcing it into the layup. It was speculated that air might be trapped in the bleeder when the vacuum was applied because the caul plate would be pressed down so tightly that air escape paths would be shut off. The altered layup scheme is described in detail and illustrated in Appendix B. Instead of separating the bleeder material from the breather material with the two layers of nonporous teflon and a caul plate, the modified layup scheme consisted of a single layer of nonporous teflon film with a series of knife slits separating the two. A glass fabric reinforced laminate was prepared in this manner. Physical and interlaminar shear properties of this laminate were determined. Table 37 presents the data for this laminate and also for comparable baseline laminates. While the physical properties of the experimental laminate prepared with the perforated film procedure are slightly inferior to those exhibited by the laminates made with the baseline procedure, the interlaminar shear strength is about 15 percent higher. Since the higher void content of the experimental laminate is higher than that of the baseline laminates, one would normally expect the interlaminar shear properties to be lower. The only reason that can be offered to explain this is that the experimental laminate was made approximately 12 months after the baseline laminates. As was discussed in Section 3.7, interlaminar shear properties delivered by laminates made with 1 year old resin are higher than those delivered by laminates made with relatively fresh resin (by about 11% in the case of 22°C (72°F) dry tests -- see Table 32).

The second variant was to utilize a double-bag vacuum scheme rather than the single-bag scheme illustrated in Figure A.1. The rationale for this approach was that while the vacuum applied in the single bag scheme supposedly aids in drawing air and volatiles out of the laminate, the compaction of the layup resulting from the vacuum bag may pinch off escape paths and trap air and volatiles in the layup. The idea of the double bag scheme is to permit the layup to "breathe" even while under vacuum by reducing the compacting force during the early part of the cure cycle. The double bag layup scheme is described in detail and illustrated in Appendix B. A graphite fabric reinforced laminate was prepared using this double bag scheme and both physical and interlaminar shear properties of this laminate were determined. Table 38 presents these data for both this

TABLE 37
 EFFECT OF PERFORATED FILM PROCESSING MODIFICATION ON
 LAMINATE PROPERTIES

Laminate Type	Processing Procedure	Ply Thickness (mm)	Ply Thickness (10 ⁻³ inch)	Specific Gravity	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)	Interlaminar Shear Strength (1) (MPa)	Interlaminar Shear Strength (1) (Psi)
E-7781 (GI)/EA9396	Standard (App. A)	0.20	8.0	1.91	55.2	26.6	5.1	39.3	5700
E-7781 (GI)/EA9396	Perforated Film (App. B)	0.19	7.6	1.86	52.8	27.6	6.7	45.2	6560

(1) All tests performed on dry, as-fabricated laminates at 22°C (72°F).

TABLE 38
 EFFECT OF DOUBLE-BAG PROCESSING MODIFICATION ON
 LAMINATE PROPERTIES

Laminate Type	Processing Procedure	Ply Thickness (mm)	Ply Thickness (10^{-3} inch)	Specific Gravity	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)	Interlaminar Shear Strength (I) (MPa)	Interlaminar Shear Strength (I) (Psi)
T300-W133 (Gr)/EA9396	Baseline (App. A)	0.36	14.3	1.48	55.8	33.6	4.9	39.3	5700
T300-W133 (Gr)/EA9396	Double Bag (App. B)	0.39	15.2	1.48	55.0	33.6	5.9	43.4	6300

(1) All tests performed on dry, as-fabricated laminates at 22°C (72°F).

laminate and also for comparable baseline laminates. While the physical properties of the experimental laminate prepared with the double-bag vacuum scheme are essentially equivalent to those exhibited by laminates made with the baseline procedure, the interlaminar shear strength values are about 10 percent higher. As noted for the laminate made with the perforated film (Table 37), the higher interlaminar shear strength listed in Table 38 for the double-bag laminate may well be attributable to the fact that the EA9396 resin used for this laminate was 13 months older than that used for the baseline laminates. Again, Table 32 shows that 1 year old resin produces an interlaminar shear strength about 11% higher than fresh resin.

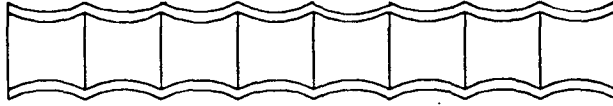
Based on the results of these two modified bagging schemes, it appears that both produced laminates that were essentially equivalent to those produced by the standard baseline processing procedure.

3.10 HONEYCOMB SANDWICH BEHAVIOR

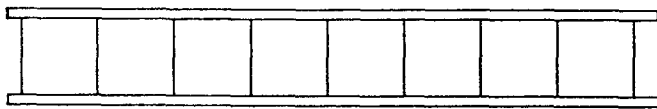
Two types of honeycomb sandwich specimens were made and tested, edgewise compression, and flatwise tension. The former type specimens were utilized to investigate whether skin dimpling, if it occurred, would reduce the edgewise compression strength. The latter type specimens were utilized to investigate the effects of adhesive fillet size on flatwise tensile strength. Both specimen types consisted of honeycomb core with composite skins bonded to the core with a layer of epoxy adhesive (EA9394 by Dexter Hysol). The honeycomb core was either 126.5 Kg/m^3 (7.9 lb/ft^3) or 91.3 Kg/m^3 (5.7 lb/ft^3) density material. Both cores were from Hexcel and were designated CRIII-1/4-5052-.004N-7.9 and CRIII-3/16-5052-.002-5.7, respectively. These two honeycomb sandwich investigations are discussed in detail in the following sections.

3.10.1 Effect of Skin Cocuring on Edgewise Compression Behavior

When skin repairs are made on honeycomb core substrates, the skin is relatively thin, typically as few as only two plies in some cases. If the skin is cocured, under a compacting vacuum bag pressure, the cured skin may exhibit the imprint of the honeycomb substrate. This is called dimpling and results in a skin that is not flat, but is somewhat rippled, as illustrated in Figure 9. Since one failure mode in edgewise compression can consist of skin buckling, it was felt that if dimpling does occur during cocure, the resulting edgewise compression strength may be reduced from what it would be with straight, undimpled skins.



- (a) Dimpled skin (exaggerated) resulting from cocuring composite skin and adhesive under vacuum bag compaction.



- (b) Flat, undimpled skin resulting from precuring the composite skin on a flat tool and then bonding it to the core in a second step.

Figure 9. Comparison of Cocured and Secondarily Bonded Honeycomb Sandwich Skins.

This possibility was investigated by preparing honeycomb sandwich panels both by cocuring and by secondarily bonding flat composite skins to the core. When graphite fabric was used for the skin, each skin was two plies thick. When glass fabric was used, each skin was four plies thick, since the glass fabric plies were only about half as thick as the graphite plies. On all sandwich panels, an adhesive layer consisting of a ply of style 120 glass fabric impregnated with 0.21 gm/cm^2 EA9394 paste adhesive was used to bond the skin to the core. This paste adhesive layer was used because the viscosity of the EA9396 resin used in the skins became so low during cure that satisfactory filleting along the honeycomb cell walls could not be achieved. Two different cores were used: one with a 6.35-mm (1/4-inch) cell size and one with a 4.76-mm (3/16-inch) cell size. It was felt that if skin dimpling indeed did occur and caused a reduction in edgewise compression strength, the effect would be greater for a larger cell size and lesser for a smaller cell size.

In the case of the cocured panels, the skins were impregnated in the standard manner, as described in Appendix A. The bottom skin rested on a flat tool surface while the upper skin was atop the core (and adhesive layer). The entire sandwich assembly was bagged in accordance with the layup illustrated in Figure A.1 except that no caul plate was used. The cure cycle was the same as that described in Appendix A.

In the case of the secondarily bonded panels, the two skins were prepared by the standard processing procedure described in Appendix A. These were then bonded to the core using a layer of EA9394 adhesive on a style 120 glass carrier fabric between each skin and the core. The two skins were lightly sanded and wiped with solvent prior to bonding to ensure a clean surface. The adhesive was cured for 1 hour at 93°C (200°F) under vacuum bag pressure.

The cocured panels were 30.5 x 30.5 cm (12 x 12 inches) and three specimens 7.6 x 22.9 cm (3 x 9 inches) were machined from each panel. The secondarily bonded specimens were prepared individually in a 10.2 x 25.4-cm (4 x 10-inch) dimension, then trimmed to the final specimen size. Individual specimens were secondarily bonded because it was found that secondary bonding of large panels resulted in disbonds. These were manifested as large blisters in the center of the panels. All specimens, whether cocured or secondarily bonded, were oriented such that the fill fibers in the fabric reinforced skins were in the length direction of the specimens.

Table 39 summarizes the results of the edgewise compression tests. As the data in Table 39 indicate, the cocured samples produced higher compression strengths than the secondarily bonded samples, by around 15-20%. All of the secondarily bonded samples failed by virtue of the skin debonding from the adhesive layer. All of the cocured samples exhibited compressive failure of one or both skins and no debonding of either skin from the adhesive layer. In addition to the failure modes described above, most of the samples made with the lower density core, regardless of the type skin/core bond, exhibited general buckling. No evidence of skin dimpling was observed on any of the cocured panels.

3.10.2 Effect of Fillet Size on Flatwise Tensile Strength

Several preliminary attempts were made to prepare honeycomb sandwich panels in which the EA9396 resin in the composite skins served simultaneously as the skin-to-core adhesive. This proved generally unsuccessful because the viscosity of the EA9396 resin became so low during cure that satisfactory filleting along the honeycomb cell walls could not be achieved along the upper skin. Suitable fillets did form on the lower skin because the resin from the upper skin ran down the cell walls and accumulated along the lower skin-to-core interface. As a consequence, it was found that suitable fillets, and a reasonable strength of the skin-to-core bond could only be achieved by the addition of a layer of paste adhesive between the skins and core. As noted earlier in Section 3.10.1, this paste adhesive layer consisted of a ply of style 120 glass scrim fabric impregnated with EA9394 epoxy adhesive. This adhesive is a filled version of the EA9396 resin system.

Since flatwise tensile strength of a sandwich construction is influenced by the size of the fillets that are formed, the purpose of the investigation described in this section was to determine how much the flatwise tensile strength is affected by various fillet sizes. Fillet size was varied by applying different amounts of adhesive to the style 120 glass scrim cloth.

Table 40 summarizes the results obtained in this study. It includes data for honeycomb panels made with no adhesive layer, with an adhesive layer along the top skin only, and with an adhesive layer of various weights along both skins. It is evident from the data in this table that the flatwise tensile strength increases as the amount of adhesive, and the accompanying fillet size, are increased. There is a dramatic increase in flatwise tensile strength as the amount of adhesive increases from zero to about

TABLE 39
 EFFECT OF SKIN BONDING APPROACH ON EDGEWISE COMPRESSION STRENGTH

Skin Type (1)	Core Density (gm/m ³)(lb/ft ³)	Type Bond (2)	Facing Stress at Failure (3)		Failure Mode
			Average MPa (10 ³ psi)	Std. Deviation MPa (10 ³ psi)	
T300-W133 Graphite, 2-ply	115 (5.7)	Cocured	286 (41.5)	47.8 (6.9)	buckling, skin compression
		Secondary	244 (35.3)	38.5 (5.6)	skin debonding
	160 (7.9)	Cocured	326 (47.2)	15.7 (2.3)	skin compression
		Secondary	271 (39.3)(4)	---	skin debonding
E-7781 Glass, 4-ply	115 (5.7)	Cocured	294 (42.6)	10.6 (1.5)	buckling, skin compression
		Secondary	252 (36.6)	62.7 (9.1)	buckling, skin debonding

(1) In both the cocure and secondary bonding processes a layer of EA9394 adhesive on a fiberglass scrim was used between the skins and the core to assure satisfactory filleting on both skins.

(2) Cocured = Skins cured and bonded to core simultaneously.
 Secondary = Skins cured separately then bonded to core in a second operation.

(3) Values represent average of three specimens unless otherwise indicated. All tests at 22°C (72°F).

(4) Two specimens.

TABLE 40
 EFFECT OF ADHESIVE APPLICATION RATE ON FLATWISE
 TENSILE STRENGTH OF HONEYCOMB SANDWICH

Sandwich Description		Fillet Size (2)			Failure Mode (4)				
Core	Skin	Adhesive Application Rate (1)	Top Skin (mm)	Bottom Skin (mm)	Flatwise Tensile Strength (3) (MPa) (psi)	A (%)	A/C (%)	A/S (%)	S (%)
CRIII-1/4-5052-.004N-7.9 2.54cm (1 in) thick	2-ply T300-W133 Gr/EA9396 Comp. each face	None	0.1-0.3	0.3-0.5	1.7 (248)	30	10	60	0
"	"	0.21 gm/cm ² adh. between core and top skin only	~1.5	0.3-0.5	4.2 (607)	92	8	0	0
"	"	0.08 gm/cm ² adh. between core and both skins	~0.5	~0.5	5.2 (751)	35	60	5	0
"	"	0.21 gm/cm ² adh. between core and both skins	~1.5	~1.5	5.8 (846)	10	50	40	0
"	"	0.73 gm/cm ² adh. between core and both skins	3.2-4.7	3.2-4.7	6.7 (980)	3	30	34	33

- NOTES:
- EA9394 adhesive on Style 120 glass resin cloth.
 - Estimated from microscopic examination of specimens after testing.
 - Average of three or four specimens. All tests performed at 22°C (72°F).
 - A = cohesive failure within the adhesive (between the base of the fillet and the adhesive layer)
 A/C = failure at fillet-to-core interface (bare cell wall)
 A/S = failure at adhesive to skin interface
 S = delamination of skin
 - Failure located between core and top skin.
 - Failure located between core and bottom skin.

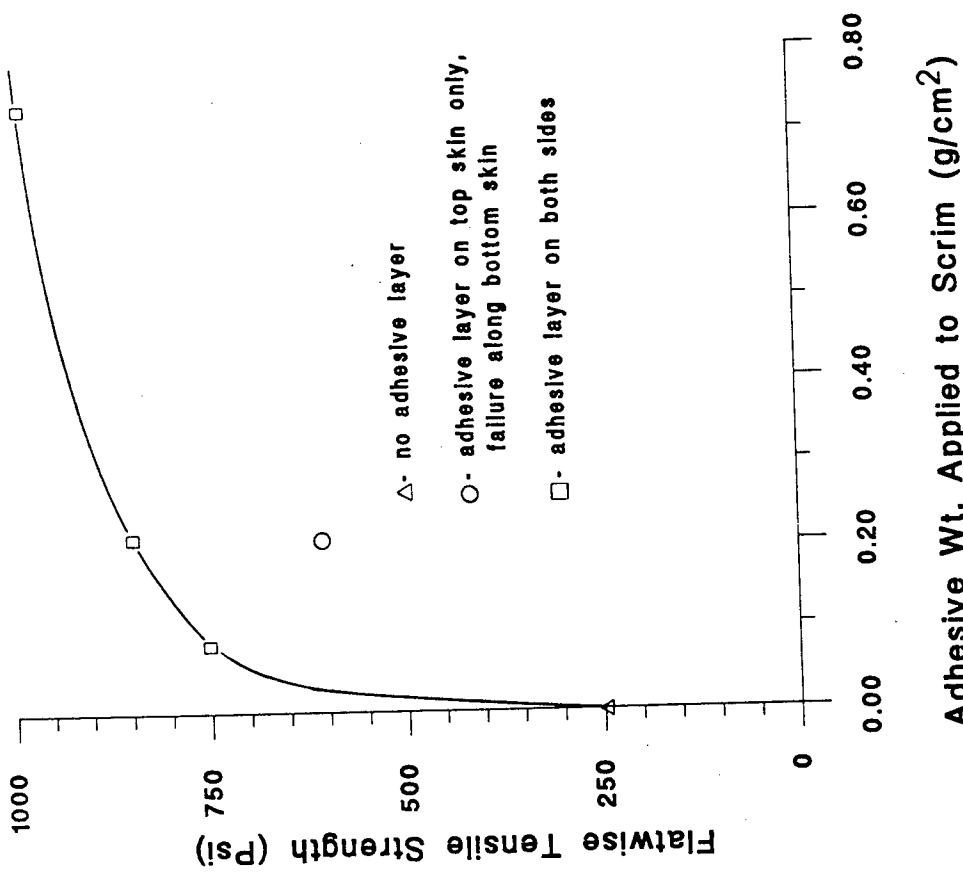
0.08 gm/cm² along the skin-core interface. Above this weight of adhesive application, additional strength increases are achieved but at a much lower rate. Figure 10 illustrates the relationship between adhesive application rate and resulting flatwise tensile strength and the relationship between fillet size (or area of contact between adhesive and core cell walls) and adhesive application rate. With no adhesive at all, the fillets result solely from the EA9396 matrix resin in the sandwich skins, and the fillet size ranges from nearly zero along the upper skin (0.1-0.3 mm by visual estimate) to approximately 0.3-0.5 mm along the lower skin. In those cases where a layer of EA9394 adhesive was employed, the fillet sizes ranged from approximately 0.5 mm for an adhesive application rate of 0.08 gm/cm², to 1.5 mm for a rate of 0.21 gm/cm², and 4 mm for a rate of 0.73 gm/cm².

While it is evident that flatwise tensile strength levels can be raised significantly by the use of large quantities of adhesive, and that without an adhesive layer the strength levels are quite low, a point of diminishing returns is reached at adhesive application rates in the vicinity of 0.1 gm/cm². Above this level the increases in strength that can be achieved may not be worth the weight penalty that accompanies it.

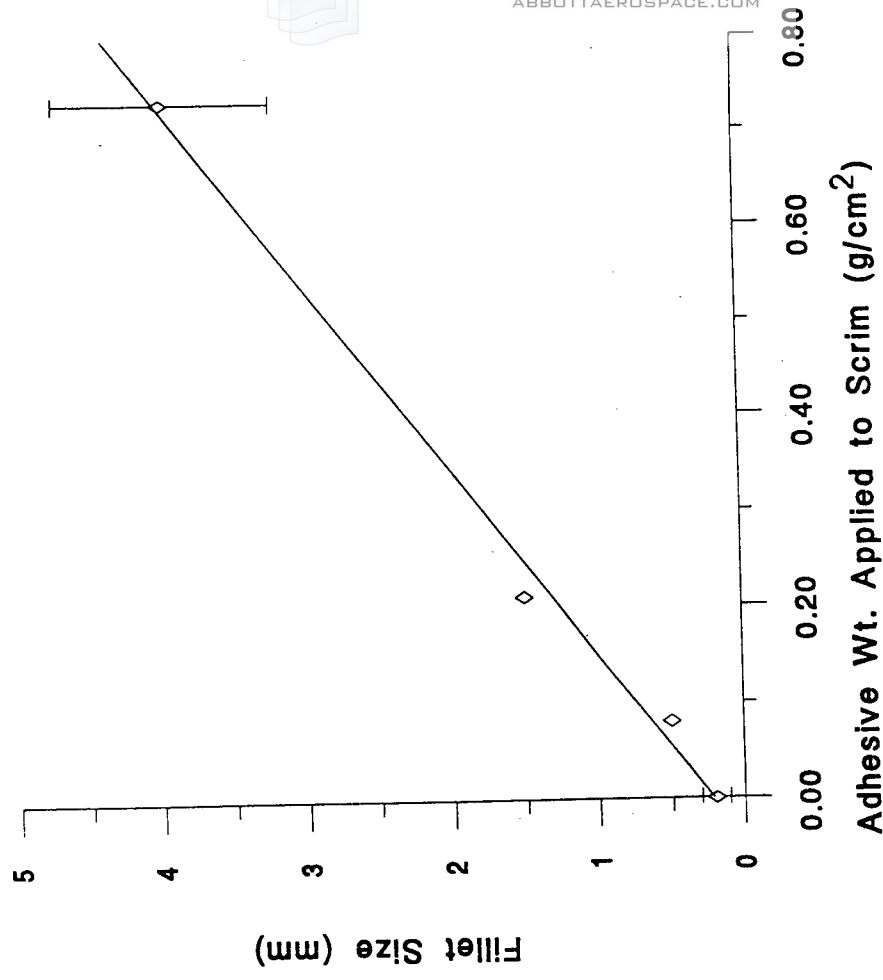
3.11 EFFECT OF SIZING ON GLASS FABRIC LAMINATES

Except for the work reported in this section, all of the glass-reinforced laminates made and tested during this program had a Volan-A type fiber sizing. This fiber sizing was used because it is the most commonly used fiberglass sizing and is epoxy-compatible, even though it is not the most environmentally durable finish. It was felt that there was a high likelihood of Volan-sized glass fabric being used in repairs, and the data would therefore provide conservative numbers. The property levels delivered by glass-reinforced laminates made with Volan-A sized fiber were listed in the various tables in Section 3.2. It is evident from these data that very significant property losses are encountered as a result of moisture absorption. Because of this substantial moisture-induced property degradation, it was decided to prepare and test a limited quantity of glass-reinforced laminates that incorporated a silane sizing rather than the Volan-A type sizing.

Laminates using silane-sized glass fabric were prepared in the same manner as those for which property data are reported in Sections 3.2.1, 3.2.3, and 3.2.4. The standard processing procedure described in Appendix A was followed in the preparation of these silane-sized laminates. Tensile, inplane shear and interlaminar shear properties were generated from specimens machined from these laminates, and the results of these



(a) Effect of Adhesive Application Rate on Flatwise Tensile Strength



(b) Effect of Adhesive Application Rate on Fillet Size

Figure 10. Effect of Adhesive on Fillet Size and Flatwise Tensile Strength of Sandwich Constructions.

tests are presented in Tables 41-43. It is apparent from these tables that the silane-sized fiber produces appreciably higher strength retention after wet aging than the Volan sizing.

3.12 EFFECT OF NONBASELINE ENVIRONMENTAL EXPOSURE

The baseline environmental exposure condition utilized during this investigation was a wet-aging exposure at conditions of 60°C (140°F)/100% R.H. until saturation was achieved. This was followed by mechanical testing at -54°C (-65°F), 22°C (72°F), or 93°C (200°F). Two nonbaseline types of environmental exposure were carried out, however, to assess durability of the repair material to various thermal environments. These are described in the following two sections.

3.12.1 Elevated Temperature Exposure

The purpose of this test was to determine whether exposure to 177°C (350°F) was detrimental to composite mechanical properties, specifically interlaminar shear. This was of interest because a repair initially cured at 93°C (200°F) might, at some later date, be exposed to one or more 177°C (350°F) cure cycles. Two exposure levels, 2 hours and 16 hours at 177°C (350°F), were carried out. Interlaminar shear tests were conducted after these exposures and the results are presented in Table 44. No degradation is evident in the shear strength values for the glass reinforced material in spite of the visual darkening that was evident. In the case of the graphite reinforced material, the shear strengths after the 177°C (350°F) exposures are approximately 15% lower than the baseline shear strength levels.

3.12.2 Exposure to Thermal Pulse

Both graphite and glass reinforced laminates were painted on one side with a standard aircraft paint scheme in a dark gray shade. Some of these painted laminates were humidity aged until saturated while some were stored in a desiccated environment. After completion of the environmental exposure, these laminates were exposed, on the painted side, to a thermal pulse by means of a quartz lamp bank. A Mach 0.7 air flow was maintained over the laminates during the thermal pulse and the laminates were not loaded.

After exposure to the pulse, the laminates were machined into compression specimens and tested for residual strength. Tables 45 and 46 present the

TABLE 41

**LONGITUDINAL (WARP) TENSILE PROPERTIES OF A1100-SIZED
 GLASS REINFORCED E-7781/EA9396 COMPOSITE MATERIAL**

Test Condition	Fiber Sizing	Test Direction	Ultimate Strength		Tensile Modulus		Ult. Strain
			(MPa)	(psi)	(GPa)	(10 ⁶ psi)	(10 ⁻⁶ in/in)
22°C(72°F), Dry	A1100	Warp	280.8	40,760	24.5	3.55	11,880
22°C (72°F), Wet(2)	A1100	Warp	246.5	35,780	21.6	3.14	12,130
93°C (200°F), Wet(2)	A1100	Warp	170.6	24,760	18.8	2.73	9,520
22°C (72°F), Dry	Volan (3)	Warp	356.6	51,750	24.9	3.62	17,740
22°C (72°F), Wet	Volan (3)	Warp	112.9	16,390	22.7	3.30	5,100
22°C (72°F), Wet	Volan (3)	Fill	120.9	17,540	23.9	3.47	5,410
93°C (200°F), Wet	Volan (3)	Fill	93.3	13,540	20.7	3.01	4,470

- (1) All average values represent five specimens.
- (2) WET = wet aged at 60°C (140°F)/100% R.H. until saturation.
- (3) The Volan sized fiber panels represent the baseline data.

TABLE 42

**IN-PLANE SHEAR PROPERTIES OF A1100-SIZED GLASS
 REINFORCED E-7781/EA9396 COMPOSITE MATERIAL**

Test Condition	Fiber Sizing	In-Plane Shear Strength		In-Plane Shear Modulus	
		(MPa)	(psi)	(GPa)	(10 ⁶ psi)
22°C (72°F), Dry	A1100	65.6	9,520	4.38	0.635
22°C (72°F), Wet (2)	A1100	44.1	6,400	2.60	0.378
93°C (200°F), Wet (2)	A1100	25.8	3,740	0.90	0.131
22°C (72°F), Dry	Volan (3)	78.5	11,400	5.27	0.765
22°C (72°F), Wet	Volan (3)	38.0	5,510	3.39	0.492
93°C (200°F), Wet	Volan (3)	18.9	2,740	1.67	0.243

- (1) All values represent average of five specimens.
- (2) WET = wet aged at 60°C (140°F)/100% R.H. until saturated.
- (3) The Volan sized fiber panels represent the baseline data.

TABLE 43

INTERLAMINAR SHEAR PROPERTIES OF A1100-SIZED GLASS
 REINFORCED E-7781/EA9396 COMPOSITE MATERIAL

Test Condition	Fiber Sizing	Interlaminar Shear Str.		Weight Gain
		(MPa)	(psi)	During Aging (%)
22°C (72°F), Dry	A1100	42.4	6,150	N.A.
22°C (72°F), Wet (2)	A1100	29.4	4,260	2.69%
93°C (200°F), Wet (2)	A1100	12.7	1,840	2.68%
22°C (72°F), Dry	Volan (3)	38.7	5,620	N.A.
22°C (72°F), Wet	Volan (3)	20.5	2,980	2.18%
93°C (200°F), Wet	Volan (3)	11.8	1,710	2.15%

- (1) All values represent average of five specimens. Four-point shear. Tested at 8:1 span-thickness ratio.
- (2) WET = wet aged at 60°C (140°F)/100% R.H. until saturation.
- (3) The volan sizing fiber panels represent the baseline data.

TABLE 44

**EFFECT OF 177°C (350°F) CURE CYCLES ON INTERLAMINAR
 SHEAR STRENGTH OF EA9396 COMPOSITE LAMINATES**

Reinforcement Type	Exposure Condition	Test Condition	Shear Strength(1,2)		Weight Gain During Aging (%)
			(MPa)	(psi)	
"E"-7781-Glass	None (3)	22°C (72°F), Dry	38.7	5620	N.A.
		93°C (200°F), Wet (4)	11.8	1710	2.15
	2 hrs. @ 177°C (350°F)	22°C (72°F), Dry	38.9	5650	N.A.
		93°C (200°F), Wet (4)	13.3	1930	2.04
16 hrs. @ 177°C (350°F) (3 seg- ments of 6 + 6 + 4 hrs)	22C (72°F), Dry	41.4	6010(5)	N.A.	
	93°C (200°F), Wet (4)	13.2	1920(5)	2.25	
T300-W133 Graphite	None (3)	22°C (72°F), Dry	39.3	5700	N.A.
		93°C (200°F), Wet (4)	16.1	2340	2.20
	2 hrs. @ 177°C (350°F)	22°C (72°F), Dry	34.5	5000	N.A.
		200°F, Wet (4)	13.7	1990	2.35
16 hrs. @ 177°C (350°F) (3 seg- ments of 6 + 6 + 4 hrs.)	22°C (72°F), Dry	36.2	5260	N.A.	
	93°C (200°F), Wet (4)	13.2	1920	2.35	

- (1) Four-point shear (Graphite tests at 16:1 span-thickness ratio Glass tests at 8:1).
- (2) Warp direction of fabric is running in length direction of specimens.
- (3) The shear strength values listed for the no exposure condition represent the baseline interlaminar shear strengths.
- (4) WET = aging at 60°C (140°F)/95-100% R.H. until saturated.
- (5) These glass reinforced specimens turned very noticeably darker after this exposure. This darkening could not be noticed on the black graphite reinforced specimens.

TABLE 45
 EFFECT OF RADIANT THERMAL PULSE ON COMPRESSION STRENGTH
 OF GLASS-REINFORCED E-7781/EA9396 COMPOSITE MATERIAL

Data Source (1)	Test Condition (2)	Compression Strength	
		(MPa)	(psi)
Baseline Panel Average	22°C(72°F) Dry, No Pulse	281.6	40,840
Test Panel	22°C(72°F) Dry, No Pulse	293.7	42,600(3)
Test Panel	22°C(72°F) Dry, Pulsed	283.4	41,100
Baseline Panel Average	93°C(200°F) Dry, No Pulse	200.1	29,020
Test Panel	93°C(200°F) Dry, Pulsed	177.5	25,740
Baseline Panel Average	-54°C(-65°F) Wet, No Pulse	320.7	46,510
Test Panel	-54°C(-65°F) Wet, Pulsed	280.3	40,650
Baseline Panel Average	22°C(72°F) Wet, No Pulse	162.4	23,560
Test Panel	22°C(72°F) Wet, No Pulse	159.2	23,090(4)
Test Panel	22°C(72°F) Wet, Pulsed	146.8	21,290
Baseline Panel Average	93°C(200°F) Wet, No Pulse	97.8	14,180
Test Panel	93°C(200°F) Wet, Pulsed	70.7	10,250

NOTES:

- Baseline panel average values from Tables 12 and 13. All test panel values represent an average of five specimens unless otherwise noted. Test panel, no pulse specimens were tested to demonstrate that the test panel was equivalent to the baseline panels.
- The listed temperature represents the temperature at which the compression test was conducted. DRY means that the specimens were in the dry condition when exposed to thermal pulse (if applicable) and also when tested in compression. WET means that the specimens had been exposed to 60°C (140°F)/100% R.H. wet aging until saturated prior to the thermal pulse exposure (if applicable) and also when tested in compression. The wet aged samples that were thermally pulsed were reaged after the pulse until resaturated before being compression tested.
- Average of two specimens.
- Average of four specimens.

TABLE 46
 EFFECT OF RADIANT THERMAL PULSE ON COMPRESSION STRENGTH
 OF GRAPHITE-REINFORCED T300-W133/EA9396 COMPOSITE MATERIAL

Data Source (1)	Test Condition (2)	Compression Strength	
		(MPa)	(psi)
Baseline Panel Average Test Panel Test Panel	22°C(72°F) Dry, No Pulse	420.3	60,960
	22°C(72°F) Dry, No Pulse	448.2	65,000(3)
	22°C(72°F) Dry, Pulsed	395.1	57,300
Baseline Panel Average Test Panel	93°C(200°F) Dry, No Pulse	278.8	40,440
	93°C(200°F) Dry, Pulsed	297.4	43,130
Baseline Panel Average Test Panel	-54°C(-65°F) Wet, No Pulse	530.8	76,990
	-54°C(-65°F) Wet, Pulsed	495.5	71,860
Baseline Panel Average Test Panel Test Panel	22°C(72°F) Wet, No Pulse	349.6	50,700
	22°C(72°F) Wet, No Pulse	314.6	45,630(4)
	22°C(72°F) Wet, Pulsed	315.1	45,690

NOTES:

1. Baseline panel average values from Tables 15 and 16. All test panel values represent an average of five specimens unless otherwise noted. Test panel, no pulse specimens were tested to demonstrate that the test panel was equivalent to the baseline panels.
2. The listed temperature represents the temperature at which the compression test was conducted. DRY means that the specimens were in the dry condition when exposed to thermal pulse (if applicable) and also when tested in compression. WET means that the specimens had been exposed to 60°C (140°F)/100% R.H. wet aging until saturated prior to the thermal pulse exposure (if applicable) and also when tested in compression. The wet aged samples that were thermally pulsed were reaged after the pulse until resaturated before being compression tested.
3. Average of two specimens.
4. Average of four specimens.

results of these tests. The data in these tables indicate that the laminates used in the thermal pulse tests were equivalent to the baseline laminates in the unpulsed condition and that exposure to a thermal pulse resulted in relatively small decreases in compression strength.

SECTION 4 CONCLUSIONS

Based on the results obtained during the test program described in this report, the following conclusions were drawn.

- Reproducible composite mechanical and physical property levels can be achieved using the wet-layup impregnation and vacuum-bag curing procedures described here.
- With vacuum-bag cure pressure, the void content of cured composites is in the vicinity of 5% by volume.
- Batch-to-batch property values are quite consistent and reproducible.
- Significant reductions in composite property levels occur with increasing temperature over the range of -65°F to 200°F.
- The property levels of EA9396 composites reinforced with a Volan-A sized glass fabric are significantly reduced when the composites become moisture saturated. A silane-type sizing on the glass reinforcement provides markedly better wet strength retention than the Volan-A type sizing and nearly equivalent to that of the graphite reinforced composites.
- Measurements made during this program indicate that nominally complete cure and peak property levels can only be achieved with elevated temperature (180°F and up) curing.
- The EA9396 resin system has a reasonable pot and work life at temperatures up to 100°F for use in repair.
- The EA9396 resin system appears to have good storage stability, even at elevated temperature.
- Exposure of EA9396 composites to simulated 350°F cure cycles had no adverse effect on mechanical properties.
- A high heat flux thermal pulse did not cause a major degradation in compressive strength levels.

SECTION 5 REFERENCES

1. Browning, C.E., Abrams, F.L., and Whitney, J.M., "A Four-Point Shear Test for Graphite/Epoxy Composites," Composite Materials: Quality Assurance and Processing, ASTM STP 7979, C.E. Browning, Ed., American Society for Testing and Materials, 1983, pp. 54-74.
2. MIL-HDBK-178, Polymer Matrix Composites, Vol. 1, Ch. 7, 29 February, 1988.

APPENDIX A STANDARD LAMINATE PROCESSING PROCEDURE

Most of the laminates prepared during this investigation were made by a procedure designated the "Standard Procedure." This "Standard" laminate processing procedure is described below, first in a general stepwise listing of the procedure, and then in a more detailed description of each step. The general step-by-step procedure consisted of the following.

- (a) Cut fabric (total number of plies = P).
- (b) Weigh or measure the total area of all the plies cut in step (a).
- (c) Compute total amount of resin needed to impregnate fabric cut in step (a), (see Table A.2).
- (d) Weigh out and mix the total amount of resin needed. This is in the ratio of 100 parts A to 30 parts B by weight. A few grams extra should be allowed since some resin will adhere to sides of mixing container (total weight of mixed resin = W).
- (e) Lay down first two plies of fabric, one atop the other.
- (f) Weigh out an amount of mixed resin equal to $2.5 W/P$. Pour this resin on top of the second ply and manually spread it over the entire surface as uniformly as possible.
- (g) Lay down two more plies on top of the two in steps (e) and (f). Manually tamp these down so that the resin applied in step (f) is soaking into these two new plies.
- (h) Weigh out an amount of mixed resin equal to $2 W/P$. Pour this resin on top of the last ply and manually spread it over the entire surface as uniformly as possible.
- (i) Do steps (g) and (h) a total of $P-4/2$ times.
- (j) Lay down the last two plies of fabric on top of the previously impregnated plies.
- (k) Lay down an amount of mixed resin equal to $1.5 W/P$. Pour this resin on top of the last ply and manually spread it over the entire surface as uniformly as possible.
- (l) Bag the layup in general accordance with Figure A.1.
- (m) Cure the laminate in accordance with the standard cure cycle.

Each of the steps listed above, and the relevant rationale is described in detail below.

(a) The graphite (W133) and glass (7781) fabrics were cut to the size needed for the laminate being made. In this investigation, laminate sizes varied depending on the type and number of specimens that were required from the laminate. Table A.1 lists the thicknesses and dimensions used for the laminates prepared in this investigation.

(b) The amount of fabric used for each laminate was weighed. Alternatively, if a scale is not available, the total area of all the plies used for a laminate could be determined by measuring the dimensions of each ply.

(c) The amount of resin needed for the laminate being prepared depends on how much fabric needs to be impregnated. After some initial experimentation, we settled on using a 50% excess to provide for flow and bleed and to provide sufficient resin to allow uniform wet out of plies during the hand layup operation. Table A.2 lists the ratio of resin to fabric, on both a weight and area basis, that was used during laminate layup.

(d) Quantities of resin mixed for laminate preparation in this program ranged from around 50-60 grams for the smallest panels to 800-900 grams for the largest. In the case of the largest quantities, as many as three separate mixing containers were used (~300 grams each). This was done both to minimize the chance of a premature exotherm/gel and because larger mixing containers were not readily available. Between 5 and 10 grams of extra resin, beyond the quantities determined in step (c), were mixed in each mixing container to allow for the fact that some of the resin would be left behind on the container walls after impregnation.

(e) The actual impregnation process was performed on an 0.16 mm (0.063 inch) thick aluminum sheet coated with Frekote 44 release agent. Two dry plies of reinforcement were laid down atop one another on the aluminum sheet. Care was taken to keep track of the warp and fill direction of each ply of fabric so that the warp fibers were all aligned in the same direction for every ply. In addition, because both the W133 graphite and 7781 glass fabrics were 8-harness satin weaves, the predominant fiber direction on one side of the fabric was in the warp direction while on the other side it was in the fill direction. The plies were stacked such that the plies in the lower half of each laminate had the warp face down while the plies in the upper half had the warp face up. This ensured symmetry about the laminate midplane.

(f) The amount of resin poured onto the top of the first two plies laid down in step (e) was $2.5 W/P$, where W represents the total weight of the resin computed and mixed in step (c) and P represents the total number of plies in the laminate being prepared. After addition of this resin to the first two plies, it was manually spread over the entire ply surface as uniformly as possible using a plastic spatula.

(g) This step is straightforward and requires no further elaboration.

(h) It will be noted that the amount of resin to be applied in this step ($2 W/P$) is less than the amount applied to the first two plies ($2.5 W/P$) in step (f). The reason for this is that since the intermediate plies pick up resin from the bottom, from previously impregnated plies, not as much resin needs to be added to these intermediate plies as to the first two plies, which do not pick up resin from below.

(i) The thinnest laminates made in this investigation were 8-ply except for those used as skins on honeycomb sandwich. For this case, steps (g) and (h) would be done a total of two times ($[8-4]/2 = 2$). For a 16-ply laminate, steps (g) and (h) would be done a total of six times. For a 4-ply laminate, steps (g) and (h) would not be done at all ($[4-4]/2 = 0$).

(j) This step is straightforward and requires no further elaboration.

(k) Again, it will be noted that the amount of resin applied in this step ($1.5 W/P$) is less than that applied in previous steps (f) and (h). The reason for this is that since these last two plies do not give up any resin to succeeding plies, but do gain resin from previously impregnated plies, not as much resin needs to be added to these top plies.

(l) In this investigation a Zip-Loc reusable vacuum bag system was used for laminate cure. The bleeder material used in the "standard" processing procedure being described here was Mochburg CW1850 ($\sim 71 \text{ gm/m}^2$). Table A.2 lists the number of bleeder plies that were used, relative to the number of plies of reinforcement in the laminate being cured. After completion of the layup and closing of the lid, the unit was placed in a circulating air oven, and a vacuum was drawn to verify that a good seal was present before heating commenced.

(m) The "standard cure cycle" consisted of curing the laminate for 45 minutes at 93°C (200°F) under vacuum pressure. The laminate was subjected to a nominal vacuum of 635 mm (25 inches) Hg before the oven was turned on. In the oven used, the

temperature of the circulating air reached 93°C (200°F) in approximately 3-4 minutes while the laminate in the vacuum bag reached 93°C (200°F) in about 50 minutes. Figure A.2 illustrates a typical heat-up curve for a laminate during a vacuum bag cure in the oven. The 45-minute cure period was started when the laminate temperature, as indicated by a thermocouple inside the vacuum bag, reached 90.5°C (195°F). At the conclusion of the 45-minute cure, the oven heaters were turned off, the door was opened, and the circulating air fan was left on. The vacuum was left on the laminate during cooldown. Cooldown time varied from as little as 1 hour to overnight, depending on time of day and oven schedule.

TABLE A.1
 LAMINATE THICKNESSES AND DIMENSIONS

Type Test	Type Reinforcement			
	7781 Glass		W133 Graphite	
	Thickness(1)	Size Range (cm) [in]	Thickness(1)	Size Range (cm) [in]
Tension (D3039)	8 ply	max. (51 x 51) [20 x 20] min. (35.5 x 51) [14 x 20]	8 ply	(51 x 51) [20 x 20]
Compression (D3410B)	16 ply	max. (51 x 51) [20 x 20] min. (23 x 43) [9 x 17]	12 ply	max. (51 x 51) [20 x 20] min. (23 x 43) [9 x 17]
45° Tension/ Inplane Shear (D3418)	8 ply	max. (51 x 51) [20 x 20] min. (30.5 x 51) [12 x 20]	8 ply	max. (51 x 51) [20 x 20] min. (30.5 x 51) [12 x 20]
Interlaminar Shear (Four- Point Shear)	16 ply	max. (51 x 51) [20 x 20] min. (12.7 x 20.3) [5 x 8]	12 ply	max. (30.5 x 30.5) [12 x 12] min. (12.7 x 20.3) [5 x 8]
Bearing (MIL- HDBK-17)	8 ply	(30.5 x 35.5) [12 x 14]	8 ply	(30.5 x 35.5) [12 x 14]
Flatwise Tension (2) (C297)	---	---	2 ply	(15.2 x 15.2) [6 x 6]
Edgewise Compression (2) (C364)	4 ply	(3.3 x 35.5) [13 x 14]	2 ply	(33 x 35.5) [13 x 14]

TABLE A.2
 EA9396 BASELINE LAMINATE FABRICATION PARAMETERS

Parameter	Reinforcement Type	
	W133 Gr Fabric	7781 G1 Fabric
Grams of Mixed Resin Per Gram of Reinforcement Used During Impregnation	0.755	0.555
-or-		
Grams of Mixed Resin Per Unit Area of Reinforcement(1) Used During Impregnation	0.178 gm/in ² 0.0276 gm/cm ²	0.104 gm/in ² 0.0161 gm/cm ²
Plies of Mochburg CW1850 Bleeder (71 gm/m ²) Per Ply of Reinforcement	0.40(2)	0.25(2)
Cure Schedule	45 minutes at 93°C (200°F) under vacuum pressure (~125 mm Hg abs. pressure) (~25 inch Hg vac.)	

(1) Total area of all reinforcement plies, not area of laminate. The values listed correspond to the mass/mass ratios listed directly above for the respective graphite and glass fabrics used. These two reinforcing fabrics are described in Table 1 and have the following weight per unit areas:

W133 - 0.236 gm/in²
 7781 - 0.190 gm/in²

(2) Round off to the next higher whole number if the calculated number of bleeder plies is a fraction.

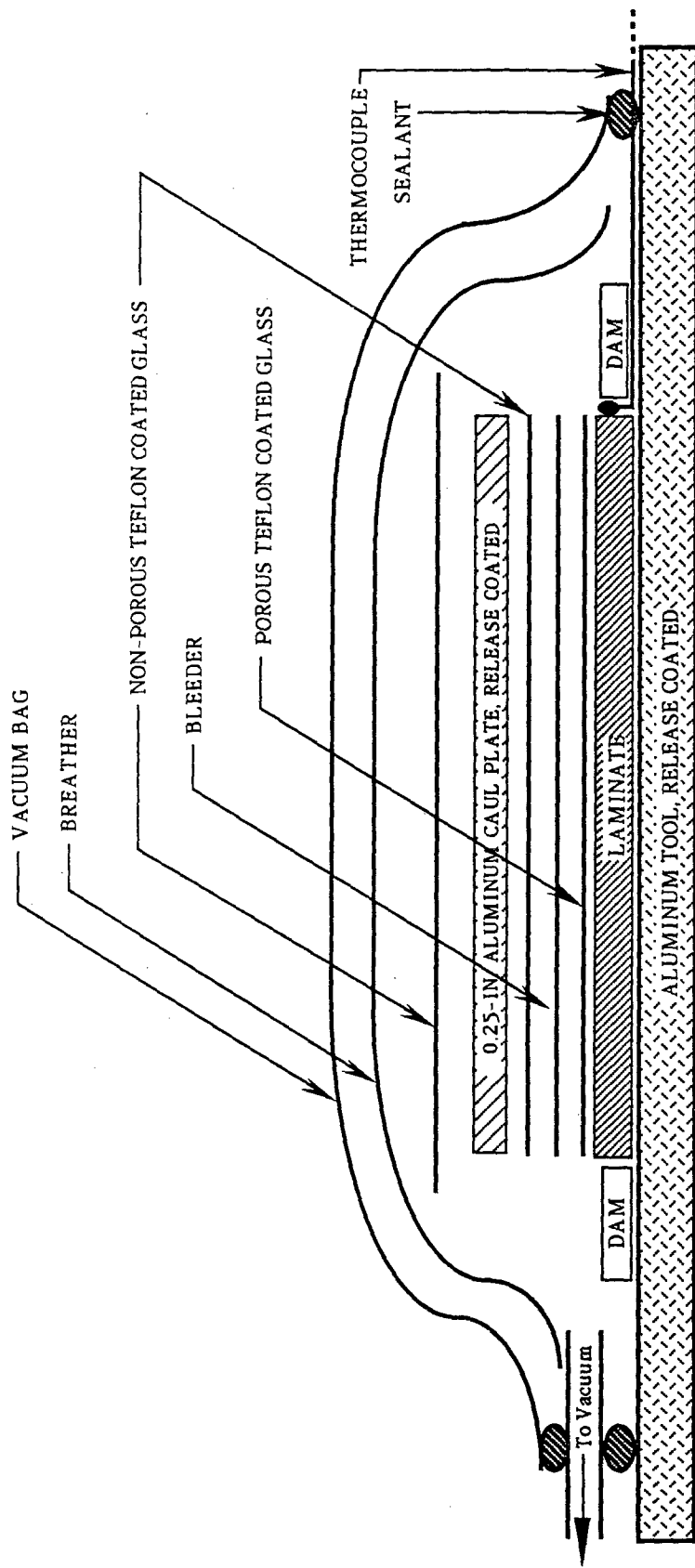


Figure A.1. Typical Vacuum Bag Layup Scheme for Curing EA9396 Composite Laminates.

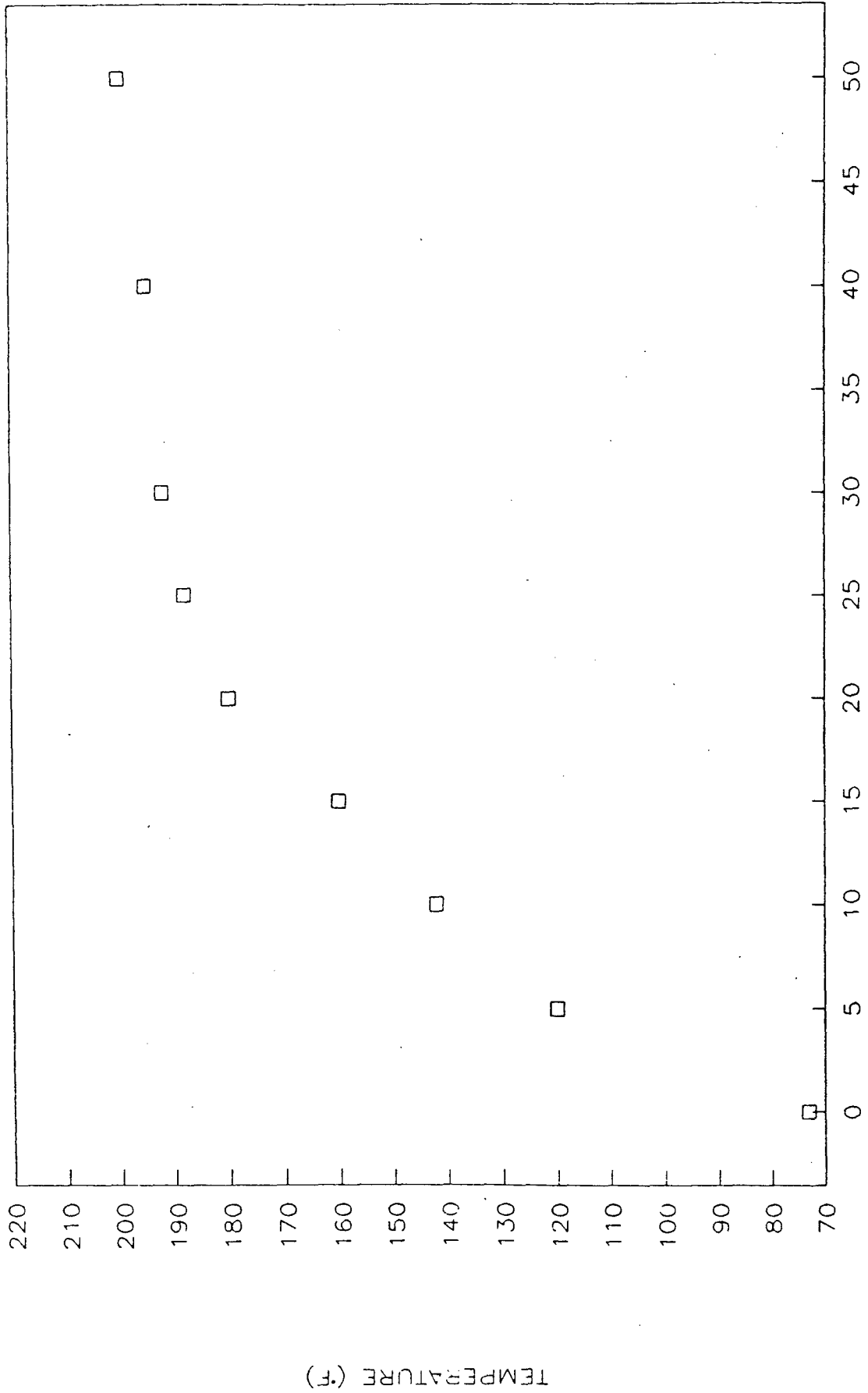


Figure A.2. Heat-Up Curve for Laminate Cure.

APPENDIX B NONSTANDARD LAMINATE PROCESSING PROCEDURES

Quite a few laminates prepared during this investigation were not made in accordance with the "Standard Procedure" described in Appendix A. The processing procedures for these nonstandard laminates were varied in order to determine the effect of processing variations that might occur in field repair situations on resulting mechanical and physical laminate properties.

The processing variations described in this Appendix are subdivided into six categories and each is addressed respectively in Sections B.1-B.6.

B.1 NONSTANDARD CURE TIME/TEMPERATURE

In Section 3.5.2, the effect of cure time and temperature on interlaminar shear strength was discussed. Five graphite reinforced laminates were prepared using different cure conditions than those described in step (m) of Appendix A. Except for this difference in cure condition, all five of these laminates were prepared in accordance with the "Standard Procedure" described in Appendix A. Table B.1 identifies the five laminates cured at alternative times/temperatures and lists the time/temperature history used for each.

B.2 NONSTANDARD CURE VACUUM PRESSURES

In Section 3.5.3, the effect of vacuum bag vacuum pressure level during cure on interlaminar shear strength was discussed. Four glass reinforced laminates were prepared using different vacuum pressure levels than that noted in step (m) of Appendix A. Except for this difference in vacuum pressure level, all four of these laminates were prepared in accordance with the "Standard Procedure" described in Appendix A. Table B.2 identifies the four laminates cured under alternate vacuum pressure levels and lists the vacuum level used.

B.3 NONSTANDARD FIBER CONTENT

In Section 3.8, the effect of fiber content on mechanical properties was discussed. Both glass and graphite fabric reinforced laminates were prepared with fiber contents ranging from the standard 55% by volume down to as low as 34% by volume. All these low fiber content laminates were cured by the "Standard" cure cycle described in step

(m) of Appendix A. The differences in fiber content were achieved by changing either the bleeder ply/reinforcement ply ratio used during cure, or the ratio of resin to reinforcement used during impregnation. Other than these differences, the laminate processing was identical to that described in Appendix A. Table B.3 identifies the laminates for which either the bleeder or resin ratios were varied and lists the particular details for each.

B.4 NONSTANDARD PLY IMPREGNATION PROCEDURES

Section 3.9.1 discusses alternative ply impregnation procedures that were investigated. The two alternate impregnation procedures that were investigated were felt to be representative of procedures that might be employed by repair personnel working in the field.

Laminate No. BIL-GL-14

The first variation consisted of applying resin to every ply instead of every other ply, as in the "Standard Procedure" described in Appendix A. The difference between this nonstandard procedure and the standard procedure was in steps (e)-(j) of Appendix A. Instead of the procedure described in steps (e)-(j) the procedure outlined below was followed.

- (e) Lay down the first ply of fabric.
- (f) Weigh out an amount of mixed resin equal to W/P. Pour this resin on top of the first ply and manually spread it over the entire surface as uniformly as possible.
- (g) Do steps (e) and (f) a total of P times.

After step (g) was completed, the procedure reverted to steps (l) and (m) of Appendix A.

Laminate No. BIL-GL-16

The second variation consisted of using a smaller quantity of resin during impregnation of the reinforcement than the 50% excess used in the "Standard Procedure" described in Appendix A. This smaller quantity of resin represented 0% excess (net resin content). Further, since no excess resin was used, no bleeder plies were used during cure.

Thus the differences between the "Standard Procedure" described in Appendix A, and that used for this laminate, occurred in step (c) (and by reference, Table A.2) and in step (l) (and by reference, Figure A.1). The resin ratio used for glass reinforced laminates in the "Standard Procedure" was 0.555 gm resin/gm reinforcement. In laminate BIL-GL-16, the ratio was 0.377 instead. In addition, the bleeder ratio used for glass reinforced laminates in the "Standard Procedure" was 0.25 plies of bleeder/ply reinforcement (Table A.2). In laminate BIL-GL-16, no bleeder plies were used at all.

B.5 NONSTANDARD BLEEDER MATERIAL

Section 3.9.2 discusses the use of alternative bleeder materials to the Mochburg CW1850 bleeder used in the "Standard Procedure" of Appendix A. Three glass and two graphite reinforced laminates were prepared using alternative bleeder material. The three glass laminates were made using the E-7781 glass fabric as bleeder while the two graphite laminates were made using the T300-W133 graphite fabric as bleeder. Other than this difference in bleeder material, the laminate processing was identical to the "Standard Procedure" described in Appendix A. Table B.4 identifies the laminates made with the nonstandard bleeder material, the applicable bleeder ratios that were used, and the resin absorption characteristics of the alternative materials.

B.6 NONSTANDARD BAGGING SCHEMES

Section 3.9.3 discusses the investigation of several laminate bagging schemes that varied from the standard scheme illustrated in Figure A.1. The goal of each of these variant bagging schemes was to improve laminate quality by reducing void content below that normally resulting from a vacuum bag cure (see Table 4). The two variant bagging schemes described in this section were felt to be readily usable in the field. Each is discussed separately below.

Perforated Barrier Film

The first approach was to perforate the normally non-porous barrier between the bleeder material and the breather material. It will be observed in Figure A.1 that in the standard bagging scheme, this nonporous barrier consists of a caul plate sandwiched between two sheets of nonporous teflon-coated glass. The purpose of the teflon-coated glass is to keep excess resin absorbed in the bleeder plies from being absorbed into the breather, where it might clog the vacuum paths and prevent full vacuum pressure from being uniformly exerted on the laminate surface. The purpose of the caul plate is to

prevent inadvertent wrinkles that may develop in the vacuum bag from imprinting the laminate surface and to prevent the vacuum bag from drawing down more tightly around the laminate edges than in the center, thereby producing nonuniform thickness. In the modified bagging scheme, the two layers of nonporous teflon-coated glass and the caul plate were replaced by a single layer of the teflon-coated glass that had been perforated with a series of knife slits. Figure B.1 illustrates this bagging scheme.

The rationale for investigating this type of bagging scheme was that perforations in the film between the bleeder and breather materials would permit the vacuum to draw air out of the bleeder instead of forcing it into the laminate layup. It was speculated that air might be trapped in the bleeder when the vacuum was applied because the caul plate would be pressed down so tightly that air escape paths would be shut off.

Other than the altered bagging scheme illustrated in Figure B.1, the processing of the laminate made with this procedure, BIL-GL-39, was identical to the "Standard Procedure" described in Appendix A.

Double-Bag

The second nonstandard bagging scheme that was investigated was the use of a double vacuum bag rather than the single bag scheme illustrated in Figure A.1. The rationale for this was that while the vacuum applied in the single bag scheme supposedly aids in drawing air and volatiles out of the laminate, the compaction of the layup resulting from the vacuum bag may pinch off escape paths and trap air and volatiles in the layup. The idea of a double bag scheme is that this approach permits the layup to "breathe" even while under vacuum by reducing the compacting force during the early part of the cure cycle. The double bag arrangement is illustrated in Figure B.2. An essential element of this arrangement is the "hardback" shell that holds the outer vacuum bag off the inner vacuum bag, thereby allowing the compacting force on the layup to be reduced during the early part of the cure cycle while simultaneously imposing a vacuum on the layup to draw off air and volatiles.

In using the bagging scheme illustrated in Figure B.2, a different cure cycle than that described in step (m) of Appendix A was followed. The cure cycle for the double-bag cure was as follows:

1. Draw a vacuum (23-24 in Hg) on the shell (#2).
2. Draw a vacuum (~25 in Hg) on the inner bag (#1).
3. Hold these two vacuum levels for 30 minutes at 22°C (72°F).
4. Vent line #2 to the atmosphere while maintaining full vacuum (~25+ in. Hg) on line #1.
5. Heat to 93°C (200°F).
6. When the temperature in the inner bag reaches 91°C (195°F), start a 45-minute hold, maintaining full vacuum on line #1.
7. Cool to 49°C (120°F) or less while maintaining full vacuum on line #1.
8. Remove.

TABLE B.1
LAMINATES CURED AT NONSTANDARD TIMES/TEMPERATURES

Laminate Number	Cure Temperature		Cure Time
	(°C)	(°F)	
"STANDARD"	93	200	45 minutes under vacuum
BIL-GR-5	107	225	45 minutes under vacuum
BIL-GR-1	93	200	30 minutes under vacuum
BIL-H7-5	82	180	30 minutes under vacuum
BIL-GR-4R	79	175	45 minutes under vacuum
BIL-GR-20	22	72	4 hours under vacuum + 7 days at ambient conditions + 3 months in either dry ambient storage or in 60°C (140°F), 95- 100% R.H. humidity cabinet

TABLE B.2
LAMINATES CURED UNDER NONSTANDARD VACUUM PRESSURE

Laminate Number	Vacuum Bag Pressure Level During Cure	
	(mm Hg Vacuum)	(in. Hg Vacuum)
"STANDARD"	635	25
BIL-GL-27	254	10
BIL-GL-28	406	16
BIL-GL-29	584	23
BIL-GL-38	686	27

TABLE B.3
LAMINATES PREPARED WITH NONSTANDARD BLEEDER
PLY IN RESIN RATIOS

Laminate Number	Bleeder Ply/Reinforcement Ply Ratio (1) (plies bleeder/ply reinforcement)	Resin/Reinforcement Ratio (1) (gm resin/ gm reinforcement)
GRAPHITE "Standard"	0.40	0.755
BIL-GR-51	0.42	0.548
BIL-GR-52	0.42	0.787
BIL-GR-53	0.33	1.000
BIL-GR-54	0.25	1.160
BIL-GR-79	0	1.150
BIL-GR-84	0.083	1.115
GLASS "Standard"	0.25	0.555
BIL-GL-10	0.25	0.755
BIL-GL-31	0.375	0.555
BIL-GL-33	0.25	0.706
BIL-GL-53	0	1.000
BIL-GL-54	0.125	1.000

NOTE:

(1) See Table A.2 (Appendix A) for baseline laminate fabrication parameters.

TABLE B.4
 LAMINATES MADE WITH NONSTANDARD BLEEDER MATERIAL

Laminate Number	Bleeder Material	Bleeder Dry Area Density (gm/m ²)	Bleeder/Laminate Ply Ratio	Bleeder Absorptivity		Bleeder Ply Equivalents (8)
				(gm/gm) (6)	(gm/cm ²) (7)	
GLASS "Standard"	CW1850	71	0.25 (1)	3	0.0213	1.0
BIL-GL-17	E-7781 fabric	295	0.25 (2)	0.50	0.0147	1.51-1.88
BIL-GL-37	E-7781 fabric	295	0.118 (3)	0.39-0.42	0.0112-0.0124	1.51-1.88
BIL-GL-47	E-7781 fabric	295	0.375 (4)	0.41	0.0121	1.51-1.88
GRAPHITE "Standard"	CW1850	71	0.40 (1)	3	0.0213	1.0
BIL-GR-58	T300-W133 fabric	366	0.25 (5)	0.58	0.0197	1.13-1.30
BIL-GR-64R	T300-W133 fabric	366	0.375 (4)	0.47	0.0171	1.13-1.30

- NOTES:
- (1) From Table A.2, Appendix A.
 - (2) Two plies bleeder, eight plies reinforcement.
 - (3) Three plies bleeder, sixteen plies reinforcement.
 - (4) Three plies bleeder, eight plies reinforcement.
 - (5) Three plies bleeder, twelve plies reinforcement.
 - (6) Grams resin absorbed per gram of bleeder. Value for CW1850 represents average for all baseline laminates.
 - (7) Grams resin absorbed per unit area of bleeder. Value for CW1850 represents average for all baseline laminates.
 - (8) Number of plies needed to absorb some quantity of resin as one ply of Mochburg CW1850.

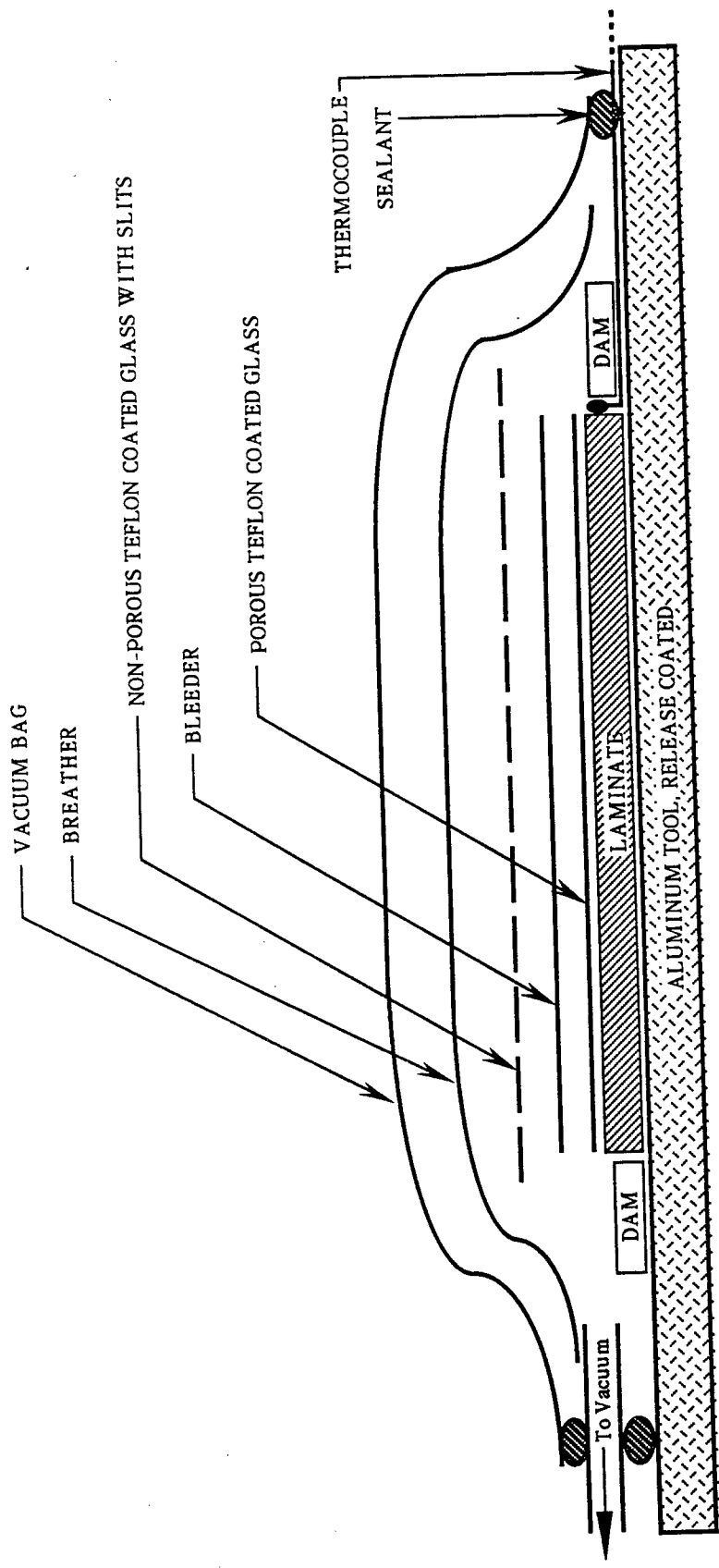


Figure B.1. Nonstandard Vacuum Bag Lay-up Scheme with Perforated Bleeder/Breather Barrier Film.

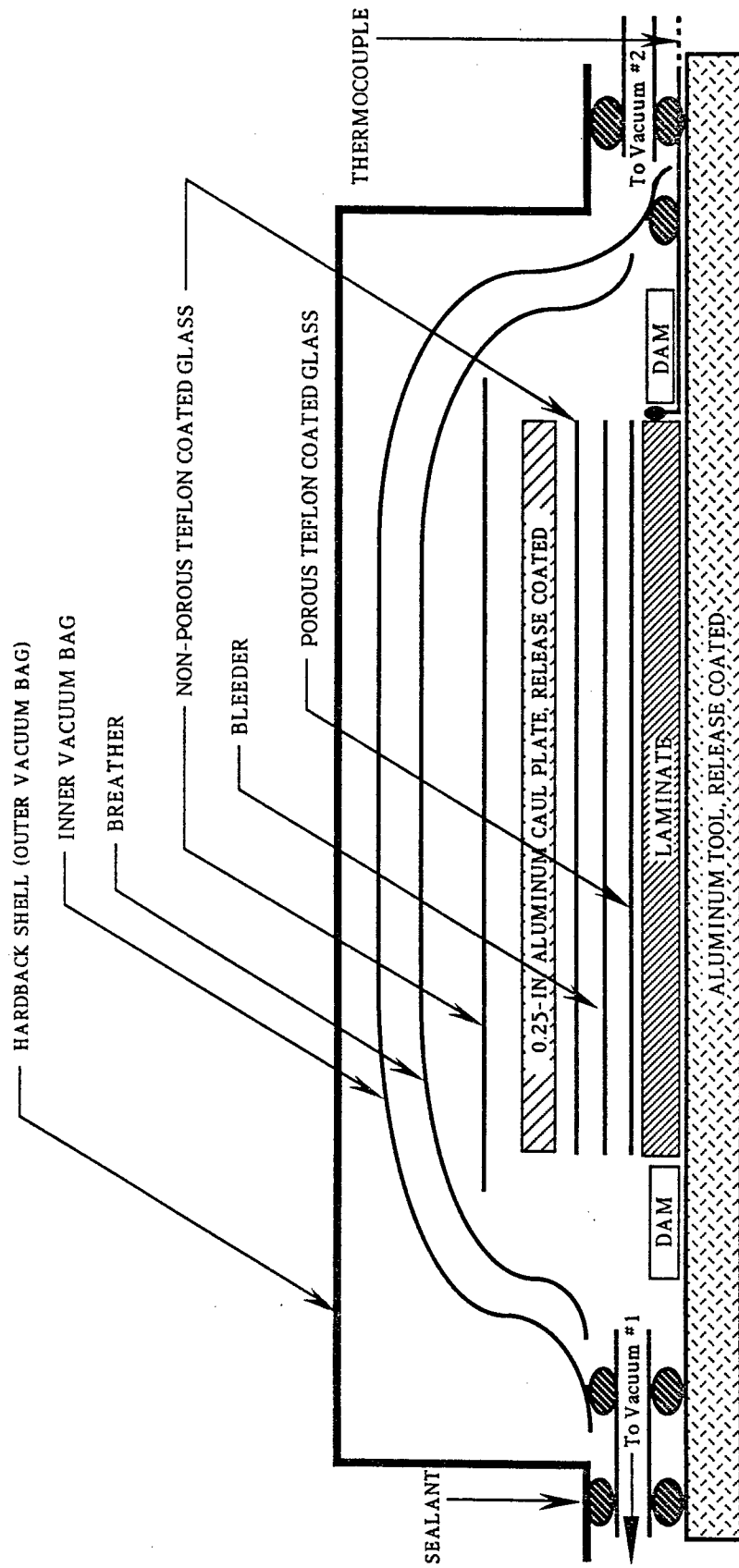


Figure B.2. Nonstandard Vacuum Bag Lay-up Using Double-Bag Scheme.

APPENDIX C LAMINATE PHYSICAL PROPERTIES

The laminate physical properties for all of the glass and graphite reinforced laminates prepared and evaluated during this investigation are listed in this Appendix. Each property value listed represents an average of three replicate determinations from various locations within the same laminate.

The data are organized generally as follows:

- Baseline Laminates
- Laminates Processed at Nonbaseline Temperatures or Pressures
- Laminates Prepared from Stored Resin
- Laminates Prepared with Variable Fiber Content
- Laminates Prepared with Alternate Impregnation and Bagging Schemes
- Laminates Prepared with Silane Sized Glass Reinforcement
- Laminates Prepared for Nonbaseline Environmental Exposure

This sequence corresponds to the sequence in which these various types of laminate, processing and test variables are discussed in Section 3 of the text.

The laminate number listed in the first column of Tables C.1 (graphite reinforced laminates) and C.2 (glass reinforced laminates) corresponds to the individual specimen numbering system that appears in the appendices to follow.

TABLE C.1
 PHYSICAL PROPERTIES OF T300-W133 GRAPHITE
 FABRIC REINFORCED LAMINATES

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10 ⁻³ inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GR-7	8	Tension	Baseline (App. A)	1.49	0.39	15.3	56.3	34.2	4.0
BIL-GR-8	8	Tension	Baseline (App. A)	1.48	0.38	15.0	56.4	33.6	4.5
BIL-GR-9	8	Tension	Baseline (App. A)	1.48	0.39	15.2	57.3	32.7	4.5
BIL-GR-10	8	Tension	Baseline (App. A)	1.48	0.38	14.8	56.6	33.3	4.8
BIL-GR-11	8	Tension	Baseline (App. A)	1.48	0.38	15.0	56.4	33.8	4.1
BIL-GR-12	8	Tension	Baseline (App. A)	1.48	0.38	15.0	56.4	33.8	4.2
BIL-GR-13	12	Compression	Baseline (App. A)	1.47	0.38	15.0	55.5	34.7	4.3
BIL-GR-14	12	Compression	Baseline (App. A)	1.49	0.39	15.2	53.7	37.1	2.8
BIL-GR-15	12	Compression	Baseline (App. A)	1.48	0.37	14.7	55.5	34.7	4.3
BIL-GR-16	12	Compression	Baseline (App. A)	1.47	0.38	15.0	54.9	34.9	4.8
BIL-GR-37	8	Inplane Shear	Baseline (App. A)	1.50	0.39	15.3	56.0	33.4	4.6
BIL-GR-38	8	Inplane Shear	Baseline (App. A)	1.48	0.39	15.2	53.9	35.4	4.7
BIL-GR-39	8	Inplane Shear	Baseline (App. A)	1.49	0.39	15.2	56.1	33.0	5.6
BIL-GR-40	8	Inplane Shear	Baseline (App. A)	1.48	0.41	16.0	56.6	32.8	4.8
BIL-GR-41	8	Inplane Shear	Baseline (App. A)	1.49	0.38	15.0	57.0	31.9	5.5
BIL-GR-42	8	Inplane Shear	Baseline (App. A)	1.49	0.39	15.2	56.9	32.1	5.5
BIL-GR-17	12	Interlaminar Shear	Baseline (App. A)	1.48	0.37	14.6	54.6	35.6	4.0
BIL-GR-18	12	Interlaminar Shear	Baseline (App. A)	1.47	0.38	14.9	54.8	33.9	5.9
BIL-GR-19	12	Interlaminar Shear	Baseline (App. A)	1.48	0.37	14.5	55.9	32.6	6.2
BIL-GR-43	8	Bearing	Baseline (App. A)	1.49	0.38	15.1	55.6	33.6	5.2
BIL-GR-1	12	ILS, Effect of Cure Time/Temp.	Appendix B.1	1.48	0.38	15.0	58.1	30.2	5.4
BIL-GR-4R	12		14.4	56.2	32.2	5.3			
BIL-GR-5	12		14.3	55.2	33.0	4.5			
BIL-GR-20	12		14.6	58.5	31.3	5.3			
BIL-H7-5	12		14.0	56.8	32.7	4.5			
Average (Baseline Process Only, 20 Laminates)				1.48	0.38	15.1	55.8	33.9	4.7
Standard Deviation				0.01	0.01	0.3	1.0	1.3	0.8

TABLE C.1
 PHYSICAL PROPERTIES OF T300-W133 GRAPHITE
 FABRIC REINFORCED LAMINATES (Continued)

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10 ⁻³ inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GR-2	12	ILS; Effect of Storage; 1 month @ 38°C (100°F)	Baseline (App. A)	1.48	0.36	14.3	55.5	33.2	4.9
BIL-GR-3	12	1 month @ 49°C (120°F)		1.45	0.37	14.6	55.6	31.9	6.6
BIL-GR-6	12	1 month @ 22°C (72°F)		1.47	0.36	14.0	56.4	32.2	5.3
BIL-GR-30	12	3 months @ 22°C (72°F)		1.48	0.36	14.0	60.6	28.6	6.2
BIL-GR-47	12	6 months @ 49°C (120°F)		1.45	0.42	16.6	50.6	37.9	6.0
BIL-GR-48	12	6 months @ 38°C (100°F)		1.47	0.41	16.3	52.2	36.8	5.2
BIL-GR-49	12	6 months @ 22°C (72°F)		1.46	0.42	16.4	52.1	36.7	5.6
BIL-GR-59	12	12 months @ 38°C (100°F)		1.47	0.37	14.5	55.8	32.2	7.0
BIL-GR-60	12	12 months @ 22°C (72°F)		1.48	0.37	14.7	55.7	32.8	6.2
BIL-GR-61	12	12 months @ 49°C (120°F)	1.47	0.37	14.7	54.6	34.0	6.1	
BIL-GR-72	12	18 months @ 49°C (120°F)	V	1.46	0.38	14.8	52.3	36.2	6.1
BIL-GR-73	12	18 months @ 38°C (100°F)		1.47	0.37	14.7	53.4	35.5	5.4
BIL-GR-74	12	18 months @ 22°C (72°F)		1.49	0.38	14.9	56.0	33.3	4.9
BIL-GR-85	12	24 months @ 22°C (72°F)		1.49	0.38	14.9	54.3	35.1	4.6
BIL-GR-86	12	24 months @ 38°C (100°F)		1.48	0.40	15.6	53.5	35.6	5.1
BIL-GR-87	12	24 months @ 49°C (120°F)		1.48	0.39	15.4	52.9	36.2	5.1
BIL-GR-89	12	43 months @ 22°C (72°F)		1.50	0.35	13.8	57.0	32.5	4.6
BIL-GR-90	12	43 months @ 38°C (100°F)		1.50	0.36	14.2	56.8	32.8	4.4
BIL-GR-91	12	50 months @ 22°C (72°F)		1.44	0.38	14.8	53.1	34.0	8.4

TABLE C.1
 PHYSICAL PROPERTIES OF T300-W133 GRAPHITE
 FABRIC REINFORCED LAMINATES (Concluded)

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10 ⁻³ inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GR-51	12	ILS; Effect of Fiber Content	Appendix B.3	1.47	0.37	14.5	55.8	32.5	6.5
BIL-GR-52	12			1.47	0.37	14.7	54.7	33.6	6.4
BIL-GR-53	12			1.46	0.40	15.7	50.1	39.0	4.9
BIL-GR-54	12			1.47	0.40	15.8	49.8	39.0	4.7
BIL-GR-79	12	Compression; Effect of	Appendix B.3	1.41	0.52	20.6	40.5	48.8	5.5
BIL-GR-84	12	Fiber Content	Appendix B.3	1.39	0.51	19.9	42.3	45.6	7.5
BIL-GR-58	12	Check Alternate Bleeder	Appendix B.5	1.48	0.37	14.4	55.4	33.1	5.8
BIL-GR-64R	8	Material		1.49	0.39	15.4	53.5	36.0	4.5
BIL-GR-63R	12	Check Alternate Bagging Scheme	Appendix B.6	1.48	0.40	15.7	55.0	33.6	5.9
BIL-GR-50	12	Compression After Thermal Pulse	Baseline (App. A)	1.47	0.41	16.3	53.6	35.3	5.5

NOTES: 1. ILS = Interlaminar Shear

TABLE C.2
PHYSICAL PROPERTIES OF E-7781 GLASS
FABRIC REINFORCED LAMINATES

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10 ⁻³ inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GL-1R	8	Tension	Baseline (App. A)	1.92	0.22	8.5	55.8	25.9	5.1
BIL-GL-2R	8	Tension	Baseline (App. A)	1.94	0.22	8.5	56.5	25.9	3.9
BIL-GL-3	8	Tension	Baseline (App. A)	1.93	0.2	8.6	55.3	27.0	3.7
BIL-GL-4	8	Tension	Baseline (App. A)	1.91	0.22	8.5	54.1	27.7	4.1
BIL-GL-5	8	Tension	Baseline (App. A)	1.92	0.22	8.6	55.7	26.0	5.0
BIL-GL-6	8	Tension	Baseline (App. A)	1.89	0.22	8.6	54.0	27.2	5.4
BIL-GL-7	16	Compression	Baseline (App. A)	1.90	0.21	8.3	53.7	27.9	4.5
BIL-GL-8	16	Compression	Baseline (App. A)	1.90	0.22	8.6	53.6	28.2	4.2
BIL-GL-9	16	Compression	Baseline (App. A)	1.89	0.22	8.6	53.8	27.6	5.0
BIL-GL-10R	16	Compression	Baseline (App. A)	1.87	0.22	8.6	51.2	30.4	4.0
BIL-GL-18	8	Inplane Shear	Baseline (App. A)	1.92	0.21	8.4	56.5	25.1	5.5
BIL-GL-19R	8	Inplane Shear	Baseline (App. A)	1.92	0.22	8.7	54.5	27.7	3.6
BIL-GL-20R	8	Inplane Shear	Baseline (App. A)	1.92	0.21	8.3	56.5	25.0	5.7
BIL-GL-21	8	Inplane Shear	Baseline (App. A)	1.94	0.22	8.5	56.9	25.2	4.6
BIL-GL-23R	8	Inplane Shear	Baseline (App. A)	1.89	0.20	7.9	54.2	27.0	5.5
BIL-GL-24	8	Inplane Shear	Baseline (App. A)	1.93	0.22	8.5	56.8	25.0	4.9
BIL-GL-11	16	Interlaminar Shear	Baseline (App. A)	1.88	0.21	8.3	55.0	25.5	7.2
BIL-GL-12	16	Interlaminar Shear	Baseline (App. A)	1.88	0.21	8.3	54.9	25.5	7.4
BIL-GL-13R	16	Interlaminar Shear	Baseline (App. A)	1.87	0.21	8.4	54.0	26.5	6.9
BIL-GL-22	8	Bearing	Baseline (App. A)	1.96	0.20	8.0	57.4	25.2	3.7
BIL-GL-27	16	ILS; Effect of Cure	Appendix B.2	1.87	0.22	8.5	52.6	28.6	5.4
BIL-GL-28	16	Vacuum Pressure		1.88	0.21	8.1	55.0	25.6	7.1
BIL-GL-29	16			1.91	0.21	8.1	56.6	24.4	6.7
BIL-GL-38	16			1.94	0.19	7.6	56.1	26.2	3.9
BIL-GL-10	16	ILS; Effect of Fiber Content	Appendix B.3	1.79	0.25	10.0	45.6	35.2	4.7
BIL-GL-30	16			1.89	0.22	8.5	54.3	26.7	6.1
BIL-GL-31	16			1.94	0.22	8.5	55.4	26.2	5.0
BIL-GL-33	16			1.86	0.23	9.2	52.3	28.4	6.4
BIL-GL-53	16	Compression; Effect of	Appendix B.3	1.59	0.36	14.3	33.9	45.6	9.3
BIL-GL-54	16	Fiber Content		1.62	0.31	12.1	35.8	43.6	8.8
Average (Baseline Process Only, 20 Laminates)				1.91	0.22	8.5	55.0	26.6	5.0
Standard Deviation				0.03	0.005	0.2	1.5	1.4	1.1

TABLE C.2
PHYSICAL PROPERTIES OF E-7781 GLASS
FABRIC REINFORCED LAMINATES (Concluded)

Laminate Number	No. of Plies	Purpose	Process	Specific Gravity	Ply Thickness (mm)	Ply Thickness (10 ⁻³ inch)	Fiber Content (o/v)	Resin Content (o/w)	Void Content (o/v)
BIL-GL-17	8	Check Alternate	Appendix B.5	1.85	0.21	8.2	49.5	31.6	4.5
BIL-GL-37	16	Bleeder Material		1.84	0.20	7.8	50.0	30.7	5.6
BIL-GL-47	8			1.89	0.23	8.9	52.5	29.2	4.2
BIL-GL-39	16	Check Alternate Bagging Scheme	Appendix B.6	1.86	0.20	7.7	52.8	27.6	6.7
BIL-GL-14	8	Check Alternate	Appendix B.4	1.87	0.21	8.1	52.6	28.4	5.9
BIL-GL-16	8	Impregnation Scheme		1.85	0.20	7.9	50.3	30.8	4.8
BIL-GL-44	8	Tension	Baseline (App. A)	1.85	0.23	8.9	53.7	25.9	8.5
BIL-GL-45	16	Interlaminar Shear	Baseline (App. A)	1.83	0.23	8.9	52.6	26.8	8.9
BIL-GL-46	8	Inplane Shear; Effect of Silane Sizing	Baseline (App. A)	1.88	0.22	8.6	53.6	27.2	6.3
BIL-GL-25	16	Compression After Thermal Pulse	Baseline (App. A)	1.91	0.23	9.0	56.5	24.4	6.8

NOTES: 1. ILS = Interlaminar Shear

APPENDIX D

INDIVIDUAL SPECIMEN TENSION PROPERTIES, BASELINE

The 48 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in tension. A summary of these data was presented and discussed in Section 3.2.1.

TABLE D.1
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :			
Material :		Batch #1	Task #2	Tested by :		Warp			
		EA-9396 A/B; 7781 Glass				PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks	
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)			
BIL-GL-1R-17	72°F (DRY)	1.005	0.0677	3,725	54.76	3,653	18,960	5/3/89	(2,3,5)
BIL-GL-1R-19	"	1.004	0.0685	3,589	52.18	3,660	17,475	5/2/89	(2,3,4)
BIL-GL-1R-21	"	1.002	0.0656	3,429	52.16	3,667	16,950	"	(2,3,4)
BIL-GL-1R-18	"	1.001	0.0671	3,464	51.57	3,535	17,670	5/3/89	(1,3,5)
BIL-GL-1R-20	"	0.996	0.0694	3,321	48.03	3,486	16,350	5/2/89	(2,3,4)
				Average	51.74	3,600	17,481		0.121
				Std. Dev.	2.41	0.084	973		0.010

				SI Conversion	
Ultimate	Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)		
				Tensile Strength (MPa)	Tensile Modulus (GPa)
	377.6	25.19	18,960		
	359.8	25.24	17,475		
	359.6	25.28	16,950		
	355.6	24.38	17,670		
	331.2	24.03	16,350		
Average	356.7	24.82	17,481		
Std. Dev.	16.6	0.58	973		

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) 2.00" gage length axial extensometer.
 - (5) 2.00" gage length biaxial extensometer.

TABLE D.2
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) DRY

Test : Straight sided tension; ASTM-D3039										
Material : EA-9396 A/B; 7781 Glass										
Batch #2					Task #2					
Fiber Orientation : Warp										
Tested by : PM										
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate					Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	
BIL-GL-5-17	72°F (DRY)	1.000	0.0683	3,954	57.89	3.713	19,130	0.104	5/11/89	(1,2,3,4)
BIL-GL-5-19	"	1.004	0.0682	3,821	55.83	3.731	21,750		"	(1,2,3,5)
BIL-GL-5-21	"	1.003	0.0671	3,554	52.79	3.767	17,250		"	(1,2,3,5)
BIL-GL-6-18	"	1.001	0.0694	3,439	49.49	3.649	16,580		"	(1,2,3,5)
BIL-GL-6-20	"	1.004	0.0693	3,564	51.22	3.541	17,850	0.116	"	(1,2,3,4)
					Average	53.44	3.680	18,512	0.110	
					Std. Dev.	3.41	0.088	2,039	0.009	

SI Conversion									
Ultimate									
	Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)						
	399.2	25.60	19,130						
	385.0	25.72	21,750						
	364.0	25.97	17,250						
	341.3	25.16	16,580						
	353.2	24.42	17,850						
Average	368.5	25.37	18,512						
Std. Dev.	23.5	0.61	2,039						

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.

TABLE D.3
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :		Warp		
Material :		Batch #3	Task #2	Tested by :		PM				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)			
BIL-GL-3-17	72°F (DRY)	1.007	0.0686	3,493	50.57	3,619	16,980	0.123	5/10/89	(1,2,3,4)
BIL-GL-3-19	"	0.999	0.0688	3,464	50.42	3,613	17,250		"	(1,2,3,5)
BIL-GL-3-21	"	1.000	0.0699	3,429	49.07	3,451	17,160		"	(1,2,3,5)
BIL-GL-4-18	"	0.994	0.0689	3,393	49.53	3,571	18,150		"	(1,2,3,5)
BIL-GL-4-20	"	1.003	0.0676	3,446	50.85	3,662	16,650	0.106	"	(1,2,3,4)
					Average	3.583	17,238	0.114		
					Std. Dev.	0.081	559	0.011		

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.

SI Conversion			
Ultimate		Ultimate	
Tensile Strength (MPa)	Tensile Modulus (GPa)	Tensile Strength (μ cm/cm)	Tensile Modulus (GPa)
348.7	24.96	16,980	24.91
347.7	24.91	17,250	23.79
338.4	23.79	17,160	24.63
341.5	24.63	18,150	25.25
350.6	25.25	16,650	24.71
Average	345.4	17,238	0.56
Std. Dev.	5.2	559	

TABLE D.4
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (µin/in)			
BIL-GL-1(R)-18	72°F (WET)	1.004	0.0713	1,144	15.99	3,187	5,068	0.072	8/22/89	(2,3,4,6)
BIL-GL-1(R)-20	"	1.003	0.0716	1,193	16.62	3,176	5,313		"	(2,3,5,6)
BIL-GL-1(R)-17	"	1.005	0.0706	1,250	17.62	3,153	5,850		"	(2,3,5,6)
BIL-GL-1(R)-19	"	1.004	0.0713	1,106	15.46	3,329	4,688	0.085	8/21/89	(2,3,4,6)
BIL-GL-1(R)-21	"	1.004	0.0708	1,159	16.30	3,067	5,498	0.061	8/22/89	(2,3,4,6)
					Average	16.40	3,182	5,283	0.073	
					Std. Dev.	0.81	0.095	438	0.012	

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; 7781 Glass
 Batch #1 : Task #2 : Fiber Orientation : Warp
 Tested by : PM

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	
110.2	21.98	5,068	
114.6	21.90	5,313	
121.5	21.74	5,850	
106.6	22.95	4,688	
112.4	21.15	5,498	
Average	113.1	21.94	5,283
Std. Dev.	5.6	0.65	438

TABLE D.5
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) WET

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :				
Material :		Batch #2	Task #2	Tested by :		Warp				
		EA-9396 A/B; 7781 Glass				PM				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-18	72°F (WET)	1.007	0.0710	1,197	16.74	3.343	5,210	0.086	8/22/89	(2,3,4,6)
BIL-GL-5-20	"	1.007	0.0718	1,206	16.67	3.224	5,381		"	(2,3,5,6)
BIL-GL-6-17	"	1.004	0.0722	987	13.63	3.189	4,258		"	(2,3,5,6)
BIL-GL-6-19	"	1.005	0.0723	1,064	14.65	3.332	4,448	0.098	"	(2,3,4,6)
BIL-GL-6-21	"	1.007	0.0704	1,094	15.44	3.278	4,678		"	(2,3,5,6)
				Average	15.42	3.273	4,795	0.092		
				Std. Dev.	1.33	0.067	484	0.008		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μ cm/cm)	Ultimate Strain (μ in/in)
115.4	23.05	5,210	5,381
115.0	22.23	4,258	4,258
94.0	21.99	4,448	4,448
101.0	22.97	4,678	4,678
106.4	22.60	4,795	4,795
106.4	22.57	484	484
9.2	0.46		

TABLE D.6
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)		
BIL-GL-3-18	72°F (WET)	0.999	0.0676	1,211	17.94	3.519	5,313	9/6/89	(2,3,5,6)
BIL-GL-3-20	"	1.003	0.0677	1,243	18.30	3.404	5,591	9/5/89	(2,3,4,6)
BIL-GL-4-17	"	1.002	0.0659	1,075	16.27	3.458	4,746	9/6/89	(2,3,5,6)
BIL-GL-4-19	"	0.998	0.0672	1,197	17.84	3.448	5,381	"	(2,3,5,6)
BIL-GL-4-21	"	1.002	0.0699	1,142	16.31	3.355	5,034	"	(2,3,4,6)
					Average	3.437	5,213		0.092
					Std. Dev.	0.061	328		0.003

Fiber Orientation : Warp
 Tested by : PM

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; 7781 Glass

Batch #3 Task #2

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
123.7	24.27	5,313	
126.2	23.47	5,591	
112.2	23.84	4,746	
123.0	23.77	5,381	
112.4	23.14	5,034	
Average	23.70	5,213	
Std. Dev.	0.42	328	

TABLE D.7
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)			
BIL-GL-1(R)-1	-65°F (DRY)	1.000	0.0669	4,875	72.88	4.298	18,429+	0.153	5/10/89	(1,2,3,4,6,7)
BIL-GL-1(R)-7	"	1.002	0.0678	5,214	76.76	4.206	25,575		5/11/89	(1,2,3,5,6)
BIL-GL-1(R)-13	"	1.003	0.0677	5,100	75.08	4.206	24,330		"	(1,2,3,5,6)
BIL-GL-2(R)-5	"	1.001	0.0667	5,093	76.26	4.278	21,000+		5/10/89	(1,2,3,5,6,7)
BIL-GL-2(R)-11	"	1.005	0.0677	5,495	80.77	4.226	26,229	0.153	"	(1,2,3,4,6)
Average					76.35	4.243	23,113+	0.153		
Std. Dev.					2.89	0.043	3,304+	0.000		

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; 7781 Glass
 Fiber Orientation : Fill
 Batch #1 : Task #3
 Tested by : PM

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimen soaked for 20 min. at test temperature.
- (7) Strain gage failure due to outer ply separation.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Average Std. Dev.
502.5	29.63	18,429+	526.4
529.3	29.00	25,575	19.9
517.7	29.00	24,330	
525.8	29.50	21,000+	
556.9	29.14	26,229	
	29.26	23,113+	
	0.29	3,304+	

TABLE D.8
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) DRY

Test :		Straight sided tension; ASTM-D3039		Batch #2		Task #3		Fiber Orientation :		
Material :		EA-9396 A/B; 7781 Glass		Ultimate				PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-1	-65°F (DRY)	1.000	0.0662	4,410	66.63	4.646	20,507	0.180	5/9/89	(1,2,3,4)
BIL-GL-5-7	"	1.000	0.0699	4,286	61.31	4.036	12,000+		5/10/89	(1,2,3,5,6)
BIL-GL-5-13	"	1.003	0.0699	4,150	59.20	3.974	19,500+		"	(1,2,3,5,6)
BIL-GL-6-5	"	1.003	0.0680	5,140	75.38	4.180	24,429	0.145	"	(1,2,3,4)
BIL-GL-6-11	"	1.002	0.0691	5,760	83.20	4.189	14,357+	0.139	5/9/89	(1,3,4,6)
				Average	69.15	4.205	18,159+	0.155		
				Std. Dev.	10.04	0.263	4,975+	0.022		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Strain gage failure due to outer ply separation.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	
459.4	32.03	20,507	
422.7	27.83	12,000+	
408.2	27.40	19,500+	
519.8	28.82	24,429	
573.7	28.88	14,357+	
Average	28.99	18,159+	
Std. Dev.	1.81	4,975+	

TABLE D.9
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (µin/in)			
BIL-GL-3-1	-65°F (DRY)	1.007	0.0683	4,835	70.31	3.999	23,036	0.164	5/10/89	(1,2,3,4)
BIL-GL-3-7	"	1.004	0.0703	4,857	68.83	4.049	21,300+		"	(1,2,3,5,6)
BIL-GL-3-13	"	0.998	0.0688	4,914	71.56	4.056	24,120		"	(1,2,3,5)
BIL-GL-4-5	"	0.998	0.0674	4,693	69.74	4.299	9,000+		"	(1,2,3,5,6)
BIL-GL-4-11	"	1.001	0.0690	4,915	71.17	4.163	24,643+	0.146	"	(1,2,3,4,6)
Average					70.32	4.113	20,419+	0.155		
Std. Dev.					1.10	0.120	6,511+	0.013		

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; 7781 Glass
 Fiber Orientation : Fill
 Tested by : PM

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Average Std. Dev.
484.8	27.57	23,036	484.9
474.6	27.92	21,300+	7.6
493.4	27.97	24,120	28.36
480.8	29.64	9,000+	0.83
490.7	28.70	24,643+	

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.
 - (6) Strain gage failure due to outer ply separation.

TABLE D.10
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :			
Material :		Batch #1	Task #3	Tested by :					
		EA-9396 A/B 7781 Glass				PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)			
BIL-GL-1(R)-2	72°F (DRY)	1.002	0.0675	3,893	57.54	3,748	0.129	4/18/89	(2,3,4)
BIL-GL-1(R)-8	"	0.986	0.0669	3,864	58.58	4,115		"	(2,3,5)
BIL-GL-1(R)-14	"	1.002	0.0678	3,296	48.53	3,812		4/25/89	(2,3,5)
BIL-GL-2(R)-6	"	0.971	0.0674	3,493	53.37	4,147		4/20/89	(2,3,5)
BIL-GL-2(R)-12	"	1.002	0.0687	3,350	48.66	3,787	0.118	"	(2,3,4)
					Average	3,922		17,052	0.124
					Std. Dev.	4.75		1,489	0.008

		SI Conversion	
Ultimate	Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)
403.9	28.37	18,705	
334.6	26.28	15,420	
368.0	28.60	16,920	
335.5	26.11	15,795	
Average	367.7	27.04	17,052
Std. Dev.	32.7	1.33	1,489

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.

