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DEVELOPMENT OF ENGINEERING DATA ON THE MECHANICAL
AND PHYSICAL PROPERTIES OF ADVANCED COMPOSITES
MATERIALS

IIT RESEARCH INSTITUTE

PREPARED FOR
AIR FORCE MATERIALS LABORATORY

FEBRUARY 1974

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were 6061 Aluminum/Boron and 6Al-4V - Titanium/BorSic Composites. The resin matrix systems were procured in the form of prepreg tapes and specimens were fabricated at IITRI materials laboratory. The metal matrix composites were fabricated by vendors in laminate form and supplied to IITRI for specimen fabrication and testing. The environments included steady state and cyclic thermal, thermo-humidity, and humidity conditioning.

AFML-TR-72-205

Part II

DEVELOPMENT OF ENGINEERING DATA ON THE
MECHANICAL AND PHYSICAL PROPERTIES
OF ADVANCED COMPOSITES MATERIALS

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IIT Research Institute

Technical Report AFML-TR-72-205, Part II

February, 1974

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Air Force Materials Laboratory
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

FOREWORD

This technical report summarizes the work accomplished during Contract No. F33615-71-C-1713, "Development of Engineering Data on the Mechanical and Physical Properties of Advanced Composite Materials;" it was prepared by the Mechanics Research Division of the IIT Research Institute. The work reported herein was accomplished under the joint sponsorship of two divisions of the Air Force Materials Laboratory the Systems Support and the Advanced Development Division, under Project No. 7381, "Material Application, Task No. 738106, Design Data Development and Advanced Composite ADP." Messrs. M. Knight, AFML/MXE, of Systems Support Division and Capt. L. Woodrum and R. Neff, of the Advanced Development Division were the Air Force Project Engineers.

An advanced composite team under the direction of the Materials Engineering Section of the Mechanics Research Division performed the work described herein. IITRI personnel associated with this program and their respective responsibilities are delineated below:

- K. E. Hofer, Program Manager
- N. Rao, Overall Engineering and Scheduling
- V. Humphreys, Analytical Methods and Reporting
- D. Larsen, Thermophysical Testing
- R. Labedz, Fabrication
- H. Lane, Static Test Engineer
- L. C. Bennett, Fatigue Test Engineer
- R. A. Stuehmer, Creep Test Engineer

This is the final technical report and summarizes the technical activities from June 1, 1971 through November 30, 1973.

This technical report has been reviewed and is approved.

Kenneth E. Hofel
Kenneth E. Hofel, Jr., Manager
Materials Engineering and
Building Technology Section
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For The Commander

Albert Olevitch
A. Olevitch

Materials Engineering Branch
Systems Support Division
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ABSTRACT AND SUMMARY OF RESULTS

The present program was initiated to generate data on the effect of various environments on the physical, thermal, and mechanical properties of three resin matrix composites: (AVCO 5505/Boron, Modmor II Graphite/Hercules 5206 and Courtaulds HMS Graphite/Hercules 3002M) and two metal matrix composites (6061 Aluminum/Boron and 6Al-4V - Titanium/BorSiC). The resin matrix systems were procured in the form of prepreg tapes and laminates and specimens were fabricated at IITRI. The metal matrix composites were fabricated by vendors in laminate form and supplied to IITRI for specimen fabrication and testing.

The environments included steady state humidity conditioning for two exposure periods, cyclic humidity conditioning which included the effects of thermal shocks and the effect of photodegradative exposures, and steady and cyclic thermal exposures.

Part I of this report described the material procurement, materials specifications, laminate fabrication, quality control and material quality assurance tests, and presents the test procedures in detail. Part II of this report presents a complete summary of the data and results of all static, fatigue, creep and thermo-physical properties of the five composites.

On a material by material basis the following conclusions were reached:

AVCO 5505/Boron

There was a general deterioration in the baseline tensile, compressive and in-plane shear strengths of AVCO 5505/Boron with increasing temperature. The elastic moduli of the 0° properties were relatively unaffected up to 350°F but the transverse (90°)

and in-plane shear moduli decreased with temperature. The $[0/45/135/0/90]_s$ baseline tensile and compressive moduli were relatively unaffected up to 350°F.

The steady state humidity conditioning caused the strengths of AVCO 5505/Boron to fall below the baseline values particularly at elevated temperatures (by up to 30% for 350°F compression). This occurred for all orientations and in tension, compression and shear (the differences were generally of the order of 10%). The elastic moduli of AVCO 5505/Boron were reduced to a small extent (generally 2-4%) by the steady state humidity conditioning; the strongest effects were noted for the in-plane shear (10%) and transverse moduli (30%). The steady state conditioning increased the moduli of the $[0/45/135/0/90]_s$ laminates by 5-10%.

High humidity and thermal shock as indicated by the thermo-humidity cycle results had the same effect as steady state humidity conditions but had greatest impact on the room temperature static strength results (up to 20% for tension of 90°). The largest degradatory effects were obtained for combined humidity and ultraviolet on both strengths and modulus of all three orientations although a mixed effect was noted at elevated temperatures (losses up to 50% of the 90° compressive strength were seen).

The steady state humidity conditioning degraded the fatigue performance of AVCO 5505/Boron composites (losses of approximately 10%). The thermo-humidity cycle degraded the fatigue performance of AVCO 5505/Boron at the higher cyclic levels thus shifting the S-N curves downward and rotating the curve about the low cycle levels (losses up to 25% were encountered at high cycle levels). Accelerated weathering had the least effect on the fatigue behavior.

The steady state humidity conditioning had a detrimental effect on stress-rupture behavior of 0° AVCO 5505/Boron (loss of 25%) but enhanced the stress rupture behavior of [0/45/135/0/90]_s composites by approximately 10%.

Steady thermal conditioning enhanced the strength (up to 8%) and modulus (up to 6%) of AVCO 5505/Boron. The cyclic thermal conditioning had a mixed (but moderate rather than severe) effect on the strength and moduli of all three orientations.

The interlaminar shear strengths were decreased by humidity conditioning (by up to 25%) but were unaffected by both steady state and cyclic thermal conditioning.

The AVCO 5505/Boron composite fatigue behavior was degraded by 10% at all temperatures by steady-state thermal conditioning. The stress-rupture behavior was improved by up to 5% by steady state thermal conditioning. Similarly stress-rupture improvement (20%) and fatigue degradation (10 to 15%) were shown for prior exposure to cyclic thermal preconditioning.

Modmor II Graphite/Narmco 5206

A general reduction in the tensile, compressive and in-plane shear strengths with increasing temperature was demonstrated for the Modmor II Graphite/Narmco 5206 composites (except for the [0/45/135/0/90]_s laminates). The elastic moduli of the 0° orientation remained relatively unaffected although the tensile modulus increased slightly with increasing temperature up to 350°F. The shear modulus and the tensile and compressive moduli of the 90° composites decreased with increasing temperature. The [0/45/135/0/90]_s tensile modulus also increased with temperature. Residual stresses are suspect in this behavior.

Steady state humidity conditioning affected the moduli of the Modmor II graphite/Narmco 5206 system the least of the three resin matrix composites studied. The strengths of this system decreased below the values of the baseline strengths particularly at elevated temperatures (up to 35%). The exception to this behavior was the 0° tensile strength which showed some improvement (about 20%) with prior steady state humidity conditioning.

The thermo-humidity cycle conditioning influenced the static behavior in a manner similar to that produced by steady state conditioning except that the effects were worse at higher temperatures (up to 25% degradation). The greatest effects on modulus and strength were observed for the combined humidity and ultraviolet conditioning particularly at room temperature.

The thermo-humidity cycle degraded the fatigue behavior of the 90° Modmor II Graphite/Narmco 5206 more substantially at the higher cyclic levels, thus shifting the S-N curves downward and rotating the curve about the low cycle levels. The accelerated weathering had the least effect on the fatigue S-N curves (less than 10%). Steady state humidity conditioning degraded the fatigue behavior as well.

The stress rupture characteristics of Modmor II Graphite/Narmco 5206 were benefited by steady state and cyclic humidity conditioning. Residual stresses in the composites become suspect.

The static response of Modmor II Graphite/Narmco 5206 to steady state and cyclic thermal conditioning was quite similar to that shown for AVCO 5505/Boron. The interlaminar shear strengths decreased for humidity conditioning but were unaffected by either steady state or cyclic thermal conditioning. The

fatigue behavior of Modmor II Graphite/Narmco 5206 was improved with prior steady state thermal exposure. Cyclic thermal exposure, on the other hand degraded the fatigue behavior but appeared to be highly dependent on cyclic levels. The stress-rupture behavior was not affected substantially by either steady state or cyclic thermal conditioning.

Courtaulds HMS Graphite/Hercules 3002M

The baseline static tensile strengths of all three orientations of Courtaulds HMS Graphite/Hercules 3002M composites increased with increasing test temperature by approximately 20%. The presence of degradatory residual stresses derived in the cure process becomes a suspect in this behavior. The 0° tensile modulus of this composite increased by 10% up to 350°F. The compressive and shear moduli exhibited mixed behavior over the temperature range. The baseline 90° moduli decreased by 10% with temperature. The $[0/45/135/0/90]_s$ moduli showed a straight increase of 20% in tension and a compressive decrease of 20%.

Steady state humidity conditioning caused a decrease of 15% in Courtaulds HMS Graphite/Hercules 3002M composite static strengths except in the case of the 0° tensile strengths which improved by 20%. The moduli of this composite was the most affected by steady state humidity conditioning (up to 50% for in-plane shear). The thermo-humidity cycle affected the strengths of this composite greatest at elevated temperatures (the 90° strength loss was 75%). The combined effects of humidity and ultraviolet light on static strengths were greatest at room temperature. Accelerated weathering also affected the elastic moduli of this composite.

The fatigue performance of Courtaulds HMS Graphite/Hercules 3002M was degraded by steady state humidity conditioning

at high test temperatures and enhanced at room temperature. Again as in the case of the other resin matrix composites, the thermo-humidity cycle had substantial effects on the S-N behavior of this composite, while the accelerated weathering cycle had the least effect.

Also, the effect of steady state and cyclic humidity conditioning on the stress-rupture properties of Courtaulds HMS Graphite/Hercules 3002M composites was beneficial as in the case of the other two resin matrix composites.

The strengths and moduli of Courtaulds HMS Graphite/Hercules 3002M composites increased by 10% with steady state thermal conditioning, while the cyclic thermal conditioning decreased the static properties by up to 20% in the case of compression. The interlaminar shear strengths were unaffected by either steady state or cyclic thermal conditioning.

The fatigue behavior was degraded by 10% steady state and cyclic thermal conditioning. The creep and stress-rupture were affected only slightly by both steady state and cyclic thermal exposure.

6061 Aluminum/Boron

The steady state thermal exposure reduced the 0° tensile strength of 6061 Aluminum/Boron by up to 20% while cyclic exposure to the same temperature reduced the tensile strengths by about 25%. The corresponding 0° compressive strengths were approximately the same as those of the tensile strengths when compared on total exposure time basis. The 90° tensile and compressive strengths were also reduced (by as much as 35%) for similar exposure periods.

Elevated temperatures reduced the tensile, compressive and fully reversed fatigue behavior of 6061 Aluminum/Boron composites, but not severely except in the case of the 90° orientation where up to 50% of the fatigue strengths were lost.

6Al-4V Titanium/BorSiC

Reductions in the 0° tensile strength of 6Al-4V titanium/BorSiC were approximately 10% for steady state and cyclic thermal exposures. The corresponding compressive strength losses were approximately 10 to 20%, the highest losses occurring at the highest test temperatures. The transverse or 90° tensile strengths degraded up to 50% for steady state and 60% for prior cyclic thermal exposures.

Corresponding compressive strengths losses were of the order of 10 to 15%.

General

Some general commentary on the resin matrix composite behavior is also in order.

The moisture weight gain for all three composites depended only on the total time of high humidity exposure and was not affected by the intervening high or low temperatures, drying periods or U.V. exposures.

The thermal expansion characteristics of the resin matrix composites are dependent on the presence of absorbed moisture in the resin.

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SECTION I

1.0 INTRODUCTION

The objective of this program was to generate basic information on the effect of various environmental variables on the physical, thermal and mechanical properties of advanced composites suitable for application to primary aircraft components. The program encompassed the following tasks:

1.0 Generation of Physical, Thermal and Mechanical Properties of Boron/Epoxy and Graphite/Epoxy composites (Resin Matrix Studies).