TABLE D.11
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :				
Material :		Batch #2	Task #3	Tested by :		PM				
EA-9396 A/B; 7781 Glass		Ultimate								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-5-2	72°F (DRY)	0.997	0.0686	3,375	49.33	3,628	16,570	0.143	5/11/89	(1,2,3,4)
BIL-GL-5-8	"	1.000	0.0671	3,607	53.75	3,592	18,450		"	(2,3,5)
BIL-GL-5-14	"	1.001	0.0672	3,589	53.36	3,531	18,150		"	(1,2,3,5)
BIL-GL-6-6	"	1.002	0.0672	3,729	55.36	3,579	18,830		"	(1,2,3,5)
BIL-GL-6-12	"	1.002	0.0701	3,875	55.16	3,381	20,250	0.113	"	(1,2,3,4)
Average					53.39	3,542	18,450	0.128		
Std. Dev.					2.43	0.097	1,324	0.021		

Remarks:

- Specimen failed within the 6.5 inch gage section.
- Specimen failed inside tab area.
- Test speed = 0.1 in/min.
- Specimen had 0° and 90° strain gages attached.
- Specimen had only 0° strain gage attached.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Ultimate Strain (µm/m)
340.1	25.02	16,570	16,570
370.6	24.77	18,450	18,450
367.9	24.35	18,150	18,150
381.7	24.68	18,830	18,830
380.3	23.31	20,250	20,250
Average	24.42	18,450	18,450
Std. Dev.	0.67	1,324	1,324

TABLE D.12
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :			
Material :		Batch #3	Task #3	Tested by :					
		EA-9396 A/B; 7781 Glass				Fill PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)			
BIL-GL-3-2	72°F (DRY)	0.997	0.0692	3,729	54.02	3.493	0.131	5/11/89	(1,3,4,9)
BIL-GL-3-8	"	1.001	0.0702	3,957	56.33	3.482		"	(1,3,5)
BIL-GL-3-14	"	1.004	0.0677	3,686	54.21	3.520		"	(1,3,5)
BIL-GL-4-6	"	0.999	0.0658	3,882	59.03	3.726		"	(1,2,3,5)
BIL-GL-4-12	"	1.001	0.0687	3,904	56.78	3.506	0.129	"	(1,2,3,4)
				Average	56.08	3.545			0.130
				Std. Dev.	2.06	0.102			0.002

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Strain gage failure due to outer ply separation.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Ultimate Strain (µcm/cm)
372.5	24.08	25,950+	25,950+
388.4	24.01	19,950	19,950
373.8	24.27	18,585	18,585
407.0	25.69	19,650	19,650
391.5	24.18	19,695	19,695
Average	24.45	20,766+	20,766+
Std. Dev.	0.70	2,945+	2,945+

TABLE D.13
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :				
Material :		Batch #1	Task #3	Tested by :		PM				
		Ultimate								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-1(R)-3	200°F (DRY)	1.001	0.0680	3,150	46.29	3.527	14,979	0.111	5/11/89	(2,3,4)
BIL-GL-1(R)-9	"	0.998	0.0671	3,018	45.08	3.575	14,445		5/12/89	(1,2,3,5)
BIL-GL-1(R)-15	"	0.999	0.0695	3,289	47.36	3.548	15,450		5/11/89	(2,3,5)
BIL-GL-2(R)-7	"	1.003	0.0692	3,507	50.54	3.680	16,500		"	(1,3,5)
BIL-GL-2(R)-13	"	0.999	0.0691	3,000	43.45	3.404	14,614	0.121	"	(1,3,4)
		Average		46.55		3.547		15,198		0.116
		Std. Dev.		2.66		0.099		824		0.008

SI Conversion			
Ultimate			
	Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)
	319.2	24.32	14,979
	310.9	24.65	14,445
	326.6	24.46	15,450
	348.5	25.37	16,500
	299.6	23.47	14,614
Average	320.9	24.45	15,198
Std. Dev.	18.4	0.68	824

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.

TABLE D.14
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :				
Material :		Batch #2	Task #3	Tested by :						
Material :		EA-9396 A/B; 7781 Glass						PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks		
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)				
					Strain (µin/in)	Poisson's Ratio				
BIL-GL-5-3	200°F (DRY)	1.002	0.0709	3,025	42.60	3.380	14,700	0.096	5/12/89	(2,3,4)
BIL-GL-5-9	"	0.998	0.0673	2,996	44.63	3.537	14,565		5/11/89	(1,3,5)
BIL-GL-5-15	"	1.001	0.0663	3,029	45.64	3.579	14,325		5/12/89	(1,2,3,5)
BIL-GL-6-7	"	1.001	0.0669	3,186	47.56	3.626	15,180		5/11/89	(1,2,3,5)
BIL-GL-6-13	"	0.999	0.0692	3,178	45.95	3.453	15,707	0.093	5/12/89	(1,3,4)
				Average	45.28	3.515	14,895	0.095		
				Std. Dev.	1.83	0.099	551	0.003		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.

SI Conversion			
Ultimate		Ultimate	
Tensile Strength (MPa)	Tensile Modulus (GPa)	Tensile Modulus (GPa)	Strain (µcm/cm)
293.7	23.30	23.30	14,700
307.7	24.39	24.39	14,565
314.7	24.68	24.68	14,325
327.9	25.00	25.00	15,180
316.8	23.81	23.81	15,707
Average		24.24	14,895
Std. Dev.		0.68	551

TABLE D.15
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) DRY

Test :		Straight sided tension; ASTM-D3039			Fiber Orientation :					
Material :		Batch #3	Task #3	Tested by :						
		Ultimate			Fill					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-3	200°F (DRY)	1.004	0.0699	2,600	37.04	3.579	13,500	0.100	5/12/89	(2,3,4)
BIL-GL-3-9	"	1.001	0.0686	3,161	46.05	3.434	9,750		5/8/89	(1,3,5)
BIL-GL-3-15	"	1.004	0.0689	2,968	42.89	3.587	13,980		5/11/89	(1,2,3,5)
BIL-GL-4-7	"	1.000	0.0674	3,246	48.16	3.629	15,795		"	(1,2,3,5)
BIL-GL-4-13	"	1.004	0.0694	3,120	44.80	3.356	12,000+	0.087	5/12/89	(1,2,3,4,6)
		Average			43.79	3.517	13,005+	0.094		
		Std. Dev.			4.23	0.116	2,268+	0.009		

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Average Std. Dev.
255.4	24.68	13,500	301.9
317.5	23.68	9,750	29.2
295.7	24.73	13,980	24.25
332.0	25.02	15,795	0.80
308.9	23.14	12,000+	

- Remarks:
- Specimen failed within the 6.5 inch gage section.
 - Specimen failed inside tab area.
 - Test speed = 0.1 in/min.
 - Specimen had 0° and 90° strain gages attached.
 - Specimen had only 0° strain gage attached.
 - Strain gage failure due to outer ply separation.

TABLE D.16
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) WET

Fiber Orientation : Fill										
Test : Straight sided tension; ASTM-D3039										
Material : EA-9396 A/B; 7781 Glass										
Batch #1 Task #3										
Tested by : DRB										
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (µin/in)			
BIL-GL-1(R)-4	-65°F (WET)	1.002	0.0682	1,238	18.11	3.890	5,024	0.154	9/13/89	(2,3,5,6)
BIL-GL-1(R)-10	"	0.996	0.0684	1,421	20.86	3.986	6,006		9/12/89	(2,3,4,6)
BIL-GL-2(R)-1	"	1.002	0.0656	1,490	22.67	3.875	6,597		9/13/89	(2,3,5,6)
BIL-GL-2(R)-8	"	1.005	0.0699	1,439	20.50	3.767	6,118		"	(2,3,5,6)
BIL-GL-2(R)-14	"	0.999	0.0677	1,048	15.49	3.880	4,000	0.133	9/12/89	(2,3,4,6)
Average					19.53	3.880	5,549	0.143		
Std. Dev.					2.78	0.078	1,037	0.015		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
124.9	26.82	5,024	0.154
143.8	27.48	6,006	
156.3	26.72	6,597	
141.4	25.97	6,118	
106.8	26.75	4,000	0.133
Average	26.75	5,549	0.143
Std. Dev.	0.53	1,037	0.015

TABLE D.17
INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) WET

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :		Fill			
Material :		EA-9396 A/B; 7781 Glass		Batch #2 Task #3		Tested by : DRB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Remarks		
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)			
BIL-GL-5-4	-65°F (WET)	1.002	0.0682	1,545	22.61	3,699	6,943	9/13/89	(1,3,5,6)
BIL-GL-5-10	"	1.003	0.0676	1,477	21.79	3,752	6,567	9/12/89	(2,3,4,6)
BIL-GL-6-1	"	0.996	0.0631	1,586	25.24	4,027	7,168	9/13/89	(2,3,5,6)
BIL-GL-6-8	"	1.000	0.0689	1,680	24.39	3,870	7,295	"	(2,3,5,6)
BIL-GL-6-14	"	0.995	0.0699	1,362	19.57	3,473	6,172	9/12/89	(2,3,4,6)
				Average	22.72	3,764	6,829		0.117
				Std. Dev.	2.23	0.206	460		0.005

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion	
Ultimate	
Tensile Strength (MPa)	155.9
Tensile Modulus (GPa)	25.51
Ultimate Strain (µcm/cm)	6,943
Average	156.7
Std. Dev.	15.4
Average	25.95
Std. Dev.	1.42

TABLE D.18

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) WET

Test :		Straight sided tension; ASTM-D3039			Batch #3		Task #3		Fiber Orientation :	
Material :		EA-9396 A/B; 7781 Glass			Ultimate		Tested by :		DRB	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-3-4	-65°F (WET)	1.003	0.0709	1,331	18.72	3.740	5,435		9/13/89	(2,3,5,6)
BIL-GL-3-10	"	1.005	0.0672	1,430	21.17	3.873	6,138	0.144	9/12/89	(2,3,4,6)
BIL-GL-4-1	"	1.000	0.0662	1,582	23.89	3.785	7,109		9/13/89	(2,3,5,6)
BIL-GL-4-8	"	0.999	0.0671	1,549	23.11	3.843	6,846		"	(2,3,5,6)
BIL-GL-4-14	"	1.006	0.0701	1,416	20.07	3.632	6,216	0.145	9/12/89	(2,3,4,6)
Average					21.39	3.775	6,349	0.145		
Std. Dev.					2.13	0.095	656	0.001		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μ cm/cm)	Poisson's Ratio
129.1	25.79	5,435	
145.9	26.71	6,138	
164.7	26.09	7,109	
159.3	26.50	6,846	
138.4	25.04	6,216	
147.5	26.03	6,349	0.145
14.7	0.65	656	0.001

TABLE D.19
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (μin/in)			
BIL-GL-1(R)-5	72°F (WET)	1.003	0.0674	1,219	18.03	3.362	5,591	0.097	9/8/89	(2,3,5,6)
BIL-GL-1(R)-11	"	1.000	0.0688	1,298	18.86	3.236	6,206	0.097	"	(2,3,4,6)
BIL-GL-2(R)-2	"	0.997	0.0672	1,364	20.36	3.316	6,460		"	(2,3,5,6)
BIL-GL-2(R)-9	"	0.999	0.0682	1,290	18.93	3.270	6,099		"	(2,3,5,6)
BIL-GL-2(R)-15	"	1.003	0.0691	1,218	17.58	3.126	5,957	0.097	"	(2,3,4,6)
				Average	18.75	3.262	6,063	0.097		
				Std. Dev.	1.06	0.090	322	0.000		

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; 7781 Glass
 Batch #1 : Task #3
 Fiber Orientation : Fill
 Tested by : DRB

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)	
124.3	23.18	5,591	
130.0	22.31	6,206	
140.4	22.86	6,460	
130.5	22.55	6,099	
121.2	21.55	5,957	
Average	22.49	6,063	
Std. Dev.	0.62	322	

TABLE D.20
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) WET

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :					
Material :		Batch #2	Task #3	Fill							
EA-9396 A/B; 7781 Glass		Tested by :						TOB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Remarks			
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)		Poisson's Ratio	Date Tested	
BIL-GL-5-5	72°F (WET)	1.004	0.0683	1,077	15.70	3.090	5,273	0.016	9/7/89	(2,3,5,6)	
BIL-GL-5-11	"	1.001	0.0676	1,142	16.87	5.200	3,135	0.016	"	(2,3,4,6,7)	
BIL-GL-6-2	"	1.001	0.0664	1,090	16.40	3.316	5,076		"	(2,3,5,6)	
BIL-GL-6-9	"	1.000	0.0691	1,181	17.09	3.198	5,527		"	(2,3,5,6)	
BIL-GL-6-15	"	1.001	0.0682	1,072	15.70	5.023	3,040	0.016	"	(2,3,4,6,7)	
					Average	16.35	3.201	5,292	0.016		
					Std. Dev.	0.64	0.113	226	0.000		

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μ cm/cm)	Poisson's Ratio
108.2	21.30	5,273	
116.3	35.85	3,135	
113.1	22.86	5,076	
117.8	22.05	5,527	
108.3	34.63	3,040	
Average	22.07	5,292	
Std. Dev.	0.78	226	

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.
- (7) Probable improper strain range set. Not included in modulus, strain or Poisson's ratio averages.

TABLE D.21
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) WET

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :		Fill			
Material :		Batch #3	Task #3	Tested by :		DRB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)			
					Strength (Ksi.)	Modulus (Msi.)			
BIL-GL-3-5	72°F (WET)	1.005	0.0706	1,168	16.46	3.167	5,430	9/11/89	(1,3,5,6)
BIL-GL-3-11	"	1.004	0.0674	1,348	19.93	3.218	6,514	"	(1,3,4,6)
BIL-GL-4-2	"	1.000	0.0676	1,219	18.03	3.207	5,957	"	(2,3,5,6)
BIL-GL-4-9	"	1.002	0.0674	1,173	17.37	3.219	5,664	"	(2,3,5,6)
BIL-GL-4-15	"	0.999	0.0685	1,085	15.86	3.148	5,303	"	(2,3,4,6)
				Average	17.53	3.192	5,773		
				Std. Dev.	1.58	0.033	483		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate			
	Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)
	113.5	21.84	5,430
	137.4	22.19	6,514
	124.3	22.12	5,957
	119.8	22.20	5,664
	109.4	21.70	5,303
Average	120.9	22.01	5,773
Std. Dev.	10.9	0.22	483

TABLE D.22
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (µin/in)		
BIL-GL-1(R)-6	200°F (WET)	0.994	0.0672	948	14.19	2.944	4,751	9/14/89	(2,3,4,6)
BIL-GL-1(R)-12	"	0.997	0.0677	934	13.85	2.910	4,697	"	(2,3,5,6)
BIL-GL-2(R)-3	"	1.000	0.0672	910	13.53	2.865	4,644	"	(2,3,5,6)
BIL-GL-2(R)-10	"	0.995	0.0672	848	12.67	2.825	4,370	"	(2,3,5,6)
BIL-GL-2(R)-16	"	1.004	0.0672	933	13.83	2.816	4,663	"	(1,3,4,6)
Average					13.61	2.872	4,625		
Std. Dev.					0.58	0.055	148		

Fiber Orientation: Fill
 Tested by: DRB

Test: Straight sided tension; ASTM-D3039
 Material: EA-9396 A/B; 7781 Glass
 Batch #1 Task #3

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
97.9	20.30	4,751	0.048
95.5	20.07	4,697	0.046
93.3	19.76	4,644	
87.4	19.48	4,370	
95.3	19.41	4,663	
Average	19.80	4,625	
Std. Dev.	4.0	148	

TABLE D.23
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (µin/in)			
BIL-GL-5-6	200°F (WET)	1.003	0.0681	903	13.21	3.497	4,873	0.126	9/14/89	(2,3,4,6)
BIL-GL-5-12	"	1.005	0.0699	895	12.75	2.592	4,658	0.076	"	(2,3,4,6)
BIL-GL-6-3	"	1.001	0.0699	908	12.98	3.671	3,364		9/15/89	(2,3,5,6)
BIL-GL-6-10	"	1.003	0.0687	881	12.78	3.253	3,711		"	(2,3,5,6)
BIL-GL-6-16	"	0.994	0.0660	1,041	15.86	3.172	4,883		9/14/89	(1,3,5,6)
Average					13.52	3.237	4,298	0.101		
Std. Dev.					1.32	0.411	710	0.035		

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; 7781 Glass

Batch #2 Task #3

Fiber Orientation : Fill

Tested by : DRB

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
91.1	24.11	4,873	0.101
87.9	17.87	4,658	0.076
89.5	25.31	3,364	
88.1	22.43	3,711	
109.3	21.87	4,883	
Average	22.32	4,298	0.101
Std. Dev.	2.84	710	0.035

TABLE D.24
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (µin/in)			
BIL-GL-3-6	200°F (WET)	1.005	0.0699	955	13.59	2.863	4,468	0.086	9/15/89	(2,3,5,6)
BIL-GL-3-12	"	1.006	0.0688	930	13.45	2.642	4,902		9/14/89	(2,3,4,6)
BIL-GL-4-3	"	1.000	0.0685	1,013	14.79	2.919	4,712		9/15/89	(2,3,5,6)
BIL-GL-4-10	"	1.002	0.0680	940	13.79	3.551	3,774		"	(2,3,5,6)
BIL-GL-4-16	"	1.004	0.0689	822	11.89	2.583	4,575	0.088	9/14/89	(2,3,4,6)
				Average	13.50	2.912	4,486	0.087		
				Std. Dev.	1.04	0.385	430	0.002		

Fiber Orientation : Fill
 Tested by : DRB

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; 7781 Glass
 Batch #3 Task #3

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion	
Ultimate Tensile Strength (MPa)	Ultimate Strain (µcm/cm)
93.7	4,468
92.7	4,902
102.0	4,712
95.1	3,774
82.0	4,575
Average	4,486
Std. Dev.	430

TABLE D.25
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :		Warp				
Material :		Batch #1	Task #2	Tested by :						
Material :		EA-9396 A/B; W133 Graphite						PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)				
BIL-GR-7-17	72°F (DRY)	1.002	0.1247	10,740	85.95	8.283	9,320		4/4/89	(2,3,4)
BIL-GR-7-19	"	1.004	0.1246	10,600	84.73	7.914	9,480		"	(2,3,4)
BIL-GR-7-21	"	1.004	0.1222	10,420	84.93	8.191	8,280		"	(2,3,4)
BIL-GR-8-18	"	1.003	0.1224	9,143	74.44	8.643	8,325	0.059	4/17/89	(2,3,5)
BIL-GR-8-20	"	1.002	0.1214	9,907	81.44	8.866	9,150	0.048	"	(2,3,5)
					Average	8.380	8,911	0.053		
					Std. Dev.	4.71	568	0.008		

		SI Conversion	
		Ultimate	
Remarks:	Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)
(1) Specimen failed within the 6.5 inch gage section.	592.7	57.11	9,320
(2) Specimen failed inside tab area.	584.2	54.57	9,480
(3) Test speed = 0.1 in/min.	585.6	56.48	8,280
(4) 2.00" gage length axial extensometer attached.	513.3	59.59	8,325
(5) Specimen had 0° and 90° strain gages attached.	561.6	61.13	9,150
Average	567.5	57.78	8,911
Std. Dev.	32.5	2.60	568

TABLE D.26
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)			
BIL-GR-11-17	72°F (DRY)	1.003	0.1290	9,775	75.53	7,689	7,950	0.065	4/3/89	(2,3,5)
BIL-GR-11-19	"	0.999	0.1234	9,750	79.07	8,272	8,700		"	(2,3,4)
BIL-GR-11-21	"	1.002	0.1200	10,340	85.97	8,647	7,200	0.040	"	(2,3,5)
BIL-GR-12-18	"	1.000	0.1252	10,650	85.06	8,227	7,150	0.053	"	(2,3,5)
BIL-GR-12-20	"	1.003	0.1264	10,300	81.24	8,084	6,535		"	(2,3,4)
Average					81.37	8,184	7,507	0.053		
Std. Dev.					4.31	0.346	835	0.013		

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; W133 Graphite
 Fiber Orientation : Warp
 Tested by : PM

Batch #2 Task #2

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) 2.00" gage length axial extensometer attached.
- (5) 2.00" gage length biaxial extensometer attached.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
520.8	53.01	7,950	0.065
545.2	57.03	8,700	0.040
592.8	59.62	7,200	0.053
586.5	56.72	7,150	
560.1	55.74	6,535	
Average	56.43	7,507	0.053
Std. Dev.	2.39	835	0.013

TABLE D.27
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039		Batch #3		Task #2		Fiber Orientation :		
Material :		EA-9396 A/B; W133 Graphite		Ultimate		Tensile		Warp		
								PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-17	72°F (DRY)	0.995	0.1251	9,150	73.54	8.519	7,400	0.075	4/4/89	(2,3,5)
BIL-GR-9-19	"	1.002	0.1245	10,630	85.18	9.215	5,500		"	(2,3,4)
BIL-GR-9-21	"	0.997	0.1263	9,200	73.08	8.619	6,900	0.071	"	(2,3,5)
BIL-GR-10-18	"	1.006	0.1272	9,475	74.07	8.131	7,200		"	(2,3,4)
BIL-GR-10-20	"	0.995	0.1238	10,500	85.28	8.325	8,300		"	(2,3,4)
				Average	78.23	8.562	7,060	0.073		
				Std. Dev.	6.40	0.410	1,016	0.003		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) 2.00" gage length axial extensometer attached.
- (5) 2.00" gage length biaxial extensometer attached.

SI Conversion	
Ultimate	Ultimate
Tensile Strength (MPa)	Tensile Modulus (GPa)
507.0	58.74
587.3	63.54
503.9	59.43
510.7	56.06
588.0	57.40
Average	59.03
Std. Dev.	2.83
	Ultimate Strain (μ cm/cm)
	7,400
	5,500
	6,900
	7,200
	8,300
	7,060
	1,016

TABLE D.28
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, WARP DIRECTION, 22°C (72°F) WET

Fiber Orientation : Warp									
Straight sided tension; ASTM-D3039					Warp				
EA-9396 A/B; W133 Graphite					PM				
Test :		Batch #1		Task #2		Tested by :			
Material :		EA-9396 A/B; W133 Graphite		Task #2		Tested by :			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)			
BIL-GR-7-18	72°F (WET)	1.004	0.1243	9,971	79.94	9,088	8.804	9/13/89	(2,3,5,6,7)
BIL-GR-7-20	"	1.004	0.1227	11,172	90.69	9,128	10,144	"	(1,3,4,6,7)
BIL-GR-8-17	"	1.005	0.1219	11,099	90.63	8,885	10,049	"	(1,3,5,6)
BIL-GR-8-19	"	1.001	0.1246	10,059	80.67	8,807	9,148	"	(1,2,3,5,6)
BIL-GR-8-21	"	0.998	0.1171	10,689	91.43	9,342	9,946	"	(1,3,4,6)
				Average	86.67	9,050	9,618		
				Std. Dev.	5.83	0.212	603		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.
- (7) Tabs debonded; specimen did not fail.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	
551.2	62.66	8,804	
625.3	62.93	10,144	
624.9	61.26	10,049	
556.2	60.72	9,148	
630.4	64.41	9,946	
597.6	62.40	9,618	
40.2	1.46	603	
Average			
Std. Dev.			

TABLE D.29
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, WARP DIRECTION, 22°C (72°F) WET

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :						
Material :		EA-9396 A/B; W133 Graphite	Batch #2	Task #2	Warp					
		Ultimate		Tested by :						
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-18	72°F (WET)	1.002	0.1286	9,575	74.28	8.280	8,796		9/12/89	(1,3,5,6)
BIL-GR-11-20	"	0.999	0.1233	10,264	83.34	8.765	9,294	0.034	"	(1,3,4,6)
BIL-GR-12-17	"	1.004	0.1279	11,045	85.98	8.773	9,595		"	(1,2,3,5,6)
BIL-GR-12-19	"	1.000	0.1254	10,718	85.43	8.536	9,873		"	(1,3,5,6)
BIL-GR-12-21	"	1.002	0.1230	9,712	78.79	8.856	8,826	0.049	"	(1,3,4,6)
		Average		81.56		8.642		0.041		
		Std. Dev.		4.96		0.235		0.011		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion	
Ultimate Tensile Strength (MPa)	Ultimate Strain (µcm/cm)
512.2	8,796
574.6	9,294
592.8	9,595
589.1	9,873
543.2	8,826
Average 562.4	Average 9,277
Std. Dev. 34.2	Std. Dev. 472

TABLE D.30
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, WARP DIRECTION, 22°C (72°F) WET

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :		Warp			
Material :		EA-9396 A/B; W133 Graphite		Batch #3		Task #2			
		Ultimate		Tensile Modulus (Msi.)		Poisson's Ratio			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain ($\mu\text{in/in}$)	Date Tested	Remarks
BIL-GR-9-18	72°F (WET)	1.002	0.1244	11,257	90.36	8.854	10,410	9/12/89	(1,3,5,6)
BIL-GR-9-20	"	0.997	0.1249	10,200	81.95	8.649	9,653	"	(1,2,3,4,6)
BIL-GR-10-17	"	1.002	0.1262	10,643	84.16	8.438	9,780	9/13/89	(2,3,5,6)
BIL-GR-10-19	"	1.000	0.1241	10,879	87.66	8.743	9,880	"	(1,2,3,5,6)
BIL-GR-10-21	"	1.001	0.1187	10,490	88.27	9.200	9,429	9/12/89	(2,3,4,6)
		Average		86.48		8.777		9.831	
		Std. Dev.		3.37		0.282		0.010	

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion	
Ultimate Tensile Strength (MPa)	Ultimate Strain ($\mu\text{cm/cm}$)
623.0	10,410
565.1	9,653
580.3	9,780
604.4	9,880
608.6	9,429
Average 596.3	Average 9,831
Std. Dev. 23.2	Std. Dev. 365

TABLE D.31
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :				
Material :		Batch #1	Task #3	Tested by :		PM				
		Ultimate								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-7-1	-65°F (DRY)	1.0005	0.1113	11,196	100.55	9.153	10,576	0.053	6/13/89	(2,3,4)
BIL-GR-7-7	"	0.9971	0.1228	11,411	93.19	9.129	10,129		"	(1,2,3,5)
BIL-GR-7-13	"	0.9972	0.1208	11,118	92.30	9.085	10,283		"	(2,3,5)
BIL-GR-8-5	"	1.0000	0.1194	10,581	88.62	9.044	10,581	0.059	"	(2,3,4)
BIL-GR-8-11	"	1.0010	0.1189	10,864	91.28	9.125	9,624	0.068	"	(1,2,3,4)
		Average		93.19		9.107		10.239		0.060
		Std. Dev.		4.46		0.043		395		0.008
SI Conversion										
Ultimate										
		Average		693.3		63.11		10,576		
		Std. Dev.		4.46		62.95		10,129		
		Average		636.4		62.64		10,283		
		Std. Dev.		611.0		62.36		10,581		
		Average		629.4		62.92		9,624		
		Std. Dev.		642.5		62.80		10,239		
		Average		30.7		0.30		395		
		Std. Dev.								

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.

TABLE D.32
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) DRY

Test :		Straight sided tension; ASTM-D3039		Batch #2		Task #3		Fiber Orientation :		
Material :		EA-9396 A/B; W133 Graphite		Ultimate		Ultimate		Tested by :		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-1	-65°F (DRY)	0.997	0.1098	11,699	106.88	10.202	10,195		6/13/89	(1,2,3,5)
BIL-GR-11-7	"	0.996	0.1229	10,147	82.89	8.333	9,031		"	(2,3,5)
BIL-GR-11-13	"	1.001	0.1180	10,205	86.38	9.159	8,958	0.050	"	(1,3,4)
BIL-GR-12-5	"	1.003	0.1159	9,912	85.28	9.083	8,936		"	(2,3,5)
BIL-GR-12-11	"	1.001	0.1180	10,361	87.73	9.369	9,294	0.045	"	(2,3,4)
		Average		89.83		9.229		0.048		
		Std. Dev.		9.69		0.670		0.003		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.

SI Conversion	
Ultimate Tensile Strength (MPa)	Ultimate Strain (µcm/cm)
736.9	10,195
571.5	9,031
595.6	8,958
588.0	8,936
604.9	9,294
Average 619.4	9,283
Std. Dev. 66.8	530

TABLE D.33

INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μin/in)	Poisson's Ratio	Date Tested	Remarks	Batch #3		Fiber Orientation :		
											Task #3	Fill	Tested by :	PM	
BIL-GR-9-1	-65°F (DRY)	0.998	0.1096	10,034	91.71	10.005	8,914		6/14/89	(1,3,5)					
BIL-GR-9-7	"	0.995	0.1192	10,137	85.46	9.251	9,900		"	(2,3,5)					
BIL-GR-9-13	"	0.988	0.1199	10,566	89.20	9.540	8,848	0.049	6/13/89	(2,3,4)					
BIL-GR-10-5	"	0.999	0.1189	10,205	85.88	9.472	9,053		6/14/89	(2,3,5)					
BIL-GR-10-11	"	0.996	0.1172	10,640	91.16	9.434	9,324	0.056	6/13/89	(1,2,3,4)					
Average											88.68	9.540	9,208	0.053	
Std. Dev.											2.91	0.281	428	0.005	

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)	
632.3	68.98	8,914	
589.2	63.78	9,900	
615.0	65.78	8,848	
592.1	65.31	9,053	
628.5	65.04	9,324	
Average	65.78	9,208	
Std. Dev.	1.94	428	

TABLE D.34
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (μin/in)			
BIL-GR-7-2	72°F (DRY)	1.004	0.1166	11,600	8,630	11,600	0.048	5/3/89	(1,2,3,4)	
BIL-GR-7-8	"	1.002	0.1275	12,243	7,943	11,100	0.048	"	(1,2,3,5)	
BIL-GR-7-14	"	0.999	0.1250	11,520	8,408	10,542	"	"	(2,3,4)	
BIL-GR-8-6	"	1.003	0.1242	12,586	8,170	11,700	"	"	(1,3,5)	
BIL-GR-8-12	"	1.004	0.1233	11,530	8,240	10,843	0.046	"	(2,3,4)	
				Average	96.28	11,157	0.048			
				Std. Dev.	3.77	493	0.001			

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; W133 Graphite
 Batch #1 : Task #3
 Fiber Orientation : Fill
 Tested by : PM

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μcm/cm)	
683.4	59.50	11,600	
661.1	54.77	11,100	
636.1	57.98	10,542	
696.5	56.33	11,700	
642.3	56.82	10,843	
Average	57.08	11,157	
Std. Dev.	1.78	493	

TABLE D.35
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :				
Material :		Batch #2	Task #3	Tested by :		PM				
		Ultimate								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-2	72°F(DRY)	0.9997	0.1192	12,065	101.25	8.870	11,616	0.053	6/13/89	(1,2,3,4)
BIL-GR-11-8	"	0.4982	0.1260	5,175	82.44	7.308	9,493	0.039	4/26/89	(1,3,4,6)
BIL-GR-11-14	"	1.0029	0.1231	12,056	97.65	8.563	10,920	0.068	6/13/89	(1,2,3,4)
BIL-GR-12-6	"	0.4981	0.1228	4,880	79.78	7.868	9,632	0.044	4/26/89	(1,3,4,6)
BIL-GR-12-12	"	1.0039	0.1227	12,329	100.09	8.936	11,148	0.068	6/13/89	(1,3,4)
		Average		99.66		8.790		11,228		0.063
		Std. Dev.		1.84		0.199		355		0.009

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	
698.1	61.16	11,616	
568.4	50.39	9,493	
673.3	59.04	10,920	
550.1	54.25	9,632	
690.1	61.61	11,148	
Average		687.2	11,228
Std. Dev.		12.7	355

- Remarks:
- (1) Specimen failed within the gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) 2.00" biaxial gage length extensometer.
 - (5) Specimen had 0° and 90° strain gages attached.
 - (6) Specimen tested in dogbone shape, not included in averages.

TABLE D.36
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) DRY

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :		Fill				
Material :		EA-9396 A/B; W133 Graphite		Batch #3 . Task #3		Tested by :				
		Ultimate				PM				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain ($\mu\text{in}/\text{in}$)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-2	72°F (DRY)	0.994	0.1149	10,200	89.32	9.445	9,180		4/20/89	(2,3,5)
BIL-GR-9-8	"	1.004	0.1237	12,500	100.70	8.890	11,085		4/24/89	(1,3,5)
BIL-GR-9-14	"	1.001	0.1216	11,457	94.13	8.978	8,940	0.044	"	(2,3,4)
BIL-GR-10-6	"	1.000	0.1216	9,129	75.07	8.635	8,520		4/20/89	(2,3,5)
Average					89.80	8.987	9,431			
Std. Dev.					10.87	0.338	1,136			

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) 2.00" gage length biaxial extensometer attached.
- (5) Specimen had only 0° strain gage attached.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain ($\mu\text{cm}/\text{cm}$)	
615.8	65.12	9,180	
694.3	61.30	11,085	
649.0	61.91	8,940	
517.6	59.54	8,520	
Average	619.2	9,431	
Std. Dev.	75.0	1,136	
	61.97		
	2.33		

TABLE D.37
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) DRY

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :				
Material :		Batch #1	Task #3	Tested by :				
		EA-9396 A/B; W133 Graphite		DH				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)		
BIL-GR-7-3	200°F (DRY)	0.999	0.1183	6,768	57.30	8.830	6/15/89	(2,3,5,6)
BIL-GR-7-9	"	1.002	0.1187	8,499	71.45	8.235	1/9/90	(2,3,5,6)
BIL-GR-7-15	"	0.999	0.1189	8,132	68.46	8.387	1/10/90	(2,3,4,6)
BIL-GR-8-7	"	0.998	0.1194	8,108	68.05	8.305	1/9/90	(2,3,5,6)
BIL-GR-8-13	"	1.000	0.1256	8,147	64.87	7.746	1/10/90	(2,3,4,6)
				Average	66.03	8.301	7,827	0.037
				Std. Dev.	5.41	0.387	785	0.020

Remarks:

- Specimen failed within the 6.5 inch gage section.
- Specimen failed inside tab area.
- Test speed = 0.1 in/min.
- Specimen had 0° and 90° strain gages attached.
- Specimen had only 0° strain gage attached.
- Tabs debonded; specimen tested without tabs.

SI Conversion	
Ultimate	Ultimate
Tensile Strength (MPa)	Tensile Modulus (GPa)
395.1	60.88
492.7	56.78
472.1	57.83
469.2	57.27
447.3	53.41
Average	57.23
Std. Dev.	2.67
Ultimate Strain (μcm/cm)	Ultimate Strain (μcm/cm)
6,460	6,460
8,467	8,467
7,998	7,998
8,066	8,066
8,145	8,145
Average	7,827
Std. Dev.	785

TABLE D.38
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)					
BIL-GR-11-3	200°F (DRY)	1.001	0.1172	10,757	91.70	9.226	9,712	6/15/89		6/15/89	(1,2,3,5)
BIL-GR-11-9	"	0.998	0.1198	8,416	70.37	8.491	8,110	1/9/90		1/9/90	(2,3,5,6)
BIL-GR-11-15	"	1.000	0.1139	9,229	81.06	8.776	9,087	"	0.046	"	(2,3,4)
BIL-GR-12-7	"	0.996	0.1172	7,686	65.83	8.366	7,749	"		"	(2,3,5,6)
BIL-GR-12-13	"	1.000	0.1170	9,583	81.89	8.119	10,039	"	0.060	"	(1,3,4)
					Average		78.17	8,940		0.053	
					Std. Dev.		10.23	992		0.010	

Fiber Orientation : Fill
 Tested by : DH

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; W133 Graphite

Batch #2 Task #3

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Tabs debonded; specimen tested without tabs.

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μ cm/cm)
632.3	63.61	9,712
485.2	58.55	8,110
558.9	60.51	9,087
453.9	57.68	7,749
564.6	55.98	10,039
Average	59.27	8,940
Std. Dev.	2.93	992

TABLE D.39
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) DRY

Test :		Straight sided tension; ASTM-D3039			Fiber Orientation :			
Material :		Batch #3	Task #3	Tested by :				
		EA-9396 A/B; W133 Graphite			PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)		
BIL-GR-9-3	200°F (DRY)	0.9982	0.1192	10,271	86.33	9.155	5/8/89	(1,2,3,5)
BIL-GR-9-9	"	1.0013	0.1233	9,929	80.42	8.910	"	(1,3,5)
BIL-GR-9-16	"	1.0024	0.1195	9,810	81.90	9.183	5/9/89	(1,3,4)
BIL-GR-10-7	"	0.9971	0.1198	8,900	74.51	8.910	5/8/89	(2,3,5)
BIL-GR-10-13	"	1.0001	0.1151	10,140	88.09	9.035	5/9/89	(1,2,3,4)
				Average	82.25	9.038		0.082
				Std. Dev.	5.34	0.130		0.028

		SI Conversion	
		Ultimate	Ultimate
		Tensile Strength (MPa)	Tensile Modulus (GPa)
		595.2	63.12
		554.5	61.43
		564.7	63.32
		513.7	61.43
		607.4	62.29
Average		567.1	62.32
Std. Dev.		36.8	0.90

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.

TABLE D.40
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, -54°C (-65°F) WET

Straight sided tension; ASTM-D3039										
Fiber Orientation : Fill										
Batch #1					Task #3					
Material : EA-9396 A/B; W133 Graphite										
Tested by : PM										
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Strain (µin/in)				
BIL-GR-7-4	-65°F (WET)	0.997	0.1239	12,505	101.24	9.214	0.052	97789	(1,2,3,4,6)	
BIL-GR-7-10	"	0.999	0.1248	11,499	92.23	8.906		"	(2,3,5,6)	
BIL-GR-8-1	"	0.998	0.1099	10,586	96.53	9.912		"	(2,3,5,6)	
BIL-GR-8-8	"	1.001	0.1213	11,470	94.46	9.454		"	(1,2,3,5,6)	
BIL-GR-8-14	"	1.003	0.1152	11,831	102.39	9.434	0.041	"	(1,2,3,4,6)	
Average					97.37	9.384	0.046			
Std. Dev.					4.35	0.369	0.008			

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
698.1	63.53	11,104	
635.9	61.41	10,225	
665.5	68.34	9,514	
651.3	65.18	7,214	
706.0	65.05	10,745	
671.4	64.70	9,760	
30.0	2.54	1,544	
Average			
Std. Dev.			

TABLE D.41
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, -54°C (-65°F) WET

Test :		Straight sided tension; ASTM-D3039		Batch #2		Task #3		Fiber Orientation :		
Material :		EA-9396 A/B; W133 Graphite		Ultimate		Ultimate		Tested by :		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-4	-65°F (WET)	0.999	0.1197	10,996	91.93	9.485	9,368	0.051	9/8/89	(1,2,3,5,6)
BIL-GR-11-10	"	0.999	0.1206	12,148	100.82	9.382	10,378		9/7/89	(1,2,3,4,6)
BIL-GR-12-1	"	0.999	0.1119	9,009	80.60	9.655	8,005		9/8/89	(1,3,5,6)
BIL-GR-12-8	"	0.998	0.1181	11,895	100.93	9.347	10,408		"	(1,2,3,5,6)
BIL-GR-12-14	"	0.999	0.1177	11,480	97.61	9.680	10,151	0.041	9/7/89	(1,2,3,4,6)
		Average			94.38	9.510	9,662	0.046		
		Std. Dev.			8.53	0.153	1,017	0.008		

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Ultimate Strain (µin/in)
633.8	65.40	9,368	9,368
695.2	64.69	10,378	10,378
555.7	66.57	8,005	8,005
695.9	64.44	10,408	10,408
673.0	66.74	10,151	10,151
Average		650.7	9,662
Std. Dev.		58.8	1,017

- Remarks:
- (1) Specimen failed within the 6.5 inch gage section.
 - (2) Specimen failed inside tab area.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen had 0° and 90° strain gages attached.
 - (5) Specimen had only 0° strain gage attached.
 - (6) Specimens aged @ 140°F/95-100% R.H.

TABLE D.42
INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, -54°C (-65°F) WET

Test :		Straight sided tension; ASTM-D3039		Batch #3		Task #3		Fiber Orientation :		
Material :		EA-9396 A/B; W133 Graphite		Ultimate		Tensile Modulus (Msi.)		Tested by :		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-9-4	-65°F (WET)	0.995	0.1178	11,670	99.59	9.620	10,217	0.050	9/8/89	(1,2,3,4,6)
BIL-GR-9-10	"	0.996	0.1213	10,527	87.12	9.164	9,353		"	(1,2,3,5,6)
BIL-GR-10-1	"	0.998	0.1078	11,284	104.89	10.359	9,976		"	(1,2,3,5,6)
BIL-GR-10-8	"	0.996	0.1181	11,221	95.40	9.301	10,129		"	(1,2,3,5,6)
BIL-GR-10-14	"	0.999	0.1149	11,948	104.09	9.852	10,613	0.086	"	(1,2,3,4,6)
		Average		98.22		10,058		0.068		
		Std. Dev.		7.28		459		0.025		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion	
Ultimate Tensile Strength (MPa)	Ultimate Strain (µcm/cm)
686.7	10,217
600.7	9,353
723.2	9,976
657.8	10,129
717.7	10,613
Average 677.2	10,058
Std. Dev. 50.2	459

TABLE D.43
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	Ultimate Strain ($\mu\text{in/in}$)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)					
BIL-GR-7-5	72°F (WET)	1.002	0.1267	9,146	72.02	8.552	8.386	0.035	9/6/89	(2,3,5,6)	
BIL-GR-7-11	"	0.999	0.1260	10,327	82.08	8.845	9.338		"	(2,3,4,6)	
BIL-GR-8-2	"	1.003	0.1152	11,533	99.84	8.958	10,994		"	(1,3,5,6)	
BIL-GR-8-4	"	1.005	0.1244	10,508	84.05	8.407	9,829		"	(1,3,5,6)	
BIL-GR-8-9	"	1.003	0.1266	9,771	76.96	8.373	9,082		"	(2,3,4,6)	
Average					82.99	8.627	9,526	0.037			
Std. Dev.					10.52	0.262	972	0.002			

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; W133 Graphite
 Batch #1 : Task #3
 Fiber Orientation : Fill
 Tested by : PM

Remarks:

- Specimen failed within the 6.5 inch gage section.
- Specimen failed inside tab area.
- Test speed = 0.1 in/min.
- Specimen had 0° and 90° strain gages attached.
- Specimen had only 0° strain gage attached.
- Specimens aged @ 140°F/95-100% R.H.

SI Conversion	
Ultimate Tensile Strength (MPa)	Ultimate Strain ($\mu\text{cm/cm}$)
496.6	8,386
566.0	9,338
688.4	10,994
579.5	9,829
530.6	9,082
Average	9,526
Std. Dev.	972

TABLE D.44
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 22°C (72°F) WET

Test :		Straight sided tension; ASTM-D3039		Batch #2		Task #3		Fiber Orientation :		
Material :		EA-9396 A/B; W133 Graphite		Ultimate		Ultimate		PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
BIL-GR-11-5	72°F (WET)	1.003	0.1171	10,586	90.17	9.150	9.543	0.043	9/11/89	(1,2,3,5,6)
BIL-GR-11-11	"	1.000	0.1118	11,318	101.27	9.633	10,430		"	(1,2,3,4,6)
BIL-GR-12-2	"	1.001	0.1177	10,332	87.66	8.581	9,998		"	(1,2,3,5,6)
BIL-GR-12-9	"	1.004	0.1237	10,176	81.94	8.383	9,653		"	(1,3,5,6)
BIL-GR-12-15	"	1.005	0.1239	10,986	88.25	8.222	11,697	0.049	"	(1,3,4,6)
Average					89.86	8.794	10,264	0.046		
Std. Dev.					7.08	0.586	872	0.004		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)
621.7	63.09	9.543
698.2	66.42	10,430
604.4	59.16	9,998
565.0	57.80	9,653
608.5	56.69	11,697
Average	60.63	10,264
Std. Dev.	4.04	872

TABLE D.45
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 22°C (72°F) WET

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :		Fill		
Material :		EA-9396 A/B; W133 Graphite		Batch #3 Task #3		Tested by : PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)		
BIL-GR-9-5	72°F (WET)	1.003	0.1240	10,703	86.08	8.624	9,741	9/11/89 (1,2,3,5,6)
BIL-GR-9-11	"	1.002	0.1247	10,762	86.10	8.881	9,683	" (1,2,3,4,6)
BIL-GR-10-2	"	1.002	0.1163	11,040	94.73	8.933	10,547	" (1,2,3,5,6)
BIL-GR-10-9	"	1.002	0.1253	10,674	85.04	8.516	10,181	" (1,3,5,6)
BIL-GR-10-15	"	1.002	0.1173	11,401	96.99	8.947	11,279	" (1,3,4,6)
				Average	89.79	8.780	10,286	
				Std. Dev.	5.62	0.197	657	

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.

SI Conversion	
Ultimate Tensile Strength (MPa)	Ultimate Strain (µcm/cm)
593.5	9,741
593.7	9,683
653.1	10,547
586.4	10,181
668.8	11,279
Average 619.1	Average 10,286
Std. Dev. 38.7	Std. Dev. 657

TABLE D.46
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, FILL DIRECTION, 93°C (200°F) WET

Test :		Straight sided tension; ASTM-D3039			Batch #1		Task #3		Fiber Orientation :		Fill
Material :		EA-9396 A/B; W133 Graphite			Ultimate		Tensile Modulus (Msi.)		Poisson's Ratio		Tested by :
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks	
BIL-GR-7-6	200°F (WET)	0.997	0.1244	7,993	64.47	7.612	7,727	0.034	1/23/90	(2,3,4,6,8)	
BIL-GR-7-12	"	1.001	0.1229	7,666	62.31	7.801	7,427	0.015	9/13/89	(1,3,4,6)	
BIL-GR-8-3	"	1.007	0.1141	8,096	70.46	9.197	3,071		9/15/89	(1,3,5,6,7)	
BIL-GR-8-10	"	0.998	0.1205	6,624	56.72	7.492	7,749		1/23/90	(2,3,5,6,8)	
BIL-GR-8-16	"	1.006	0.1138	8,140	71.10	7.679	9,316	0.052	"	(1,3,4,6,8)	
		Average		65.01		7.956		0.034			
		Std. Dev.		5.98		0.703		0.018			
SI Conversion											
		Average		448.3		54.86		7.058			
		Std. Dev.		41.2		4.84		2,348			

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed at grip edge.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° Strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.
- (7) Strain gage failed prematurely due to ply failure.
- (8) Tested without tabs.

TABLE D.47
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, FILL DIRECTION, 93°C (200°F) WET

Test :		Straight sided tension; ASTM-D3039		Batch #2		Task #3		Fiber Orientation :		Fill	
Material :		EA-9396 A/B; W133 Graphite		Ultimate		Ultimate		Tested by :		PM & DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (μ in/in)	Poisson's Ratio	Date Tested	Remarks	
BIL-GR-11-6	200°F (WET)	0.994	0.1195	7,935	66.81	8.581	8.262	0.048	1/23/90	(3,4,6,7,8)	
BIL-GR-11-12	"	0.998	0.1189	7,188	60.59	8.861	5.530	0.052	9/14/89	(3,4,6,8)	
BIL-GR-12-3	"	0.998	0.1177	7,434	63.30	8.131	9.067		1/23/90	(1,2,3,5,6,7)	
BIL-GR-12-4	"	1.001	0.1176	7,405	62.91	7.083	9.521	0.036	"	(3,4,6,7,8)	
BIL-GR-12-10	"	0.999	0.1157	7,141	61.78	7.754	8.438	0.061	"	(3,4,6,7,8)	
				Average	63.08	8.082	8.164	0.049			
				Std. Dev.	2.34	0.701	1.556	0.010			
SI Conversion											
Ultimate											
				Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (μ cm/cm)					
				460.6	59.17	8.262					
				417.8	61.09	5.530					
				436.5	56.06	9.067					
				433.8	48.83	9.521					
				426.0	53.47	8.438					
				Average	55.72	8.164					
				Std. Dev.	4.83	1.556					

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.
- (7) Tested without tabs.
- (8) Failed at grip edge.

TABLE D.48
 INDIVIDUAL SPECIMEN TENSILE TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, FILL DIRECTION, 93°C (200°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)					
BIL-GR-9-6	200°F (WET)	0.999	0.1203	7,598	63.22	8.047	7,939	0.085	1/23/90	(1,3,5,6,7)	
BIL-GR-9-12	"	0.999	0.1197	7,715	64.50	8.091	7,603	0.085	9/13/89	(1,3,4,6)	
BIL-GR-10-3	"	1.001	0.1132	8,169	72.13	7.596	6,929		1/23/90	(3,5,6,7,8)	
BIL-GR-10-10	"	0.998	0.1197	7,705	64.47	8.027	5,339		9/14/89	(1,3,5,6)	
BIL-GR-10-12	"	1.002	0.1181	7,019	59.31	7.014	8,540	0.066	1/23/90	(1,3,4,6)	
BIL-GR-10-16	"	0.998	0.1122	7,202	64.31	8.766	5,522	0.048	9/13/89	(1,3,4,6)	
					Average	64.66	7.923	6,979	0.067		
					Std. Dev.	4.16	0.513	1,308	0.018		

Test : Straight sided tension; ASTM-D3039
 Material : EA-9396 A/B; W133 Graphite
 Batch #3 Task #3 Fiber Orientation : Fill
 Tested by : PM & DH

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H.
- (7) Tested without tabs.
- (8) Failed at grip edge.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
435.9	55.48	7,939	
444.7	55.79	7,603	
497.3	52.37	6,929	
444.5	55.34	5,339	
409.0	48.36	8,540	
443.4	60.44	5,522	
Average	54.63	6,979	
Std. Dev.	4.02	1,308	

APPENDIX E INDIVIDUAL SPECIMEN COMPRESSION PROPERTIES, BASELINE

The 48 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in compression. A summary of these data was presented and discussed in Section 3.2.2. Two types of compressive failure modes are referred to in this Appendix. Figure E.1 illustrates the type of failure behavior associated with each verbal description.

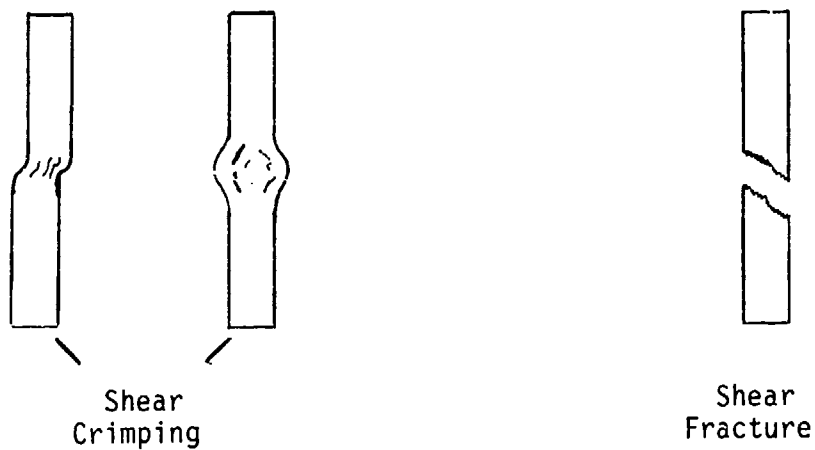


Figure E.1. Types of Compressive Failure Modes Observed.

TABLE E.1
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-8-17	72°F (DRY)	1.001	0.1317	6,140	46.58	3.635	6/20/89	(1,4,5)
BIL-GL-8-19	"	0.998	0.1311	6,960	53.18	3.665	6/21/89	(1,4)
BIL-GL-8-22	"	1.003	0.1369	6,025	43.89	3.168	"	(1,2,4)
BIL-GL-8-24	"	1.004	0.1372	7,104	51.60	4.110	"	(1,4)
BIL-GL-8-25	"	1.003	0.1375	6,721	48.74	3.597	"	(1,4)
Average					48.80	3.635		15,086
Std. Dev.					3.74	0.334		2,573

Test : IITRI Compression; ASTM-D3410
 Material : EA-9396 A/B; 7781 Glass
 Fiber Orientation: Warp
 Tested By: PM

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (3) Failed outside gage section.
- (4) Test speed = 0.05 in/min.
- (5) Specimen did not fail; tab debonded.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)	
321.2	25.06	13,506	
366.7	25.27	13,608	
302.6	21.84	19,585	
355.8	28.34	14,876	
336.0	24.80	13,857	
Average	336.4	25.06	15,086
Std. Dev.	25.8	2.30	2,573

TABLE E.2

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) DRY

Test :		iITRI Compression; ASTM-D3410		Fiber Orientation:		Waip			
Material :	EA-9396 A/B; 7781 Glass	Batch #2	Task #4	Tested By:		PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μ in/in)	Date Tested	Remarks
BIL-GL-9-17	72°F (DRY)	1.003	0.1408	6,545	46.36	3.415	11,704	6/21/89	(1,3)
BIL-GL-9-19	"	1.003	0.1401	6,770	48.16	3.693	12,869	"	(1,3)
BIL-GL-9-22	"	1.000	0.1348	7,473	55.47	3.719	14,648	"	(1,3)
BIL-GL-9-24	"	1.000	0.1359	6,807	50.07	3.895	14,392	6/22/89	(1,3)
BIL-GL-9-25	"	0.998	0.1361	6,650	48.96	3.897	13,184	"	(1,3)
Average				49.80		3.724	13,359		
Std. Dev.				3.44		0.197	1,198		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μ cm/cm)	
319.7	23.55	11,704	
332.1	25.46	12,869	
382.4	25.64	14,648	
345.2	26.85	14,392	
337.6	26.87	13,184	
Average	343.4	25.68	13,359
Std. Dev.	23.7	1.36	1,198

TABLE E.3
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		-Initial		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)	Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-10(R)-17	72°F (DRY)	1.003	0.1360	6,760	49.56	3.512	15,380	10/26/89	(1,3)	
BIL-GL-10(R)-19	"	1.004	0.1320	6,430	48.52	3.735	16,500	"	(1,3)	
BIL-GL-10(R)-22	"	1.002	0.1410	7,205	51.00	3.663	15,040	"	(1,3)	
BIL-GL-10(R)-24	"	1.007	0.1370	7,215	52.30	3.842	16,600	"	(1,3)	
BIL-GL-10(R)-25	"	1.003	0.1420	7,145	50.17	3.704	14,480	"	(1,3)	
Average					50.31	3.691	15,600			
Std. Dev.					1.43	0.120	926			

Test : IITRI Compression; ASTM-D3410
 Material : EA-9396 A/B; 7781 Glass
 Batch #3 Task #4
 Fiber Orientation: Warp
 Tested By: BH

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear: crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain ($\mu\text{cm/cm}$)	Initial Tangent Modulus (GPa)
341.7	24.21	15,380	25.45
334.5	25.75	16,500	0.83
351.6	25.26	15,040	
360.6	26.49	16,600	
345.3	25.54	14,480	
Average	346.9	15,600	
Std. Dev.	9.9	926	

TABLE E.4

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) WET

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		
Material :		Batch #1	Task #4				Warp	
Material :		EA-9396 A/B; 7781 Glass				TB		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Compressive Strength		Date Tested	Remarks
					(Ksi.)	(M.s.)		
BIL-GL-8-18	72°F (WET)	1.003	0.1354	3,259	24.01	3.210	1/10/90	(1,3,4,5)
BIL-GL-8-21	"	1.005	0.1458	2,515	17.16	2.563	"	(1,3,4,5)
BIL-GL-8-23	"	1.002	0.1431	3,430	23.92	3.280	"	(1,3,4,5)
BIL-GL-8-26	"	1.007	0.1416	3,809	26.72	3.253	"	(1,3,4,5)
BIL-GL-8-28	"	1.002	0.1424	3,856	27.03	3.044	"	(1,3,4,5)
Average					23.77	3.070		
Std. Dev.					3.97	0.298		
					Ultimate			
					Initial			
					Tangent Modulus			
					Strain			

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 180 days.
- (5) Average weight gain = 1.9643%

SI Conversion				
	Ultimate		Initial	
	Compressive Strength (MPa)	Tangent Modulus (GPa)	Compressive Strength (MPa)	Tangent Modulus (GPa)
	165.5	22.13	163.9	21.17
	118.3	17.67	27.4	2.05
	164.9	22.61		
	184.3	22.43		
	186.3	20.99		
Average		21.17		8,524
Std. Dev.		2.05		1,300

TABLE E.5
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) WET

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Warp			
Material :		EA-9396 A/B; 7781 Glass		Batch #2 Task #4		TB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Initial		Date Tested	Remarks
				Maximum Load (lbs.)	Compressive Strength (Ksi.)	Tangent Modulus (Msi.)	Ultimate Strain (µin/in)		
BIL-GL-9-18	200°F (WET)	0.999	0.1454	2,295	15.80	3.132	5,166	12/5/89	(3,4,5)
BIL-GL-9-21	"	1.001	0.1400	1,636	11.68	2.969	5,469	"	(3,4,5)
BIL-GL-9-23	"	1.001	0.1395	2,100	15.04	3.074	4,775	"	(3,4,5)
BIL-GL-9-26	"	1.001	0.1396	1,953	13.98	2.763	6,572	"	(3,4,5)
BIL-GL-9-28	"	1.000	0.1400	1,794	12.82	3.307	4,160	"	(3,4,5)
				Average	13.86	3.049	5,229		
				Std. Dev.	1.66	0.202	896		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
- (5) Average weight gain = 2.3264%

SI Conversion				
	Ultimate		Initial	
	Compressive Strength (MPa)	Tangent Modulus (GPa)	Compressive Strength (MPa)	Tangent Modulus (GPa)
	108.9	21.60	108.9	21.60
	80.5	20.47	80.5	20.47
	103.7	21.19	103.7	21.19
	96.4	19.05	96.4	19.05
	88.4	22.80	88.4	22.80
Average	95.6	21.02	95.6	21.02
Std. Dev.	11.4	1.39	11.4	1.39

TABLE E.6
INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) WET

Test :		IITRI Compression; ASTM-D3410			Fiber Orientation:				
Material :	EA-9396 A/B; 7781 Glass	Batch #3	Task #4	Tested By:	RG				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μ in/in)	Date Tested	Remarks
BIL-GL-10(R)-18	72°F (WET)	1.004	0.1350	3,418	25.22	3.395	8,262	1/5/90	(1,3,4,5)
BIL-GL-10(R)-21	"	1.001	0.1370	3,687	26.88	3.308	7,920	"	(1,3,4,5)
BIL-GL-10(R)-23	"	1.002	0.1410	3,711	26.27	2.921	10,495	"	(1,3,4,5)
BIL-GL-10(R)-26	"	1.002	0.1430	3,809	26.58	3.854	6,182	"	(1,3,4,5)
BIL-GL-10(R)-28	"	1.003	0.1420	3,174	22.28	3.618	5,850	"	(1,3,4,5)
				Average	25.45	3.419	7,742		
				Std. Dev.	1.88	0.350	1,864		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
- (5) Average weight gain = 1.6754%

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μ cm/cm)	Average Std. Dev.
173.9	23.41	8,262	7,742
185.4	22.81	7,920	1,864
181.1	20.14	10,495	
183.3	26.58	6,182	
153.6	24.94	5,850	
Average	23.58	7,742	
Std. Dev.	2.41	1,864	

TABLE E.7

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) DRY

Test :		IITRI Compression; ASTM-D3410			Fiber Orientation:				
Material :		Batch #1	Task #5	Tested By:					
		EA-9396 A/B; 7781 Glass			PM				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Date Tested	Remarks		
				Maximum Load (lbs.)	Compressive Strength (Ksi.)			Initial Tangent Modulus (Msi.)	Ultimate Strain (μin/in)
BIL-GL-7-4	-65°F (DRY)	1.000	0.1325	8,671	65.43	4.042	19,170	5/1/89	(1,3)
BIL-GL-7-25	"	1.002	0.1361	9,293	68.15	3.903	16,545	"	(1,3)
BIL-GL-7-47	"	1.002	0.1309	8,979	68.46	4.139	16,935	"	(1,3)
BIL-GL-8-11	"	1.003	0.1359	7,898	57.92	4.057	17,512	6/22/89	(1,3)
BIL-GL-8-40	"	1.004	0.1385	8,450	60.75	3.924	17,395	"	(1,3)
				Average	64.14	4.013	17,511		
				Std. Dev.	4.65	0.099	1,004		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

		SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μm/cm)	Initial
			Tangent Modulus (GPa)
451.2	27.87	19,170	
469.9	26.91	16,545	
472.0	28.54	16,935	
399.4	27.98	17,512	
418.9	27.06	17,395	
Average	442.3	17,511	27.67
Std. Dev.	32.1	1,004	0.68

TABLE E.8
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) DRY

Test :		IITRI Compression, ASTM-D3410		Fiber Orientation:		Fill			
Material :		Batch #2	Task #5	Tested By:		PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Date	Remarks		
				Maximum Load (lbs.)	Compressive Strength (Ksi.)			Tangent Modulus (Msi.)	Ultimate Strain (µin/in)
BIL-GL-9-4	-65°F (DRY)	1.002	0.1380	7,969	57.61	4,138	15,960	6/22/83	(1,3)
BIL-GL-9-11	"	1.002	0.1329	7,429	55.80	4,348	13,433	"	(1,3)
BIL-GL-9-30	"	1.002	0.1339	7,683	57.25	4,545	14,070	"	(1,3)
BIL-GL-9-37	"	1.005	0.1361	8,171	59.77	3,626	14,971	"	(1,3)
BIL-GL-9-41	"	1.005	0.1360	7,854	57.47	4,276	14,678	"	(1,3)
Average					57.58	4.187	14,622		
Std. Dev.					1.42	0.346	953		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Ultimate Strain (µcm/cm)	Ultimate Strain (µcm/cm)
397.2	28.53	15,960	14,622
384.7	29.98	13,433	953
394.7	31.34	14,070	
412.1	25.00	14,971	
396.2	29.48	14,678	
Average		397.0	28.87
Std. Dev.		9.8	2.39

TABLE E.9

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) DRY

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:			
Material :		Batch #3	Task #5	Tested By:		Fill	RG		
Material :		EA-9396 A/B; 7781 Glass							
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
BIL-GL-10(R)-1	-65°F (DRY)	1.002	0.1340	9,497	70.73	4.470	16,924	1/2/90	(1,3)
BIL-GL-10(R)-8	"	1.004	0.1380	8,984	64.84	4.211	18,994	"	(1,3)
BIL-GL-10(R)-15	"	1.001	0.1370	9,998	72.91	4.344	17,305	"	(1,3)
BIL-GL-10(R)-34	"	1.009	0.1370	10,156	73.47	4.363	20,800	"	(1,3)
BIL-GL-10(R)-43	"	1.006	0.1370	9,204	56.78	4.363	16,582	"	(1,3)
				Average	69.75	4.350	18,121		
				Std. Dev.	3.80	0.092	1,761		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial Tangent Modulus (GPa)
487.7	30.82	16,924	30.82
447.1	29.04	18,994	29.04
502.7	29.95	17,305	29.95
506.6	30.08	20,800	30.08
460.5	30.09	16,582	30.09
Average	480.9	18,121	30.00
Std. Dev.	26.2	1,761	0.64

TABLE E.10

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) DRY

Test :		IITRI Compression; ASTM-D3410			Fiber Orientation:			
Material :		EA-9396 A/B; 7781 Glass	Batch #1	Task #5	Tested By: PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate	Initial	Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-7-2	72°F (DRY)	1.001	0.1357	5,986	44.07	3.549	9,345	5/1/89 (1,4)
BIL-GL-7-23	"	1.002	0.1347	6,214	46.03	3.783	13,710	" (1,2,4)
BIL-GL-7-45	"	1.002	0.1283	5,143	40.02	3.863	14,115	" (1,2,4)
BIL-GL-8-9	"	1.004	0.1335	5,000	37.32	3.862	10,400	6/20/89 (1,4)
BIL-GL-8-38	"	1.001	0.1351	5,547	41.00	3.880	10,781	" (1,2,4)
				Average	41.69	3.788	11,670	
				Std. Dev.	3.42	0.138	2,118	

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (3) Specimen failed outside gage section.
- (4) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	
		Ultimate Strain (µcm/cm)	Ultimate Strain (µcm/cm)
	303.8	24.47	9,345
	317.4	26.09	13,710
	275.9	26.64	14,115
	257.3	26.63	10,400
	282.7	26.75	10,781
Average	287.4	26.12	11,670
Std. Dev.	23.6	0.95	2,118

TABLE E.11

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 22°C (72°F) DRY

Test :		IITRI Compression; AL M-D3410			Fiber Orientation:				
Material :		EA-9396 A/B; 7781 Glass	Batch #2	Task #5	Tested By.	Fill			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate	Initial	Date Tested	Remarks	
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)			Strain (μ in/in)
BIL-GL-9-2	72°F (DRY)	1.004	0.1351	5,396	39.80	3.388	9,360	6/26/89	(1,3)
BIL-GL-9-9	"	1.002	0.1351	5,134	37.95	3.676	11,543	"	(1,3)
BIL-GL-9-16	"	1.004	0.1305	5,083	38.80	3.873	10,730	"	(1,3)
BIL-GL-9-35	"	1.003	0.1332	5,823	43.58	3.433	14,898	"	(1,3)
BIL-GL-9-44	"	1.003	0.1338	4,736	35.29	3.581	12,092	"	(1,3)
Average					39.08	3.590	11,725		
Std. Dev.					3.02	0.195	2,050		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Ultimate Strain (μ cm/cm)	Ultimate Strain (μ cm/cm)
274.4	23.36	9,360	11,725
261.6	25.35	11,543	2,050
267.5	26.70	10,730	
300.5	23.67	14,898	
243.3	24.69	12,092	
Average		269.5	24.75
Std. Dev.		20.8	1.35

TABLE E.12
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) DRY

Test :		IITRI Compression; ASTM-D3410		Batch #3		Task #5		Fiber Orientation:	
Material :		EA-9396 A/B; 7781 Glass						BH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain ($\mu\text{in/in}$)	Date Tested	Remarks
BIL-GL-10(R)-2	72°F (DRY)	1.002	0.1340	5,110	38.06	3.929	9,020	10/26/89	(1,3)
BIL-GL-10(R)-9	"	0.997	0.1370	5,510	40.34	3.130	17,800	"	(1,3)
BIL-GL-10(R)-16	"	1.001	0.1400	5,975	42.64	3.336	12,240	"	(1,3)
BIL-GL-10(R)-35	"	1.007	0.1390	6,310	45.08	3.715	11,420	"	(1,3)
BIL-GL-10(R)-44	"	1.006	0.1360	5,840	42.69	3.874	10,752	"	(1,3)
Average					41.76	3.597	12,246		
Std. Dev.					2.66	0.349	3,323		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain ($\mu\text{cm/cm}$)	
262.4	27.09	9,020	
278.1	21.58	17,800	
294.0	23.00	12,240	
310.8	25.61	11,420	
294.3	26.71	10,752	
Average	24.80	12,246	
Std. Dev.	2.41	3,323	

TABLE E.13
INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) DRY

		IITRI Compression; ASTM-D3410			Fiber Orientation:				
		Batch #1	Task #5	Tested By:	Fill	PM			
Material :		EA-9396 A/B; 7781 Glass							
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
GL8-10	200°F (DRY)	1.004	0.1345	3,805	28.17	3,530	9,360	6/26/89	(1,3)
GL8-39	"	1.004	0.1382	3,848	27.72	3,412	9,119	"	(1,3)
Average					27.95	3,471	9,240		
Std. Dev.					0.32	0.083	171		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear Fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

		SI Conversion	
		Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)
		194.3	24.34
		191.2	23.53
Average		192.7	23.93
Std. Dev.		2.2	0.58
			Ultimate Strain (µcm/cm)
			9,360
			9,119
			9,240
			171

TABLE E.14
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-9-3	200°F (DRY)	1.003	0.1375	3,225	23.39	3.753	6/23/89	(1,3)
BIL-GL-9-10	"	1.002	0.1320	3,318	25.09	3.373	"	(1,3)
BIL-GL-9-09	"	1.003	0.1265	2,975	23.45	3.399	"	(2,3)
BIL-GL-9-06	"	1.003	0.1359	3,661	26.85	3.257	"	(1,3)
BIL-GL-9-40	"	1.006	0.1377	3,656	26.39	2.985	"	(1,3)
Average					25.04	3.353		7,450
Std. Dev.					1.61	0.277		1,077

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Remarks
161.3	25.88	7,280	
173.0	23.25	7,537	
161.7	23.44	6,658	
185.2	22.46	9,229	
182.0	20.58	6,548	
Average	172.6	23.12	7,450
Std. Dev.	11.1	1.91	1,077

- Remarks:
- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
 - (2) Specimen failed outside gage section.
 - (3) Test speed = 0.05 ir/min.

TABLE E.15
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Initial		Date Tested	Remarks
					Compressive Strength (Ksi.)	Compressive Strength (Msi.)	Tangent Modulus (Msi.)	Tangent Modulus (Msi.)		
BIL-GL-10(R)-3	200°F (DRY)	1.009	0.1350	4,248	31.19	3.827	3.827	7,500	1/2/90	(1,3)
BIL-GL-10(R)-10	"	0.997	0.1380	4,712	34.25	3.244	3.244	12,412	"	(1,3)
BIL-GL-10(R)-29	"	0.998	0.1350	4,346	32.25	3.752	3.752	8,369	"	(1,3)
BIL-GL-10(R)-36	"	1.011	0.1390	4,529	32.23	3.621	3.621	9,775	"	(1,3)
BIL-GL-10(R)-40	"	1.010	0.1350	5,075	37.22	3.667	3.667	10,070	"	(1,3)
Average					33.43	3.622	3.622	9,625		
Std. Dev.					2.39	0.226	0.226	1,876		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial Tangent Modulus (GPa)
215.0	26.39	7,500	26.39
236.1	22.37	12,412	22.37
222.4	25.87	8,369	25.87
222.2	24.97	9,775	24.97
256.6	25.28	10,070	25.28
Average	24.98	9,625	24.98
Std. Dev	1.56	1,876	1.56

TABLE E.16

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) WET

Test :		IITRI Compression; ASTM-D3410			Fiber Orientation:				
Material :		Batch #1	Task #5	Tested By:					
		EA-9396 A/B; 7781 Glass			TB				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (μ in/in)	Date Tested	Remarks
BIL-GL-7-1	-65°F (WET)	1.001	0.1306	5,906	45.17	4.111	10,450	1/10/90	(1,3,4,5)
BIL-GL-7-22	"	1.000	0.1351	7,019	51.94	4.295	13,848	"	(1,3,4,5)
BIL-GL-7-44	"	1.002	0.1306	6,482	49.55	4.171	10,313	"	(1,3,4,5)
BIL-GL-8-8	"	1.004	0.1385	5,786	41.61	4.130	12,969	"	(1,3,4,6)
BIL-GL-8-37	"	1.003	0.1425	6,200	43.40	3.872	13,400	"	(1,3,4,6)
				Average	46.34	4.116	12,196		
				Std. Dev.	4.30	0.154	1,686		
SI Conversion									
				Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μ cm/cm)			
				311.5	28.35	10,450			
				358.1	29.61	13,848			
				341.7	28.76	10,313			
				286.9	28.48	12,969			
				299.2	26.70	13,400			
Average				319.5	28.38	12,196			
Std. Dev.				29.7	1.06	1,686			

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 180 days.
- (5) Weight gain = 1.6916%
- (6) Weight gain = 1.9759%

TABLE E.17
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) WET

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:	
Material :		Batch #2	Task #5	Tested By:		Fill	
EA-9396 A/B; 7781 Glass						TB	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Date Tested	Remarks
				Maximum Load (lbs.)	Compressive Strength (Ksi.)		
BIL-GL-9-1	-65°F (WET)	1.002	0.1341	5,322	39.61	1/10/90	(1,3,4,5)
BIL-GL-9-8	"	1.002	0.1376	6,113	44.33	"	(1,3,4,5)
BIL-GL-9-15	"	1.002	0.1419	5,481	38.55	"	(1,3,4,5)
BIL-GL-9-34	"	1.003	0.1393	6,433	46.04	"	(1,3,4,5)
BIL-GL-9-43	"	1.002	0.1394	6,628	47.44	"	(1,3,4,5)
				Average	43.19	3.881	11,330
				Std. Dev.	3.93	0.342	1,090

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)	Average
			Std. Dev.
273.1	26.08	9,893	26.76
305.7	26.72	10,685	2.36
265.8	23.51	12,324	
317.4	30.06	11,289	
327.1	27.41	12,461	
297.8			
27.1			

- Remarks:
- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
 - (2) Specimen failed outside gage section.
 - (3) Test speed = 0.05 in/min.
 - (4) Specimens aged @ 140°F/95-100% R.H. for 180 days.
 - (5) Weight gain = 2.0685%

TABLE E.18
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) WET

Test :		ASTM-D3410		Fiber Orientation:					
Material :		EA-9396 A/B: 7781 Glass		Fill					
		Batch #3	Task #5	Tested By:					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
BIL-GL-10(R)-4	-65°F (WET)	1.004	0.1360	6,836	50.06	4.221	13,916	1/10/90	(1,3,4,5)
BIL-GL-10(R)-11	"	0.995	0.1370	7,642	56.06	3.984	15,693	"	(1,3,4,5)
BIL-GL-10(R)-30	"	1.001	0.1340	6,299	46.96	4.459	13,721	"	(1,3,4,5)
BIL-GL-10(R)-37	"	1.005	0.1370	6,580	47.79	4.046	11,777	"	(1,3,4,5)
BIL-GL-10(R)-41	"	1.004	0.1370	6,750	49.08	4.427	13,057	"	(1,3,4,5)
				Average	49.99	4.227	13,633		
				Std. Dev.	3.60	0.215	1,424		

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Average Std. Dev.
345.2	29.11	13,916	13,633
386.5	27.47	15,693	1,424
323.8	30.74	13,721	
329.5	27.90	11,777	
338.4	30.52	13,057	
Average	29.15	13,633	13,633
Std. Dev.	1.48	1,424	1,424

- Remarks:
- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
 - (2) Specimen failed outside gage section.
 - (3) Test speed = 0.05 in/min.
 - (4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
 - (5) Weight gain = 1.7721%

TABLE E.19

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Initial		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)	Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-7-5	72°F (WET)	1.001	0.1308	3,174	24.24	3.385	6,172	1/4/90	(1,3,4,5)	
BIL-GL-7-26	"	1.000	0.1345	3,186	23.70	3.276	8,945	"	(1,3,4,5)	
BIL-GL-7-48	"	1.003	0.1301	2,466	18.90	3.320	8,750	"	(1,3,4,5)	
BIL-GL-8-12	"	1.004	0.1422	2,991	20.94	3.335	4,570	"	(1,3,4,6)	
BIL-GL-8-41	"	1.004	0.1415	2,763	19.44	3.232	8,480	"	(1,3,4,6)	
Average					21.44	3.310	7,384			
Std. Dev.					2.43	0.058	1,929			

Test : IITRI Compression; ASTM-D3410 Fiber Orientation: Fill
 Material : EA-9396 A/B; 7781 Glass Batch #1 Task #5 Tested By: TB

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
- (5) Weight gain = 1.4829%
- (6) Weight gain = 2.1793%

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)
167.1	23.34	23.34	6,172
163.4	22.59	22.59	8,945
130.3	22.89	22.89	8,750
144.4	23.00	23.00	4,570
134.0	22.29	22.29	8,480
Average	147.9	22.82	7,384
Std. Dev.	16.8	0.40	1,929

TABLE E.20

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) WET

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Fill		
Material :		EA-9396 A/B; 7781 Glass		Tested By:		RG		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-10(R)-5	72°F (WET)	1.003	0.1360	3,137	23.00	3,490	1/9/90	(1,3,4,5)
BIL-GL-10(R)-12	"	0.992	0.1390	3,821	27.71	4,568	"	(1,3,4,5)
BIL-GL-10(R)-31	"	1.001	0.1370	3,394	24.75	3,261	"	(1,3,4,5)
BIL-GL-10(R)-38	"	1.006	0.1380	3,638	26.20	3,355	"	(1,3,4,5)
BIL-GL-10(R)-42	"	1.005	0.1370	3,681	26.74	3,405	"	(1,3,4,5)
Average					25.68	3,616		8,214
Std. Dev.					1.84	0.539		815

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
- (5) Weight gain = 1.7721%

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial
			Tangent Modulus (GPa)
158.6	24.06	9,307	
191.1	31.50	7,314	
170.6	22.49	7,949	
180.7	23.13	8,789	
184.3	23.47	7,710	
Average			24.93
Std. Dev.			3.71

TABLE E.21
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) WET

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Fill			
Material :		EA-9396 A/B; 7781 Glass		Batch #1		Task #5			
				Ultimate		Tested By:			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Compressive Strength (Ksi.)	Tangent Modulus (Msi.)	Ultimate Strain ($\mu\text{in/in}$)	Date Tested	Remarks
BIL-GL-7-6	200°F (WET)	1.001	0.1335	1,917	14.34	3.160	4,609	12/4/89	(3,4,5)
BIL-GL-7-27	"	0.999	0.1333	1,978	14.85	3.373	4,326	"	(3,4,5)
BIL-GL-8-13	"	1.002	0.1376	1,697	12.30	3.585	3,896	"	(3,4,6)
BIL-GL-8-42	"	1.002	0.1401	1,953	13.91	2.827	5,140	"	(3,4,6)
				Average	13.85	3.236	4,493		
				Std. Dev.	1.10	0.323	521		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
- (5) Weight gain = 1.6563%
- (6) Weight gain = 2.0359%

SI Conversion			
Ultimate		Initial	
Compressive Strength (MPa)	Tangent Modulus (GPa)	Compressive Strength (MPa)	Tangent Modulus (GPa)
98.9	21.79	22.31	2.23
102.4	23.25	4,493	521
84.8	24.72		
95.9	19.49		
Average	95.5		
Std. Dev.	7.6		

TABLE E.22

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-9-6	200°F (WET)	1.003	0.1384	1,721	12.39	2.544	12/4/89	(1,3,4,5)
BIL-GL-9-13	"	1.004	0.1392	1,721	12.31	2.806	"	(1,3,4,5)
BIL-GL-9-32	"	1.003	0.1421	1,953	13.70	3.330	"	(1,3,4,5)
BIL-GL-9-39	"	1.005	0.1405	1,672	11.84	3.017	"	(1,3,4,5)
BIL-GL-9-33	"	1.002	0.1420	2,283	16.04	2.316	1/18/90	(1,3,4,5)
Average					13.26	2.803		4,809
Std. Dev.					1.70	0.396		1,335

Test : IITRI Compression; ASTM-D3410
 Material : EA-9396 A/B; 7781 Glass

Batch #2 : Task #5 : Fiber Orientation: Fill
 Tested By: TB

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 143 days..
- (5) Weight gain = 1.9580%

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	
85.5	17.54	5,352	
84.9	19.35	4,268	
94.4	22.96	3,838	
81.7	20.81	3,691	
110.6	15.97	6,895	
Average	19.32	4,809	
Std. Dev.	2.73	1,335	

TABLE E.23
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) WET

Test :		IITRI Compression: ASTM-D3410				Fiber Orientation:		Fill
Material :		Batch #2	Task #5	Tested By:		TB		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GL-9-5	200°F (WET)	1.001	0.1362	1,850	13.56	2.979	12/5/89	(3,4,5,6)
BIL-GL-9-12	"	1.002	0.1358	1,721	12.65	2.862	"	(3,4,5,6)
BIL-GL-9-31	"	1.003	0.1404	1,660	11.80	3.606	"	(3,4,5,6)
BIL-GL-9-38	"	1.005	0.1395	1,782	12.72	2.958	"	(3,4,5,6)
BIL-GL-9-42	"	1.002	0.1400	1,863	13.28	2.897	"	(3,4,5,6)
Average				12.80	3.060	4,156		
Std. Dev.				0.68	0.308	836		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 143 days.
- (5) Weight gain = 2.3254%
- (6) These specimens were supposed to have been tested at 72°F(Wet) condition. They were inadvertently tested at 200°F(Wet).

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Ultimate Strain (µm/cm)	Ultimate Strain
93.5	20.54	3,620	4,156
87.2	19.73	4,189	836
81.3	24.86	3,320	
87.7	20.39	5,500	
91.6	19.98	4,150	
Average		88.3	4,156
Std. Dev.		4.1	836

TABLE E.24

**INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) WET**

Test :		ASTM-D3410				Fiber Orientation:		Fill	
Material :		Batch #3	Task #5	Tested By:		TB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load		Ultimate Strain		Date Tested	Remarks
				(lbs.)	(Ksi.)	(µin/in)	(µin/in)		
		Initial Tangent Modulus (Msi.)		Initial Tangent Modulus (GPa)		Ultimate Strain (µcm/cm)			
BIL-GL-10(R)-6	200°F (WET)	1.003	0.1370	2,515	18.30	3,673	4,238	1/9/90	(1,3,4,5)
BIL-GL-10(R)-32	"	1.001	0.1390	2,515	18.07	3,915	2,881	"	(1,3,4,5)
BIL-GL-10(R)-33	"	1.005	0.1380	2,234	16.11	2,767	5,801	"	(1,3,4,5)
BIL-GL-10(R)-39	"	1.006	0.1400	2,393	16.99	2,736	5,986	"	(1,3,4,5)
				Average	17.37	3,273	4,727		
				Std. Dev.	1.02	0.610	1,459		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 68 days.
- (5) Weight gain = 1.7721%

		SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	
		126.2	25.33
124.6	26.99	5,801	5,986
111.1	19.08	4,727	1,459
117.1	18.86		
Average	119.7	22.57	4,727
Std. Dev.	7.0	4.21	1,459

TABLE E.25
INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) DRY

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		
Material :		Batch #1	Task #4	Tested By:		Warp		
EA-9396 A/B; W133 Graphite				TB		TB		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-14-22	72°F (DRY)	1.003	0.1905	14,392	75.34	8.388	11/14/89	(1,3)
BIL-GR-14-24	"	1.004	0.1817	10,300	56.44	8.289	"	(1,3)
BIL-GR-14-25	"	1.003	0.1908	12,830	67.02	6.333	"	(1,3)
Average					66.27	7.670		9.627
Std. Dev.					9.47	1.159		2.860

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Tangent Modulus (GPa)	Ultimate Strain (μcm/cm)
519.5	57.84	57.84	8,720
389.2	57.15	57.15	7,330
462.1	43.67	43.67	12,830
Average		52.88	9.627
Std. Dev.		7.99	2.860

TABLE E.26
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) DRY

Test : IITRI Compression: ASTM-D3410										Fiber Orientation: Warp
Material : EA-9396 A/B; W133 Graphite										TB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks	Tested By:	
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)			Strain (µin/in)	TB
BIL-GR-15-17	72°F (DRY)	1.001	0.1790	13,288	74.16	8.441	11/15/89	(1,3)		
BIL-GR-15-19	"	1.002	0.1800	14,163	78.52	9.363	"	(1,3)		
BIL-GR-15-22	"	1.003	0.1840	12,263	66.44	8.399	"	(1,3)		
BIL-GR-15-24	"	1.002	0.1830	13,363	72.87	7.226	"	(1,3)		
BIL-GR-15-25	"	1.003	0.1770	12,122	68.28	10.245	"	(1,3)		
Average					72.06	8.735		8,062		
Std. Dev.					4.81	1.135		1,534		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
	Ultimate		Ultimate Strain (µcm/cm)
	Compressive Strength (MPa)	Tangent Modulus (GPa)	
	511.3	58.20	10,580
	541.4	64.56	8,330
	458.1	57.91	7,150
	502.5	49.82	7,580
	470.8	70.64	6,670
Average	496.8	60.23	8,062
Std. Dev.	33.2	7.82	1,534

TABLE E.27

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) DRY

Test :		IITRI Compression: ASTM-D3410			Fiber Orientation:				
Material :		EA-9396 A/B; W133 Graphite		TB					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Date Tested	Remarks		
				Maximum Load (lbs.)	Compressive Strength (Ksi.)			Initial Tangent Modulus (Msi.)	Ultimate Strain (μ in/in)
BIL-GR-16-17	72°F (DRY)	1.001	0.1810	12,183	67.24	7.927	9,380	11/15/89	(1,3)
BIL-GR-16-19	"	1.001	0.1830	13,425	73.29	10.236	7,680	"	(1,3)
BIL-GR-16-22	"	1.001	0.1850	12,475	67.37	8.843	6,800	"	(1,3)
BIL-GR-16-24	"	1.002	0.1820	13,063	71.63	6.154	14,268+	"	(1,3)
				Average	69.88	8.290	9,532+		
				Std. Dev.	3.05	1.711	3,334+		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)
463.6	54.66
505.3	70.57
454.5	60.97
493.9	42.43
Average	57.16
Std. Dev.	11.80
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)
463.6	54.66
505.3	70.57
454.5	60.97
493.9	42.43
Average	57.16
Std. Dev.	11.80

TABLE E.28

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 1, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Initial		Date Tested	Remarks
					Compressive Strength (Ksi.)	Compressive Strength (Msi.)	Tangent Modulus (Msi.)	Tangent Modulus (µin/in)		
BIL-GR-14-18	72°F (WET)	0.994	0.1867	11,163	60.17	8.008	6,570	1/12/90	(1,3,4,5)	
BIL-GR-14-21	"	1.001	0.1900	12,450	65.43	6.660	12,285	"	(1,3,4,5)	
BIL-GR-14-23	"	0.998	0.1914	8,081	42.30	7.438	5,762	"	(1,3,4,5)	
BIL-GR-14-26	"	1.006	0.1854	10,852	58.20	8.117	7,246	"	(1,3,4,5)	
BIL-GR-14-28	"	1.003	0.1881	11,600	61.47	7.286	9,700	"	(1,3,4,5)	
Average					57.51	7.502	8,313			
Std. Dev.					8.91	0.590	2,664			

Test : !ITRI Compression; ASTM-D3410
 Material : EA-9396 A/B; W133 Graphite
 Fiber Orientation: Warp
 Tested By: TB

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
- (5) Weight gain = 2.4270%

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial Tangent Modulus (GPa)
414.9	55.21	6,570	51.72
451.2	45.92	12,285	4.07
291.6	51.28	5,762	
401.3	55.97	7,246	
423.8	50.24	9,700	
396.5	51.72	8,313	
61.4	4.07	2,664	
Average			
Std. Dev.			

TABLE E.29

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 2, 22°C (72°F) WET

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Warp		
Material :		EA-9396 A/B; W133 Graphite		Batch #2 Task #4		Tested By: RG		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-15-18	72°F (WET)	1.001	0.1790	9,985	55.73	9.178	1/12/90	(1,3,4,5)
BIL-GR-15-21	"	1.002	0.1820	9,387	51.48	9.142	"	(1,3,4,5)
BIL-GR-15-23	"	1.003	0.1840	9,705	52.58	6.442	"	(1,3,4,5)
BIL-GR-15-26	"	1.002	0.1760	10,193	57.80	7.811	"	(1,3,4,5)
BIL-GR-15-28	"	1.003	0.1770	8,997	50.68	7.216	"	(1,3,4,5)
				Average	53.65	7.958		7,397
				Std. Dev.	3.01	1.200		1,794

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
- (5) Weight gain = 2.2206%

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial
			Tangent Modulus (GPa)
384.2	63.29	5,889	
354.9	63.03	6,270	
362.6	44.42	10,420	
398.5	53.86	6,963	
349.4	49.75	7,441	
Average	54.87	7,397	
Std. Dev.	8.27	1,794	

TABLE E.30
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, WARP DIRECTION, BATCH 3, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Initial		Date Tested	Remarks
					Compressive Strength (Ksi.)	Compressive Strength (Msi.)	Tangent Modulus (Msi.)	Strain (µin/in)		
BIL-GR-16-18	72°F (WET)	1.002	0.1830	9,180	50.06	6.051	9,111	1/4/90	(1,3,4,5)	
BIL-GR-16-21	"	1.002	0.1860	9,802	52.60	6.661	10,300	"	(1,3,4,5)	
BIL-GR-16-23	"	1.002	0.1840	9,595	52.04	8.848	6,084	"	(1,3,4,5)	
BIL-GR-16-26	"	1.001	0.1830	8,630	47.11	9.209	5,410	"	(1,3,4,5)	
BIL-GR-16-28	"	1.002	0.1790	9,009	50.23	7.507	8,130	"	(1,3,4,5)	
Average					50.41	7.655	7,807			
Std. Dev.					2.15	1.362	2,045			

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Weight Gain (%)
345.2	41.72	9,111	
362.6	45.93	10,300	
358.8	61.01	6,084	
324.8	63.50	5,410	
346.3	51.76	8,130	
Average	52.78	7,807	
Std. Dev.	9.39	2,045	

- Remarks:
- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
 - (2) Specimen failed outside gage section.
 - (3) Test speed = 0.05 in/min.
 - (4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
 - (5) Weight gain = 2.1824%

TABLE E.31
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) DRY

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		Fill	
Material :		EA-9396 A/B; W133 Graphite		Batch #1	Task #5	Tested By:		BH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
BIL-GR-13-1	-65°F (DRY)	0.998	0.1680	13,123	78.27	8.946	8,400	11/6/89	(1,3)
BIL-GR-13-22	"	1.001	0.1830	15,963	87.14	11.191	8,860	"	(1,3)
BIL-GR-13-44	"	1.000	0.1810	16,513	91.23	8.910	12,040	11/13/89	(1,3)
BIL-GR-14-8	"	1.003	0.1804	15,763	87.14	8.949	10,670	11/6/89	(1,3)
BIL-GR-14-37	"	1.000	0.1822	15,650	85.87			"	(1,3,4)
Average					85.93	9.499	9,993		
Std. Dev.					4.74	1.128	1,680		
SI Conversion									
Ultimate Compressive Strength (MPa)					539.7	61.69	8,400		
					600.8	77.16	8,860		
					629.0	61.44	12,040		
					600.8	61.70	10,670		
592.1									
Average					592.5	65.50	9,993		
Std. Dev.					32.7	7.78	1,680		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.

TABLE E.32

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) DRY

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		
Material :		Batch #2	Task #5	Tested By:		Fill	BH	
		EA-9396 A/B; W133 Graphite				BH		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-15-1	-65°F (DRY)	1.000	0.1724	12,338	71.53	8.806	10/31/89	(1,3)
BIL-GR-15-15	"	1.004	0.1766	12,513	70.60	7.899	11/2/89	(1,3)
BIL-GR-15-34	"	1.000	0.1790	15,250	85.21	7.728	"	(1,3)
BIL-GR-15-43	"	1.007	0.1738	13,725	78.44	8.109	10/31/89	(1,3)
BIL-GR-15-8	"	1.004	0.1724	13,725	79.28		"	(1,3,4)
				Average	77.01	8.135		11,615
				Std. Dev.	6.03	0.473		2,264

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	SI Conversion
			Initial Tangent Modulus (GPa)
493.2	60.72	8,230	
486.8	54.46	12,490	
587.5	53.29	12,850	
540.9	55.91	12,891	
546.6			
Average	56.09	11,615	
Std. Dev.	3.26	2,264	

TABLE E.33

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) DRY

Test :		IITRI Compression: ASTM-D3410			Fiber Orientation: Fill				
Material :		Batch #3	Task #5	Tested By: BH					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
BIL-GR-16-1	-65°F (DRY)	1.001	0.1732	14,771	85.18	8.255	11,934	11/6/89	(1,3)
BIL-GR-16-8	"	1.001	0.1821	16,463	90.36	7.547	13,400	"	(1,3)
BIL-GR-16-15	"	1.004	0.1796	16,438	91.14	7.381	13,590	"	(1,3)
BIL-GR-16-34	"	1.006	0.1783	16,126	89.95	8.367	12,300	"	(1,3)
BIL-GR-16-43	"	1.003	0.1754	13,367	75.97	7.886	14,014	"	(1,3)
				Average	86.52	7.887	13,047		
				Std. Dev.	6.34	0.429	888		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

		SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial Tangent Modulus (GPa)
587.3	56.92	11,934	56.92
623.0	52.04	13,400	52.04
628.4	50.89	13,590	50.89
620.2	57.69	12,300	57.69
523.8	54.37	14,014	54.37
Average	596.5	13,047	54.38
Std. Dev.	43.7	888	2.96

TABLE E.34

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-13-2	72°F (DRY)	0.998	0.1720	10,088	58.77	8.229	10/26/89	(1,3,4)
BIL-GR-13-23	"	1.001	0.1840	9,838	53.41	5.938	"	(1,3)
BIL-GR-13-45	"	1.001	0.1824	11,694	64.02	8.361	12/15/89	(1,3)
BIL-GR-14-9	"	1.002	0.1802	10,675	59.13	7.097	"	(1,3)
BIL-GR-14-38	"	1.001	0.1824	11,888	65.08	7.733	11/2/89	(1,3)
Average					60.08	7.471		7,919
Std. Dev.					4.68	0.990		872

Test : IITRI Compression; ASTM-D3410
 Material : EA-9396 A/B; W133 Graphite
 Batch #1 Task #5
 Fiber Orientation: Fill
 Tested By: BH

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Tabs debonded.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial Tangent Modulus (Msi.)
405.2	56.74	8.100	8.229
368.3	40.94	8.380	5.938
441.4	57.65	6.377	8.361
407.7	48.93	8.450	7.097
448.7	53.32	8.290	7.733
Average	414.3	51.52	7.471
Std. Dev.	32.3	6.83	0.990
		7,919	
		872	

TABLE E.35

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 22°C (72°F) DRY

Test :		IITRI Compression: ASTM-D3410				Fiber Orientation:			
Material :		Batch #2	Task #5	Tested By:		Fill			
		EA-9396 A/B: W133 Graphite				BH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain ($\mu\text{in/in}$)	Date Tested	Remarks
BIL-GR-15-2	72°F (DRY)	1.003	0.1753	11,388	64.79	9.210	7,640	10/31/89	(1,3)
BIL-GR-15-9	"	1.002	0.1783	10,488	58.70	8.500	6,580	"	(1,3)
BIL-GR-15-35	"	1.000	0.1772	11,013	62.15	7.443	10,590	"	(1,3)
BIL-GR-15-44	"	1.007	0.1710	9,000	52.29	8.133	7,780	"	(1,3)
				Average	59.48	8.322	8,148		
				Std. Dev.	5.41	0.737	1,714		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain ($\mu\text{cm/cm}$)	
446.7	63.50	7,640	
404.7	58.61	6,580	
428.5	51.32	10,590	
360.5	56.08	7,780	
Average	57.4	8,148	
Std. Dev.	5.1	1,714	

TABLE E.36
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) DRY

Test :		ASTM-D3410				Fiber Orientation:		Fill		
Material :		EA-9396 A/B; W133 Graphite	Batch #3	Task #5	Tested By:		TB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)				
BIL-GR-16-2	72°F (DRY)	1.002	0.1767	11,425	64.56	7.707	13,926	11/13/89	(1,3)	
BIL-GR-16-9	"	1.004	0.1821	11,275	61.66	6.905	10,300	"	(1,3)	
BIL-GR-16-16	"	1.004	0.1798	11,838	65.59	8.588	7,270	"	(1,3)	
BIL-GR-16-35	"	1.006	0.1810	10,632	58.37	7.720	5,580	"	(1,3)	
BIL-GR-16-44	"	1.003	0.1735	11,304	64.98	8.489	6,416	12/15/89	(1,3)	
Average					63.03	7.882	8,698			
Std. Dev.					3.01	0.685	3,423			

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Ultimate Strain (µcm/cm)	Tangent Modulus (GPa)
445.1	53.14	13,926	7.707
425.2	47.61	10,300	6.905
452.2	59.21	7,270	8.588
402.5	53.23	5,580	7.720
448.0	58.53	6,416	8.489
Average		8,698	7.882
Std. Dev.		3,423	0.685

TABLE E.37
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) DRY

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		Fill	
Material :		Batch #1	Task #5	Tested By:		RG			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
BIL-GR-13-3	200°F (DRY)	0.997	0.1760	7,363	41.96	8.691	4,830	11/15/89	(1,3,4)
BIL-GR-13-24	"	0.998	0.1840	8,413	45.81	8.237	5,254	"	(1,3)
BIL-GR-13-46	"	1.001	0.1790	7,800	43.53	8.957	4,350	"	(1,3)
BIL-GR-14-10	"	1.002	0.1804	7,642	42.28	7.180	7,120	"	(1,3)
BIL-GR-14-39	"	1.001	0.1799	7,947	44.13	7.496	5,156	11/16/89	(1,3)
				Average	43.54	8.112	5,342		
				Std. Dev.	1.55	0.760	1,055		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Tabs debonded.