The evaluation of the resin matrix materials was further subdivided into the following activities:

- 1.1 material procurement
- 1.2 laminate fabrication
- 1.3 quality assurance testing
- 1.4 baseline data establishment in the following specific areas:
 - 1.4.1 tension
 - 1.4.2 compression
 - 1.4.3 in plane shear
 - 1.4.4 interlaminar shear
 - 1.4.5 flexural tests
 - 1.4.6 fatigue
 - 1.4.7 creep and stress rupture
 - 1.4.8 thermo-physical properties thermal expansion, thermal conductivity
 - 1.4.9 density

- 1.5 exposure of samples to elevated humidity environments
- 1.6 exposure of samples to elevated temperature environments
- 1.7 data generation on the samples exposed to items 1.5 and 1.6 and tested similar to items 1.4.1 through 1.4.8
- 1.8 selective testing of coated samples analysis, correlation of data and reporting activities.

2.0 Generation of similar data for Boron/Aluminum and BorSiC/Titanium Composites (Metal Matrix Studies). The evaluation of the metal matrix composites followed the same general process except that the effect of humidity exposure was not examined.

An outline of the entire program is presented in Tables I through IV. Tables I through III show the overall resin matrix material programs that include baseline tests consisting of unexposed specimens, humidity exposure tests and thermal exposure tests. Table IV shows the metal matrix material program including both baseline and thermal exposure tests.

Table 1
RESIN MATRIX BASE LINE DATA PROGRAM

Property	Fiber Orient.	Boron/Awco 5505			Módor II Graphite/Harnco 5206			Mercurius 3002M/Courtenails 888			Overall Total
		RT	260°F	350°F	Total	RT	260°F	350°F	Total		
Tension	0°	5 (3)*	5 (3)	5 (3)	15 (9)	5 (3)	5 (3)	5 (3)	15 (9)	15 (9)	45 (27)
	90°	5 (3)	5 (3)	5 (3)	15 (9)	5 (3)	5 (3)	5 (3)	15 (9)	15 (9)	45 (27)
	0°/90°/± 45°	5 (3)	5 (3)	5 (3)	15 (9)	5 (3)	5 (3)	5 (3)	15 (9)	15 (9)	45 (27)
Compression Sandwich Beam	0°	5 (3)	-	5 (3)	10 (6)	5 (3)	-	5 (3)	10 (6)	10 (3)	30 (18)
	90°	5 (3)	-	5 (3)	10 (6)	5 (3)	-	5 (3)	10 (6)	10 (3)	30 (18)
	0°/90°/± 45°	5 (3)	-	5 (3)	10 (6)	5 (3)	-	5 (3)	10 (6)	10 (3)	30 (18)
Compression Coupon	0°	5 (3)	5 (3)	5 (3)	15 (9)	5 (3)	5 (3)	5 (3)	15 (9)	15 (9)	45 (27)
	90°	5 (3)	5 (3)	5 (3)	15 (9)	5 (3)	5 (3)	5 (3)	15 (9)	15 (9)	45 (27)
	0°/90°/± 45°	5 (3)	5 (3)	5 (3)	15 (9)	5 (3)	5 (3)	5 (3)	15 (9)	15 (9)	45 (27)
In Plane Shear Int. Shear	± 45°	5 (3)	5 (3)	5 (3)	15 (9)	5 (3)	5 (3)	5 (3)	15 (9)	15 (9)	45 (27)
	0°	5	5	5	15	5	5	5	15	15	45
	0°/90°/± 45°	5	5	5	15	5	5	5	15	15	45
Flexure	0°	5	5	5	15	5	5	5	15	15	45
	90°	5	5	5	15	5	5	5	15	15	45
	0°/90°/± 45°	5	5	5	15	5	5	5	15	15	45
Fatigue R = 0.1	0°	10	10	10	30	10	10	10	30	30	90
	90°	10	10	10	30	10	10	10	30	30	90
	0°/90°/± 45°	10	10	10	30	10	10	10	30	30	90
Creep & Stress Rupture	0°	-	10 (10)	10 (10)	20 (20)	-	10 (10)	10 (10)	20 (20)	20 (20)	60 (60)
	90°	-	10 (10)	10 (10)	20 (20)	-	10 (10)	10 (10)	20 (20)	20 (20)	60 (60)
	0°/90°/± 45°	-	10 (10)	10 (10)	20 (20)	-	10 (10)	10 (10)	20 (20)	20 (20)	60 (60)
Thermal Expansion	0°	-	-	3	3	-	-	3	3	3	12
	90°	-	-	3	3	-	-	3	3	3	12
	0°/90°/± 45°	-	-	3	3	-	-	3	3	3	12
Thermal Conductivity	0°	-	-	3	3	-	-	3	3	3	12
	90°	-	-	3	3	-	-	3	3	3	12
	0°/90°/± 45°	-	-	3	3	-	-	3	3	3	12
Density (at RT)	0°	3	-	-	3	3	-	-	3	3	12
	90°	3	-	-	3	3	-	-	3	3	12
	0°/90°/± 45°	3	-	-	3	3	-	-	3	3	12

* Numbers in parenthesis indicate instrumented specimens.

TABLE 11

RESIN MATRIX HUMIDITY EXPOSURE DATA PROGRAM

(THIS TABLE APPLIES FOR EACH OF THE FOLLOWING MATERIALS:)

(1) BONDW/ADCO 5505 (2) WIDNER 11/WARMOO 5206 (3) COURTAULDS NPS/HEUCULES 3002M)

Property	Humidity Conditioning	0° Orientation RT 260°F 350°F	Total	90° Orientation RT 260°F 350°F	Total	0/45/135/0/90° RT 260°F 350°F	Orient. Total	-45° Orientation RT 260°F 350°F	Total	Overall Total
Tension	Steady 500 Hrs.**	3(3)	9(3)	3(3)	9(3)	3(3)	9(3)	-	-	27(9)
	Steady 1000 Hrs.**	3(3)	9(9)	3(3)	9(9)	3(3)	9(9)	-	-	27(27)
	Thermo-Hum. Cyc.***	3(3)	9(3)	3(3)	9(3)	3(3)	9(3)	-	-	27(9)
	Acc. Wehrng. ***	3(3)	9(9)	3(3)	9(9)	3(3)	9(9)	-	-	27(27)
Compression	Steady 500 Hrs.**	3(3)	9(3)	3(3)	9(3)	3(3)	9(3)	-	-	27(9)
	Steady 1000 Hrs.**	3(3)	9(9)	3(3)	9(9)	3(3)	9(9)	-	-	27(27)
	Thermo-Hum. Cyc.***	3(3)	9(3)	3(3)	9(3)	3(3)	9(3)	-	-	27(9)
	Acc. Wehrng. ***	3(3)	9(9)	3(3)	9(9)	3(3)	9(9)	-	-	27(27)
In Plane Shear	Steady 500 Hrs.**	-	-	-	-	-	-	3(3)	3	9(3)
	Steady 1000 Hrs.**	-	-	-	-	-	-	3(3)	3(3)	9(9)
	Thermo-Hum. Cyc.***	-	-	-	-	-	-	3(3)	3	9(3)
	Acc. Wehrng. ***	-	-	-	-	-	-	3(3)	3(3)	9(9)
Interlaminar Shear	Steady 500 Hrs.**	3	9	-	-	-	-	-	-	9
	Steady 1000 Hrs.**	3	9	-	-	-	-	-	-	9
	Thermo-Hum. Cyc.***	3	9	-	-	-	-	-	-	9
	Acc. Wehrng. ***	3	9	-	-	-	-	-	-	9
Fatigue R = 0.1	Steady 500 Hrs.**	-	15	-	-	5	15	-	-	30
	Steady 1000 Hrs.**	5	15	-	-	5	15	-	-	30
	Thermo-Hum. Cyc.***	5	15	-	-	5	15	-	-	30
	Acc. Wehrng. ***	5	15	-	-	5	15	-	-	30
Creep and Stress Rupture	Steady 500 Hrs.**	-	10(10)	-	-	-	10(10)	-	-	20(20)
	Steady 1000 Hrs.**	-	10(10)	-	-	-	10(10)	-	-	20(20)
	Thermo-Hum. Cyc.***	-	10(10)	-	-	-	10(10)	-	-	20(20)
	Acc. Wehrng. ***	-	10(10)	-	-	-	10(10)	-	-	20(20)

- Numbers in parenthesis indicate instrumented specimens

- The Steady State Humidity Conditioning Consisted of 90% RH, 120°F for the stated time period see Section 2.1.4.1

- Thermo-Humidity and Accelerated Weathering Cycles are defined in Section 2.1.4.2

TABLE III

RESIN MATRIX THERMAL EXPOSURE DATA PROGRAM

(T IS TABLE APPLIES FOR EACH OF THE FOLLOWING MATERIALS:)

(1) BOBON AVCC 5505 (2) MODROR 11/NARCO 5206 (3) OCCURTAULDS HNS/NERCULES 3002M)

Property	Thermal Conditioning	0° Orientation RT 260°F 350°F Total	90° Orientation RT 260°F 350°F Total	0/45/135/0/90° RT 260°F 350°F Total	±45° Orientation RT 260°F 350°F Total	Overall Total
Tension	Steady 260°F/100 hrs **	3	3	3	-	6
	Steady 260°F/500 hrs **	3(3)	3(3)	3(3)	-	6(6)
	Steady 350°F/100 hrs ***	3	3	3	3	9
	Steady 350°F/500 hrs ***	3(3)	3(3)	3(3)	-	6(6)
	Cyclic 260°F/500 Cyc	3	3	3	-	6
	Cyclic 260°F/1000 Cy	3(3)	3(3)	3(3)	-	6(6)
	Cyclic 350°F/500 Cyc	3	3	3	3	9
	Cyclic 350°F/1000 Cy	3(3)	3(3)	3(3)	-	6(6)
Compression	Steady 260°F/100 hrs	3	3	3	-	6
	Steady 260°F/500 hrs	3(3)	3(3)	3(3)	-	6(6)
	Steady 350°F/100 hrs	3	3	3	3	6
	Steady 350°F/500 hrs	3(3)	3(3)	3(3)	-	6(6)
	Cyclic 260°F/500 Cyc	3	3	3	-	6
	Cyclic 260°F/1000 Cy	3(3)	3(3)	3(3)	-	6(6)
	Cyclic 350°F/500 Cyc	3	3	3	3	6
	Cyclic 350°F/1000 Cy	3(3)	3(3)	3(3)	-	6(6)
In Plane Shear	Steady 260°F/100 hrs	-	-	-	3	3
	Steady 260°F/500 hrs	-	-	-	3(3)	3(3)
	Steady 350°F/100 hrs	-	-	-	3	3
	Steady 350°F/500 hrs	-	-	-	3(3)	3(3)
	Cyclic 260°F/500 Cyc	-	-	-	3	3
	Cyclic 260°F/1000 Cy	-	-	-	3(3)	3(3)
	Cyclic 350°F/500 Cyc	-	-	-	3	3
	Cyclic 350°F/1000 Cy	-	-	-	3(3)	3(3)

* Numbers in parenthesis indicate instrumented specimens

** For the details of the steady state thermal conditioning, see Section 2.1.4.3

*** Cyclic thermal conditioning involved thermal changes from 100°F to the stated temperature and back to 100°F at a rate of one cph for the stated number of cycles, see Section 2.1.4.4

Continued -

TABLE III - Continued

Property	Thermal Conditioning	0° Orientation RT 260°F 350°F		90° Orientation RT 260°F 350°F		45° Orientation RT 260°F 350°F		Overall Total
Interlaminar Shear	Steady 260°F/100 hrs **	3*	-	-	-	-	-	6
	Steady 260°F/500 hrs **	3	-	-	-	-	-	6
	Steady 330°F/100 hrs ***	3	-	-	-	-	-	6
	Steady 330°F/500 hrs ***	3	-	-	-	-	-	6
	Cyclic 260°F/500 Cycles	3	-	-	-	-	-	6
	Cyclic 260°F/1000 Cycles	3	-	-	-	-	-	6
	Cyclic 330°F/500 Cycles	3	-	-	-	-	-	6
	Cyclic 330°F/1000 Cycles	3	-	-	-	-	-	6
Fatigue R = 0.1	Steady 260°F/500 hrs	5	-	-	-	-	-	20
	Steady 330°F/500 hrs	5	-	-	-	-	-	20
	Cyclic 260°F/500 Cycles	5	-	-	-	-	-	20
	Cyclic 260°F/1000 Cycles	5	-	-	-	-	-	20
	Cyclic 330°F/500 Cycles	5	-	-	-	-	-	20
	Cyclic 330°F/1000 Cycles	5	-	-	-	-	-	20
	Steady 260°F/500 hrs	-	5(5)	5(5)	10(10)	-	-	20(20)
	Steady 330°F/500 hrs	-	5(5)	5(5)	10(10)	-	-	20(20)
Creep and Stress Rupture	Cyclic 260°F/500 Cycles	-	5(5)	5(5)	10(10)	-	-	20(20)
	Cyclic 260°F/1000 Cycles	-	5(5)	5(5)	10(10)	-	-	20(20)
	Cyclic 330°F/500 Cycles	-	5(5)	5(5)	10(10)	-	-	20(20)
	Cyclic 330°F/1000 Cycles	-	5(5)	5(5)	10(10)	-	-	20(20)

* Numbers in parenthesis indicate instrumented specimens

** For the details of the steady state thermal conditioning, see Section 2.1.4.3

*** Cyclic thermal conditioning involved thermal changes from 100°F to the stated temperature and back to 100°F at a rate of one c.p.h. for the stated number of cycles, see Section 2.1.4.4

Table IV

METAL MATRIX DATA PROGRAM

Thermal Conditioning of Specimens		NO. OF SPECIMENS TO BE TESTED AT VARIOUS TEMP.*		
		6064 Al/Boron 0° 90°	6Al-4V - Ti/BorSiC 0° 90°	TOTAL
Tension:	None	20(12)	20(12)	20(12)
	Steady State @ T-max** for 100, 500 & 1000 hrs.	60(36)	60(36)	60(36)
	Cyclic @ T-max for 100, 500 & 1000 cycles***	60(36)	60(36)	60(36)
Compressor:	None	20(12)	20(12)	20(12)
	Steady State @ T-max for 100 & 500 hrs.	40(24)	40(24)	40(24)
	Cyclic @ T-max for 500 cycles	20(12)	20(12)	20(12)
Flexure:	None	20	20	20
Int. Shear	None	10	10	10
Fatigue (R = 0.1, -1, 10)	None	60	60	60
Creep and Stress Rupture	None	20	20	20
Thermal Exp.*** & Conductivity	None	10	10	10

* Test Temperatures
 ** T-max
 *** Temp. Range
 **** Thermal cycles consisted of a thermal change from 100°F to the stated temperature and back to 100°F at one CPH for the stated number of cycles.

Al/Boron
 RT, 160°F, 400°F, 600°F
 600°F
 -320°F to 700°F

Ti/BorSiC
 RT, 400°F, 600°F, 800°F
 800°F
 -320°F to 900°F

NCTE: Numbers in parenthesis indicate instrumented specimens.

SECTION II

2.0 TECHNICAL DISCUSSION

2.1 Resin Matrix Studies

2.1.1 Materials

Advanced composite materials have been under intensive development because of their promise for aircraft structural weight savings, improved capability and potential lower cost compared to conventional structural materials such as aluminum, steel and titanium. The advanced composite materials possess a high strength-to-weight and stiffness-to-weight ratios.

Three resin matrix material systems were selected for study in this portion of the program.

The boron/epoxy system selected was the AVCO 5505/Boron prepreg material. This system was extensively characterized at room temperature and at several elevated temperatures. However, little or no data existed for the effect on the material properties of long-term aging in high humidity and elevated temperature environments. This program included several conditioning environments which will be of interest to designers with boron/epoxy components as flying hardware.

In the time intervening between the purchase of the AVCO 5505/Boron prepreg for use on this program and the completion of this report, the prepreg material was substantially upgraded in average tensile strength. Therefore the values for the AVCO 5505/Boron composites are somewhat lower than can be expected from the newer materials, however, the degradation of the material as a percentage of the ultimate strength will be of value to the designer. In the text, the AVCO 5505/Boron composite summary curves are shown as percentages of the baseline room temperature values.

Two graphite/epoxy systems were also selected:

- 1) Modmor II/Graphite Narmco 5206 (a high strength system), and
- 2) Courtaulds HMS Graphite/Hercules 3002M system (a high-modulus system, a stiffness of 25×10^6 psi).

The raw material was supplied in the three-inch wide tape form for all three systems.

The specifications, to which the systems were ordered and fabricated, were:

- 1) For boron/AVCO 5505 system: General Dynamics specification F.M S.-2001A "Advanced Composite Materials Specifications." The specific type material was Type II "Heat Resistant to 420°F. AVCO 5505 has qualified under this specification.
- 2) For Narmco 5206/Modmor II graphite system: McDonnell Douglas Corporation specification DMS-1936B and all amendments "Tape Unidirectional High Modulus Graphite Filament" was employed. The specific type of interest was Type 1 - Continuous filament tape of specified width, Class 2 (35×10^6 psi modulus filaments and 195,000 laminate U.T.S.). The Modmor II/Narmco 5206 system has been qualified by McDonnell Corporation under class 2.
- 3) For Hercules 3002M/Courtaulds HMS graphite: McDonnell Douglas Corporation Specification MMS 546, "Type III Graphite/Epoxy Prepreg Material," and IITRI Specification 0316, "Type HMS Graphite/Epoxy Prepreg Material."

Copies of the three specifications were presented in the Annual Report (AFML-TR-72-205, Part I) and are not repeated here.

2.1.2 Material Procurement, Quality Assurance, and Processing

The following quantities of prepreg tape were ordered and received for use on this program: -

AVCO 5505/Boron - 45 lbs.

Modulite 5206 Type II Modmor II/

Narmco 5206 Graphite - 38 lbs.

Hercules 3002M/Courtaulds HMS

Graphite - 55 lbs.

The incoming materials were checked for quality assurance in accordance with the specifications listed in section 2.1.1 of this report. The quality assurance requirements and quality certification reports were presented in AFML TR-72-205, Part I and are not repeated here. A summary of the quality assurance test results are shown in Table V.

Note that the elevated temperature 0° tensile strengths of the Courtaulds HMS Graphite/Hercules 3002M are higher than the room temperature tensile strengths. It is common to this particular system. A more detailed study of this phenomenon is made later in the discussion of the program results.

2.1.3 Fabrication of Laminates

The resin matrix laminates were fabricated using an autoclave to provide the pressure and temperature cycle required.

The autoclave, with internal dimensions of 5'3" in length and 1'8" in diameter provide for the fabrication of either one large plate or several smaller plates simultaneously. The movement of the aluminum heating plate into and out of the autoclave was facilitated by a trolley. The autoclave itself is

TABLE V

QUALITY ASSURANCE TEST DATA FOR RESIN

MATRIX PREPREG TAPE MATERIALS

ACCEPTANCE PANEL		THICKNESS OF FIFTEEN PLIES Min/ Nom/Max (in) (in) (in)	0° FLEXURE		90° FLEXURE		HORIZONTAL SHEAR	
Material	Panel		RT (ksi)	260°F (ksi)	350°F (ksi)	RT (ksi)	260°F (ksi)	350°F (ksi)
Bacon/Avco 5505	Gen Dyn FMS-2001 requirements	.076/.079/.081	225	195	170	13.0	10.0	8.0
	Vendor Q.C. Batch 419	-	306	-	227	15.8	-	15.6
	IITRI Q.C. Batch 419	.077/.078/.079	263	240	218	14.0	-	9.5
	MAC AIR DMS 1935 Requirements	-	195	-	-	-	-	-
McDor II Graphite/ Narmco 5206	Vendor Q.C.	-	205.9	-	-	-	-	-
	IITRI Q.C. Batch 342	-	195.1	-	-	-	-	-
	MAC AIR HMS 548 Type III Requirements	-/.075/-	0° Tensile Modulus Room Temp. 26 x 10 ⁶ psi	0° Tensile Strength Room Temp. 100 ksi	0° Tensile Strength 350°F 100 ksi	90° Tensile Strength Room Temp. 5,000 psi	90° Tensile Strength 350°F 3,500 psi	-
	Vendor Q.C. Batch 110	-/.075/-	32.8 x 10 ⁶	138 ksi	-	5,440 psi	-	3,679 psi
Courtaulds HMS Graphite/ Hercules 3002M	IITRI Q.C. Batch L110	-/.075/-	29.0 x 10 ⁶	119 ksi	136 ksi	5,300 psi	-	4,670 psi

permanently mounted on a steel frame. The heat cycle (maximum capacity 550°F) was automatically controlled. There was a provision for two separate vacuum systems that were used at the same time for fabricating two plates simultaneously. Air pressure up to 100 psi was obtained directly from the air line in the fabrication laboratory.

The preliminary layup procedures followed were developed for the autoclave process. (For the purposes of description in this section, a laminate will mean any composite of several layers of fibers, although the fiber may all be in the same direction.) The tape was first removed from the freezer storage area but was not unwrapped until it had reached ambient conditions. This was done to prevent moisture condensation on the tape surface. The tape was cut to required lengths using a conventional paper cutter and was stacked to the appropriate orientation. (The AVCO 5505/boron laminates required an additional layer of plain woven fiberglass scrim-cloth placed over the entire laminate.) After all plies had been stacked the plate was ready for cure, if convenient, or storage. (Green uncured laminates were sealed in a Mylar bag and stored in a freezer prior to cure if a delay was encountered.)

A stainless steel caul plate, approximately three inches longer and wider than the boron laminate, was used during the curing process. A sheet of TX-1040 separator sheet of the same size as the boron laminate, was placed directly on the stainless steel plate. Next the green laminate and a second separator sheet was added. The aggregate was covered with fiberglass bleeder cloth which was also trimmed to the size of the green laminate. A chloroprene dam consisting of 3/8 inch wide strips of chloroprene was placed around the aggregate. A Mylar perforated sheet was then added. A sheet of 181 fiberglass cloth was then placed on top this stack. The complete package was then placed

on the heater plate in a vacuum bag. Before the cure cycle was initiated, full vacuum was applied to the package, any leaks were corrected, and a check was made to insure that there were no wrinkles on the laminate.

The cure cycles and postcure used for the three material systems were described in AFML TR-72-205, Part I. Following the cure the individual plates went to specimen cutting, tabbing or environmental conditioning processes as appropriate. Individual specimens were inspected visually for flaws and delaminations. Composite densities and fiber and resin volume percentages were determined as described in AFML TR-72-205, Part I. The data for individual laminates are presented in Tables VI through VIII.

The densities shown in Tables VI through VIII were determined using the gravimetric process. The values for the densities of the fibers and matrices were obtained from the tape suppliers. No void contents are shown in Tables VI through VIII. This does not imply that the composites were void-free but of low voids. Several inherent inaccuracies are present in resin dissolution methods currently available thus leading to void contents with errors of 100% or greater.

2.1.4 Conditioning Treatments

The various conditioning treatments, to which the composite materials were exposed are described in this section. The equipment and procedures followed in the accomplishment of these conditioning treatments are found in AFML TR-72-205, Part I and are not repeated here.