SI Conversion			
Ultimate		Initial	
Compressive Strength (MPa)	Tangent Modulus (GPa)	Compressive Strength (µcm/cm)	Tangent Modulus (µcm/cm)
289.3	59.92	4,830	8.691
315.9	56.79	5,254	8.237
300.2	61.76	4,350	8.957
291.5	49.51	7,120	7.180
304.3	51.69	5,156	7.496
Average	300.2	5,342	8.112
Std. Dev.	10.7	1,055	0.760

TABLE E.38

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) DRY

Test :	IITRI Compression; ASTM-D3410		Batch #2		Task #5	Fiber Orientation:		Fill	
Material :	EA-9396 A/B; W133 Graphite					Tested By:		TB	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
BIL-GR-15-3	200°F (DRY)	0.998	0.1772	7,141	40.40	9,584	3,779	11/16/89	(1,3)
BIL-GR-15-10	"	1.002	0.1783	7,031	39.34	6,461	5,957	"	(1,3)
BIL-GR-15-29	"	1.002	0.1697	5,975	35.15	7,905	4,200	"	(1,3)
BIL-GR-15-36	"	1.000	0.1769	6,363	35.96	9,446	3,590	"	(1,3)
BIL-GR-15-40	"	1.006	0.1736	6,213	35.59	7,447	5,030	"	(1,3)
Average					37.29	8.164	4,511		
Std. Dev.					2.40	1.331	980		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	
278.5	65.94	3,779	
271.3	44.55	5,957	
242.4	54.50	4,200	
248.0	65.13	3,590	
245.4	51.35	5,030	
Average	257.1	56.29	4,511
Std. Dev.	16.5	9.18	980

TABLE E.39

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) DRY

Test :		ASTM-D3410				Fiber Orientation:		Fill
Material :		EA-9396 A/B; W133 Graphite	Batch #3	Task #5	Tested By:		RG	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate	Initial	Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-16-3	200°F (DRY)	1.001	0.1797	7,471	41.55	7.636	11/16/89	(1,3)
BIL-GR-16-10	"	1.004	0.1804	7,738	42.70	7.102	"	(1,3)
BIL-GR-16-29	"	1.006	0.1706	6,625	38.62	7.778	"	(1,3)
BIL-GR-16-36	"	1.007	0.1776	7,166	40.03	7.612	"	(1,3)
BIL-GR-16-40	"	1.006	0.1774	7,043	39.47	7.741	"	(1,3)
Average					40.48	7.574		6,217
Std. Dev.					1.64	0.273		853

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.

SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)
286.5	52.65
294.4	48.97
266.3	53.63
276.0	52.49
272.2	53.38
Average 279.1	52.22
Std. Dev. 11.3	1.88
	Ultimate Strain (µcm/cm)
	7,610
	5,566
	6,220
	6,210
	5,479
	6,217
	853

TABLE E.40

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, -54°C (-65°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Initial		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)	Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-13-4	-65°F (WET)	0.996	0.1750	12,268	70.38	8.831	8.831	8.311	1/16/90	(1,3,4,5,6)
BIL-GR-13-25	"	0.994	0.1840	15,735	86.03	9.315	9.315	9,600	"	(1,3,5,6)
BIL-GR-13-47	"	1.000	0.1760	13,538	76.92	10.211	10.211	7,500	"	(1,3,5,6)
BIL-GR-14-11	"	1.002	0.1809	13,538	74.66	8.401	8.401	9,189	"	(1,3,5,7)
BIL-GR-14-40	"	1.001	0.1767	13,806	78.09	9.139	9.139	14,072	"	(1,3,5,7)
Average					78.92	9.179	9.179	10,090		
Std. Dev.					4.95	0.673	0.673	2,806		

Test : IITRI Compression; ASTM-D3410 Fiber Orientation: Fill
 Material : EA-9396 A/B; W133 Graphite Batch #1 Task #5 Tested By: RG

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Tabs debonded. Not included in average strength or ultimate strain.
- (5) Specimens aged @ 140°F/95-100% R.H. for 99 days.
- (6) Weight gain = 2.3016%
- (7) Weight gain = 2.4270%

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)
485.3	60.89	60.89	8,311
593.2	64.23	64.23	9,600
530.4	70.40	70.40	7,500
514.7	57.93	57.93	9,189
538.4	63.01	63.01	14,072
Average	544.2	63.29	10,090
Std. Dev.	34.1	4.64	2,806

TABLE E.41
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, -54°C (-65°F) WET

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:				
Material :		EA-9396 A/B; W133 Graphite		Batch #2		Task #5		Tested By:		Fill
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain ($\mu\text{in/in}$)	Date Tested	Remarks	
BIL-GR-15-4	-65°F (WET)	1.004	0.1781	13,074	73.10	8.390	10,039	11/16/89	(1,3,4,5)	
BIL-GR-15-11	"	1.004	0.1791	14,612	81.27	8.426	10,273	"	(1,3,4,5)	
BIL-GR-15-30	"	1.004	0.1732	12,940	74.45	8.671	11,729	"	(1,3,4,5)	
BIL-GR-15-37	"	1.007	0.1756	13,330	75.38	8.635	8,486	"	(1,3,4,5)	
BIL-GR-15-41	"	1.006	0.1717	11,853	68.59	8.897	11,853	"	(1,3,4,5)	
Average					74.56	8.604	10,476			
Std. Dev.					4.57	0.206	1,383			

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
- (5) Weight gain = 2.2206%

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain ($\mu\text{cm/cm}$)	
504.0	57.85	10,039	
560.3	58.09	10,273	
513.3	59.79	11,729	
519.7	59.54	8,486	
473.0	61.35	11,853	
Average	59.32	10,476	
Std. Dev.	1.42	1,383	

TABLE E.42

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, -54°C (-65°F) WET

Test :		IITRI Compression: ASTM-D3410			Fiber Orientation:			
Material :		EA-9396 A/B; W133 Graphite	Batch #3	Task #5	Tested By: BH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-16-4	-65°F (WET)	1.001	0.1819	15,283	83.97	9.062	1/11/90	(1,3,4,5)
BIL-GR-16-11	"	1.006	0.1806	14,356	79.02	8.186	"	(1,3,4,5)
BIL-GR-16-30	"	1.006	0.1755	11,938	67.61	8.247	"	(1,3,4,5)
BIL-GR-16-37	"	1.004	0.1757	14,941	84.73	8.394	"	(1,3,4,5)
BIL-GR-16-41	"	1.005	0.1759	12,756	72.16	9.129	"	(1,3,4,5)
Average					77.50	8.604		9.337
Std. Dev.					7.46	0.456		2.256

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 99 days.
- (5) Weight gain = 2.1824%

SI Conversion			
Ultimate Compressive Strength (MPa)	Tangent Modulus (GPa)	Initial	
		Ultimate Strain ($\mu\text{cm/cm}$)	Ultimate Strain ($\mu\text{cm/cm}$)
579.0	62.48	9.336	9.337
544.9	56.44	9.854	9.854
466.2	56.87	7.720	7.720
584.2	57.88	12.315	12.315
497.5	62.94	7.461	7.461
Average		59.32	59.32
Std. Dev.		3.14	3.14

TABLE E.43
INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 22°C (72°F) WET

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		Fill			
Material :		Batch #1	Task #5	Tested By:		TB					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks	
					Compressive Strength (Ksi.)	Strength					
BIL-GR-13-5	72°F (WET)	0.999	0.1770	9,650	54.57	54.57	9.225	5,350	12/6/89	(1,3,4,5)	
BIL-GR-13-26	"	0.996	0.1860	11,100	59.92	59.92	8.805	7,340	"	(1,3,4,5)	
BIL-GR-13-48	"	0.998	0.1760	8,275	47.11	47.11	9.109	5,230	"	(1,3,4,5)	
BIL-GR-14-12	"	1.002	0.1774	9,188	51.70	51.70	8.934	5,870	"	(1,3,4,6)	
BIL-GR-14-41	"	1.001	0.1761	9,167	52.00	52.00	8.515	5,674	"	(1,3,4,6)	
Average					53.06	53.06	8.918	5,893			
Std. Dev.					4.68	4.68	0.277	848			

- Remarks:
- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
 - (2) Specimen failed outside gage section.
 - (3) Test speed = 0.05 in/min.
 - (4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
 - (5) Weight gain = 2.2390%
 - (6) Weight gain = 2.0577%

SI Conversion			
Ultimate		Initial	
Compressive Strength (MPa)	Tangent Modulus (GPa)	Compressive Strength (MPa)	Tangent Modulus (GPa)
376.3	63.61	376.3	63.61
413.1	60.71	413.1	60.71
324.8	62.81	324.8	62.81
356.5	61.60	356.5	61.60
358.5	58.71	358.5	58.71
Average		Average	
365.9		61.49	
Std. Dev. 32.3		Std. Dev. 1.91	
Ultimate Strain (µcm/cm)		Ultimate Strain (µcm/cm)	
5,350		5,350	
7,340		7,340	
5,230		5,230	
5,870		5,870	
5,674		5,674	
Average		Average	
5,893		5,893	
Std. Dev. 848		Std. Dev. 848	

TABLE E.44
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 22°C (72°F) WET

Test :		ASTM-D3410		Fiber Orientation:		Fill			
Material :		W133 Graphite		Tested By:		TB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Date Tested	Remarks		
				Maximum Load (lbs.)	Compressive Strength (Ksi.)			Tangent Modulus (Msi.)	Ultimate Strain (µin/in)
BIL-GR-15-5	72°F (WET)	1.005	0.1797	8,716	48.25	6,563	6,738	12/6/89	(1,3,4,5)
BIL-GR-15-12	"	1.004	0.1755	8,850	50.25	7,389	6,390	"	(1,3,4,5)
BIL-GR-15-31	"	1.003	0.1757	8,911	50.55	7,025	12,900	"	(1,3,4,5)
BIL-GR-15-38	"	1.007	0.1749	8,801	49.95	8,432	5,664	"	(1,3,4,5)
BIL-GR-15-42	"	1.007	0.1715	8,008	46.36	9,337	5,137	12/11/89	(1,3,4,5)
Average					49.07	7,749	7,366		
Std. Dev.					1.76	1,123	3,156		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
- (5) Weight gain = 1.9091%

SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)
332.7	45.26
346.5	50.95
348.5	48.44
344.4	58.14
319.6	64.38
Average 338.4	53.43
Std. Dev. 12.1	7.74
Ultimate Compressive Strength (MPa)	Ultimate Strain (µcm/cm)
332.7	6,738
346.5	6,390
348.5	12,900
344.4	5,664
319.6	5,137
Average 338.4	7,366
Std. Dev. 12.1	3,156

TABLE E.45

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 22°C (72°F) WET

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:			
Material :		Batch #3	Task #5	Tested By:		TB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs)	Ultimate Compressive Strength (Ksi.)	Initial Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Date Tested	Remarks
BIL-GR-16-5	72°F (WET)	1.001	0.1788	9,338	52.19	7.488	6,826	12/11/89	(1b,3,4,5)
BIL-GR-16-12	"	1.005	0.1812	9,570	52.55	7.587	6,299	"	(1b,3,4,5)
BIL-GR-16-31	"	1.007	0.1779	8,179	45.66	8.043	8,350	"	(1b,3,4,5)
BIL-GR-16-38	"	1.005	0.1794	9,937	55.13	8.590	7,334	"	(1b,3,4,5)
BIL-GR-16-42	"	1.005	0.1762	7,861	44.39	8.538	4,961	"	(1a,3,4,5)
				Average	49.98	8.049	6,754		
				Std. Dev.	4.69	0.515	1,256		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- (1a) Shear fracture
- (1b) Shear crimping
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
- (5) Weight gain = 2.0033%

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	
359.8	51.63	6,826	
362.3	52.31	6,299	
314.8	55.46	8,350	
380.1	59.23	7,334	
306.1	58.87	4,961	
Average	344.6	55.50	6,754
Std. Dev.	32.3	3.55	1,256

TABLE E.46

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 1, 93°C (200°F) WET

Test :		IITRI Compressor; ASTM-D3410		Fiber Orientation:		Fill		
Material :		EA-9396 A/B; W133 Graphite		Tested By:		RG		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-13-6	200°F (WET)	1.000	0.1780	3,516	19.75	10.689	1,934	11/29/89 (3,4,5,7,8)
BIL-GR-13-43	"	0.998	0.1840	4,944	26.92	9.817	2,959	11/30/89 (1b,3,4,5,8)
BIL-GR-14-13	"	1.003	0.1774	4,480	25.18	8.718	2,520	12/1/89 (1a,3,4,6,8)
BIL-GR-14-42	"	1.002	0.1768	4,541	25.14	9.580	2,529	11/30/89 (1a,3,4,6,8)

Average 24.37 9.701 2,485
 Std. Dev. 3.17 0.810 421

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- (1a) Shear fracture
- (1b) Shear crimping
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
- (5) Weight gain = 2.2390%
- (6) Weight gain = 2.0377%
- (7) Tabs debonded.
- (8) Tested without tabs.

		SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Initial
			Tangent Modulus (GPa)
136.2	73.70	1,934	
185.6	67.68	2,959	
173.6	60.11	2,520	
176.8	66.05	2,529	
Average	67.16	2,485	
Std. Dev.	6.81	421	

TABLE E.47

INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS, GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 2, 93°C (200°F) WET

Test :	IITRI Compression; ASTM-D3410			Fiber Orientation: Fill		
Material :	EA-9396 A/B; W133 Graphite	Batch #2	Task #5	Tested By: RG		

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-15-6	200°F (WET)	1.005	0.1791	4,919	27.32	7.701	11/30/89	(1b,3,4,5,6)
BIL-GR-15-13	"	1.000	0.1739	5,825	33.50	7.365	12/4/89	(1a,3,4,5,6)
BIL-GR-15-32	"	1.003	0.1765	3,833	21.66	9.152	11/30/89	(1a,3,4,5,6)
BIL-GR-15-33	"	1.000	0.1787	5,611	31.40	8.128	12/4/89	(1a,3,4,5,6)
BIL-GR-15-39	"	1.007	0.1742	4,236	24.15	8.386	11/30/89	(1a,3,4,5,6)
Average					27.61	8.146		3,783
Std. Dev.					4.91	0.685		1,064

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- (1a) Shear fracture
- (1b) Shear crimping
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
- (5) Weight gain = 1.9091%
- (6) Tested without tabs.

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	SI Conversion
			Initial Tangent Modulus (GPa)
188.4	53.10	3,262	
231.0	50.78	5,127	
149.3	63.10	2,295	
216.5	56.04	4,023	
166.5	57.82	4,210	
Average			190.3
Std. Dev.			33.9
			56.17
			4.73
			3,783
			1,064

TABLE E.48
 INDIVIDUAL SPECIMEN COMPRESSION TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, FILL DIRECTION, BATCH 3, 93°C (200°F) WET

Test :		IITRI Compression: ASTM-D3410				Fiber Orientation:		
Material :		EA-9396 A/B; W133 Graphite	Batch #3	Task #5	Tested By: RG			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
					Compressive Strength (Ksi.)	Tangent Modulus (Msi.)		
BIL-GR-16-6	200°F (WET)	1.002	0.1791	5,432	30.28	7.548	11/30/89	(1,3,4,5,7)
BIL-GR-16-13	"	1.005	0.1807	6,738	37.12	8.469	12/4/89	(1,3,4,5,7)
BIL-GR-16-32	"	1.005	0.1789	5,750	31.97	8.235	11/30/89	(1,3,4,5,7)
BIL-GR-16-39	"	1.005	0.1780	5,298	29.61	9.731	"	(1,3,4,5,6,7)
Average					32.24	8.495	3,950	
Std. Dev.					3.40	0.912	704	

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	SI Conversion
			Initial Tangent Modulus (GPa)
208.8	52.04	4,482	58.39
255.9	56.78	4,375	67.10
220.4	56.78	4,004	58.58
204.1	67.10	2,939	6.29
Average			222.3
Std. Dev.			23.4

- Remarks:
- (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
 - (2) Specimen failed outside gage section.
 - (3) Test speed = 0.05 in/min.
 - (4) Specimens aged @ 140°F/95-100% R.H. for 62 days.
 - (5) Weight gain = 2.0033%
 - (6) Tested without tabs.

APPENDIX F
INDIVIDUAL SPECIMEN $\pm 45^\circ$ TENSION/INPLANE SHEAR
PROPERTIES, BASELINE

The 36 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in inplane shear. A summary of these data was presented and discussed in Section 3.2.3.

TABLE F.1

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)		In-Plane Shear Modulus (Msi.)		Poisson's Ratio	Date Tested	Remarks
					Strength (Ksi.)	Modulus (Msi.)	Strength (Ksi.)	Modulus (Msi.)	Strength (Ksi.)	Modulus (Msi.)			
BIL-GL-18-T1	-65°F (DRY)	1.000	0.0699	2,842	40.68	2,956	20.34	1.058	0.397	8/17/89	(1,2,3,5)		
BIL-GL-18-T7	"	1.001	0.0673	2,375	35.25	3,185	17.63	1.085	0.468	8/16/89	(1,2,3,5)		
BIL-GL-18-T13	"	0.998	0.0665	1,964	29.59	3,267	14.80	1.140	0.433	"	(1,2,3,5)		
BIL-GL-19-T4	"	0.999	0.0640	1,862	29.12	2,871	14.56	1.041	0.378	8/17/89	(1,2,3,5)		
BIL-GL-19-T10	"	1.001	0.0710	1,857	26.13	2,779	13.06	0.981	0.417	"	(1,2,3,5)		
BIL-GL-19(R)-T4	"	1.003	0.0640	2,075	32.32	3,573	16.16	1.289	0.386	"	(1,2,3,5)		
BIL-GL-19(R)-T10	"	1.007	0.0720	2,920	40.29	2,633	20.15	0.912	0.444	8/16/89	(1,2,3,5)		
Average					33.34	3,038	16.67	1.072	0.418				
Std. Dev.					5.64	0.323	2.82	0.120	0.033				

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Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

Ultimate Tensile Strength (MPa)	SI Conversion		In-Plane Shear Modulus (GPa)
	Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)	
280.5	20.38	140.2	7.294
243.1	21.96	121.5	7.480
204.1	22.52	102.0	7.858
200.8	19.79	100.4	7.179
180.2	19.16	90.1	6.761
222.9	24.63	111.4	8.888
277.8	18.15	138.9	6.286
Average	20.94	114.9	7.392
Std. Dev.	2.23	19.4	0.831

TABLE F.2
INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	In-Plane		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Shear Strength (Ksi.)		In-Plane Shear Modulus (Msi.)	Shear Modulus (Msi.)			
BIL-GL-23(R)-X1	-65°F (DRY)	0.627	0.0616	1,395	36.12	18.06	2.818	1.031	0.366	0.366	3/15/90	(1,2,3,5)
BIL-GL-23(R)-X3	"	0.990	0.0636	1,759	27.93	13.97	2.547	0.904	0.408	0.408	"	(1,2,3,5)
BIL-GL-23(R)-X7	"	0.875	0.0635	1,831	32.97	16.48	2.561	0.901	0.421	0.421	"	(1,2,3,5)
BIL-GL-23(R)-16	"	0.999	0.0628	2,430	38.74	19.37	2.610	0.929	0.405	0.405	"	(1,2,3,5)
BIL-GL-20(R)-T4	"	0.996	0.0657	2,587	39.54	19.77	3.338	1.136	0.469	0.469	7/31/89	(1,2,3,5)
BIL-GL-20(R)-T10	"	0.997	0.0656	2,004	30.66	15.33	3.273	1.129	0.449	0.449	"	(1,2,3,5)
				Average	34.33	17.16	2.858	1.005	0.420	0.420		
				Std. Dev.	4.61	2.30	0.361	0.109	0.036	0.036		

SI Conversion					
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)	Average	Std. Dev.
249.1	19.43	124.5	7.112	118.3	6.931
192.6	17.56	96.3	6.236	15.9	0.755
227.3	17.66	113.7	6.214		
267.1	18.00	133.6	6.405		
272.6	23.01	136.3	7.834		
211.4	22.57	105.7	7.784		
236.7	19.70	118.3	6.931		
31.8	2.49	15.9	0.755		

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

TABLE F.3
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			In-Plane			Fiber Orientation: ±45°			Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Modulus (Msi.)	Ratio	Date Tested	In-Plane Shear Modulus (Msi.)	In-Plane Shear Modulus (Msi.)	
BIL-GL-24-T1	-65°F (DRY)	1.000	0.0662	2,246	33.93	2.970	16.96	0.396	1.064	8/17/89	(1,2,3,5)			
BIL-GL-24-T7	"	1.000	0.0693	2,211	31.90	2.647	15.95	0.376	0.962	"	(1,2,3,5)			
BIL-GL-24-T13	"	0.999	0.0705	1,945	27.61	2.762	13.81	0.416	0.975	"	(1,2,3,5)			
BIL-GL-21-T4	"	0.996	0.0676	2,725	40.46	3.388	20.23	0.457	1.163	"	(1,2,3,5)			
BIL-GL-21-T10	"	0.998	0.0703	2,374	33.84	2.458	16.92	0.341	0.917	8/18/89	(1,2,3,5)			
Average					33.55	2.845	16.77	0.397	1.016					
Std. Dev.					4.64	0.356	2.32	0.043	0.098					

Ultimate	SI Conversion		
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
233.9	20.48	117.0	7.337
220.0	18.25	110.0	6.632
190.4	19.04	95.2	6.724
279.0	23.36	139.5	8.018
233.3	16.95	116.7	6.320
Average	231.3	19.62	7.006
Std. Dev.	32.0	2.45	0.675

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

TABLE F.4

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Task #6		Fiber Orientation: ±45°		Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	
BIL-GL-18-T2	72°F (DRY)	1.002	0.0675	1,828	27.03	2,565	13.52	0.880	0.457	8/11/89	(1,2,3,5)
BIL-GL-18-T8	"	1.000	0.0670	1,729	25.80	2,683	12.90	0.928	0.445	"	(1,2,3,5)
BIL-GL-18-T14	"	0.998	0.0663	1,525	23.06	2,390	11.53	0.836	0.429	"	(1,2,3,5)
BIL-GL-19-T5	"	0.995	0.0640	1,204	18.91	2,645	9.45	0.876	0.510	8/16/89	(1,2,3,5)
BIL-GL-19-T11	"	1.001	0.0650	1,371	21.07	2,212	10.54	0.765	0.446	"	(1,2,3,5)
BIL-GL-19(R)-T5	"	1.003	0.0640	1,366	21.28	2,515	10.64	0.878	0.432	"	(1,2,3,5)
BIL-GL-19(R)-T11	"	1.008	0.0720	1,565	21.56		10.78	0.878	0.425	"	(1,2,3,5,6)
Average					22.67	2,502	11.34	0.861	0.449		
Std. Dev.					2.85	0.176	1.43	0.055	0.029		

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G = E/2(1 + \nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Incorrect load range; modulus calculations not included in averages.

Ultimate	SI Conversion			
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
186.4	17.68	93.2	6.068	
177.9	18.50	88.9	6.401	
159.0	16.48	79.5	5.765	
130.4	18.24	65.2	6.039	
145.3	15.25	72.6	5.273	
146.7	17.34	73.3	6.054	
148.7		74.3		
Average	156.3	17.25	78.2	5.933
Std. Dev.	19.7	1.21	9.8	0.381

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			In-Plane			Fiber Orientation: ±45°			Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Tested	Ratio	
BIL-GL-23(R)-1	72°F (DRY)	0.994	0.0625	1,365	21.97	2,068	10.98	0.742	0.394	2/22/90	(1,2,3,5)			
BIL-GL-23(R)-7	"	1.001	0.0651	1,537	23.59	2,208	11.79	0.746	0.480	"	(1,2,3,5)			
BIL-GL-23(R)-13	"	1.001	0.0617	1,344	21.75	2,101	10.88	0.784	0.340	"	(1,2,3,5)			
BIL-GL-23(R)-2	"	0.998	0.0648	1,415	21.88	1,829	10.94	0.664	0.377	"	(1,2,3,5)			
BIL-GL-23(R)-8	"	1.001	0.0643	1,601	24.89	1,817	12.44	0.625	0.454	"	(1,2,3,5)			
BIL-GL-23(R)-14	"	1.002	0.0623	1,396	22.38	2,268	11.19	0.817	0.388	"	(1,2,3,5)			
BIL-GL-23(R)-3	"	0.999	0.0657	1,488	22.67	1,800	11.34	0.674	0.336	"	(1,2,3,5)			
BIL-GL-23(R)-9	"	0.999	0.0642	1,542	24.06	1,953	12.03	0.652	0.498	"	(1,2,3,5)			
BIL-GL-23(R)-15	"	1.000	0.0614	1,552	25.27	2,230	12.64	0.800	0.394	"	(1,2,3,5)			
BIL-GL-20(R)-T5	"	0.995	0.0657	1,743	26.67	2,095	13.34	0.686	0.526	7/26/89	(1,2,3,5)			
BIL-GL-20(R)-T1	"	0.996	0.0655	1,475	22.59	2,412	11.30	0.765	0.577	"	(1,2,3,5)			
Average					23.43	2,071	11.71	0.723	0.433					
Std. Dev.					1.62	0.203	0.81	0.066	0.079					
SI Conversion														
Ultimate					Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)						
Average					161.5	14.26	75.7	5.113						
Std. Dev.					11.2	1.40	5.6	0.453						

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Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

TABLE F.6
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Test :		+45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°						
Material :		EA-9396 /JB; 7781 Glass		Tested By: TOB						
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi)	Shear Strength (Ksi.)				
BIL-GL-24-T2	72° (DRY)	1.000	0.0685	1,628	23.77	2.215	0.772	0.435	8/11/89	(1,2,3,5)
BIL-GL-24-T8	"	.000	0.0696	1,434	20.60	1.972	0.705	0.398	"	(1,2,3,5)
BIL-GL-24-T14	"	0.999	0.0706	1,379	19.56	1.922	0.669	0.437	"	(1,2,3,5)
BIL-GL-21-T5	"	0.998	0.0686	1,584	23.12	2.137	0.747	0.431	"	(1,2,3,5)
BIL-GL-21-T11	"	0.997	0.0721	1,756	24.42	1.802	0.667	0.351	"	(1,2,3,5)
Average				1,628	22.29	2.010	0.712	0.411		
Std. Dev.					2.11	0.166	0.047	0.037		

		SI Conversion			
Ultimate	In-Plane	In-Plane	In-Plane	In-Plane	In-Plane
Tensile Strength (MPa)	Tensile Modulus (GPa)	Shear Strength (MPa)	Shear Modulus (GPa)	Shear Strength (MPa)	Shear Modulus (GPa)
163.9	15.27	82.0	5.323		
142.0	13.60	71.0	4.862		
134.9	13.25	67.4	4.611		
159.4	14.73	79.7	5.148		
168.4	12.42	84.2	4.597		
Average	13.86	76.9	4.908		
Std. Dev.	1.15	7.3	0.323		

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

TABLE F.7
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, 93°C (200°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Task #6		Fiber Orientation: ±45°		Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio		
BIL-GL-18-T3	200°F (DRY)	1.000	0.0671	1,218	18.15	1.406	9.08	0.392	0.794	8/18/89	(1,2,3,5)	
BIL-GL-18-T9	"	1.000	0.0684	985	14.40	1.514	7.20	0.477	0.589	"	(1,2,3,5)	
BIL-GL-18-T15	"	0.997	0.0677	1,012	14.99	1.698	7.50	0.505	0.681	"	(1,2,3,4)	
BIL-GL-19-T6	"	1.000	0.0650	597	9.18	1.035	4.59	0.289	0.793	"	(1,2,3,5)	
BIL-GL-19-T12	"	1.001	0.0650	898	13.80	1.591	6.90	0.499	0.594	"	(1,2,3,5)	
BIL-GL-19(R)-T6	"	1.006	0.0690	935	13.47	1.578	6.73	0.485	0.628	"	(1,2,3,5)	
BIL-GL-19(R)-T12	"	1.006	0.0710	1,061	14.85	1.567	7.43	0.474	0.652	"	(1,2,3,4)	
Average					14.12	1.484	7.06	0.446	0.676			
Std. Dev.					2.66	0.217	1.33	0.079	0.087			

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Incorrect load range; modulus calculations not included in averages.

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
125.2	9.69	62.6	2.701
99.3	10.44	49.6	3.287
103.4	11.71	51.7	3.481
63.3	7.14	31.7	1.989
95.2	10.97	47.6	3.443
92.9	10.88	46.4	3.341
102.4	10.81	51.2	3.270
Average	10.23	48.7	3.073
Std. Dev.	1.49	9.2	0.544

TABLE F.8
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, 93°C (200°F) DRY

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°								
Material :		EA-9396 A/B; 7781 Glass		Tested By: PM & DH								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)						
BIL-GL-23(R)-X2	200°F (DRY)	1.002	0.0635	865	13.60	1.463	6.80	0.512	0.429	3/15/90	(1,2,3,5)	
BIL-GL-23(R)-X4	"	0.997	0.0641	779	12.18	1.246	6.09	0.413	0.508	"	(1,2,3,5)	
BIL-GL-23(R)-X5	"	1.001	0.0616	747	12.12	1.301	6.06	0.418	0.555	"	(1,2,3,5)	
BIL-GL-23(R)-X6	"	0.876	0.0637	820	14.71	1.459	7.35	0.451	0.617	"	(1,2,3,5)	
BIL-GL-23(R)-7	"	1.022	0.0610	814	13.07	1.432	6.53	0.450	0.591	"	(1,2,3,5)	
BIL-GL-20(R)-T6	"	0.994	0.0655	989	15.19	1.377	7.59	0.423	0.630	7/28/89	(1,2,3,5)	
BIL-GL-20(R)-T12	"	0.999	0.0644	1,050	16.33	1.596	8.16	0.467	0.709	"	(1,2,3,5)	
Average					13.88	1.411	6.94	0.448	0.577			
Std. Dev.					1.59	0.116	0.79	0.035	0.091			

SI Conversion			
Ultimate	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
	93.8	10.09	3.532
	84.0	8.59	2.848
	83.5	8.97	2.884
	101.4	10.06	3.111
	90.1	9.88	3.103
	104.7	9.50	2.913
	112.6	11.00	3.219
Average	95.7	9.73	3.087
Std. Dev.	10.9	0.80	0.239

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

TABLE F.9
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, 93°C (200°F) DRY

Test :		+45° Tension/Inplane Shear, ASTM-D3518		Fiber Orientation:		±45°					
Material :		EA-9396 A/B; 7781 Glass		Batch #3		Task #6					
		Ultimate		In-Plane		In-Plane					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
BIL-GL-24-T3	200°F (DRY)	1.000	0.0689	1,106	16.06	1.777	8.03	0.549	0.619	8/21/89	(1,2,3,5)
BIL-GL-24-T9	"	1.001	0.0679	891	13.11	1.503	6.56	0.466	0.614	"	(1,2,3,5)
BIL-GL-24-T15	"	1.000	0.0655	895	13.67	1.479	6.83	0.433	0.710	"	(1,2,3,5)
BIL-GL-21-T6	"	0.998	0.0689	845	12.29	1.443	6.14	0.456	0.583	"	(1,2,3,5)
BIL-GL-21-T12	"	0.998	0.0699	1,334	19.11	1.785	9.56	0.547	0.631	"	(1,2,3,5)
Average				14.85	14.85	1.597	7.42	0.490	0.631		
Std. Dev.				2.77	2.77	0.169	1.38	0.054	0.047		

		SI Conversion			
		Ultimate		In-Plane	
		Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
		110.7	12.25	55.4	3.785
		90.4	10.36	45.2	3.210
		94.2	10.20	47.1	2.982
		84.7	9.95	42.4	3.142
		131.8	12.31	65.9	3.772
Average		102.4	11.01	51.2	3.378
Std. Dev.		19.1	1.17	9.5	0.375

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

TABLE F.10

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, -54°C (-65°F) WET

Test :		±45° Tension/Inplane Shear: ASTM-D3518		Fiber Orientation: ±45°						
Material :		EA-9396 A/B; 7781 Glass		DH						
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)				
BIL-GL-18-T4	-65°F (WET)	0.997	0.0670	1,071	16.93	2,806	8.02	0.519	1/18/90	(1,2,3,4,6,7)
BIL-GL-18-T10	"	0.999	0.0660	1,296	19.56	2,789	9.83	0.454	"	(1,2,3,4,6,7)
BIL-GL-19-T1	"	0.993	0.0650	1,375	21.31	2,793	10.66	0.496	"	(1,2,3,4,6,7)
BIL-GL-19-T7	"	1.000	0.0640	1,011	15.80	2,636	7.90	0.392	"	(1,2,3,5,6,7)
BIL-GL-19-T13	"	1.003	0.0660	1,404	21.21	2,752	10.61	0.421	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T1	"	1.003	0.0670	1,021	15.20	2,670	7.60	0.509	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T7	"	1.006	0.0730	1,084	14.75	2,568	7.38	0.476	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T13	"	1.006	0.0710	1,133	15.87	2,934	7.93	0.543	"	(1,2,3,4,6,7)
				Average	17.48	2,743	8.74	0.930		0.476
				Std. Dev.	2.77	0.115	1.38	0.035		0.051

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 112 days.
- (7) Weight gain = 1.9484%

		SI Conversion	
Ultimate		In-Plane Tensile Strength (MPa)	In-Plane Shear Modulus (GPa)
110.5	19.35	55.3	6.370
135.6	19.23	67.8	6.610
146.9	19.26	73.5	6.435
108.9	18.17	54.5	6.528
146.3	18.98	73.1	6.678
104.8	18.41	52.4	6.102
101.7	17.71	50.9	5.999
109.4	20.23	54.7	6.558
Average	120.5	60.3	6.407
Std. Dev.	19.1	9.5	0.377

TABLE F.11
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, -54°C (-65°F) WET

Specimen Number:	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		In-Plane		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Modulus (Msi.)	Shear Strength (Ksi.)	Modulus (Msi.)	Shear Modulus (Msi.)	Shear Modulus (Msi.)			
BIL-GL-23(R)-4	-65°F (WET)	1.000	0.0644	1,179	18.31	2.403	9.15	0.867	0.385	4/5/90	(1,2,3,5,6,8)		
BIL-GL-23(R)-10	"	1.002	0.0629	1,178	18.70	2.494	9.35	0.855	0.458	"	(1,2,3,4,6,8)		
BIL-GL-20(R)-T1	"	0.997	0.0640	1,105	17.32	2.297	8.66	0.749	0.534	1/18/90	(1,2,3,4,6,7)		
BIL-GL-20(R)-T7	"	0.995	0.0660	1,045	15.92	2.279	7.96	0.749	0.521	"	(1,2,3,4,6,7)		
BIL-GL-20(R)-T13	"	0.996	0.0690	927	13.49	2.051	6.74	0.624	0.644	"	(1,2,3,4,6,7)		
				Average	16.75	2.305	8.37	0.769	0.508				
				Std. Dev.	2.12	0.166	1.06	0.099	0.096				

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
126.2	16.57	63.1	5.981
128.9	17.19	64.5	5.897
119.5	15.84	59.7	5.163
109.8	15.71	54.9	5.167
93.0	14.14	46.5	4.301
Average	15.89	57.7	5.302
Std. Dev.	1.14	7.3	0.681

Test : ±45° Tension/Inplane Shear; ASTM-D3518
 Material : EA-9396 A/B; 7781 Glass
 Fiber Orientation: ±45°
 Batch #2 Task #6 Tested By: PM & DH

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.
 - (6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
 - (7) Weight gain = 1.5524%
 - (8) Weight gain = 2.1134%

TABLE F.12

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, -54°C (-65°F) WET

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°					
Material :		EA-9396 A/B; 7781 Glass		Tested By: DH					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Poisson's Ratio	Date Tested	Remarks
					Strength (Ksi.)	Tensile Modulus (Msi.)			
BIL-GL-21-T1	-65°F (WET)	0.996	0.0660	1,203	18.29	2,954	0.976	1/18/90	(1,2,3,4,6,7)
BIL-GL-21-T7	"	0.997	0.0670	916	13.71	2,394	0.800	"	(1,2,3,4,6,7)
BIL-GL-21-T13	"	0.998	0.0680	1,187	17.48	2,822	0.965	"	(1,2,3,4,6,7)
BIL-GL-24-T4	"	0.998	0.0680	1,151	16.96	2,540	0.847	"	(1,2,3,4,6,8)
BIL-GL-24-T10	"	1.001	0.0670	1,115	16.62	2,350	0.774	"	(1,2,3,4,6,8)
Average				16.61		2.612	0.872		
Std. Dev.				1.74		0.266	0.093		

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
126.1	20.37	63.1	6.727
94.5	16.51	47.3	5.517
120.6	19.46	60.3	6.653
116.9	17.52	58.5	5.842
114.6	16.21	57.3	5.335
Average	18.01	57.3	6.015
Std. Dev.	1.83	6.0	0.643

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Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G = E/2(1 + \nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 112 days.
- (7) Weight gain = 1.7099%
- (8) Weight gain = 1.8162%

TABLE F.13

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°						
Material :		EA-9396 A/B; 7781 Glass		Tested By: DH						
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Batch #1		Task #6		Date Tested	Remarks
					Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)		
BIL-GL-18-T5	72°F (WET)	0.997	0.0670	792	11.86	1.643	5.93	0.478	1/16/90	(1,2,3,5,6,7)
BIL-GL-18-T11	"	1.000	0.0650	789	12.13	1.533	6.07	0.492	"	(1,2,3,5,6,7)
BIL-GL-19-T2	"	0.998	0.0660	753	11.43	1.318	5.72	0.438	"	(1,2,3,5,6,7)
BIL-GL-19-T8	"	1.000	0.0640	533	8.32	1.589	4.16	0.559	"	(1,2,3,5,6,7)
BIL-GL-19-T14	"	1.002	0.0680	759	11.14	1.558	5.57	0.436	"	(1,2,3,5,6,7)
BIL-GL-19(R)-T2	"	1.004	0.0690	834	12.04	1.385	6.02	0.419	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T8	"	1.004	0.0720	634	8.77	1.450	4.38	0.467	"	(1,2,3,4,6,7)
BIL-GL-19(R)-T14	"	1.007	0.0710	733	10.25	1.821	5.13	0.540	"	(1,2,3,4,6,7)
Average					10.74	1.537	5.37	0.479		0.610
Std. Dev.					1.49	0.158	0.74	0.050		0.121

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
- (7) Weight gain = 2.0141%

SI Conversion	
Ultimate Tensile Strength (MPa)	In-Plane Shear Strength (MPa)
81.8	40.9
83.6	41.8
78.8	39.4
57.4	28.7
76.8	38.4
83.0	41.5
60.5	30.2
70.7	35.3
Average	37.0
Std. Dev.	5.1

SI Conversion	
Ultimate Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
11.33	3.293
10.57	3.390
9.08	3.020
10.96	3.851
10.74	3.005
9.55	2.892
10.00	3.221
12.55	3.726
Average	3.291
Std. Dev.	0.484

TABLE F.14

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518										Fiber Orientation: ±45°	
Material : EA-9396 A/B; 7781 Glass										Tested By: PM & DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)			
BIL-GL-23(R)-5	72°F (WET)	0.998	0.0644	713	11.10	1.543	5.55	0.510	0.511	4/5/90	(1,2,3,5,6,8)
BIL-GL-23(R)-11	"	1.002	0.0626	714	11.39	1.575	5.70	0.564	0.397	"	(1,2,3,5,6,8)
BIL-GL-20(R)-T2	"	0.998	0.0720	730	10.17	1.279	5.08	0.363	0.761	1/16/90	(1,2,3,4,6,7)
BIL-GL-20(R)-T8	"	0.996	0.0650	660	10.20	1.121	5.10	0.336	0.668	"	(1,2,3,5,6,7)
BIL-GL-20(R)-T14	"	0.999	0.0680	818	12.05	1.461	6.02	0.429	0.703	"	(1,2,3,4,5,7)
Average					10.98	1.396	5.49	0.441	0.608		
Std. Dev.					0.81	0.192	0.40	0.096	0.150		

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Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
- (7) Weight gain = 1.5177%
- (8) Weight gain = 2.3245%

SI Conversion			
Ultimate	In-Plane	In-Plane	In-Plane
Tensile Strength (MPa)	Tensile Modulus (GPa)	Shear Strength (MPa)	Shear Modulus (GPa)
76.6	10.64	38.3	3.519
78.5	10.86	39.3	3.887
70.1	8.82	35.0	2.503
70.3	7.73	35.2	2.318
83.1	10.08	41.5	2.959
Average	9.62	37.9	3.037
Std. Dev.	1.32	2.8	0.664

TABLE F.15
INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		Fiber Orientation: ±45°		Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)	Ratio	Tested		
BIL-GL-21-T2	72°F (WET)	0.993	0.0670	817	12.28	1.997	6.14	0.585	0.706	1/17/90	(1,2,3,4,6,7)	
BIL-GL-21-T8	"	0.996	0.0650	588	9.09	1.653	4.54	0.541	0.529	"	(1,2,3,5,6,7)	
BIL-GL-21-T14	"	0.996	0.0690	885	12.88	2.203	6.44	0.666	0.655	"	(1,2,3,5,6,7)	
BIL-GL-24-T5	"	0.997	0.0670	810	12.12	1.629	6.06	0.535	0.524	"	(1,2,3,4,6,8)	
BIL-GL-24-T11	"	0.998	0.0670	694	10.38	1.778	5.19	0.457	0.945	"	(1,2,3,4,6,8)	
Average					11.35	1.852	5.67	0.557	0.672			
Std. Dev.					1.57	0.244	0.79	0.076	0.172			

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1+\nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 111 days.
- (7) Weight gain = 1.6932%
- (8) Weight gain = 1.8157%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
84.7	13.77	42.3	4.035
62.7	11.40	31.3	3.729
88.8	15.19	44.4	4.589
83.6	11.23	41.8	3.686
71.5	12.26	35.8	3.151
Average	78.3	39.1	3.838
Std. Dev.	10.8	5.4	0.527

TABLE F.16
INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH I, 93°C (200°F) WET

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°							
Material :		EA-9396 A/B; 7781 Glass		Tested By: DH							
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Poisson's Ratio	Date Tested	Remarks		
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)					
		In-Plane Shear Strength (Ksi.)		In-Plane Shear Modulus (Msi.)							
BIL-GL-18-T6	200°F (WET)	0.999	0.0680	465	6.85	0.824	3.42	0.262	0.571	1/19/90	(1,2,3,5,6,7)
BIL-GL-18-T12	"	0.998	0.0650	360	5.55	0.724	2.78	0.206	0.758	"	(1,2,3,5,6,7)
BIL-GL-19-T3	"	0.999	0.0640	305	4.77	0.888	2.38	0.249	0.784	"	(1,2,3,5,6,7)
BIL-GL-19-T9	"	1.001	0.0650	286	4.39	0.967	2.20	0.319	0.514	"	(1,2,3,5,6,7)
BIL-GL-19-T15	"	1.003	0.0670	408	6.08	0.673	3.04	0.157	1.139	"	(1,2,3,5,6,7)
BIL-GL-19(R)-T3	"	1.004	0.0690	413	5.96	0.667	2.98	0.164	1.039	"	(1,2,3,5,6,7)
BIL-GL-19(R)-T9	"	1.003	0.0700	304	4.34	0.921	2.17	0.284	0.620	"	(1,2,3,4,6,7)
Average				465	5.42	0.809	2.71	0.234	0.775		
Std. Dev.					0.95	0.122	0.48	0.061	0.237		

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G = E/2(1 + \nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 117 days.
- (7) Weight gain = 2.0860%

		SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)		In-Plane Shear Modulus (GPa)	
		Strength	Modulus	Strength	Modulus
47.2	5.68	23.6	1.809		
38.3	4.99	19.1	1.419		
32.9	6.12	16.4	1.716		
30.3	6.67	15.1	2.202		
41.9	4.64	21.0	1.084		
41.1	4.60	20.5	1.128		
29.9	6.35	14.9	1.960		
Average		18.7	1.571		
Std. Dev.		3.3	0.341		

TABLE F.17

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°								
Material :		EA-9396 A/B; 7781 Glass		Tested By: PM & DH								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	In-Plane Shear		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)		In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)			
BIL-GL-23(R)-6	200°F (WET)	1.002	0.0643	377	5.86	0.739	2.93	0.208	0.778	0.208	4/5/90	(1,2,3,5,6,8)
BIL-GL-23(R)-12	"	1.000	0.0633	349	5.51	0.770	2.76	0.252	0.529	0.252	"	(1,2,3,5,6,8)
BIL-GL-20(R)-T3	"	0.996	0.0660	386	5.87	0.856	2.94	0.202	1.124	0.202	1/22/90	(1,2,3,5,6,7)
BIL-GL-20(R)-T9	"	0.993	0.0660	345	5.26	0.537	2.63	0.146	0.842	0.146	"	(1,2,3,5,6,7)
BIL-GL-20(R)-T15	"	1.000	0.0670	366	5.47	0.529	2.73	0.163	0.927	0.163	"	(1,2,3,5,6,7)
Average					5.59	0.706	2.80	0.194	0.840	0.194		
Std. Dev.					0.26	0.125	0.13	0.041	0.217	0.041		

		SI Conversion			
Ultimate	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear		
			Strength (MPa)	Modulus (GPa)	
	40.4	5.09	20.2	1.432	
	38.0	5.31	19.0	1.735	
	40.5	5.91	20.2	1.390	
	36.3	3.70	18.1	1.005	
	37.7	4.34	18.9	1.125	
Average	38.6	4.87	19.3	1.338	
Std Dev.	1.8	0.86	0.9	0.285	

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 114 days.
- (7) Weight gain = 1.5621%
- (8) Weight gain = 1.9967%

TABLE F.18
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°							
Material :		EA-9396 A/B; 7781 Glass		DH							
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Batch #3 Task #6		Date Tested	Remarks			
					Ultimate Tensile Strength (Ksi.)	In-Plane Shear Strength (Ksi.)					
BIL-GL-21-T3	200°F (WET)	0.998	0.0680	371	5.46	1.175	2.73	0.309	0.898	1/22/90	(1,2,3,4,6,7)
BIL-GL-21-T9	"	0.998	0.0700	320	4.58	1.479	2.29	0.436	0.695	"	(1,2,3,5,6,7)
BIL-GL-21-T15	"	0.996	0.0660	432	6.57	1.268	3.29	0.363	0.746	"	(1,2,3,4,6,7)
BIL-GL-24-T6	"	0.999	0.0670	360	5.37	0.673	2.69	0.183	0.842	"	(1,2,3,5,6,8)
BIL-GL-24-T12	"	0.998	0.0690	348	5.05	0.860	2.53	0.215	0.996	"	(1,2,3,5,6,8)
Average				5.41		1.091	2.70	0.301	0.835		
Std. Dev.				0.74		0.323	0.37	0.104	0.120		

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear	
		Strength (MPa)	Modulus (GPa)
37.7	8.10	18.8	2.134
31.6	10.19	15.8	3.006
45.3	8.74	22.7	2.504
37.0	4.64	18.5	1.260
34.8	5.93	17.4	1.485
Average	7.52	18.6	2.078
Std. Dev.	2.22	2.5	0.719

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 114 days.
- (7) Weight gain = 1.7197%
- (8) Weight gain = 1.8613%

TABLE F.19
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			In-Plane			Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio			
BIL-GR-37-1	-65°F (DRY)	1.003	0.1163	5,090	43.62	3.222	21.81	0.967	0.666	12/29/89	(1,2,3,5)	
BIL-GR-37-7	"	1.002	0.1236	4,778	38.56	2.718	19.28	0.776	0.751	"	(1,2,3,5)	
BIL-GR-37-13	"	1.001	0.1223	4,248	34.69	2.744	17.35	0.766	0.792	"	(1,2,3,5)	
BIL-GR-42-T4	"	0.996	0.1212	4,011	33.22	2.544	16.61	0.758	0.679	1/2/90	(1,2,3,5)	
BIL-GR-42-T10	"	0.999	0.1229	3,848	31.34	2.482	15.67	0.719	0.726	"	(1,2,3,5)	
Average					35.29	2.742	18.14	0.797	0.723			
Std. Dev.					4.88	0.290	2.44	0.097	0.052			

Test : ±45° Tension/Inplane Shear; ASTM-D3518
 Material : EA-9396 A/B; W133 Graphite
 Batch #1 Task #6 Fiber Orientation: ±45°
 Tested By: PM

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

Ultimate	SI Conversion		
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
300.8	22.21	150.4	6.667
265.9	18.74	132.9	5.350
239.2	18.92	119.6	5.279
229.0	17.54	114.5	5.224
216.1	17.11	108.1	4.959
Average	250.2	18.90	5.496
Std. Dev.	33.7	2.00	0.671

TABLE F.20
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Fiber Orientation: ±45°			Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	
BIL-GR-38-1	-65°F (DRY)	1.003	0.1220	4,167	34.05	2.673	17.03	0.819	0.632	1/2/90	(1,2,3,5)
BIL-GR-38-7	"	1.002	0.1243	4,797	38.50	3.204	19.25	0.940	0.704	"	(1,2,3,5)
BIL-GR-38-13	"	1.002	0.1245	4,063	32.58	2.972	16.29	0.898	0.656	"	(1,2,3,5)
BIL-GR-39-4	"	0.996	0.1220	4,456	36.67	2.559	18.33	0.772	0.659	"	(1,2,3,5)
BIL-GR-39-10	"	0.997	0.1220	4,014	33.00	2.647	16.50	0.769	0.722	"	(1,2,3,5)
Average					34.96	2.811	17.48	0.839	0.674		
Std. Dev.					2.54	0.269	1.27	0.077	0.037		

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1+\nu)$.
- (2) Specimen had 0° and 90° strain gages attached
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

Ultimate	SI Conversion		
	In-Plane Tensile Strength (MPa)	In-Plane Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
234.8	18.43	117.4	5.649
265.5	22.09	132.7	6.482
224.7	20.49	112.3	6.188
252.8	17.65	126.4	5.320
227.6	18.25	113.8	5.301
241.1	19.38	120.5	5.788
17.5	1.85	8.8	0.529
Average			
Std. Dev.			

TABLE F.21
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, -54°C (-65°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Batch #3		Task #6		Fiber Orientation: ±45°			Remarks
					Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	
BIL-GR-40-1	-65°F (DRY)	0.998	0.1187	4,697	39.64	3.122	19.82	0.874	0.787	1/2/90	(1,2,3,5)	
BIL-GR-40-7	"	1.001	0.1305	4,951	37.89	2.588	18.95	0.769	0.682	"	(1,2,3,5)	
BIL-GR-40-13	"	1.002	0.1283	5,098	39.65	2.889	19.83	0.834	0.733	1/3/90	(1,2,3,5)	
BIL-GR-41-T4	"	1.000	0.1202	4,878	40.50	3.180	20.30	0.890	0.787	"	(1,2,3,5)	
BIL-GR-41-T10	"	0.998	0.1195	4,504	37.75	2.943	18.88	0.862	0.668	"	(1,2,3,5)	
Average					39.11	2.945	19.55	0.850	0.731			
Std. Dev.					1.24	0.233	0.62	0.050	0.056			

F.22

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

Ultimate Tensile Strength (MPa)	SI Conversion	
	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
273.3	136.6	6.024
261.3	130.6	5.305
273.4	136.7	5.749
280.0	140.0	6.134
260.3	130.2	6.083
269.6	134.8	5.859
8.5	4.3	0.344
Average		
Std. Dev.		

TABLE F.22
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		In-Plane		Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)		
BIL-GR-37-2	72°F (DRY)	1.002	0.1201	3,599	29.91	2,582	14.95	0.721	0.790	12/11/89	(1,2,3,5)	
BIL-GR-37-8	"	1.004	0.1236	3,413	27.50	1,937	13.75	0.535	0.810	"	(1,2,3,5)	
BIL-GR-37-14	"	1.003	0.1227	3,125	25.39	2,107	12.69	0.560	0.881	"	(1,2,3,5)	
BIL-GR-42-T5	"	0.992	0.1238	2,883	23.49	1,979	11.74	0.568	0.742	"	(1,2,3,5)	
BIL-GR-42-T11	"	0.998	0.1238	2,864	23.17	1,766	11.59	0.510	0.733	"	(1,2,3,5)	
Average					25.89	2,074	12.95	0.579	0.791			
Std. Dev.					2.83	0.309	1.42	0.083	0.060			

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

Ultimate	SI Conversion			
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
206.2	17.81	103.1	4.974	
189.6	13.35	94.8	3.689	
175.1	14.53	87.5	3.861	
162.0	13.64	81.0	3.916	
159.8	12.18	79.9	3.513	
Average	178.5	14.30	89.3	3.991
Std. Dev.	19.5	2.13	9.8	0.572

TABLE F.23
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			Fiber Orientation: ±45°			Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Tested		
BIL-GR-38-2	72°F (DRY)	1.002	0.1213	3.064	25.20	2.208	12.60	0.657	0.679	11/27/89	(1,2,3,5)	
BIL-GR-38-8	"	1.004	0.1241	2.939	23.58	2.186	11.79	0.676	0.618	"	(1,2,3,5)	
BIL-GR-38-14	"	0.999	0.1229	2.803	22.84	2.275	11.42	0.668	0.702	"	(1,2,3,5)	
BIL-GR-39-5	"	0.990	0.1231	2.958	24.27	1.929	12.13	0.550	0.753	"	(1,2,3,5)	
BIL-GR-39-11	"	0.990	0.1236	2.804	22.91	2.041	11.46	0.551	0.851	"	(1,2,3,5)	
Average					23.76	2.128	11.88	0.621	0.721			
Std. Dev.					0.99	0.140	0.50	0.064	0.087			

Ultimate	SI Conversion		
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
173.7	15.23	86.9	4.533
162.6	15.07	81.3	4.658
157.5	15.69	78.7	4.608
167.3	13.30	83.7	3.794
158.0	14.07	79.0	3.802
Average	163.8	14.67	4.279
Std. Dev.	6.8	0.97	0.441

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

TABLE F.24
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		in-Plane		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)			
BIL-GR-40-2	72°F (DRY)	0.999	0.1203	3,696	30.75	2,402	15.37	0.673	0.783	11/27/89	(1,2,3,5)
BIL-GR-40-8	"	1.001	0.1312	3,229	24.60	1,984	12.30	0.568	0.747	"	(1,2,3,5)
BIL-GR-40-14	"	1.001	0.1242	3,390	27.26	2,232	13.63	0.626	0.783	"	(1,2,3,5)
BIL-GR-41-5	"	1.000	0.1213	3,435	28.32	2,423	14.16	0.659	0.840	"	(1,2,3,5)
BIL-GR-41-11	"	0.997	0.1208	3,051	25.32	2,012	12.66	0.685	0.468	"	(1,2,3,5)
Average					27.25	2,211	13.62	0.642	0.724		
Std. Dev.					2.46	0.208	1.23	0.047	0.147		

Test : ±45° Tension/Inplane Shear; ASTM-D3518 Fiber Orientation: ±45°
 Material : EA-9396 A/B; W133 Graphite Batch #3 Task #6 Tested By: DH

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

Ultimate	SI Conversion		In-Plane Shear Modulus (GPa)
	Tensile Strength (MPa)	Tensile Modulus (GPa)	
212.0	16.56	106.0	4.642
169.6	13.68	84.8	3.916
187.9	15.39	94.0	4.318
195.2	16.71	97.6	4.540
174.6	13.88	87.3	4.725
187.9	15.24	93.9	4.428
16.9	1.43	8.5	0.325

TABLE F.25
INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, 93°C (200°F) DRY

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		In-Plane		Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)	Shear Modulus (Msi.)	Poisson's Ratio		
BIL-GR-37-3	200°F (DRY)	1.004	0.1242	2,319	18.60	1.654	9.30	0.433	0.908	1/3/90	(1,2,3,5)	
BIL-GR-37-9	"	1.005	0.1241	2,122	17.01	1.380	8.50	0.357	0.933	"	(1,2,3,5)	
BIL-GR-37-15	"	1.005	0.1231	1,718	13.88	1.423	6.94	0.365	0.951	"	(1,2,3,5)	
BIL-GR-42-T6	"	0.998	0.1233	1,710	13.90	1.381	6.95	0.378	0.827	"	(1,2,3,5)	
BIL-GR-42-T12	"	0.997	0.1231	1,747	14.23	1.356	7.12	0.366	0.851	"	(1,2,3,5)	
Average					15.52	1.439	7.76	0.380	0.894			
Std. Dev.					2.16	0.122	1.08	0.031	0.053			

Test : ±45° Tension/Inplane Shear; ASTM-D3518
Material : EA-9396 A/B; W133 Graphite

Batch #1 Task #6

Fiber Orientation: ±45°
Tested By: DH

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1+\nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

Ultimate	SI Conversion			
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
128.2	11.40	64.1	2.988	
117.3	9.51	58.6	2.461	
95.7	9.81	47.9	2.514	
95.8	9.52	47.9	2.606	
98.1	9.35	49.1	2.526	
Average	107.0	9.92	53.5	2.619
Std. Dev.	14.9	0.84	7.4	0.213

TABLE F.26
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, 93°C (200°F) DRY

Fiber Orientation: ±45°											
Test : ±45° Tension/Inplane Shear; ASTM-D3518											
Material : EA-9396 A/B; W133 Graphite											
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)			
BIL-GR-38-3	200°F (DRY)	0.999	0.1205	2,065	17.16	1.945	8.58	0.546	0.780	1/5/90	(1,2,3,5)
BIL-GR-38-9	"	1.004	0.1228	1,812	14.70	1.667	7.35	0.477	0.747	"	(1,2,3,5)
BIL-GR-38-15	"	0.998	0.1207	1,747	14.50	1.887	7.25	0.561	0.683	"	(1,2,3,5)
BIL-GR-39-6	"	0.998	0.1222	1,816	14.89	1.406	7.45	0.372	0.891	"	(1,2,3,5)
BIL-GR-39-12	"	0.990	0.1226	1,831	15.09	1.318	7.54	0.347	0.896	"	(1,2,3,5)
Average					15.27	1.645	7.63	0.461	0.799		
Std. Dev.					1.08	0.280	0.54	0.098	0.093		

SI Conversion					
Ultimate	In-Plane		In-Plane		Remarks
	Tensile Strength (MPa)	Tensile Modulus (GPa)	Shear Strength (MPa)	Shear Modulus (GPa)	
118.3	13.41	59.2	3.768		
101.3	11.49	50.7	3.290		
100.0	13.01	50.0	3.866		
102.7	9.70	51.3	2.563		
104.0	9.08	52.0	2.396		
105.3	11.34	52.6	3.176		
7.4	1.93	3.7	0.675		
Average					
Std. Dev.					

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $[G = E/2(1 + \nu)]$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

TABLE F.27
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, 93°C (200°F) DRY

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°								
Material :		EA-9396 A/B; W133 Graphite		DH								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane Shear Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
					Strength (Ksi.)	Modulus (Msi.)						
BIL-GR-40-3	200°F (DRY)	1.002	0.1208	2,041	16.86	1.640	8.43	0.449	0.824	1/5/90	(1,2,3,5)	
BIL-GR-40-9	"	1.004	0.1296	1,897	14.58	1.386	7.29	0.377	0.835	"	(1,2,3,5)	
BIL-GR-40-15	"	1.005	0.1225	2,014	16.37	1.475	8.18	0.399	0.851	"	(1,2,3,5)	
BIL-GR-41-6	"	0.998	0.1218	2,133	17.54	1.603	8.77	0.409	0.960	"	(1,2,3,5)	
BIL-GR-41-12	"	0.999	0.1212	1,846	15.24	1.236	7.62	0.357	0.732	"	(1,2,3,5)	
				Average	16.12	1.468	8.06	0.398	0.840			
				Std. Dev.	1.20	0.164	0.60	0.035	0.081			

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Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E / (2(1 + \nu))$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.

SI Conversion					
Ultimate	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)	Poisson's Ratio
100.6	9.55	50.3	2.603	0.835	
112.9	10.17	56.4	2.748	0.851	
120.9	11.05	60.5	2.819	0.960	
105.1	8.52	52.5	2.461	0.732	
Average	111.1	10.12	55.6	2.746	
Std. Dev.	8.3	1.13	4.1	0.241	

TABLE F.28
INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, -54°C (-65°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518										Fiber Orientation: ±45°	
Material : EA-9396 A/B; W133 Graphite										Tested By: PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)			
BIL-GR-37-4	-65°F (WET)	1.004	0.1236	5,164	41.60	3,246	20.80	0.894	0.816	2/16/90	(1,2,3,5,6,7)
BIL-GR-37-10	"	1.003	0.1233	3,779	30.55	2,985	15.27	0.881	0.694	"	(1,2,3,5,6,7)
BIL-GR-42-T1	"	0.985	0.1121	3,278	29.69	2,825	14.84	0.879	0.606	"	(1,2,3,5,6,8)
BIL-GR-42-T7	"	0.997	0.1221	3,746	30.76	2,633	15.38	0.834	0.578	"	(1,2,3,5,6,8)
BIL-GR-42-T13	"	0.997	0.1216	3,690	30.44	2,795	15.22	0.837	0.671	"	(1,2,3,5,6,8)
Average					32.61	2,897	16.30	0.865	0.673		
Std. Dev.					5.04	0.232	2.52	0.028	0.093		

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
286.8	22.38	143.4	6.163
210.6	20.58	105.3	6.074
204.7	19.48	102.3	6.063
212.1	18.16	106.1	5.754
209.9	19.27	105.0	5.768
Average	19.97	112.4	5.964
Std. Dev.	1.60	17.4	0.190

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (7) Weight gain = 2.1103%
- (8) Weight gain = 2.1150%

TABLE F.29
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, -54°C (-65°F) WET

Test : ±45° Tension/Inplane Shear; ASTM-D3518										Fiber Orientation: ±45°		
Material : EA-9396 A/B; W133 Graphite										Tested By: PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Batch #2		Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane		Date Tested	Remarks
					Task #6	Task #6			Shear Strength (Ksi.)	Shear Modulus (Msi.)		
BIL-GR-38-4	-65°F (WET)	1.001	0.1227	4,800	39.09	3.685	19.54	3.685	1.080	0.706	2/20/90	(1,2,3,5,6,7)
BIL-GR-38-10	"	0.982	0.1226	3,977	33.04	3.295	16.52	3.295	1.015	0.623	"	(1,2,3,5,6,7)
BIL-GR-39-1	"	0.996	0.1119	3,567	32.01	2.998	16.01	2.998	0.867	0.729	"	(1,2,3,5,6,8)
BIL-GR-39-7	"	0.996	0.1247	4,032	32.46	2.663	16.23	2.663	0.794	0.677	"	(1,2,3,5,6,8)
BIL-GR-39-13	"	0.996	0.1227	3,878	31.74	2.774	15.87	2.774	0.862	0.609	"	(1,2,3,5,6,8)
Average					33.67	3.083	16.83	3.083	0.924	0.669		
Std. Dev.					3.07	0.414	1.54	0.414	0.119	0.052		

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1+\nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (7) Weight gain = 2.0754%
- (8) Weight gain = 2.3377%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
269.5	25.41	134.8	7.449
227.8	22.72	113.9	6.997
220.7	20.67	110.4	5.980
223.8	18.36	111.9	5.474
218.8	19.12	109.4	5.945
Average	21.26	116.1	6.369
Std. Dev.	2.86	10.6	0.820

TABLE F. 30
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, -54°C (-65°F) WET

Test		±45° Tension/Inplane Shear: ASTM-D3518		Fiber Orientation: ±45°						
Material	EA-9396 A/B: W133 Graphite	Batch #3	Task #6	Tested By: DH						
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Date Tested	Remarks			
				Maximum Load (lbs.)	Tensile Strength (Ksi.)			Tensile Modulus (Msi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio
BIL-GR-40-4	-65°F (WET)	1.002	0.1233	4,675	37.84	2,790	0.761	0.834	2/16/90	(1,2,3,5,6,7)
BIL-GR-40-10	"	1.000	0.1227	3,647	27.50	2,116	0.623	0.698	"	(1,2,3,5,6,7)
BIL-GR-41-1	"	0.989	0.1152	4,202	36.86	2,594	0.714	0.816	"	(1,2,3,5,6,8)
BIL-GR-41-7	"	0.999	0.1220	4,521	37.11	2,696	0.775	0.740	"	(1,2,3,5,6,8)
BIL-GR-41-13	"	0.998	0.1182	3,955	33.53	2,509	0.672	0.868	"	(1,2,3,5,6,8)
Average				34.57	34.57	2,541	709	0.791		
Std. Dev.				4.29	4.29	0.260	0.063	0.070		

SI Conversion

Ultimate	In-Plane Tensile Strength (MPa)	In-Plane Shear Strength (MPa)	In-Plane Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
260.9	130.5	19.23	5.244	4.296
189.6	94.8	14.59	4.924	5.343
254.2	127.1	17.88	4.631	
255.8	127.9	18.59		
231.2	115.6	17.30		
Average	119.2	17.52	4.898	
Std. Dev.	14.8	1.79	0.433	

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G = E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (7) Weight gain = 2.0638%
- (8) Weight gain = 2.1628%

TABLE F.31
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test		+45° Tension/Inplane Shear: ASTM-C3518		Fiber Orientation: ±45°						
Material		EA-9396 A/B; W133 Graphite		Tested By: DH						
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Batch #1		Task #6		Date Tested	Remarks
					Ultimate Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)		
BIL-GR-37-5	72°F (WET)	1.004	0.1232	3.014	1.789	24.37	12.19	0.477	2/16/90	(1,2,3,5,6,7)
BIL-GR-37-11	"	1.003	0.1232	2.504	1.920	20.25	10.13	0.563	"	(1,2,3,5,6,7)
BIL-GR-42-T2	"	0.996	0.1168	2.264	1.697	19.46	9.73	0.508	"	(1,2,3,5,6,8)
BIL-GR-42-T8	"	1.000	0.1245	2.188	1.530	17.57	8.79	0.452	"	(1,2,3,5,6,8)
BIL-GR-42-T14	"	0.998	0.1219	2.196	1.573	18.05	9.02	0.462	"	(1,2,3,5,6,8)
				Average	19.94	1.702	9.97	0.492		
				Std. Dev.	2.70	0.159	1.35	0.045		

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached
- (3) Test speed = 0.1 in/min
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
- (7) Weight gain = 2.1103%
- (8) Weight gain = 2.1150%

		SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)		In-Plane Shear Modulus (GPa)	
		168.1	12.34	84.0	3.288
139.7	13.24	69.8	3.118	3.118	3.186
134.2	11.70	67.1	3.118	3.118	3.186
121.1	10.55	60.6	3.118	3.118	3.186
124.4	10.84	62.2	3.118	3.118	3.186
Average	11.73	68.7	3.395	3.395	3.307
Std. Dev.	1.10	9.3	0.307	0.307	0.307

TABLE F.32
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate			In-Plane			Fiber Orientation: ±45°		
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Tested By:		
											Strength (Ksi.)	Modulus (Msi.)	Strength (Ksi.)
BIL-GR-38-5	72°F (WET)	0.993	0.1218	3,062	25.30	2.818	12.65	0.757	0.861	2/15/90	(1,2,3,5,6,7)		
BIL-GR-38-11	"	0.990	0.1208	2,283	19.09	2.428	9.54	0.744	0.631	"	(1,2,3,5,6,7)		
BIL-GR-39-2	"	0.993	0.1159	2,175	18.90	1.998	9.45	0.512	0.951	"	(1,2,3,5,6,8)		
BIL-GR-39-8	"	0.996	0.1243	2,476	20.00	1.853	10.00	0.526	0.762	"	(1,2,3,5,6,8)		
BIL-GR-39-14	"	0.995	0.1228	2,324	19.03	1.719	9.51	0.508	0.691	"	(1,2,3,5,6,8)		
Average					20.46	2.163	10.23	0.610	0.719				
Std. Dev.					2.74	0.453	1.37	0.129	0.125				

Ultimate	SI Conversion						
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)				
				In-Plane Shear Strength (MPa)			
174.5	19.43	87.2	5.221				
131.6	16.74	65.8	5.132				
130.3	13.78	65.2	3.531				
137.9	12.78	69.0	3.626				
131.2	11.85	65.6	3.504				
Average				141.1	14.92	70.6	4.203
Std. Dev.				18.9	3.12	9.4	0.891

- Remarks
- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1+\nu)$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.
 - (6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
 - (7) Weight gain = 2.0754%
 - (8) Weight gain = 2.3377%

TABLE F.33
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) WCT

Test		Fiber Orientation: ±45°											
Material		Batch #3					Task #6					Tested By: PM	
EA-9396 A/B; W133 Graphite		ASTM-D3518											
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	In-Plane		Poisson's Ratio	Date Tested	Remarks	
					Tensile Strength (Ksi.)	Shear Strength (Ksi.)		Shear Modulus (Msi.)	Shear Modulus (Msi.)				
BIL-GR-40-5	72°F (WET)	1.002	0.1264	2,921	23.07	1,785	11.53	0.471	0.894	2/16/90	(1,2,3,5,6,7)		
BIL-GR-40-11	"	1.003	0.1311	2,617	19.90	1,788	9.95	0.514	0.738	"	(1,2,3,5,6,7)		
BIL-GR-41-T2	"	0.996	0.1188	2,943	24.88	2,103	12.44	0.550	0.912	"	(1,2,3,5,6,8)		
BIL-GR-41-T8	"	0.998	0.1210	2,772	22.97	2,193	11.48	0.613	0.788	"	(1,2,3,5,6,8)		
BIL-GR-41-T14	"	0.997	0.1181	2,474	21.01	1,888	10.51	0.469	1.014	"	(1,2,3,5,6,8)		
Average				22.37	1.952	11.18	0.524	0.869					
Std. Dev.				1.94	0.187	0.97	0.060	0.108					

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
- (7) Weight gain = 2.0838%
- (8) Weight gain = 2.1628%

SI Conversion			
Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
159.1	12.31	79.5	3.249
137.2	12.33	68.6	3.547
171.6	14.50	85.8	3.792
158.4	15.12	79.2	4.230
144.9	13.02	72.4	3.233
Average	13.46	77.1	3.610
Std. Dev.	1.29	6.7	0.416

TABLE F.34

INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 1, 93°C (200°F) WET

±45° Tension/Inplane Shear: ASTM-D3518										Fiber Orientation: ±45°	
Material: EA-9396 A/B: W133 Graphite		Batch #1		Task #6		Tested By:		DH			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)			
BIL-GR-37-6	200°F (WET)	1.001	0.1230	1,343	10.91	0.784	5.46	0.201	0.954	2/20/90	(1,2,3,5,6,7,9)
BIL-GR-37-12	"	1.002	0.1238	1,179	9.51	1.168	4.75	0.330	0.772	"	(1,2,3,5,6,7,9)
BIL-GR-42-T3	"	0.998	0.1194	1,069	8.97	0.985	4.49	0.290	0.696	"	(1,2,3,5,6,8,9)
BIL-GR-42-T9	"	0.990	0.1240	1,008	8.21	0.694	4.11	0.200	0.732	"	(1,2,3,5,6,8,9)
BIL-GR-42-T15	"	1.000	0.1107	846	7.64	0.699	3.82	0.216	0.621	"	(1,2,3,5,6,8,9)
Average					9.05	0.866	4.52	0.247	0.755		
Std. Dev.					1.26	0.206	0.63	0.059	0.124		

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (7) Weight gain = 2.1103%
- (8) Weight gain = 2.1150%
- (9) These specimens were supposed to have been tested at the 200°F(Wet) condition. They were inadvertently tested at 72°(Wet).

SI Conversion

Ultimate	In-Plane		In-Plane
	Tensile Strength (MPa)	Modulus (GPa)	
75.2	5.41	37.6	1.383
65.6	8.05	32.8	2.272
61.9	6.79	30.9	2.002
56.6	4.78	28.3	1.380
52.7	4.82	26.3	1.487
Average		31.2	1.705
Std. Dev.		4.4	0.408

TABLE F.35
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test:		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°							
Material:		EA-9396 A/B: W133 Graphite		Tested By: PM							
		Batch #2		Task #6							
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
					Strength (Ksi.)	Modulus (Msi.)					
BIL-GR-38-6	200°F (WET)	1.001	0.1226	1.315	10.71	1.276	5.36	0.303	1.106	2/20/90	(1,2,3,5,6,7,9)
BIL-GR-38-12	"	0.999	0.1245	1.053	8.47	1.560	4.23	0.468	0.666	"	(1,2,3,5,6,7,9)
BIL-GR-39-3	"	0.996	0.1194	1.011	8.50	0.775	4.25	0.198	0.961	"	(1,2,3,5,6,8,9)
BIL-GR-39-9	"	0.999	0.1244	1.034	8.31	0.740	4.16	0.218	0.699	"	(1,2,3,5,6,8,9)
BIL-GR-39-15	"	0.996	0.1184	1.025	8.70	0.592	4.35	0.153	0.934	"	(1,2,3,5,6,8,9)
				Average	8.94	0.989	4.47	0.268	0.873		
				Std. Dev.	1.00	0.410	0.50	0.124	0.186		

SI Conversion					
Ultimate	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)	Remarks
58.4	10.75	29.2	3.227		
58.6	5.34	29.3	1.363		
57.3	5.10	28.7	1.502		
60.0	4.08	30.0	1.055		
Average	61.6	6.82	30.8	1.847	
Std. Dev.	6.9	2.83	3.5	0.858	

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimens were tested at 0.1 in/min.
- (3) Specimens were tested inside the "tab area".
- (4) Specimens were tested within the 6.5 inch gage section.
- (5) Specimens were tested @ 140°F/95-100% R.H. to saturation.
- (6) Weight gain = 2.0754%
- (7) Weight gain = 2.3377%
- (8) These specimens were supposed to have been tested at the 200°F(Wet) condition. They were inadvertently tested at 72°(Wet).

TABLE F.36
 INDIVIDUAL SPECIMEN INPLANE SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane Shear		Date Tested	Remarks	
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)			
					Batch #3	Task #6	Batch #3	Task #6			
BIL-GR-40-6	200°F (WET)	1.003	0.1284	1,213	9.42	0.848	4.71	0.209	1.029	2/20/90	(1,2,3,5,6,7)
BIL-GR-40-12	"	1.003	0.1297	1,139	8.75	1.048	4.38	0.266	0.969	"	(1,2,3,5,6,7)
BIL-GR-41-T3	"	0.996	0.1202	1,234	10.31	1.030	5.15	0.262	1.015	"	(1,2,3,5,6,8,9)
BIL-GR-41-T9	"	0.979	0.1196	999	8.53	1.054	4.26	0.176	1.284	"	(1,2,3,5,6,8)
BIL-GR-41-T15	"	1.000	0.1213	941	7.76	0.803	3.88			"	(1,2,3,5,6,8)
Average					8.95	0.956	4.48	0.228	1.074		
Std. Dev.					0.96	0.121	0.48	0.043	0.142		

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1 + \nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. for 91 days.
- (7) Weight gain = 2.0838%
- (8) Weight gain = 2.1628%
- (9) 90° strain gage failed.

Ultimate	SI Conversion			
	Tensile Strength (MPa)	Tensile Modulus (GPa)	In-Plane Shear Strength (MPa)	In-Plane Shear Modulus (GPa)
65.0	5.84	5.84	32.5	1.440
60.4	7.22	7.22	30.2	1.835
71.1	7.10	7.10	35.5	3.551
58.8	7.27	7.27	29.4	1.804
53.5	5.53	5.53	26.8	1.211
Average	61.7	6.59	30.9	1.968
Std. Dev.	6.6	0.84	3.3	0.922

APPENDIX G

INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR PROPERTIES, BASELINE

The 18 tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in interlaminar shear. A summary of these data was presented and discussed in Section 3.2.4.

TABLE G.1
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear: ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp
 Material : EA-9396 A/B; 7781 Glass Batch #1 Task #7 Tested By: TOB

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Ultimate		Date Tested	Remarks
					Maximum Load (lbs.)	Shear Strength (Ksi.)		
BIL-GL-13(R)-3	72°F (DRY)	1.001	0.1357	1.063	1,040	5.742	4/14/89	
BIL-GL-13(R)-11	"	0.999	0.1371	1.063	1,066	5.839	"	
BIL-GL-13(R)-24	"	1.001	0.1359	1.063	1,120	6.174	"	
BIL-GL-13(R)-33	"	1.002	0.1341	1.063	1,036	5.786	"	
BIL-GL-13(R)-53	"	1.001	0.1336	1.063	980	5.493	"	

Average 5.806
 Std. Dev. 0.244

SI Conversion	
Ultimate Shear Strength (MPa)	39.59
	40.26
	42.57
	39.89
	37.87
Average	40.04
Std. Dev.	1.69

TABLE G.2
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; 7781 Glass		Batch #2	Task #7	Tested By: TOB				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Ultimate		Date Tested	Remarks
					Maximum Load (lbs.)	Shear Strength (Ksi.)		
BIL-GL-11-1	72°F (DRY)	0.998	0.1309	1.063	926	5.316	4/14/89	
BIL-GL-11-4	"	1.001	0.1312	1.063	969	5.530	"	
BIL-GL-11-7	"	0.992	0.1316	1.063	1,012	5.816	"	
BIL-GL-11-10	"	1.002	0.1315	1.063	974	5.543	"	
BIL-GL-11-13	"	1.000	0.1345	1.063	996	5.549	"	
					Average	5.551		
					Std. Dev.	0.177		
SI Conversion:								
Ultimate								
Shear Strength (MPa)								
					36.66			
					38.13			
					40.10			
					38.22			
					38.26			
					Average	38.27		
					Std. Dev.	1.22		

TABLE G.3
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1)										Specimen Orientation: Warp		
Material : EA-9396 A/B; 7781 Glass										Tested By: TOB		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks	Batch #3	Task #7		
											Average	Std. Dev.
BIL-GL-12-1	72°F (DRY)	0.996	0.1281	1.063	922	5.419	4/14/89					
BIL-GL-12-4	"	1.000	0.1332	1.063	1,017	5.729	"					
BIL-GL-12-7	"	1.001	0.1304	1.063	958	5.508	"					
BIL-GL-12-10	"	1.003	0.1313	1.063	905	5.156	"					
BIL-GL-12-13	"	1.001	0.1342	1.063	1,025	5.721	"					
											Average	5.507
											Std. Dev.	0.238
SI Conversion												
Ultimate Shear Strength (MPa)												
											Average	37.97
											Std. Dev.	1.64

TABLE G.4
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 8/1)										Specimen Orientation: Warp	
Material : EA-9396 A/B; 7781 Glass										Tested By: DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear		Date Tested	Remarks		
						Strength (Ksi.)	Strength (MPa)				
BIL-GL-13(R)-4	72°F (WET)	1.001	0.1353	1.0804	482	2.669	18.40	10/30/89	(1,2)		
BIL-GL-13(R)-12	"	0.999	0.1344	1.0804	477	2.663	18.36	"	(1,2)		
BIL-GL-13(R)-25	"	1.001	0.1369	1.0804	510	2.793	19.26	"	(1,2)		
BIL-GL-13(R)-34	"	1.000	0.1352	1.0804	489	2.714	18.71	"	(1,2)		
BIL-GL-13(R)-54	"	1.000	0.1320	1.0804	473	2.690	18.55	"	(1,2)		
Average						2.706	18.66				
Std. Dev.						0.053	0.36				

Remarks:

(1) Specimens aged @ 140°F/95%RH to saturation.

(2) Average weight gain = 2.32%

SI Conversion

Ultimate Shear Strength (MPa)

18.40

18.36

19.26

18.71

18.55

Average 18.66

Std. Dev. 0.36

TABLE G.5
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Test : Apparent Interlaminar Shear: ASTM-D2344		(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; 7781 Glass		Batch #2	Task #7	Tested By: DH				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-11-2	72°F (WET)	0.998	0.1318	1.063	511	2.912	10/27/89	(1,2)
BIL-GL-11-5	"	0.998	0.1325	1.063	533	3.019	"	(1,2)
BIL-GL-11-8	"	0.991	0.1315	1.063	499	2.874	"	(1,2)
BIL-GL-11-11	"	1.006	0.1337	1.063	547	3.049	"	(1,2)
BIL-GL-11-14	"	1.001	0.1346	1.063	573	3.188	"	(1,2)
Average						3.008		
Std. Dev.						0.124		
SI Conversion								
Ultimate Shear Strength (MPa)								
Average						20.74		
Std. Dev.						0.85		

Remarks:
 (1) Specimens aged @ 140°F/95-100% R.H. to saturation.
 (2) Average weight gain = 2.10%

TABLE G.6
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 3, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp					
Material : EA-9396 A/B; 7781 Glass		Batch #3	Task #7	Tested By: DH					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Shear Strength (Ksi.)	Date Tested	Remarks	
									Ultimate
BIL-GL-12-2	72°F (WET)	1.000	0.1324	1.066	572	3.244	10/27/89	(1,2)	
BIL-GL-12-5	"	1.000	0.1340	1.066	562	3.148	"	(1,2)	
BIL-GL-12-8	"	1.000	0.1318	1.066	559	3.180	"	(1,2)	
BIL-GL-12-11	"	0.999	0.1319	1.066	569	3.240	"	(1,2)	
BIL-GL-12-14	"	1.006	0.1355	1.066	594	3.271	"	(1,2)	
Average						3.216			
Std. Dev.						0.051			

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.09%

SI Conversion	
Ultimate Shear Strength (MPa)	
22.36	
21.70	
21.92	
22.34	
22.55	
Average	22.18
Std. Dev.	0.35

TABLE G.7
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 1, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pis. L/D = 8/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; 7781 Glass		Batch #1		Task #7				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-13(R)-5	200°F (WET)	1.001	0.1369	1.080	230	1.258	10/30/89	(1,2)
BIL-GL-13(R)-13	"	1.002	0.1349	1.080	229	1.272	"	(1,2)
BIL-GL-13(R)-26	"	1.002	0.1350	1.080	247	1.369	"	(1,2)
BIL-GL-13(R)-35	"	1.001	0.1346	1.080	249	1.388	"	(1,2)
BIL-GL-13(R)-55	"	1.002	0.1353	1.080	257	1.421	"	(1,2)

Average 1.342
 Std. Dev. 0.073

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.24%

SI Conversion	
Ultimate Shear Strength (MPa)	
8.67	
8.77	
9.44	
9.57	
9.80	
Average	9.25
Std. Dev.	0.50

TABLE G.8
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
GLASS REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp		
Material : EA-9396 A/B; 7781 Glass		Batch #2	Task #7	Tested By: DH		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Date Tested	Remarks
BIL-GL-11-3	200°F (WET)	1.002	0.1312	1.063	10/27/89	(1,2)
BIL-GL-11-6	"	0.999	0.1324	1.063	"	(1,2)
BIL-GL-11-9	"	1.001	0.1291	1.063	"	(1,2)
BIL-GL-11-12	"	1.002	0.1359	1.063	"	(1,2)
BIL-GL-11-15	"	0.995	0.1357	1.063	"	(1,2)
		Ultimate				
		Maximum Load (lbs.)	Shear Strength (Ksi.)			
		349	1.989			
		329	1.865			
		313	1.817			
		351	1.931			
		362	2.011			
		Average	1.922			
		Std. Dev.	0.082			

Remarks:

- (1) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (2) Average weight gain = 2.09%

SI Conversion	
Ultimate Shear Strength (MPa)	13.71
	12.86
	12.53
	13.32
	13.86
Average	13.26
Std. Dev.	0.56

TABLE G.9
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GLASS REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; 7781 Glass		Batch #3	Task #7	Tested By: DH				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GL-12-3	200°F (WET)	1.002	0.1331	1.066	336	1.887	10/27/89	(1,2)
BIL-GL-12-6	"	1.003	0.1335	1.066	349	1.952	"	(1,2)
BIL-GL-12-9	"	1.002	0.1329	1.066	313	1.765	"	(1,2)
BIL-GL-12-12	"	1.001	0.1333	1.066	328	1.840	"	(1,2)
BIL-GL-12-15	"	1.001	0.1337	1.066	345	1.930	"	(1,2)
Average						1.875		
Std. Dev.						0.075		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.11%

SI Conversion	
Ultimate Shear Strength (MPa)	
13.01	
13.46	
12.17	
12.69	
13.31	
Average	12.93
Std. Dev.	0.52

TABLE G.10
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; W133 Graphite		Batch #1	Task #7	Tested By: PM				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Ultimate		Date Tested	Remarks
					Maximum Load (lbs.)	Shear Strength (Ksi.)		
BI--GR-17-3	72°F (DRY)	1.002	0.1711	2.816	1,188	5.196	4/17/89	
BI--GR-17-11	"	1.002	0.1771	2.816	1,333	5.637	"	
BI--GR-17-24	"	1.000	0.1764	2.816	1,338	5.688	"	
BI--GR-17-33	"	1.000	0.1817	2.816	1,526	6.301	"	
BI--GR-17-37	"	0.999	0.1738	2.816	1,275	5.506	"	
Average					5.665			
Std. Dev.					0.403			
SI Conversion								
Ultimate								
Shear Strength (MPa)								
					35.82			
					38.86			
					39.22			
					43.44			
					37.96			
Average					39.06			
Std. Dev.					2.78			

TABLE G.11
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear: ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; W133 Graphite		Batch #2	Task #7	Tested By: PM				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Ultimate		Date Tested	Remarks
					Maximum Load (lbs.)	Shear Strength (Ksi.)		
B:L-GR-18-1	72°F (DRY)	1.002	0.1682	2.816	1.077	4.794	4/17/89	
B:L-GR-18-4	"	1.000	0.1683	2.816	1.455	6.481	"	
B:L-GR-18-7	"	1.002	0.1806	2.816	1.515	6.277	"	
B:L-GR-18-10	"	1.002	0.1703	2.816	1.277	5.613	"	
B:L-GR-18-13	"	1.000	0.1889	2.816	1.439	5.712	"	
					Average	5.776		
					Std. Dev.	0.660		
SI Conversion								
Ultimate Shear Strength (MPa)								
					Average	39.82		
					Std. Dev.	4.55		

TABLE G.12
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) DRY

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)				Specimen Orientation: Warp		
Material : EA-9396 A/B; W133 Graphite		Batch #3	Task #7			Tested By: PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Ultimate		Date Tested	Remarks
					Maximum Load (lbs.)	Shear Strength (Ksi.)		
BIL-GR-19-1	72°F (DRY)	1.003	0.1676	2.816	1,181	5.270	4/17/89	
BIL-GR-19-4	"	1.000	0.1771	2.816	1,304	5.522	"	
BIL-GR-19-7	"	1.001	0.1782	2.816	1,459	6.136	"	
BIL-GR-19-10	"	1.001	0.1689	2.816	1,234	5.471	"	
BIL-GR-19-13	"	1.002	0.1790	2.816	1,397	5.839	"	
					Average	5.648		
					Std. Dev.	0.341		
SI Conversion								
Ultimate Shear Strength (MPa)								
					36.34			
					38.07			
					42.31			
					37.72			
					40.26			
					Average	38.94		
					Std. Dev.	2.35		

TABLE G.13
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation: Warp		
Material : EA-9396 A/B; W133 Graphite		Batch #1	Task #7	Tested By: DH		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate
						Shear Strength (Ksi.)
BIL-GR-17-4	72°F (WET)	1.001	0.1716	2.827	1,001	4.369
BIL-GR-17-12	"	1.001	0.1759	2.827	1,129	4.808
BIL-GR-17-24	"	0.999	0.1735	2.827	1,062	4.597
BIL-GR-17-34	"	1.000	0.1804	2.827	1,305	5.424
BIL-GR-17-44	"	1.001	0.1727	2.827	1,047	4.543
Average						4.748
Std. Dev.						0.409

SI Conversion	
Ultimate Shear Strength (MPa)	30.12
	33.15
	31.70
	37.40
	31.33
Average	32.74
Std. Dev.	2.82

Remarks:
 (1) Specimens aged @ 140°F/95-100% R.H. to saturation.
 (2) Average weight gain = 2.19%

TABLE G.14
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
GRAPHITE REINFORCEMENT, BATCH 2, 22°C (72°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; W133 Graphite		Batch #2	Task #7	Tested By: DH				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-18-2	72°F (WET)	1.002	0.1746	2.827	1,048	4.495	12/7/89	(1,2)
BIL-GR-18-5	"	1.002	0.1821	2.827	1,136	4.670	"	(1,2)
BIL-GR-18-8	"	1.002	0.1773	2.827	1,167	4.927	"	(1,2)
BIL-GR-18-11	"	1.006	0.1809	2.827	1,134	4.676	"	(1,2)
BIL-GR-18-14	"	1.000	0.1887	2.827	1,232	4.899	"	(1,2)
Average						4.733		
Std. Dev.						0.180		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.32%

SI Conversion
Ultimate Shear Strength (MPa)
30.99
32.20
33.97
32.24
33.78
Average
32.64
Std. Dev.
1.24

TABLE G.15
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, 22°C (72°F) WET

Test : Apparent Interlaminar Shear: ASTM-D2344		(4pt loading at 1.4 pts. L/D = 16/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; W133 Graphite		Batch #3		Task #7				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-19-2	72°F (WET)	1.000	0.1718	2.827	1,036	4.522	12/7/89	(1,2)
BIL-GR-19-5	"	1.002	0.1741	2.827	1,079	4.641	"	(1,2)
BIL-GR-19-8	"	1.000	0.1733	2.827	1,037	4.486	"	(1,2)
BIL-GR-19-11	"	1.001	0.1758	2.827	1,089	4.644	"	(1,2)
BIL-GR-19-14	"	1.002	0.1776	2.827	1,128	4.754	"	(1,2)
Average						4.609		
Std. Dev.						0.107		
SI Conversion								
Ultimate Shear Strength (MPa)						31.18		
						32.00		
						30.93		
						32.02		
						32.78		
Average						31.78		
Std. Dev.						0.74		

Remarks:
 (1) Specimens aged @ 140°F/95-100% R.H. to saturation.
 (2) Average weight gain = 2.24%

TABLE G.16
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 1, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344 (4pt loading at 1/4 pts. L/D = 16/1)										Specimen Orientation: Warp	
Material : EA-9396 A/B; W133 Graphite										Tested By: DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks		
						Shear Strength (Ksi.)	Shear Strength (MPa)			Average	Std. Dev.
BIL-GR-17-5	200°F (WET)	1.001	0.1802	2.846	564	2.345	12/7/89	(1,2)			
BIL-GR-17-13	"	1.000	0.1716	2.846	432	1.890	"	(1,2)			
BIL-GR-17-26	"	0.999	0.1752	2.846	470	2.011	"	(1,2)			
BIL-GR-17-35	"	1.001	0.1792	2.846	473	1.975	"	(1,2)			
BIL-GR-17-43	"	1.001	0.1761	2.846	490	2.084	"	(1,2)			
						Average				2.061	
						Std. Dev.					0.173
										SI Conversion	
										Ultimate Shear Strength (MPa)	
										16.17	
										13.03	
										13.87	
										13.62	
										14.37	
						Average				14.21	
						Std. Dev.					1.19

Remarks:
 (1) Specimens aged @ 140°F/5-100% R.H. to saturation.
 (2) Average weight gain = 2.22%

TABLE G.17
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 2, 93°C (200°F) WET

Test : Apparent Interlaminar Shear: ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation: Warp		
Material :	EA-9396 A/B: W133 Graphite	Batch #2	Task #7	Tested By: DH		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Ultimate
						Shear Strength (Ksi.)
BIL-GR-18-3	200°F (WET)	1.002	0.1787	2.846	565	2.366 12/7/89 (1,2)
BIL-GR-18-6	"	1.004	0.1816	2.846	538	2.212 " (1,2)
BIL-GR-18-9	"	1.002	0.1725	2.846	521	2.260 " (1,2)
BIL-GR-18-12	"	0.999	0.1832	2.846	541	2.215 " (1,2)
BIL-GR-18-15	"	1.000	0.1873	2.846	549	2.197 " (1,2)

Average 2.250
 Std. Dev. 0.069

Remarks:

- (1) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (2) Average weight gain = 2.32%

SI Conversion	
Ultimate Shear Strength (MPa)	
16.31	
15.25	
15.58	
15.27	
15.15	
Average	15.51
Std. Dev.	0.47

TABLE G.18
 INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR TEST RESULTS, BASELINE TESTS,
 GRAPHITE REINFORCEMENT, BATCH 3, 93°C (200°F) WET

Test : Apparent Interlaminar Shear; ASTM-D2344		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation: Warp				
Material : EA-9396 A/B; W133 Graphite		Batch #3	Task #7	Tested By: DH				
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Shear Strength (Ksi.)	Date Tested	Remarks
BIL-GR-19-3	"	0.999	0.1761	2.846	662	2.820	12/7/89	(1,2)
BIL-GR-19-6	"	1.002	0.1757	2.846	665	2.833	"	(1,2)
BIL-GR-19-9	"	1.000	0.1716	2.846	571	2.493	"	(1,2)
BIL-GR-19-12	"	1.001	0.1774	2.846	632	2.667	"	(1,2)
BIL-GR-19-15	"	1.002	0.1716	2.846	634	2.765	"	(1,2)
Average						2.716		
Std. Dev.						0.140		

Remarks:

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

(2) Average weight gain = 2.24%

SI Conversion	
Ultimate Shear Strength (MPa)	19.44
	19.53
	17.19
	18.39
	19.06
Average	18.72
Std. Dev.	0.97

APPENDIX H INDIVIDUAL SPECIMEN BEARING PROPERTIES, BASELINE

The four tables in this appendix present the detailed mechanical property test data measured during this program for each baseline specimen tested in bearing. A summary of these data was presented and discussed in Section 3.4.

TABLE H.1
INDIVIDUAL SPECIMEN BOLT-BEARING TEST RESULTS,
GLASS REINFORCEMENT, DRY CONDITION

Test :		Bolt-Bearing: ASTM-D953		Fiber Orientation : (0°±45°/90°)							
Material :		EA-9396 A/B; 7781 Glass		Tested by : PM							
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diameter (in.)	Load at 4% Hol Deform. (lbs.)	Maximum Bearing Strength (Ksi.)	% Elong. @ Max. Load (%)	Ultimate Load (lbs.)	% Elong. @ Ult. Load (%)	Date Tested	Remarks
BIL-GL-22-1	72°F (DRY)	1.498	0.0631	0.2515	660	41.59	56.71	12.80	900	12.00	7/14/89
BIL-GL-22-5	"	1.499	0.0649	0.2518	713	43.62	51.75	12.00	850	12.30	"
BIL-CL-22-7	"	1.498	0.0647	0.2517	686	42.11	56.23	11.00	920	11.38	"
Average						42.44	54.90	11.93			11.89
Std. Dev.						1.06	2.74	0.90			0.47

Remarks:

- (1) Type of failure:
 - a) tension.
 - b) shear-out
 - c) cleavage-tension.
 - d) bearing.