TABLE VI
VOLUMETRIC MEASURES OF FIBER AND MATRIX CONTENTS
IN BORON/AVCO 5505 COMPOSITES

Fiber Orientation	No. of Plies	Specimen Number	Specimen Length (in.)	Specimen Width (in.)	Density of Composite Gm/cc	Fiber Volume (Percent)	Resin Volume (Percent)	Fiberglass Volume * (Percent)
0°	6	N-1005	1.018	0.972	2.000	49.87	43.77	6.36
		N-1007	2.000	0.250	2.001	49.96	43.70	6.34
		N-1008	2.000	0.250	2.013	50.75	42.89	6.36
		N-1009	2.000	0.250	1.996	49.41	44.08	6.51
		N-1011	2.000	0.250	1.992	49.25	44.34	6.41
		N-1012	2.000	0.250	1.995	50.00	44.08	5.92
AVERAGE					2.000	49.87	43.81	6.32
90°	8	N-1002	2.050	0.441	1.980	48.60	45.25	6.15
		N-1013	2.000	0.250	1.960	47.26	46.77	5.97
		N-1014	2.000	0.250	1.962	47.36	46.58	6.06
		N-1015	2.000	0.250	1.961	47.31	46.77	5.92
		N-1017	2.000	0.250	1.959	47.11	46.82	6.07
		N-1018	2.000	0.250	1.985	48.70	45.20	6.10
AVERAGE					1.968	47.72	46.23	6.05
±45°	8	N-1022	2.000	0.222	2.010	50.44	42.98	6.58
		N-1023	2.000	0.250	1.979	48.43	45.45	6.12
		N-1024	2.000	0.250	1.992	49.31	44.50	6.19
		N-1025	2.000	0.250	1.993	49.41	44.36	6.23
		N-1026	2.000	0.250	1.992	49.39	44.44	6.17
AVERAGE					1.993	49.40	44.35	6.25
10/45/135/0/90, 9	9	N-1027	1.553	0.561	1.980	48.74	45.23	6.03
		N-1028	2.000	0.250	1.979	48.71	45.36	5.93
		N-1029	2.000	0.250	1.959	47.14	46.89	5.97
		N-1030	2.000	0.250	1.978	48.60	45.50	5.90
		N-1031	2.000	0.250	1.966	47.75	46.40	5.85
		N-1032	2.000	0.250	1.985	49.00	44.91	6.09
		N-1033	2.000	0.250	1.996	49.71	44.15	6.14
		N-1034	2.000	0.250	1.985	48.70	45.18	6.12
		N-1034	2.000	0.250	1.972	47.55	46.48	5.97
		N-1036	2.000	0.250	1.973	48.19	45.8	5.99
		N-1037	2.000	0.250	1.969	47.77	46.02	6.15
		N-1038	2.000	0.250	1.973	47.93	45.86	6.21
		N-1040	2.000	0.250	1.967	47.36	46.33	6.31
		N-1041	2.000	0.250	1.965	47.44	46.35	6.21
		N-1042	2.000	0.250	1.964	47.65	46.51	5.84
AVERAGE					1.974	48.19	45.80	6.05

* of carrier glass scrim cloth

Table VII

VOLUMETRIC MEASURES OF FIBER AND MATRIX CONTENTS
IN MODMOR II GRAPHITE/NARMCO 5206 COMPOSITES

Fiber Orientation	No. of Plies	Specimen Number	Density of Composite (gm/cc)	Fiber Volume (percent)	Resin Volume (percent)
0°	6	M1105	1.491	53.15	46.85
		M1106	1.521	60.46	39.54
		M1107	1.515	58.81	41.19
		M1108	1.517	58.79	41.21
		M1109	1.493	54.21	45.79
		M1110	1.481	51.70	48.30
		M1111	1.496	54.48	45.52
		M1112	1.485	51.45	48.55
		AVERAGE	1.499	55.38	44.62
	15	M1101	1.513	58.09	41.91
	10	M1147	1.503	55.97	44.03
90°	8	M1102	1.516	58.72	41.28
		M1103	1.474	49.80	50.20
		M1104	1.501	55.55	44.45
		M1113	1.473	61.03	38.97
		M1114	1.504	55.13	44.87
		M1115	1.467	47.27	52.73
		M1116	1.479	50.74	49.26
		M1117	1.516	58.71	41.29
		M1118	1.504	56.57	43.43
		M1120	1.486	51.84	48.16
		AVERAGE	1.492	54.54	45.46
± 45°	8	M1122	1.490	53.47	46.53
		M1123	1.496	54.55	45.45
		M1124	1.475	49.84	50.16
		M1125	1.484	52.04	47.96
		M1126	1.488	52.72	47.22
		AVERAGE	1.486	52.53	47.47
[0/45/135/0/90] _s	9	M1127	1.479	50.76	49.24
		M1128	1.473	49.64	50.36
		M1129	1.471	49.22	50.78
		M1130	1.481	51.28	48.72
		M1131	1.465	52.11	47.89
		M1132	1.480	51.14	48.86
		M1133	1.465	47.92	52.08
		M1134	1.473	49.52	50.48
		M1135	1.495	54.25	45.75
		M1136	1.505	56.49	43.51
		M1137	1.489	52.95	47.05
		M1138	1.483	48.68	51.32
		M1139	1.488	52.83	47.17
		M1140	1.479	50.32	49.68
		M1141	1.498	54.87	45.13
		M1142	1.477	50.41	49.59
		M1146	1.472	49.36	50.64
		AVERAGE	1.481	51.30	48.70

Table VIII

VOLUMETRIC MEASURES OF FIBER AND MATRIX CONTENTS
IN HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES

Orientation	No. of Plies	Specimen Number	Density of Composite (gm/cc)	Fiber Volume (percent)	Resin Volume (percent)
0°	6	C1205	1.593	49.72	50.28
		C1206	1.568	45.73	54.27
		C1207	1.585	48.44	51.56
		C1208	1.573	46.50	53.50
		C1209	1.605	51.61	48.39
		C1210	1.589	49.07	50.93
		C1211	1.574	46.72	53.28
		C1212	1.567	45.58	54.42
		AVERAGE	1.581	47.92	52.08
	10	C1247	1.607	51.91	48.09
	8	C1202	1.578	47.45	52.66
		C1203	1.601	50.95	49.05
		C1204	1.569	45.90	54.10
		C1213	1.555	43.35	56.65
		C1214	1.580	47.63	52.37
		C1215	1.572	46.37	53.63
		C1216	1.591	49.38	50.62
		C1217	1.594	49.85	50.15
		C1218	1.584	48.25	51.75
		C1219	1.569	45.88	54.12
		AVERAGE	1.579	47.49	52.51
± 45°	8	C1222	1.613	52.86	47.14
		C1223	1.589	49.06	50.94
		C1224	1.573	46.43	53.57
		C1225	1.584	48.26	51.74
		C1226	1.578	47.31	52.69
		AVERAGE	1.587	48.78	51.22
0/45/135/90° S	9	C1221	1.589	49.06	50.94
		C1227	1.599	48.10	51.90
		C1228	1.579	47.46	52.54
		C1230	1.550	42.85	57.15
		C1231	1.583	48.10	51.90
		C1232	1.539	41.11	58.89
		C1233	1.560	44.44	55.56
		C1234	1.553	48.86	51.14
		C1236	1.552	43.20	56.80
		C1237	1.531	39.85	60.15
		C1238	1.550	42.87	57.13
		C1239	1.566	45.37	54.63
		C1240	1.560	44.45	55.55
		C1241	1.572	46.35	53.65
		C1242	1.555	43.66	56.34
		C1243	1.570	46.04	53.96
		AVERAGE	1.563	45.11	54.89

In addition, a comparison base of data was obtained against which the effects of these various conditioning treatments might be measured. The extent of this baseline data program was described in Section I, Table I. The individual baseline data for the three resin matrix systems are found in Appendices I through III.

2.1.4.1 Steady State Humidity Conditioning

The steady state humidity conditioning of specimens includes 500 and 1000 hr. (3 weeks and 6 weeks) exposure to $98\% \pm 2\%$ relative humidity and 120°F (see Table II). This exposure is the same as that recommended by Mil Handbook 17.

The specimens which were subjected to humidity exposure were prepared as follows:

- 1) All specimens were finish machined and the appropriate room temperature or elevated temperature tabs were bonded prior to initiation of the pre-conditioning treatment. For elevated temperature tests subject to prior humidity exposure the tab adhesive was Metalbond 329. For room temperature tests subject to prior humidity conditioning the adhesive was FM 1000.
- 2) All specimens for static and creep tests were instrumented (as required) with electrical resistance foil strain gages. The gages were protected with M-coat resin coating taking care to cover a minimum area.
- 3) The edges of the samples were not protected since protection could not be guaranteed to be only to the edges and not to the surfaces of specimen.

- 4) The samples were individually weighed prior to insertion in the chamber.
- 5) Each sample was arranged in the chamber to permit maximum exposure to the moisture-laden air as it flowed from the inlet orifice to the chamber.

These steps were followed to permit rapid testing of the samples after removal from the chamber. Upon removal from the chamber, the specimens were reweighed, wires were attached to the strain gages and the specimens were tested within 8 hours of removal from the chamber. For certain long term fatigue and creep tests, where the tests were held up for a longer time due to machine unavailability, the samples were sealed in a protective vinyl, moisture proof container. These samples were then reweighed, prior to testing, to determine if moisture loss had occurred.

2.1.4.2 Cyclic Humidity Conditioning

2.1.4.2.1 Thermo-Humidity Cycle

Table II listed two cyclic humidity conditioning exposures for resin matrix composites. The first humidity cycle was the Thermo-Humidity cycle selected from a review of previous aerospace practices. The Webber Environmental Chamber was again used for the humidity exposure.

The details of the Thermo-Humidity cycle employed are:
(1) The total time period for the cycle was 500 hours. (2) During this period the specimens were placed in the environmental chamber and exposed to a relative humidity of $95 \pm 2\%$ at $120^\circ \pm 5^\circ\text{F}$ except for one and one half hour each work day of the week when they were taken out and subjected to thermal shock. (3) This shock treatment consisted of exposing the

specimens for one hour at -65°F in a cold chamber followed by an exposure of one half hour at 250°F in an oven. (4) During The weekend the specimens remained in the environmental chamber continuously exposed to the humidity conditions mentioned above.

The frost conditions on the samples after exposure to -65°F were noted and some sample delaminations occurred after removal from the 250°F portion of the cycle.

All appropriate specimens were strain gaged in the same manner as the steady-state exposure and were wired after exposure prior to testing. The test specimens were made ready for testing within eight hours after removal from the test chamber as was done for the steady state humidity conditioning exposures.

2.1.4.2.2 Accelerated Weathering Humidity Cycle

The second humidity cycle was an accelerated weathering cycle. An Atlas Twin ARC Weatherometer, Type D as specified in ASTM G23-69 was employed for these tests. All panels and/or specimens were exposed in the weatherometer to the following operation schedule. The recommended practice for this equipment was as described in ASTM D1499-64 and ASTM G23-69. The apparatus was operated 5 days per week, and each 2-hour cycle of operation was divided into periods, during which the panels and specimens were exposed 102 minutes to light without water and 18 minutes of light with water spray. The test specimens remained undisturbed during the remaining 2 days of the week.

The exposure procedures followed were as follows:

The black panel thermometer unit was placed in the test panel rack and with the light on and the water off, the thermostat was set so that the temperature of the thermometer read $145^{\circ} \pm 5^{\circ}\text{F.}$, when the thermometer was at the point where the maximum heat was produced as the panel rack revolved around the light.

The water supply was adjusted so that the pressure of the water at the spray nozzle was between 12 and 15 pounds per square inch so that the water struck the specimens in a fine spray in sufficient volume to wet the entire surface of the specimens upon impact.

New carbons and clean filters were installed in the light assembly and the weatherometer was started. At the end of the burning period, the old carbons were removed and the decomposition ash was cleaned from the carbon holders and other parts of the light assembly, and the filters were washed with detergent and water. The position of the test panels and specimens were transposed to provide a uniform distribution of light in a vertical plane over the entire surface of the test specimens. New carbons were installed, the filters were replaced and the weatherometer restarted. These operations were repeated after each burning period of the light until the test specimens were exposed for a time period of 500 hours including weekend rest periods. (This resulted in a 360 hour active exposure time plus 140 hours of rest periods.)

2.1.4.3 Steady State Thermal Conditioning

For steady state thermal exposure conditioning conventional circulating air ovens were used to obtain exposures at 260°F for time periods of 100 and 500 hrs. The samples were arranged to get uniform distribution of air circulation over the specimens without localized hot spots.

2.1.4.4 Cyclic Thermal Conditioning

Thermal cycles from 100°F to 260°F to 100°F and from 100°F to 350°F to 100°F were adopted for cyclic thermal conditioning. Exposure of test samples for both 500 cycles and 1000 cycles were undertaken. A cyclic rate of one cycle per hour was established.

2.1.5 Testing Specimens and Test Procedures

This section briefly lists the test specimens and procedures utilized for generating the data during this program.

A detailed description of the test specimens, specimen fabrication procedures and test equipment is found in Appendix II of AFML TR-72-205, Part I.

2.1.5.1 Tensile, Fatigue and Creep Specimens

The same specimen configuration was utilized for tension, fatigue ($R = 0.1$) and tensile creep tests. In addition in plane shear properties were determined using a $\pm 45^\circ$ tensile test. The IITRI straight-sided tab ended coupon was utilized for these properties. After environmental conditioning, each static tensile specimen was fitted with three electrical-resistance foil strain gages.

2.1.5.2 Compression Testing

Two types of specimens were employed for compressive testing. The first was the sandwich beam compression specimen which was utilized only in the generation of baseline data. The second specimen was a coupon specimen commonly known as the Celanese specimen which is an adaptation of the IITRI tensile coupon with longer tabs, reduced gage section and a narrower width. The coupon test fixture was the IITRI compression coupon test fixture.

(All comparative performance results are shown using the coupon test data for the baseline and conditioned curves).