SI Conversion	
Maximum Bearing Strength (MPa)	
Bearing Strength (MPa)	286.8
Bearing Strength (MPa)	391.0
Bearing Strength (MPa)	300.8
Bearing Strength (MPa)	356.8
Bearing Strength (MPa)	290.3
Bearing Strength (MPa)	387.7
Average	292.6
Std. Dev.	7.3
Average	378.5
Std. Dev.	18.9

TABLE H.2
INDIVIDUAL SPECIMEN BOLT-BEARING TEST RESULTS,
GLASS REINFORCEMENT, WET CONDITION

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diameter (in.)	4% Hol Deform. (lbs.)	Maximum Load (lbs.)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	% Elong. @ Max. Load (%)	Fiber Orientation : (0°/±45°/90°)			
										Batch #1	Task #10	Tested by: PM	
BIL-GL-22-2	72°F (WET)	1.498	0.0651	0.2499	381	555	23.42	34.12	9.36	NA	NA	2/26/90	(1a,2,3)
BIL-GL-22-4	"	1.499	0.0645	0.2505	375	615	23.21	38.06	10.52	NA	NA	"	(1a,2,3)
BIL-GL-22-8	"	1.498	0.0640	0.2512	292	532	18.16	33.09	28.72	532	28.72	"	(1a,2,3)
							Average	21.60	35.09	16.20			
							Std. Dev.	2.98	2.63	10.86			

Remarks:

- (1) Type of failure:
 - a) tension.
 - b) shear-out
 - c) cleavage-tension.
 - d) bearing.
- (2) Specimens aged @ 140°F/95-100% R.H. for 148 days to saturation.
- (3) Average weight gain = 0.6418%

SI Conversion	
Bearing Strength (MPa)	161.5
Bearing Strength (MPa)	160.0
Bearing Strength (MPa)	125.2
Average	148.9
Std. Dev.	20.5
Maximum Bearing Strength (MPa)	235.2
Maximum Bearing Strength (MPa)	262.4
Maximum Bearing Strength (MPa)	228.2
Average	241.9
Std. Dev.	18.1

TABLE H.3
 INDIVIDUAL SPECIMEN BOLT-BEARING TEST RESULTS,
 GRAPHITE REINFORCEMENT, DRY CONDITION

Test :		Bolt-Bearing: ASTM-D953		Batch #1		Task #10		Fiber Orientation : (0°/±45°/90°) _s					
Material :		EA-9396 A/B ; W133 Graphite		Load at		Tested by : PM		% Elong.		% Elong.			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diameter (in.)	4% Hol Deform. (lbs.)	Maximum Load (lbs.)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	@ Max. Load (%)	Ultimate Load (lbs.)	@ Ult. Load (%)	Date Tested	Remarks
BIL-GR-43-1	72°F (DRY)	1.499	0.1154	0.2502	1,482	1,861	51.33	64.44	1.50	1,875	6.63	7/14/89	
BIL-GR-43-5	"	1.499	0.1232	0.2505	1,575	2,204	51.03	71.40	3.50	2,250	10.75	"	
BIL-GR-43-7	"	1.500	0.1196	0.2508	2,179	2,339	72.63	77.99	5.25	2,350	12.88	"	
Average						58.33		71.28	3.42	10.09			
Std. Dev.						12.38		6.77	1.88	3.18			

Remarks:

- (1) Type of failure:
 - a) tension.
 - b) shear-out
 - c) cleavage-tension.
 - d) bearing.

SI Conversion	
	Maximum
Bearing Strength (MPa)	444.3
Bearing Strength (MPa)	492.3
Bearing Strength (MPa)	537.7
Average	491.5
Std. Dev.	46.7

TABLE H.4
 INDIVIDUAL SPECIMEN BOLT-BEARING TEST RESULTS,
 GRAPHITE REINFORCEMENT, WET CONDITION

Test :		Bolt-Bearing; ASTM-D953										Fiber Orientation : (0°/±45°/90°) _s											
Material :		EA-9396 A/B		W133 Graphite		Batch #1		Task #10		Tested by : PM		% Elong.		Ultimate @ Ult.		Date Tested		Remarks					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Hole Diameter (in.)	4% Hol Deform. (lbs.)	Maximum Load (lbs.)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	Load (%)	Maximum Load (%)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	Load (%)	Maximum Load (%)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)	Load (%)	Maximum Load (%)	Bearing Strength (Ksi.)	Maximum Bearing Strength (Ksi.)			
BIL-GR-43-2	72°F (WET)	1.501	0.1224	0.2512	930	2,660	30.25	86.51	19.64	2,660	19.64	2,660	19.64	2,660	19.64	2,660	19.64	2,660	19.64	2,660	2/26/90	(1a,2,3)	
BIL-GR-43-4	"	1.500	0.1224	0.2509	1,040	2,750	33.87	89.55	22.32	2,700	22.32	2,700	23.20	2,700	23.20	2,700	23.20	2,700	23.20	2,700	"	(1a,2,3)	
BIL-GR-43-6	"	1.499	0.1209	0.2510	1,125	2,760	37.07	90.95	20.28	2,725	20.28	2,725	22.08	2,725	22.08	2,725	22.08	2,725	22.08	2,725	"	(1a,2,3)	
Average										33.73		89.00		20.75		21.64		20.75					
Std. Dev.										3.41		2.27		1.40		1.82		1.40					

Remarks:

- (1) Type of failure:
 - a) tension.
 - b) shear-out
 - c) cleavage-tension.
 - d) bearing.
- (2) Specimens aged @ 140°F/95-100% R.H. for 148 days to saturation.
- (3) Average weight gain = 0.6129%

SI Conversion	
Maximum Bearing Strength (MPa)	
208.6	596.5
233.5	617.4
255.6	627.1
Average	613.7
Std. Dev.	15.6

APPENDIX I INDIVIDUAL SPECIMEN GLASS TRANSITION TEMPERATURE MEASUREMENTS

This appendix presents the results of the glass transition temperature (T_g) measurements on each individual specimen. The specimens were in the form of neat resin castings with approximate dimensions of 22 x 13 x 2 mm (7/8 x 1/2 x 1/16 inch). The measurements were performed by dynamic mechanical analysis (DMA) at a heating rate of 0.5°C/minute. Glass transition temperature was taken from the peak of the log E'' (loss modulus) vs. temperature curve. The tests were performed on a DuPont Model 983 DMA. Table I.1 summarizes the individual results and Figures I.1-I.18 illustrate the DMA curves for each specimen. The curves for specimen Nos. 1-2 (I.1) and 1-1 (I.10) are labelled to indicate the location at which the T_g was identified for the dry and wet test conditions.

TABLE I.1
 INDIVIDUAL SPECIMEN GLASS TRANSITION TEMPERATURE

Specimen Number	Batch Number	Test Condition	Wt. Gain (%) (1)	Glass Transition Temp.(2)	
				(°C)	(°F)
1-2	1	Dry	N.A.	174	345
1-4	1	Dry	N.A.	176	349
1-6	1	Dry	N.A.	175	347
Avg.				175	347
Std. Dev.				1.0	2.0
2-2	2	Dry	N.A.	176	349
2-4	2	Dry	N.A.	176	349
2-6	2	Dry	N.A.	177	351
Avg.				176	350
Std. Dev.				0.6	1.0
3-2	3	Dry	N.A.	177	351
3-4	3	Dry	N.A.	178	352
3-6	3	Dry	N.A.	176	349
Avg.				177	351
Std. Dev.				1.0	1.5
1-1	1	Wet	9.2	107	225
1-3	1	Wet	9.1	106	223
1-5	1	Wet	9.1	106	223
Avg.				106	224
Std. Dev.				0.6	1.0
2-1	2	Wet	8.7	108	226
2-3	2	Wet	8.6	111	
2-5	2	Wet	8.9	106	223
Avg.				108	227
Std. Dev.				2.5	4.6
3-1	3	Wet	8.8	109	228
3-3	3	Wet	8.9	107	225
3-5	3	Wet	8.7	105	221
Avg.				107	225
Std. Dev.				2.0	3.5

NOTES: (1) After aging at 60°C (140°F) and 95-100% R.H. until saturated.
 (2) Specimens cured for 45 minutes at 93°C (200°F).

Sample : EA 9396 1-2 DRY
 Size : 21.81 x 13.50 x 2.11 mm
 Method : DMA-STEP 2°
 Comments: STEP 2°C

DMA

File : E: RUN1880.01
 Operator: GALASKA
 Run Date: 06/08/89 10:53

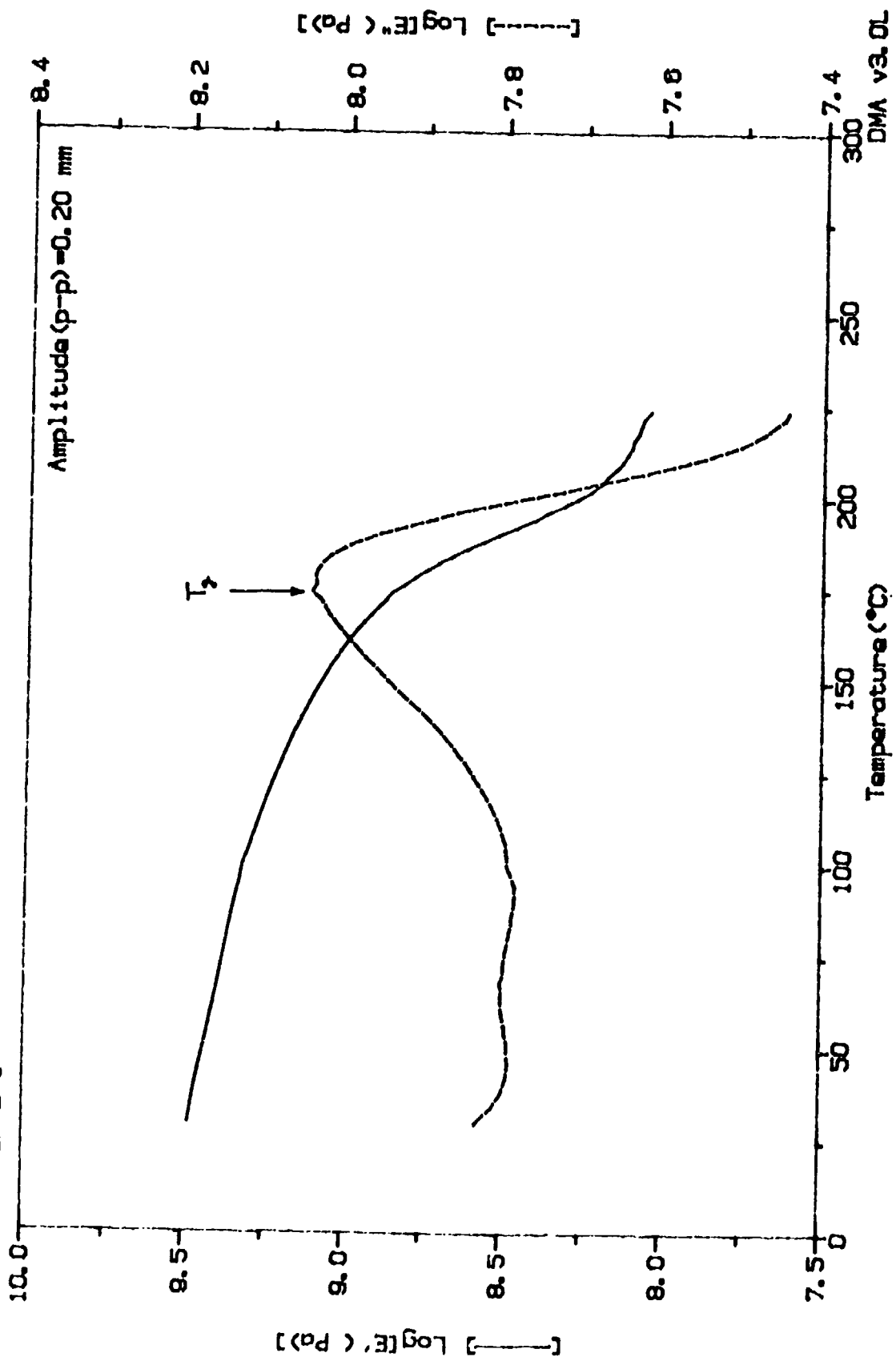


Figure I.1. Determination of Tg for Specimen 1-2, Batch 1, Dry Condition.

File : E: RUN1881.02
 Operator: GALASKA
 Run Date: 08/12/89 10:28

DMA

Sample : EA 9398 1-4 DRY
 Size : 22.05 x 13.77 x 2.15 mm
 Method : DMA-STEP 2°
 Comments: STEP 2°C

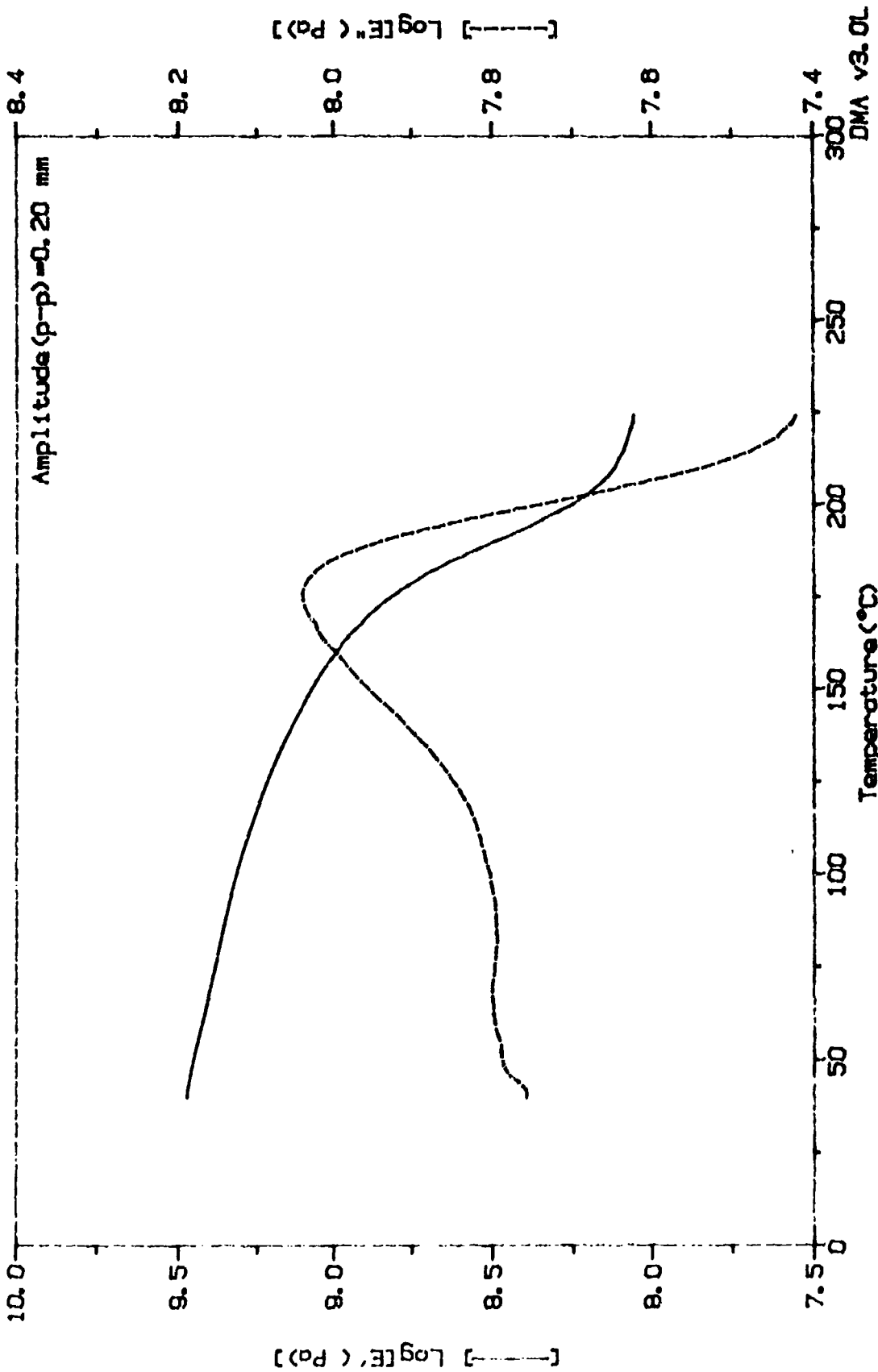


Figure 1.2. Determination of Tg for Specimen 1-4, Batch 1, Dry Condition.

Sample : EA 8398 1-6 DRY
 Size : 22.18 x 12.80 x 2.15 mm
 Method : DMA-STEP 2°
 Comments : STEP 2°C
 File : E: RUN1882.01
 Operator: GALASKA
 Run Date: 06/13/88 07:41
DMA

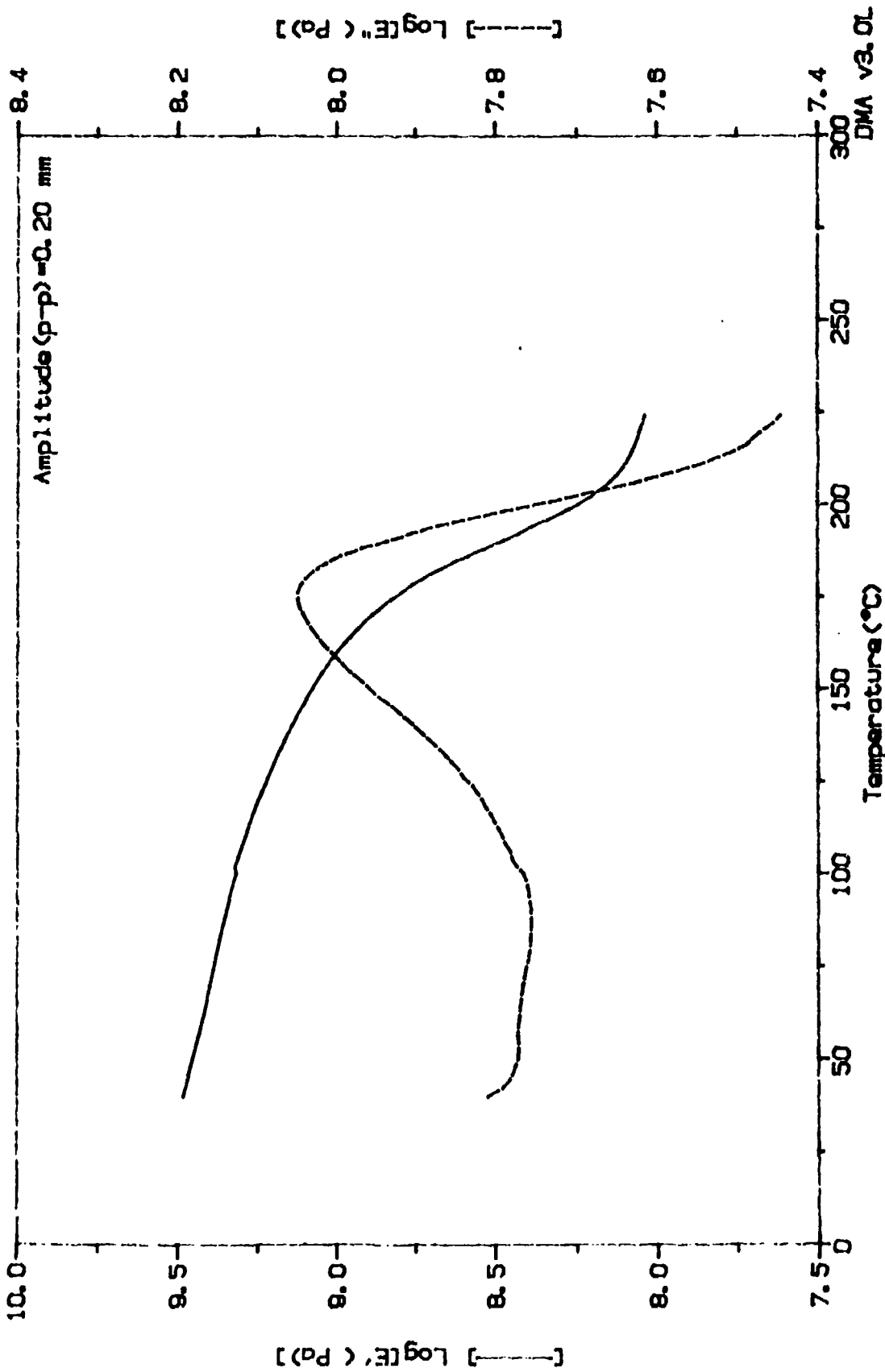


Figure 1.3. Determination of Tg for Specimen 1-6, Batch 1, Dry Condition.

Sample : SA 9396 2-2 DRY
Size : 22.70 x 13.90 x 1.85 mm
Method : DMA-STEP 2°
Comment: STEP 2°C

File : E: RUN1883.01
Operator: GALASKA
Run Date: 06/13/89 16:05

DMA

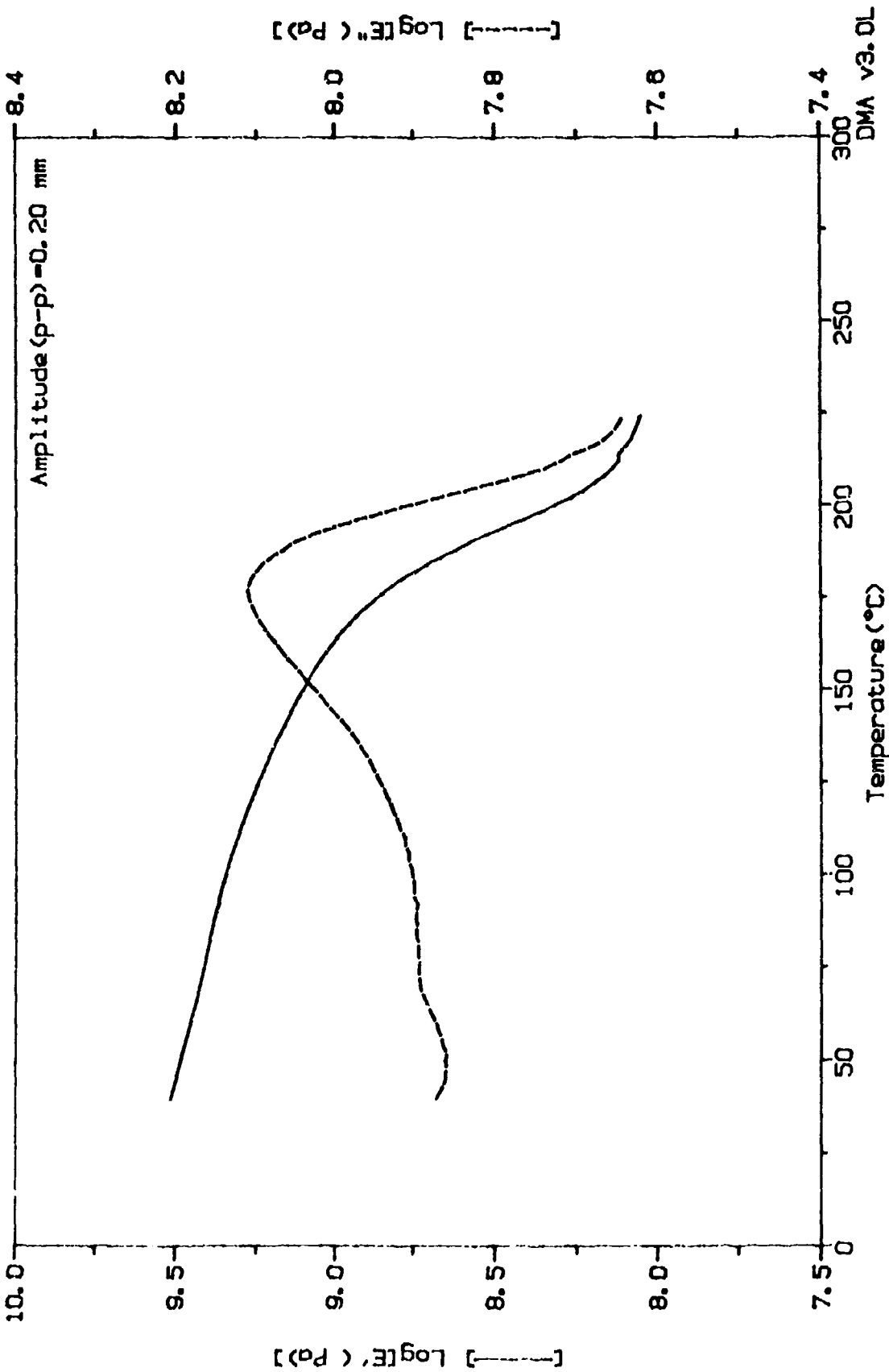


Figure I.4. Determination of Tg for Specimen 2-2, Batch 2, Dry Condition.

Sample : EA 9396 2-4 DRY
 Size : 22.89 x 14.01 x 2.00 mm
 Method : DMA-STEP 2°
 Comments : STEP 2°C

DMA

File : E:\RUN1884.01
 Operator: GALASKA
 Run Date: 06/14/89 07:28

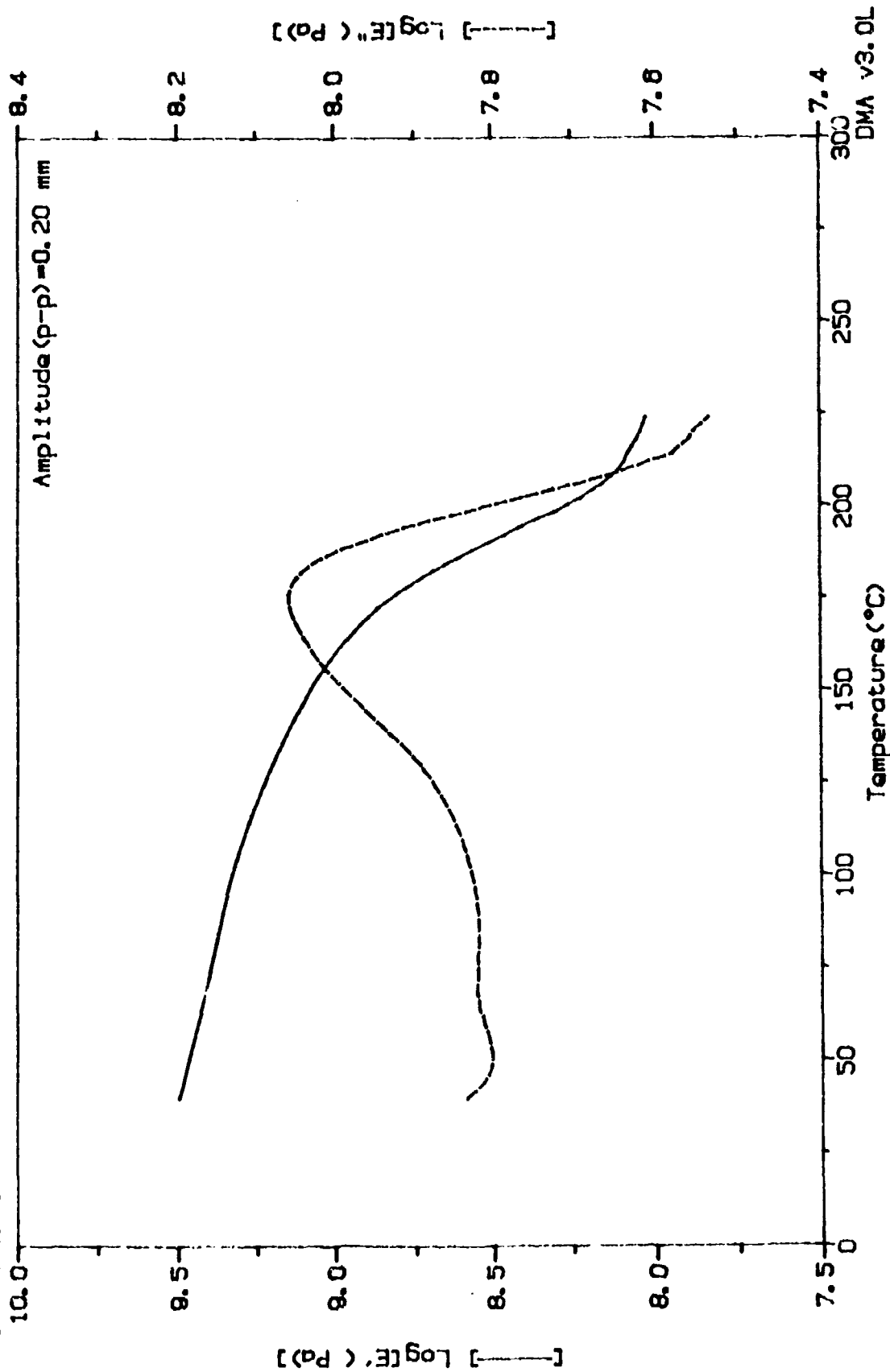


Figure 1.5. Determination of Tg for Specimen 2-4, Batch 2, Dry Condition.

File : E: RUN1885.01
 Operator: GALASKA
 Run Date: 08/14/89 15:45

DMA

Sample : EA 9398 2-6 DRY
 Size : 23.18 x 13.17 x 1.95 mm
 Method : DMA-STEP 2°
 Comment: STEP 2°C

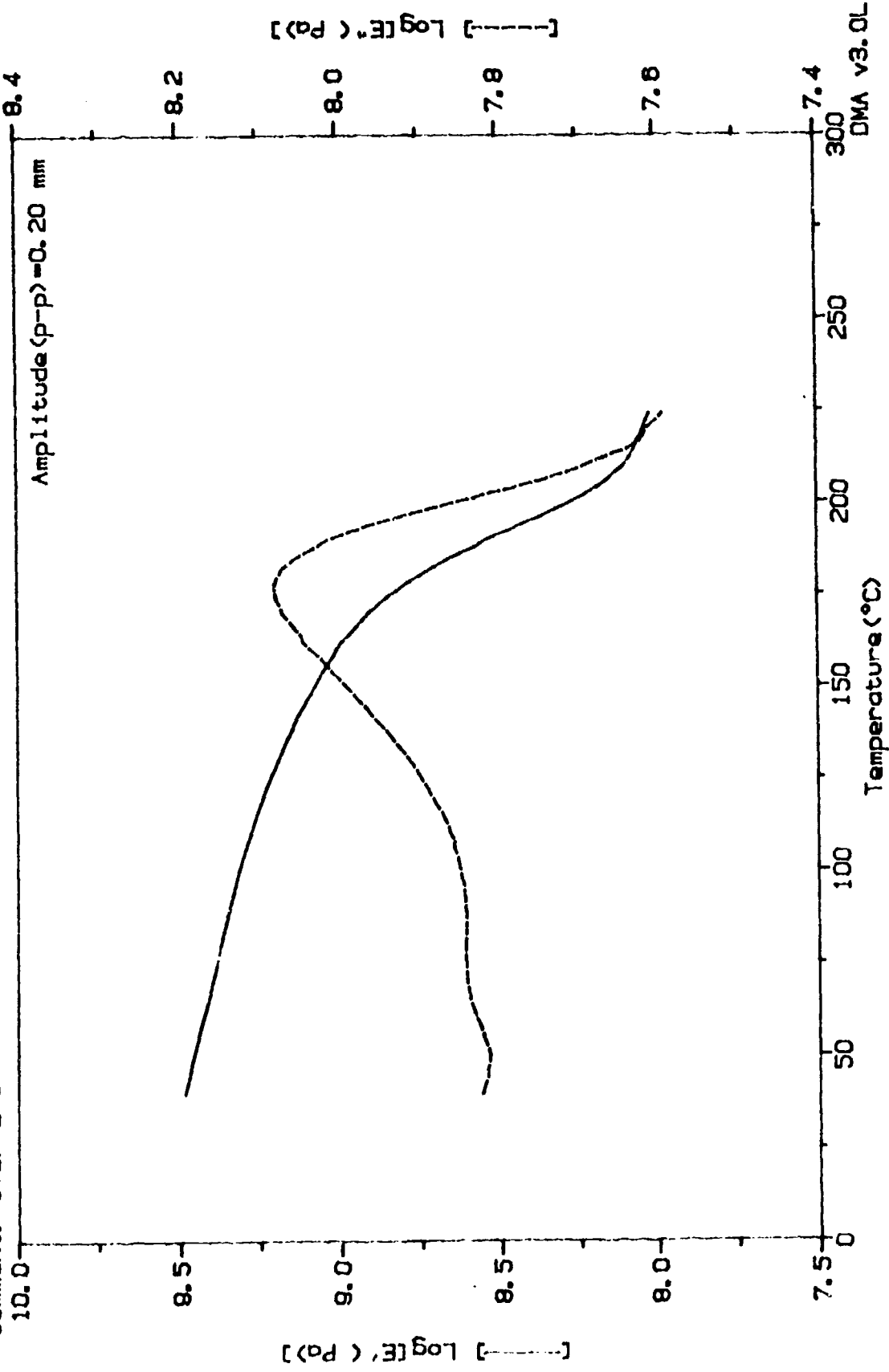


Figure 1.6. Determination of Tg for Specimen 2-6, Batch 2, Dry Condition.

Sample : EA 9396 3-2 DRY
 Size : 23.59 x 14.68 x 1.94 mm
 Method : DMA-STEP 2°
 Comment: STEP 2°C
 File : E1 RUN1888.01
 Operator: GALASKA
 Run Date: 06/15/89 07:27
DMA

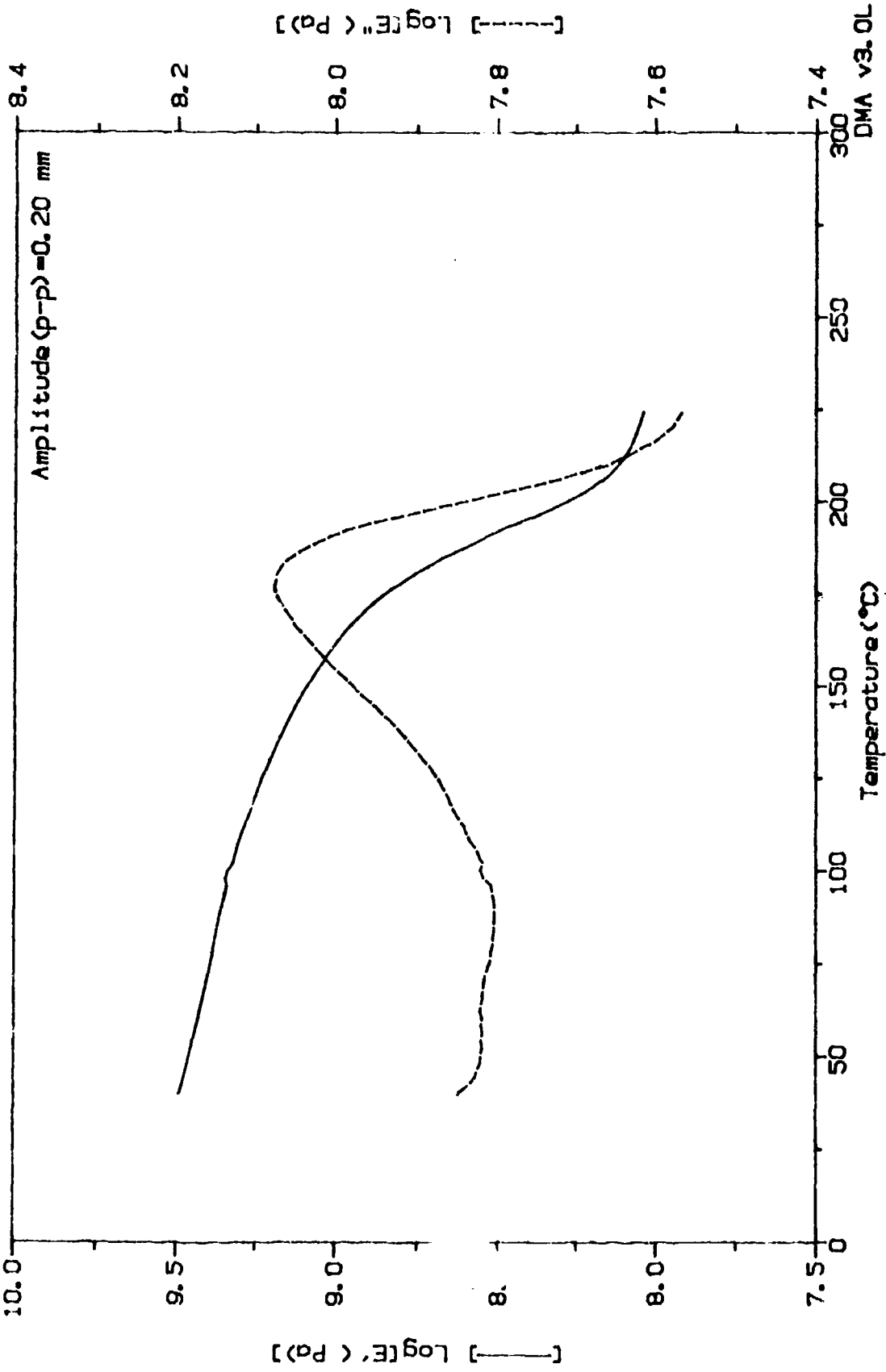


Figure 1.7. Determination of Tg for Specimen 3-2, Batch 3, Dry Condition.

Sample : EA 9396 3-4 DRY
 Size : 23.86 x 11.79 x 2.01 mm
 Method : DMA-STEP 2°
 Comment: STEP 2°C

DMA

File : E: RUN1887.01
 Operator: GALASKA
 Run Date: 06/15/89 15:08

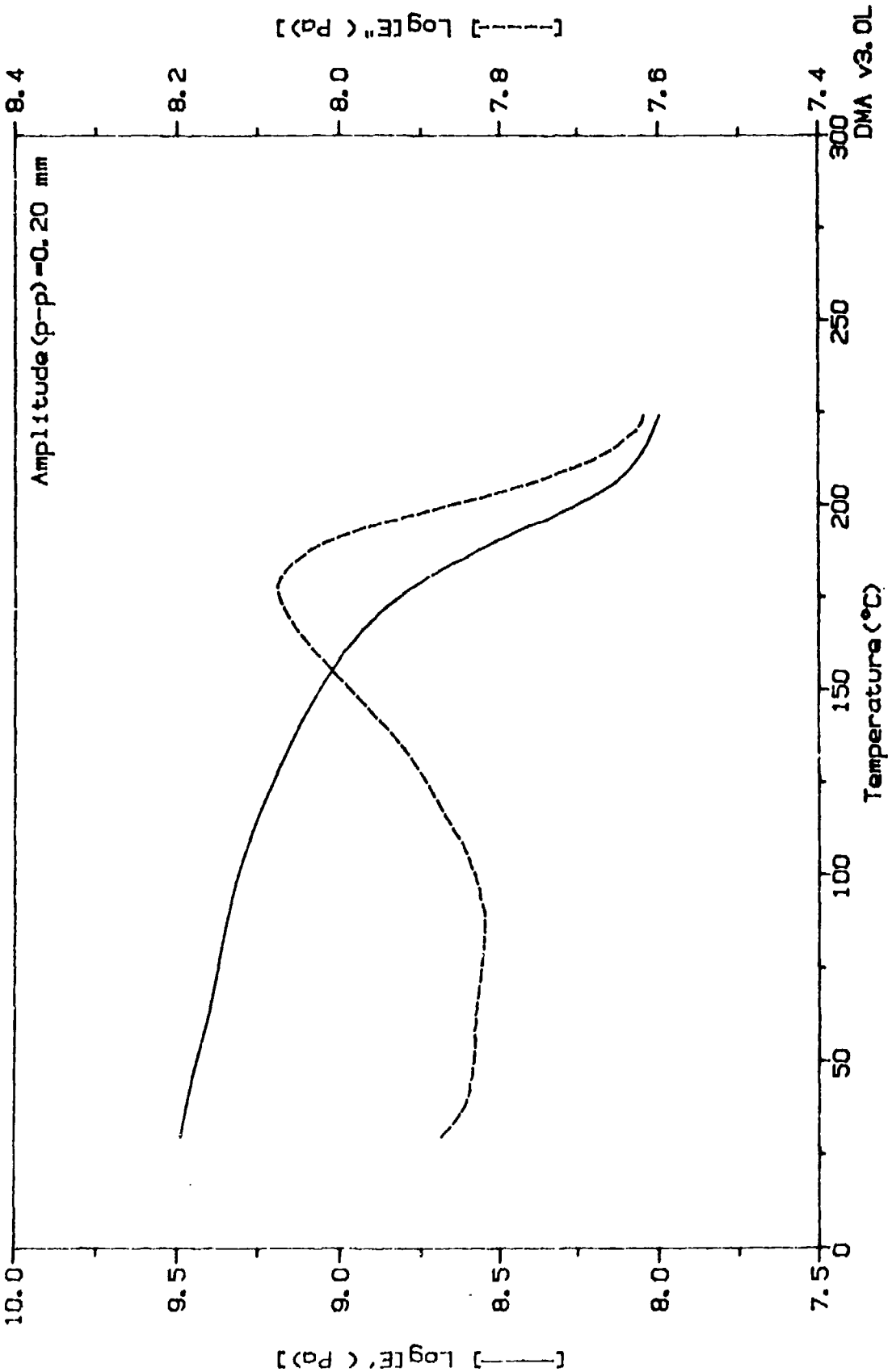


Figure 1.8. Determination of Tg for Specimen 3-4, Batch 3, Dry Condition.

Sample : EA 9396 3-6 DRY
 Size : 24.21 x 13.75 x 2.97 mm
 Method : DMA-STEP 2°
 Comments : STEP 2°C

File : E:RUN1888.01
 Operator: WEISSMAN
 Run Date: 08/16/89 07:46

DMA

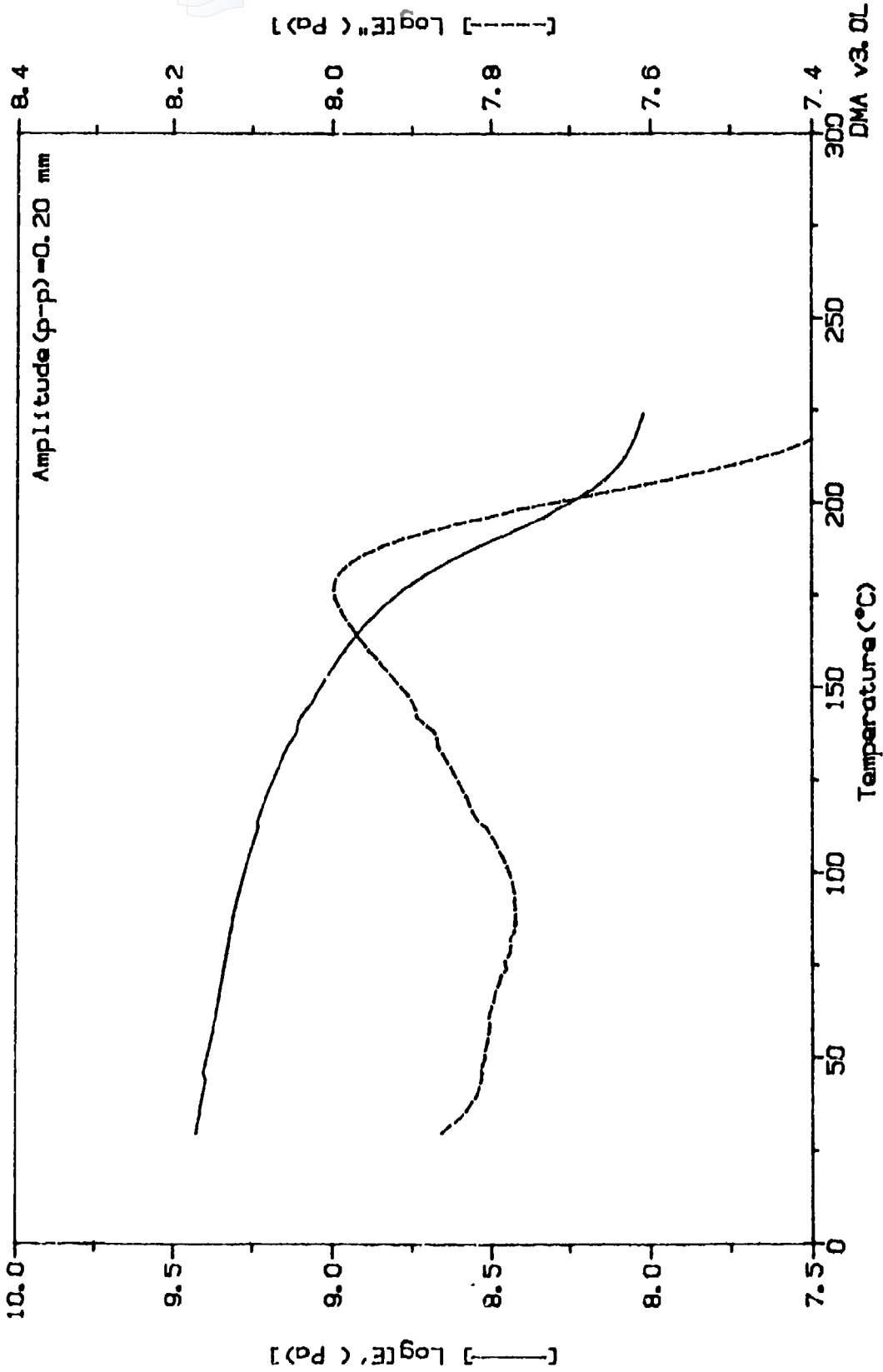


Figure I.9. Determination of Tg for Specimen 3-6, Batch 3, Dry Condition.

File : E: RUN1917.01
 Operator: GALASKA
 Run Date: 07/20/89 14:09

DMA

Sample : EA 9398 1-1 WET
 Size : 24.40 x 13.77 x 2.21 mm
 Method : DMA-STEP 2°
 Comments : 2°C/STEP, NIT

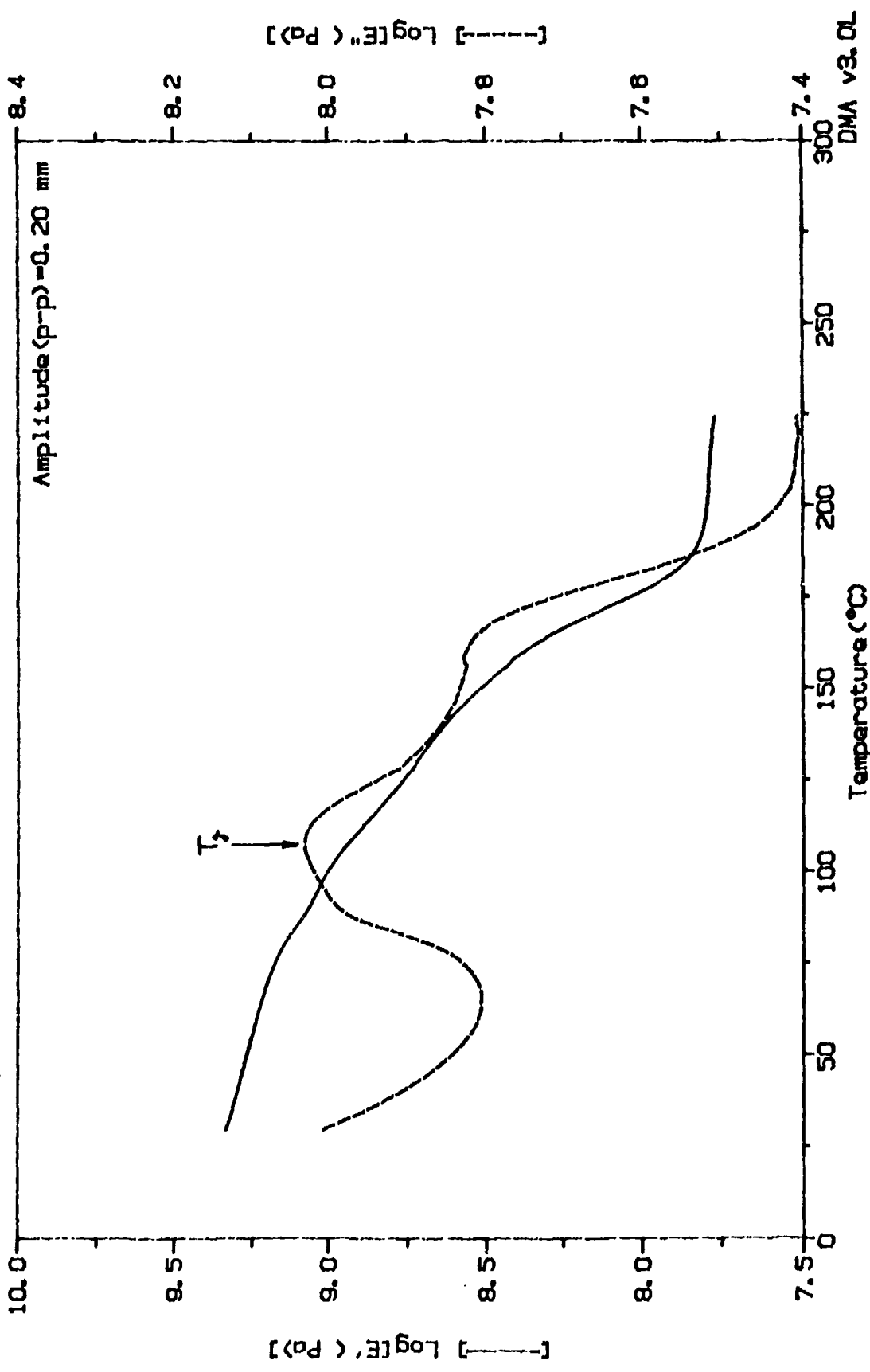


Figure 1.10. Determination of Tg for Specimen 1-1, Batch 1, Wet Condition.

File : E1 RUN1918.01
 Operator: GALASKA
 Run Date: 07/21/89 08:26

DMA

Sample : EA 9398 1-3 WET
 Size : 24.61 x 13.42 x 2.25 mm
 Method : DMA-STEP 2°
 Comments : 2°C/STEP, NIT

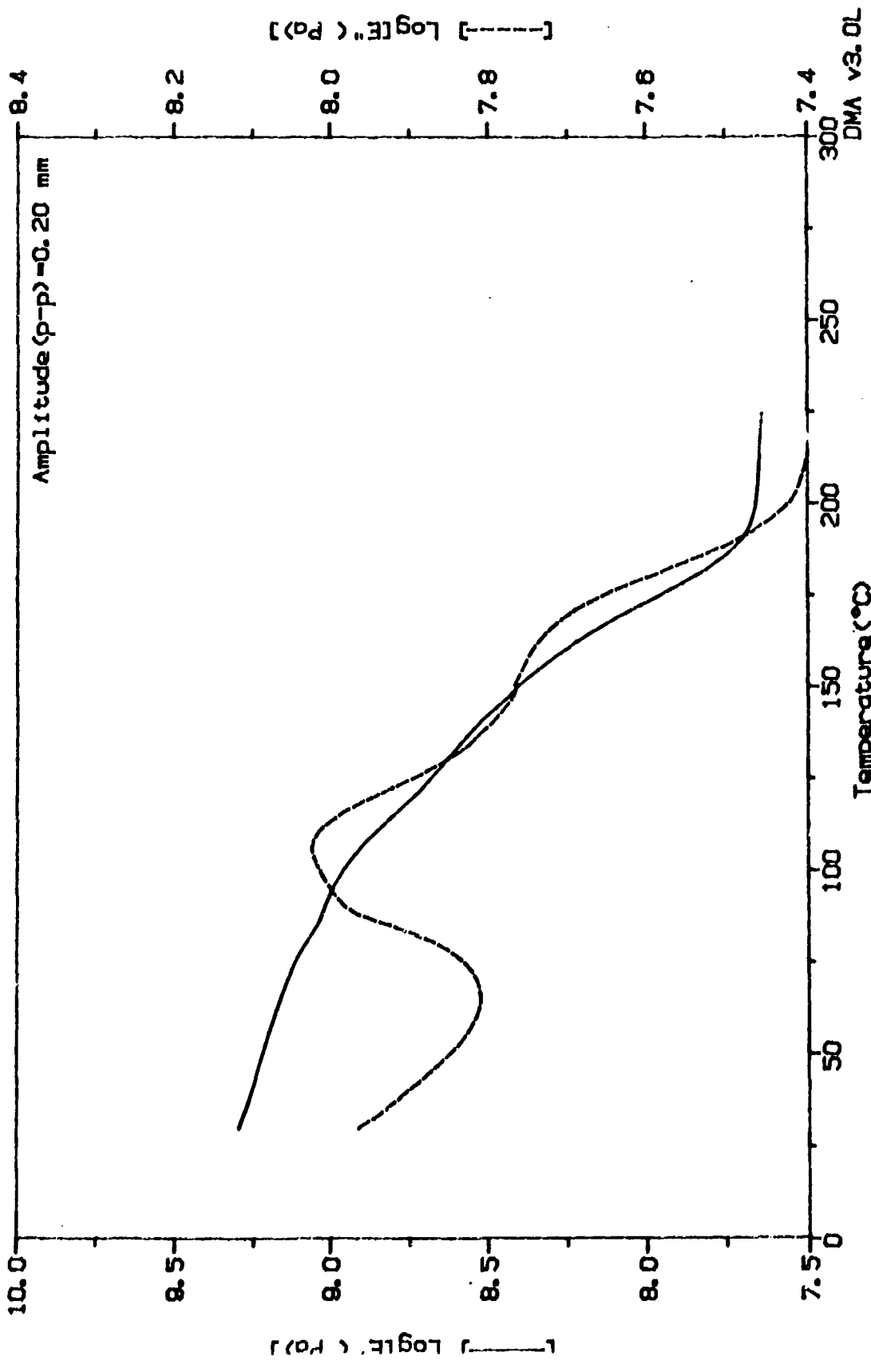


Figure I.11. Determination of Tg for Specimen 1-3, Batch 1, Wet Condition.

Sample : EA 9398 1-5 WET
 Size : 24.87 x 13.42 x 2.23 mm
 Method : DMA-STEP 2°
 Comments : 2°C/STEP, NIT

File : E:RUN1920.01
 Operator: GALASKA
 Run Date: 07/24/89 10:19

DMA

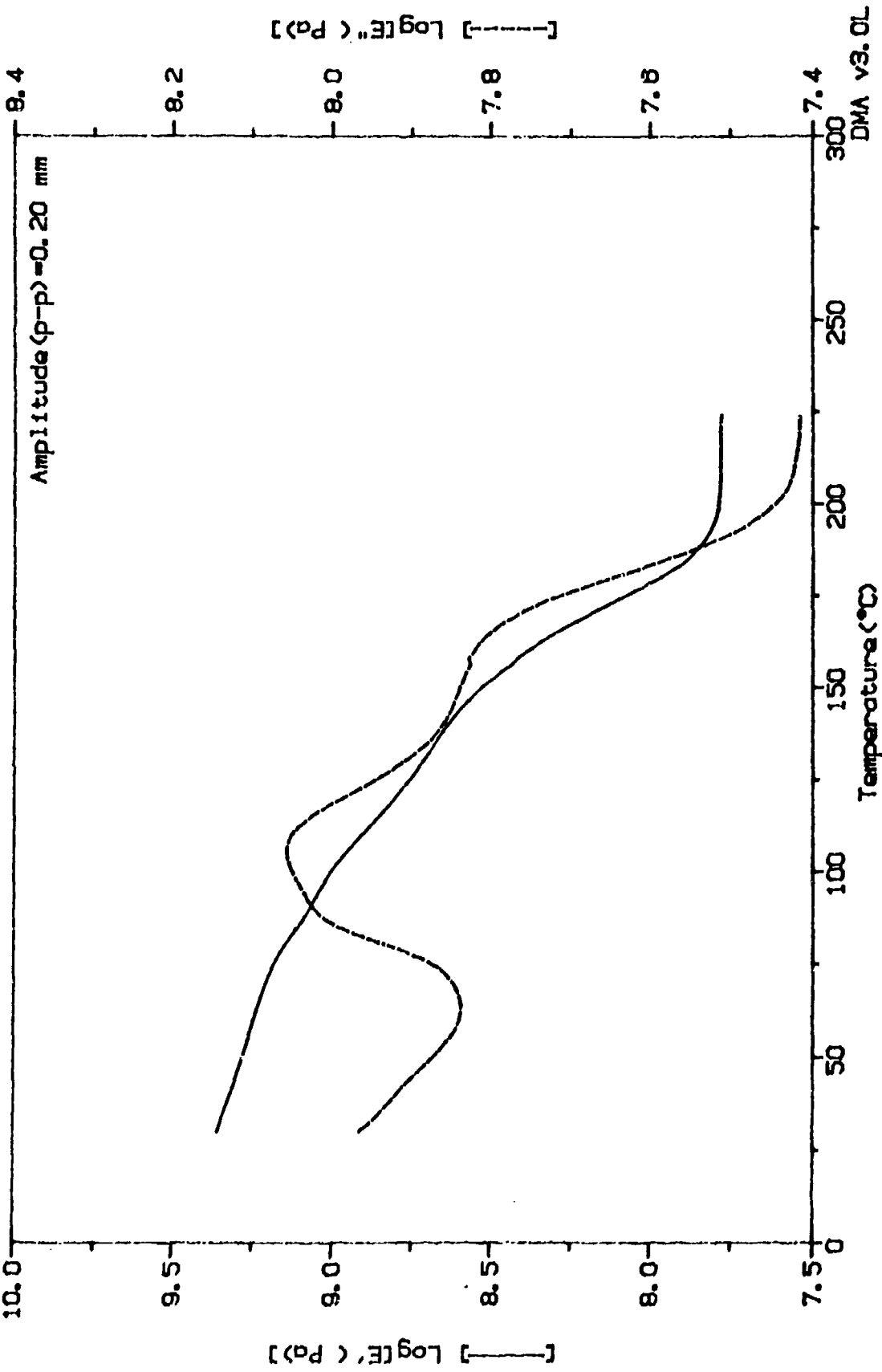


Figure I.12. Determination of Tg for Specimen 1-5, Batch 1, Wet Condition.

Sample : EA 9398 2-1 WET
 Size : 25.10 x 14.18 x 1.93 mm
 Method : DMA-STEP 2°
 Comments : 2°C/STEP, NIT

File : E:RUN1921.01
 Operator: GALASKA
 Run Date: 07/25/89 08:20

DMA

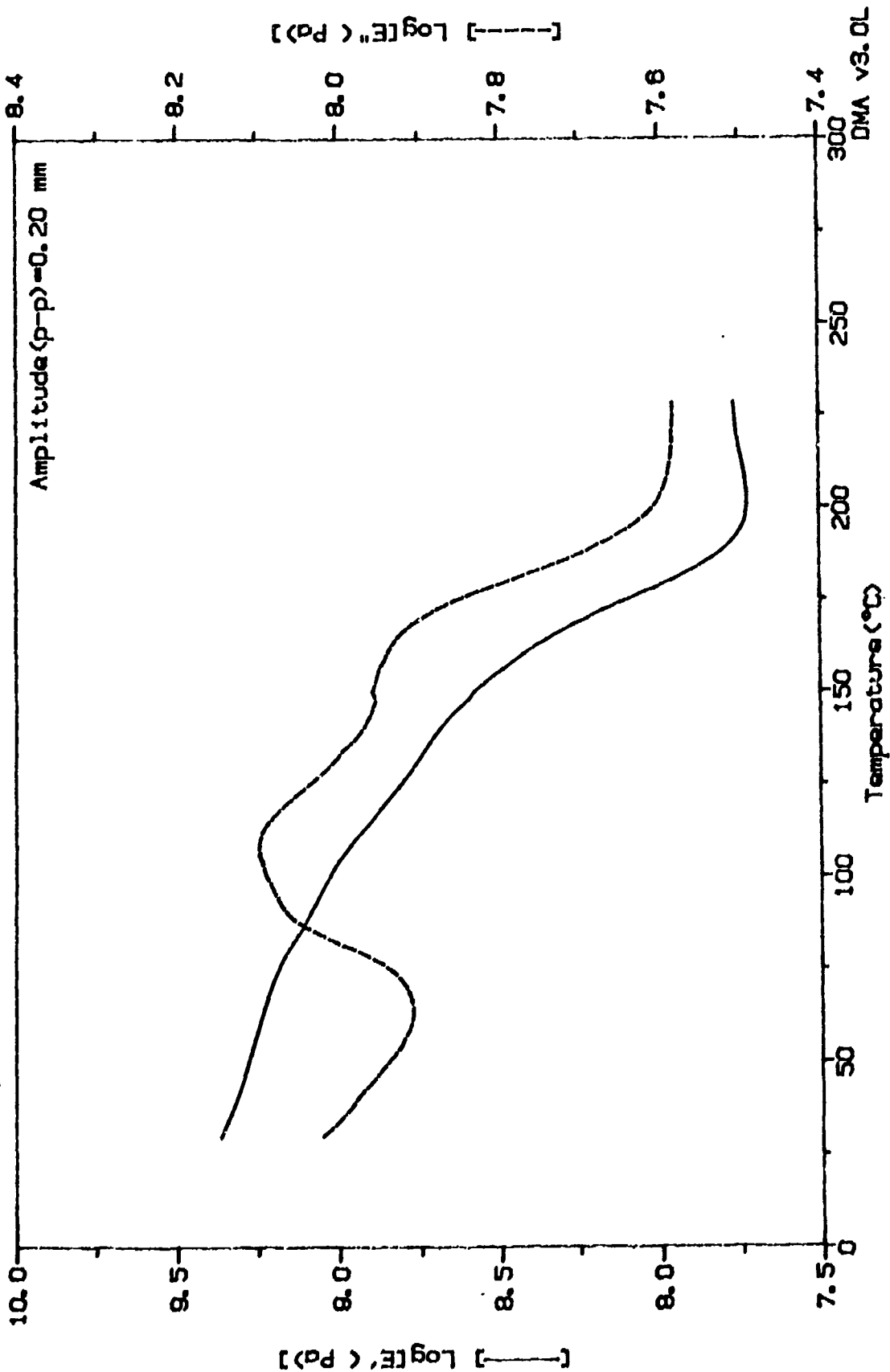


Figure I.13. Determination of Tg for Specimen 2-1, Batch 2, Wet Condition.

Sample : EA 9398 2-3 WET
 Size : 25.32 x 13.96 x 1.92 mm
 Method : DMA-STEP 2°
 Comments : 2°C/STEP,NIT
 File : E:RUN1922.01
 Operator: GALASKA
 Run Date: 07/25/89 16:15
DMA
 Amplitude (p-p) = 0.20 mm

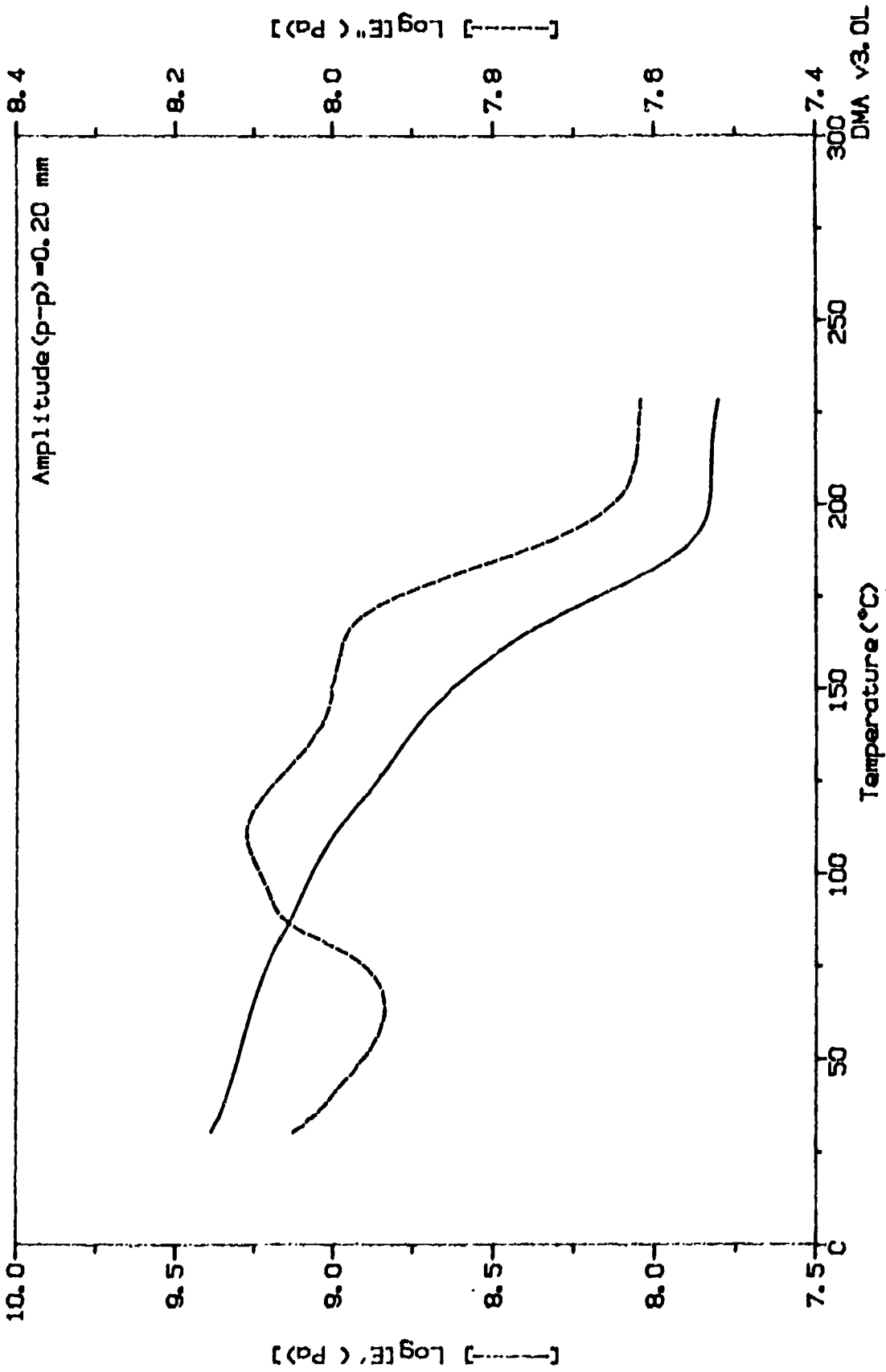


Figure I.14. Determination of Tg for Specimen 2-3, Batch 2, Wet Condition.

File : E, RUN1923.01
Operator: GALASKA
Run Dates: 07/26/89 08, 27

DMA

Sample : EA 9398 2-5 WET
Size : 25.52 x 13.60 x 2.03 mm
Method : DMA-STEP 2°
Comments : 2°C/STEP. NIT

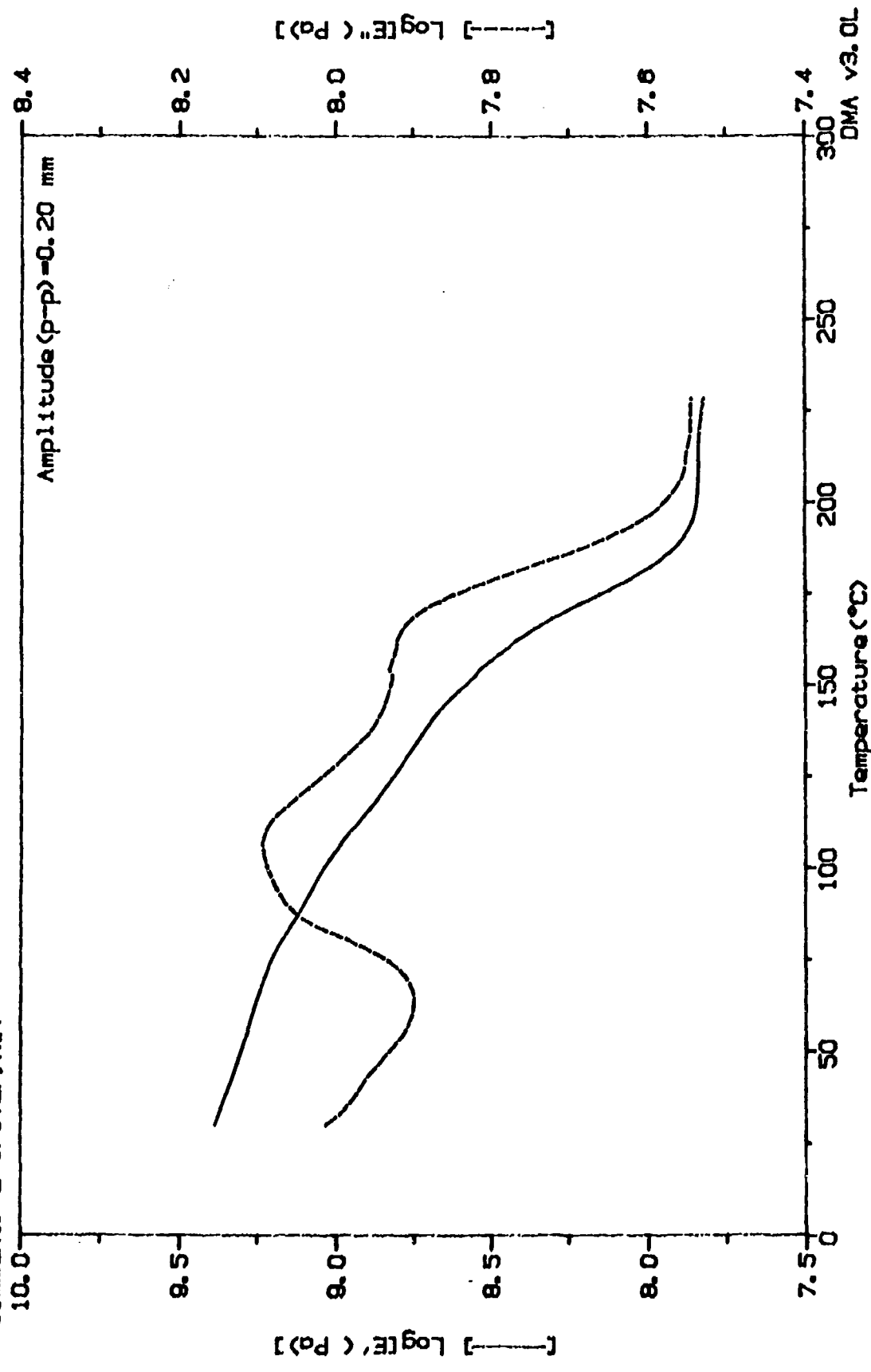


Figure I.15. Determination of Tg for Specimen 2-5, Batch 2, Wet Condition.

Sample : EA 9398 3-1 WET
Size : 25.67 x 13.58 x 1.94 mm
Method : DMA-STEP 2°
Comments : 2°C/STEP.NIT

File : E:RUN1924.01
Operator: GALASKA
Run Date: 07/27/89 08:24

DMA

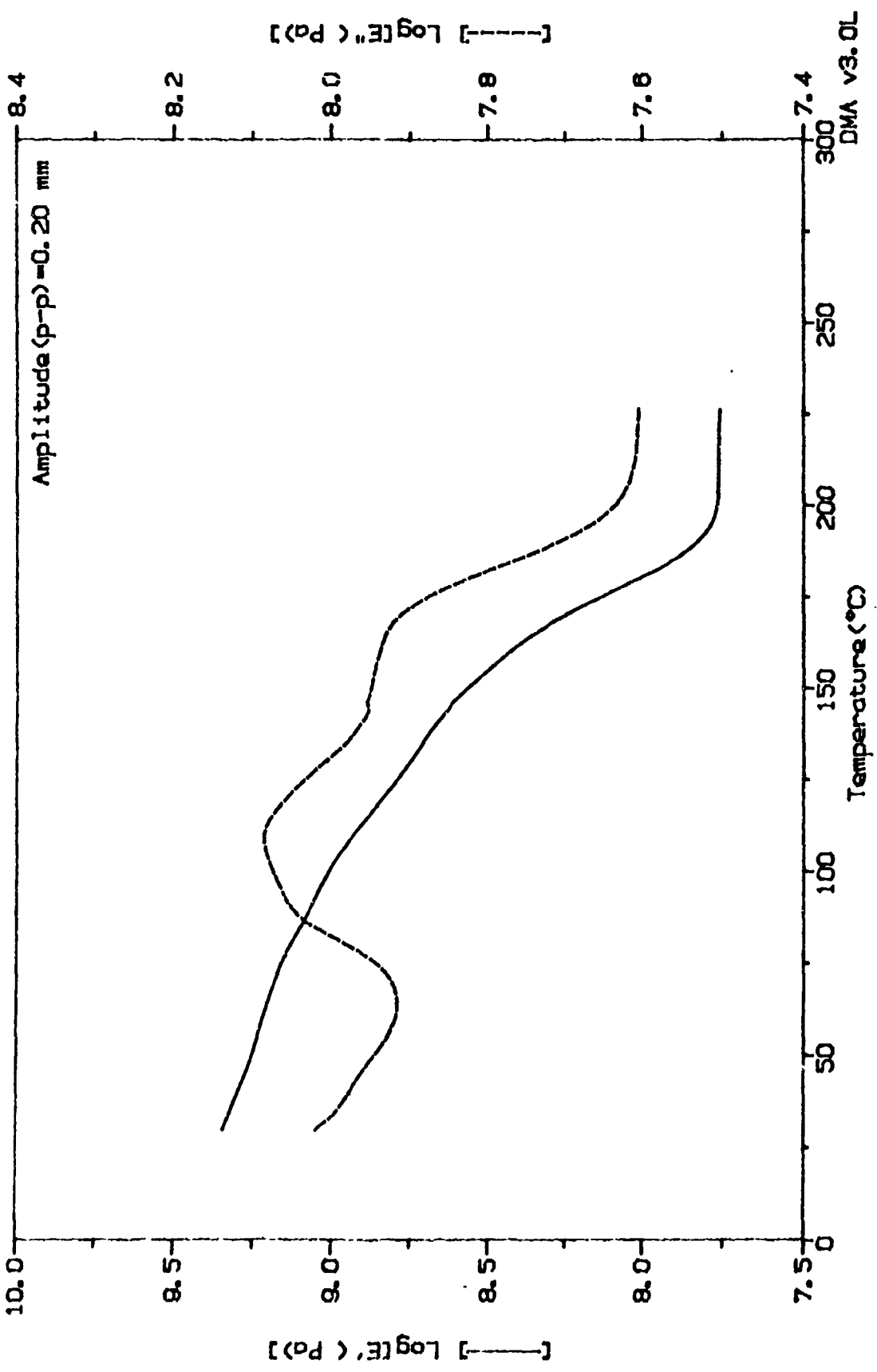


Figure I.16. Determination of Tg for Specimen 3-1, Batch 3, Wet Condition.

Sample : EA 9398 3-3 WET
 Size : 24.37 x 14.76 x 2.13 mm
 Method : DMA-STEP 2°
 Comments : 2°C/STEP, NIT
 File : E, RUN1925.01
 Operator: GALASKA
 Run Date: 07/27/89 16:25
DMA

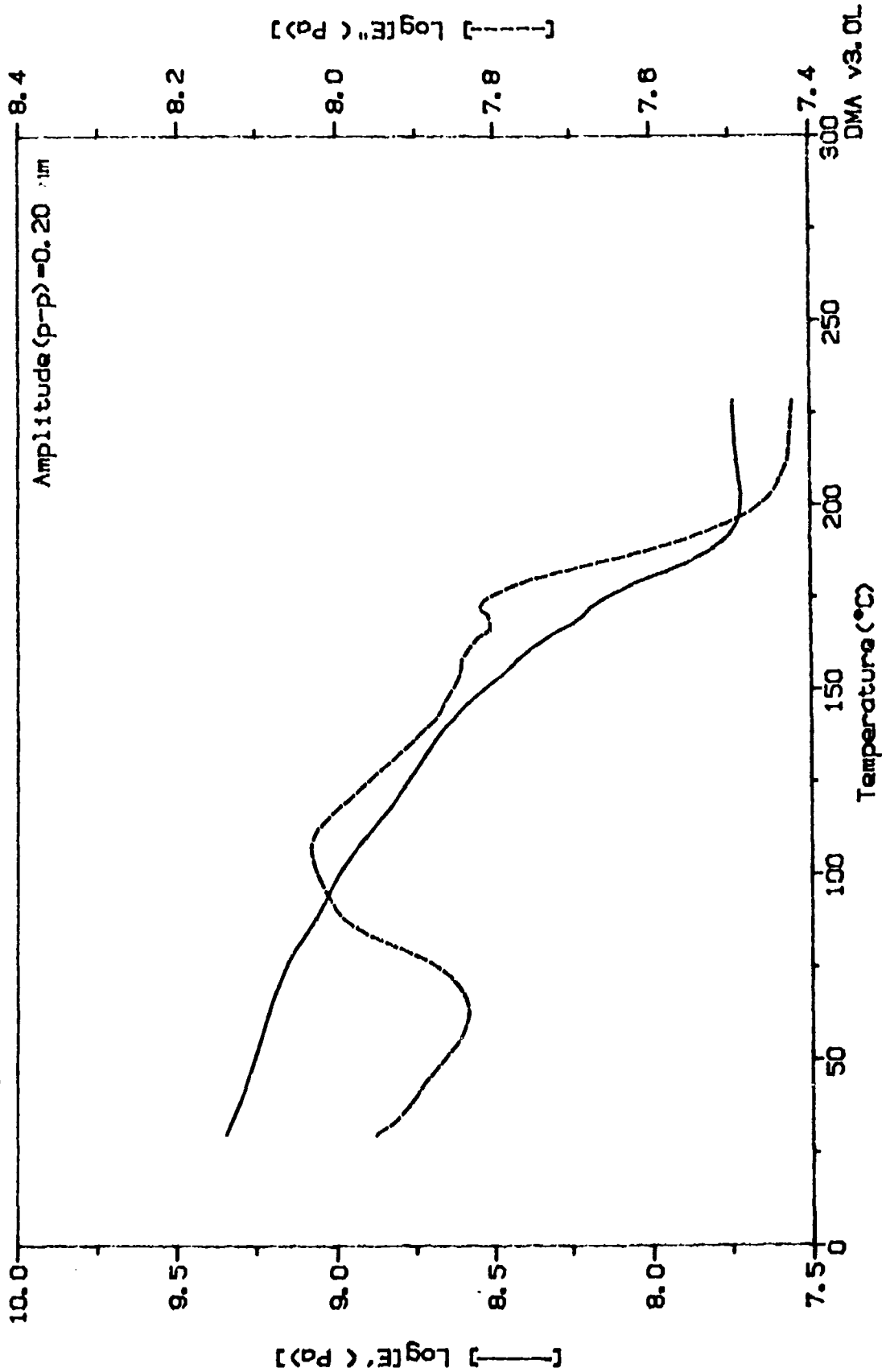


Figure I.17. Determination of Tg for Specimen 3-3, Batch 3, Wet Condition.

File : E, RUN1926. 01
 Operator: GALASKA
 Run Date: 07/31/89 08:38

DMA

Sample : EA 9396 3-5 WET
 Size : 24.80 x 14.80 x 2.38 mm
 Method : DMA-STEP 2°
 Comments : 2°C/STEP, NIT

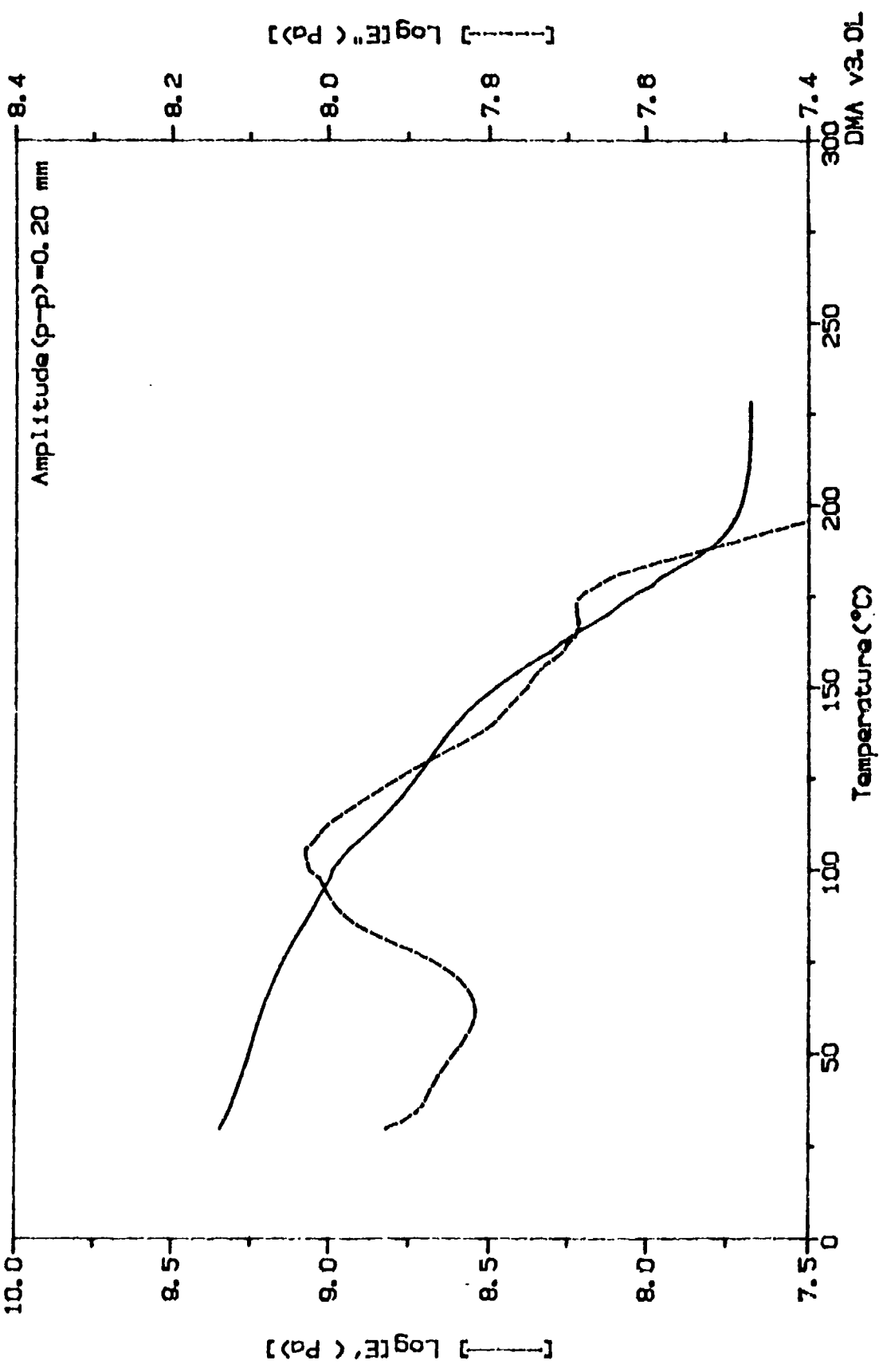


Figure I.18. Determination of Tg for Specimen 3-5, Batch 3, Wet Condition.

APPENDIX J
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR
STRENGTHS, EFFECT OF CURE TIME/TEMPERATURE/
PRESSURE VARIATIONS

The six tables in this appendix present the detailed interlaminar shear strength data for specimens prepared with nonstandard cure schedules. These nonstandard cure schedules involved curing at temperatures and vacuum pressures both above and below the baseline levels of 93°C (200°F) and 635 mm (25 in.) Hg, respectively, or for other than the standard cure time of 45 minutes. A summary of these data was presented and discussed in Section 3.5.2.

TABLE J.1
 EFFECT OF CURE VACUUM PRESSURE ON INTERLAMINAR SHEAR STRENGTH OF
 GLASS REINFORCED EA9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp	
Material :		EA-9396 A/B; 7781 Glass		Batch #4		Task #17		Tested By: DH	
Specimen Number	Cure Pressure (1) (in. g. Vac.)	Width (in.)	Thickness (in.)	Span (in.)	Maximum		Date Tested	Remarks	
					Load (lbs.)	Interlaminar Shear Strength (Ksi.)			
BIL-GL-27-A	10	0.500	0.1360	1.088	435	4.798	33.08	12/11/89	
BIL-GL-27-C	"	0.750	0.1340	1.072	500	4.478	30.87	"	
					Average	4.638	31.98		
					Std. Dev.	0.226	1.56		
BIL-GL-28-1	16	1.003	0.1292	1.050	888	5.139	35.44	10/26/89	
BIL-GL-28-3	"	1.003	0.1328	1.050	925	5.208	35.91	"	
					Average	5.174	35.67		
					Std. Dev.	0.049	0.34		
BIL-GL-29-1	23	1.002	0.1281	1.030	801	4.680	32.27	10/31/89	
BIL-GL-29-3	"	1.002	0.1290	1.030	832	4.828	33.29	"	
BIL-GL-29-C	"	0.500	0.1300	1.040	379	4.373	30.15	12/11/89	
					Average	4.627	31.90		
					Std. Dev.	0.232	1.60		
BIL-GL-38-1	27	0.997	0.1212	0.978	922	5.723	39.46	12/4/89	
BIL-GL-38-3	"	0.997	0.1224	0.978	917	5.636	38.86	"	
BIL-GL-38-5	"	0.996	0.1211	0.978	1,039	6.461	44.55	"	
					Average	5.940	40.95		
					Std. Dev.	0.453	3.13		

(1) All cures were at 93°C (200°F) for 45 minutes.

TABLE J.2
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
 COMPOSITE LAMINATES CURED 45 MINUTES AT 107°C (225°F)

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp			
Material :		EA-9396 A/B, W133 Graphite				Task #16		Tested By: TOB			
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks	
BIL-GR-5-1	45 min. @ 107°C (225°F)	22°C (72°F) (DRY)	0.997	0.1732	2.800	1,448	6.289	43.36	1/23/89		
BIL-GR-5-3	"	"	1.000	0.1743	2.800	1,496	6.437	44.38	"		
BIL-GR-5-5	"	"	0.995	0.1681	2.800	1,340	6.007	41.42	"		
BIL-GR-5-7	"	"	0.998	0.1739	2.800	1,386	5.993	41.32	"		
BIL-GR-5-9	"	"	1.000	0.1717	2.800	1,348	5.889	40.61	"		
							Average	6.123	42.22		
							Std. Dev.	0.230	1.58		
BIL-GR-5-2	45 min. @ 107°C (225°F)	22°C (72°F) (WET)	0.997	0.1741	2.800	1,107	4.783	32.98	5/25/89		
BIL-GR-5-4	"	"	0.997	0.1704	2.800	1,028	4.538	31.29	"		
BIL-GR-5-6	"	"	0.996	0.1740	2.800	992	4.255	29.62	"		
BIL-GR-5-8	"	"	1.000	0.1740	2.800	1,093	4.713	32.49	"		
BIL-GR-5-10	"	"	0.996	0.1681	2.800	977	4.376	30.17	"		
							Average	4.541	31.31		
							Std. Dev.	0.210	1.44		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
 (2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.3
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
 COMPOSITE LAMINATES CURED 30 MINUTES AT 93°C (200°F)

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 8/1)				Specimen Orientation: Warp	
Material :		EA-9396 A/B; W133 Graphite				Task #16				Tested By: TOB	
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Shear Strength (MPa)	Date Tested	Remarks	
BIL-GR-1-5	30 min. @ 22°C (72°F) (DRY)	"	1.000	0.1809	2.800	1,526	6.325	43.61	1/23/89		
BIL-GR-1-9	93°C (200°F)	"	0.998	0.1759	2.800	1,420	6.065	41.82	"		
BIL-GR-1-14	"	"	0.998	0.1807	2.800	1,508	6.271	43.24	"		
							Average	6.220	42.89		
							Std. Dev.	0.137	0.94		
BIL-GR-1-1	30 min. @ 22°C (72°F) (WET)	"	1.001	0.1758	2.816	1,089	4.640	32.00	4/24/89		
BIL-GR-1-7	93°C (200°F)	"	1.001	0.1804	2.816	1,027	4.266	29.41	"		
BIL-GR-1-16	"	"	1.000	0.1793	2.816	1,051	4.396	30.31	"		
							Average	4.434	30.57		
							Std. Dev.	0.190	1.31		
BIL-GR-1-4	30 min. @ 93°C (200°F) (WET)	"	1.001	0.1802	2.816	539	2.241	15.45	4/25/89		
BIL-GR-1-10	93°C (200°F)	"	0.999	0.1770	2.816	533	2.262	15.59	"		
BIL-GR-1-13	"	"	0.999	0.1804	2.816	557	2.319	15.99	"		
							Average	2.274	15.68		
							Std. Dev.	0.040	0.28		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
 (2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.4
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA3396
COMPOSITE LAMINATES CURED 30 MINUTES AT 82°C (180°F)

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp			
Material :		EA-9396 A/B; W133 Graphite				Task #16		Tested By:			
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thickness (in.)	Span (in.)	Maximum		Interlaminar		Date Tested	Remarks
						Load (lbs.)	Shear Strength (Ksi.)	Shear Strength (MPa)			
BIL-H7-5-ILS-5	30 min. @ 22°C (72°F) (DRY)	"	0.500	0.1700	2.765	760	6.706	46.24	2/16/88		
BIL-H7-5-ILS-14	82°C (180°F)	"	0.500	0.1720	2.765	688	6.000	41.37	"		
BIL-H7-5-ILS-25	"	"	0.502	0.1680	2.765	674	5.994	41.33	"		
							Average	6.233	42.98		
							Std. Dev.	0.409	2.82		
BIL-H7-5-ILS-8	30 min. @ 22°C (72°F) (WET)	"	0.499	0.1730	2.765	504	4.379	30.19	3/9/88		
BIL-H7-5-ILS-17	82°C (180°F)	"	0.498	0.1730	2.765	472	4.109	28.33	"		
BIL-H7-5-ILS-21	"	"	0.501	0.1720	2.765	520	4.526	31.21	"		
							Average	4.338	29.91		
							Std. Dev.	0.211	1.46		
BIL-H7-5-ILS-3	30 min. @ 93°C (200°F) (WET)	"	0.501	0.1690	2.765	205	1.816	12.52	3/9/88		
BIL-H7-5-ILS-9	82°C (180°F)	"	0.499	0.1720	2.765	233	2.036	14.04	"		
BIL-H7-5-ILS-19	"	"	0.499	0.1720	2.765	212	1.853	12.77	"		
							Average	1.901	13.11		
							Std. Dev.	0.118	0.81		

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
 (2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.5
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
COMPOSITE LAMINATES CURED 45 MINUTES AT 79°C (175°F)

Test :		(4pt loading at 1/4 pts. L/D = 8/1)				Specimen Orientation: Warp				
Material :		EA-9396 A/B; W133 Graphite				TOB				
		Task #16				Tested By:				
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thickness (in.)	Span (in.)	Maximum		Date Tested	Remarks	
						Load (lbs.)	Interlaminar Shear Strength (MPa)			
BIL-GR-4(R)-1	45 min. @ 79°C (175°F)	22°C (72°F) (DRY)	0.996	0.1746	2.800	1,270	5.477	37.77	1/23/89	
BIL-GR-4(R)-3	"	"	0.995	0.1723	2.800	1,354	5.925	40.85	"	
BIL-GR-4(R)-5	"	"	0.996	0.1659	2.800	1,230	5.584	38.50	"	
BIL-GR-4(R)-7	"	"	0.997	0.1757	2.800	1,310	5.606	38.66	"	
BIL-GR-4(R)-9	"	"	0.996	0.1732	2.800	1,287	5.596	38.58	"	
							Average	38.87		
							Std. Dev.	0.169	1.16	
BIL-GR-4(R)-2	45 min. @ 79°C (175°F)	22°C (72°F) (WET)	0.998	0.1741	2.800	962	4.153	28.63	5/25/89	
BIL-GR-4(R)-4	"	"	0.997	0.1712	2.800	937	4.119	28.40	"	
BIL-GR-4(R)-6	"	"	0.997	0.1763	2.800	933	3.983	27.46	"	
BIL-GR-4(R)-8	"	"	0.998	0.1740	2.800	930	4.019	27.71	"	
BIL-GR-4(R)-10	"	"	0.997	0.1675	2.800	849	3.813	26.29	"	
							Average	4.017	27.70	
							Std. Dev.	0.134	0.92	

(1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
 (2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.

TABLE J.6
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396
 COMPOSITE LAMINATES CURED 7 DAYS AT 22°C (72°F)

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp		
Material :		EA-9396 A/B, W133 Graphite				Task #16		Tested By: TOB		
Specimen Number	Cure Time & Temperature (1)	Test Conditions (2)	Width (in.)	Thickness (in.)	Span (in.)	Maximum		Interlaminar		
						Load (lbs.)	Shear Strength (Ksi.)	Shear Strength (MPa)	Date Tested	Remarks
BIL-GR-20-1	7 days @ 22°C (72°F) (DRY)	"	1.004	0.1814	2.816	979	4.031	27.79	5/25/89	
BIL-GR-20-4	22°C (72°F) plus additional 3 mos.	"	1.005	0.1753	2.816	1,216	5.179	35.71	"	
BIL-GR-20-5	dry storage or wet-aging (Note 3)	"	1.004	0.1728	2.816	1,227	5.306	36.59	"	
BIL-GR-20-8	"	"	1.005	0.1760	2.816	1,196	5.074	34.98	"	
BIL-GR-20-9	"	"	1.005	0.1771	2.816	1,117	4.708	32.46	"	
BIL-GR-20-12	"	"	1.005	0.1758	2.816	1,222	5.188	35.77	"	
BIL-GR-20-13	"	"	1.005	0.1735	2.816	1,282	5.515	38.03	"	
BIL-GR-20-16	"	"	0.998	0.1730	2.816	1,167	5.071	34.97	"	
						Average	5.009	34.54		
						Std. Dev.	0.457	3.15		
BIL-GR-20-3	7 days @ 22°C (72°F) (WET)	"	1.004	0.1747	2.816	823	3.519	24.26	5/25/89	
BIL-GR-20-7	22°C (72°F) plus additional 3 mos.	"	1.005	0.1728	2.816	880	3.804	26.23	"	
BIL-GR-20-11	dry storage or wet-aging (Note 3)	"	1.005	0.1797	2.816	734	3.050	21.03	"	
BIL-GR-20-15	"	"	1.005	0.1741	2.816	814	3.491	24.07	"	
BIL-GR-20-17	"	"	1.004	0.1761	2.816	749	3.176	21.90	"	
						Average	3.408	23.50		
						Std. Dev.	0.299	2.06		

- (1) Pressure during cure was nominal 635 mm (25 in.) Hg vacuum.
- (2) Wet = wet-aged at 60°C (140°F)/95-100% R.H. until saturated.
- (3) Vacuum pressure was applied only during first four hours of cure.

APPENDIX K
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR STRENGTH,
EFFECT OF EXPOSURE TO 177°C (350°F)

The two tables in this appendix present the detailed interlaminar shear strength data for specimens exposed to 177°C (350°F). A summary of these data was presented and discussed in Section 3.12.1.