2.1.5.3 Flexural and Interlaminar Shear Tests

The specimens used for all flexural testing was the fifteen ply, coupon universally used for testing advanced composites. Specimens were loaded in a 3 or 4-point bending fixture. Elevated temperature tests were conducted in a Missimer circulating air oven and loads were applied in tension to a flexural test rig.

The maximum interlaminar shear strength of oriented fiber composites was determined on short beam shear specimens.

Elevated temperature tests were performed with the assistance of the fixture described above.

2.1.5.4 In-Plane Shear Properties

The in-plane shear stress-strain curve was determined from a $\pm 45^\circ$ angle ply laminate tested in uniaxial tension supplemented with data from the 0° and 90° tests, and the incrementation of the $\pm 45^\circ$ tensile stress strain curve.

2.1.5.5 Fatigue Tests

The fatigue tests ($R = 0.1$) were performed at a cyclic rate of 1800 cpm, employing eccentric weight mechanical dynamic-load applicators.

2.1.5.6 Creep and Stress Rupture Tests

The creep equipment consisted of 32 tensile stands located on a vibration-free floor. Each stand was provided with a set of tensile grips enclosed in individually controlled ovens. The ovens are capable of achieving specimen temperatures of up to 800°F . A jig was used to align and grip the specimens prior to installation on the creep stands. For the creep stands employed, the load multiplication factor was 10:1.

2.1.5.7 Thermophysical and Density Properties

The linear expansion was measured by an automatic recording dilatometer similar to that described in ASTM Designation: C337-57. The dilatometer used had an accuracy of more than 99% and a reproducibility within $\pm 2\%$.

Thermal conductivity measurements were made using the steady state longitudinal heat flow technique. The sample consisted of ten $3/64 \times 1/2 \times 2$ -inch laminates sandwiched together to form a $1/2 \times 1/2 \times 2$ -inch conductivity specimen. Data are obtained from ambient room temperature to 350°F in air for three specimens in each of three laminate orientations. Densities of the laminates were determined by the gravimetric method.

2.1.6 Static Properties

2.1.6.1 Baseline Data

The static baseline data are found summarized in Appendices I through III including average stress strain curves in tension compression, and shear for 0° , 90° and $[0/45/135/0/90]_s$ laminates. The data were obtained from strain gages and were reduced and plotted using computer plotting routines. To average the values of stress and strain obtained from three tests conducted at a given temperature, a program (least squares) to fit a curve to the data was used as a sub-routine to the plotting program.

2.1.6.2 Effects of Humidity Conditioning

The steady state exposure of the three resin matrix composite materials to 98% relative humidity resulted in moisture pickup by the exposed uncoated samples. Fig. 1 shows the moisture pickup versus time for AVCO 5505/Boron. This figure is an aggregate of moisture pickup for three orientations three thicknesses (ply thickness) and two widths of sample so that the ratio of surface area to volume of the samples varies over a substantial range and the ratio of exposed fiber ends to surface area also varies.

Figures 2 and 3 also present the moisture pickup versus time for the Modmor II/Narmco 5206 Composite and the Courtaulds HMS Graphite/Hercules 3002M epoxy composites respectively. The moisture pickups are presented as a percentage of the original weight of the specimens. In plotting these gains for the four different humidity environments account was taken of the various orientations, specimens sizes etc. (see legend on each figure). Thus while the surface area to volume ratio for a nine ply $[0/45/135/0/90]_s$ laminate may remain virtually the same as a six ply $[0]_s$ laminate, the exposed fiber ends on the $[0/45/135/0/90]_s$

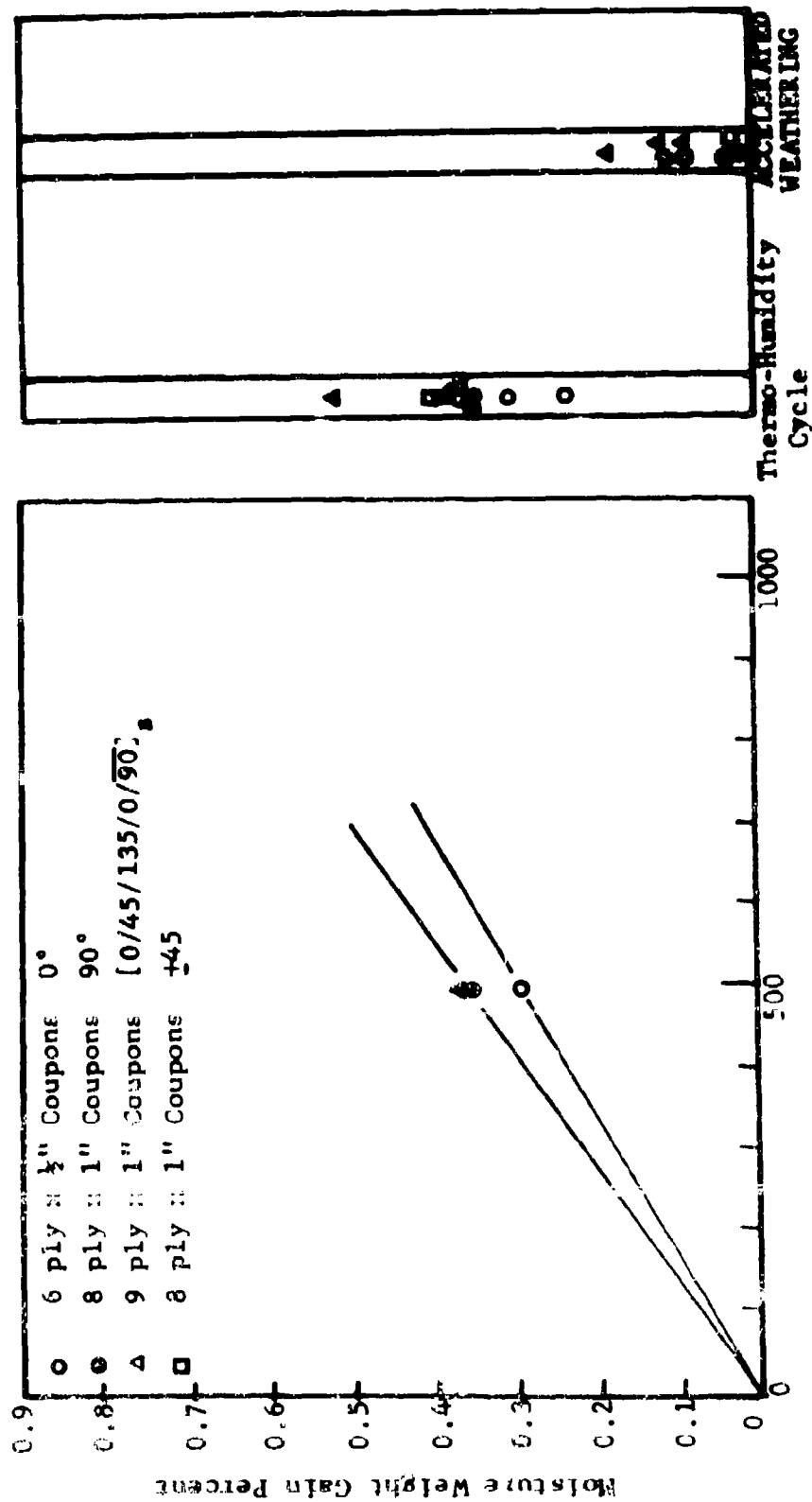


FIG. 1 MOISTURE WEIGHT GAIN PERCENTAGES FOR VARIOUS HUMIDITY CONDITIONING FOR AVCO 5505/BORON COMPOSITES

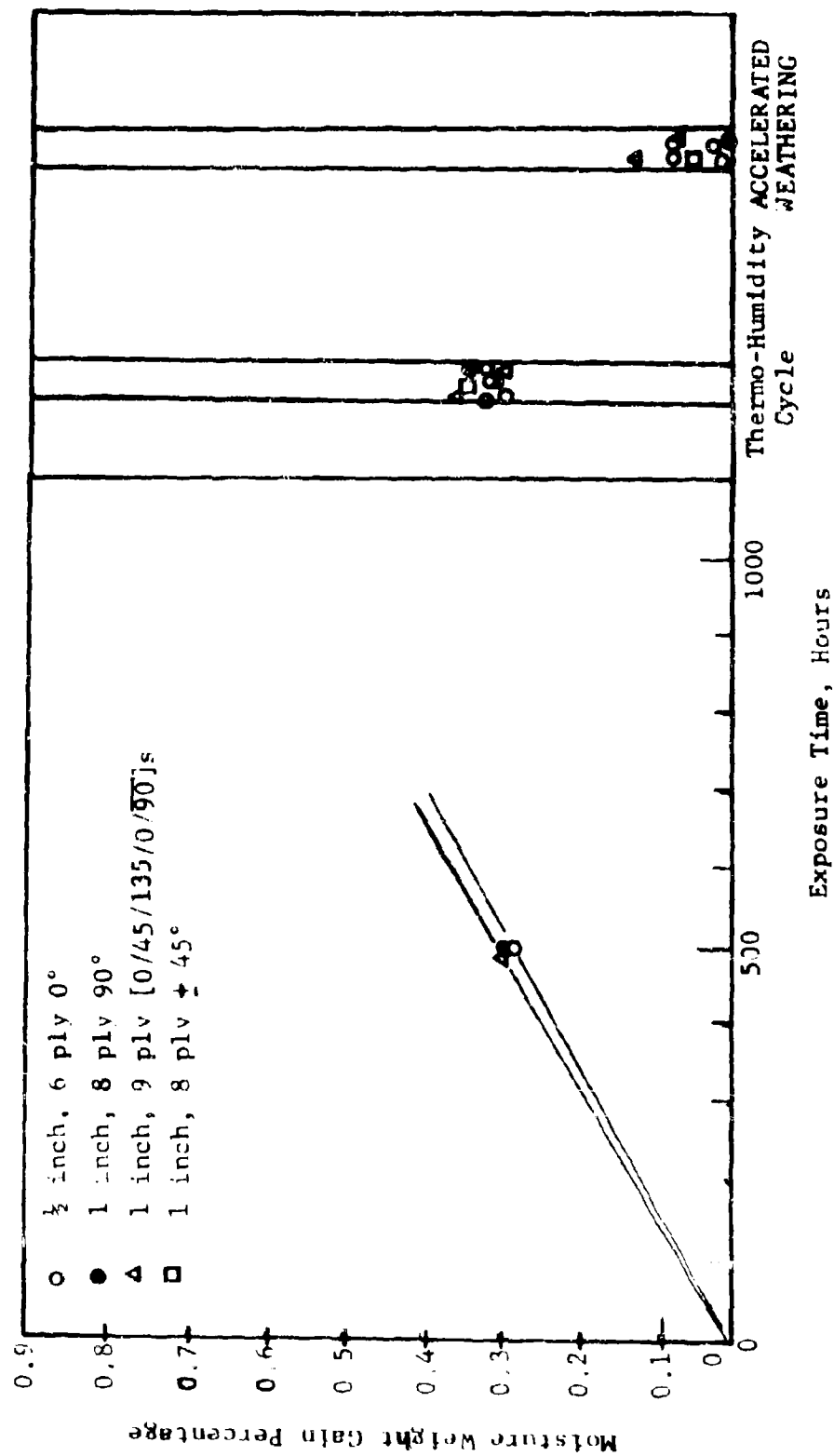


FIG. 2 MOISTURE WEIGHT GAIN PERCENTAGES FOR VARIOUS HUMIDITY CONDITIONING FOR NARMCO 5206/MODMOR II GRAPHITE COMPOSITES

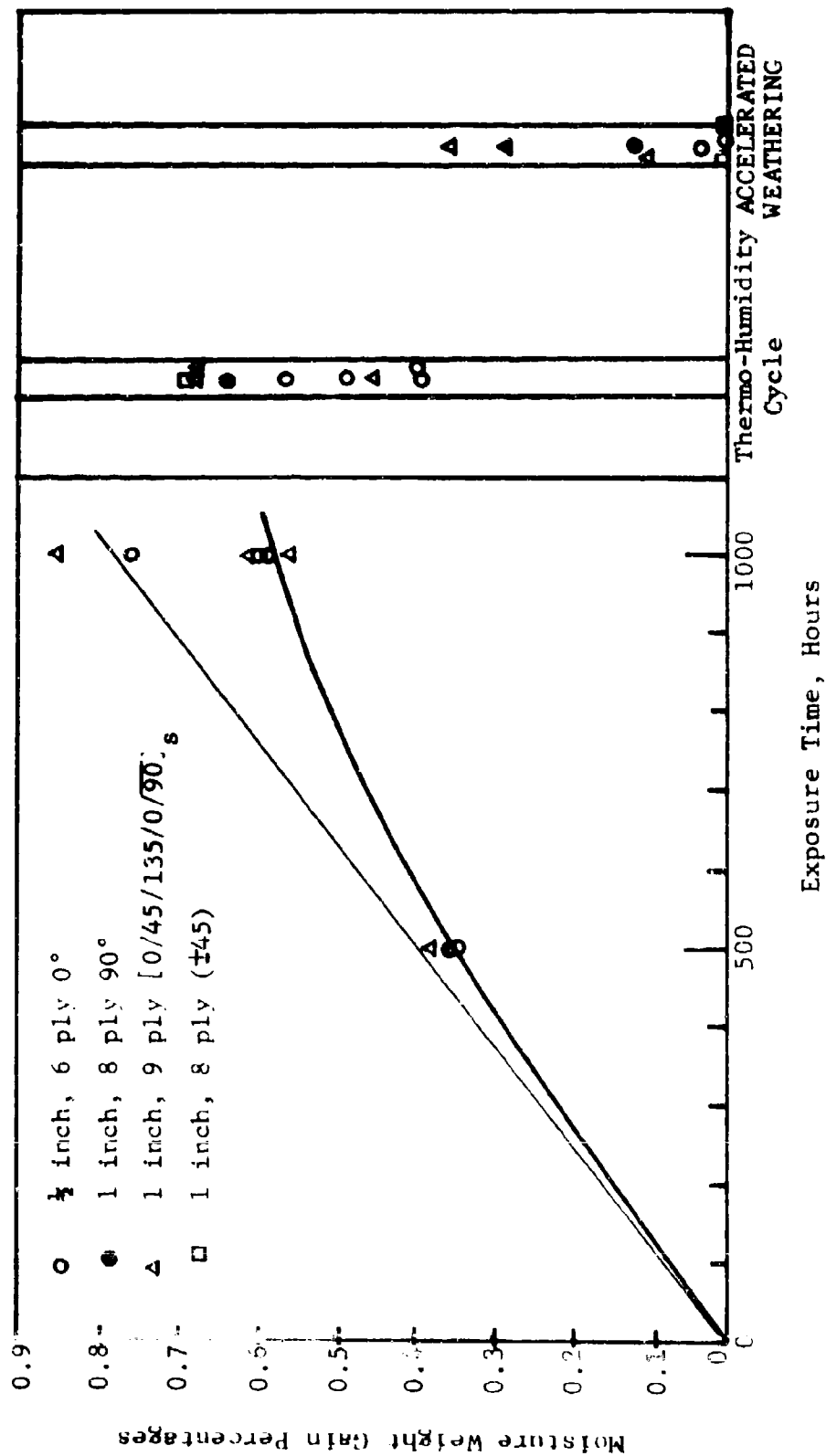


Fig. 3 MOISTURE WEIGHT GAIN PERCENTAGES FOR VARIOUS HUMIDITY CONDITIONING
FOR HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES

laminate provide more potential entry paths for moisture to enter the specimen.

Groups of specimens of a given type were inserted at various times into the humidity chamber on their appropriate schedules. Therefore several different points appear at the same total exposure time. Each point represents an average of from 10 to 20 specimens of the type indicated. Thus the variability of moisture pickup from group to group can be obtained from Figs. 1 - 3 as well. Figs. 1 and 2 do not show any 1000 hour steady-state moisture pickups. This data was not obtained.

The results for the Thermo-Humidity Cycle and the accelerated weathering cycles show marked differences between specimen orientation. By examining the AVCO 5505/Boron spread for the Thermo-Humidity cycle one sees that the 0° specimens percentage weight gain falls to the lower side of the spread of data while the 90° and [0/45/135/0/90]_s specimens generally lie at the top of the spread of data (indicating higher moisture pickup percentages). The same qualitative remarks apply to the accelerated weathering moisture pickup data even though the mean and spread of the accelerated weathering data are smaller.

In general, the Thermo-Humidity cycle data corresponds to approximately 500 hour of constant humidity exposure and the accelerated weathering data corresponds with approximately 50 to 150 hours of constant humidity exposure (for AVCO 5505/Boron). Slightly smaller weight gains were recorded for the Narmco 5206/Modmor II Graphite than were recorded for the AVCO 5505/Boron system. However, qualitatively the relationship of fiber orientation to moisture pickup remained the same. Similarly the correspondence of the constant relative humidity to the Thermo-Humidity cycle and the accelerated weathering cycles remained the same.

The largest moisture pickups and greatest data spreads were found in the Courtaulds HMS Graphite/Hercules 3002M system. Here the moisture pickup for the Thermo-Humidity cycle exceeded the moisture pickup for constant humidity at 500 hours, corresponding more closely with a constant humidity exposure of approximately 800 hours. Similarly, the accelerated weathering moisture pickup was greater, but less than in the Thermo-Humidity cycle, and corresponded to constant humidity exposures ranging from a couple of hours up to 500 hours. The greatest number of data points fell nearer the bottom of this range (at or near 75 hours exposure on the constant humidity moisture pickup curve).

These correspondences with the constant humidity moisture pickup curves were not surprising since, in fact, the total exposure time for the Thermo-Humidity cycle to 98% RH at 120°F (the constant humidity exposure) was 500 hours less than the 1-1/2 hours per day times 15 days or approximately 478 hours exposure. Similarly the net exposure time for the accelerated weathering samples to high moisture was,

$15 \times \left(\frac{18}{60}\right) \times 12 \text{ periods} = 54 \text{ hours of net exposure time to moisture with } 306 \text{ hours of light and heat plus } 140 \text{ hours of inactivity out of a total of } 500 \text{ hours in the exposure cycle.}$

In summary the cyclic humidity conditioning treatment produce moisture gains approximately the same as that for the net moisture exposure time during the constant humidity exposures.

The room temperature longitudinal tensile stress-strain behavior of AVCO 5505/Boron composite material is shown in Fig. 4 after 500 and 1000 hours exposure to 98% RH. The transverse tensile stress-strain behavior of AVCO 5505/Boron is shown in Figs. 5 to 7 for room temperature, 260°F and 350°F respectively. It is apparent from these curves that the effect of moisture is

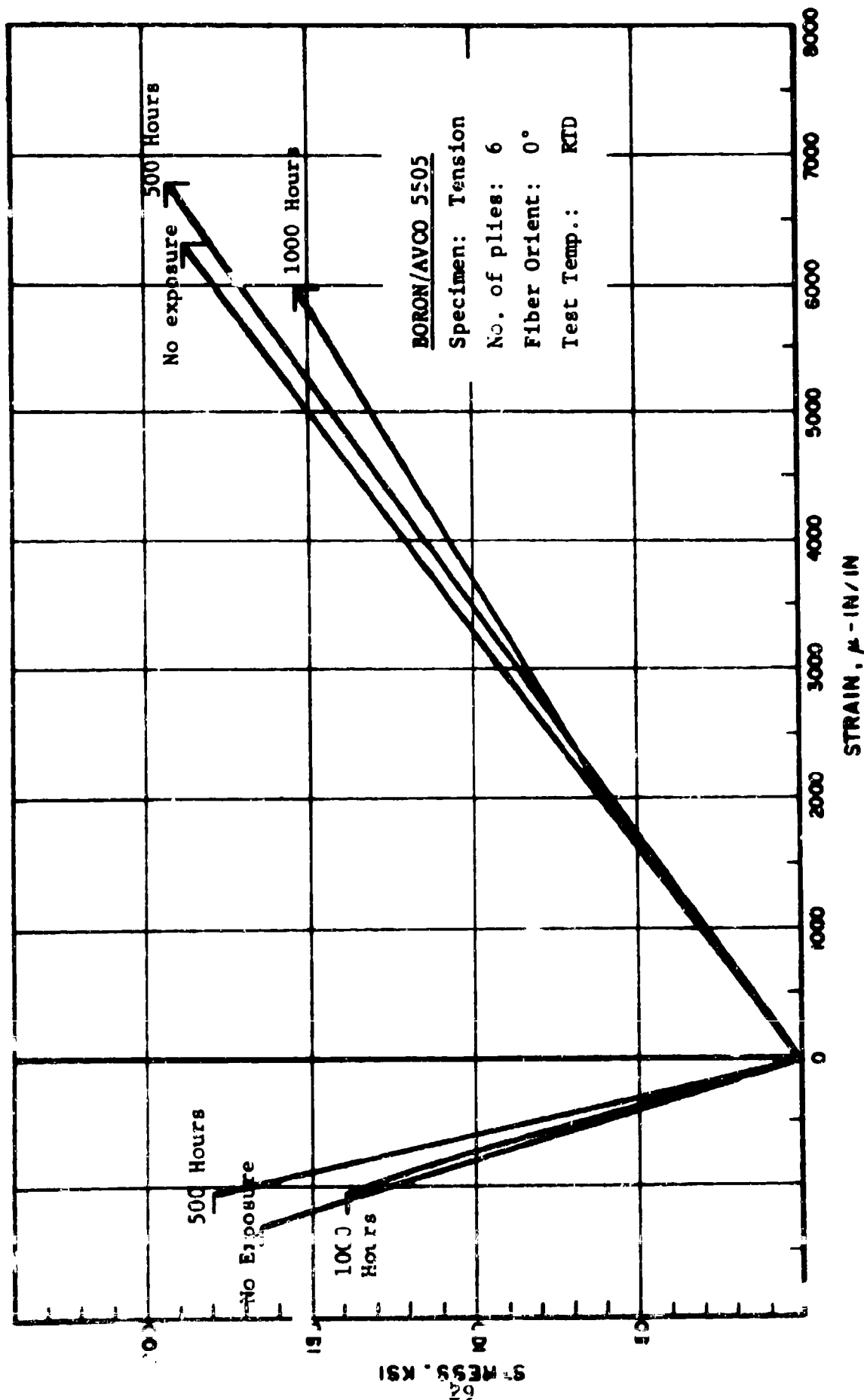


Fig. 4 COMPARATIVE TENSILE BEHAVIOR OF 0° BORON/AVCO 5505 BEFORE AND AFTER 500 AND 1000 HOURS EXPOSURE TO 98% R.H. WHEN TESTED AT ROOM TEMPERATURE

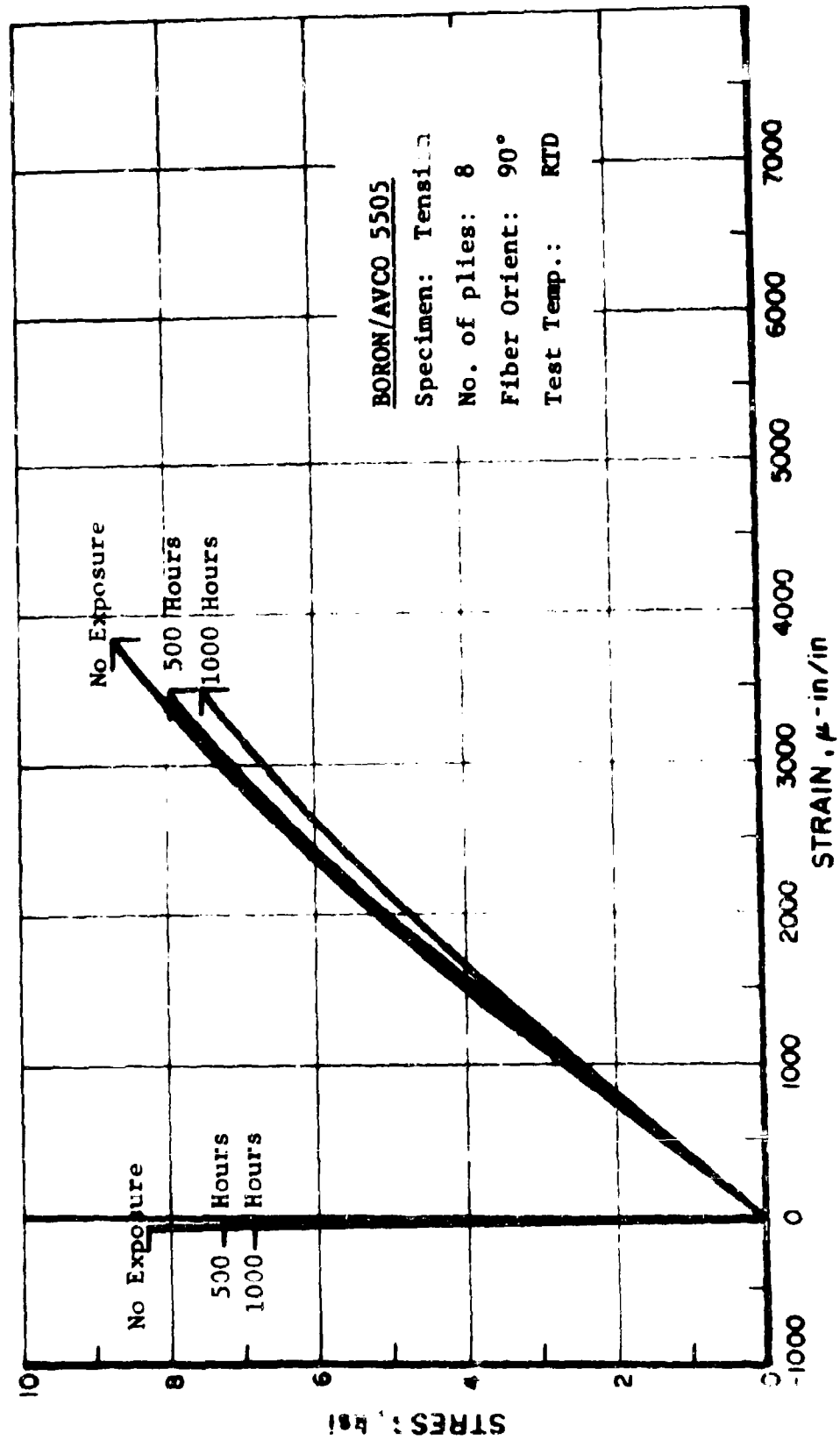


Fig. 5 COMPARATIVE TENSILE BEHAVIOR OF 90° BORON/AVCO 5505 BEFORE AND AFTER 500 AND 1000 HOURS EXPOSURE TO 98% R.H. WHEN TESTED AT ROOM TEMPERATURE