TABLE K.1
 EFFECT OF ELEVATED TEMPERATURE EXPOSURE ON INTERLAMINAR SHEAR STRENGTH OF
 GLASS REINFORCED EA9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation:		Warp				
Material :		EA-9396 A/B; 7781 Glass		Batch #1 Task #8		Tested By:		TOB & DH				
Specimen Number	Exposure Condition	Test Conditions (3)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks	Wt. Gain	
											During Aging (%)	
BIL-GL-13(R)-6	2 hrs. @ 22°C (72°F) (DRY)	"	1.002	0.1334	1.063	986	5.528	38.12	4/19/89	(1)	NA	(1)
BIL-GL-13(R)-16	177°C (350°F)	"	0.999	0.1322	1.063	951	5.397	37.21	"	(1)	NA	(1)
BIL-GL-13(R)-38	"	"	1.000	0.1352	1.063	1,084	6.016	41.48	"	(1)	NA	(1)
		Average				5.647		38.94				
		Std. Dev.				0.326		2.25				
BIL-GL-13(R)-8	2 hrs. @ 93°C (200°F) (WET)	"	1.001	0.1352	1.080	326	1.807	12.46	10/30/89	(1)	1.98	(1)
BIL-GL-13(R)-18	177°C (350°F)	"	1.005	0.1329	1.080	350	1.965	13.55	"	(1)	2.04	(1)
BIL-GL-13(R)-40	"	"	1.002	0.1365	1.080	370	2.029	13.99	"	(1)	2.10	(1)
		Average				1.934		13.33				
		Std. Dev.				0.114		0.79				
BIL-GL-13(R)-7	16 hrs. @ 22°C (72°F) (DRY)	"	1.001	0.1329	1.063	1,038	5.850	40.34	4/19/89	(2)	NA	(2)
BIL-GL-13(R)-17	177°C (350°F)	"	1.002	0.1349	1.063	1,079	5.985	41.27	"	(2)	NA	(2)
BIL-GL-13(R)-39	(Note 4)	"	1.000	0.1373	1.063	1,135	6.201	42.76	"	(2)	NA	(2)
		Average				6.012		41.45				
		Std. Dev.				0.177		1.22				
BIL-GL-13(R)-9	16 hrs. @ 93°C (200°F) (WET)	"	1.000	0.1316	1.080	314	1.790	12.34	10/30/89	(2)	2.20	(2)
BIL-GL-13(R)-19	177°C (350°F)	"	1.001	0.1326	1.080	336	1.899	13.09	"	(2)	2.27	(2)
BIL-GL-13(R)-41	(Note 4)	"	1.001	0.1369	1.080	381	2.085	14.38	"	(2)	2.29	(2)
		Average				1.924		13.27				
		Std. Dev.				0.150		1.03				

- (1) Specimens turned slightly brown as result of exposure.
- (2) Specimens turned dark brown as result of exposure.
- (3) Wet = wet-aging at 60°C (140°F)/95-100% R. H. until saturated.
- (4) Three segments of 6+6+4 hours.

TABLE K.2

EFFECT OF ELEVATED TEMPERATURE EXPOSURE ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE REINFORCED EA9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 16/1)				Specimen Orientation:	
Material :		EA-9396 A/B; W133 Graphite				Batch #1 Task #8				Tested By: Warp TOB & DH	
Specimen Number	Exposure Condition	Test Conditions (1)	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-17-6	2 hrs. @ 22°C (72°F) (DRY)	"	1.000	0.1819	2.816	1,220	5.028	34.67	NA	4/19/89	
BIL-GR-17-16	177°C (350°F)	"	1.003	0.1752	2.816	1,119	4.776	32.93	NA	"	
BIL-GR-17-38	"	"	1.000	0.1726	2.816	1,197	5.201	35.86	NA	"	
			Average				5.002	34.49			
			Std. Dev.				0.214	1.47			
BIL-GR-17-8	2 hrs. @ 93°C (200°F) (WET)	"	1.001	0.1825	2.846	510	2.094	14.44	2.42	12/7/89	
BIL-GR-17-18	177°C (350°F)	"	1.002	0.1829	2.846	453	1.854	12.78	2.49	"	
BIL-GR-17-40	"	"	1.002	0.1742	2.846	471	2.024	13.95	2.15	"	
			Average				1.990	13.72			
			Std. Dev.				0.123	0.85			
BIL-GR-17-7	16 hrs. @ 22°C (72°F) (DRY)	"	1.003	0.1802	2.816	1,244	5.163	35.60	NA	4/19/89	
BIL-GR-17-17	177°C (350°F)	"	1.000	0.1829	2.816	1,343	5.507	37.97	NA	"	
BIL-GR-17-39	(Note 2)	"	0.999	0.1731	2.816	1,177	5.107	35.21	NA	"	
			Average				5.259	36.26			
			Std. Dev.				0.216	1.49			
BIL-GR-17-9	16 hrs. @ 93°C (200°F) (WET)	"	1.000	0.1770	2.846	438	1.856	12.80	2.31	12/7/89	
BIL-GR-17-19	177°C (350°F)	"	1.002	0.1851	2.846	454	1.836	12.66	2.49	"	
BIL-GR-17-41	(Note 2)	"	1.002	0.1762	2.846	484	2.056	14.18	2.24	"	
			Average				1.916	13.21			
			Std. Dev.				0.122	0.84			

(1) Wet = wet-aging at 60°C (140°F)/95-100% R.H. until saturated.

(2) Three segments of 6+6+4 hours.

APPENDIX L
INDIVIDUAL SPECIMEN INTERLAMINAR SHEAR STRENGTH,
EFFECT OF RESIN/FIBER CONTENT

The 12 tables in this appendix present the detailed interlaminar shear strength data for specimens prepared with nonstandard fiber contents. All of the laminates from which these specimens were machined were cured in accordance with the baseline cure schedule. The reduced fiber contents were achieved by varying the resin/reinforcement ratios during impregnation and the bleeder ratio during bagging. The laminate preparation details were described in Appendix B.3. A summary of these data was presented and discussed in Section 3.8.

TABLE L.1
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS REINFORCED
 EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation:		Warp	
Material :		EA-9396 A/B; 7781 Glass			Batch #4 Task #12			Tested By:		DH & PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain		Date Tested	Remarks
								Aging (%)	During Aging (%)		
BIL-GL-31-1	22°C (72°F) (DRY)	1.002	0.1387	1.100	981	5.295	36.51	NA	NA	10/30/89	(1)
BIL-GL-31-3	"	1.002	0.1327	1.100	943	5.320	36.68	NA	NA	"	(1)
BIL-GL-31-5	"	1.000	0.1398	1.100	979	5.250	36.20	NA	NA	"	(1)
						Average	5.288	36.46			
						Std. Dev.	0.035	0.24			
BIL-GL-31-2	22°C (72°F) (WET)	1.002	0.1339	1.069	532	2.974	20.50	1.88	1.88	10/30/89	(1,2)
BIL-GL-31-4	"	1.002	0.1324	1.069	575	3.251	22.41	1.87	1.87	"	(1,2)
						Average	3.112	21.46	1.87		
						Std. Dev.	0.196	1.35	0.00		

Remarks:

(1) Physical Properties:

Fiber Content (vol. %) = 55.4

Resin Content (wt. %) = 26.2

Void content (vol. %) = 5.0

Specific Gravity = 1.94

(2) Specimens aged @ 140°F/95-100% R.H. for 79 days.

TABLE L.2
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation:	
Material :		EA-9396 A/B; 7781 Glass			Batch #4 Task #12			Tested By:	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength		Date Tested	Remarks
						(Ksi.)	(MPa)		
BIL-GL-30-1	22°C (72°F) (DRY)	1.003	0.1397	1.080	1,018	5.449	37.57	10/30/89	(1)
BIL-GL-30-3	"	1.002	0.1312	1.080	973	5.551	38.27	"	(1)
BIL-GL-30-5	"	1.003	0.1392	1.080	1,044	5.608	38.67	"	(1)
						Average	38.17		
						Std. Dev.	0.56		
BIL-GL-30-2	22°C (72°F) (WET)	1.002	0.1337	1.069	570	3.191	22.00	1/22/90	(1,2)
BIL-GL-30-4	"	1.003	0.1345	1.069	570	3.169	21.85	"	(1,2)
						Average	21.93		
						Std. Dev.	0.11		
							1.86		
							0.02		

Remarks:

(1) Physical Properties:

Fiber Content (vol. %) = 54.3

Resin Content (wt. %) = 26.7

Void content (vol. %) = 6.1

Specific Gravity = 1.89

(2) Specimens aged @ 140°F/95-100% R.H. for 79 days.

TABLE L.3
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 8/1)			Specimen Orientation:		Warp	
Material :		EA-9396 A/B: 7781 Glass			Batch #4 Task #12			Tested By:		DH & PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain		Date Tested	Remarks
								During Aging (%)			
BIL-GL-33-1	22°C (72°F) (DRY)	1.001	0.1756	1.462	1,126	4.804	33.13	NA		10/30/89	(1)
BIL-GL-33-3	"	1.001	0.1378	1.100	1,042	5.666	39.06	NA		"	(1)
BIL-GL-33-5	"	1.001	0.1382	1.100	1,108	6.007	41.42	NA		"	(1)
						Average	37.87				
						Std. Dev.	4.27				
BIL-GL-33-2	22°C (72°F) (WET)	1.001	0.1456	1.206	476	2.449	16.89	2.17		1/22/90	(1,2)
BIL-GL-33-4	"	1.000	0.1413	1.206	659	3.498	24.12	2.09		"	(1,2)
						Average	20.50	2.13			
						Std. Dev.	5.11	0.06			

Remarks:

- (1) Physical Properties:
 Fiber Content (vol. %) = 52.3
 Resin Content (wt. %) = 28.4
 Void content (vol. %) = 6.4
 Specific Gravity = 1.86
- (2) Specimens aged @ 140°F/95-100% R.H. for 79 days.

TABLE L.4
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent interlaminar shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp	
Material :		EA-9396 A/B; 7781 Glass				Batch #4 Task #12		Tested By: PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks
BIL-GL-10-21	22°C (72°F) (DRY)	1.000	0.1605	1.286	1,206	5.636	38.86	5/26/89	(1)
BIL-GL-10-22	"	0.998	0.1616	1.286	1,174	5.460	37.64	"	(1)
BIL-GL-10-23	"	0.997	0.1622	1.286	1,155	5.357	36.93	"	(1)
BIL-GL-10-24	"	0.997	0.1587	1.286	1,167	5.532	38.14	"	(1)
						Average	37.89		
						Std. Dev.	0.81		

Remarks:
 (1) Physical Properties:
 Fiber Content (vol. %) = 45.6
 Resin Content (wt. %) = 35.2
 Void Content (vol. %) = 4.7
 Specific Gravity = 1.79

TABLE L.5
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation:		Fill
Material :		EA-9396 A/B: 7781 Glass				Batch #5 Task #12		Tested By:		DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength		Date Tested	Remarks	
						(Ksi.)	(MPa)			
BIL-GL-54-2	22°C (72°F) (DRY)	0.998	0.1788	1.600	1,098	4.617	31.83	10/7/91	(1)	
BIL-GL-54-6	"	0.999	0.1997	1.600	1,253	4.709	32.47	"	(1)	
BIL-GL-54-8	"	0.999	0.2064	1.600	1,407	5.116	35.28	"	(1)	
						Average	4.814	33.19		
						Std. Dev.	0.266	1.83		

Remarks:

- (1) Physical Properties:
 - Fiber Content (vol. %) = 35.8
 - Resin Content (wt. %) = 43.6
 - Void content (vol. %) = 8.8
 - Specific Gravity = 1.62

TABLE L.6
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GLASS
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation:		Fill
Material :		EA-9396 A/B; 7781 Glass				Batch #5 Task #12		Tested By:		DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs)	Interlaminar Shear Strength (Ksi.)	MPa	Date Tested	Remarks	
BIL-GL-53-6	22°C (72°F) (DRY)	0.999	0.2218	1.600	1,521	5.150	35.51	10/7/91	(1)	
BIL-GL-53-8	"	0.998	0.2252	1.600	1,473	4.915	33.89	"	(1)	
					Average	5.033	34.70			
					Std. Dev.	0.166	1.15			

Remarks:

- (1) Physical Properties:
- Fiber Content (vol. %) = 33.9
- Resin Content (wt. %) = 45.6
- Void content (vol. %) = 9.3
- Specific Gravity = 1.59

TABLE L.7
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp		
Material :		EA-9396 A/B: W133 Graphite		Batch #4 Task #12		Tested By:		DH & PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain		
								During Aging (%)	Date Tested	Remarks
BIL-GR-51-1	22°C (72°F) (DRY)	1.002	0.1721	2.789	1,348	5.863	40.42	NA	11/1/89	(1)
BIL-GR-51-3	"	1.002	0.1746	2.789	1,401	6.006	41.41	NA	"	(1)
BIL-GR-51-5	"	1.001	0.1733	2.789	1,325	5.729	39.50	NA	"	(1)
				Average		40.44				
				Std Dev.		0.139				
BIL-GR-51-2	22°C (72°F) (WET)	1.001	0.1742	2.832	990	4.258	29.36	2.32	2/23/90	(1,2)
BIL-GR-51-4	"	1.002	0.1753	2.832	1,009	4.308	29.71	2.29	"	(1,2)
				Average		29.53				
				Std Dev.		0.24				

Remarks:

(1) Physical Properties:

Fiber Content (vol. %) = 55.8

Resin Content (wt. %) = 32.5

Void content (vol. %) = 6.5

Specific Gravity = 1.47

(2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.8
EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp	
Material :		EA-9396 A/B; W133 Graphite				Batch #4 Task #12		Tested By:		DH & PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain		Date Tested	Remarks
								During Aging (%)	Date Tested		
BIL-GR-52-1	22°C (72°F) (DRY)	1.001	0.1714	2.789	1,231	5.381	37.10	NA	NA	11/1/89	(1)
BIL-GR-52-3	"	1.002	0.1791	2.789	1,492	6.235	42.99	NA	NA	"	(1)
BIL-GR-52-5	"	1.002	0.1757	2.789	1,397	5.951	41.03	NA	NA	"	(1)
					Average	5.856	40.38				
					Std. Dev.	0.435	3.00				
BIL-GR-52-2	22°C (72°F) (WET)	1.002	0.1778	2.832	1,099	4.627	31.90	2.29	2.29	2/23/90	(1,2)
BIL-GR-52-4	"	1.002	0.1773	2.832	1,149	4.851	33.45	2.29	2.29	"	(1,2)
					Average	4.739	32.67				
					Std. Dev.	0.158	1.09				

Remarks:

- (1) Physical Properties:
 Fiber Content (vol. %) = 54.7
 Resin Content (wt. %) = 33.6
 Void content (vol. %) = 6.4
 Specific Gravity = 1.47
- (2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.9
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp	
Material :		EA-9396 A/B; W133 Graphite			Batch #4 Task #12		Tested By:		DH & PM	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain		
								During Aging (%)	Date Tested	Remarks
BIL-GR-53-1	22°C (72°F) (DRY)	1.001	0.1826	3.017	1,509	6.192	42.69	NA	11/1/89	(1)
BIL-GR-53-3	"	1.001	0.1957	3.017	1,615	6.183	42.63	NA	"	(1)
BIL-GR-53-5	"	1.001	0.1865	3.017	1,640	6.589	45.43	NA	"	(1)
						Average	43.58			
						Std. Dev.	1.60			
BIL-GR-53-2	22°C (72°F) (WET)	1.000	0.1866	3.033	1,185	4.763	32.84	2.58	2/23/90	(1,2)
BIL-GR-53-4	"	1.002	0.1895	3.033	1,305	5.155	35.54	2.62	"	(1,2)
						Average	34.19			
						Std. Dev.	1.91			

Remarks:

- (1) Physical Properties:
 Fiber Content (vol. %) = 50.1
 Resin Content (wt. %) = 39.0
 Void content (vol. %) = 4.9
 Specific Gravity = 1.46
- (2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.10
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp			
Material :	EA-9396 A/B; W133 Graphite		Batch #4 Task #12		Tested By:		DH & PM			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-54-1	22°C (72°F) (DRY)	0.999	0.1853	3.017	1,561	6.324	43.61	NA	11/1/89	(1)
BIL-GR-54-3	"	1.000	0.1931	3.017	1,684	6.541	45.10	NA	"	(1)
BIL-GR-54-5	"	1.000	0.1883	3.017	1,549	6.170	42.54	NA	"	(1)
					Average	6.345	43.75			
					Std. Dev.	0.186	1.28			
BIL-GR-54-2	22°C (72°F) (WET)	1.001	0.1901	3.033	1,300	5.124	35.33	2.73	2/23/90	(1,2)
BIL-GR-54-4	"	1.001	0.1921	3.033	1,311	5.113	35.26	2.72	"	(1,2)
					Average	5.119	35.29	2.72		
					Std. Dev.	0.007	0.05	0.00		

Remarks:

- (1) Physical Properties:
 Fiber Content (vol. %) = 49.8
 Resin Content (wt. %) = 39.0
 Void content (vol. %) = 4.7
 Specific Gravity = 1.47
- (2) Specimens aged @ 140°F/95-100% R.H. for 112 days.

TABLE L.11
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear			(4pt loading at 1/4 pts. L/D = 12/1)			Specimen Orientation:		Fill
Material :		EA-9396 A/B; W133 Graphite			Batch #5 Task #12			Tested By:		DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks	
BIL-GR-84-2	22°C (72°F) (DRY)	1.004	0.2329	2.920	1,446	4.638	31.98	10/7/91	(1)	
BIL-GR-84-6	"	1.003	0.2402	2.920	1,450	4.513	31.12	"	(1)	
BIL-GR-84-8	"	1.003	0.2394	2.920	1,442	4.503	31.05	"	(1)	
					Average	4.552	31.38			
					Std. Dev.	0.075	0.52			

Remarks:

- (*) Physical Properties:
- Fiber Content (vol. %) = 42.3
- Resin Content (wt. %) = 45.6
- Void content (vol. %) = 7.5
- Specific Gravity = 1.39

TABLE L.12
 EFFECT OF FIBER CONTENT ON INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA 9396 COMPOSITE LAMINATES

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 12/1)		Specimen Orientation:		Fill
Material :		EA-9396 A/B; W133 Graphite				Batch #5 Task #12		Tested By:		DRB
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks	
BIL-GR-79-2	22°C (72°F) (DRY)	1.001	0.2433	2.920	1,690	5.206	35.90	10/7/91	(1)	
BIL-GR-79-6	"	0.999	0.2572	2.920	1,668	4.868	33.57	"	(1)	
BIL-GR-79-8	"	1.002	0.2582	2.920	1,555	4.509	31.09	"	(1)	
					Average	4.861	33.52			
					Std. Dev.	0.349	2.40			

Remarks:
 (1) Physical Properties:
 Fiber Content (vol. %) = 40.5
 Resin Content (wt. %) = 48.8
 Void content (vol. %) = 5.5
 Specific Gravity = 1.41

TABLE L. 13
 EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GLASS REINFORCED
 EA 9396 COMPOSITE LAMINATES

Test :		IITRI Compressor; ASTM-D3410		Fiber Orientation:		Fill					
Material :		EA-9396 A/B; 7781 Glass		Batch #5 Task #12		DRB					
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tangent Modulus (Msi.)	Ultimate Strain (μ in/in)	Poisson's Ratio	Date Tested	Remarks
					Compressive Strength (Ksi.)	Strength (Ksi.)					
BIL-GL-53-1	72°F (DRY)	0.998	0.2124	5,945	28.05	2.425	12,312	0.142	11/15/90	(1b,3,4)	
BIL-GL-53-3	"	0.998	0.2043	7,114	34.89	2.426	13,879	0.142	11/16/90	(1b,3,4)	
BIL-GL-53-5	"	0.998	0.2141	7,351	34.40	2.349	15,535		11/15/90	(1a,3,4)	
BIL-GL-53-7	"	0.999	0.1873	7,444	39.80	2.758	14,927		"	(1b,3,4)	
BIL-GL-53-9	"	0.998	0.2184	7,915	36.30	2.375	14,209	0.082	11/16/90	(1b,3,4)	
BIL-GL-53-11	"	0.999	0.2007	6,746	33.66	2.493	13,535		11/15/90	(1b,3,4)	
				Average	34.52	2.471	14,066	0.112			
				Std. Dev.	3.84	0.149	1,124	0.042			

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- (a) Shear crimping
- (b) Shear fracture
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Physical Properties:
 Fiber Content (vol. %) = 33.9
 Resin Content (wt. %) = 45.6
 Void Content (vol. %) = 9.3
 Specific Gravity = 1.59

SI Conversion	
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)
193.4	16.72
240.6	16.73
237.2	16.20
274.4	19.02
250.3	16.37
232.1	17.19
Average 238.0	17.04
Std. Dev. 26.5	1.03

TABLE L. 14
 EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GLASS REINFORCED
 EA 9396 COMPOSITE LAMINATES

Test :		II TRI Compression; ASTM-D3410				Fiber Orientation:					
Material :		Batch #5		Task #12		Tested By: DRB					
Material :		EA-9396 A/B; 7781 Glass									
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Initial		Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
						Tangent Modulus (Msi.)	Tangent Modulus (GPa)				
BIL-GL-54-1	72°F (DRY)	0.998	0.1806	6,587	36.56	2.447	14,634	0.181	0.181	11/13/90	(1a,3,4)
BIL-GL-54-3	"	0.997	0.1847	6,868	37.29	2.901	15,828	0.181	0.181	11/14/90	(1a,3,4)
BIL-GL-54-5	"	0.998	0.1966	7,549	38.47	2.403	17,849			11/13/90	(1b,3,4)
BIL-GL-54-7	"	0.992	0.2050	7,515	36.95	2.656	17,007			"	(1b,3,4)
BIL-GL-54-9	"	0.998	0.2032	7,136	35.19	2.860	15,857	0.158	0.158	11/14/90	(1a,3,4)
BIL-GL-54-11	"	0.991	0.1892	6,873	36.65	2.989	12,173			11/13/90	(1a,3,4)
Average					36.85	2.709	15,558		0.170		
Std. Dev.					1.07	0.246	1,991		0.017		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- (a) Shear crimping
- (b) Shear fracture
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Physical Properties:
 Fiber Content (vol. %) = 35.8
 Resin Content (wt. %) = 43.6
 Void Content (vol. %) = 8.8
 Specific Gravity = 1.62

SI Conversion	
Ultimate Compressive Strength (MPa)	Ultimate Strain (µcm/cm)
252.1	14,634
257.1	15,828
265.3	17,849
254.8	17,007
242.6	15,857
252.7	12,173
Average	15,558
Std. Dev.	1,991

SI Conversion	
Initial Tangent Modulus (GPa)	Initial Tangent Modulus (Msi.)
16.87	2.447
20.01	2.901
16.57	2.403
18.31	2.656
19.72	2.860
20.61	2.989
Average	2.709
Std. Dev.	0.246

TABLE L. 15
 EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GRAPHITE REINFORCED
 EA 9396 COMPOSITE LAMINATES

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tangent Modulus (Msi.)	Ultimate Strain (µin/in)	Poisson's Ratio	Date Tested	Remarks
					Compressive Strength (Ksi.)	Compressive Strength (Ksi.)					
BIL-GR-79-1	72°F (DRY)	0.997	0.2335	10.835	46.53	46.53	5.470	10.557	0.021	11/16/90	(1a,3,4)
BIL-GR-79-3	"	1.001	0.2519	11.738	46.57	46.57	5.751	7.860	0.021	11/19/90	(1a,3,4)
BIL-GR-79-5	"	0.995	0.2565	11,201	43.90	43.90	4.252	12,340		11/16/90	(1a,3,4)
BIL-GR-79-7	"	1.001	0.2615	11,118	42.47	42.47	5.549	7,490		"	(1a,3,4)
BIL-GR-79-9	"	0.999	0.2507	9,038	36.09	36.09	5.388	6,800	0.213	11/19/90	(1a,3,4)
BIL-GR-79-11	"	1.000	0.2322	12,456	53.64	53.64	6.036	9,106		11/16/90	(1a,3,4)
Average					44.87	44.87	5.408	9,026	0.117		
Std. Dev.					5.77	5.77	0.612	2,098	0.136		

SI Conversion			
Ultimate Compressive Strength (MPa)	Initial Tangent Modulus (GPa)	Ultimate Strain (µcm/cm)	Poisson's Ratio
320.8	37.72	10.557	0.117
321.1	39.66	7.860	0.136
302.7	29.32	12,340	
292.8	38.26	7,490	
249.8	37.15	6,800	
369.9	41.62	9,106	
Average	37.29	9,026	
Std. Dev.	4.22	2,098	

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
 - (a) Shear crimping
 - (b) Shear fracture
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Physical Properties:
 - Fiber Content (vol. %) = 40.5
 - Resin Content (wt. %) = 48.8
 - Void Content (vol. %) = 5.5
 - Specific Gravity = 1.41

TABLE L. 16
 EFFECT OF FIBER CONTENT ON COMPRESSION STRENGTH OF GRAPHITE REINFORCED
 EA 9396 COMPOSITE LAMINATES

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Initial		Poisson's Ratio	Date Tested	Remarks
					Compressive Strength (Ksi.)	Compressive Strength (Msi.)	Tangent Modulus (Msi.)	Strain (μ in/in)			
BIL-GR-84-1	72°F (DRY)	1.002	0.2254	11,357	50.30	6.101	8,945	11/20/90	0.037	11/20/90	(1a,3,4)
BIL-GR-84-3	"	1.003	0.2395	10,933	45.49	5.687	9,473	"	0.037	"	(1b,3,4)
BIL-GR-84-5	"	1.003	0.2458	10,900	44.19	5.599	6,533	11/19/90		11/19/90	(1b,3,4)
BIL-GR-84-7	"	1.003	0.2435	8,975	36.75	4.665	7,647	"		"	(1a,3,4)
BIL-GR-84-9	"	1.004	0.2460	10,854	43.97	5.378	8,042	11/20/90	0.007	11/20/90	(1a,3,4)
BIL-GR-84-11	"	1.004	0.2309	8,901	38.40	5.276	7,500	11/19/90		11/19/90	(1b,3,4)
Average					43.18	5.451	8,023	0.022			
Std. Dev.					4.94	0.480	1,057	0.021			

Remarks:

- Specimen failed within the 1/2 inch gage section.
 - Shear crimping
 - Shear fracture
- Specimen failed outside gage section.
- Test speed = 0.05 in/min.
- Physical Properties:
 - Fiber Content (vol. %) = 42.3
 - Resin Content (wt. %) = 45.6
 - Void Content (vol. %) = 7.5
 - Specific Gravity = 1.39

SI Conversion			
Ultimate	Initial	Ultimate	Initial
Compressive Strength (MPa)	Tangent Modulus (GPa)	Strain (μ cm/cm)	Strain (μ cm/cm)
346.8	42.06	8,945	8,945
313.7	39.21	9,473	9,473
304.7	38.60	6,533	6,533
253.4	32.16	7,647	7,647
303.2	37.08	8,042	8,042
264.7	36.38	7,500	7,500
Average	37.58	8,023	8,023
Std. Dev.	3.31	1,057	1,057

APPENDIX M

INDIVIDUAL SPECIMEN PROPERTIES, EFFECT OF STORAGE TIME AND TEMPERATURE

The tables and figures in this appendix present the detailed mechanical, physical, thermophysical, and chemical property data measured during this program. The data include HPLC spectra, viscosity measurements on both parts A and B, DSC analyses, FTIR spectra, Rheometrics viscosity profiles, and interlaminar shear strengths. Each of these specific types of data are presented separately in sections M.1 through M.6 of this appendix. These data are summarized in Section 3.7.

M.1 HPLC SPECTRA

Figures M.1 through M.6 present the HPLC spectra obtained during the program. It can be seen from Figures M.1(b) that part B of the EA9396 resin system produced no significant features. As a result, no further HPLC tests were performed on part B. Table M.1 summarizes the pertinent features and test parameters for each of the tests represented by Figures M.1 through M.6. It will be observed, both in Figures M.4 and M.6 as well as in Table M.1, that the retention times for the 12- and 24-month tests are about twice what they are in the other tests. This is due to the fact that the flow rate during the test was only half what it was in the other tests, thereby doubling the retention times.

In each case the test samples were prepared for analysis by making a 1% solution by weight in dioxane and filtering the solution through a 0.5-micron PTFE filter to remove insolubles.

M.2 BROOKFIELD VISCOSITY MEASUREMENTS

Viscosity measurements were made on both parts A and B of the EA9396 resin system using a Brookfield type RV Viscometer. This viscometer comes with a set of seven spindles to cover a wide range of viscosities. Spindle No. 7 was used for viscosity measurements of Part A, while Spindle No. 3 was used for Part B.

The samples that were tested were tested in the cans they were received in from Hysol. In the case of Part A, this was a quart can, while Part B was in a pint can. In each case the cans were not large enough to accommodate the spindle guard so this was removed during the viscosity measurements. While this is not in strict accordance with

the recommended procedure, since all of the tests were performed in the same way, the measurements do provide a consistent comparison of the material for each aging time from its initial receipt until the final measurement after 36 months of storage. In all cases the spindles were immersed to the recommended depths. Table M.2 lists the results of all the viscosity measurements made on both Parts A and B. These results were summarized and discussed in Section 3.7 (see Table 31 in particular).

M.3 HEAT OF REACTION TESTS (DSC)

Dynamic scanning calorimetric (DSC) tests were conducted on EA9396 in the as-received condition and after storage times of up to 24 months at various temperatures. From these tests the heat released during cure is obtained. Resin samples of approximately 5 mg were heated at a rate of 10°C (18°F)/min in these tests. Figures M.7 through M.22 present the DSC curves from each of these tests and the heat release during cure in these tests is tabulated in Table M.3.

If one considers only the heat release data for the 6-24 month storage times, there is a relatively consistent decrease in heat release as aging time increases and the decrease is greatest for the highest temperature storage condition.

M.4 FTIR SPECTRA

Figures M.23 through M.54 present the FTIR spectra obtained during the program. The tests were carried out using a Nicolet FTIR instrument. Spectra were obtained on both Parts A and B of the EA9396 resin system after storage times of up to 24 months at various temperatures. Samples were deposited on NaCl plates to perform the FTIR tests. No attempt has been made to interpret these spectra.

M.5 RHEOMETRIC VISCOSITY PROFILES

A Rheometrics Solids Analyzer (RSA-II) was used to measure the changing viscosity of EA9396 during cure. The test was carried out using approximately 0.1 gm samples in a parallel plate arrangement. The plates were positioned about 0.36 mm apart and oscillated at a frequency of 1 Hz. The motion of the plates was to slightly open and close in a tensile mode rather than to rotate with respect to one another in a torsional mode. The amount of motion represented a cyclic strain of 1.0% (± 0.0036 mm) about the midpoint.

Both dynamic viscosity (η') and loss viscosity (η'') were measured in these tests. Since the dynamic viscosity is the most commonly used measure of material viscosity, only these charts are included in this section. Several points should be cited in regard to these data. First, the viscosity values plotted in the accompanying charts are not quantitative. The parallel plate arrangement was a novel way to use the RSA instrument. Normally the tests are carried out using a shear sandwich type arrangement. The low viscosity of the EA9396 system precluded use of the shear sandwich arrangement because the minimum gap setting was 0.5 mm and the material ran out of the fixture during the test. While the parallel plate approach was nonstandard, the viscosity vs. temperature curve was very similar to that obtained with the shear sandwich fixture. For this reason it is felt that so long as all of the tests were carried out in the same manner, comparisons of test results would be valid (i.e., temperatures at which minimum viscosity and gel occur). Second, due to compliance limitations of the RSA instrument, data recorded after gel are meaningless.

Figures M.55 through M.70 present the viscosity profiles obtained after various storage times up to 2 years and at storage temperatures up to 49°C (120°F). Pertinent features from these figures were listed in Table 29 of Section 3.7.

M.6 INTERLAMINAR SHEAR STRENGTH

Tables M.4-M.19 list the individual specimen interlaminar shear strength properties of laminates made with EA9396 resin that had been in storage for up to two years at temperatures up to 49°C (120°F). These data are summarized and discussed in Section 3.7 (Table 32 in particular).

TABLE M.1
HPLC TEST PARAMETERS AND RESULTS

Sample Age	Flow Rate (ml/min)	Solvent Gradient (1)	Retention Time (min.)		
			22°C (72°F) Storage	38°C (100°F) Storage	40°C (120°F) Storage
Initial	1.0	A	18.88	---	---
1 Month	1.0	A	---	18.48	18.44
6 Months	1.0	A	20.14	20.16	21.15
12 Months	0.5	A	39.24 (2)	37.68 (2)	37.92 (2)
18 Months	1.0	A	18.73	18.43	18.81
24 Months	0.5	B	40.87 (2)	41.22 (2)	41.36 (2)

NOTE:

(1) A: Time % Water % Dioxane

0	00	50
10	50	50
40	30	70
50	30	70

B: 50% Water/50% Dioxane throughout test.

(2) These retention times are higher than the others by a factor of 2 because the flow rate during the test was half the flow rate in the other tests. This caused the retention times to be doubled. Thus, these test results are equivalent to those obtained for the other sample ages.

TABLE M.2
BROOKFIELD VISCOSITY MEASUREMENTS ON EA9396
AS A FUNCTION OF STORAGE TIME AT
VARIOUS TEMPERATURES

Date of Measurement	Storage Time(1)	Storage Temperature		Viscosity (Poise)	
		(°C)	(°F)	Part A	Part B
11/9/88	As received	N.A.		840	1
12/19/88	1 month	38	100	840	0.75
		49	120	880	0.75
2/9/89	3 months	22	72	920	1
5/16/89	6 months	22	72	720	1
7/20/89	8 months	38	100	840	1
		49	120	880	1
11/16/89	12 months	22	72	720	1
		38	100	960	1
		49	120	1000	1
5/16/90	18 months	22	72	1120	1
		38	100	1080	0.9
		49	120	2380	0.9
8/22/90	21 months	49	120	3440	0.75
11/17/90	24 months	22	72	820	1
		38	100	840	1
		49	120	6500	1
5/16/91	30 months	22	72	776	---
		38	100	2340	---
		49	120	>20,000(2)	---
11/15/91	36 months	22	72	800	---
		38	100	4600	---
6/15/92	43 months	22	72	1000	---
		38	100	>20,000 (2)	---
1/7/93	50 months	22	72	1000	---
		38	100	(3)	---

NOTES:

- (1) Storage times are nominal, after receipt of material. Material was manufactured three months before receipt.
- (2) This material was no longer processible into laminates and further storage was discontinued.
- (3) Material had hard crust on surface.

TABLE M.3
EFFECT OF LONG-TERM STORAGE ON HEAT
RELEASE DURING CURE

Storage Time	Heat Release During Cure (J/gm)			
	22°C (72°F) Storage	38°C (100°F) Storage	49°C (120°F) Storage	Average of All 3 Temperatures
1 Month	576.2	588.8	576.4	580.5
3 Months	572.9			
6 Months	633.8	593.5	624.6	617.3
12 Months	613.4	589.5	601.6	601.5
18 Months	615.4	564.6	586.8	588.9
24 Months	599.6	575.6	560.6	578.6

TABLE M.4
 EFFECT OF RESIN STORAGE FOR 1 MONTH AT 22°C (72°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp			
Material :		EA-9396 A/B; W133 Graphite		Batch #1	Task #13	Tested By:		DRB			
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-6-1	1 month @ 22°C (72°F)	22°C (72°F) (DRY)	0.996	0.1662	2.800	1,182	5.354	36.92	NA	1/22/89	
BIL-GR-6-3	22°C (72°F)	"	0.997	0.1711	2.800	1,258	5.530	38.13	NA	"	
BIL-GR-6-5	"	"	0.993	0.1664	2.800	1,160	5.265	36.30	NA	"	
						Average	5.383	37.12			
						Std. Dev.	0.135	0.93			
BIL-GR-6-2	1 month @ 22°C (72°F)	22°C (72°F) (WET)	0.999	0.1687	2.800	810	3.606	24.86	3.86	4/24/89	(1)
BIL-GR-6-4	22°C (72°F)	"	0.998	0.1691	2.800	855	3.801	26.21	3.96	"	(1)
						Average	3.704	25.54	3.91		
						Std. Dev.	0.138	0.95	0.07		

(1) Specimens aged by water immersion 140°F.

TABLE M.5
 EFFECT OF RESIN STORAGE FOR 1 MONTH AT 38°C (100°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. LD = 16/1)		Specimen Orientation:		Warp			
Material :		EA-9396 A/B, W133 Graphite		Batch #1 Task #13		Tested By:		DRB			
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-2-1	1 month @ 38°C (100°F)	22°C (72°F) (DRY)	1.003	0.1693	2.800	1,380	6.131	42.28	NA	1/22/89	
BIL-GR-2-3	"	"	1.001	0.1741	2.800	1,438	6.186	42.65	NA	"	
BIL-GR-2-5	"	"	1.002	0.1695	2.800	1,400	6.180	42.61	NA	"	
						Average	6.166	42.51			
						Std. Dev.	0.030	0.21			
BIL-GR-2-2	1 month @ 38°C (100°F)	22°C (72°F) (WET)	0.998	0.1709	2.816	1,078	4.742	32.69	2.71	4/24/89	(1)
BIL-GR-2-4	"	"	0.998	0.1724	2.816	1,099	4.790	33.03	2.69	"	(1)
						Average	4.766	32.86	2.70		
						Std. Dev.	0.034	0.24	0.01		

(1) Specimens aged by water immersion @ 140°F.

TABLE M.6
 EFFECT OF RESIN STORAGE FOR 1 MONTH AT 49°C (120°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp	
Material :		EA-9396 A/B; W133 Graphite				Batch #1 Task #13		Tested By:		DRB	
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-3-1	1 month @ 49°C (120°F)	22°C (72°F) (DRY)	0.983	0.1727	2.800	1,267	5.597	38.59	NA	1/23/89	
BIL-GR-3-3	"	"	0.983	0.1760	2.800	1,332	5.774	39.81	NA	"	
BIL-GR-3-5	"	"	0.983	0.1745	2.800	1,309	5.723	39.46	NA	"	
						Average	5.698	39.29			
						Std. Dev.	0.091	0.63			
BIL-GR-3-2	1 month @ 49°C (120°F)	22°C (72°F) (WET)	0.983	0.1747	2.816	987	4.307	29.70	2.81	4/24/89	(1)
BIL-GR-3-4	"	"	0.979	0.1764	2.816	1,001	4.347	29.97	3.00	"	(1)
						Average	4.327	29.84	2.91		
						Std. Dev.	0.028	0.19	0.13		

(*) Specimens aged by water immersion @ 140°F.

TABLE M.7
 EFFECT OF RESIN STORAGE FOR 3 MONTHS AT 22°C (72°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 16/1)				Specimen Orientation:		
Material :		EA-9396 A/B; W133 Graphite				Batch #1 Task #13				Tested By:		
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Aging (%)	Date Tested	Remarks	Warp
												DRB
BIL-GR-30-1	3 mos. @ 22°C (72°F)	22°C (72°F) (DRY)	1.002	0.1660	2.678	1,246	5.617	38.73	NA	2/22/89		
BIL-GR-30-3	22°C (72°F)	"	1.003	0.1689	2.678	1,289	5.706	39.34	NA	"		
BIL-GR-30-5	"	"	1.002	0.1672	2.678	1,167	5.222	36.01	NA	"		
							Average	5.515	38.03			
							Std. Dev.	0.257	1.78			
BIL-GR-30-2	3 mos. @ 22°C (72°F) (WET)	"	1.003	0.1683	2.816	999	4.441	30.62	1.53		(1)	
BIL-GR-30-4	22°C (72°F)	"	1.003	0.1688	2.816	1,057	4.684	32.30	1.58		(1)	
							Average	4.562	31.46	1.56		
							Std. Dev.	0.172	1.19	0.04		

(1) Specimens aged by water immersion @ 140°F.

TABLE M.8
 EFFECT OF RESIN STORAGE FOR 6 MONTHS AT 22°C (72°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp			
Material :		EA-9396 A/B; W133 Graphite		Batch #1 Task #13		Tested By:		TOB & DH			
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-49-1	6 mos. @ 22°C (72°F)	22°C (72°F) (DRY)	1.005	0.1888	2.816	1,499	5.928	40.87	NA	5/25/89	
BIL-GR-49-3	22°C (72°F)	"	1.005	0.1925	2.816	1,698	6.586	45.41	NA	"	
BIL-GR-49-5	"	"	1.005	0.1892	2.816	1,526	6.019	41.50	NA	"	
						Average	6.178	42.60			
						Std. Dev.	0.356	2.46			
BIL-GR-49-2	6 mos. @ 22°C (72°F)	22°C (72°F) (WET)	1.005	0.1975	3.159	1,159	4.379	30.20	2.66	12/12/89	(1)
BIL-GR-49-4	22°C (72°F)	"	1.005	0.1962	3.159	1,166	4.435	30.58	2.70	"	(1)
						Average	4.407	30.39			
						Std. Dev.	0.039	0.27			

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.9
 EFFECT OF RESIN STORAGE FOR 6 MONTHS AT 38°C (100°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength		Date Tested	Remarks
							(Ksi.)	(MPa)		
BIL-GR-48-1	6 mos. @ 38°C (100°F)	22°C (72°F) (DRY)	1.006	0.1838	2.816	1,462	5.929	40.88	5/25/89	
BIL-GR-48-3	"	"	1.006	0.1994	2.816	1,591	5.950	41.02	"	
BIL-GR-43-5	"	"	1.005	0.1818	2.816	1,639	6.727	46.38	"	
						Average	6.202	42.76		
						Std. Dev.	0.455	3.13		
BIL-GR-48-2	6 mos. @ 38°C (100°F)	22°C (72°F) (WET)	1.005	0.1943	3.159	1,229	4.720	32.55	12/12/89	(1)
BIL-GR-48-4	"	"	1.004	0.1974	3.159	1,230	4.655	32.09	"	(1)
						Average	4.687	32.32		
						Std. Dev.	0.046	0.32		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.10
 EFFECT OF RESIN STORAGE FOR 6 MONTHS AT 49°C (120°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp			
Material :		EA-9396 A/B; W133 Graphite		Batch #1 Task #13		Tested By:		TOB & DH			
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-47-1	6 mos. @ 49°C (120°F)	22°C (72°F) (DRY)	1.007	0.1873	2.816	1,559	6.199	42.74	NA	5/25/89	
BIL-GR-47-3	"	"	1.007	0.1923	2.816	1,640	6.353	43.80	NA	"	
BIL-GR-47-5	"	"	1.006	0.1825	2.816	1,493	6.099	42.05	NA	"	
						Average	6.217	42.87			
						Std. Dev.	0.128	0.86			
BIL-GR-47-2	6 mos. @ 49°C (120°F)	22°C (72°F) (WET)	1.004	0.1975	3.159	1,128	4.266	29.42	2.79	12/12/89	(1)
BIL-GR-47-4	"	"	1.005	0.2018	3.159	1,143	4.227	29.14	2.78	"	(1)
						Average	4.247	29.28	2.79		
						Std. Dev.	0.028	0.19	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.11
EFFECT OF RESIN STORAGE FOR 12 MONTHS AT 22°C (72°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear				Specimen Orientation:				Warp			
Material :		EA-9396 A/B; W133 Graphite				Batch #1 Task #13				Tested By:		DH	
		(4pt loading at 1/4 pts. L/D = 16/1)											
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks		
BIL-GR-60-1	12 mos. @ 22°C (72°F) (DRY)	"	0.998	0.1700	2.807	1,161	5.132	35.39	NA	5/25/99			
BIL-GR-60-3	22°C (72°F)	"	0.997	0.1791	2.807	1,324	5.561	38.34	NA	"			
BIL-GR-60-5	"	"	0.994	0.1762	2.807	1,257	5.383	37.11	NA	"			
						Average	5.359	36.95					
						Std. Dev.	0.215	1.49					
BIL-GR-60-2	12 mos. @ 22°C (72°F) (WET)	"	0.997	0.1768	2.832	978	4.161	28.69	2.59	12/12/89	(1)		
BIL-GR-60-4	22°C (72°F)	"	0.997	0.1773	2.832	1,066	4.523	31.19	2.59	"	(1)		
						Average	4.342	29.94					
						Std. Dev.	0.256	1.76					

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.12
 EFFECT OF RESIN STORAGE FOR 12 MONTHS AT 38°C (100°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear				(4pt loading at 1/4 pts. L/D = 16/1)				Specimen Orientation:	
Material :		EA-9396 A/B; W133 Graphite				Batch #1 Task #13				Tested By: Warp DH	
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-59-1	12 mos. @ 38°C (100°F)	22°C (72°F) (DRY)	0.998	0.1677	2.807	1,410	6.319	43.57	NA	12/6/89	
BIL-GR-59-3	"	"	0.997	0.1768	2.807	1,482	6.306	43.48	NA	"	
BIL-GR-59-5	"	"	0.997	0.1727	2.807	1,468	6.394	44.09	NA	"	
						Average	6.340	43.71			
						Std. Dev.	0.048	0.33			
BIL-GR-59-2	12 mos. @ 38°C (100°F)	22°C (72°F) (WET)	0.998	0.1750	2.832	1,109	4.762	32.84	2.55	2/23/90	(1)
BIL-GR-59-4	"	"	0.998	0.1761	2.832	1,111	4.741	32.69	2.54	"	(1)
						Average	4.752	32.76	2.54		
						Std. Dev.	0.015	0.10	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.13
 EFFECT OF RESIN STORAGE FOR 12 MONTHS AT 49°C (120°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. LD = 16/1)		Specimen Orientation:		Warp		
Material		EA-9396 A/B; W133 Graphite		Batch #1	Task #13	Tested By:		DH		
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks
BIL-GR-61-1	12 mos. @ 49°C (120°F)	22°C (72°F) (DRY)	0.996	0.1699	2.807	1,362	6.037	41.62	12/6/89	
BIL-GR-61-3	"	"	0.999	0.1810	2.807	1,469	6.093	42.01	"	
BIL-GR-61-5	"	"	1.001	0.1754	2.807	1,491	6.369	43.91	"	
						Average	6.166	42.52		
						Std. Dev.	0.178	1.23		
BIL-GR-61-2	12 mos. @ 49°C (120°F)	22°C (72°F) (WET)	0.996	0.1770	2.832	883	3.757	25.90	2/23/90	(1)
BIL-GR-61-4	"	"	1.001	0.1801	2.832	915	3.807	26.25	"	(1)
						Average	3.782	26.07		
						Std. Dev.	0.035	0.24		
						Wt. Gain				
						During Aging (%)				
						NA				
						NA				
						NA				

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.14
 EFFECT OF RESIN STORAGE FOR 18 MONTHS AT 22°C (72°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test : Material :	Apparent Interlaminar Shear EA-9396 A/B; W133 Graphite		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp PM & DRB				
	Batch #1	Task #13	Batch #1	Task #13	Tested By:	Wt. Gain					
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	During Aging (%)	Date Tested	Remarks
BIL-GR-74-1	18 mos. @ 22°C (72°F)	DRY	1.000	0.1730	2.827	1,318	5.714	39.40	NA	6/12/90	
BIL-GR-74-3	22°C (72°F)	"	1.004	0.1820	2.827	1,590	6.526	45.00	NA	"	
BIL-GR-74-5	"	"	1.003	0.1770	2.827	1,450	6.126	42.24	NA	"	
						Average	6.122	42.21			
						Std. Dev.	0.406	2.80			
BIL-GR-74-2	18 mos. @ 22°C (72°F)	WET	1.002	0.1800	2.848	1,073	4.462	30.76	2.64	10/16/90	(1)
BIL-GR-74-4	22°C (72°F)	"	1.003	0.1800	2.848	1,152	4.786	33.00	2.66	"	(1)
						Average	4.624	31.88			
						Std. Dev.	0.229	1.58			

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.15
EFFECT OF RESIN STORAGE FOR 18 MONTHS AT 38°C (200°F) ON
INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp			
Material :		EA-9396 A/B; W133 Graphite		Batch #1 Task #13		Tested By:		PM & DRB			
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-73-1	18 mos. @ 38°C (100°F)	22°C (72°F) (DRY)	1.000	0.1700	2.827	1,465	6.463	44.56	NA	6/12/90	
BIL-GR-73-3	"	"	1.000	0.1850	2.827	1,545	6.264	43.19	NA	"	
BIL-GR-73-5	"	"	0.993	0.1730	2.827	1,510	6.553	45.18	NA	"	
						Average	6.427	44.31			
						Std. Dev.	0.148	1.02			
BIL-GR-73-2	18 mos. @ 38°C (100°F)	22°C (72°F) (WET)	1.000	0.1760	2.848	1,222	5.207	35.90	2.64	10/16/90	(1)
BIL-GR-73-4	"	"	1.000	0.1760	2.848	1,215	5.178	35.70	2.66	"	(1)
						Average	5.192	35.80	2.65		
						Std. Dev.	0.021	0.15	0.01		

(1) Specimens aged @ 100% R.H. to saturation.

TABLE M.16
 EFFECT OF RESIN STORAGE FOR 18 MONTHS AT 49°C (120°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test	Apparent Interlaminar Shear	(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:	Warp						
Material	EA-9396 A/B: W133 Graphite	Batch #1	Task #13	Tested By:	PM & DRB						
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlamina Shear Strer. (Ksi.)	Interlamina Shear Strer. (Ksi.)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-72-1	18 mos. @ 22°C (72°F) (DRY)	22°C (72°F) (DRY)	0.999	0.1750	2.827	1,555	6.671	46.00	NA	6/12/90	
BIL-GR-72-3	49°C (120°F)	"	1.000	0.1800	2.827	1,605	6.688	46.11	NA	"	
BIL-GR-72-5	"	"	1.000	0.1750	2.827	1,595	6.836	47.13	NA	"	
						Average	6.731	46.41			
						Std. Dev.	0.091	0.63			
BIL-GR-72-2	18 mos. @ 22°C (72°F) (WET)	22°C (72°F) (WET)	0.995	0.1780	2.848	1,251	5.298	36.53	2.64	10/16/90	(1)
BIL-GR-72-4	49°C (120°F)	"	1.000	0.1770	2.848	1,190	5.042	34.77	2.66	"	(1)
						Average	5.170	35.65	2.65		
						Std. Dev.	0.180	1.24	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.17
 EFFECT OF RESIN STORAGE FOR 24 MONTHS AT 22°C (72°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp			
Material		EA-9396 A/B; W133 Graphite		Batch #1	Task #13	Tested By:		DRB			
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-85-1	24 mos. @ 22°C (72°F)	(DRY)	1.002	0.1798	2.940	1,567	6.523	44.98	NA	1/4/91	
BIL-GR-85-3	22°C (72°F)	"	1.002	0.1821	2.940	1,650	6.782	46.76	NA	"	
BIL-GR-85-5	"	"	1.002	0.1738	2.940	1,587	6.835	47.13	NA	"	
						Average	6.713	46.29			
						Std. Dev.	0.167	1.15			
BIL-GR-85-2	24 mos. @ 22°C (72°F)	(WET)	1.002	0.1806	2.940	1,120	4.642	32.01	2.65	6/14/91	(1)
BIL-GR-85-4	22°C (72°F)	"	1.002	0.1790	2.940	1,110	4.642	32.00	2.62	"	(1)
						Average	4.642	32.00	2.63		
						Std. Dev.	0.000	0.00	0.02		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.18
 EFFECT OF RESIN STORAGE FOR 24 MONTHS AT 38°C (100°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test	Apparent Interlaminar Shear	Specimen Orientation:		Warp							
Material	EA-9396 A/B: W133 Graphite	(4pt loading at 1/4 pts. L/D = 16/1)	Tested By:	DRB							
	Batch #1	Task #13	Wt. Gain								
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	During Aging (%)	Date Tested	Remarks
BIL-GR-86-1	24 mos. @ 38°C (100°F)	22°C (72°F) (DRY)	1.003	0.1845	2.940	1,520	6.160	42.48	NA	1/4/91	
BIL-GR-86-3	"	"	1.002	0.1904	2.940	1,445	5.681	39.17	NA	"	
BIL-GR-86-5	"	"	1.002	0.1829	2.940	1,410	5.770	39.79	NA	"	
						Average	5.870	40.48			
						Std. Dev.	0.255	1.76			
BIL-GR-86-2	24 mos. @ 38°C (100°F)	22°C (72°F) (WET)	1.002	0.1885	2.940	1,060	4.209	29.02	2.80	6/14/91	(1)
BIL-GR-86-4	"	"	1.002	0.1887	2.940	990	3.927	27.08	2.80	"	(1)
						Average	4.068	28.05	2.80		
						Std. Dev.	0.199	1.38	0.00		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.19
 EFFECT OF RESIN STORAGE FOR 24 MONTHS AT 49°C (120°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test	Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp				
Material	EA-9396 A/B	W133 Graphite	Batch #1	Task #13	Tested By:		DRB				
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	During Aging (%)	Date Tested	Remarks
BIL-GR-87-1	24 mos. @ 49°C (120°F)	22°C (72°F) (DRY)	1.004	0.1882	2.940	1.580	6.271	43.24	NA	1/4/91	
BIL-GR-87-3	"	"	1.005	0.1861	2.940	1.595	6.396	44.10	NA	"	
BIL-GR-87-5	"	"	1.003	0.1798	2.940	1.465	6.093	42.01	NA	"	
						Average	6.253	43.12			
						Std. Dev.	0.152	1.05			
BIL-GR-87-2	24 mos. @ 49°C (120°F)	22°C (72°F) (WET)	1.005	0.1860	2.940	1.150	4.614	31.81	2.82	6/14/91	(1)
BIL-GR-87-4	"	"	1.005	0.1856	2.940	1.130	4.544	31.33	2.84	"	(1)
						Average	4.579	31.57	2.83		
						Std. Dev.	0.050	0.34	0.01		

(1) Specimens aged @ 140°F/95-100% R.H. to saturation.

TABLE M.20
 EFFECT OF RESIN STORAGE FOR 43 MONTHS AT 22°C (72°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear			(4pt loading at 1/4 pts. LD = 16/1)		Specimen Orientation:		Warp		
Material :		EA-9396 A/B; W133 Graphite			Batch #1 Task #13		Tested By:		PM		
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	During Aging (%)	Date Tested	Remarks
BIL-GR-89-1	43 mos. @ 22°C (72°F)	(DRY)	0.998	0.1632	2.685	1,446	6.659	45.91	NA	7/20/92	
BIL-GR-89-3	22°C (72°F)	"	1.001	0.1699	2.685	1,499	6.611	45.58	NA	"	
BIL-GR-89-5	"	"	1.001	0.1645	2.685	1,442	6.568	45.29	NA	"	
						Average	6.612	45.59			
						Std. Dev.	0.045	0.31			
B/L-GR-89-2	43 mos. @ 22°C (72°F)	(WET)	1.001	0.1648	2.690	1,080	4.910	33.86	2.87	2/19/93	(1)
B/L-GR-89-4	22°C (72°F)	"	0.999	0.1691	2.690	1,106	4.910	33.86	2.85	"	(1)
						Average	4.910	33.86			
						Std. Dev.	0.000	0.00			

(1) Specimens aged by water immersion at 140°F.

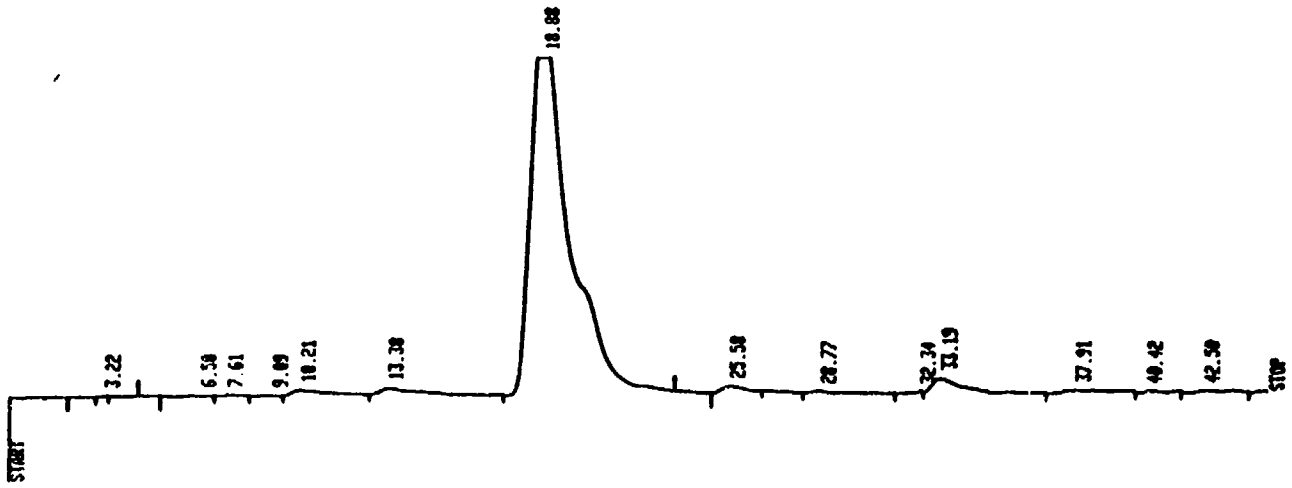
TABLE M.21
 EFFECT OF RESIN STORAGE FOR 43 MONTHS AT 38°C (100°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pls. L/D = 16/1)		Specimen Orientation:		Warp			
Material :		EA-9396 A/B; W133 Graphite		Batch #1	Task #13	Tested By:		PM			
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Wt. Gain During Aging (%)	Date Tested	Remarks
BIL-GR-90-1	43 mos. @ 38°C (100°F)	22°C (72°F) (DRY)	1.001	0.1683	2.685	1,479	6.584	45.40	NA	7/20/92	
BIL-GR-90-3	"	"	1.000	0.1709	2.685	1,497	6.570	45.30	NA	"	
BIL-GR-90-5	"	"	1.000	0.1698	2.685	1,513	6.683	46.08	NA	"	
						Average	6.612	45.59			
						Std. Dev.	0.062	0.42			
BIL-GR-90-2	43 mos. @ 38°C (100°F)	22°C (72°F) (WET)	1.001	0.1720	2.690	1,146	4.992	34.42	3.08	2/19/93	(1)
BIL-GR-90-4	"	"	1.001	0.1705	2.690	1,074	4.720	32.54	2.95	"	(1)
						Average	4.856	33.48	3.02		
						Std. Dev.	0.193	1.33	0.09		

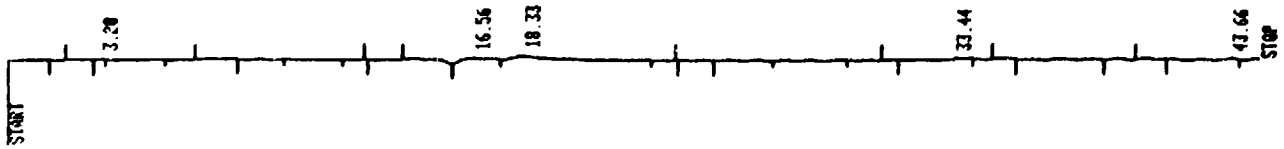
(1) Specimens aged by water immersion at 140°F.

TABLE M.22
 EFFECT OF RESIN STORAGE FOR 50 MONTHS AT 22°C (72°F) ON
 INTERLAMINAR SHEAR STRENGTH OF GRAPHITE
 REINFORCED EA9396 COMPOSITE LAMINATE

Test :		Apparent Interlaminar Shear		(4pt loading at 1/4 pts. L/D = 16/1)		Specimen Orientation:		Warp		
Material :		EA-9396 A/B; W133 Graphite		Batch #1 Task #13		Tested By:		PM		
Specimen Number	Storage Condition	Test Condition	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Date Tested	Remarks
BIL-GR-91-1	50 mos. @ 22°C (72°F)	22°C (72°F) (DRY)	1.000	0.1764	2.842	1,490	6.335	43.68	2/19/93	
BIL-GR-91-2	"	"	1.000	0.1793	2.842	1,500	6.275	43.27	"	
BIL-GR-91-3	"	"	1.001	0.1795	2.842	1,454	6.069	41.84	"	
BIL-GR-91-4	"	"	1.000	0.1784	2.842	1,608	6.759	46.61	"	
BIL-GR-91-5	"	"	1.001	0.1746	2.842	1,467	6.295	43.41	"	
							Average	43.76		
							Std. Dev.	0.253		

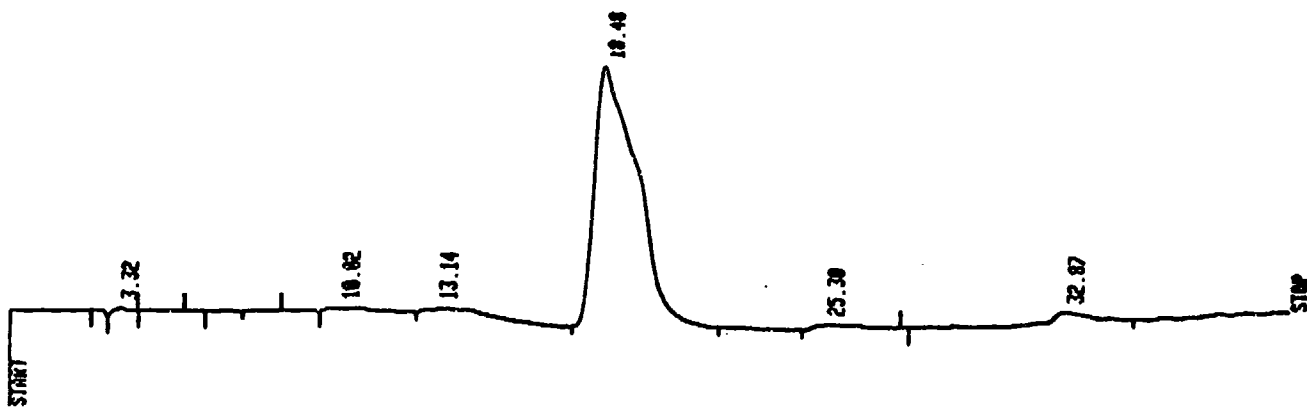


(a) Part A

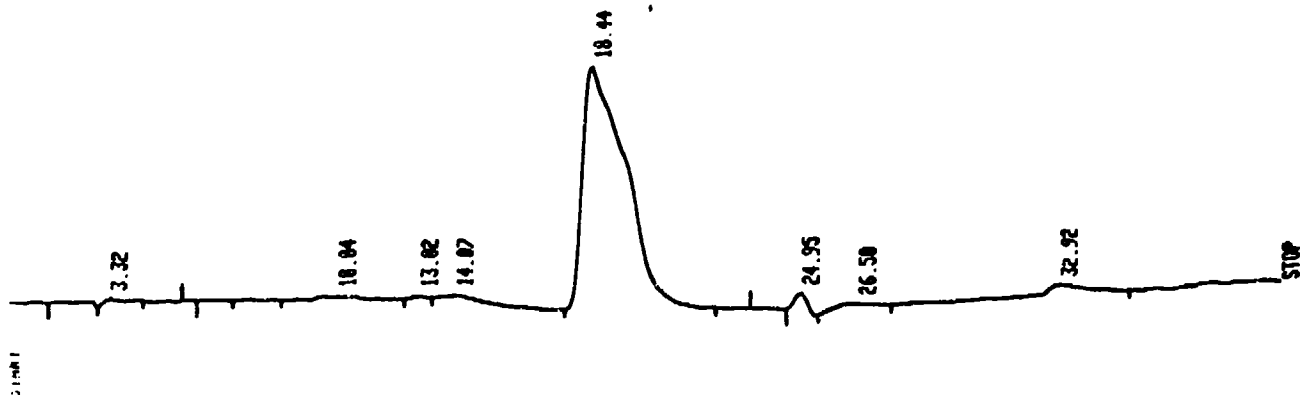


(b) Part B

Figure M.1. Initial HPLC Spectra for EA9396 Parts A and B.

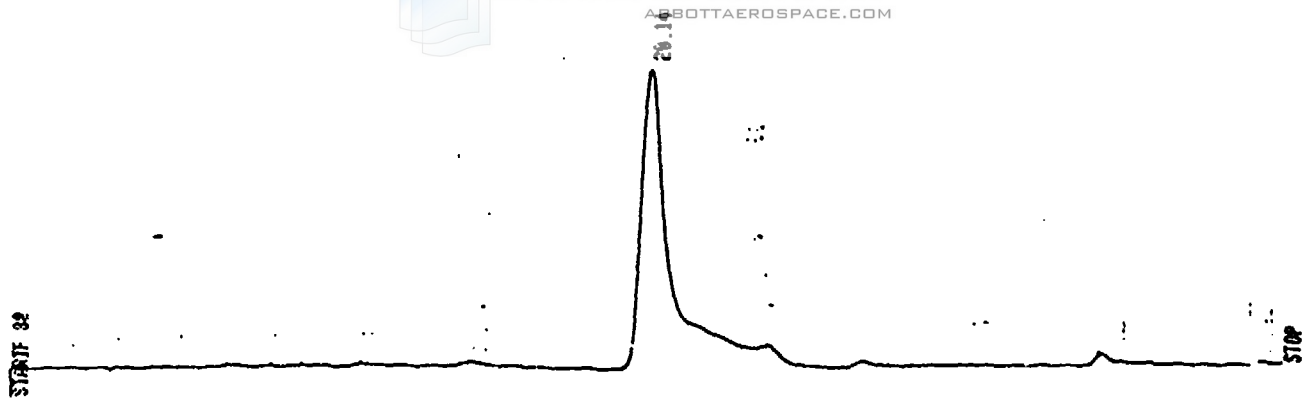


(a) Stored 1 month at 38°C (100°F).

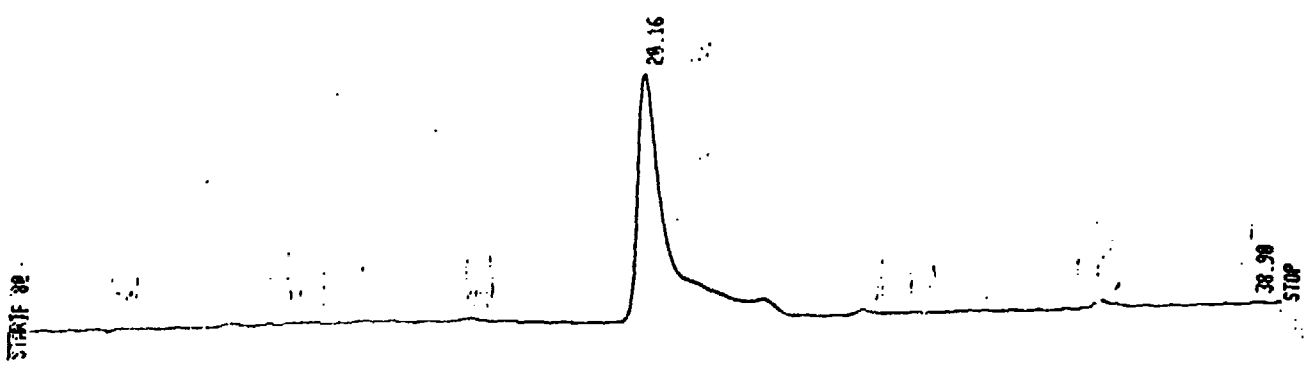


(b) Stored 1 month at 49°C (120°F).

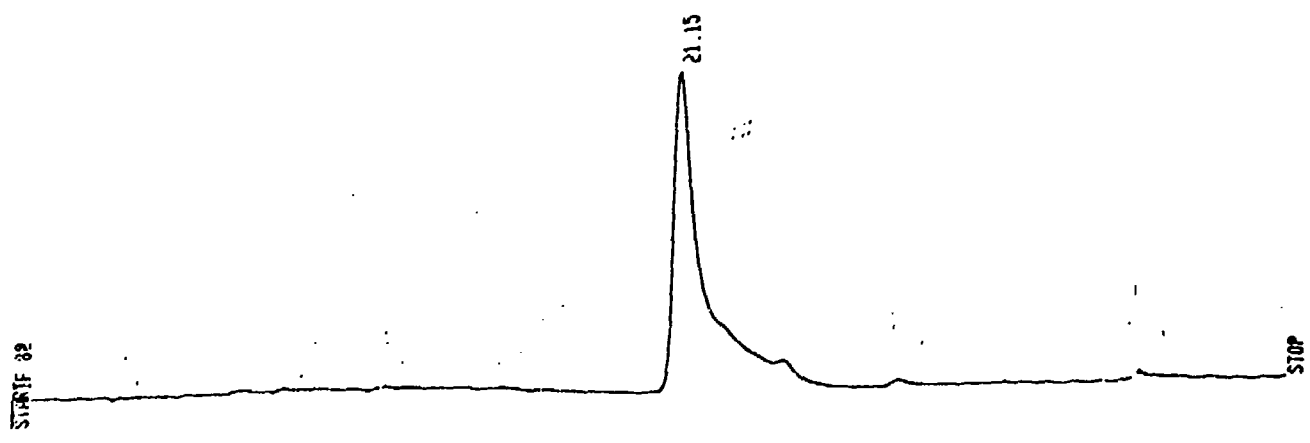
Figure M.2. HPLC Spectra for EA9396, Part A After One Month Storage.



(a) Stored 6 months at 22°C (72°F).

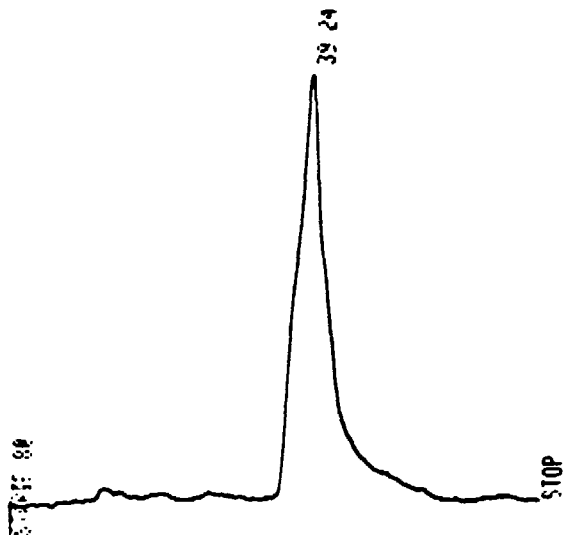


(b) Stored 6 months at 38°C (100°F).

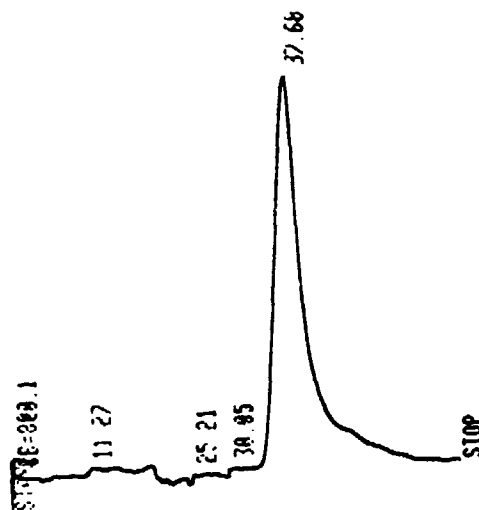


(c) Stored 6 months at 49°C (120°F).

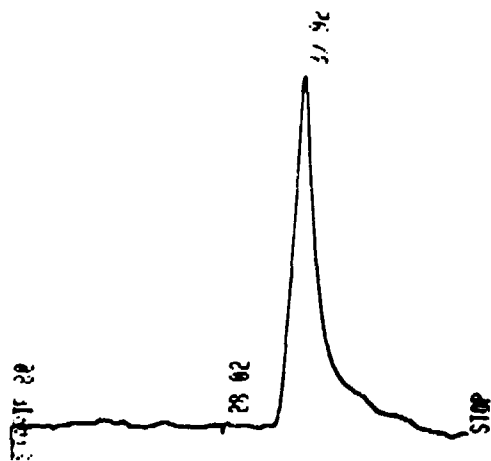
Figure M.3. HPLC Spectra for EA9396, Part A After Six Months Storage.



(a) Stored 12 Months at 22°C (72°F).



(b) Stored 12 Months at 38°C (100°F).

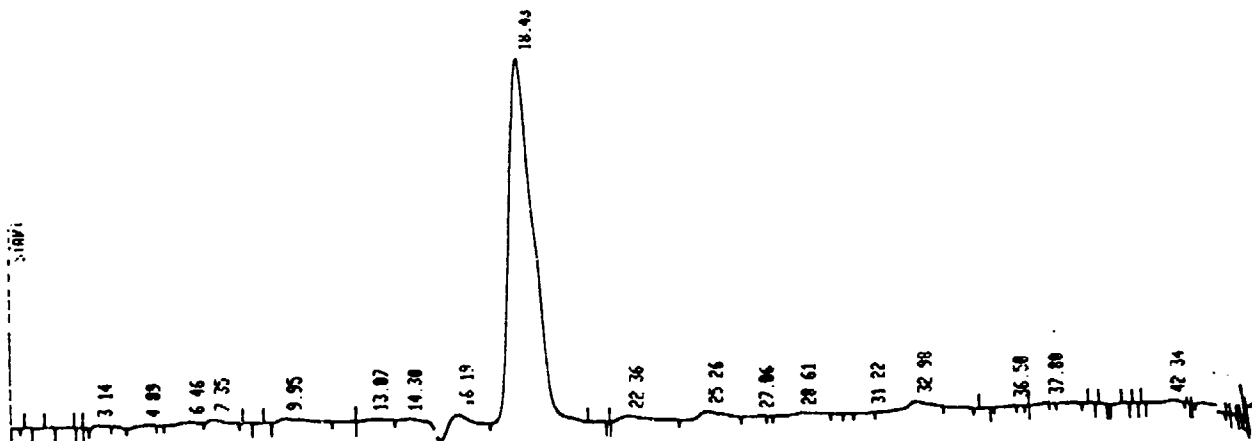


(c) Stored 12 Months at 49°C (120°F).

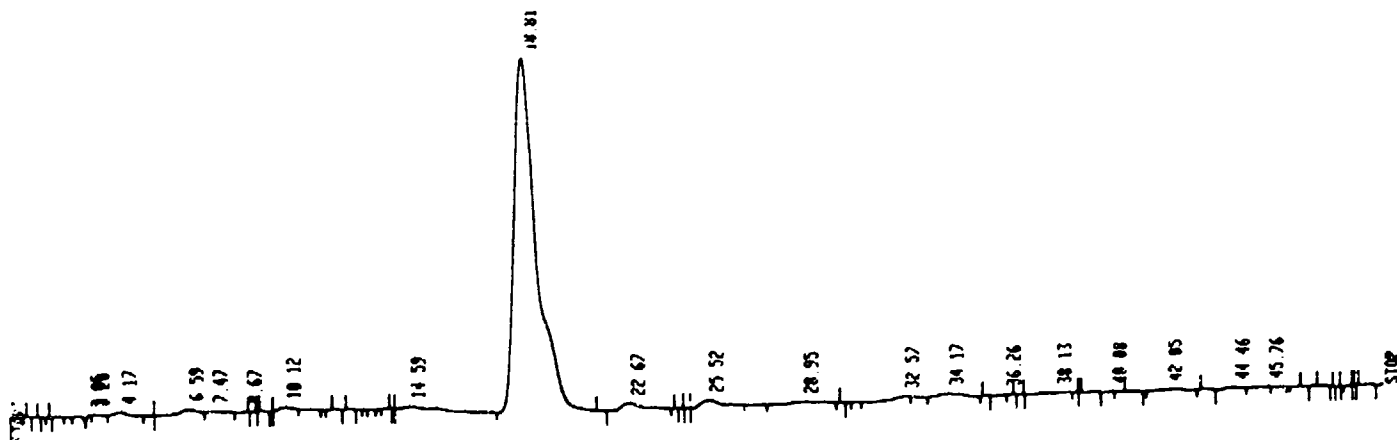
Figure M.4. HPLC Spectra for EA9396, Part A After 12 Months Storage.



(a) Stored 18 months at 22°C (72°F).

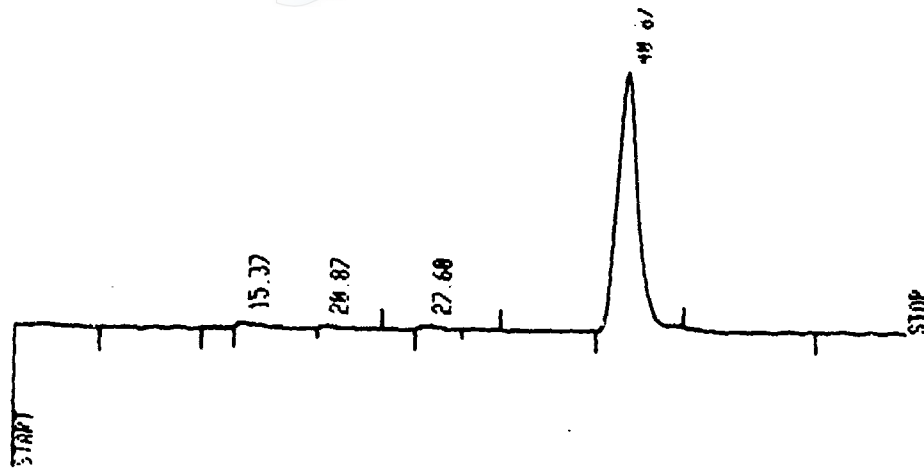


(b) Stored 18 months at 38°C (100°F).

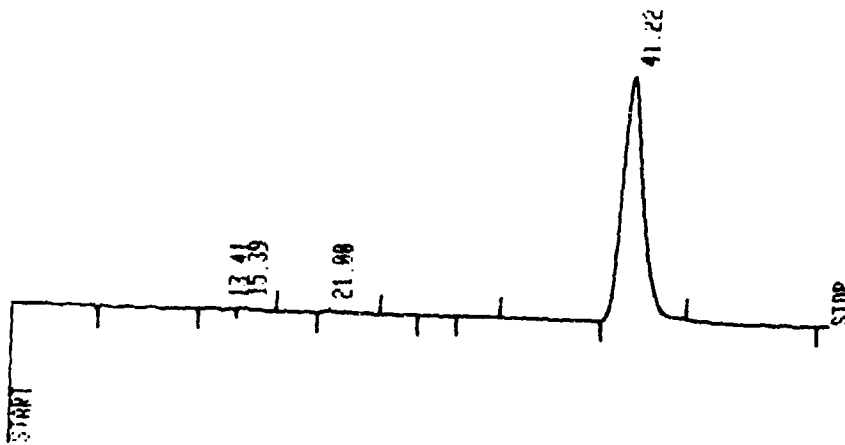


(c) Stored 18 months at 49°C (120°F).

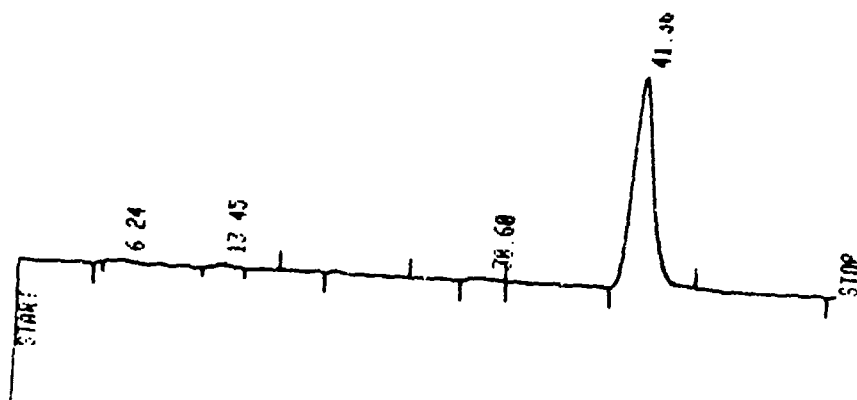
Figure M.5. HPLC Spectra of EA9396, Part A After 18 Months Storage.



(a) Stored 24 months at 22°C (72°F).



(b) Stored 24 months at 38°C (100°F).



(c) Stored 24 months at 49°C (120°F).

Figure M.6. HPLC Spectra of EA9396, Part A After 24 Months Storage.

Sample: EA 9398 (imp. J 72°F) REPEAT
Size: 5.2460 mg
Method: BMI-Tg & HR
Comment: 10°C/min
Files: DSC0934.01
Operator: GALASKA
Run Date: 12/19/88 13:50

DSC

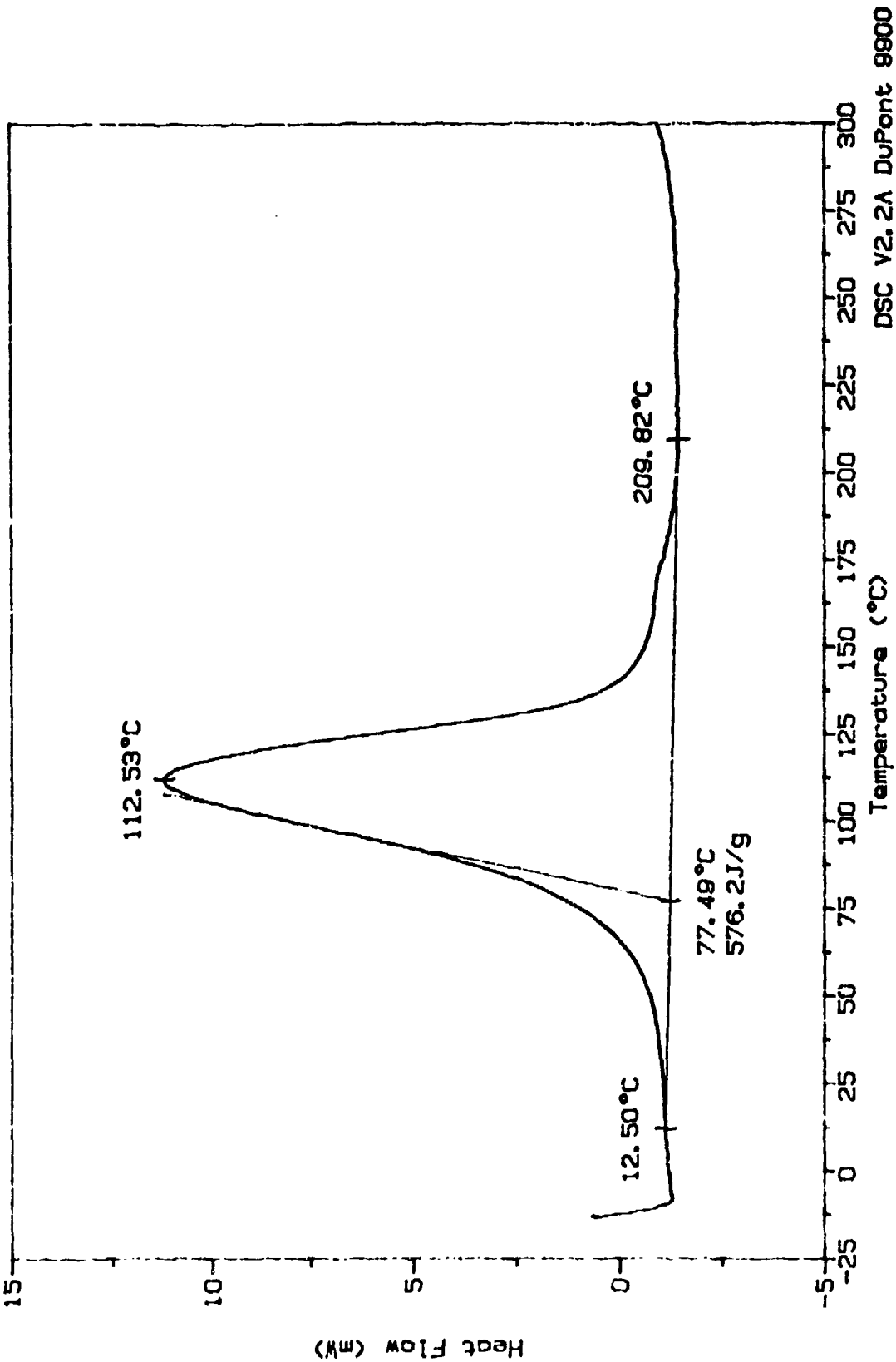


Figure M.7. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 1 Month.

Sample: EA 9396 (1 mth @ 100°F) File: DSC0932.01
Size: 5.3540 mg Operator: GALASKA
Method: BMI-Ig & HR Run Date: 12/19/88 09:40
Comments: 10°C/min

DSC

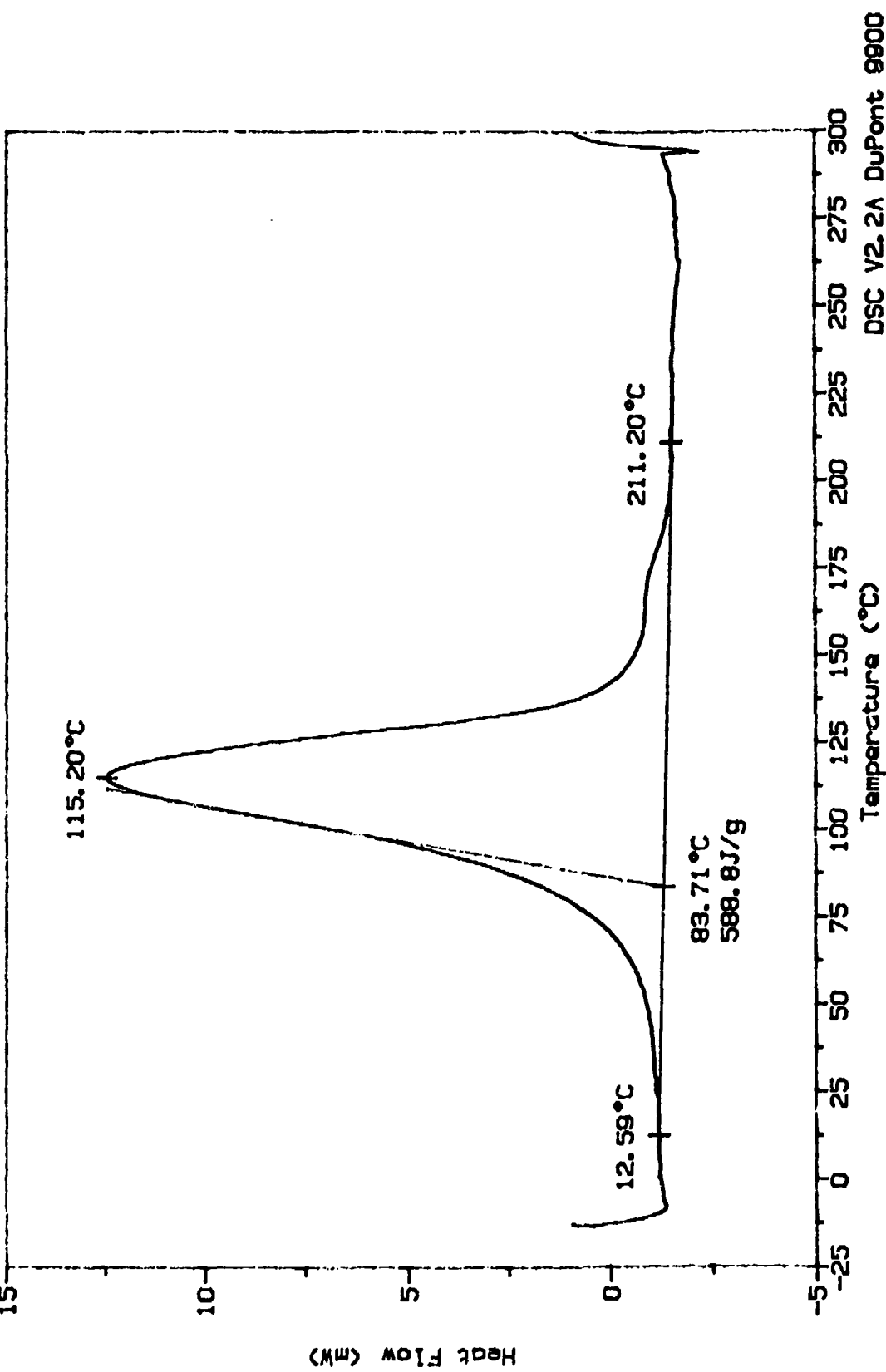
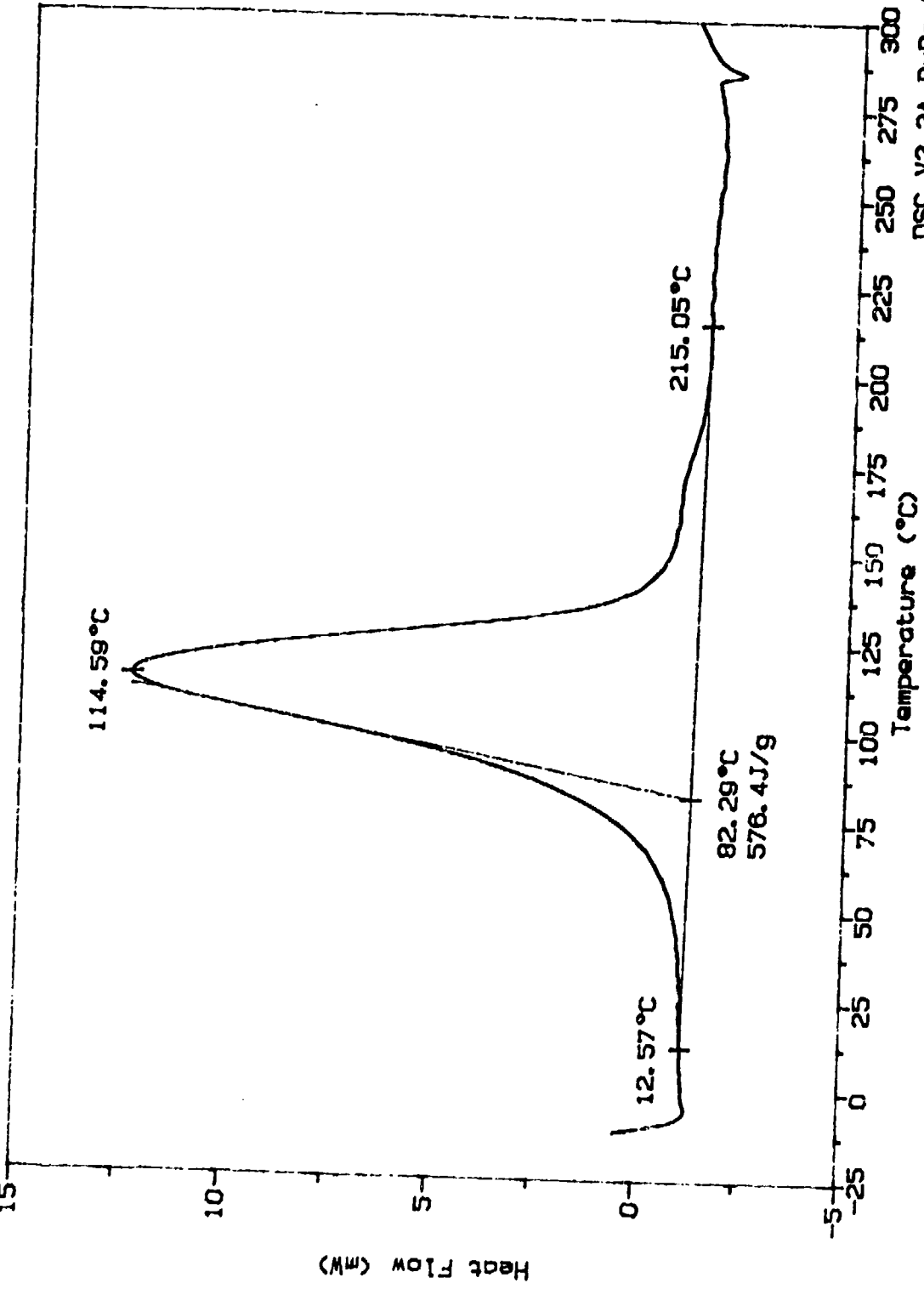


Figure M.8. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 1 Month.

Sample: EA 9396 (1 mth @ 120°F)
Size: 5.4340 mg
Method: BMI-Tg & HR
Comments: 10°C/min

DSC

File: DSC0393.01
Operator: GALASKA
Run Date: 12/19/88 12:08



DSC V2.2A DuPont 9900

Figure M.9. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 1 Month.

Sample: EA 9386 (3 mth @ RT) File: E1DSC0387.01
Size: 5.1680 mg Operator: GALASKA
Method: BMI-Tg & HR Run Date: 02/09/99 10:43
Comments: 10°C/MIN-NIT

DSC

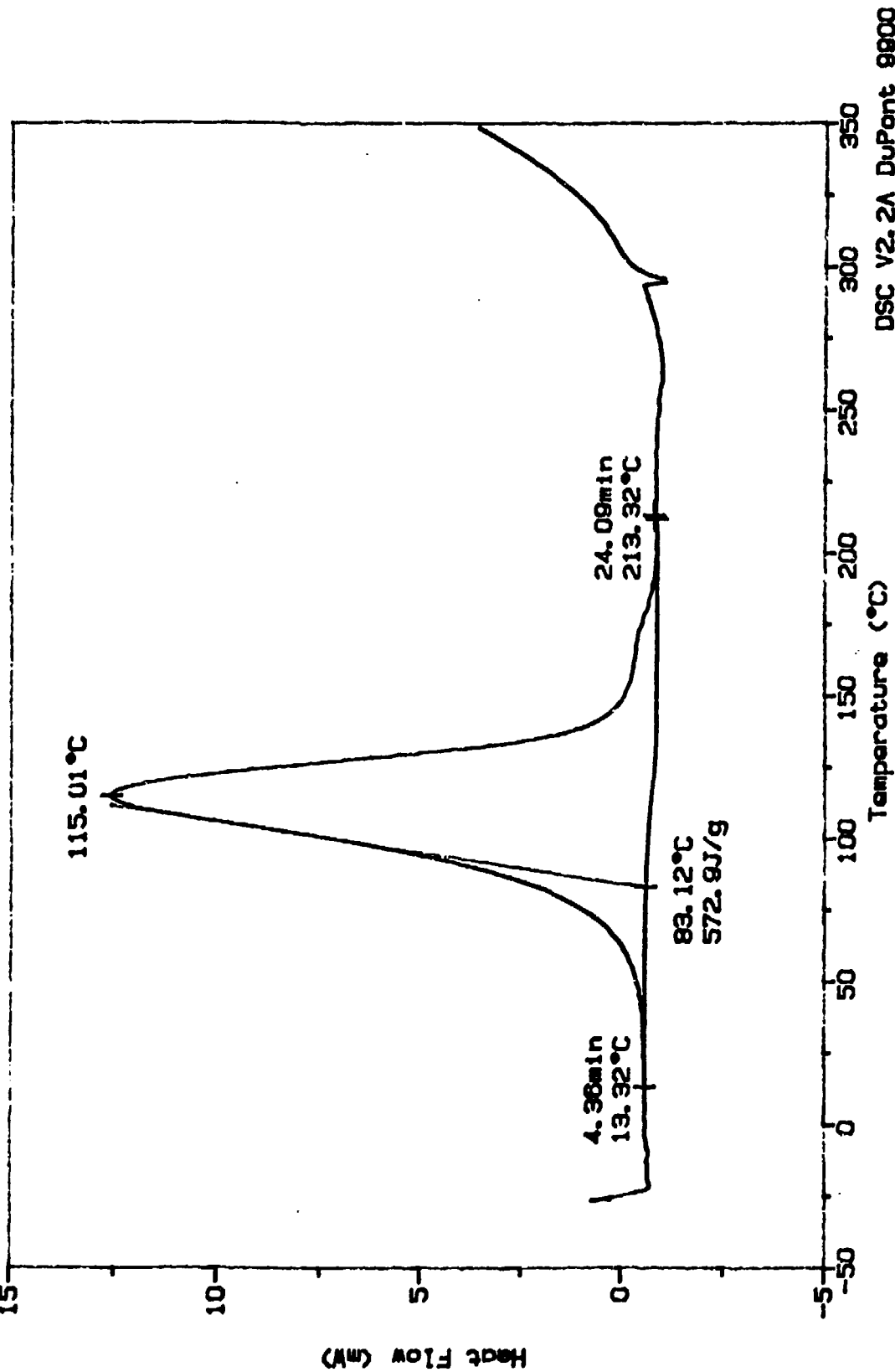


Figure M.10. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 3 Months.