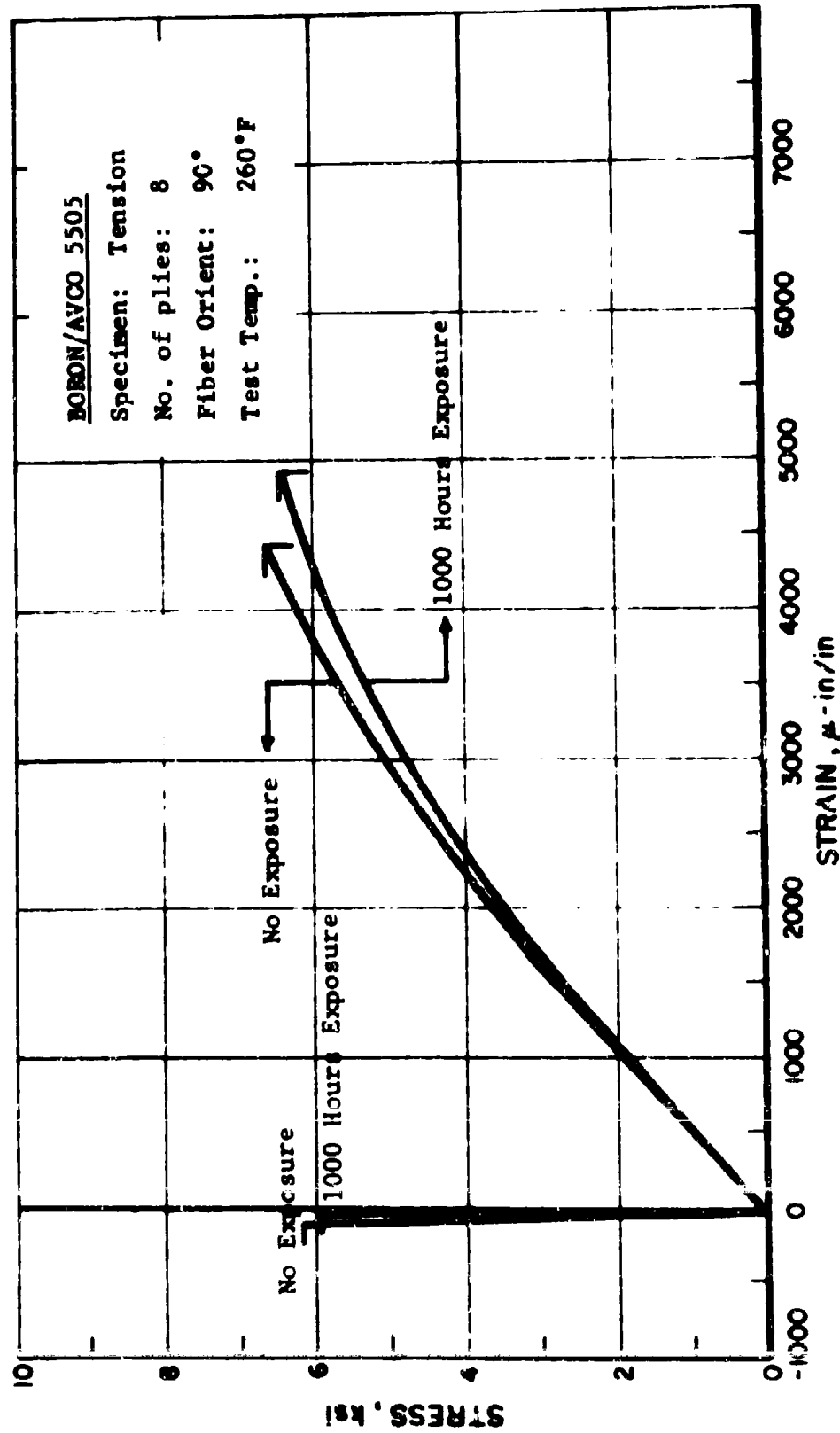


FIG. 6 COMPARATIVE TENSILE BEHAVIOR OF 90° BORON/AVCO 5505 BEFORE AND AFTER 1000 HOURS EXPOSURE TO 98% R.H. WHEN TESTED AT 260°F

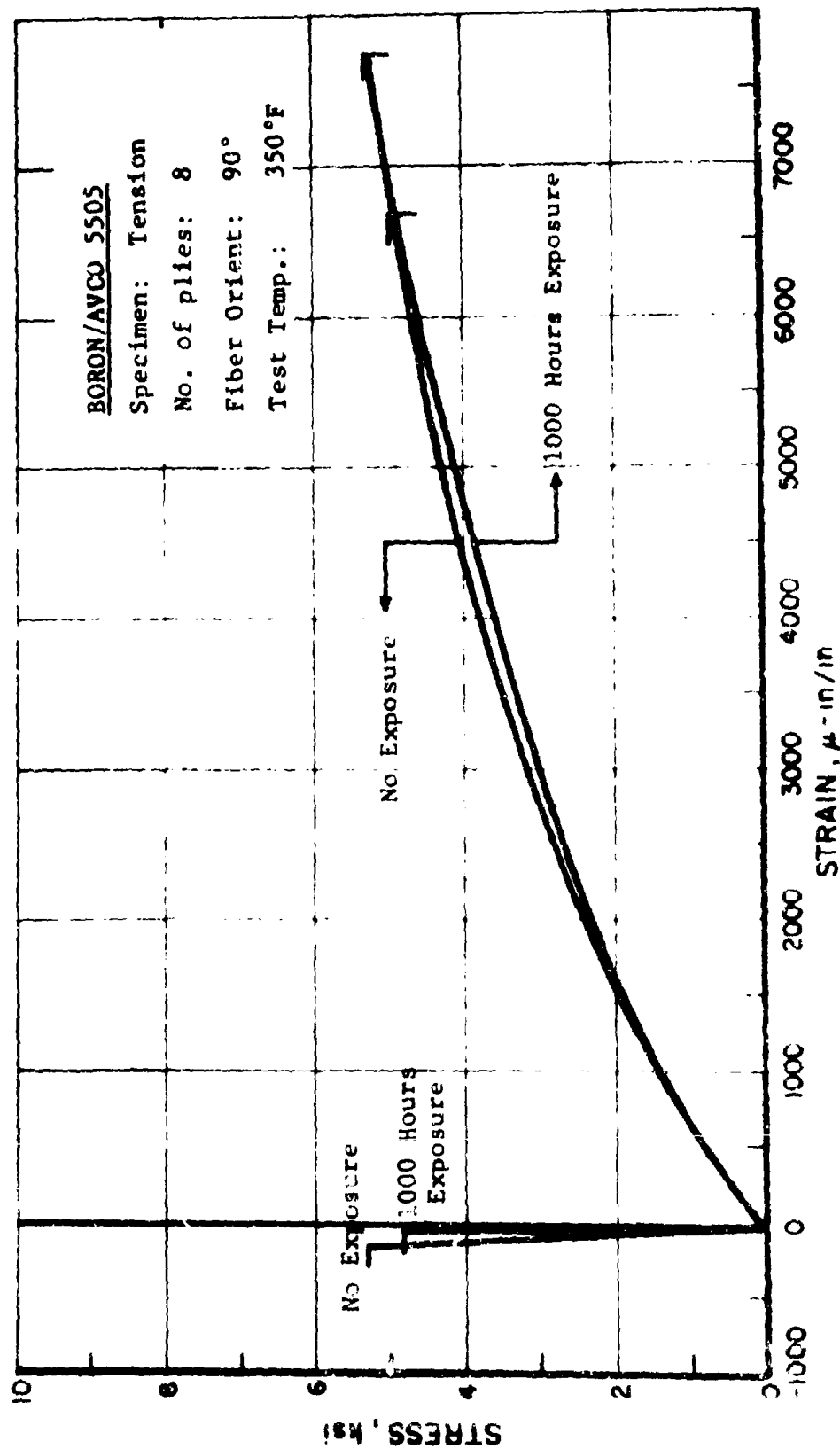


Fig. 7 COMPARATIVE TENSILE BEHAVIOR OF 90° BORON/AVCO 5505 BEFORE AND AFTER 1000 HOURS EXPOSURE TO 98% R.H. WHEN TESTED AT 350°F

to generally reduce the strength (and ultimate strain) capabilities of the 90° composite. However, the stress-strain characteristics, and particularly, the initial modulus, were not radically altered by the exposure. The effect on cross-ply laminates is shown in Figs. 8 and 9 where no significant changes in strength or modulus are observed.

The in-plane shear behavior as affected by moisture is shown in Fig. 10. Here there is a gradual loss in modulus, a slight reduction in strength and a slight gradual increase in ultimate strain capability. This loss in modulus is reflective of a matrix and interface change and does not indicate a change in fiber modulus.

The Thermo-Humidity cycle delaminated several of the samples after a hundred hours of exposure. The back-to-back high-low thermal changes were chiefly responsible. This effect was most noticeable in the high-modulus graphite and seemed to be least present for the boron/AVCO 5505 epoxy composites. This effect is caused more by the high differential thermal expansion present in the graphite/epoxy composites compared with that in the boron/epoxy composites.

The greatest damage was sustained by the Hercules 3002M/Courtaulds HMS Graphite system. Damage was noted in some of the [0/45/135/0/90]_s systems with delamination clear to the end of the sample. Where such damage was detected, the samples were tested and the delamination noted in the data tables in the appendices to this report.

The Thermo-Humidity cycle is discussed in (1)*.

* Numbers in parenthesis refer to the References at the end of this report.