Sample: EA 9396 8 mth @ RT
Size: 5.2100 mg
Method: DSC-DYNAMIC TO 300°C
Comments: 10°C/MIN, N2

DSC
File: DSC0547.01
Operator: GALASKA
Run Date: 18-May-89 14:27

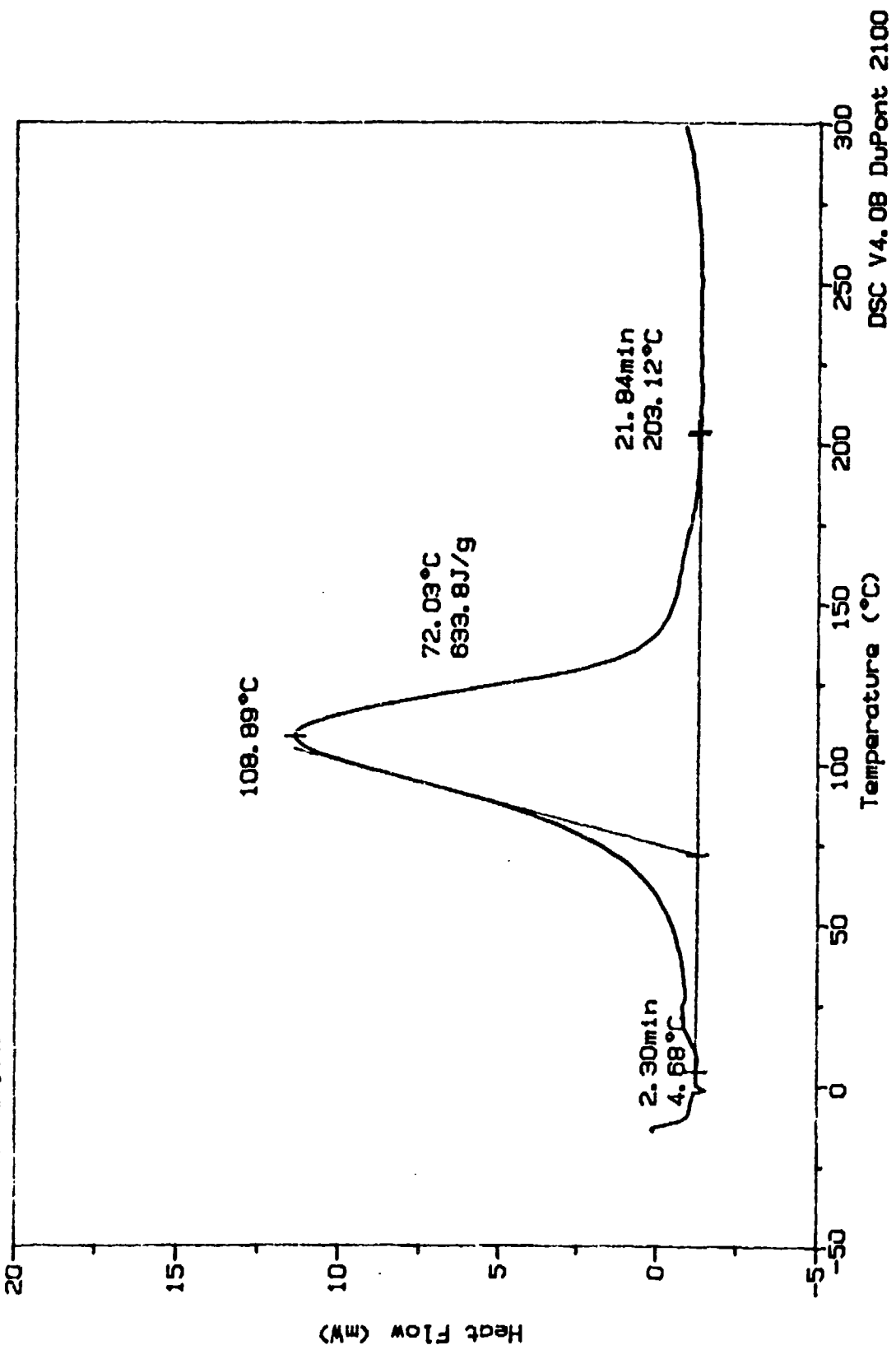


Figure M.11. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 6 Months.

Sample: EA 9396 6 mth @ 100°F
Size: 5.1780 mg
Method: DSC-DYNAMIC TO 300°C
Comments: 10°C/MIN, N2

DSC

File: DSC0548.01
Operator: GALASKA
Run Date: 16-May-89 12:32

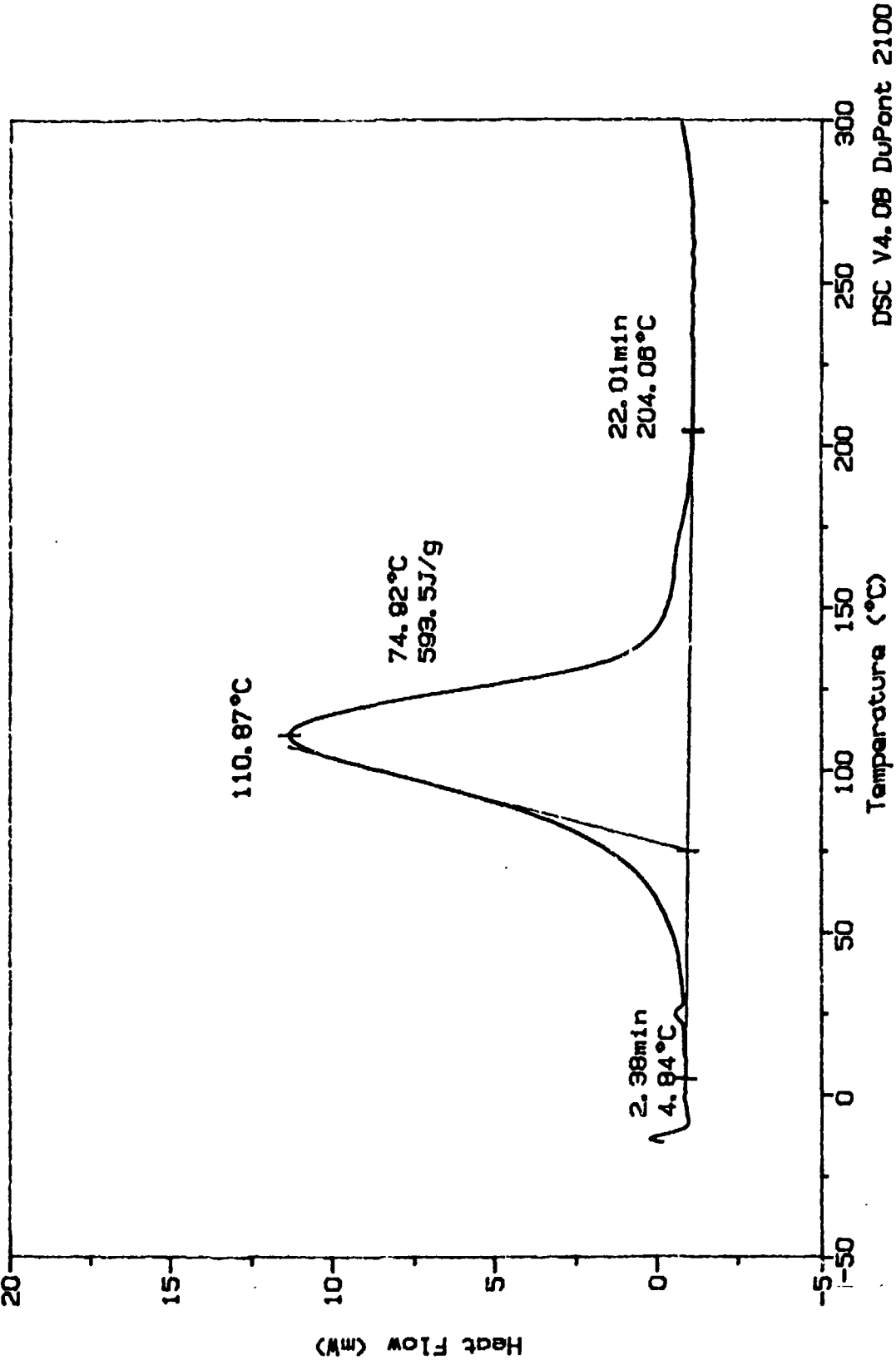


Figure M.12. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 6 Months.

Sample: EA 9396 8 mth @ 120°F
Size: 6.5940 mg
Method: DSC-DYNAMIC TO 300°C
Comments: 10°C/MIN, N2

DSC

File: DSC0545.01
Operator: GALASKA
Run Date: 18-May-89 11:24

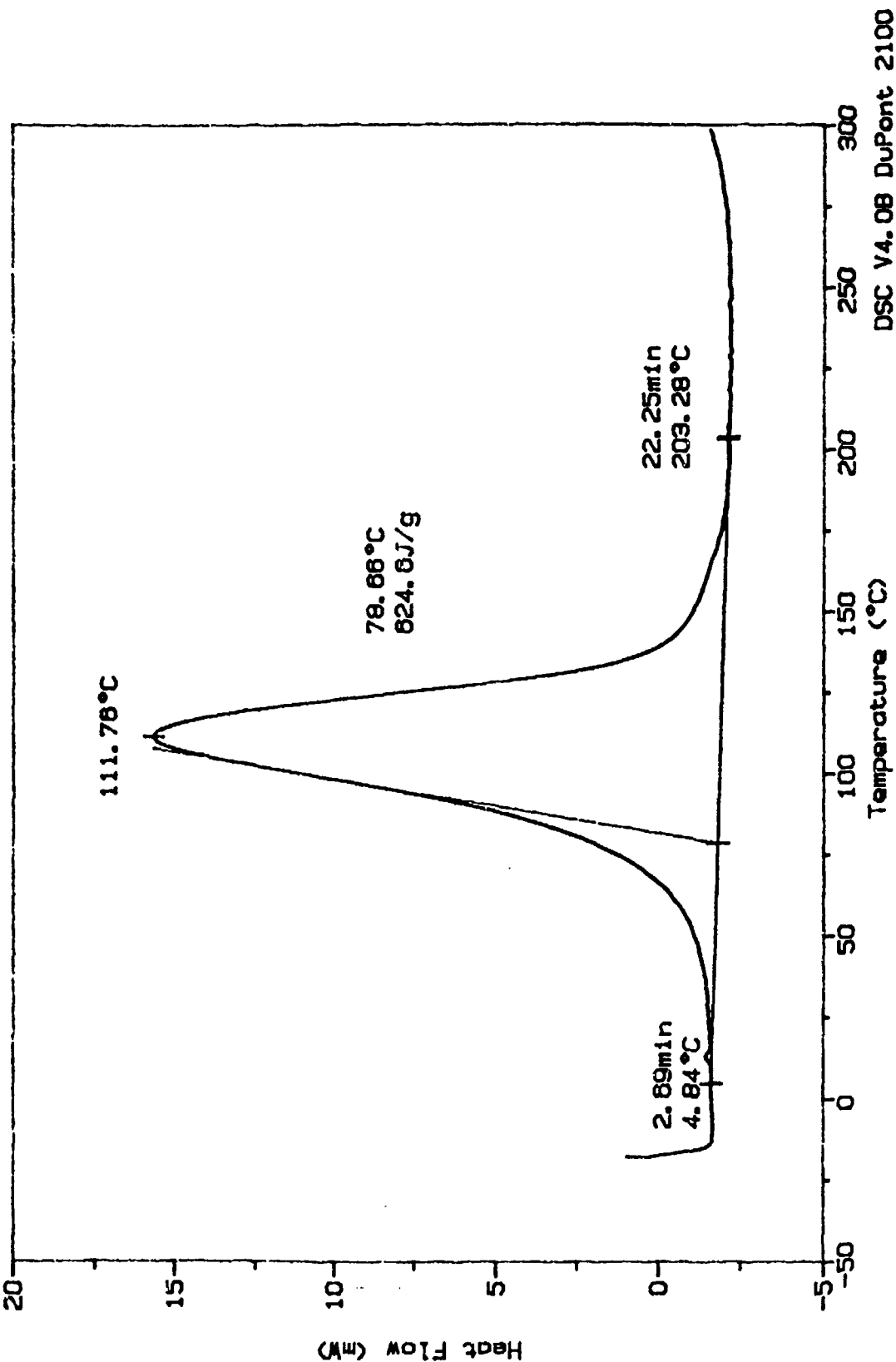


Figure M.13. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 6 Months.

Sample: EA 9396 1 yr 0 RT
Size: 4.6700 mg
Method: DSC-HI-TEMP
Comment: 10°/MIN. NIT

DSC

File: DSC0970.01
Operator: GALASKA
Run Date: 17-Nov-89 09:07

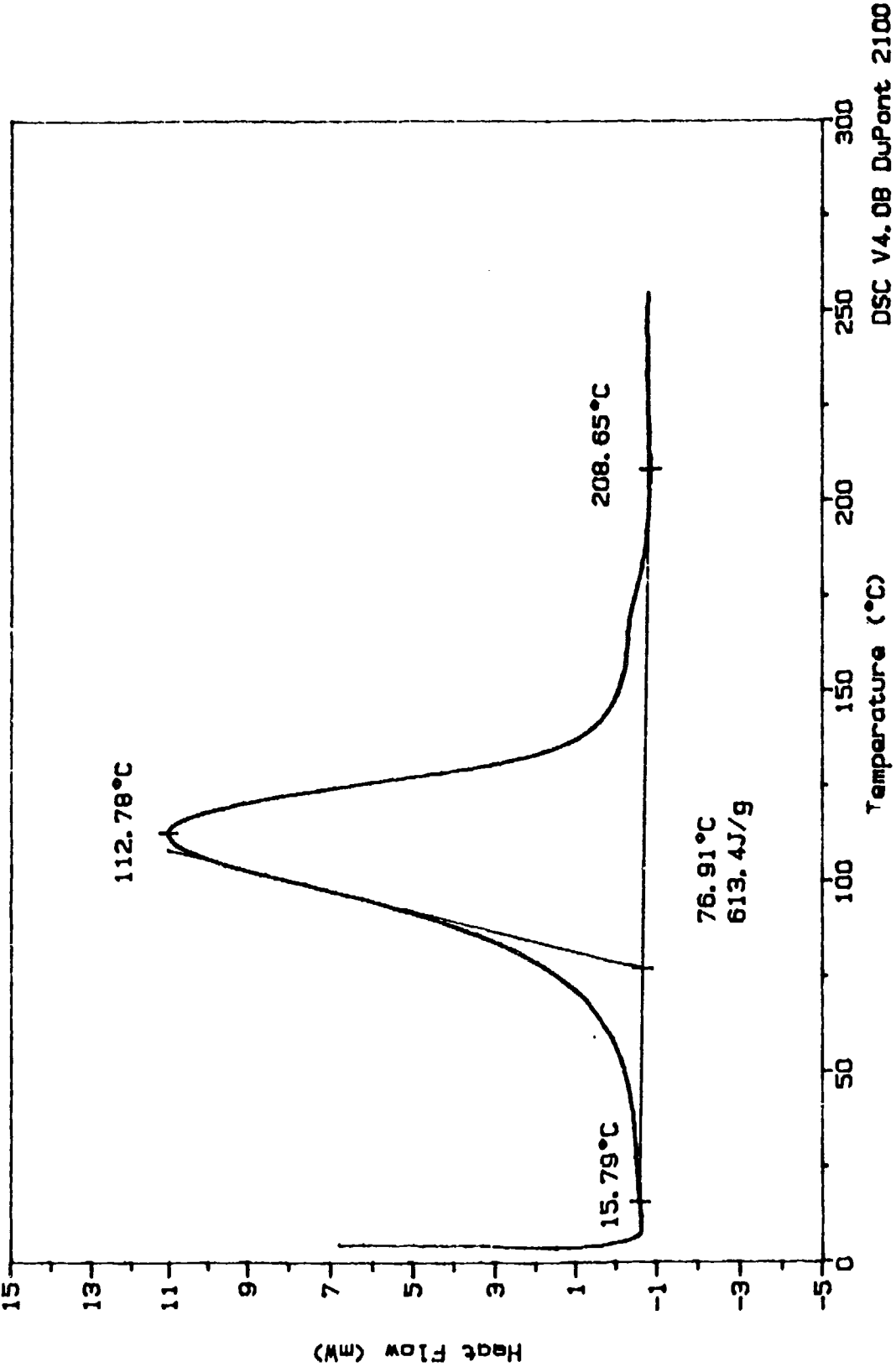


Figure M.14. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 12 Months.

File: DSC0972.01
Operator: GALASKA
Run Date: 17-Nov-89 10:50

DSC

Sample: EA 9398 1 yr @ 100°F
Size: 5.7120 mg
Method: DSC-HI-TEMP
Comments: 10°/MIN,NIT

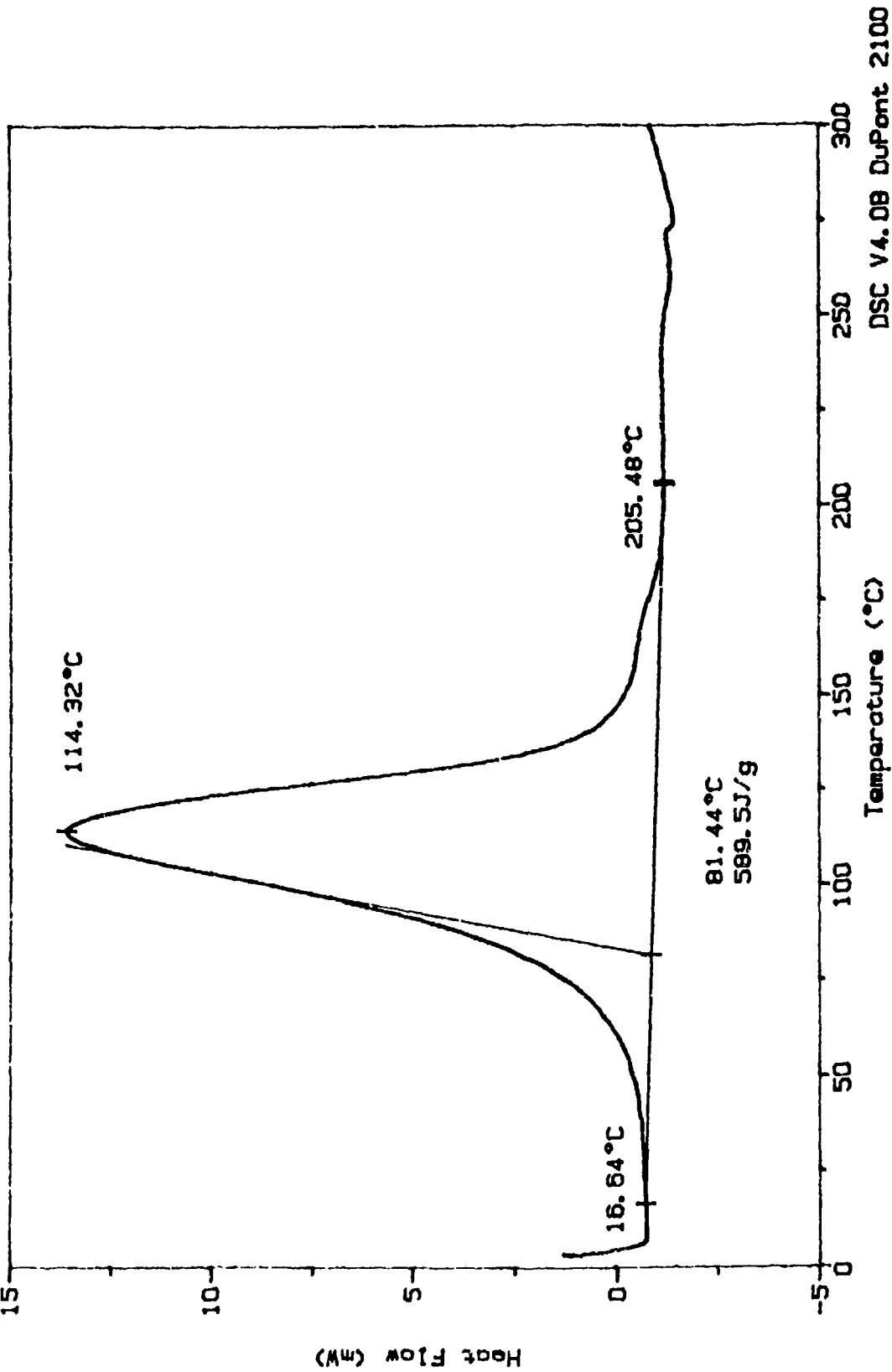


Figure M.15. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 12 Months.

File: DSC0971.D1
Operator: GALASKA
Run Date: 17-Nov-89 10:06

DSC

Sample: EA 9396 1 yr @ 120°F
Size: 5.0580 mg
Method: DSC-HI-TEMP
Comment: 10°/MIN. NIT

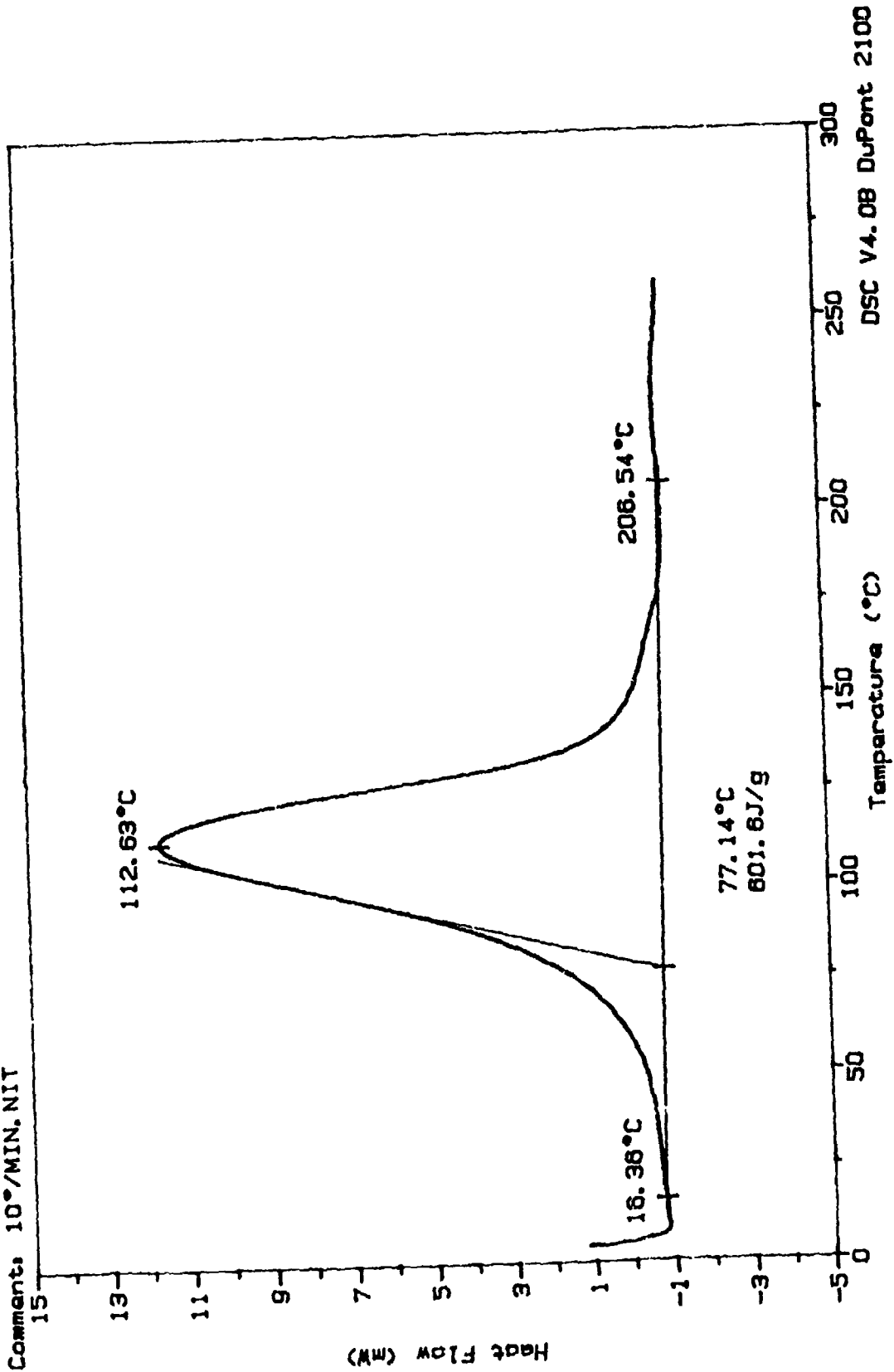


Figure M.16. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 12 Months.

Sample: EA 9396 18 m @ RT
Size: 6.7880 mg
Method: DSC-HIGH TEMP
Comment: 10°C/MIN

File: DSC1151.01
Operator: GALASKA
Run Date: 21-May-90 11:14

DSC

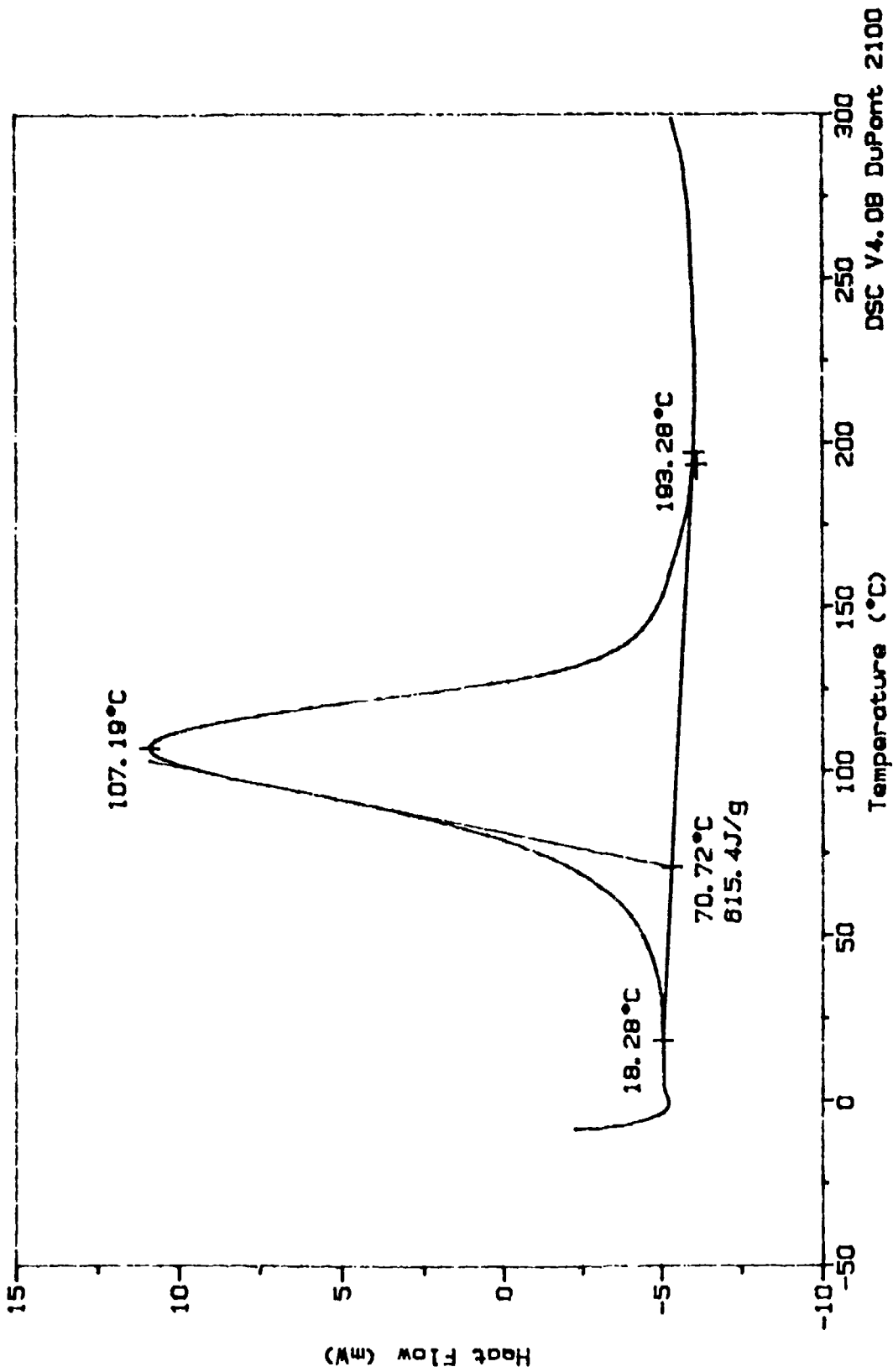


Figure M.17. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 18 Months.

Sample: EA 9396 18 m @ 100°F
Size: 7.0800 mg
Method: DSC-HIGH TEMP
Comment: 10°C/MIN

DSC

File: DSC1152.01
Operator: CALASKA
Run Date: 21-May-90 13:41

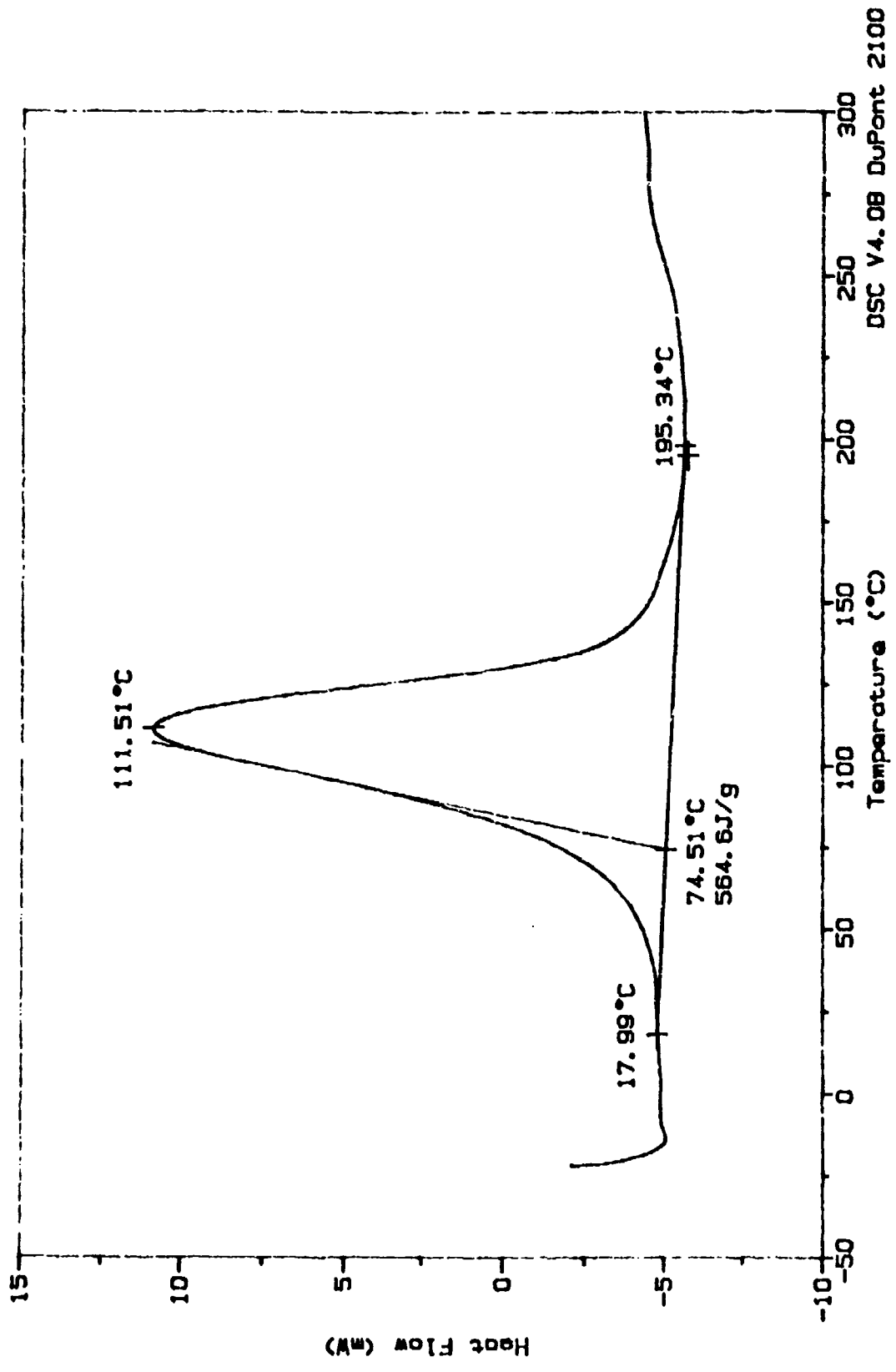


Figure M.18. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 18 Months.

Sample: EA 9396 18 m @ 120°F
Size: 6.2500 mg
Method: DSC-HIGH TEMP
Comment: 10°C/MIN

DSC

File: DSC1153.01
Operator: GALASKA
Run Date: 21-May-90 15:23

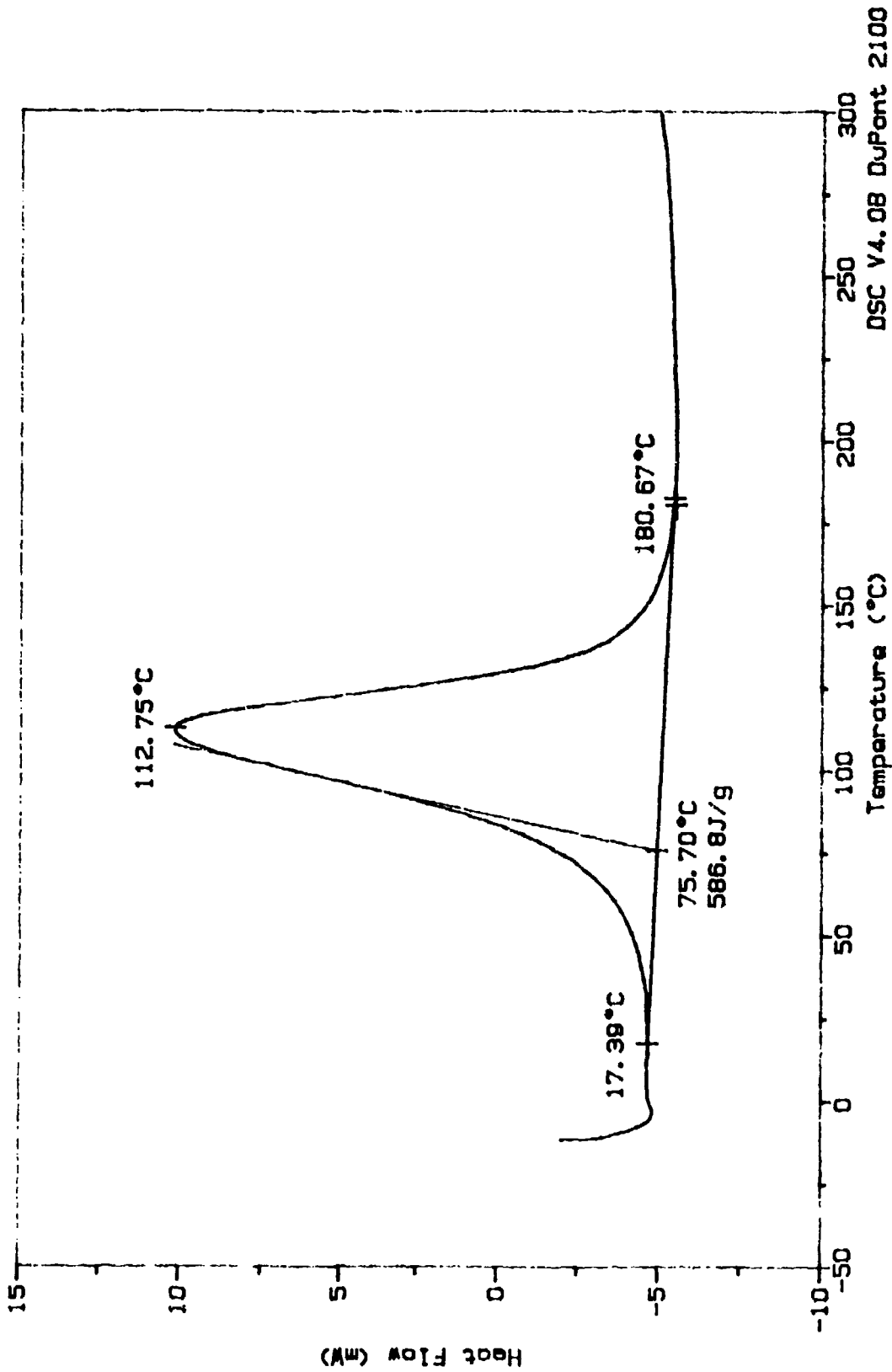


Figure M.19. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 18 Months.

Sample: EA 9396 2 YR @ RT
Size: 5.3760 mg
Method: BMI-TG & HR
Comment: 10°C/MIN, NIT

DSC

File: NDSC178.01
Operator: GALASKA
Run Date: 20-Nov-90 09:00

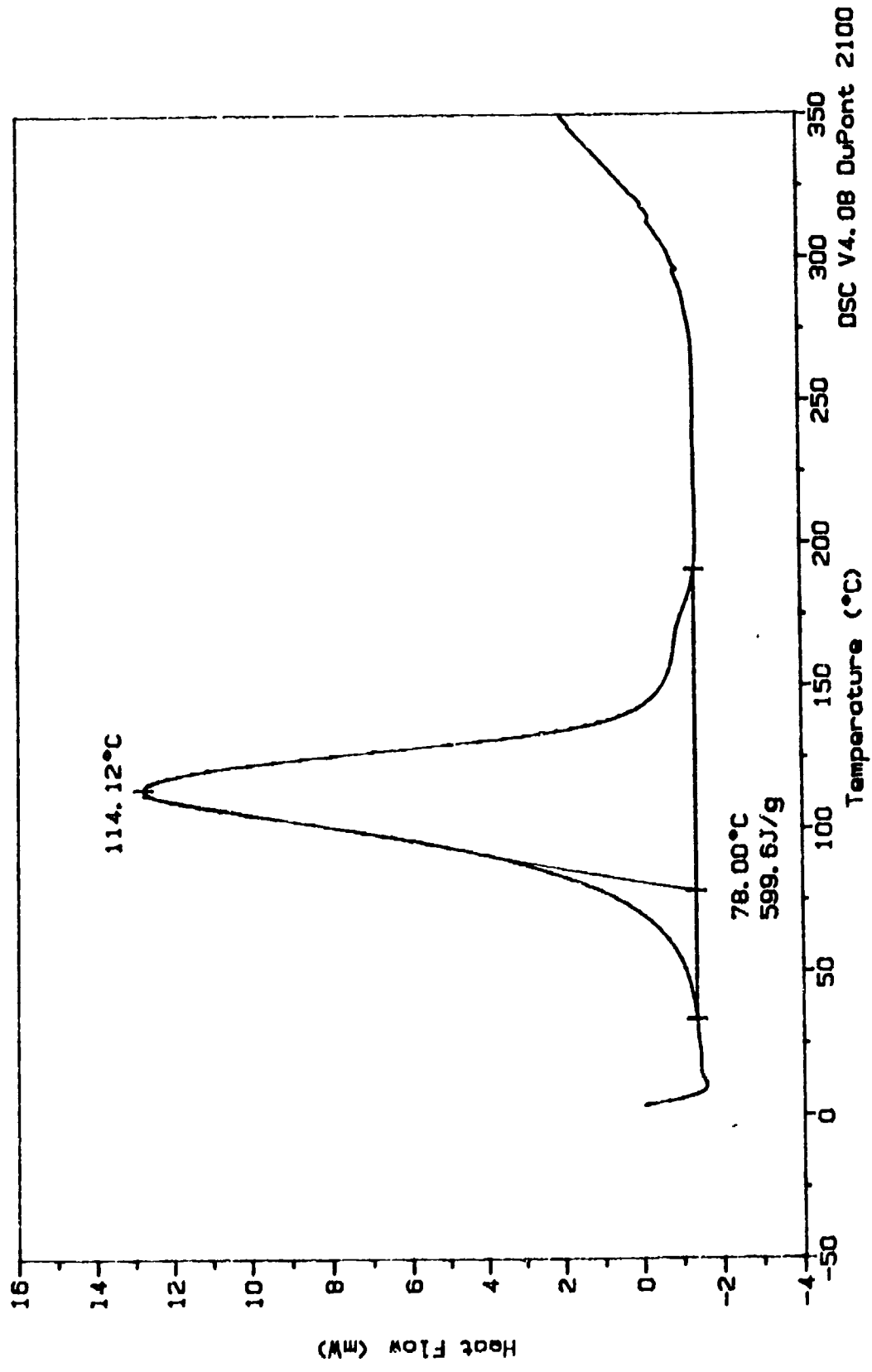


Figure M.20. Heat Release Curve for EA9396 Stored at 22°C (72°F) for 24 Months.

File: NOSC179.01
Operator: GALASKA
Run Date: 20-Nov-90 10:25

DSC

Sample: EA 9396 2 YR @ 100°F
Size: 4.1800 mg
Method: BMI-TG & HR
Comment: 10°C/MIN. NIT

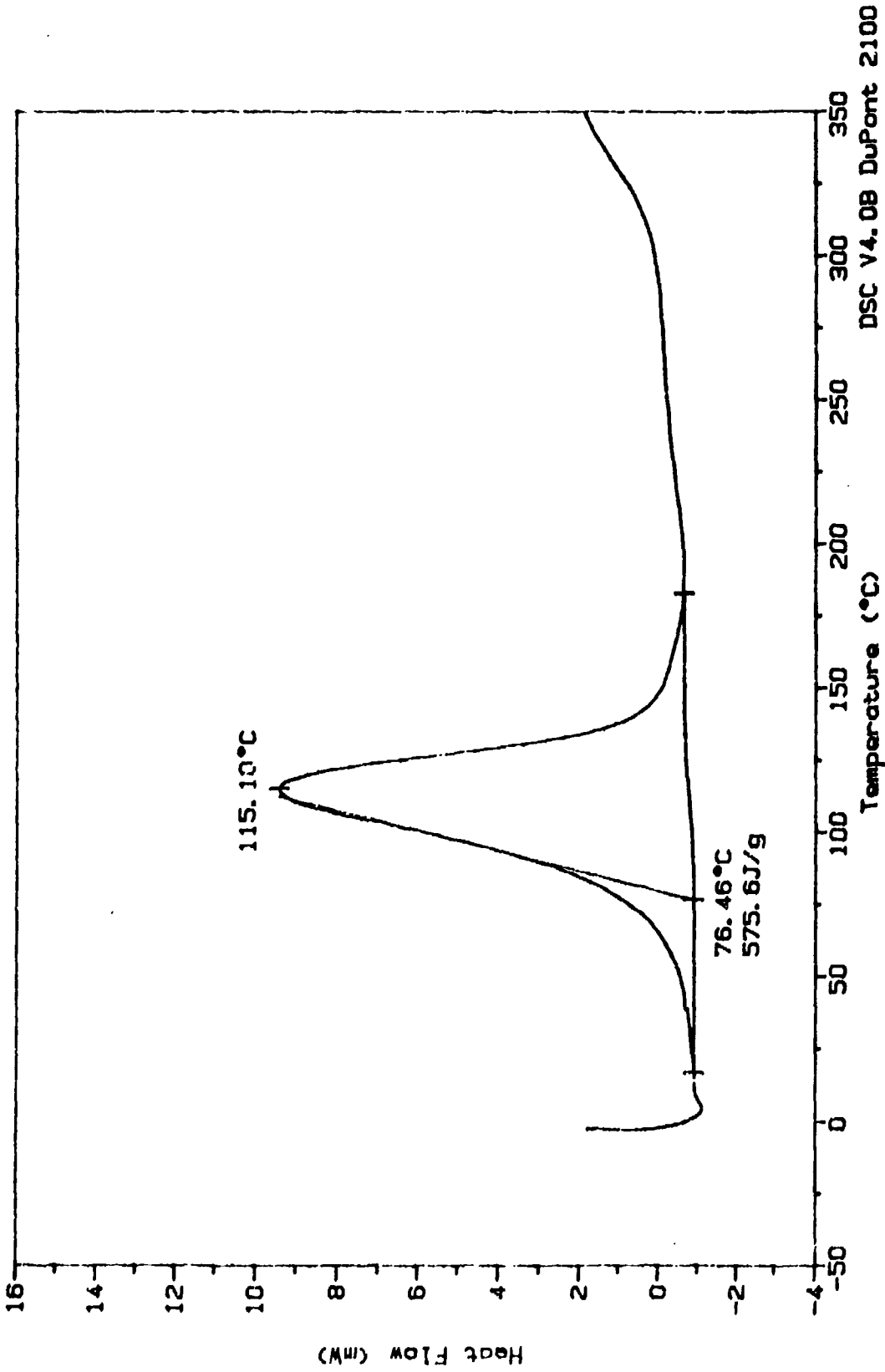


Figure M.21. Heat Release Curve for EA9396 Stored at 38°C (100°F) for 24 Months.

Sample: EA 9396 2 YR @ 120°F
Size: 4.9140 mg
Method: BMI-TG & HR
Comments: 10°C/MIN, NIT

DSC

File: NDSC180.01
Operator: GALASKA
Run Date: 20-Nov-90 11:22

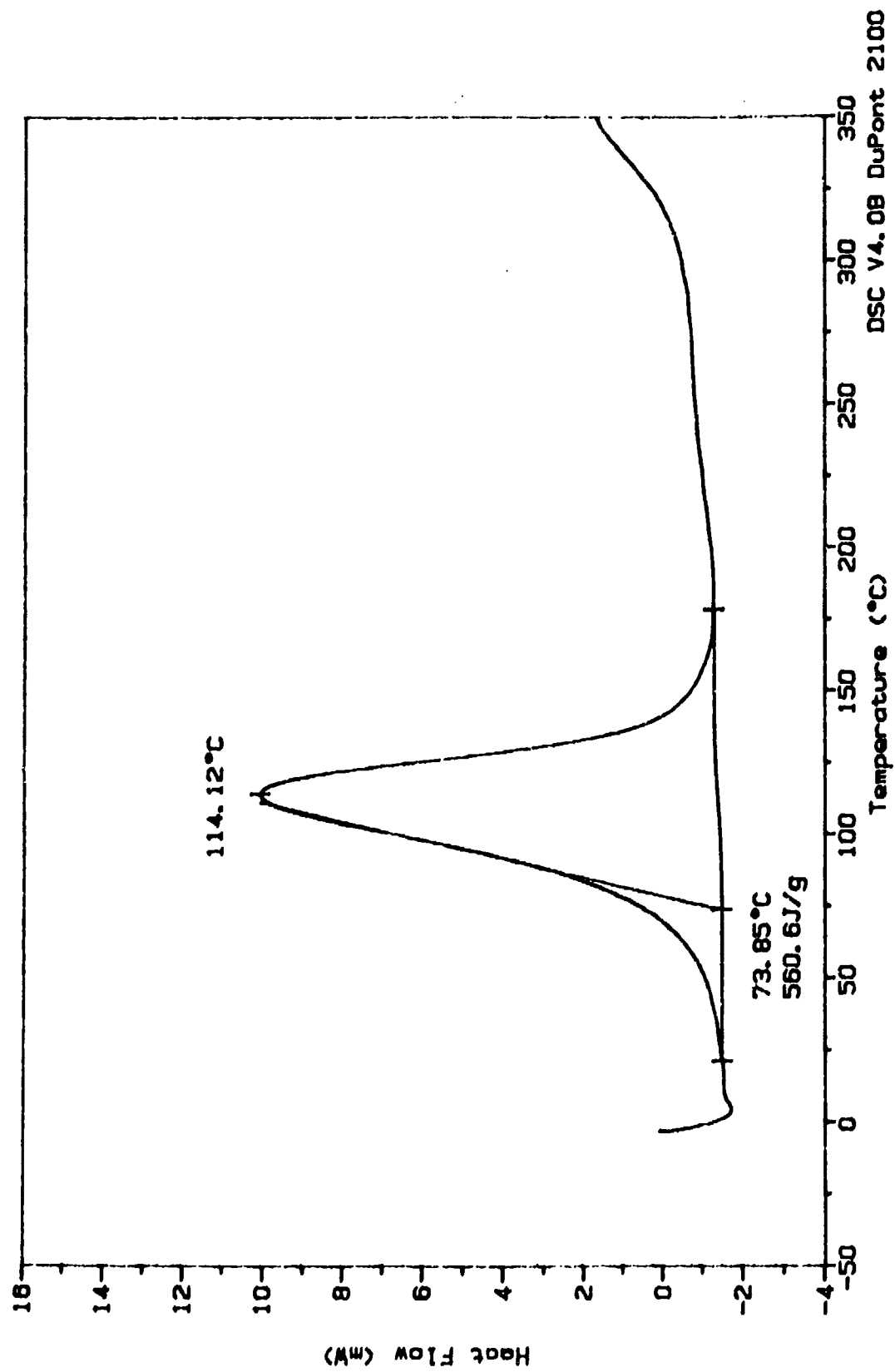


Figure M.22. Heat Release Curve for EA9396 Stored at 49°C (120°F) for 24 Months.

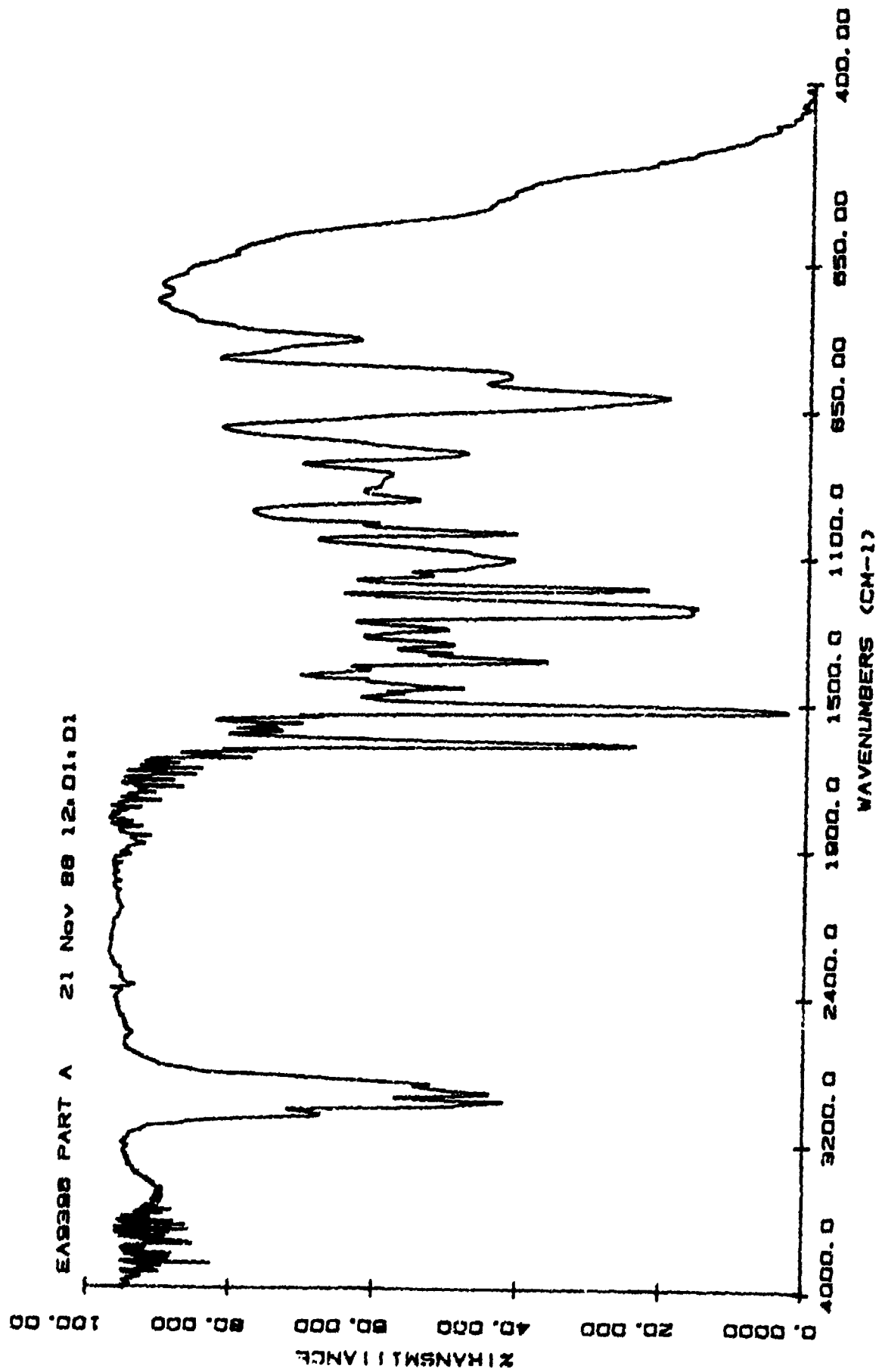


Figure M.23. FTIR Spectra for EA9396, Part A, Initial.

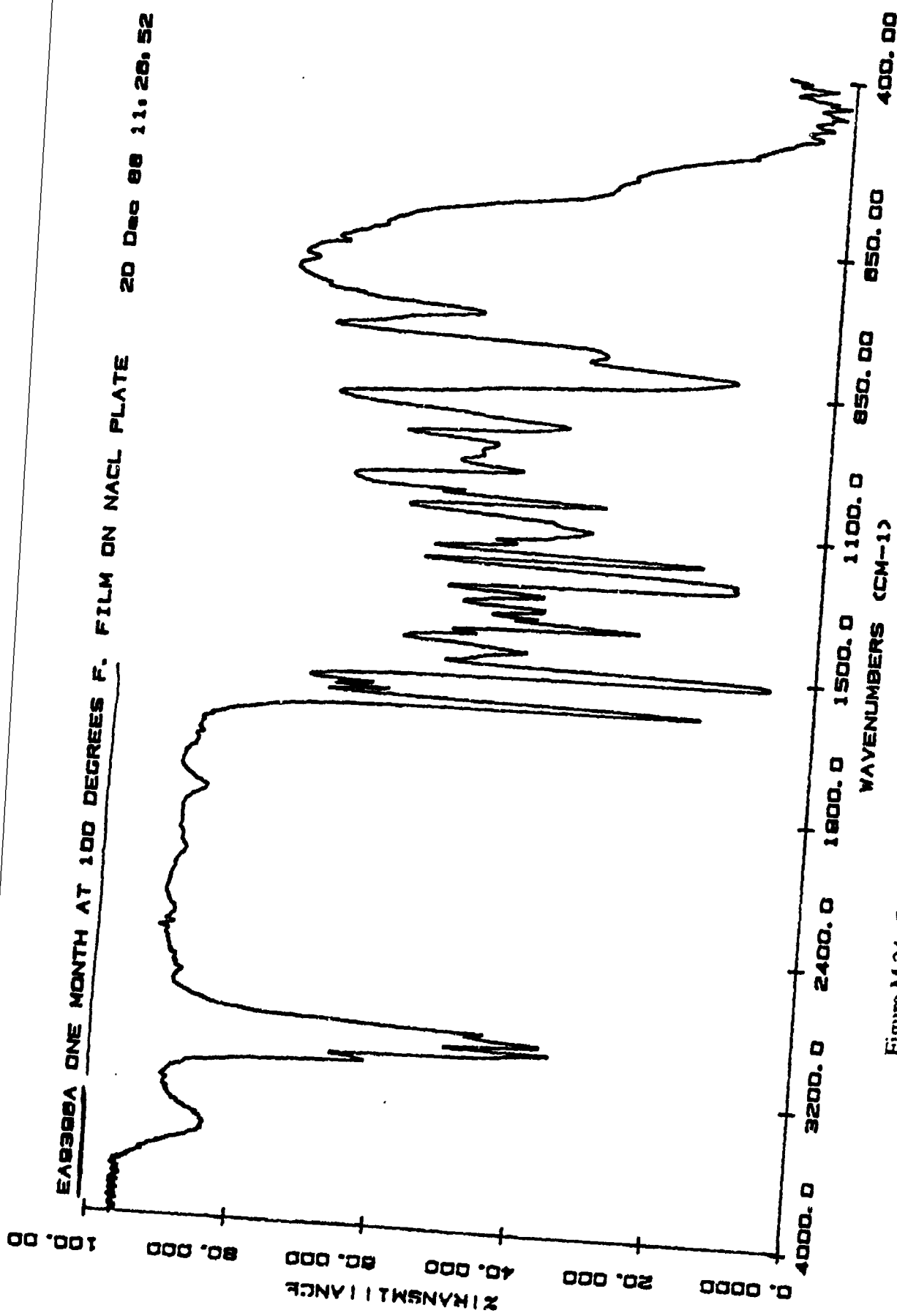


Figure M.24. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 1 Month.

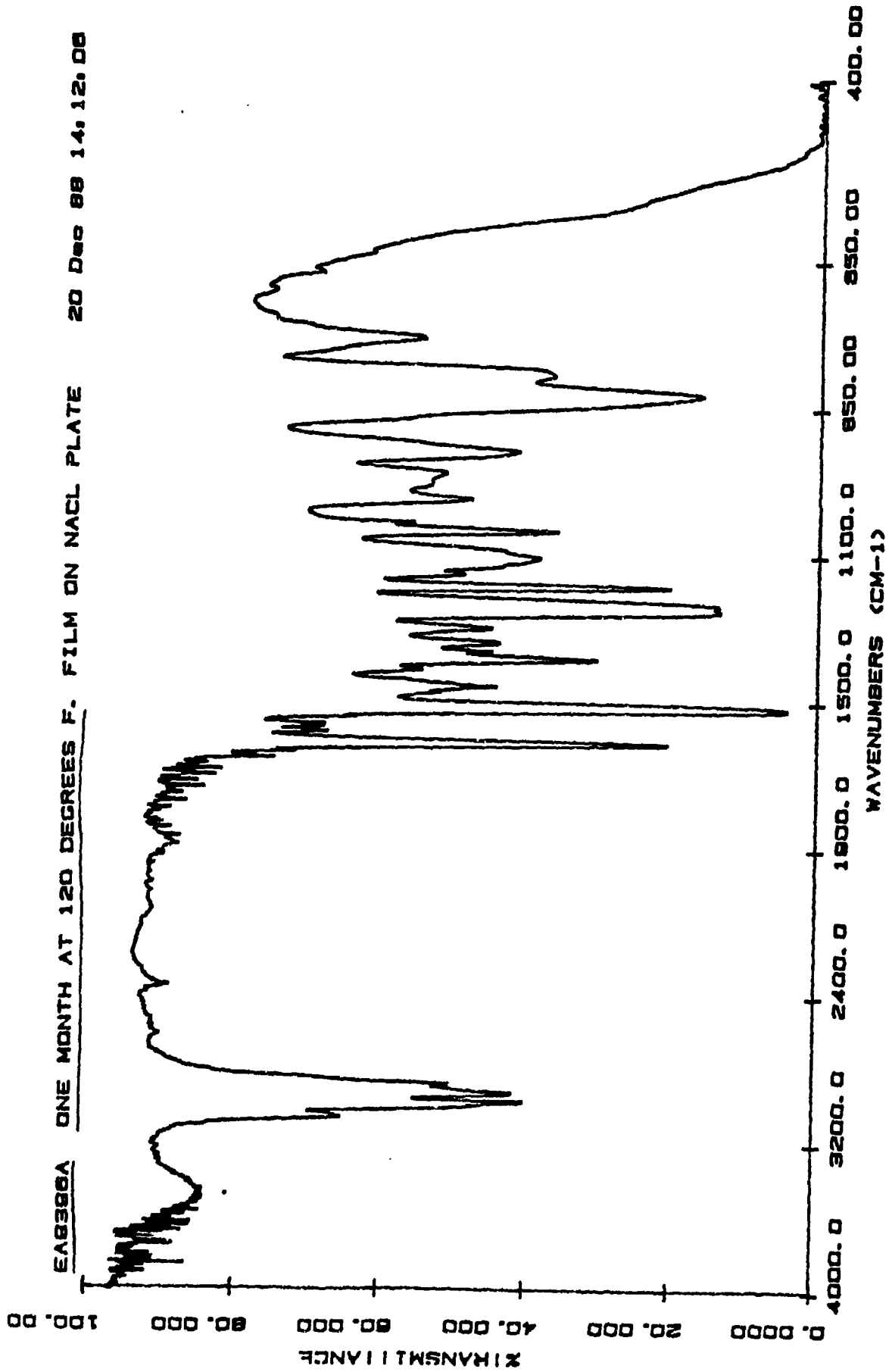


Figure M.25. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 1 Month.

EA9396 PART A 3 MONTHS AT ROOM TEMPERATURE FILM ON NAACL PLATE 22 Feb 89 9:48:24

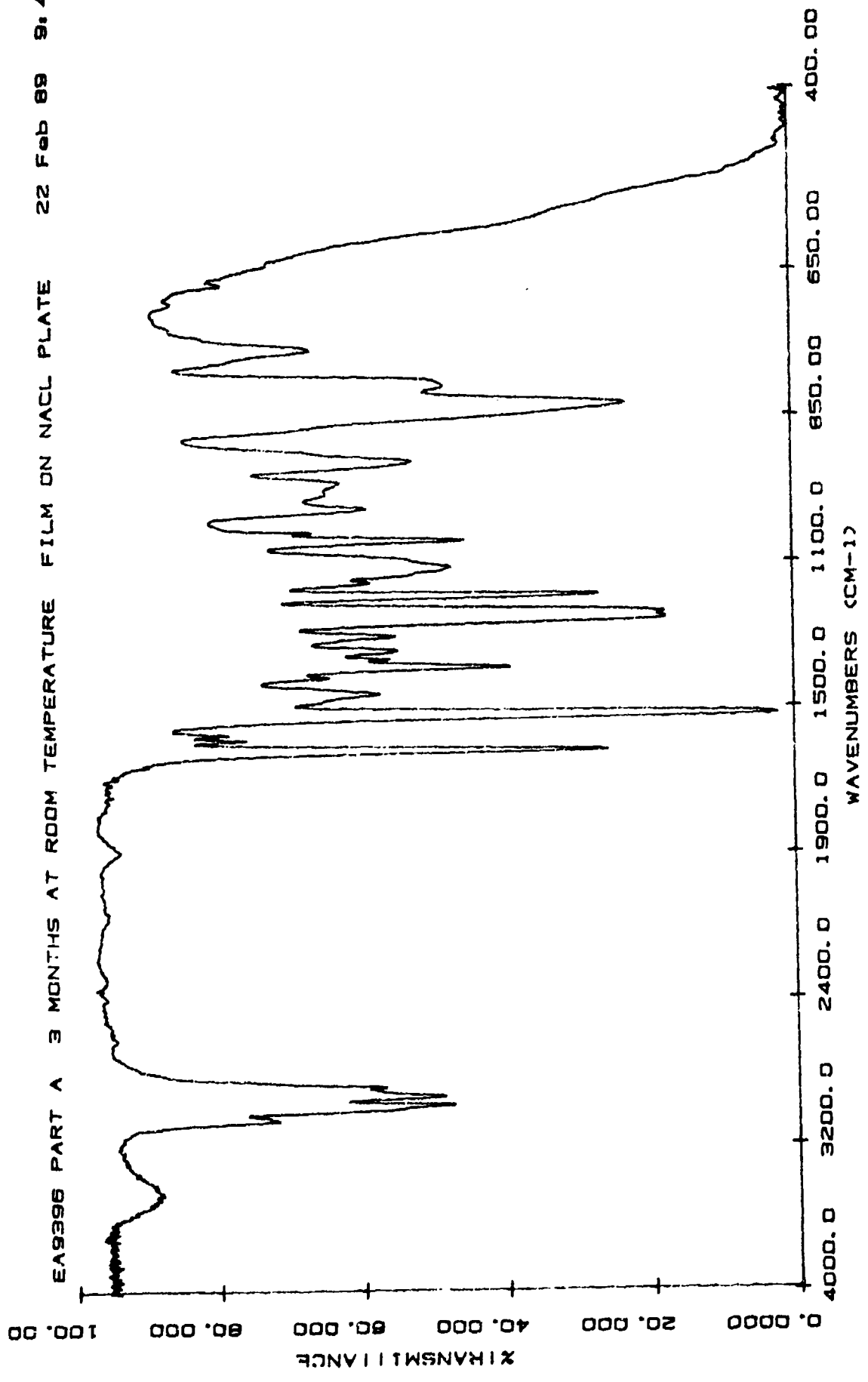


Figure M.26. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 3 Months.

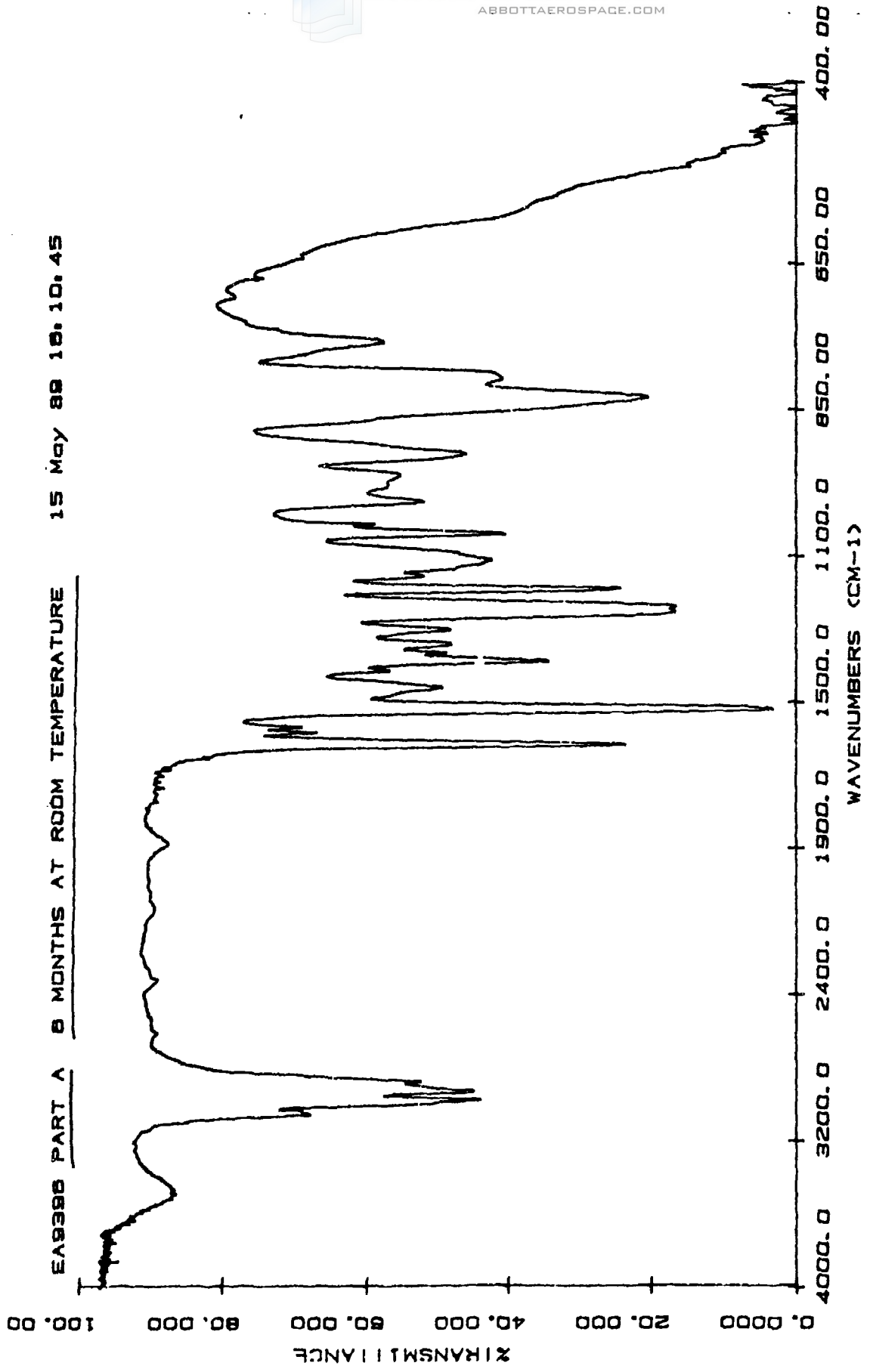


Figure M.27. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 6 Months.

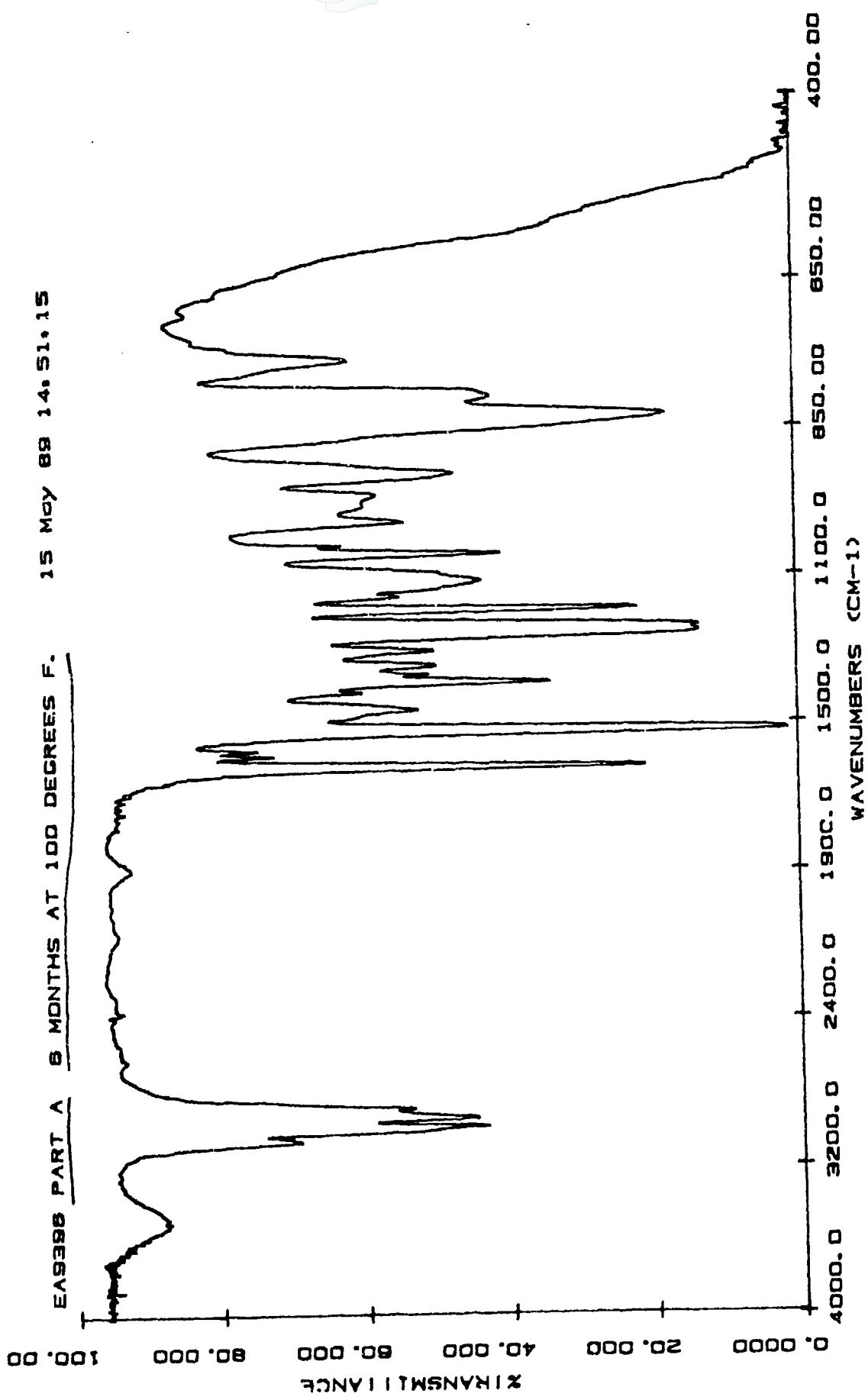


Figure M.28. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 6 Months.

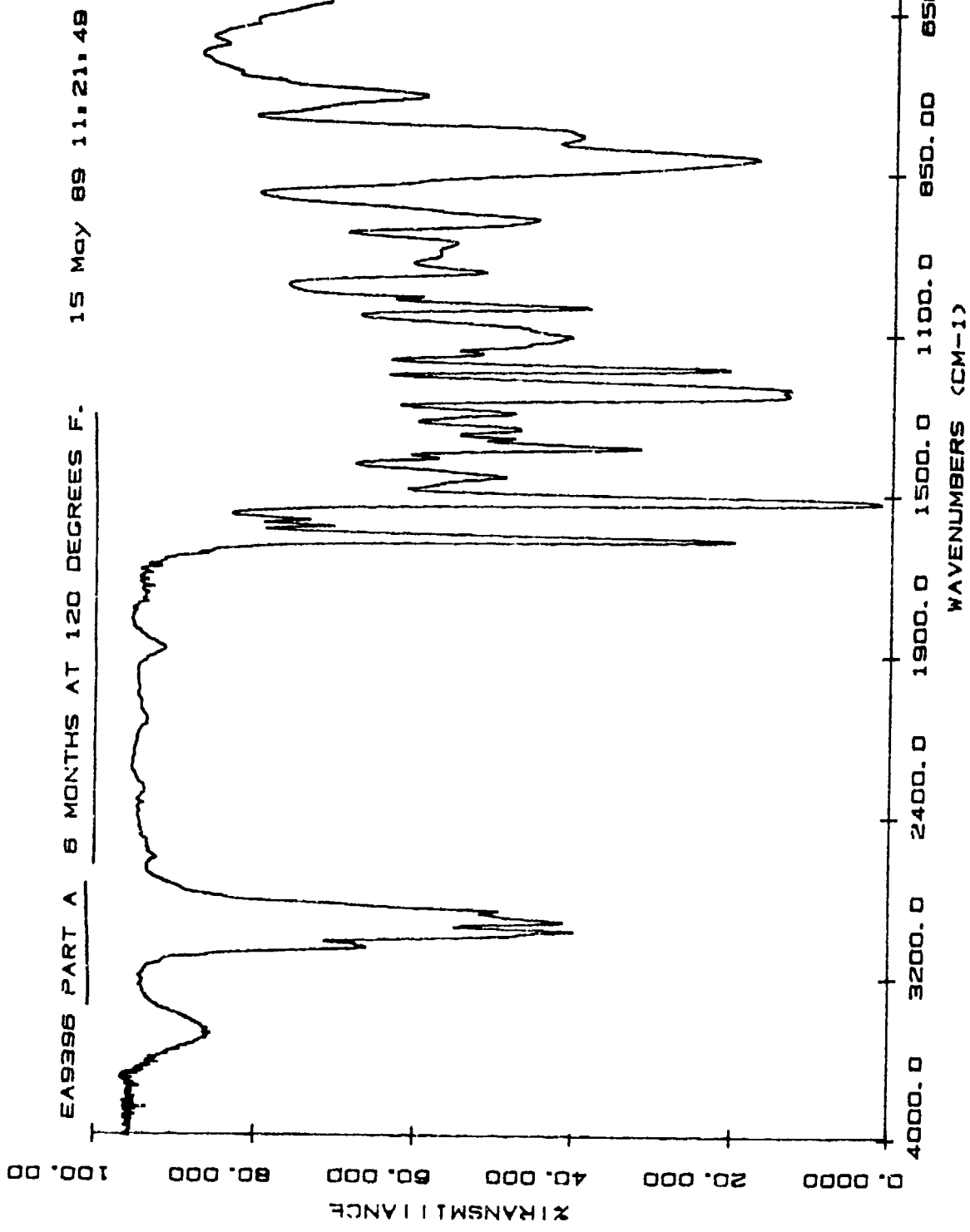


Figure M.29. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 6 Months.

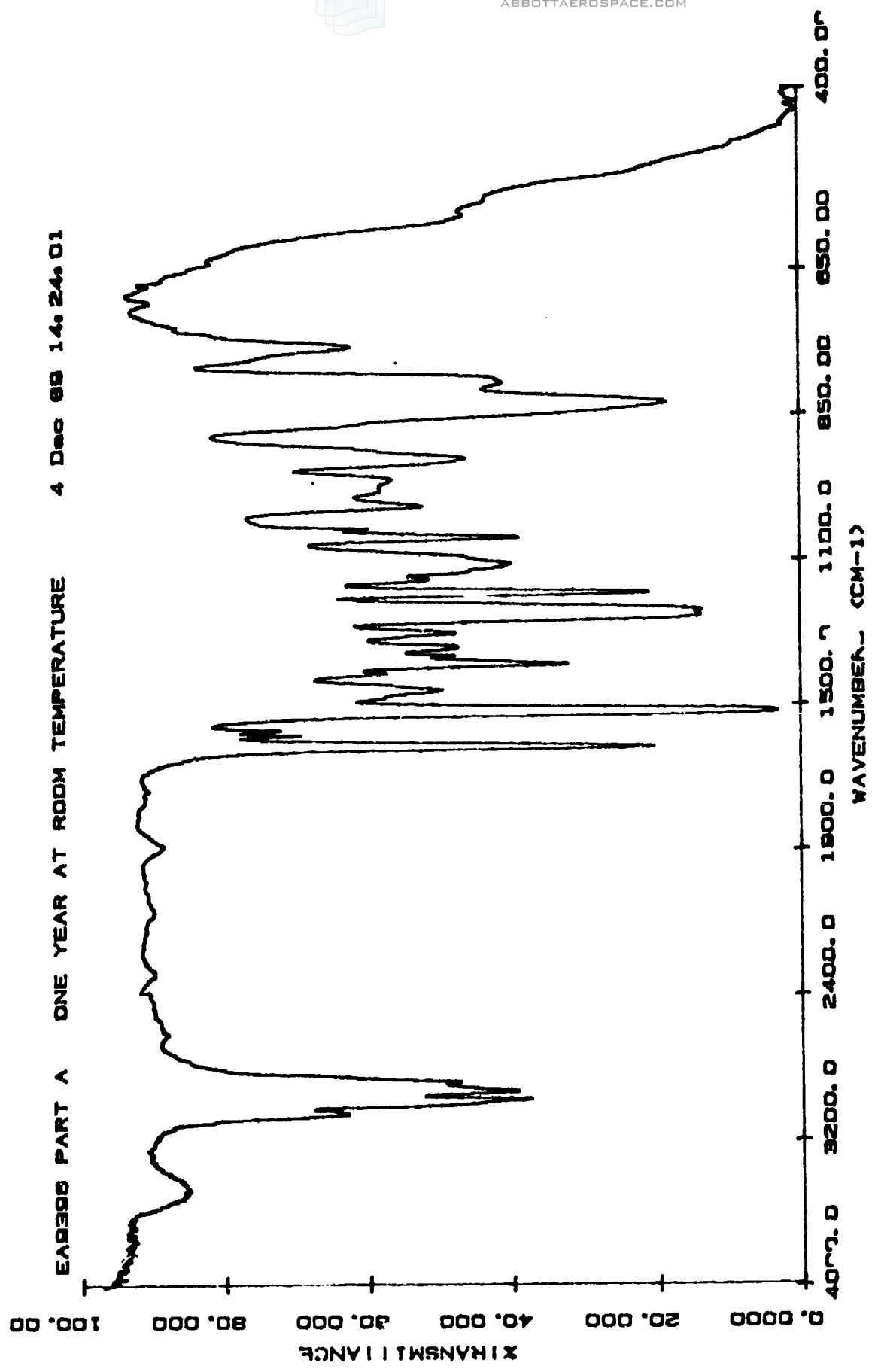


Figure M.30. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 12 Months.

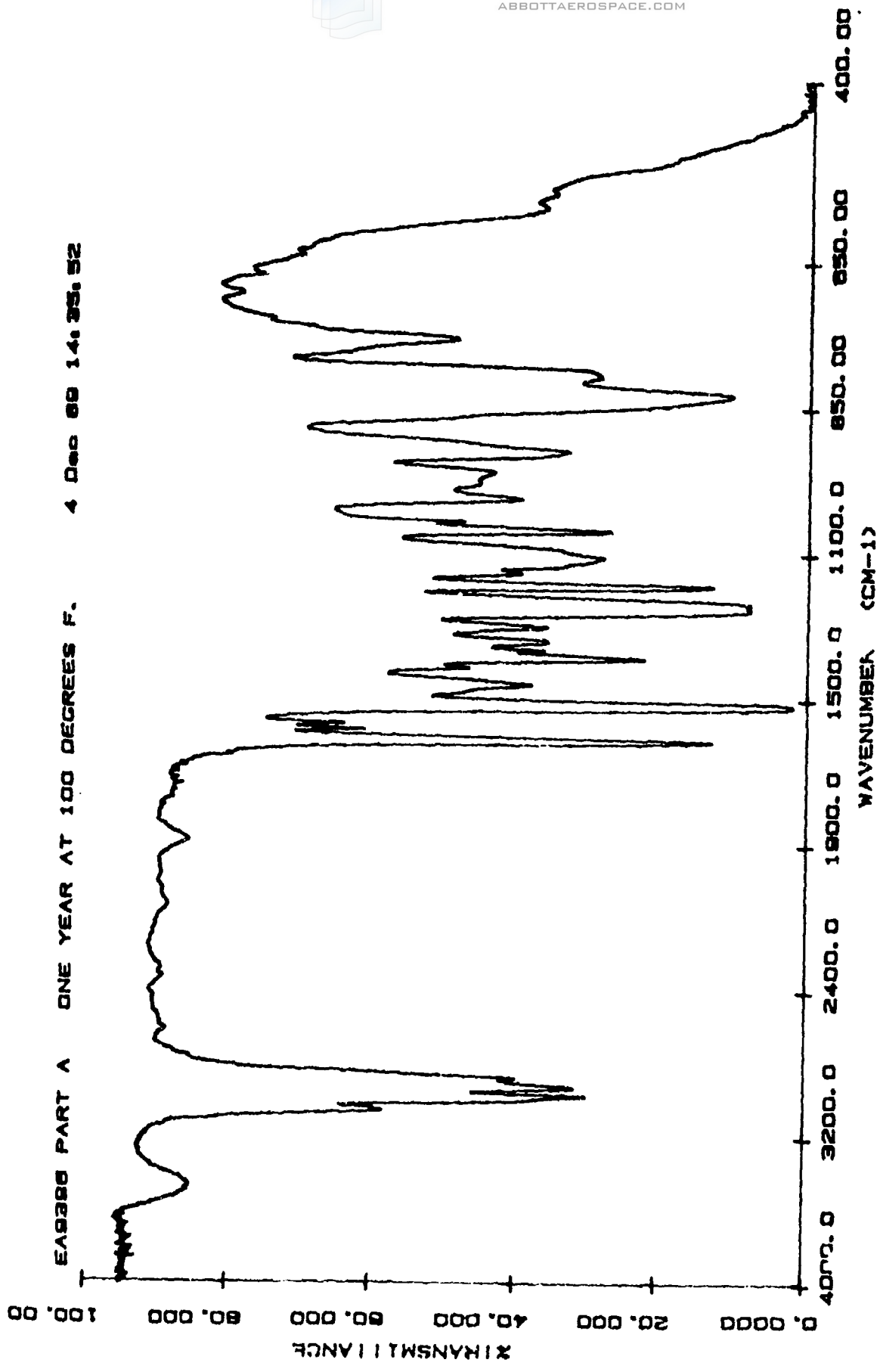


Figure M.31. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 12 Months.

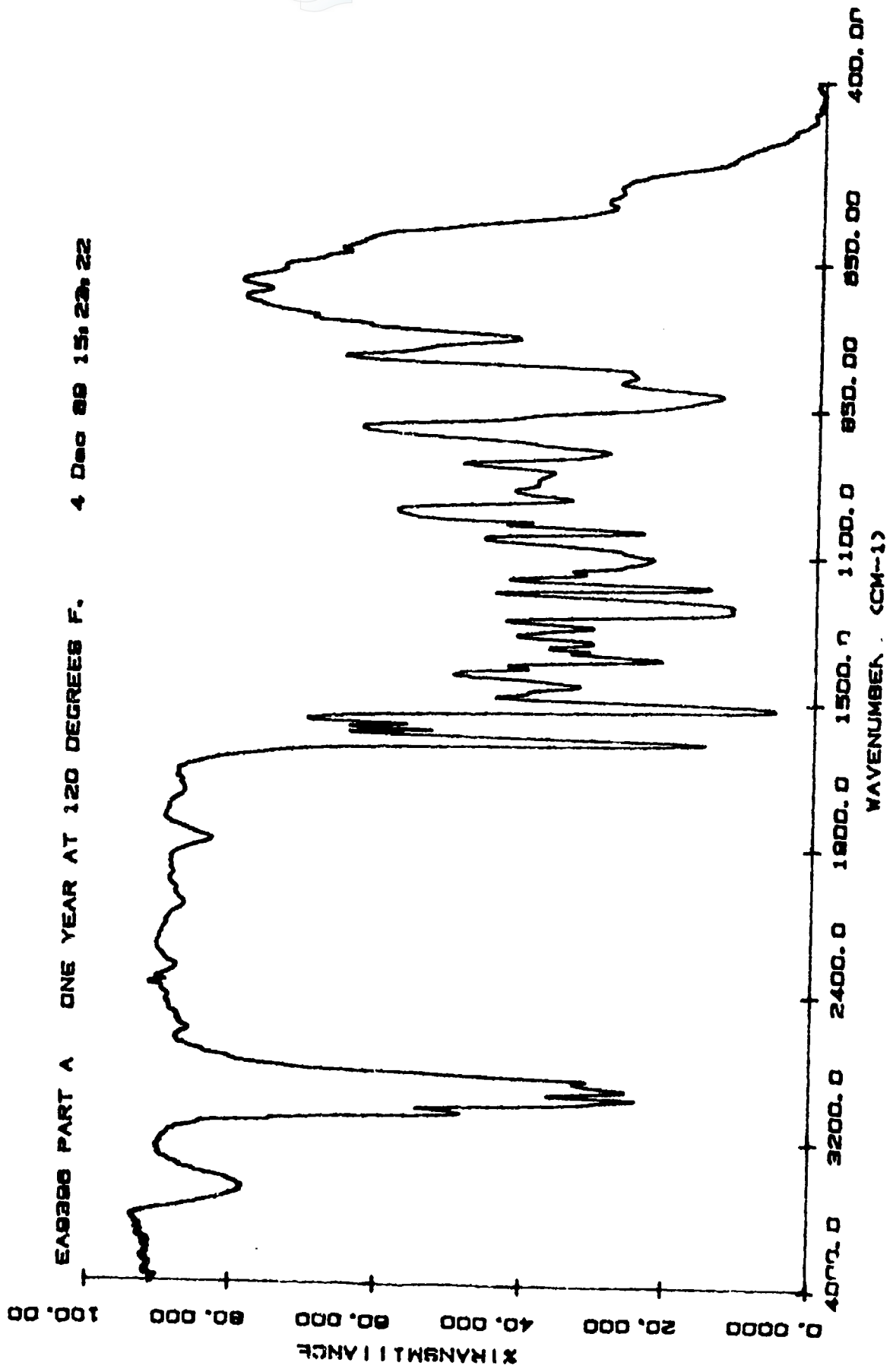


Figure M.32. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 12 Months.

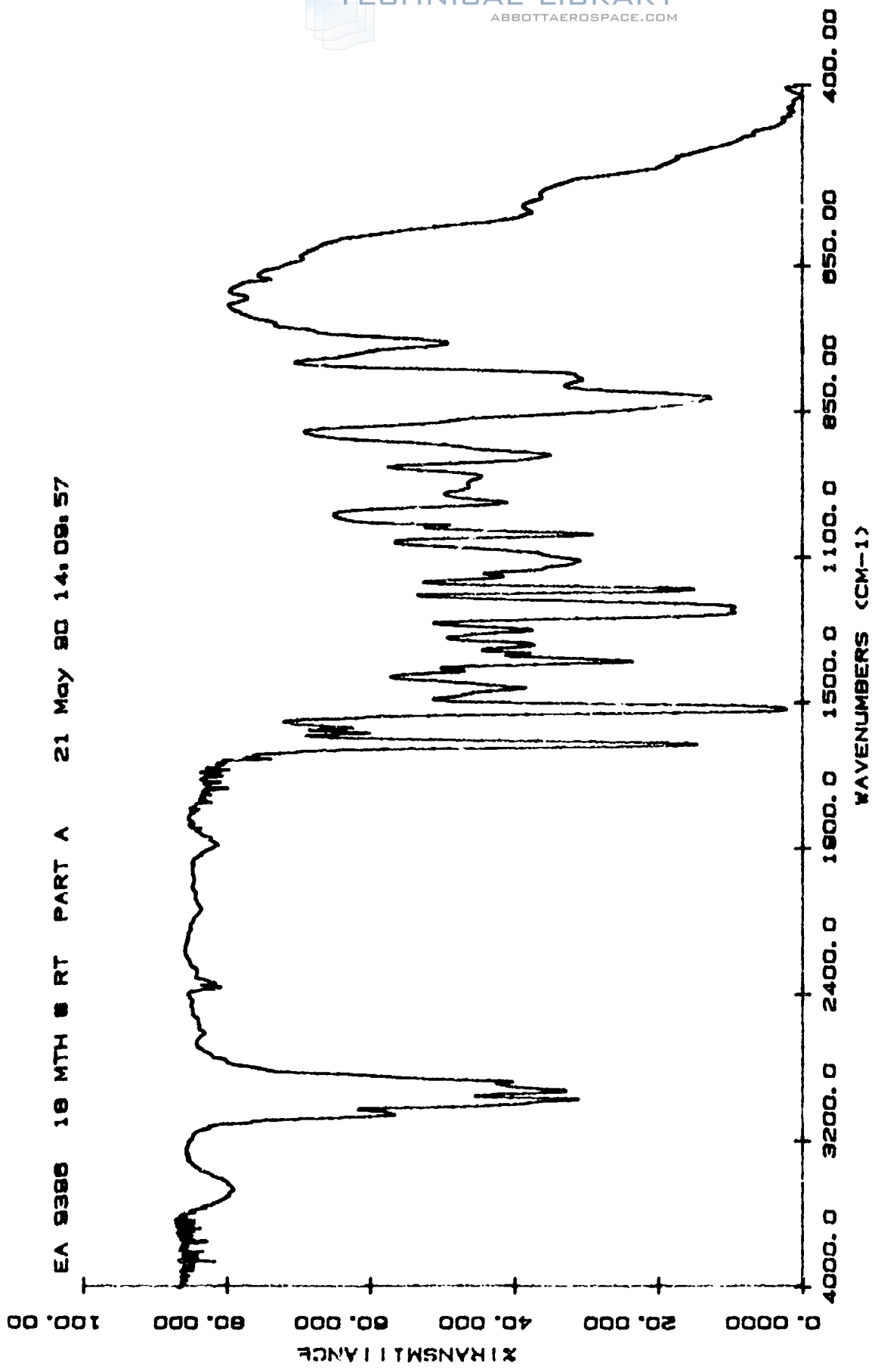


Figure M.33. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 18 Months.

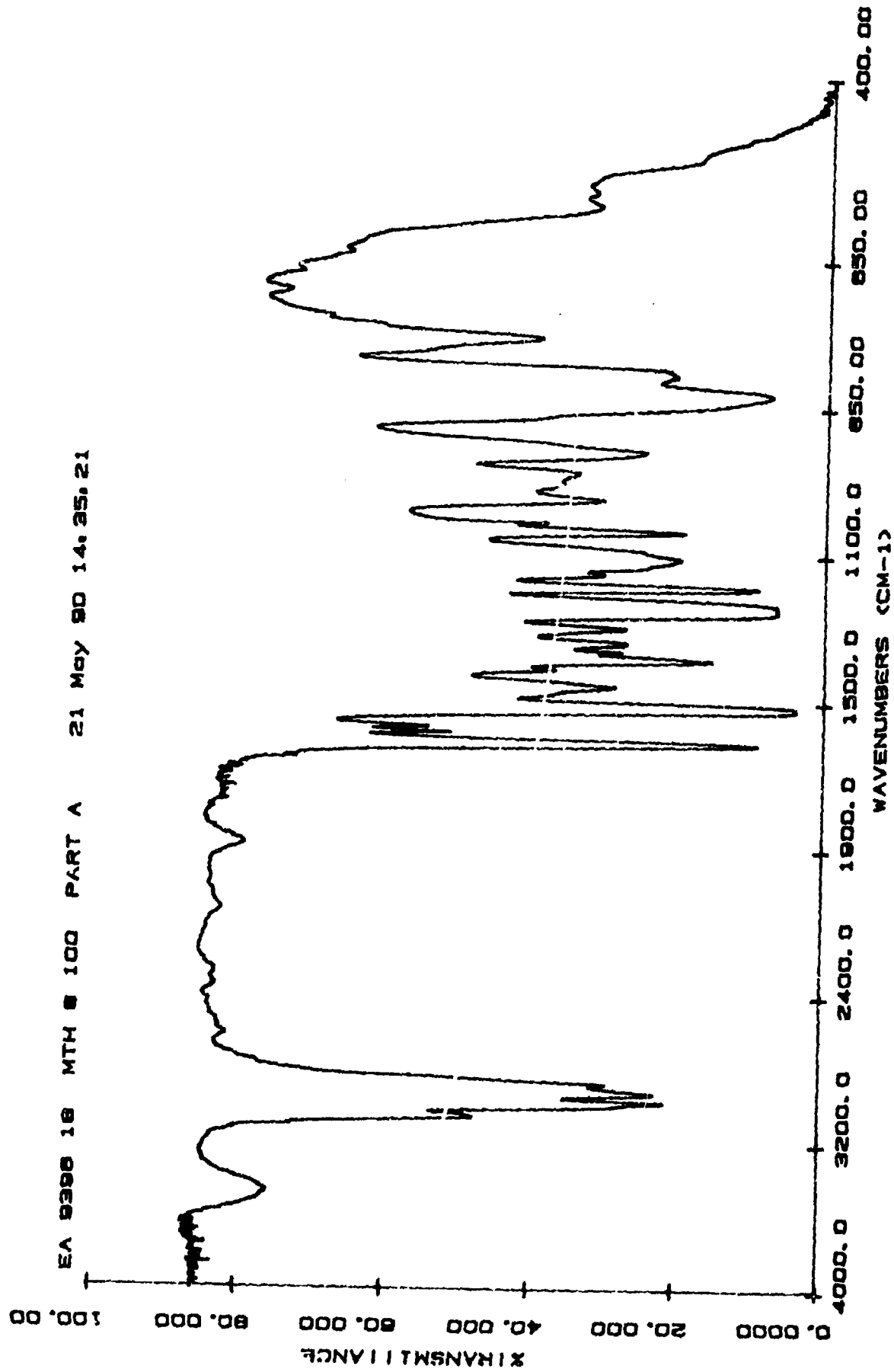


Figure M.34. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 18 Months.

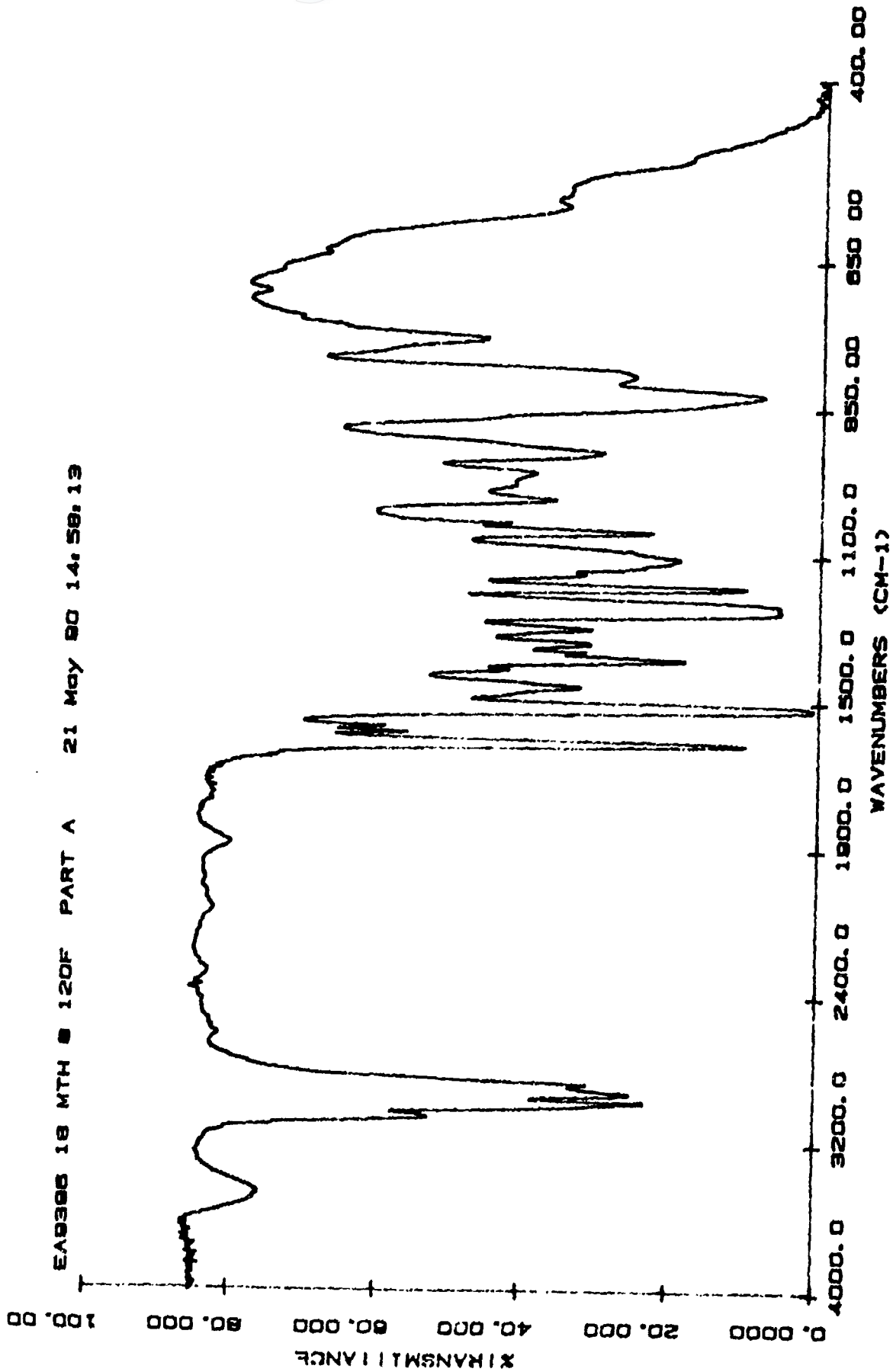


Figure M.35. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 18 Months.

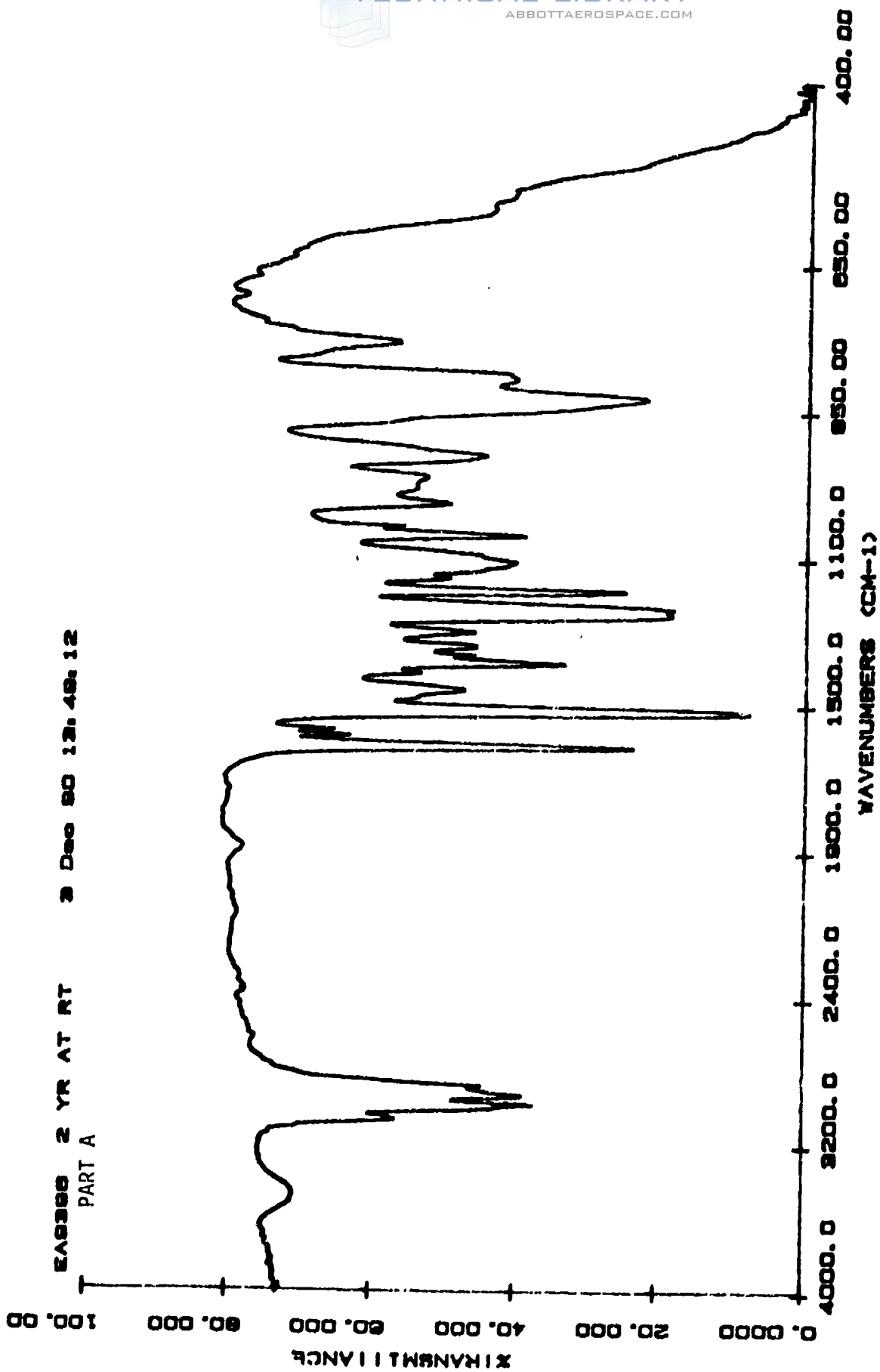
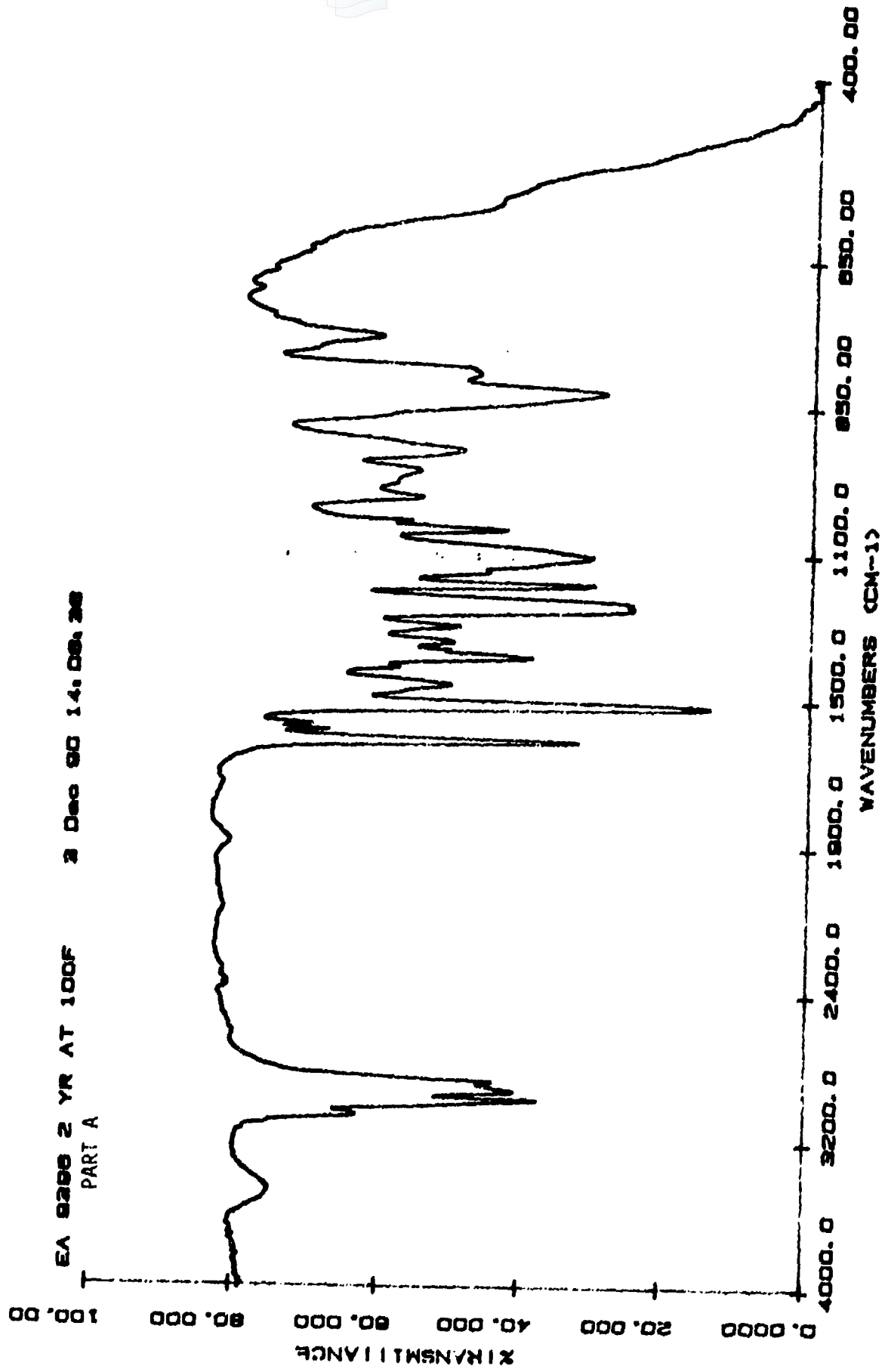


Figure M.36. FTIR Spectra for EA9396, Part A, Stored at 22°C (72°F) for 24 Months.



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Figure M.37. FTIR Spectra for EA9396, Part A, Stored at 38°C (100°F) for 24 Months.

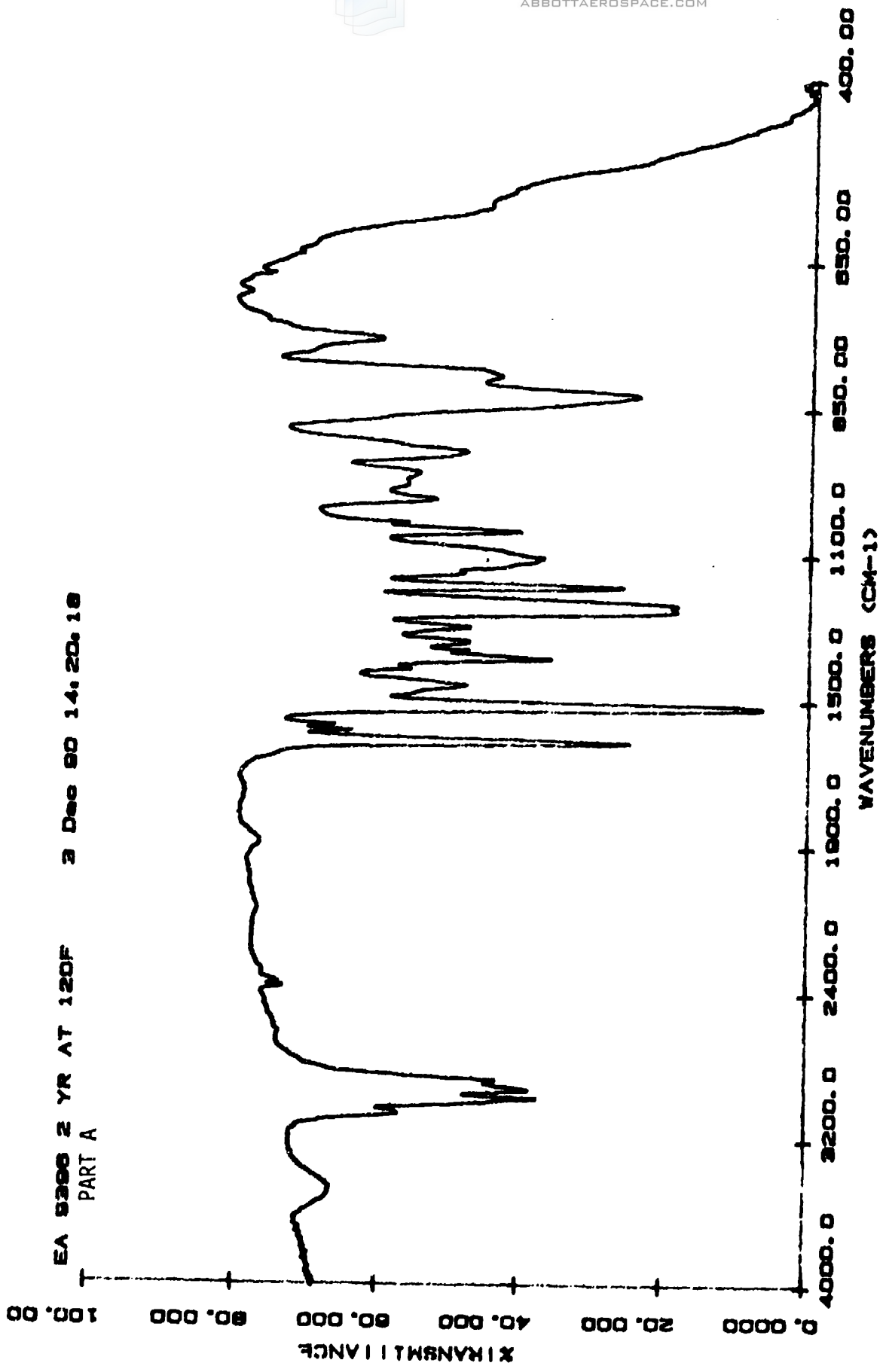


Figure M.38. FTIR Spectra for EA9396, Part A, Stored at 49°C (120°F) for 24 Months.

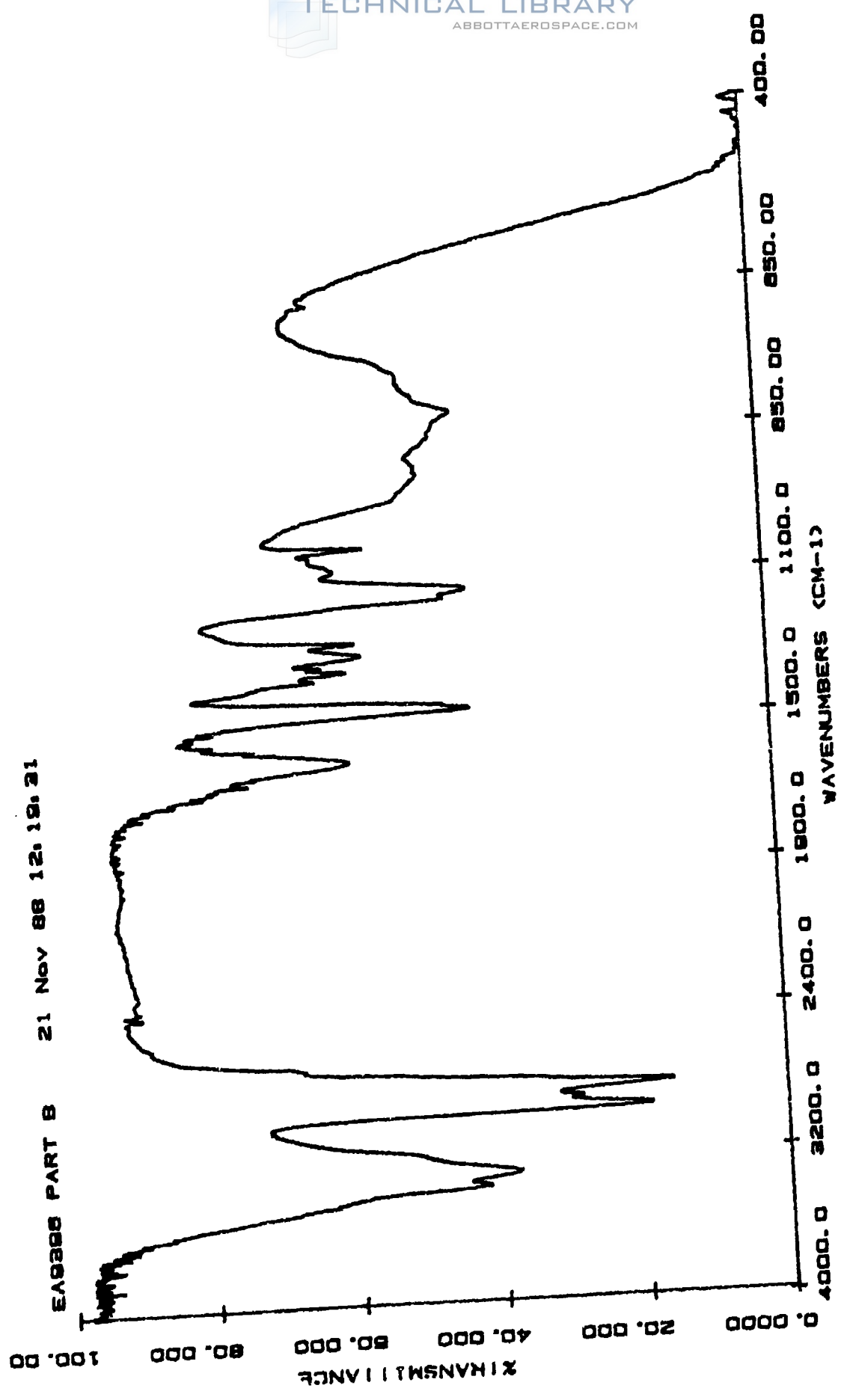


Figure M.39. FTIR Spectra for EA9396, Part B, Initial.

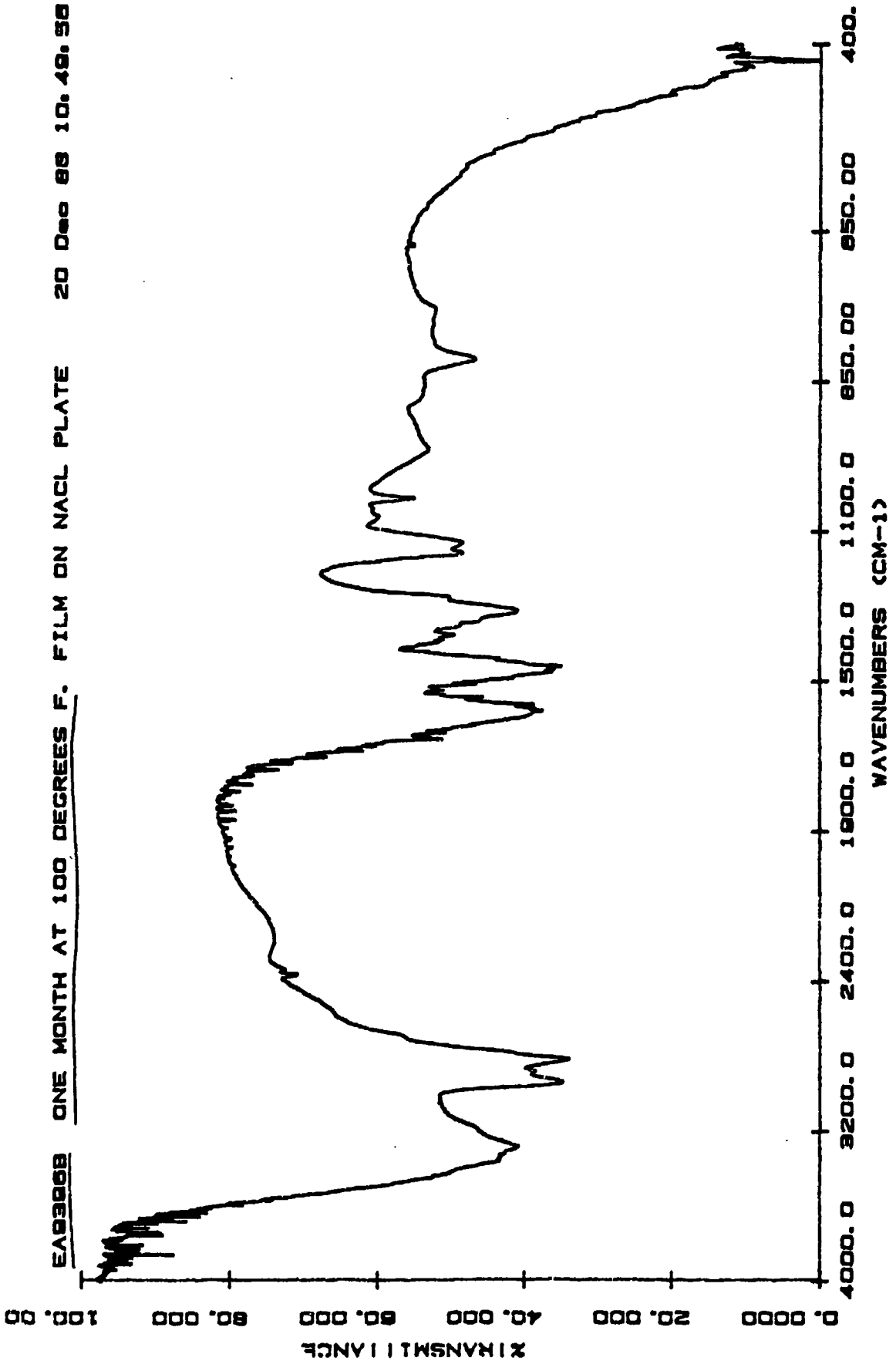


Figure M.40. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 1 Month.

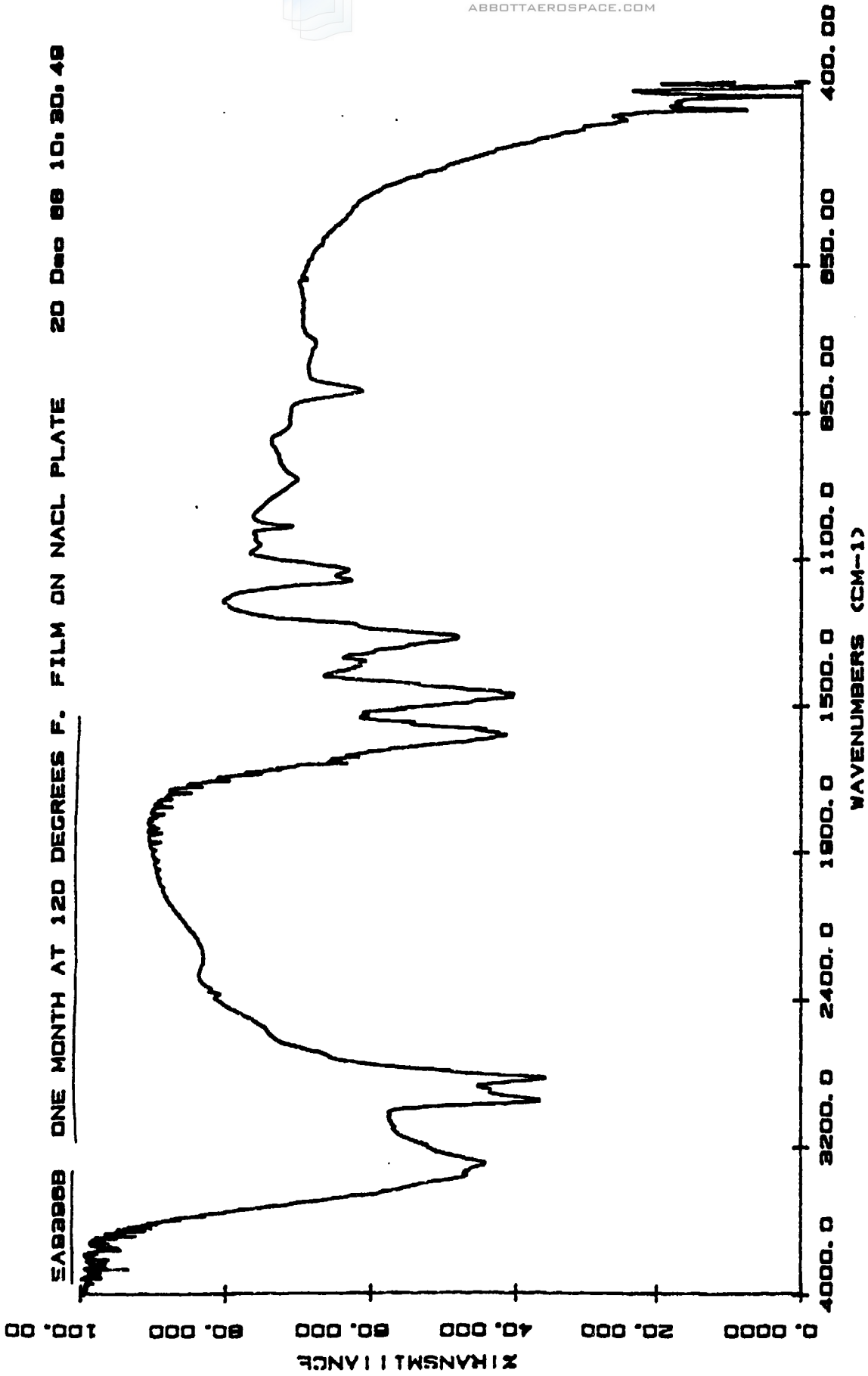


Figure M.41. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 1 Month.

EA9398 PART B 3 MONTHS AT ROOM TEMPERATURE FILM ON NaCl PLATE 23 Feb 89 8.53.57

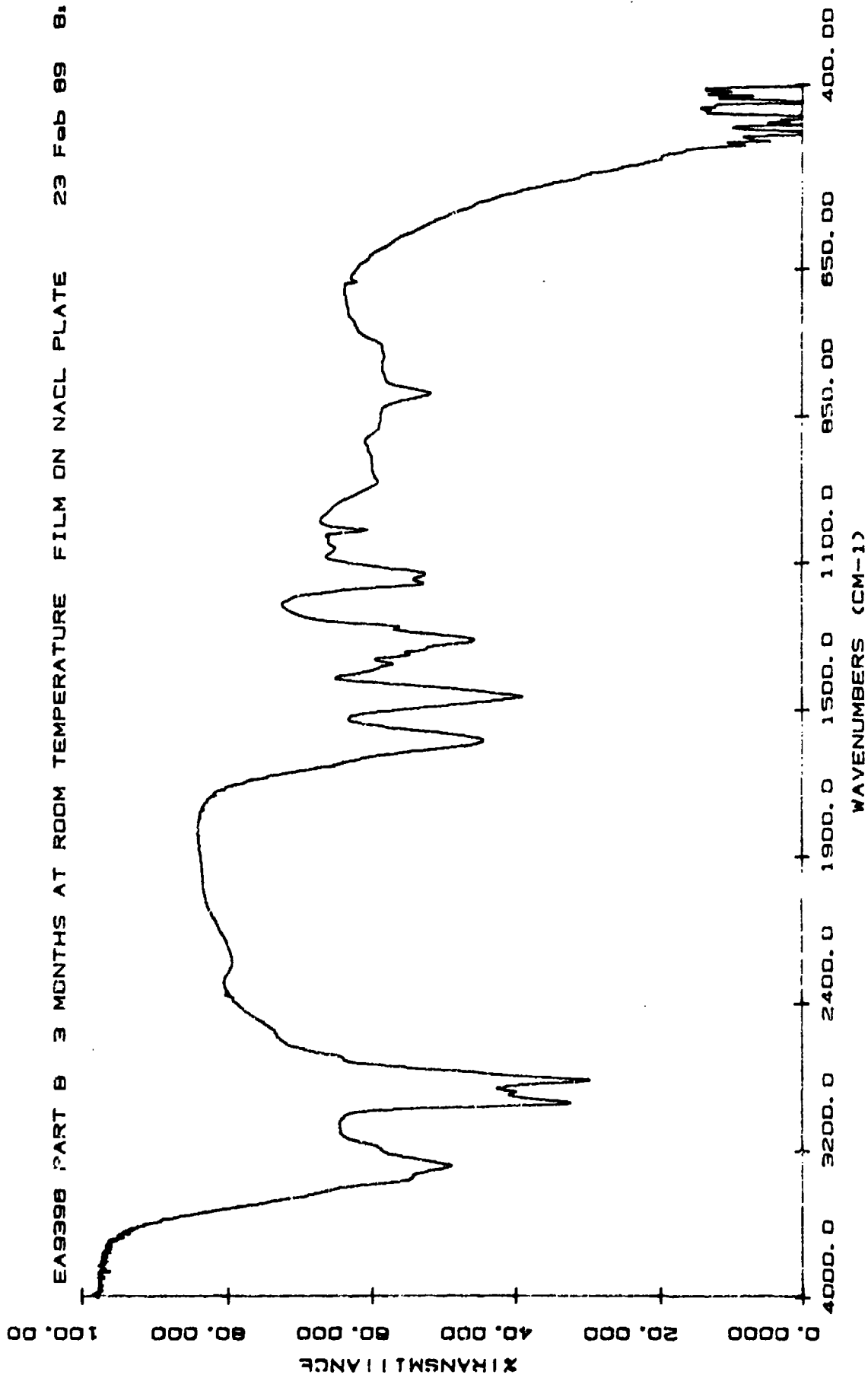


Figure M.42. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 3 Months.

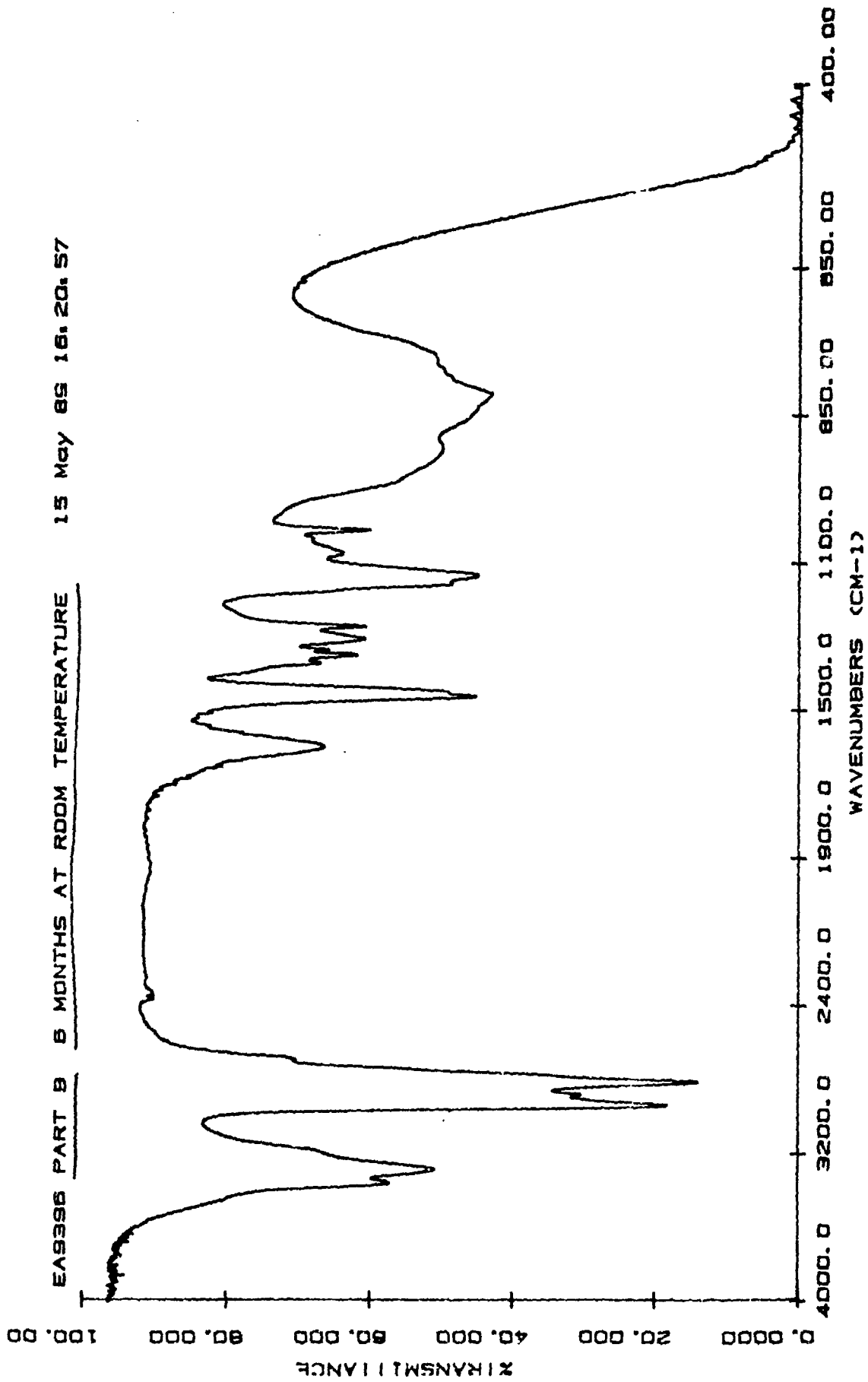


Figure M.43. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 6 Months.

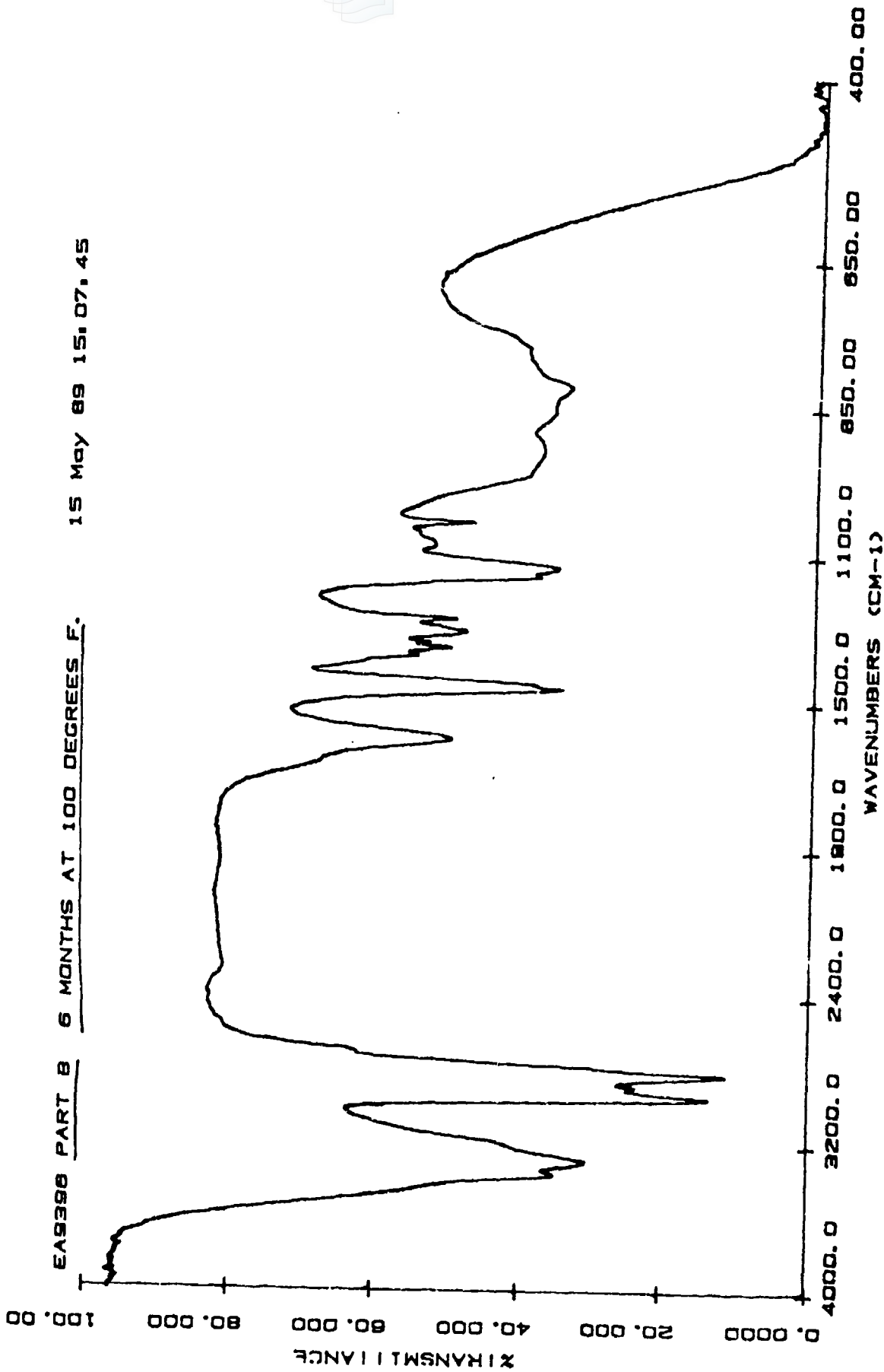


Figure M.44. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 6 Months.

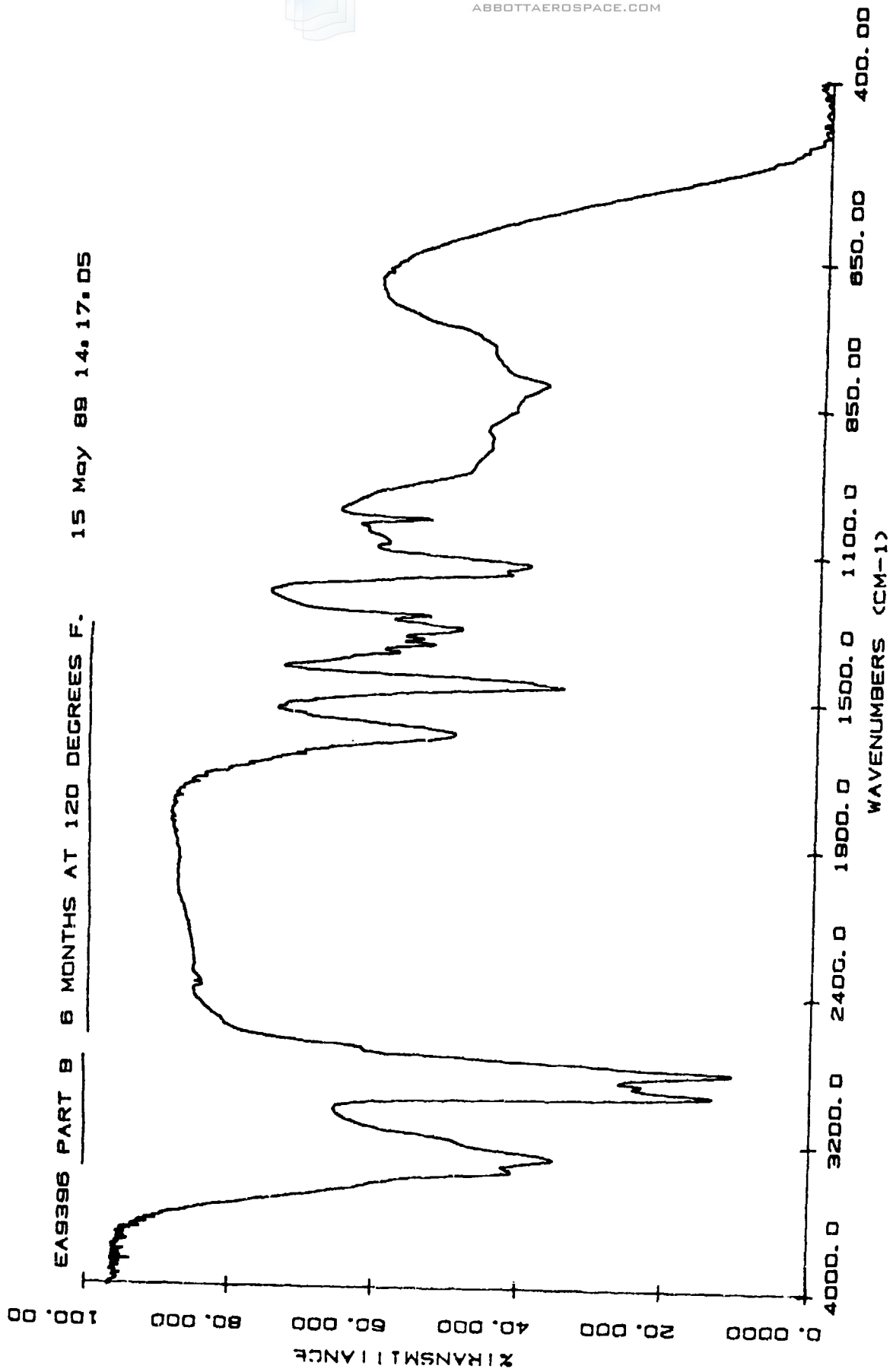


Figure M.45. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 6 Months.

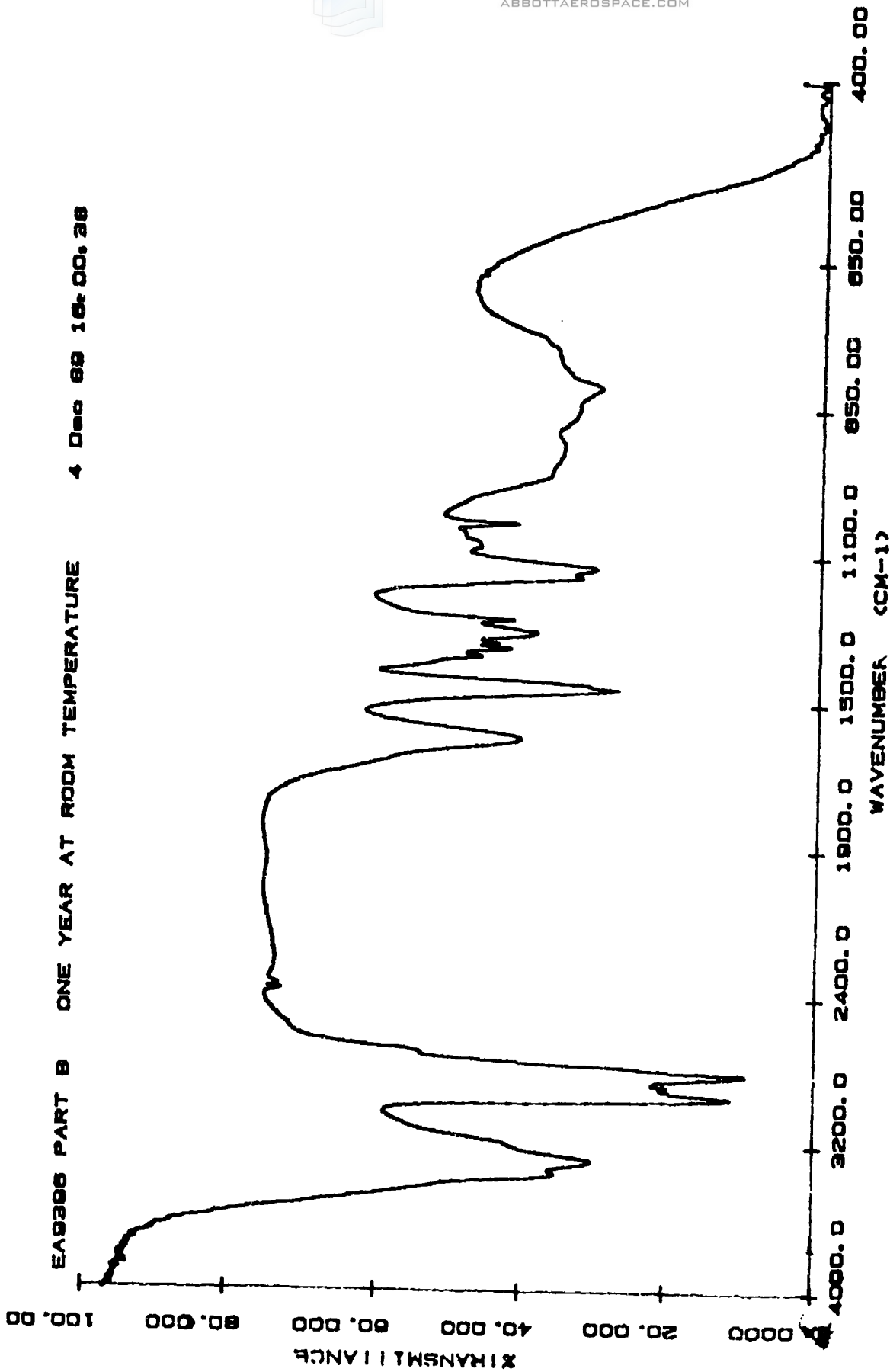


Figure M.46. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 12 Months.

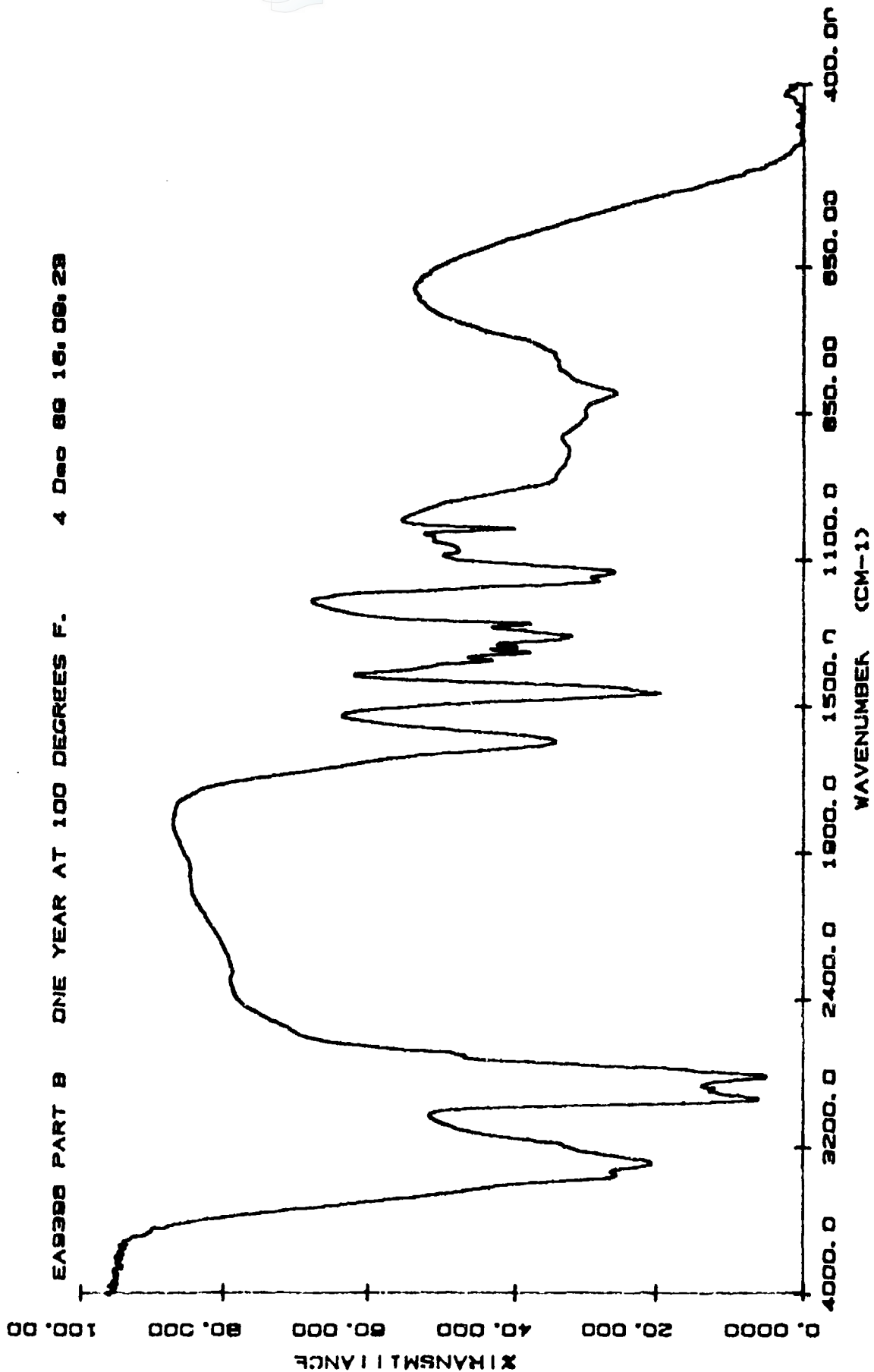


Figure M.47. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 12 Months.

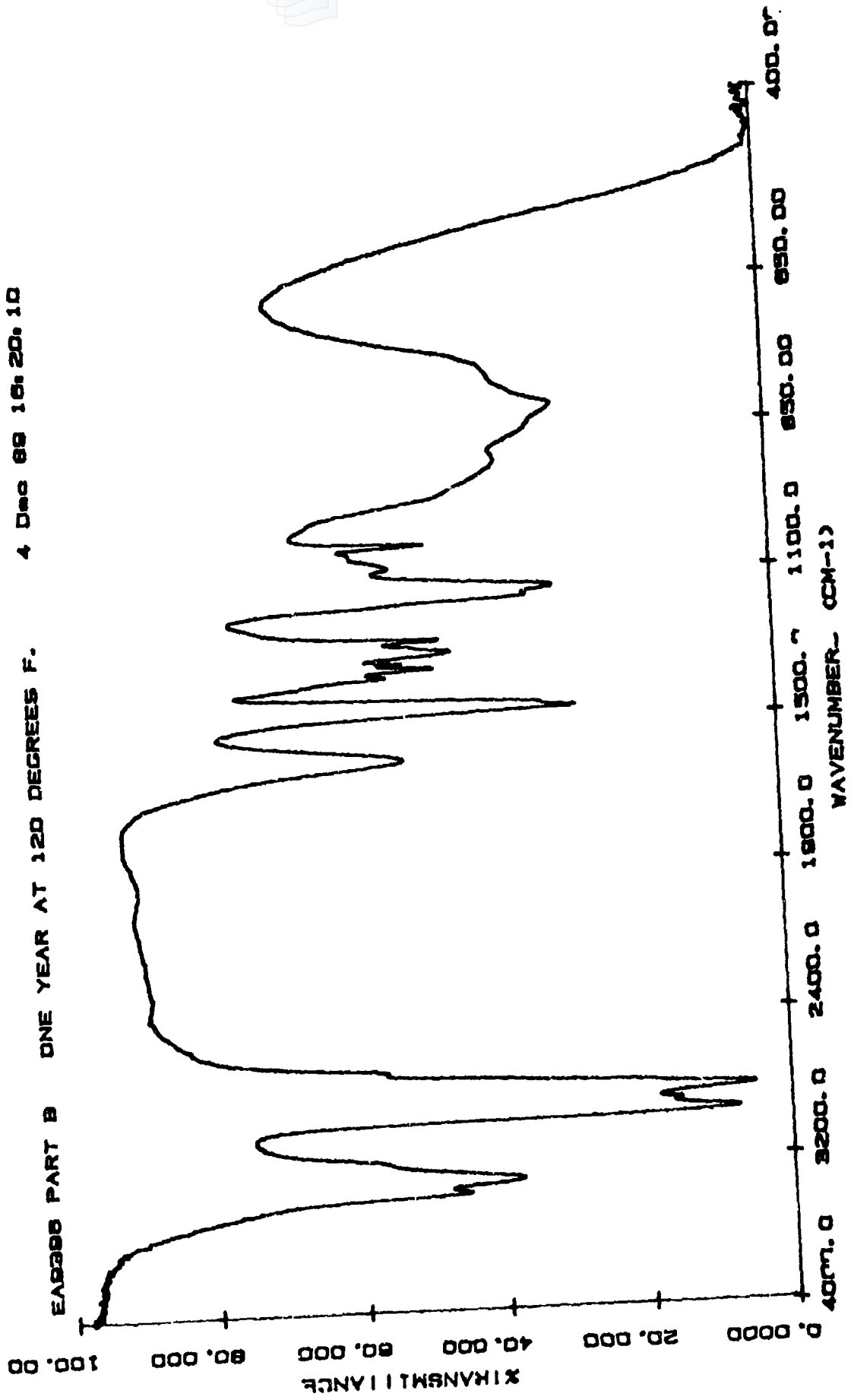
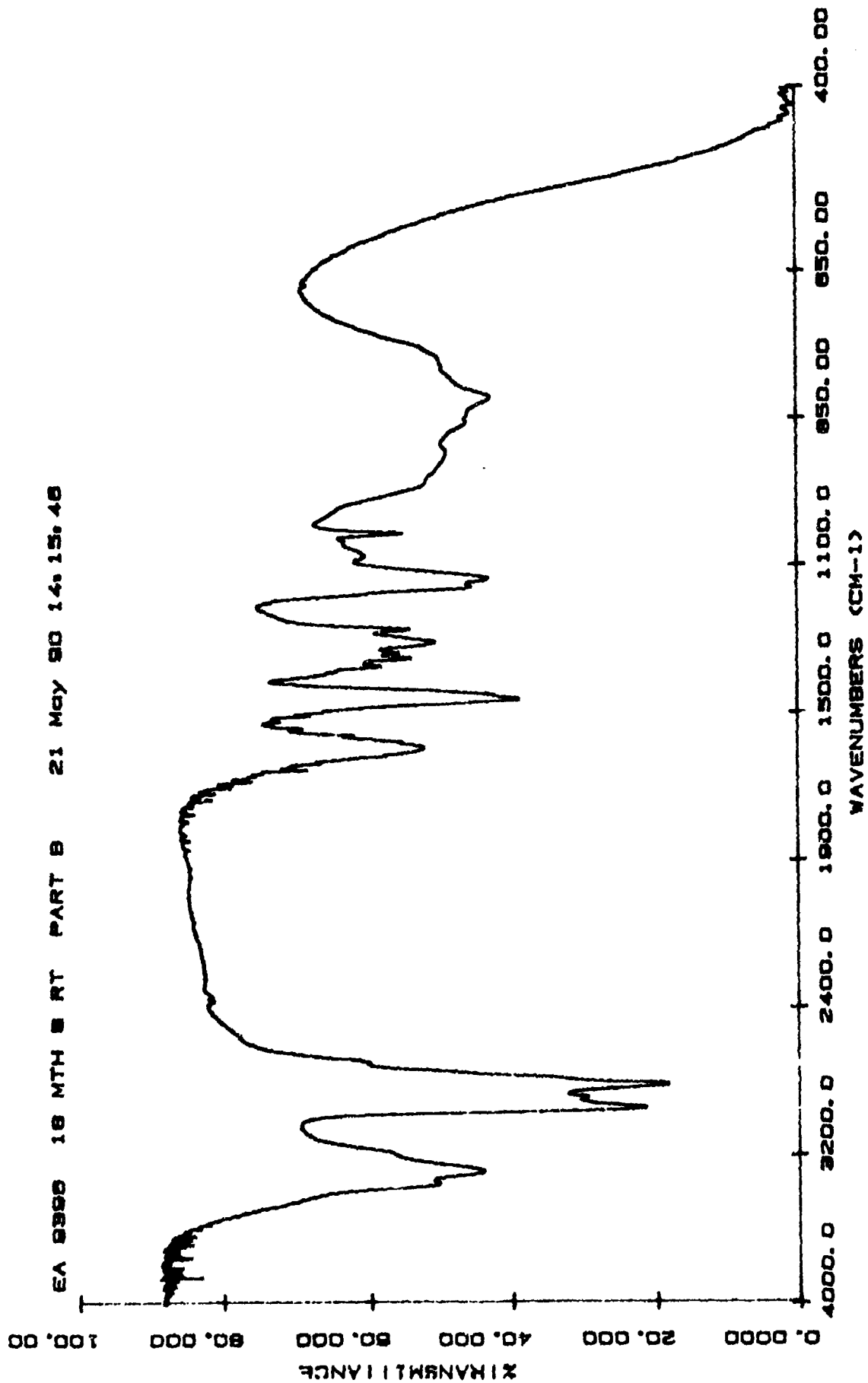


Figure M.48. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 12 Months.



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Figure M.49. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 18 Months.

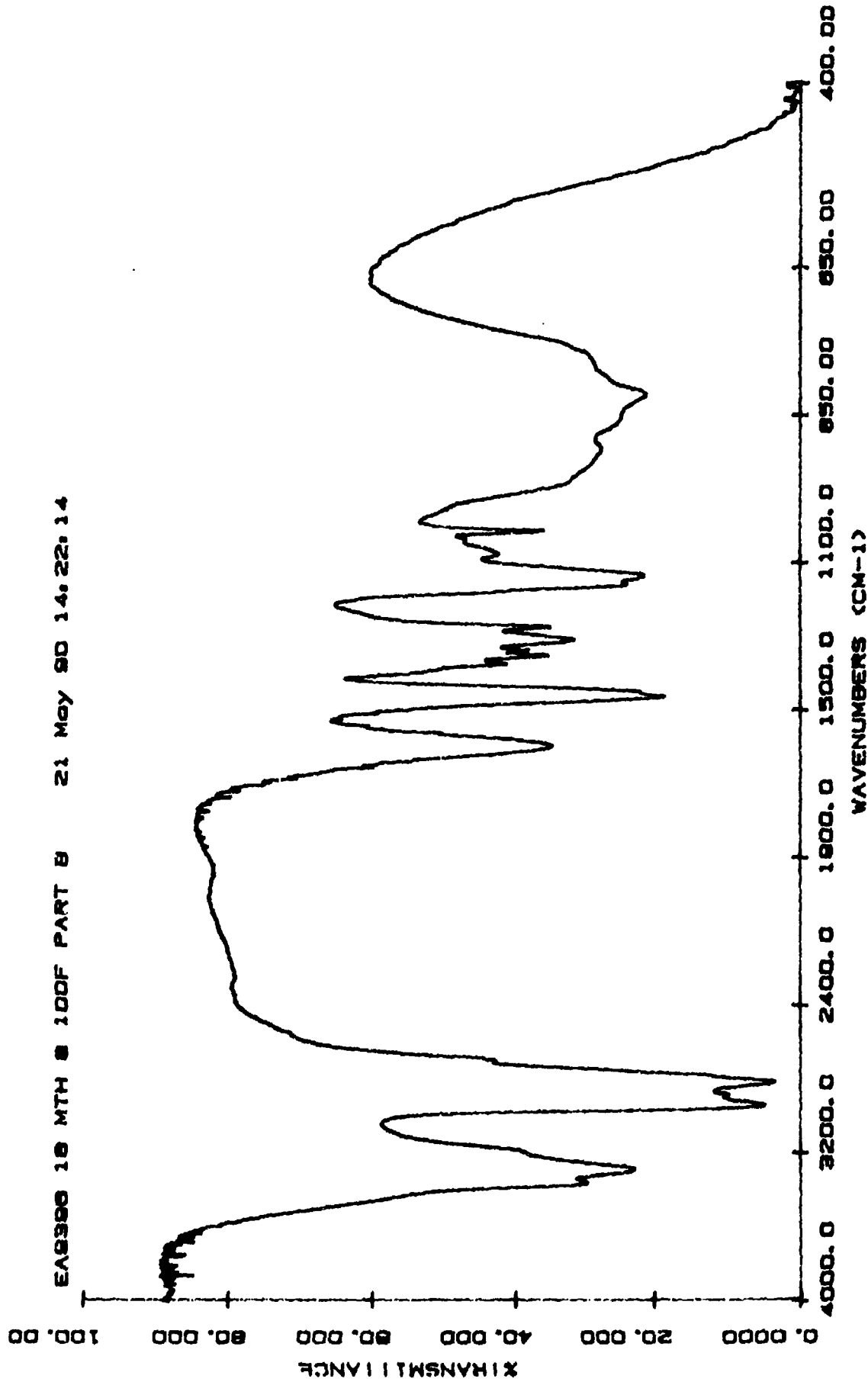


Figure M.50. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 18 Months.

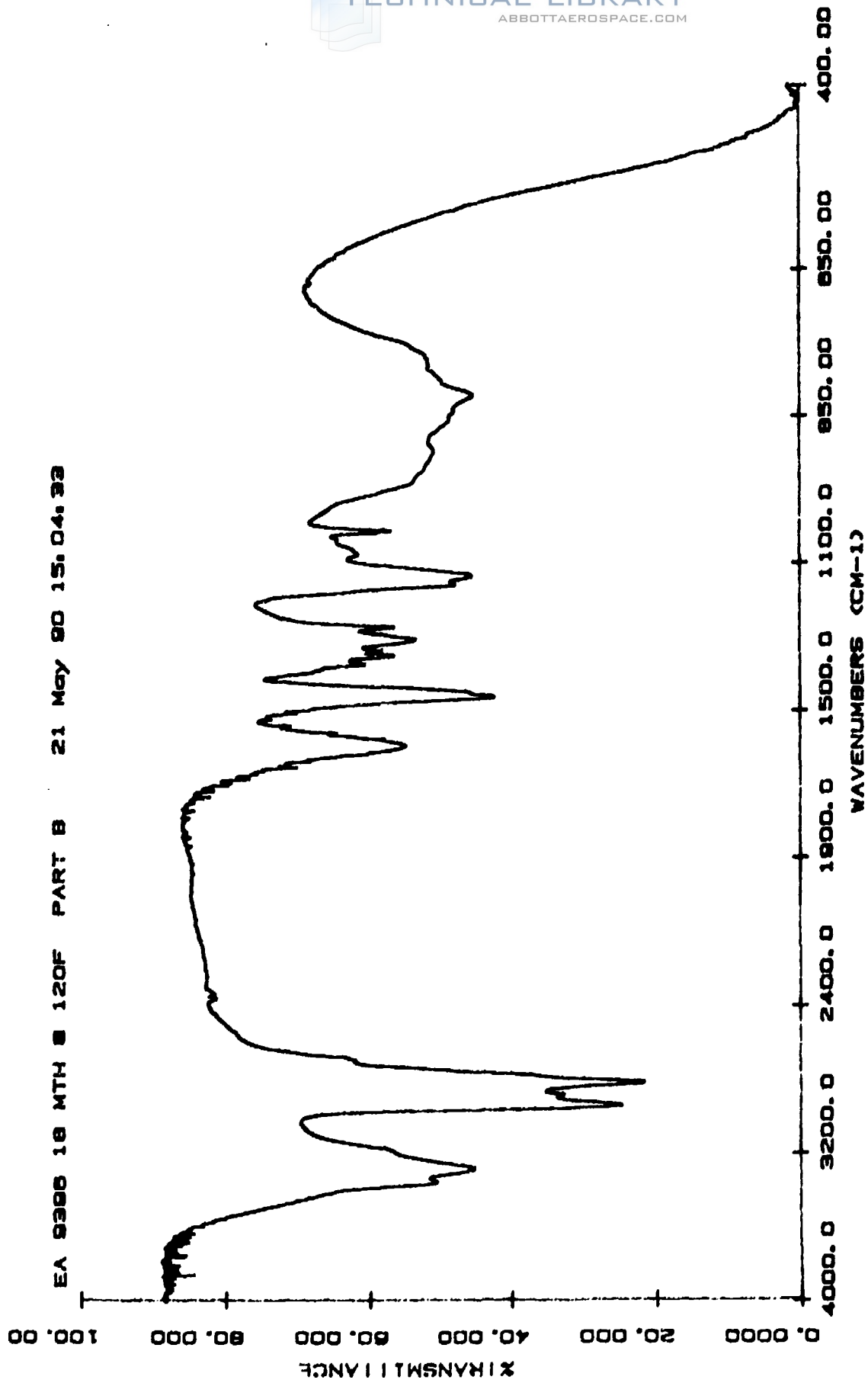


Figure M.51. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 18 Months.

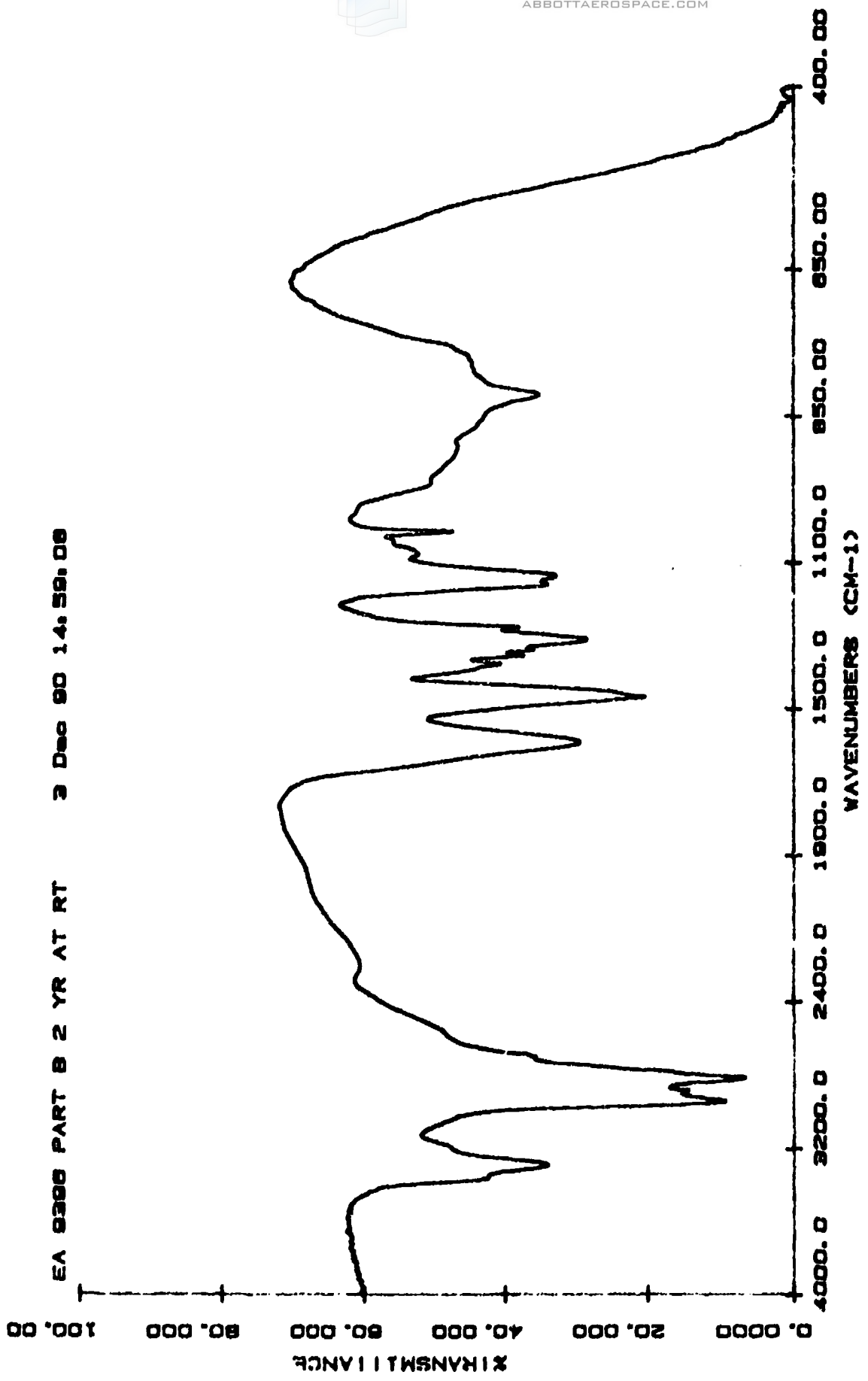


Figure M.52. FTIR Spectra for EA9396, Part B, Stored at 22°C (72°F) for 24 Months.

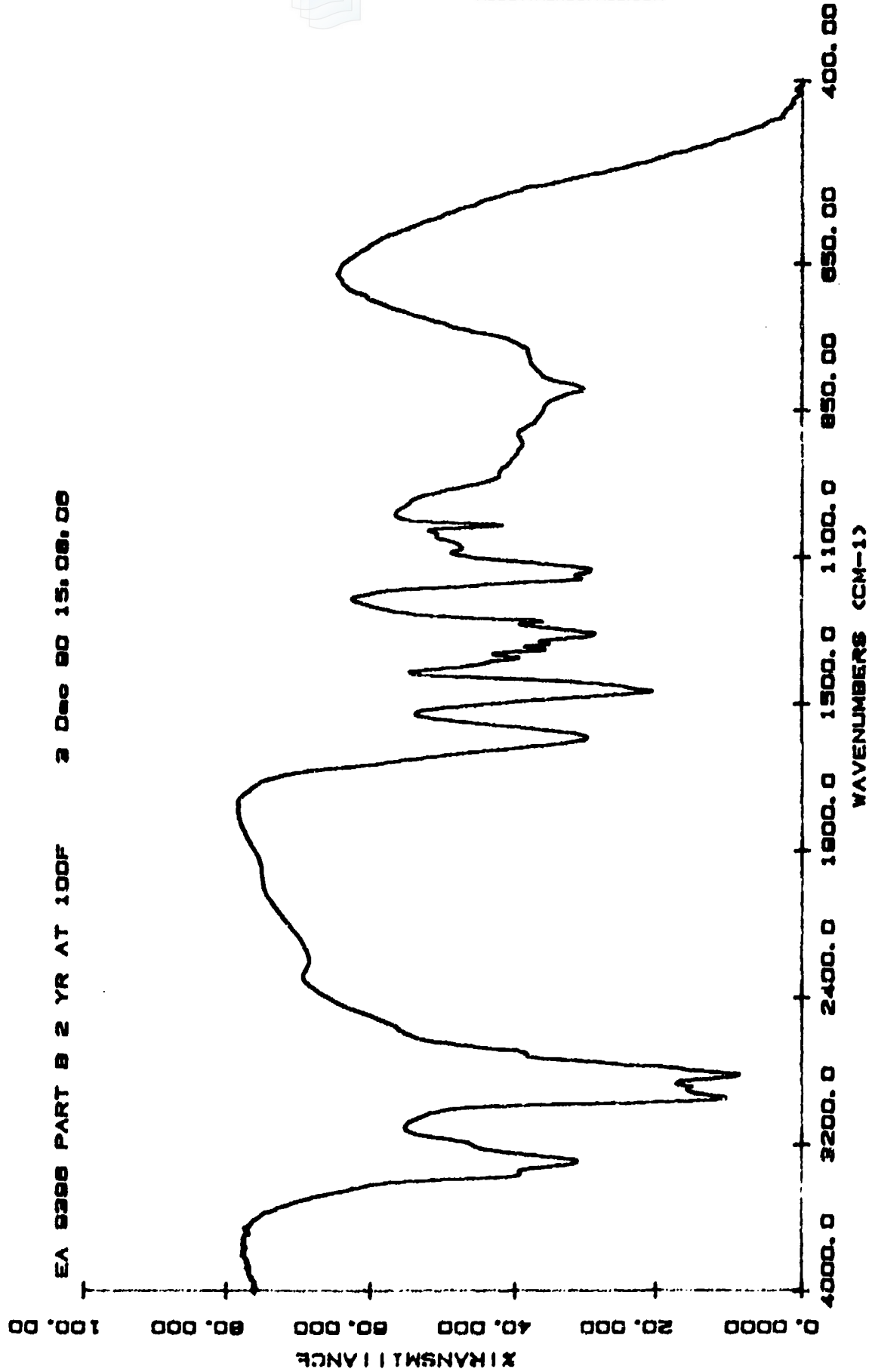


Figure M.53. FTIR Spectra for EA9396, Part B, Stored at 38°C (100°F) for 24 Months.

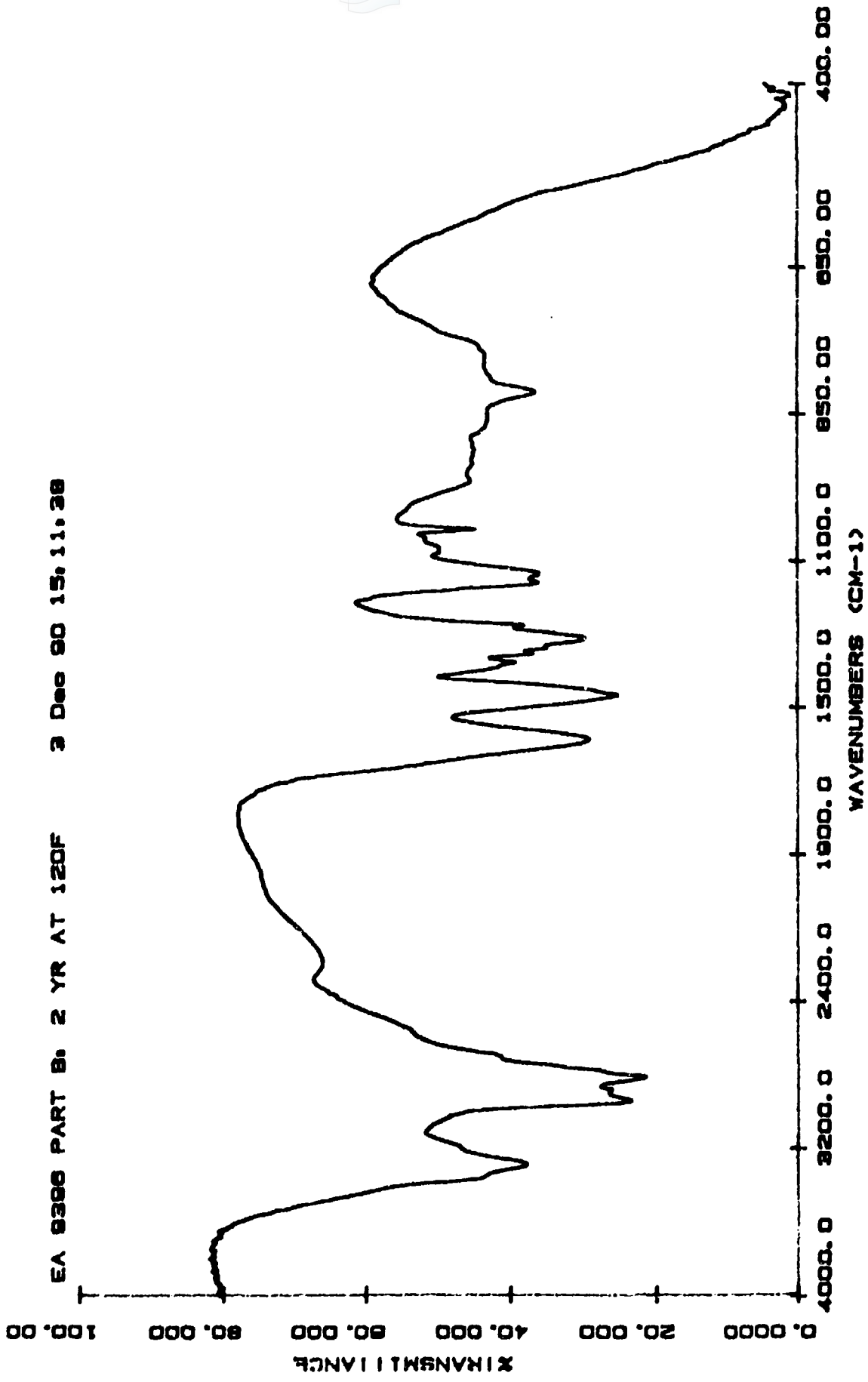


Figure M.54. FTIR Spectra for EA9396, Part B, Stored at 49°C (120°F) for 24 Months.

Initial testing of EA9396.

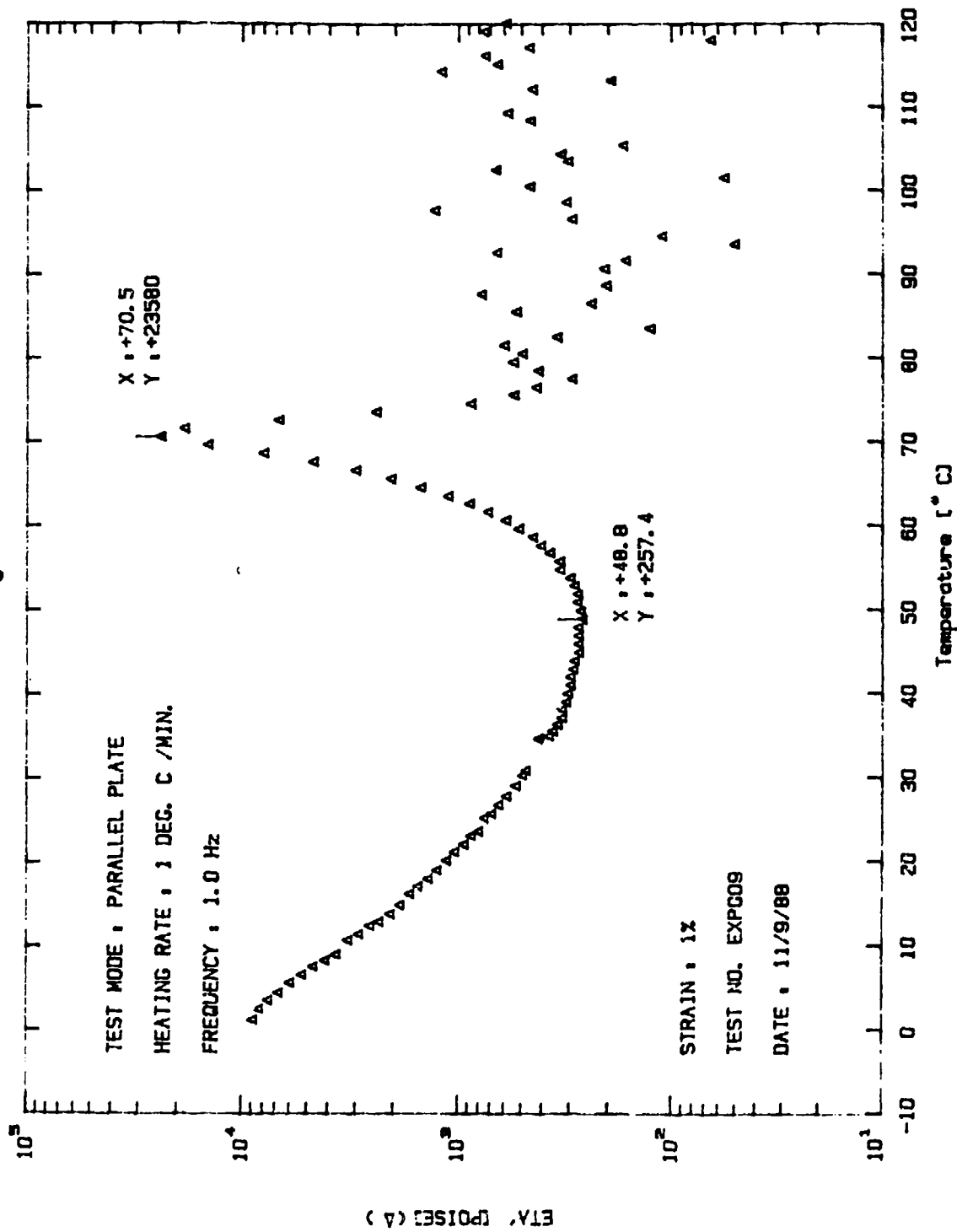


Figure M.55. Viscosity Cure Profile for EA9396, Initial.

EA9396 Aged 1 month @ 100 deg. F.

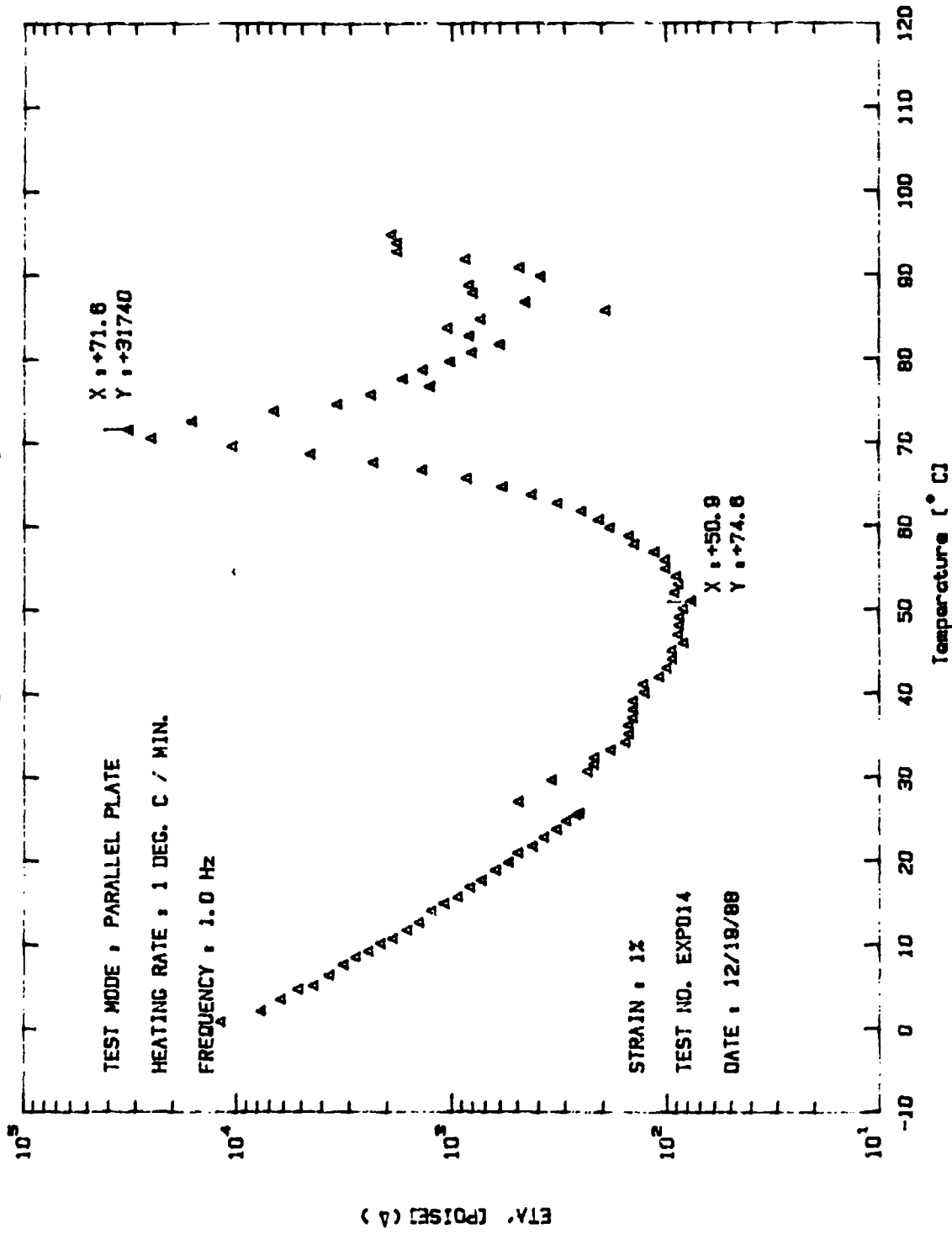


Figure M.56. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 1 Month.

EA9396 . Aged 1 month @ 120 deg. F .

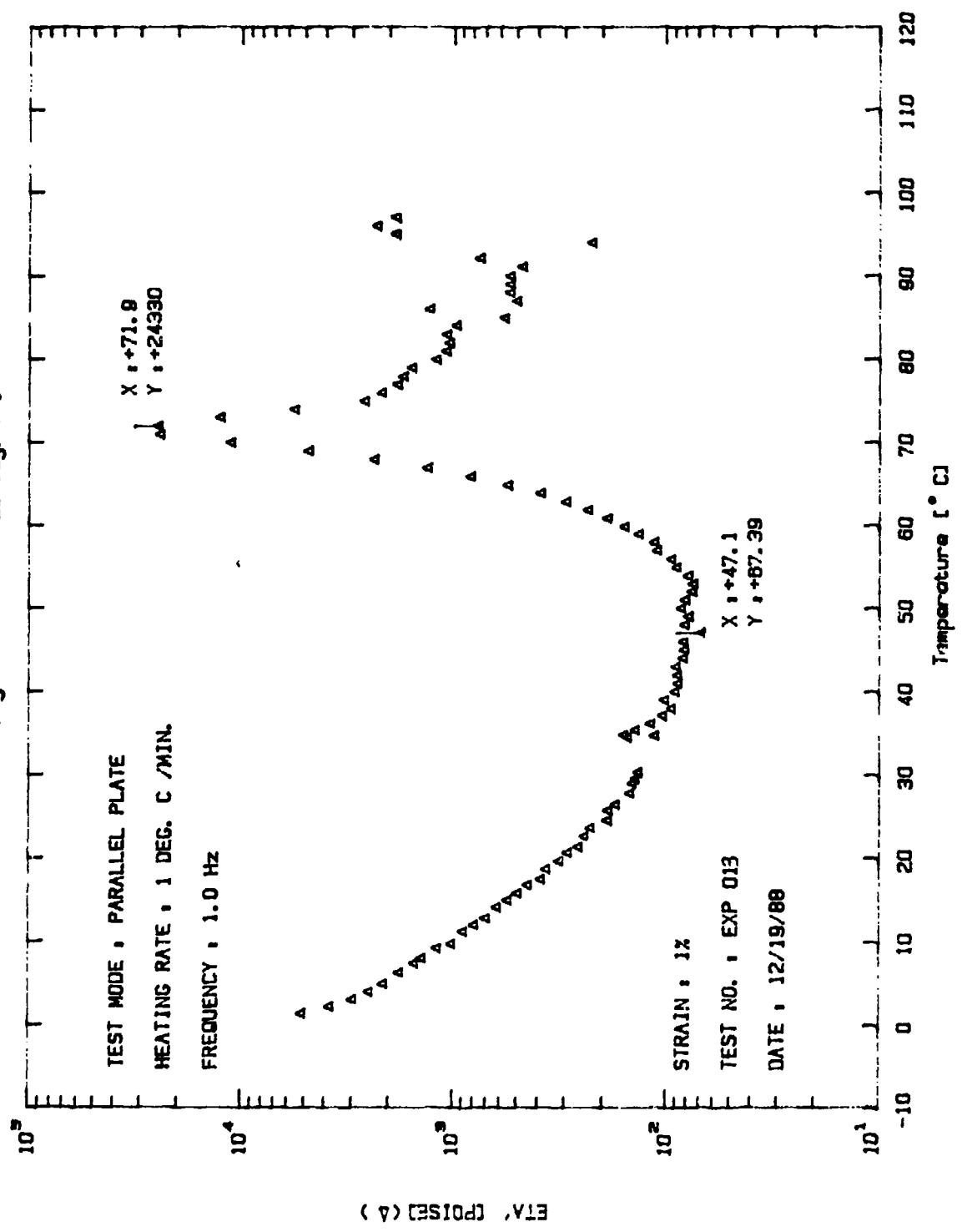
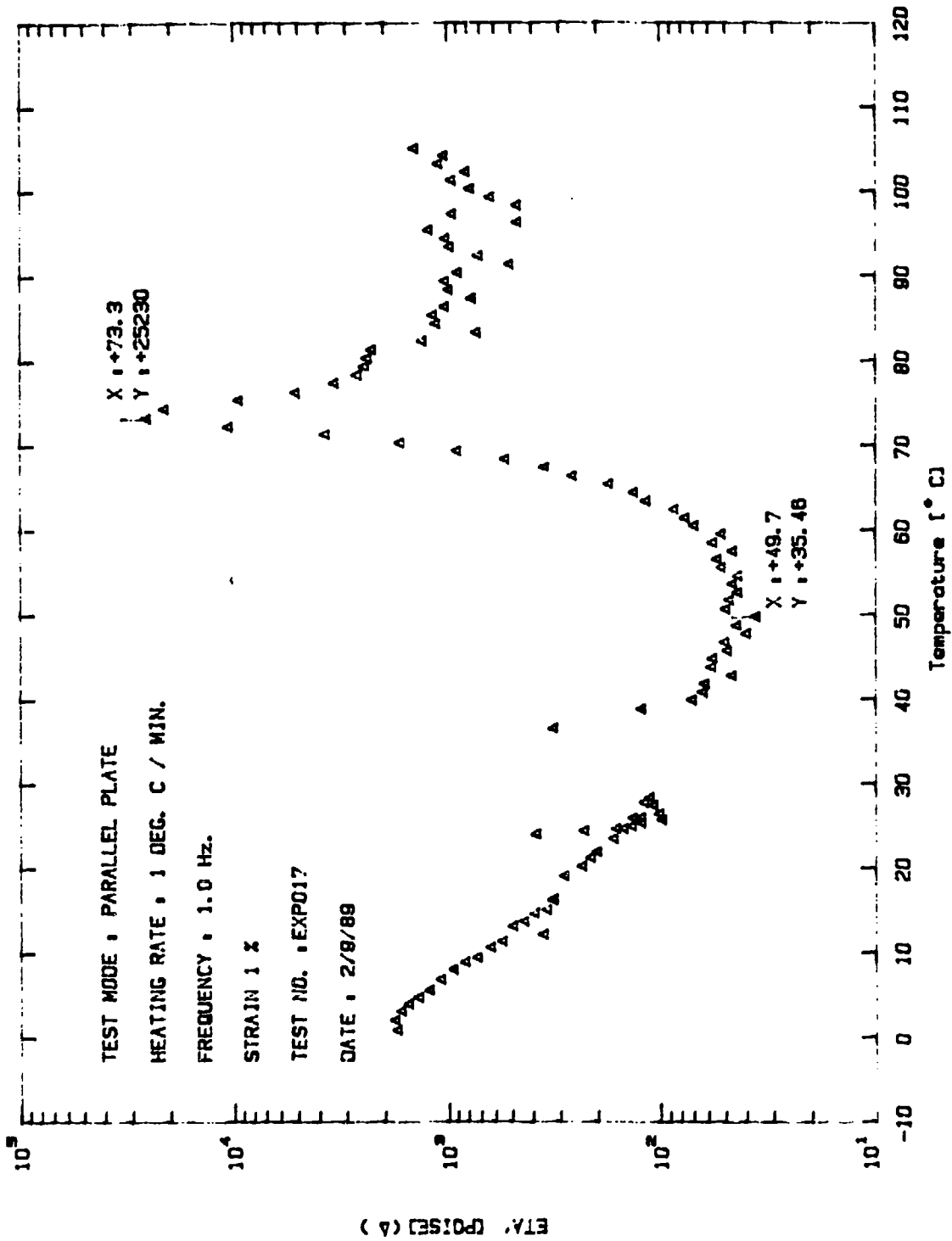


Figure M.57. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 1 Month.

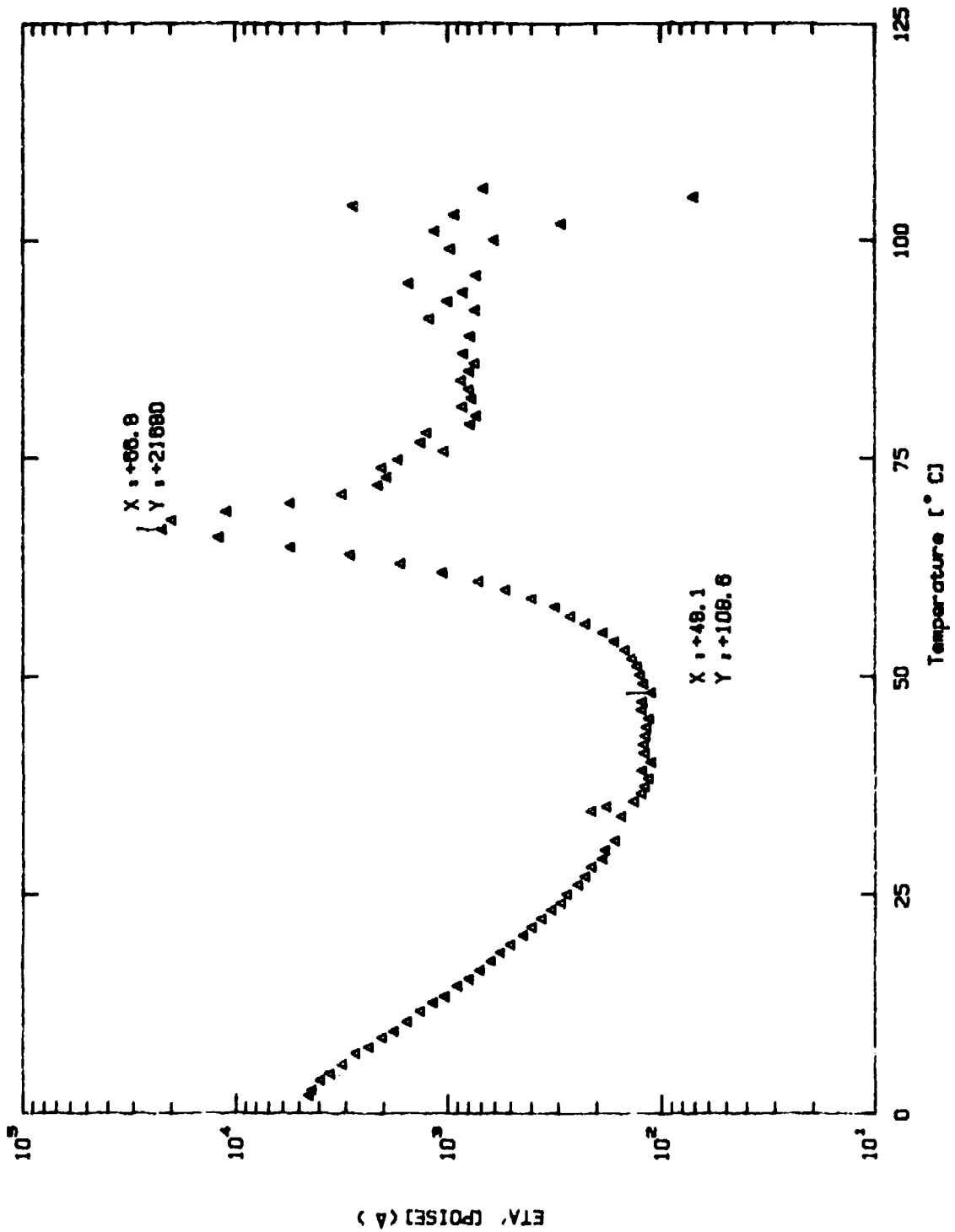
EA 9396 3 WITH 8 RT



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Figure M.58. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 3 Months.

EA-9396, 6 Months @ RT



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Figure M.59. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 6 Months.

EA-9396, 6 Months @ 100 deg. F

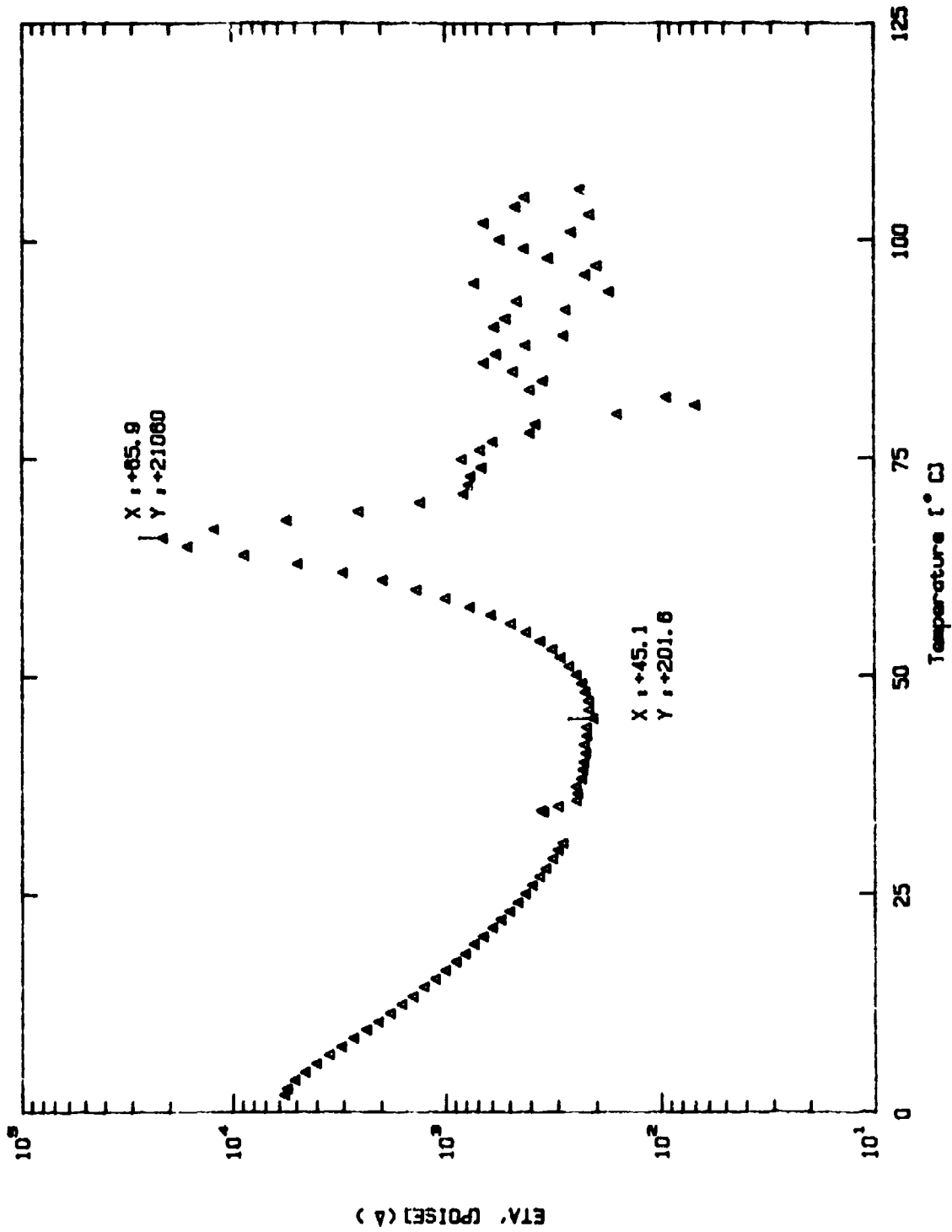


Figure M.60. Viscosity Cure Profile for EA9396. After Storage at 38°C (100°F) for 6 Months.

EA-9396, 6 Months @ 120 deg. F

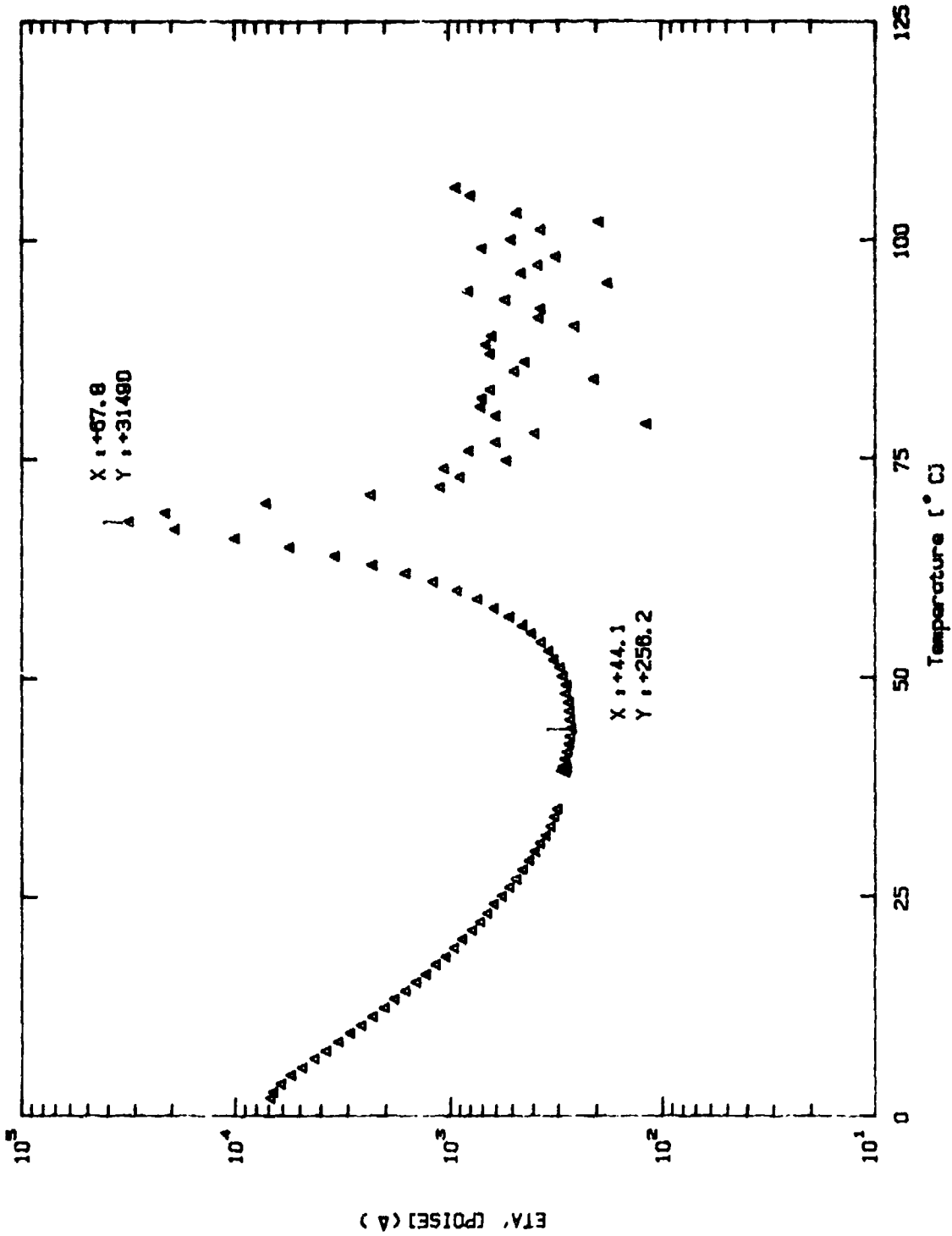


Figure M.61. Viscosity Cure Profile for EA9396, After Storage at 49°C (120°F) for 6 Months.

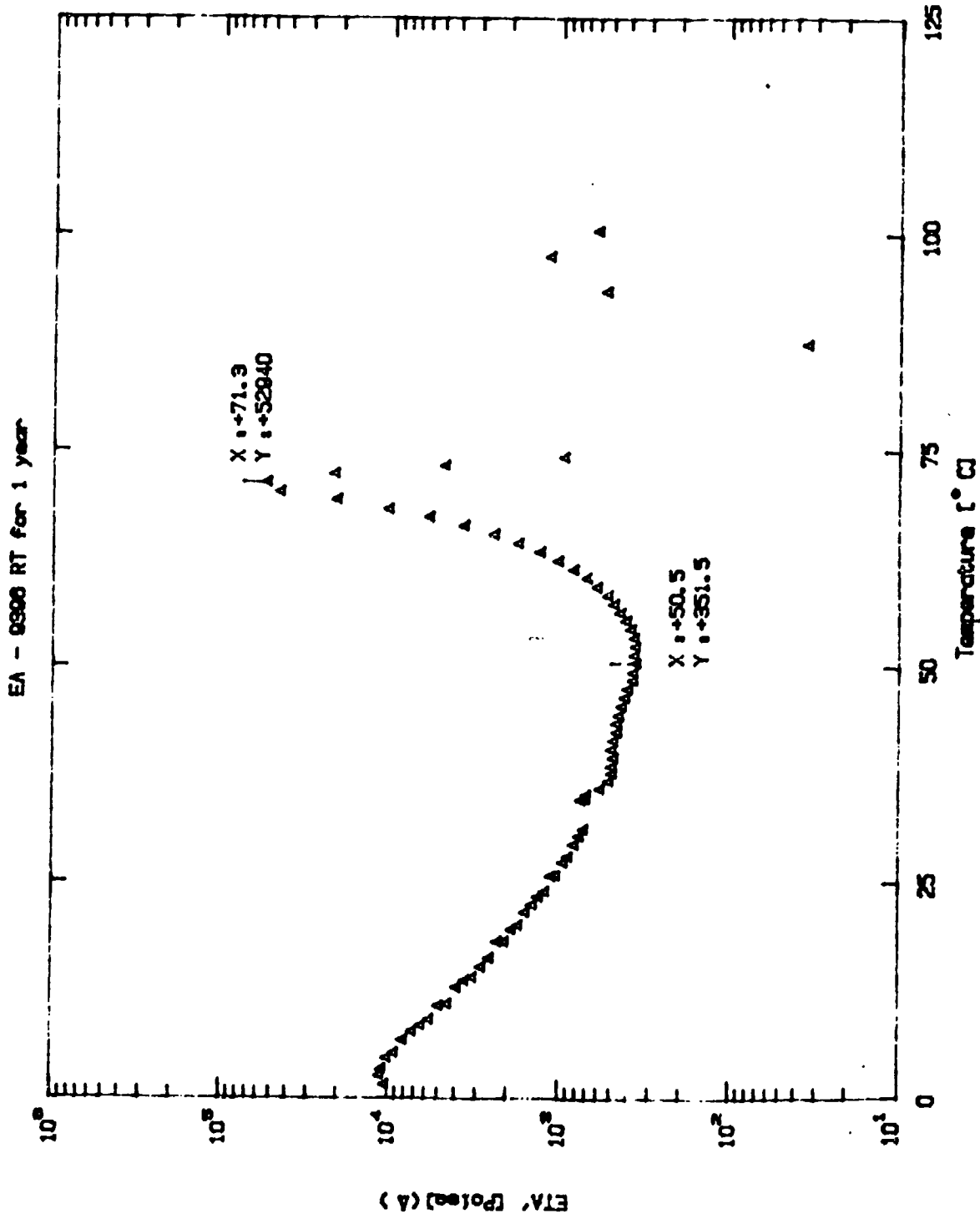


Figure M.62. Viscosity Cure Profile for EA9996, After Storage at 22°C (72°F) for 12 Months.

EA-9396 1 yr. @ 100 deg. F

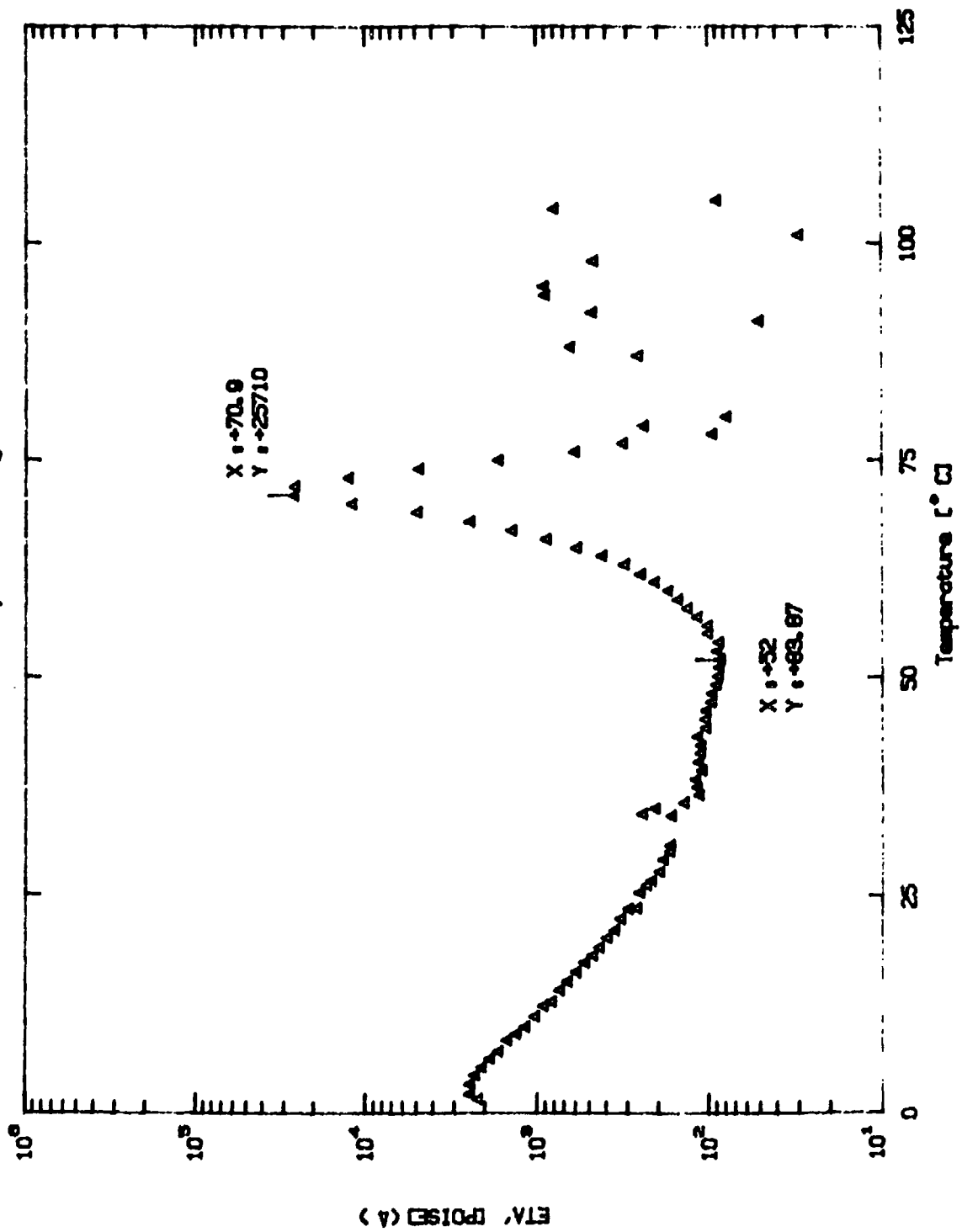


Figure M.63. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 12 Months.

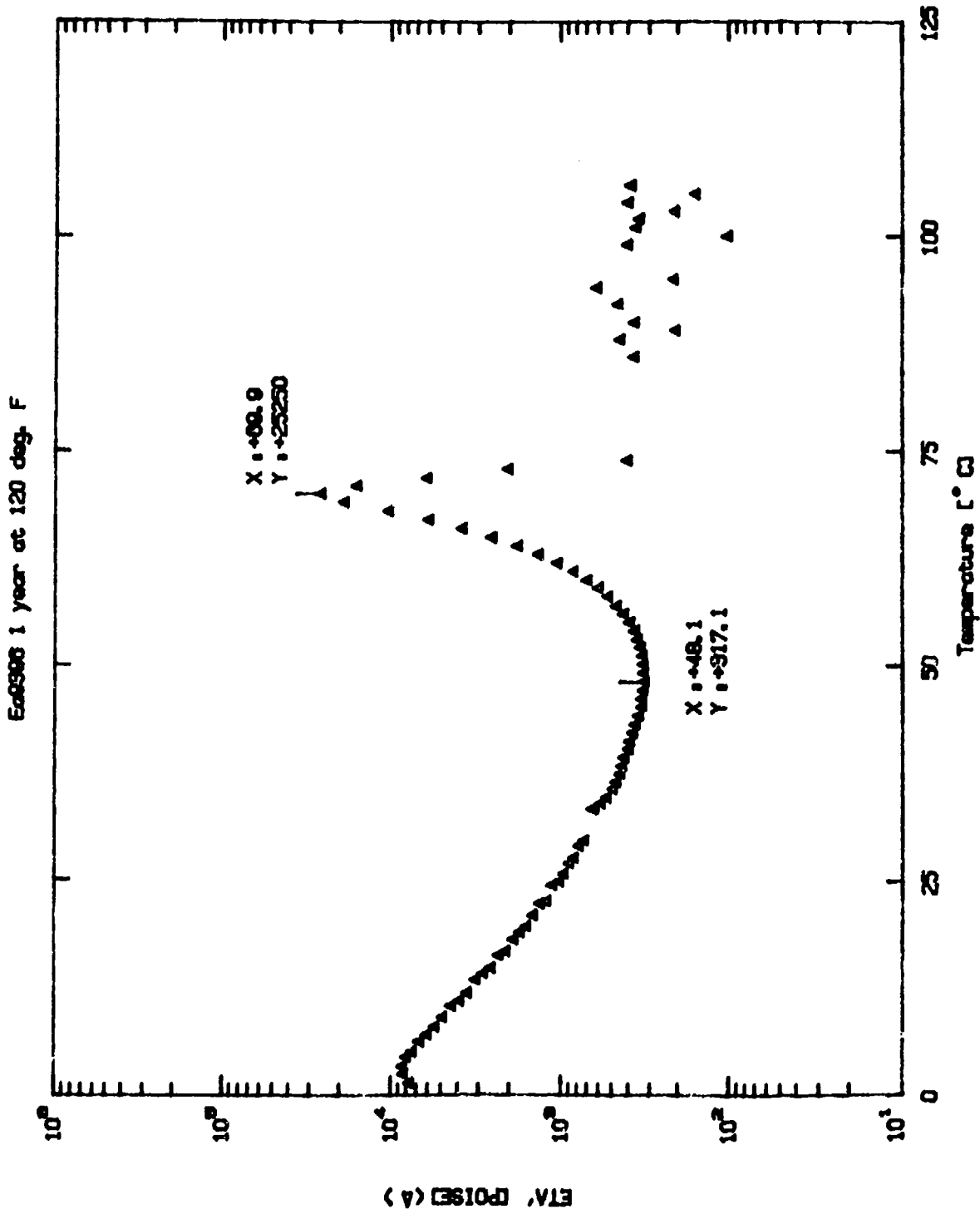


Figure M.64. Viscosity Cure Profile for E.A.9396, After Storage at 49°C (120°F) for 12 Months.

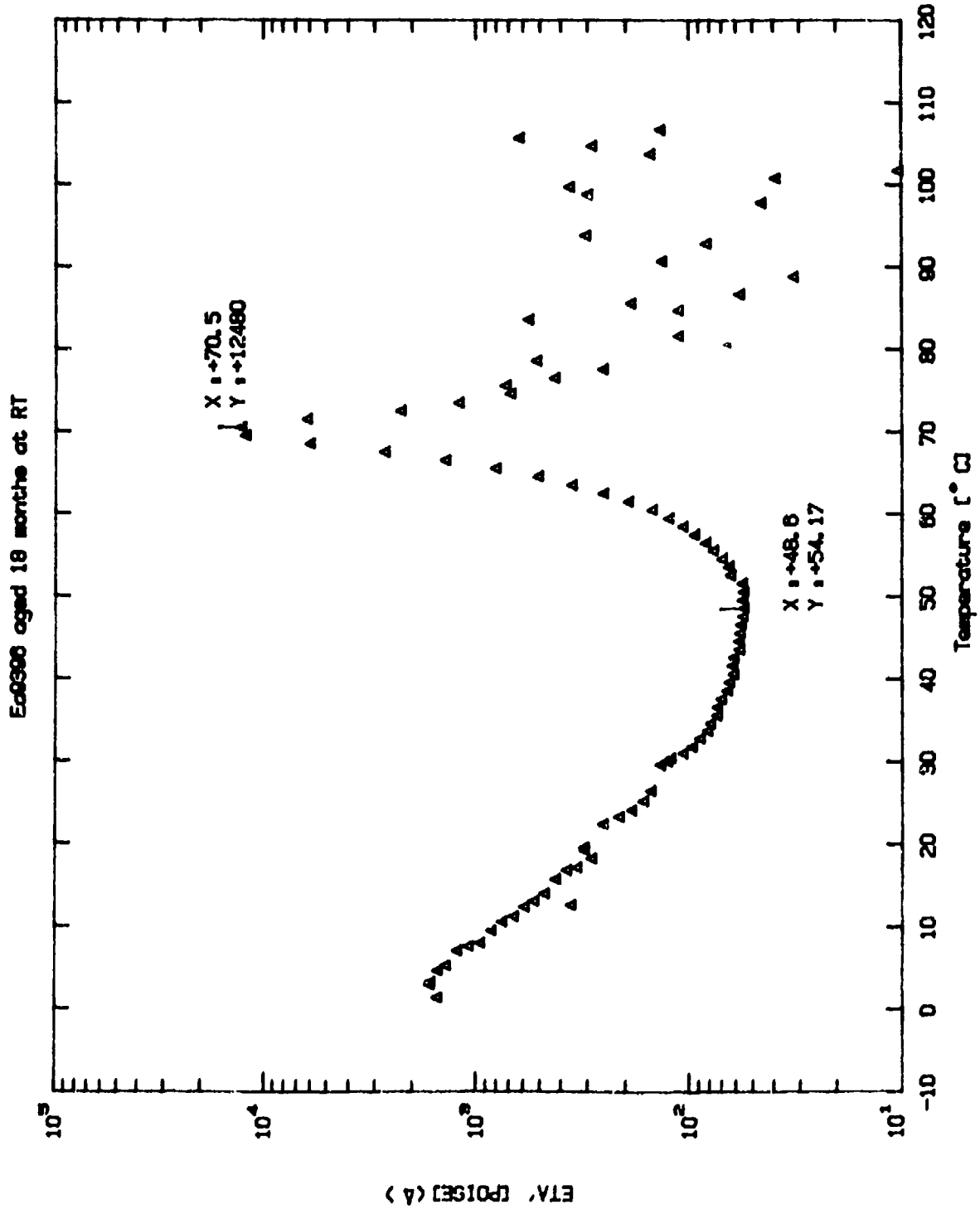


Figure M.65. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 18 Months.

Ea 9598 Aged 18 months at 100 deg. F

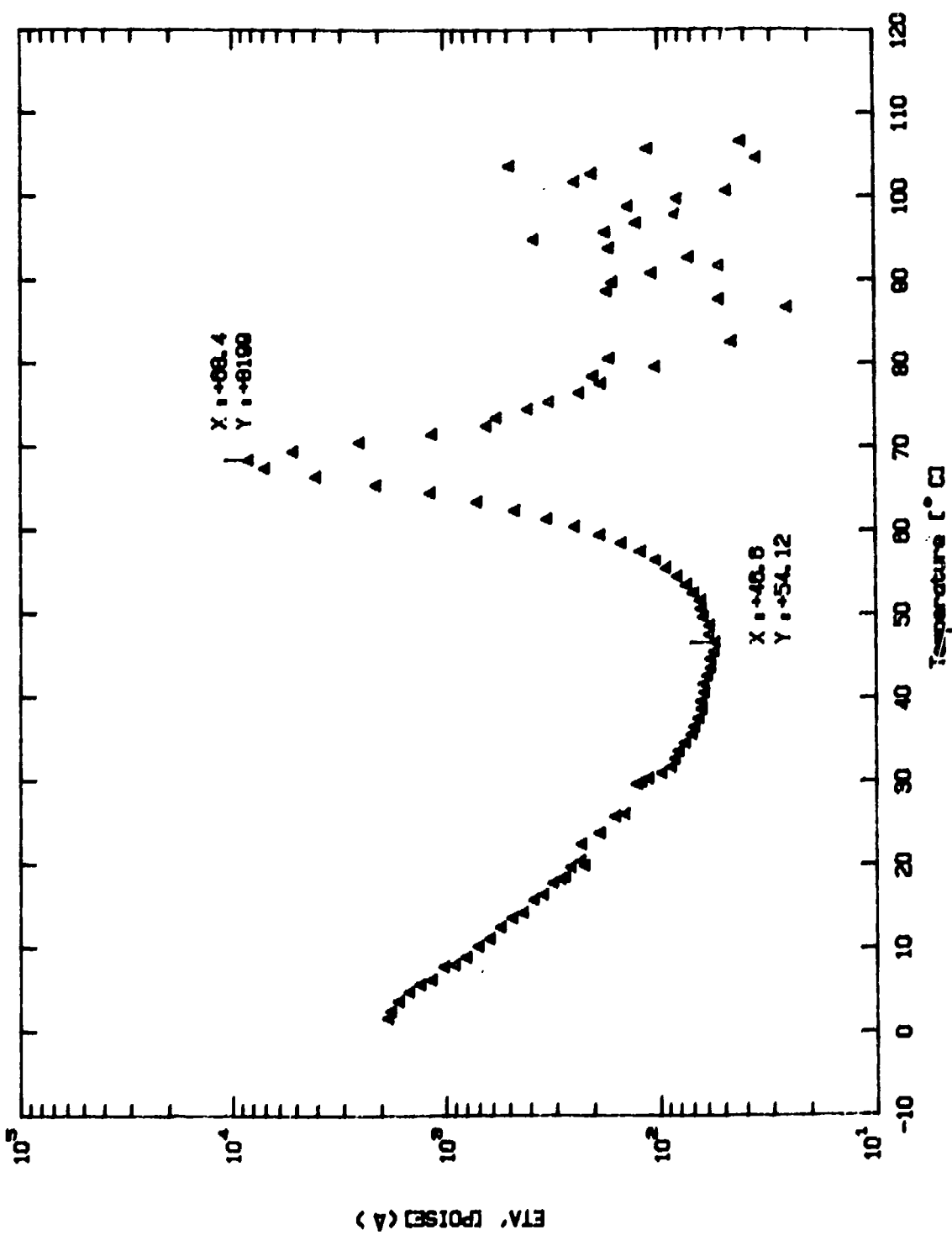


Figure M.66. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 18 Months.

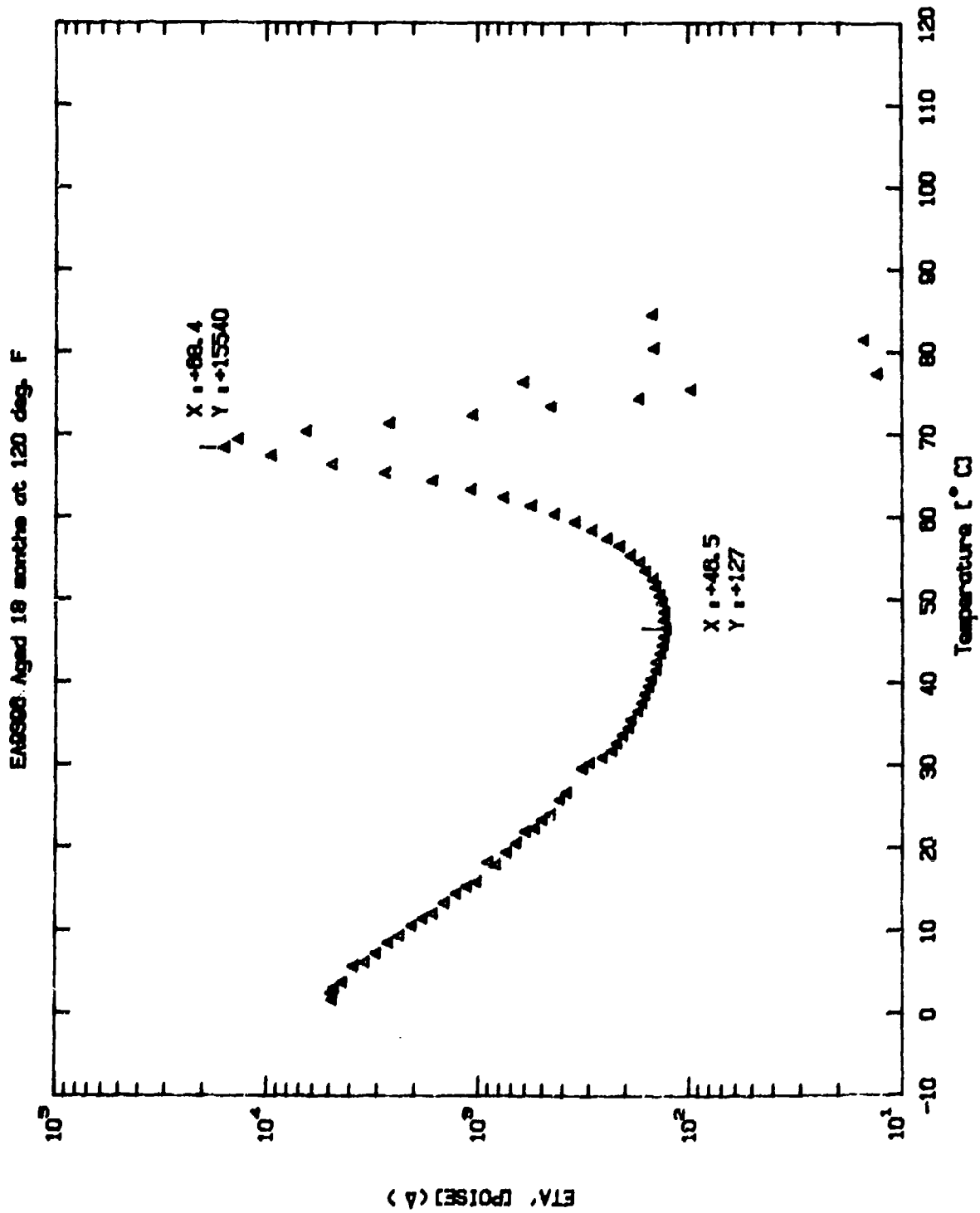


Figure M.67. Viscosity Cure Profile for EA9396, After Storage at 49°C (120°F) for 18 Months.

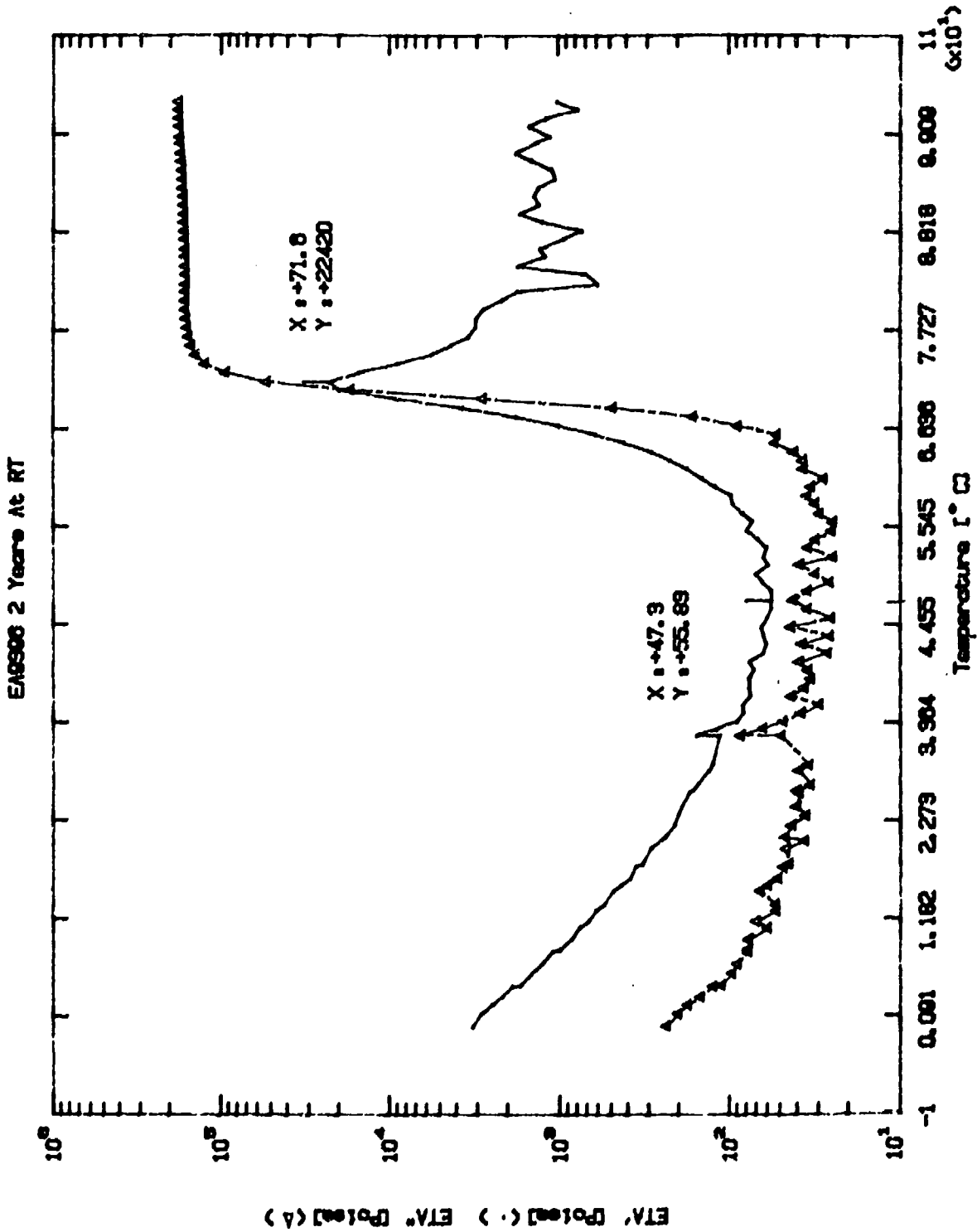


Figure M.68. Viscosity Cure Profile for EA9396, After Storage at 22°C (72°F) for 24 Months.

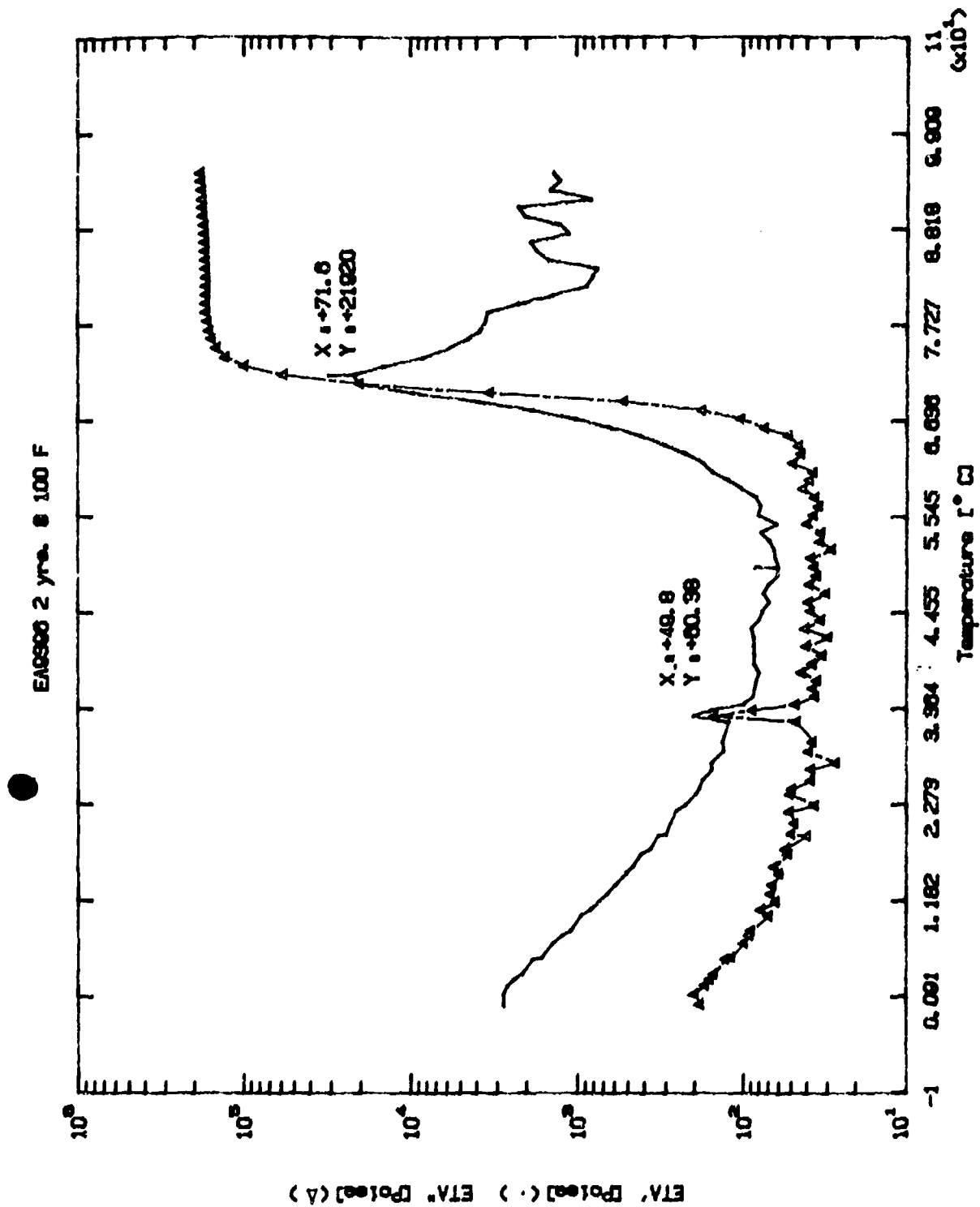


Figure M.69. Viscosity Cure Profile for EA9396, After Storage at 38°C (100°F) for 24 Months.

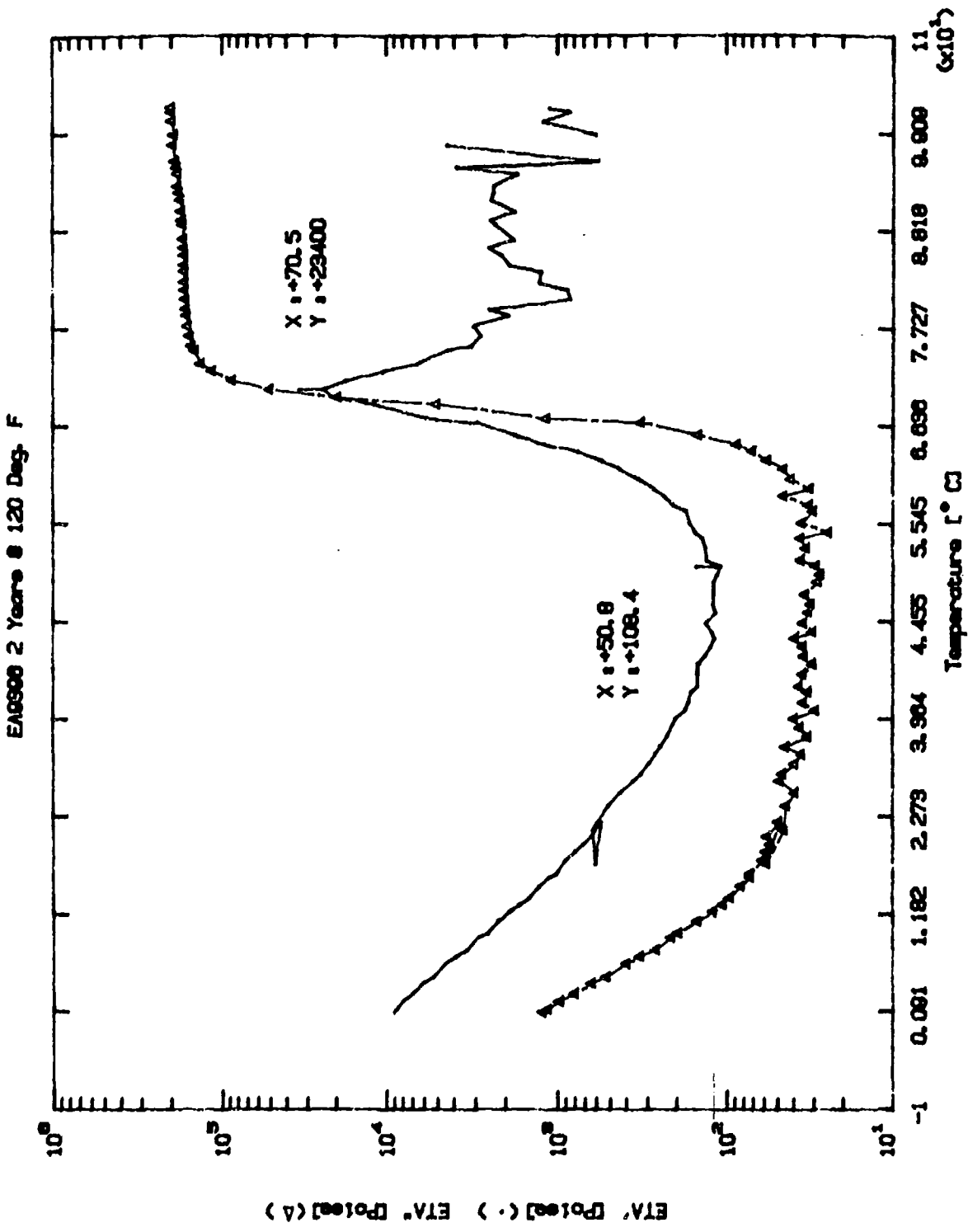


Figure M.70. Viscosity Cure Profile for EA9396, After Storage at 49°C (120°F) for 24 Months.

APPENDIX N

INDIVIDUAL SPECIMEN HONEYCOMB FLATWISE TENSILE PROPERTIES, EFFECT OF ADHESIVE FILLET SIZE

When honeycomb sandwich constructions are pulled apart in a flatwise tension mode, the limiting strength is that of the core. Heavier core, with smaller cell size and higher cell wall thickness obviously requires higher loads to tear the core than lighter core. The strength of the core however does not necessarily determine the flatwise tensile strength of a honeycomb construction. Failure may occur at lower loads than that required to fail the core because a variety of other failure modes can occur. Some of these alternative failure modes include debonding of the adhesive from the facing skin, debonding of the adhesive fillets from the core cell walls, cohesive failure within the adhesive itself, or, in the case of composite skins, delamination of the facing skins. Whichever of these various locations is the "weakest-link-in-the-chain" will fail first.

Probably the most common of these alternative failure modes is the failure of the bond between the adhesive fillets and the core cell walls and the leading reason for this is inadequate fillet size. It is intuitively obvious that as the adhesive fillet size increases, and concurrently the area of the fillet-cell wall bond increases, this "link-in-the-chain" will become stronger and failure loads will increase until the strength of the next weakest link in the chain is exceeded.

Since the fillet size is the most easily controlled variable in a honeycomb sandwich bond (one only has to use more adhesive to increase the fillet size), the effect of this variable on flatwise tensile strength was investigated.

Honeycomb sandwich panels were prepared and tested with varying amounts of adhesive (ranging from none to 0.73 gm/cm^2) between the skin and the core. The individual specimen flatwise tensile strengths obtained from these panels are presented in Tables N.1 - N.5. These results were summarized and discussed in Section 3.10.2.

TABLE N.1
 FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
 WITH NO SUPPLEMENTAL ADHESIVE

Test :		Flatwise tension; ASTM C297-88		Task #9		Tested by:		DRB				
Material:		Hysol EA-9396 A/B; W133 Graphite Skins		CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core								
Specimen Number	Test Temperature	Specimen Width		Maximum Load (lbs.)	Flatwise Tensile Strength		Failure Mode			Date Tested	Remarks	
		1 (in.)	2 (in.)		(Psi.)	(MPa)	A/S (%)	A (%)	C (%)			
BIL-GR-65-1	22°C (72°F) (DRY)	2.000	2.000	725	181.3	1.250	10	80	10	0	3/29/90	(1,2,3)
BIL-GR-65-2	"	2.000	2.000	625	156.3	1.077	10	80	10	0	"	(1,2,3)
BIL-GR-65-3	"	2.000	2.000	875	218.8	1.508	10	80	10	0	"	(1,2,3)
BIL-GR-65-4	"	2.000	2.000	1,750	437.5	3.017	10	0	90	0	"	(1,2,3)
				Average	248.4	1.713						
				Std. Dev.	128.6	0.887						

Remarks:

- (1) Failure Mode:
 - A/C: Fillet-to-core interface (bare honeycomb)
 - A/S: Adhesive-to-skin interface (bare aluminum or composite skin)
 - A: Cohesive within adhesive (between base of fillet and adhesive layer)
 - C: Core tearing
- (2) Failed on top side of core.
- (3) No adhesive present between core and either skin.

TABLE N.2
 FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
 WITH MODERATE ADHESIVE LAYER ALONG TOP SKIN

Test :		Flatwise tension; ASTM C297-88				Task #9		Tested by: DRB				
Material:		Hysol EA-9396 A/B; W133 Graphite Skins				CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core						
Specimen Number	Test Temperature	Specimen Width		Maximum Load (lbs.)	Flatwise Tensile Strength		Failure Mode			Date Tested	Remarks	
		1 (in.)	2 (in.)		(Psi.)	(MPa)	A/S (%)	A (%)	C (%)			
BIL-GR-64-1	22°C (72°F) (DRY)	2.000	2.000	2,550	637.5	4.396	10	0	90	0	3/29/90	(1,2,3)
BIL-GR-64-2	"	2.000	2.000	2,875	718.8	4.956	5	0	95	0	"	(1,2,3)
BIL-GR-64-3	"	2.000	2.000	2,320	580.0	3.999	5	0	95	0	"	(1,2,3)
BIL-GR-64-4	"	2.000	2.000	1,975	493.8	3.404	10	0	90	0	"	(1,2,3)
					Average	607.5	4.189					
					Std. Dev.	94.8	0.654					

Remarks:

(1) Failure Mode:
 A/C: Fillet-to-core interface (bare honeycomb)
 A/S: Adhesive-to-skin interface (bare aluminum or composite skin)
 A: Cohesive within adhesive (between base of fillet and adhesive layer)
 C: Core tearing

(2) Failed on bottom side of core.
 (3) 0.21 gm/cm² adhesive between core and top skin.

TABLE N.3
 FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
 WITH LIGHT ADHESIVE LAYER ALONG BOTH SKINS

Test :		Flatwise tension; ASTM C297-88		Task #9b		Tested by: DRB						
Material:		Hysol EA-9396 A/B; W133 Graphite Skins										
		CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core										
Specimen Number	Test Temperature	Specimen Width		Maximum Load (lbs.)	Flatwise Tensile Strength		Failure Mode		Date Tested	Remarks		
		1 (in.)	2 (in.)		(Psi.)	(MPa)	A/S (%)	A (%)			C (%)	
BIL-GR-81-1	22°C (72°F) (DRY)	2.000	2.000	2,889	722.3	4.980	20	65	15	0	9/10/90	(1,2)
BIL-GR-81-2	"	2.000	2.000	3,267	816.8	5.631	35	60	5	0	"	(1,2)
BIL-GR-81-3	"	2.000	2.000	2,901	725.3	5.001	50	45	5	0	"	(1,2)
BIL-GR-81-4	"	2.000	2.000	2,959	739.8	5.101	30	70	0	0	"	(1,2)
				Average	751.0	5.178						
				Std. Dev.	44.5	0.307						

Remarks:
 (1) Failure Mode:
 A/C: Fillet-to-core interface (bare honeycomb)
 A/S: Adhesive-to-skin interface (bare aluminum or composite skin)
 A: Cohesive within adhesive (between base of fillet and adhesive layer)
 C: Core tearing
 (2) 0.08 gm/cm² adhesive between core and both skins.

TABLE N.4
 FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
 WITH MODERATE ADHESIVE LAYER ALONG BOTH SKINS

Test :		Flatwise tension: ASTM C297-88		Task #9b		Tested by: DRB						
Material:		Hysol EA-9396 A/B; W133 Graphite Skins		CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core								
Specimen Number	Test Temperature	Specimen Width		Maximum Load (lbs.)	Flatwise Tensile Strength			Date Tested	Remarks			
		1 (in.)	2 (in.)		A/S (%)	A (%)	C (%)					
BIL-GR-83-1	22°C (72°F) (DRY)	2.000	2.000	3,219	804.8 (Psi.)	5.549 (MPa)	0	65	35	0	9/10/90	(1,2)
BIL-GR-83-2	"	2.000	2.000	3,279	819.8	5.652	10	50	40	0	"	(1,2)
BIL-GR-83-3	"	2.000	2.000	3,490	872.5	6.016	20	40	40	0	"	(1,2)
BIL-GR-83-4	"	2.000	2.000	3,552	888.0	6.123	10	45	45	0	"	(1,2)
				Average	846.3	5.835						
				Std. Dev.	40.2	0.277						

Remarks:
 (1) Failure Mode:
 A/C: Fillet-to-core interface (bare honeycomb)
 A/S: Adhesive-to-skin interface (bare aluminum or composite skin)
 A: Cohesive within adhesive (between base of fillet and adhesive layer)
 C: Core tearing

(2) 0.21 gm/cm² adhesive between core and both skins.

TABLE N.5
 FLATWISE TENSILE STRENGTH OF HONEYCOMB SANDWICH
 WITH HEAVY ADHESIVE LAYER ALONG BOTH SKINS

Test		Flatwise tension; ASTM C297-88		Task #9b		Tested by:		DRB					
Material:		Hysol EA-9396 A/B; W133 Graphite Skins		CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core									
Specimen Number	Test Temperature	Specimen Width		Maximum Load (lbs.)	Flatwise Tensile Strength		Failure Mode			Date Tested	Remarks		
		1 (in.)	2 (in.)		(Psi.)	(MPa)	A/S (%)	A (%)	C (%)				
BIL-GR-88-1	22°C (72°F) (DRY)	2.000	2.000	3,915	978.8	6.748	55	45	0	0	0	7/23/91	(1,2,3)
BIL-GR-88-2	"	2.000	2.000	3,725	931.3	6.421	55	45	0	0	0	"	(1,2,3)
BIL-GR-88-3	"	2.000	2.000	4,120	1030.0	7.102	0	0	0	0	0	"	(1,2,4)
					Average	980.0	6.757						
					Std. Dev.	49.4	0.341						

Remarks:

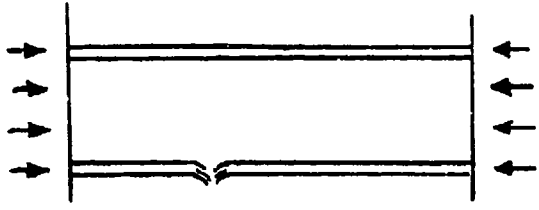
- (1) Failure Mode:
 - A/C: Fillet-to-core interface (bare honeycomb)
 - A/S: Adhesive-to-skin interface (bare aluminum or composite skin)
 - A: Cohesive within adhesive (between base of fillet and adhesive layer)
 - C: Core tearing
- (2) 0.75 gm/cm² adhesive between core and both skins.
- (3) Most of the failure within the adhesive layer consisted of debonding of the adhesive from the glass scrim fabric.
- (4) Failure was 75% delamination of facing skin and 25% debonding between facing skin and loading blocks.

APPENDIX O
INDIVIDUAL SPECIMEN HONEYCOMB SANDWICH
EDGEWISE COMPRESSION PROPERTIES, EFFECT OF
COCURING VS. SECONDARY BONDING

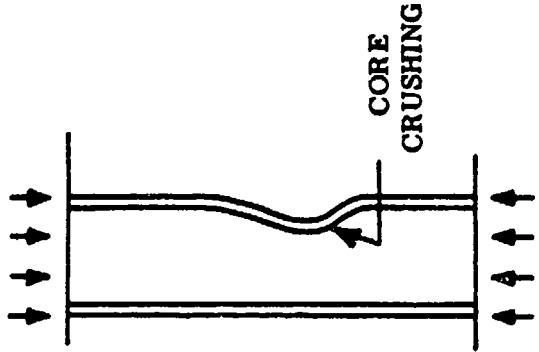
The six tables in this appendix present the detailed edgewise compression strength data for honeycomb sandwich specimens prepared by either cocuring of the skins to the core or secondarily bonding the skins to the core. The specimens consisted of either graphite or glass fabric reinforced skins on two different density aluminum honeycomb cores.

In order to prevent crushing of the ends of the sandwich specimens during loading, approximately 4.5 cm (1.75 in) of the core on each end of the specimen was filled with epoxy resin, leaving a central, unpotted, gage section between the loading fixtures of approximately 14 cm (5.5 in).

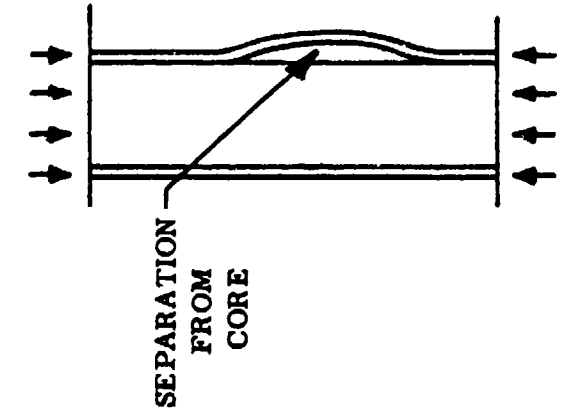
Figure O.1 illustrates the various failure modes observed for these specimens.



C. Skin Compression



B. Wrinkling of Facings



A. General Buckling

Figure 0.1. Types of Failure Modes Observed in Edgewise Compression Tests.

TABLE 0.1
 EDGEWISE COMPRESSION STRENGTH OF COCURED HONEYCOMB SANDWICH WITH LIGHT
 CORE AND GRAPHITE REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; W133 Graphite	2-ply skins	CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core
Reinforcement Orientation:	Fill	Core Orientation: "W"	Bonding Approach: Cocured

Specimen Number	Test Conditions	Width (in.)	Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	Maximum Stress (MPa)	Date Tested	Remarks
9A-1-1	22°C (72°F) (DRY)	2.980	0.0710	7,388	34.92	240.8	1/22/90	(1a,1e,2)
9A-1-2	"	2.975	0.0710	10,293	48.73	336.0	1/23/91	(1a,1e,2)
9A-1-3	"	2.970	0.0710	8,628	40.92	282.1	"	(1a,1e,2)
				Average	41.52	286.3		
				Std. Dev.	6.93	47.8		

Remarks:

(1) Failure Mode:

- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
 - x) Core crushing.
 - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.2
 EDGEWISE COMPRESSION STRENGTH OF SECONDARILY BONDED HONEYCOMB SANDWICH
 WITH LIGHT CORE AND GRAPHITE REINFORCED SKINS

Test :		Edgewise Compression; ASTM-C364		Task #9A	Tested By: PM		
Material :		EA-9396 A/B; W133 Graphite		2-ply skins	CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core		
Reinforcement Orientation:		Fill	Core Orientation: "W"		Bonding Approach: Secundarily Bonded		
Combined Skin							
Specimen Number	Test Conditions	Width (in.)	Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.) (MPa)	Date Tested	Remarks
9A-2-1	22°C (72°F) (DRY)	3.024	0.0670	8,081	39.89	1/23/91	(1dy,2)
9A-2-2	"	3.088	0.0670	6,021	29.10	"	(1dy,1e,2)
9A-2-3	"	3.020	0.0670	7,495	37.04	"	(1dy,2)
				Average	35.34	243.7	
				Std. Dev.	5.59	38.5	

Remarks:
 (1) Failure Mode:
 a) General buckling.
 b) Shear crimping (with skin damage).
 c) Dimpling of facings.
 d) Wrinkling of facings:
 x) Core crushing.
 y) Separation from core.
 e) Skin compression.
 (2) Test speed = 0.02 in/min.

TABLE 0.3
 EDGEMISE COMPRESSION STRENGTH OF COCURED HONEYCOMB SANDWICH WITH HEAVY
 CORE AND GRAPHITE REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; W133 Graphite	2-ply skins	CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core
Reinforcement Orientation:	Fill	Core Orientation: "W"	Bonding Approach: Cocured

Specimen Number	Test Conditions	Width (in.)	Thicknesses (T1 + T2) (in.)	Maximum Load		Date Tested	Remarks
				(lbs.)	(Ksi.)		
9A-3-1	22°C (72°F) (DRY)	2.983	0.0670	9,536	47.71	1/23/91	(1dx,1e,2)
9A-3-2	"	2.960	0.0670	9,766	49.24	1/24/91	(1dx,1e,2)
9A-3-3	"	2.964	0.0670	8,892	44.77	"	(1dx,1e,2)
Combined Skin				Average	47.24	325.7	
				Std. Dev.	2.27	15.7	

Remarks:

(1) Failure Mode:

- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
 - x) Core crushing.
 - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.4
 EDGEWISE COMPRESSION STRENGTH OF SECONDARILY BONDED HONEYCOMB SANDWICH
 WITH HEAVY CORE AND GRAPHITE REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; W133 Graphite	2-ply skins	CR III-1/4-5052-.004N-7.9-2.54 cm (1 inch) thick honeycomb core
Reinforcement Orientation:	Fill	Core Orientation: "L"	Bonding Approach: Secundarily Bonded

Specimen Number	Test Conditions	Width (in.)	Combined Skin Thicknesses		Maximum Load (lbs.)	Maximum Stress in Facings		Date Tested	Remarks
			(T1 + T2) (in.)	(in.)		(Ksi.)	(MPa)		
9A-4-2	22°C (72°F) (DRY)	2.975	0.0650	0.0650	7,647	39.54	272.6	1/24/91	(1dy,1e,2)
9A-4-3	"	2.962	0.0650	0.0650	7,524	39.08	269.5	"	(1dy,2)
						Average			
						Std. Dev.			
						39.31		271.1	
						0.33		2.2	

Remarks:

- (1) Failure Mode:
 - a) General buckling.
 - b) Shear crimping (with skin damage).
 - c) Dimpling of facings.
 - d) Wrinkling of facings:
 - x) Core crushing.
 - y) Separation from core.
 - e) Skin compression.
- (2) Test speed = 0.02 in/min.

TABLE 0.5
 EDGEWISE COMPRESSION STRENGTH OF COCURED HONEYCOMB SANDWICH WITH LIGHT
 CORE AND GLASS REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; 7781 Glass 4-ply skins	CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core	
Reinforcement Orientation:	Fill	Core Orientation: "W"	Bonding Approach: Cocured

Specimen Number	Test Conditions	Width (in.)	Thicknesses (T1 + T2) (in.)	Maximum Load (lbs.)	Maximum Stress in Facings (Ksi.)	Maximum Stress (MPa)	Date Tested	Remarks
9A-5-1	22°C (72°F) (DRY)	2.955	0.0860	11,271	44.35	305.8	1/24/91	(1a,dx,e,2)
9A-5-2	"	2.970	0.0860	10,625	41.60	286.8	"	(1a,dx,e,2)
9A-5-3	"	2.965	0.0860	10,654	41.78	288.1	"	(1a,dx,e,2)
				Average	42.58	293.6		
				Std. Dev.	1.54	10.6		

Remarks:

(1) Failure Mode:

- a) General buckling.
- b) Shear crimping (with skin damage).
- c) Dimpling of facings.
- d) Wrinkling of facings:
 - x) Core crushing.
 - y) Separation from core.
- e) Skin compression.

(2) Test speed = 0.02 in/min.

TABLE 0.6
 EDGWISE COMPRESSION STRENGTH OF SECONDARILY BONDED HONEYCOMB SANDWICH
 WITH LIGHT CORE AND GLASS REINFORCED SKINS

Test :	Edgewise Compression; ASTM-C364	Task #9A	Tested By: PM
Material :	EA-9396 A/B; 7781 Glass 4-ply skins	CR III-3/16-5052-.002N-5.7-2.54 cm (1 inch) thick honeycomb core	
Reinforcement Orientation:	Fill	Core Orientation: "L"	Bonding Approach: Secondarily Bonded

Specimen Number	Test Conditions	Width (in.)	Thicknesses (T1 + T2) (in.)	Maximum Load		Date Tested	Remarks
				(lbs.)	(Ksi.)		
9A-6-1	22°C (72°F) (DRY)	3.025	0.0800	8,408	34.74	1/24/91	(1a,dy,2)
9A-6-2	"	2.915	0.0800	6,660	28.56	1/25/91	(1a,dx,dy,e,2)
9A-6-3	"	3.010	0.0800	11,191	46.47	"	(1a,dx,e,2)
Combined Skin				Average	36.59	252.3	
				Std. Dev.	9.10	62.7	

Remarks:
 (1) Failure Mode:
 a) General buckling.
 b) Shear crimping (with skin damage).
 c) Dimpling of facings.
 d) Wrinkling of facings:
 x) Core crushing.
 y) Separation from core.
 e) Skin compression.
 (2) Test speed = 0.02 in/min.

APPENDIX P
INDIVIDUAL SPECIMEN COMPRESSION PROPERTIES,
EFFECT OF THERMAL PULSE

The 13 tables in this appendix present the detailed compression strength data for specimens exposed to a thermal pulse. A summary of these data was presented and discussed in Section 3.12.2.

TABLE P.1
 ROOM TEMPERATURE DRY COMPRESSION STRENGTH
 OF GLASS REINFORCED SPECIMENS THAT WERE
 NOT SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compressor; ASTM-D3410		Fiber Orientation:		Fill			
Material :		EA-9396 A/B; 7781-E Glass		Batch #1 Task #15		DRB			
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength		Date Tested	Remarks
						(Ksi.)	(MPa)		
BIL-GL-25-27	None	22°C (72°F) (DRY)	0.990	0.1405	5,800	41.71	287.6	10/17/90	(1,3,4)
BIL-GL-25-29	"	"	0.999	0.1416	6,140	43.42	299.4	"	(1,3,4)
						Average	293.5		
						Std. Dev.	8.4		

Remarks:
 (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
 (2) Specimen failed outside gage section.
 (3) Test speed = 0.05 in/min.
 (4) Load only recorded.

TABLE P.2
 ROOM TEMPERATURE DRY COMPRESSION STRENGTH
 OF GLASS REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Fill			
Material :		EA-9396 A/B; 781-E Glass		Batch #1 Task #15		DRB			
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GL-25-1	Thermal		1.040	0.1366	5,670	39.90	275.1	10/17/90	(1,3,4)
BIL-GL-25-3	Pulsed	"	1.039	0.1422	5,940	40.22	277.3	"	(1,3,4)
BIL-GL-25-15	"	"	1.042	0.1414	5,610	38.08	262.6	"	(1,3,4)
BIL-GL-25-12	"	"	1.042	0.1413	6,160	41.85	288.6	"	(1,3,4)
BIL-GL-25-24	"	"	1.042	0.1451	6,850	45.29	312.3	"	(1,3,4)
						Average	41.07	283.2	
						Std. Dev.	2.71	18.7	

Remarks:

(1) Specimen failed within the 1/2 inch gage section. (Shear fracture)

(2) Specimen failed outside gage section.
 (3) Test speed = 0.05 in/min.
 (4) Load only recorded.

TABLE P.3
 ELEVATED TEMPERATURE DRY COMPRESSION STRENGTH
 OF GLASS REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		Fill		
Material :		EA-9396 A/B; 7781-E Glass		Batch #1	Task #15	Tested By:		PM		
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum		Ultimate		Date Tested	Remarks
					Load (lbs.)	Compressive Strength (Ksi.)	Compressive Strength (MPa)			
BIL-GL-25-2	Thermal pulsed	93°C (200°F) (DRY)	1.003	0.1409	3,540	25.06	172.8	11/29/90	(1,3,4,5)	
BIL-GL-25-4	"	"	1.003	0.1422	3,750	26.30	181.3	"	(1,3,4,5)	
BIL-GL-25-11	"	"	1.002	0.1394	3,440	24.63	169.8	"	(1,3,4,5)	
BIL-GL-25-13	"	"	1.003	0.1443	4,025	27.82	191.8	"	(1,3,4,5)	
BIL-GL-25-15	"	"	1.003	0.1449	3,620	24.91	171.7	"	(1,3,4,5)	
					Average	25.74	177.5			
					Std. Dev.	1.33	9.1			

Remarks:
 (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
 (2) Specimen failed outside gage section.
 (3) Test speed = 0.05 in/min.
 (4) Load only recorded.
 (5) 15 min. soak at test temperature.

TABLE P.4
 LOW TEMPERATURE WET COMPRESSION STRENGTH
 OF GLASS REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression; ASTM-D3410					Fiber Orientation:		
Material :		EA-9396 A/B; 7781-E Glass		Batch #1	Task #15	Tested By: PM			
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
						Compressive Strength (Ksi.)	Compressive Strength (MPa)		
BIL-GL-25-7	Wet aged then	-54°C (-65°F) (WET)	0.999	0.1467	5,640	38.49	265.4	11/27/90	(1,3,4,5,6,7)
BIL-GL-25-9	thermal pulsed	"	1.000	0.1464	6,630	45.31	312.4	"	(1,3,4,5,6,7)
BIL-GL-25-17	"	"	1.005	0.1463	6,120	41.64	287.1	"	(1,3,4,5,6,7)
BIL-GL-25-19	"	"	1.004	0.1432	5,780	40.19	277.1	"	(1,3,4,5,6,7)
BIL-GL-25-22	"	"	1.002	0.1468	5,530	37.60	259.2	"	(1,3,4,5,6,7)
						Average	40.64	280.2	
						Std. Dev.	3.04	20.9	

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.

- (5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
- (6) Average Weight Gain before thermal pulse = 2.52%
- (7) 15 min. soak at test temperature.

TABLE P.5
 ROOM TEMPERATURE WET COMPRESSION STRENGTH
 OF GLASS REINFORCED SPECIMENS THAT WERE
 NOT SUBJECTED TO A THERMAL PULSE

Test		IITRI Compression: ASTM-D3410		Fiber Orientation:					
Matrix:		EA-9396 A/B: 7781 - E Glass		Tested By: DRB					
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GL-25-26	Wet aged: no thermal pulse	22°C (72°F) (WET)	0.988	0.1423	3,200	22.76	157.0	11/20/90	(1,3,4,5,6)
BIL-GL-25-28	"	"	0.994	0.1470	3,560	24.37	168.0	"	(1,3,4,5,6)
BIL-GL-25-30	"	"	0.981	0.1400	3,040	22.14	152.7	"	(1,3,4,5,6)
					Average	23.09	159.2		
					Std. Dev.	1.15	7.9		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.
- (5) Specimens aged @ 140°F/95-100% R.H. until saturated.
- (6) Average Weight Gain = 1.85%

TABLE P.6
 ROOM TEMPERATURE WET COMPRESSION STRENGTH
 OF GLASS REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression; ASTM-D3410				Fiber Orientation:		Fill	
Material :		Batch #1	Task #15	Tested By:		DRB			
Material :		EA-9396 A/B; 7781-E Glass						DRB	
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
						Compressive Strength (Ksi.)	Compressive Strength (MPa)		
BIL-GL-25-6	Wet aged then	22°C (72°F) (WET)	0.999	0.1476	3,420	23.21	160.0	11/20/90	(1,3,4,5,6)
BIL-GL-25-10	thermal pulsed	"	0.998	0.1446	3,550	24.60	169.6	"	(1,3,4,5,6)
BIL-GL-25-18	"	"	1.004	0.1446	3,235	22.27	153.6	"	(1,3,4,5,6)
BIL-GL-25-21	"	"	1.002	0.1461	2,845	19.43	134.0	"	(1,3,4,5,6)
BIL-GL-25-24	"	"	1.002	0.1454	2,470	16.95	116.9	"	(1,3,4,5,6)
						Average	21.29	146.8	
						Std. Dev.	3.08	21.2	

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.

- (5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
- (6) Average Weight Gain before thermal pulse = 2.52%

TABLE P.7
 ELEVATED TEMPERATURE WET COMPRESSION STRENGTH
 OF GLASS REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Fill		
Material :		EA-9396 A/B; 7781-E Glass		Batch #1	Task #15	PM		
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Date Tested	Remarks
BIL-GL-25-8	Wet aged then	93°C (200°F) (WET)	0.998	0.1443	1,430	9.93	11/26/90	(1,3,4,5,6,7)
BIL-GL-25-16	thermal pulsed	"	1.004	0.1455	1,565	10.71	"	(1,3,4,5,6,7)
BIL-GL-25-20	"	"	1.003	0.1388	1,485	10.66	"	(1,3,4,5,6,7)
BIL-GL-25-23	"	"	1.002	0.1438	1,420	9.86	"	(1,3,4,5,6,7)
BIL-GL-25-25	"	"	1.001	0.1429	1,440	10.06	"	(1,3,4,5,6,7)
Average						10.25		
Std. Dev.						0.41		
Average						70.6		
Std. Dev.						2.8		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section. (Shear fracture)
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.

- (5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
- (6) Average Weight Gain before thermal pulse = 2.52%
- (7) 4 min. soak after test oven door closed.

TABLE P.8
 ROOM TEMPERATURE DRY COMPRESSION STRENGTH
 OF GRAPHITE REINFORCED SPECIMENS THAT WERE
 NOT SUBJECTED TO A THERMAL PULSE

Test :		ASTM-D3410		Fiber Orientation:		Fill			
Material :		EA-9396 A/B; W133 Graphite		Task #15		DRB			
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum		Date Tested	Remarks	
					Load (lbs.)	Compressive Strength (Ksi.)			
			Ultimate						
			Average	Std. Dev.	Compressive Strength (MPa)				
BIL-GR-50-27	None	22°C (72°F) (DRY)	0.996	0.1892	11,270	59.82	412.5	10/17/90	(1a,3,4)
BIL-GR-50-29	"	"	1.001	0.1942	13,630	70.14	483.6	"	(1a,3,4)
					64.98		448.0		
					7.29		50.3		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- a) Shear crimping
- b) Shear fracture
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.

TABLE P.9
 ROOM TEMPERATURE DRY COMPRESSION STRENGTH
 OF GRAPHITE REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Fill			
Material :		EA-9396 A/B; W133 Graphite		Task #15		DRB			
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GR-50-1	Thermal pulsed	22°C (72°F) (DRY)	1.040	0.1901	12,970	65.58	452.2	10/17/90	(1a,3,4)
BIL-GR-50-3	"	"	1.040	0.1905	10,300	52.00	358.6	"	(1b,3,4)
BIL-GR-50-5	"	"	1.043	0.1956	12,380	60.69	418.5	"	(1a,3,4)
BIL-GR-50-12	"	"	1.043	0.1970	10,240	49.83	343.6	"	(1b,3,4)
BIL-GR-50-14	"	"	1.040	0.1897	11,550	58.56	403.7	"	(1a,3,4)
						Average	57.33	395.3	
						Std. Dev.	6.43	44.4	

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- a) Shear crimping
- b) Shear fracture

- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.

TABLE P.10
 ELEVATED TEMPERATURE DRY COMPRESSION STRENGTH
 OF GRAPHITE REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression; ASTM-D3410		Fiber Orientation:		Fill			
Material :		EA-9396 A/B; W133 Graphite		Tested By:		PM			
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GR-50-2	Thermal pulsed	93°C (200°F) (DRY)	0.979	0.1891	8,157	44.06	303.8	4/17/91	(1,3,4)
BIL-GR-50-4	"	"	1.001	0.1919	7,905	41.17	283.9	"	(1,3,4)
BIL-GR-50-11	"	"	0.988	0.1947	7,949	41.32	284.9	"	(1,3,4)
BIL-GR-50-13	"	"	0.988	0.1960	8,406	43.40	299.2	"	(1,3,4)
BIL-GR-50-15	"	"	0.985	0.1788	8,047	45.68	315.0	"	(1,3,4)
				Average		43.12	297.3		
				Std. Dev.		1.91	13.2		

Remarks:
 (1) Specimen failed within the 1/2 inch gage section. (Shear crimping)
 (2) Specimen failed outside gage section.
 (3) Test speed = 0.05 in/min.
 (4) 15 min. soak at test temperature.

TABLE P.11
 LOW TEMPERATURE WET COMPRESSION STRENGTH
 OF GRAPHITE REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Date Tested	Remarks
						Compressive Strength (Ksi.)	Compressive Strength (MPa)		
BIL-GR-50-7	Wet aged then	-54°C (-65°F) (WET)	0.995	0.2068	13,760	66.85	460.9	11/28/90	(1a,3,4,5,6,7)
BIL-GR-50-9	thermal pulsed	"	0.998	0.2050	15,660	76.54	527.7	"	(1a,3,4,5,6,7)
BIL-GR-50-17	"	"	1.006	0.2061	13,800	66.55	458.9	"	(1a,3,4,5,6,7)
BIL-GR-50-19	"	"	1.007	0.1913	14,340	74.43	513.2	"	(1a,3,4,5,6,7)
BIL-GR-50-22	"	"	1.000	0.1975	14,800	74.94	516.7	"	(1a,3,4,5,6,7)
						Average	71.86	495.5	
						Std. Dev.	4.78	32.9	

Test : IITRI Compression: ASTM-D3410 Fiber Orientation: Fill
 Material : EA-9396 A/B: W133 Graphite Batch #1 Task #15 Tested By: DRB

Remarks:
 (1) Specimen failed within the 1/2 inch gage section.
 a) Shear crimping
 b) Shear fracture
 (2) Specimen failed outside gage section.
 (3) Test speed = 0.05 in/min.

(4) Load only recorded.
 (5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
 (6) Average Weight Gain before thermal pulse = 1.90%
 (7) 15 min. soak at test temperature.

TABLE P.12
 ROOM TEMPERATURE WET COMPRESSION STRENGTH
 OF GRAPHITE REINFORCED SPECIMENS THAT WERE
 NOT SUBJECTED TO A THERMAL PULSE

Test :		ASTM-D3410				Fiber Orientation:		Fill
Material :		EA-9396 A/B; W133 Graphite				Tested By:		DRB
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum		Date Tested	Remarks
					Load (lbs.)	Compressive Strength (Ksi.)		
					Ultimate			
					Average	314.6		
					Std. Dev.	0.68		
BIL-GR-50-26	Wet aged; no thermal pulse	22°C (72°F) (WET)	0.998	0.1983	8,900	44.97	310.0	11/20/90 (1a,3,4,5,6)
BIL-GR-50-28	"	"	0.991	0.1977	9,080	46.33	319.5	" (1b,3,4,5,6)
BIL-GR-50-30	"	"	0.995	0.1874	8,500	45.59	314.4	" (1a,3,4,5,6)

Remarks:
 (1) Specimen failed within the 1/2 inch gage section.
 a) Shear crimping
 b) Shear fracture
 (2) Specimen failed outside gage section.

(3) Test speed = 0.05 in/min.
 (4) Load only recorded.
 (5) Specimens aged @ 140°F/95-100% R.H. until saturated.
 (6) Average Weight Gain = 2.14%

TABLE P.13
 ROOM TEMPERATURE WET COMPRESSION STRENGTH
 OF GRAPHITE REINFORCED SPECIMENS THAT WERE
 SUBJECTED TO A THERMAL PULSE

Test :		IITRI Compression: ASTM-D3410		Fiber Orientation:		Fill			
Material :		EA-9396 A/B; W133 Graphite		Batch #1 Task #15		DRB			
Specimen Number	Exposure Conditions	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Compressive Strength (Ksi.)	Ultimate Compressive Strength (MPa)	Date Tested	Remarks
BIL-GR-50-6	Wet aged then thermal pulsed	"	0.998	0.2034	8,570	42.24	291.2	"	(1b,3,4,5,6)
BIL-GR-50-10	"	"	1.005	0.1969	9,510	48.04	331.2	"	(1b,3,4,5,6)
BIL-GR-50-18	"	"	0.999	0.1980	9,080	45.93	316.7	"	(1a,3,4,5,6)
BIL-GR-50-21	"	"	0.999	0.1984	9,790	49.42	340.7	"	(1b,3,4,5,6)
BIL-GR-50-24	"	"							
					Average	45.69	315.1		
					Std. Dev.	3.14	21.7		

Remarks:

- (1) Specimen failed within the 1/2 inch gage section.
- a) Shear crimping
- b) Shear fracture
- (2) Specimen failed outside gage section.
- (3) Test speed = 0.05 in/min.
- (4) Load only recorded.
- (5) Specimens aged @ 140°F/95-100% R.H. until saturated and before thermal pulse.
- (6) Average Weight Gain before thermal pulse = 1.90%

APPENDIX Q
INDIVIDUAL SPECIMEN MECHANICAL PROPERTIES,
EFFECT OF SILANE SIZING ON ENVIRONMENTAL DEGRADATION
OF GLASS REINFORCED LAMINATES

The nine tables in this appendix present the detailed mechanical property data for specimens prepared with silane-sized glass reinforcement. The properties measured on these laminates included tensile, inplane shear, and interlaminar shear. It will be noted in Tables Q.1 - Q.3 that the tensile specimens failed inside the tab area. Figure Q.1 illustrates the location and nature of these failures. A summary of these data was presented and discussed in Section 3.11.

TABLE Q.1
 ROOM TEMPERATURE DRY TENSILE PROPERTIES OF EA9396 LAMINATES
 REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :		Straight sided tension; ASTM-D3039		Fiber Orientation :		Warp		
Material :		EA-9396 A/B; 7781 Glass (A1100-538)		Batch #3		Task #19		
		Ultimate		Poisson's		Date		
Specimen Number	Test Conditions	Maximum Load (lbs.)	Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)	Ratio	Tested	Remarks
BIL-GL-44-1	22°C (72°F) (DRY)	2,773	43.38	3,842	12,627	0.103	2/5/90	(2,3,4)
BIL-GL-44-4	"	2,916	40.11	3,483	12,048		"	(2,3,5)
BIL-GL-44-7	"	3,152	43.87	3,435	10,122		"	(2,3,5)
BIL-GL-44-10	"	2,557	34.75	3,503	11,001		"	(2,3,5)
BIL-GL-44-13	"	3,032	41.67	3,460	13,579	0.106	"	(2,3,4)
Average			40.76	3,545	11,876	0.104		
Std. Dev.			3.67	0.168	1,354	0.002		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.

SI Conversion			
Ultimate			
Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)	
299.1	26.49	12,627	
276.6	24.01	12,048	
302.5	23.69	10,122	
239.6	24.16	11,001	
287.3	23.86	13,579	
Average	24.44	11,876	
Std. Dev.	1.16	1,354	

TABLE Q.2
ROOM TEMPERATURE WET TENSILE PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :		Straight sided tension; ASTM-D3039				Fiber Orientation :		Warp	
Material :		Batch #3	Task #19	Tested by :		DRB			
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Ultimate Strain (µin/in)		
BIL-GL-44-2	22°C (72°F) (WET)	0.994	0.0660	2,506	38.19	3,244	12,432	3/19/90	(2,3,5,6,7)
BIL-GL-44-5	"	0.997	0.0728	2,457	33.86	3,068	11,758	"	(2,3,4,6,7)
BIL-GL-44-8	"	0.997	0.0747	2,675	35.91	3,099	12,466	"	(2,3,5,6,7)
BIL-GL-44-11	"	0.997	0.0726	2,562	35.38	3,093	12,075	"	(2,3,4,6,7)
BIL-GL-44-14	"	0.997	0.0703	2,494	35.57	3,207	11,904	"	(2,3,5,6,7)
Average					35.78	3,142	12,127		0.079
Std. Dev.					1.56	0.078	315		0.011

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H. for 43 days.
- (7) Average Weight Gain = 3.0870%

SI Conversion

Ultimate	
Tensile Strength (MPa)	Ultimate Strain (µcm/cm)
263.3	12,432
233.5	11,758
247.6	12,466
244.0	12,075
245.3	11,904
Average	
246.7	12,127
Std. Dev.	
10.7	315

TABLE Q.3
ELEVATED TEMPERATURE WET TENSILE PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test : Straight sided tension; ASTM-D3039 Fiber Orientation : Warp
Material : EA-9396 A/B; 7781 Glass (A1100-538) Batch #3 Task #19 Tested by : DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate				Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)	Strain (in/in)	Poisson's Ratio		
BIL-GL-44-3	93°C (200°F) (WET)	0.997	0.0707	1,821	25.83	2.797	9.614	0.102	3/19/90	(2,3,5,6,7)
BIL-GL-44-6	"	0.999	0.0738	1,887	25.59	2.724	9.897	0.102	"	(2,3,4,6,7)
BIL-GL-44-9	"	0.996	0.0746	1,721	23.16	2.691	9.258	0.113	"	(2,3,5,6,7)
BIL-GL-44-12	"	1.000	0.0736	1,830	24.87	2.536	10,034	0.113	"	(2,3,4,6,7)
BIL-GL-44-15	"	0.997	0.0686	1,666	24.37	2.900	8,794	0.108	"	(2,3,5,6,7)
				Average	24.76	2.730	9,520	0.108		
				Std. Dev.	1.07	0.135	503	0.008		

Remarks:

- (1) Specimen failed within the 6.5 inch gage section.
- (2) Specimen failed inside tab area.
- (3) Test speed = 0.1 in/min.
- (4) Specimen had 0° and 90° strain gages attached.
- (5) Specimen had only 0° strain gage attached.
- (6) Specimens aged @ 140°F/95-100% R.H. for 42 days.
- (7) Average Weight Gain = 2.9160%

SI Conversion

Ultimate Tensile Strength (MPa)	Tensile Modulus (GPa)	Ultimate Strain (µcm/cm)
178.1	19.28	9,614
176.4	18.78	9,897
159.7	18.56	9,258
171.5	17.48	10,034
168.0	20.00	8,794
Average	18.82	9,520
Std. Dev.	0.93	503

TABLE Q.4
 ROOM TEMPERATURE DRY INPLANE SHEAR PROPERTIES OF EA9396 LAMINATES
 REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :		±45° Tension/Inplane Shear: ASTM-D3518		Fiber Orientation: ±45°						
Material :		EA-9396 A/B: 7781 Glass (A1100-538)		Tested By: DH						
		Batch #3	Task #19							
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Ultimate		Date Tested	Remarks			
				Maximum Load (lbs.)	Tensile Strength (Ksi.)			Tensile Modulus (Msi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio
BIL-GL-46-1	22°C (72°F) (DRY)	0.994	0.0679	1,386	20.52	1,900	0.622	0.527	2/6/90	(1,2,3,5)
BIL-GL-46-4	"	1.002	0.0705	1,364	19.30	1,784	0.632	0.412	"	(1,2,3,5)
BIL-GL-46-7	"	1.004	0.0713	1,165	16.28	1,828	0.621	0.472	"	(1,2,3,5)
BIL-GL-46-10	"	1.004	0.0685	1,305	18.97	2,035	0.625	0.628	"	(1,2,3,5)
BIL-GL-46-13	"	1.004	0.0669	1,350	20.10	2,125	0.677	0.570	"	(1,2,3,5)
Average				19.03	1.934	0.635	0.522			
Std. Dev.				1.66	0.143	0.023	0.084			

		SI Conversion			
Ultimate	Tensile Strength (MPa)	In-Plane		In-Plane	
		Tensile Modulus (GPa)	Shear Strength (MPa)	Shear Modulus (GPa)	Shear Modulus (GPa)
	141.5	13.10	70.8	4.290	4.290
	133.1	12.30	66.5	4.356	4.356
	112.2	12.60	56.1	4.281	4.281
	130.8	14.03	65.4	4.310	4.310
	138.6	14.65	69.3	4.665	4.665
Average	131.2	13.34	65.6	4.380	4.380
Std. Dev.	11.4	0.98	5.7	0.161	0.161

- Remarks:
- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
 - (2) Specimen had 0° and 90° strain gages attached.
 - (3) Test speed = 0.1 in/min.
 - (4) Specimen failed inside the "tab area".
 - (5) Specimen failed within the 6.5 inch gage section.

TABLE Q.5
 ROOM TEMPERATURE WET INPLANE SHEAR PROPERTIES OF EA9396 LAMINATES
 REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :		±45° Tension/Inplane Shear; ASTM-D3518		Fiber Orientation: ±45°								
Material :		EA-9396 A/B; 7781 Glass (A1100-538)		Tested By: PM								
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		Tensile Modulus (Msi.)	In-Plane Shear Strength (Ksi.)	In-Plane Shear Modulus (Msi.)	Poisson's Ratio	Date Tested	Remarks
					Tensile Strength (Ksi.)	Tensile Modulus (Msi.)						
BIL-GL-46-2	22°C (72°F) (WET)	1.001	0.0693	928	13.37	1.194	6.69	0.394	0.514	4/24/90	(1,2,3,5,6,7)	
BIL-GL-46-5	"	0.999	0.0694	876	12.65	1.180	6.32	0.404	0.459	4/23/90	(1,2,3,5,6)	
BIL-GL-46-8	"	1.001	0.0699	861	12.31	1.186	6.16	0.365	0.624	"	(1,2,3,5,6)	
BIL-GL-46-11	"	1.002	0.0685	892	12.99	1.323	6.49	0.392	0.687	"	(1,2,3,5,6)	
BIL-GL-46-14	"	0.999	0.0677	855	12.64	1.118	6.32	0.335	0.669	"	(1,2,3,5,6)	
Average			12.79		1.200		6.40		0.378		0.591	
Std. Dev.			0.40		0.075		0.20		0.028		0.100	

		SI Conversion	
Ultimate Tensile Strength (MPa)	In-Plane Shear Strength (MPa)	Ultimate Tensile Modulus (GPa)	In-Plane Shear Modulus (GPa)
92.2	46.1	8.23	2.720
87.2	43.6	8.14	2.789
84.9	42.4	8.18	2.518
89.5	44.8	9.12	2.705
87.2	43.6	7.71	2.308
Average	44.1	8.28	2.608
Std. Dev.	1.4	0.52	0.195

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $G = E/2(1+\nu)$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen: failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (7) Weight Gain = 2.37%
 (Only one specimen tracked).

TABLE Q.6
ELEVATED TEMPERATURE WET INPLANE SHEAR PROPERTIES OF EA9396 LAMINATES
REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test : ±45° Tension/Inplane Shear; ASTM-D3518										Fiber Orientation: ±45°		
Material : EA-9396 A/B; 7781 Glass (A1100-538)										Tested By: PM		
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Maximum Load (lbs.)	Ultimate		In-Plane		Poisson's Ratio	Date Tested	Remarks	
					Tensile Strength (Ksi.)	Modulus (Msi.)	Shear Strength (Ksi.)	Shear Modulus (Msi.)				
Batch #3	Task #19											
BIL-GL-46-3	93°C (200°F) (WET)	1.001	0.0706	533	7.54	0.381	3.77	0.117	0.629	4/24/90	(1,2,3,5,6,7)	
BIL-GL-46-6	"	0.998	0.0693	453	6.55	0.470	3.27	0.134	0.758	"	(1,2,3,5,6)	
BIL-GL-46-9	"	1.005	0.0691	531	7.65	0.536	3.83	0.142	0.893	"	(1,2,3,5,6)	
BIL-GL-46-12	"	1.003	0.0667	567	8.48	0.487	4.24	0.124	0.961	"	(1,2,3,5,6)	
BIL-GL-46-15	"	1.000	0.0639	456	7.14	0.487	3.57	0.140	0.732	"	(1,2,3,5,6)	
Average					7.47	0.472	3.74	0.131	0.795			
Std. Dev.					0.71	0.057	0.35	0.011	0.132			
SI Conversion												
Ultimate					In-Plane		In-Plane					
Tensile Strength (MPa)					Tensile Modulus (GPa)		Shear Strength (MPa)		Shear Modulus (GPa)			
52.0					2.62		26.0		0.805			
45.2					3.24		22.6		0.922			
52.8					3.70		26.4		0.976			
58.5					3.36		29.2		0.856			
49.2					3.36		24.6		0.969			
Average					3.25		25.8		0.906			
Std. Dev.					0.39		2.4		0.074			

Remarks:

- (1) The in-plane shear modulus is calculated using the equation $[G=E/2(1+\nu)]$.
- (2) Specimen had 0° and 90° strain gages attached.
- (3) Test speed = 0.1 in/min.
- (4) Specimen failed inside the "tab area".
- (5) Specimen failed within the 6.5 inch gage section.
- (6) Specimens aged @ 140°F/95-100% R.H. to saturation.
- (7) Weight Gain = 2.43%
(Only one specimen tracked).

TABLE Q.7
 ROOM TEMPERATURE DRY INTERLAMINAR SHEAR PROPERTIES OF EA9396 LAMINATES
 REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test: Apparent interlaminar shear (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp
 Material: EA-9396 A/B; 7781 Glass (A1100-538) Batch #3 Task #19 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum		Interlaminar		Date Tested	Remarks
					Load (lbs.)	(Ksi.)	Shear Strength (MPa)			
BIL-GL-45-1	±2°C (72°F) (DRY)	1.000	0.1405	1.141	1,142	6.095	42.02	42.02	1/11/90	
BIL-GL-45-4	"	0.999	0.1436	1.141	1,235	6.454	44.50	44.50	"	
BIL-GL-45-7	"	1.001	0.1426	1.141	1,150	6.044	41.67	41.67	"	
BIL-GL-45-10	"	1.001	0.1425	1.141	1,171	6.158	42.46	42.46	"	
BIL-GL-45-13	"	1.001	0.1437	1.141	1,145	5.973	41.18	41.18	"	

Average 6.145 42.37
 Std. Dev. 0.186 1.28

TABLE Q.8
 ROOM TEMPERATURE WET INTERLAMINAR SHEAR PROPERTIES OF EA9396 LAMINATES
 REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test :		Apparent interlaminar shear				(4pt loading at 1/4 pts. L/D = 8/1)		Specimen Orientation: Warp			
Material :		EA-9396 A/B; 7781 Glass (A1100-538)				Batch #3		Task #19		Tested By: DH	
Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength (Ksi.)	Interlaminar Shear Strength (MPa)	Weight Gain (%)	Date Tested	Remarks	
BIL-3L-45-2	22°C (72°F) (WET)	0.998	0.1407	1.142	794	4.241	29.24	2.69	3/20/90	(1,2)	
BIL-3L-45-5	"	1.001	0.1451	1.142	859	4.436	30.58	2.71	"	(1,2)	
BIL-GL-45-8	"	1.000	0.1404	1.142	747	3.990	27.51	2.62	"	(1,2)	
BIL-GL-45-11	"	1.001	0.1434	1.142	846	4.420	30.48	2.70	"	(1,2)	
BIL-GL-45-14	"	1.000	0.1433	1.142	805	4.213	29.05	2.73	"	(1,2)	
Average					4.260	29.37	2.69				
Std. Dev.					0.182	1.25	0.04				

Remarks:

- (1) Specimens aged @ 140°F/95-100% R.H. for 68 days.
- (2) Average Weight Gain = 2.69%

TABLE Q.9
 ELEVATED TEMPERATURE WET INTERLAMINAR SHEAR PROPERTIES OF
 EA9396 LAMINATES REINFORCED WITH SILANE SIZED GLASS REINFORCEMENT

Test : Apparent interlaminar shear (4pt loading at 1/4 pts. L/D = 8/1) Specimen Orientation: Warp
 Material : EA-9396 A/B; 7781 Glass (A1100-538) Batch #3 Task #19 Tested By: DH

Specimen Number	Test Conditions	Width (in.)	Thickness (in.)	Span (in.)	Maximum Load (lbs.)	Interlaminar Shear Strength		Date Tested	Remarks
						(Ksi.)	(MPa)		
BIL-GL-45-3	93°C (200°F) (WET)	1.001	0.1425	1.142	343	1.803	12.43	2.72	S/21/90 (1,2)
BIL-GL-45-6	"	1.001	0.1452	1.142	346	1.785	12.31	2.67	" (1,2)
BIL-GL-45-9	"	1.000	0.1398	1.142	350	1.878	12.95	2.63	" (1,2)
BIL-GL-45-12	"	1.000	0.1439	1.142	355	1.850	12.76	2.70	" (1,2)
BIL-GL-45-15	"	0.998	0.1437	1.142	356	1.862	12.84	2.67	" (1,2)
Average						1.836	12.66	2.58	
Std. Dev.						0.039	0.27	0.03	

Remarks:

- (1) Specimens aged @ 140°F/95-100% R.H. for 68 days.
- (2) Average Weight Gain = 2.68%

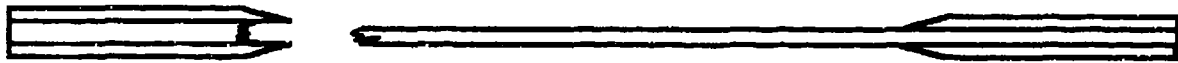


Figure Q.1. Failure Location of Tensile Specimens
That Failed Inside Tab Area.

APPENDIX R DETERMINATION OF BLEEDER ABSORPTIVITY

The bleeder materials used in this program may not be available when performing a repair. If an alternative bleeder material is used, its absorptivity can be determined by the procedure outlined below. It is suggested that absorptivity be determined by this procedure for several bleeder/laminate ply ratios that bracket the layup actually used so that a reliable average value can be determined. The primary reason that bleeder absorptivity is of interest is to provide guidance in selecting a bleeder/laminate ply ratio that will produce the desired final resin content. It must be recognized, however, that not all resin is removed by the bleeder. Some will be lost around the edges of the layup. Additionally, the amount absorbed by the bleeder will probably vary if the amount of excess resin used in the laminate layup or the bleeder/laminate ply ratio varies significantly from those used in the absorptivity determination.

1. Select Bleeder/Laminate ply ratio.
2. Bleeder plies are to be same size as laminate plies, and should be both weighed and measured (length x width) prior to layup.
3. Compute area density (gm/m²) of dry bleeder material

$$\frac{\text{wt. of DBPS}}{\text{area of DBPS} \times \text{no. of plies in DBPS}} = \text{area density of DBP (gm / m}^2\text{)}$$

where DBPS = dry bleeder ply stack.

4. Layup and impregnate laminate plies in accordance with standard procedure described in Appendix A (except for bleeder ply differences if using other than Mochburg CW 1850).
5. Bag and cure in accordance with the standard procedure described in Appendix A.
6. After cure, dismantle the bagged layup and separate the impregnated stack of bleeder plies from the nonporous teflon/glass and the porous teflon/glass sheets.
7. Weigh and remeasure the impregnated bleeder stack.
8. Compute amount of resin absorbed in each unit area of bleeder

$$\frac{\text{wt. of IBS}}{\text{area of IBS} \times \text{no. of plies in IBS}} = \text{area density of IBS (gm / m}^2\text{)}$$

where IBS = impregnated bleeder stack.

$$\frac{\text{area density of IBS} - \text{area density of DBPS}}{\text{no. of plies in IBS}} = \text{area density of resin in bleeder, or absorptivity (gm / m}^2\text{)}$$

9. Compute amount of resin absorbed in each unit weight of bleeder

$$\frac{\text{wt. of IBS} - \text{wt. of DBPS}}{\text{wt. of DBPS}} = \text{absorptivity (gm resin / gm bleeder)}$$