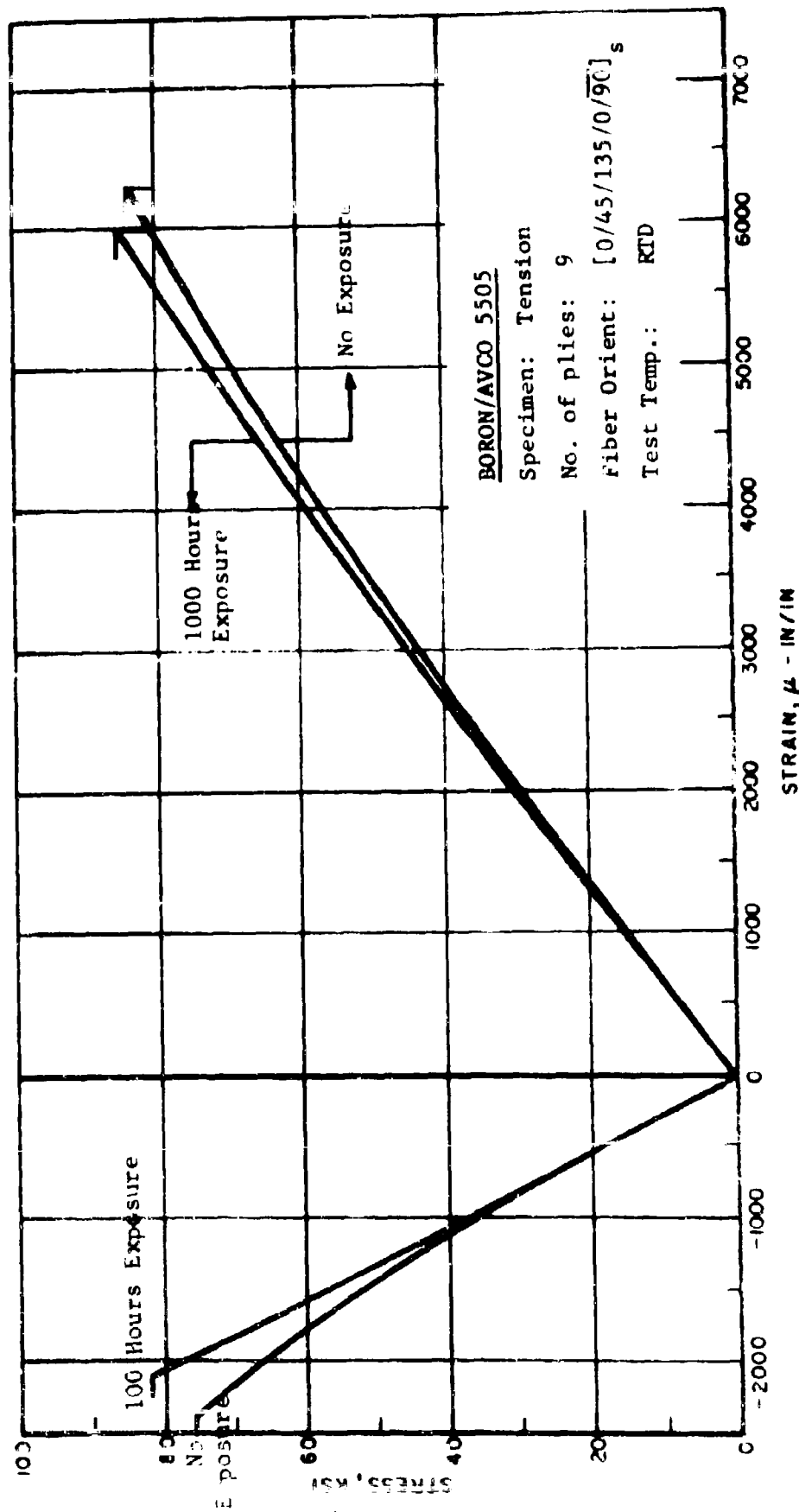


FIG. 3 COMPARATIVE TENSILE BEHAVIOR OF BORON/AVCO 5505 LAMINATE $[0/45/135/0/90]_s$ BEFORE AND AFTER 1000 HOURS EXPOSURE TO 98% R.H. WHEN TESTED AT ROOM TEMPERATURE

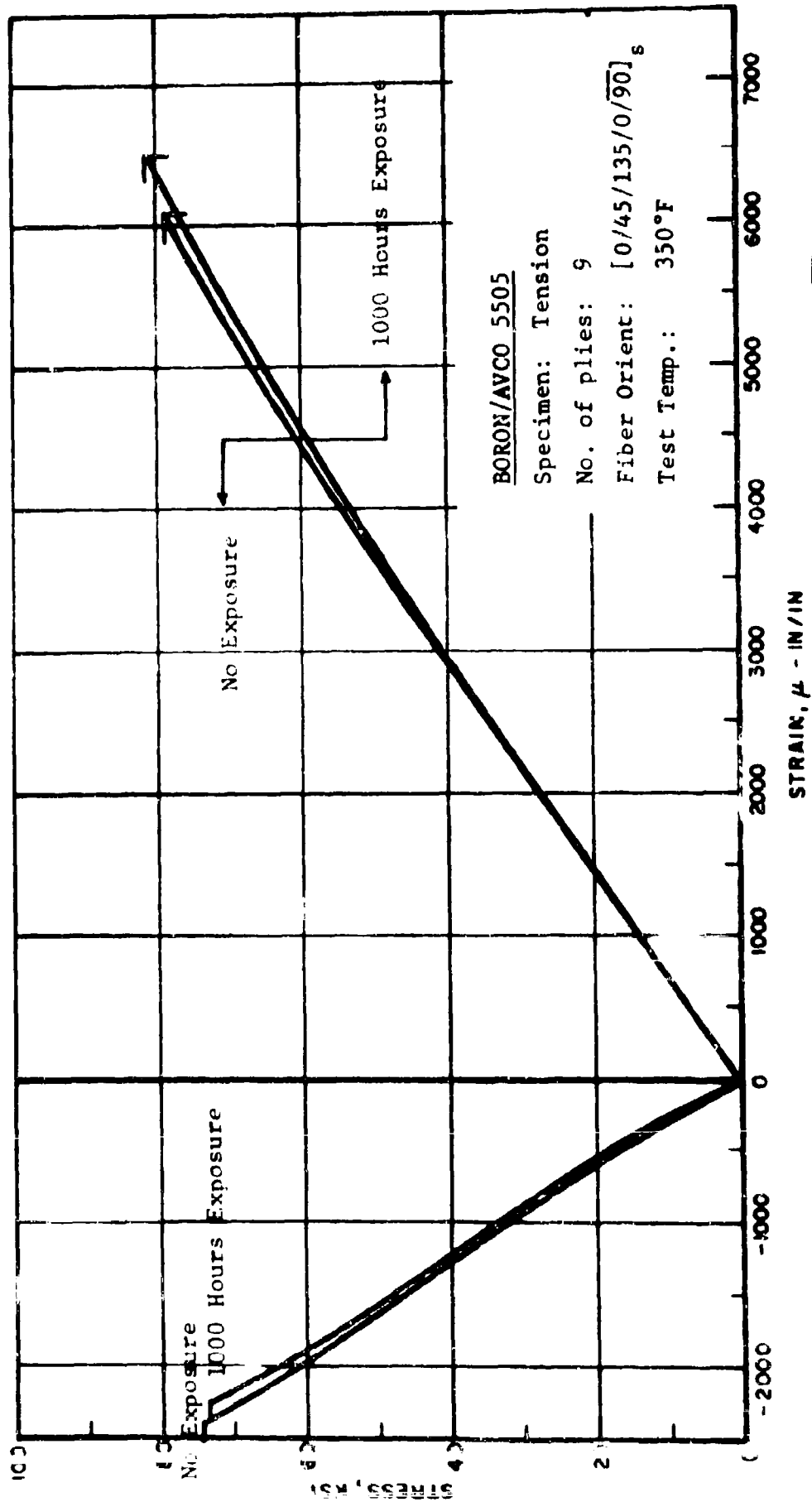


Fig. 9 COMPARATIVE TENSILE BEHAVIOR OF BORON/AVCO 5505 LAMINATE $[0/45/135/0/90]_s$ BEFORE AND AFTER 1000 HOURS EXPOSURE TO 98% R.H. WHEN TESTED AT 350°F

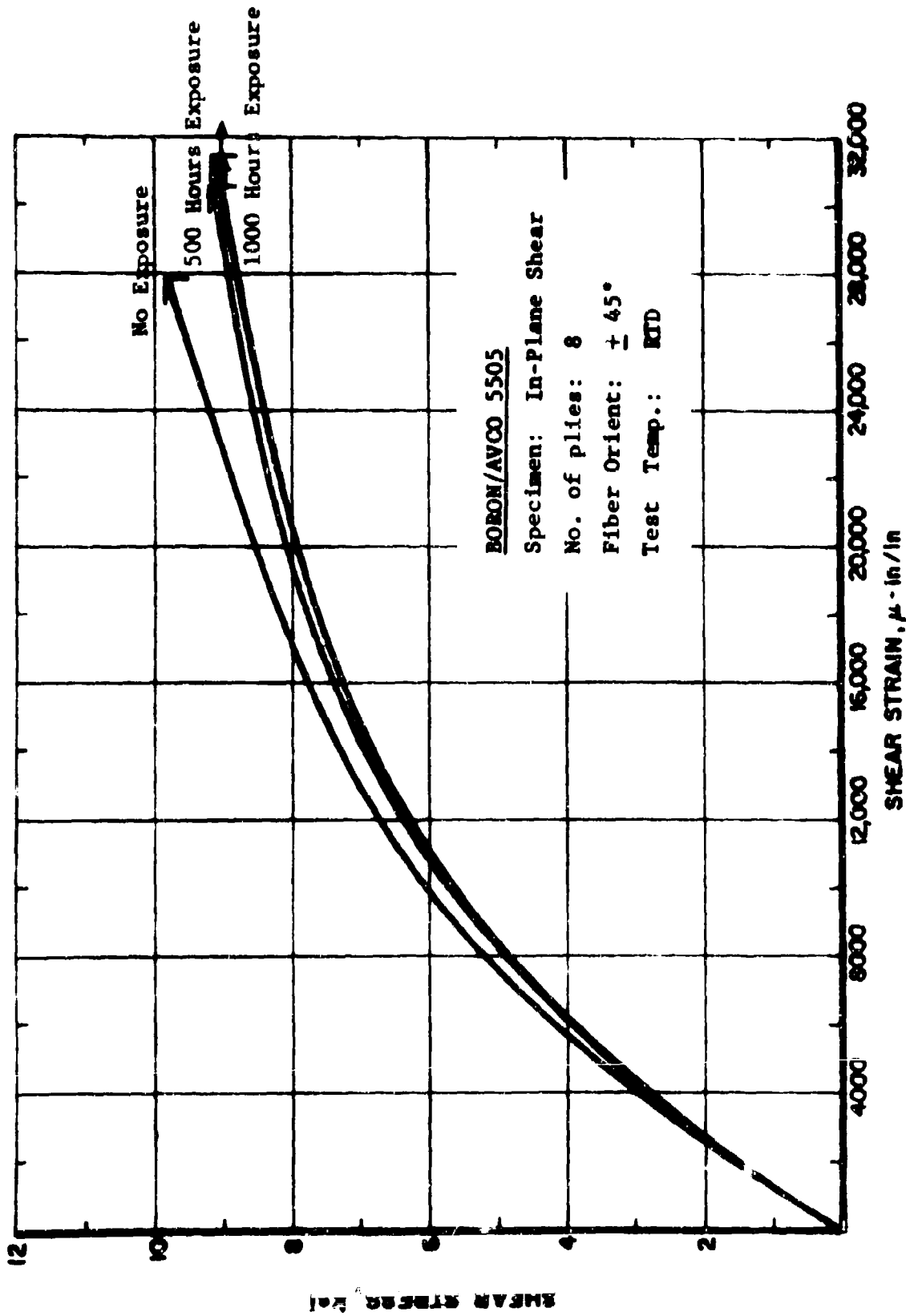


FIG. 10 COMPARATIVE SHEAR STRESS-SHEAR STRAIN BEHAVIOR OF BORON/AVCO 5505 COMPOSITE BEFORE AND AFTER 500 AND 1000 HOURS EXPOSURE TO 98% R.H. WHEN TESTED AT ROOM TEMPERATURE

The accelerated weathering cycle contained a U.V. exposure contribution which was not present in the other humidity cycles. A great deal has been published on the correlation between laboratory exposure times and field times, or on the relationship between exposure duration in one area versus exposure duration in another area. The basic photodegradative process is fairly simply stated: the weathering mechanism is a process of chemical change in which the ultraviolet radiation is the source of the energy for these changes and the air and/or water provides the oxygen etc. for the chemical change. The photodegradative efficiency of the solar energy is inversely related to the wavelength, the shorter or U.V. wavelengths causing the greatest damage.

Accelerated weathering cycles are discussed more extensively in references (2) through (13).

Several parametric crossplots illustrating the effect of moisture pickup on the mechanical properties were prepared. Figures 11 to 13 show the effects of moisture on strengths of 0°, 90° and [0/45/135/0/90]_s laminates of AVCO 5505/Boron composite material. Figures 14 to 16 show the effects of moisture on the elastic moduli of these three composites.

There is a gradual decay of the 0° tensile strength of AVCO 5505/Boron with temperature for the baseline data as shown in Fig. 11. Similar effects are seen for the 0° compressive and 0° shear strengths. With the exception of the room temperature tensile strengths, Figs. 11a -c show that the strengths generally decrease for 500 hours exposure to 98% RH with additional decrease after 1000 hours exposure. The room temperature tensile strengths are probably too low in Fig. 11a. The cyclic humidity conditioning resulted in generally greater

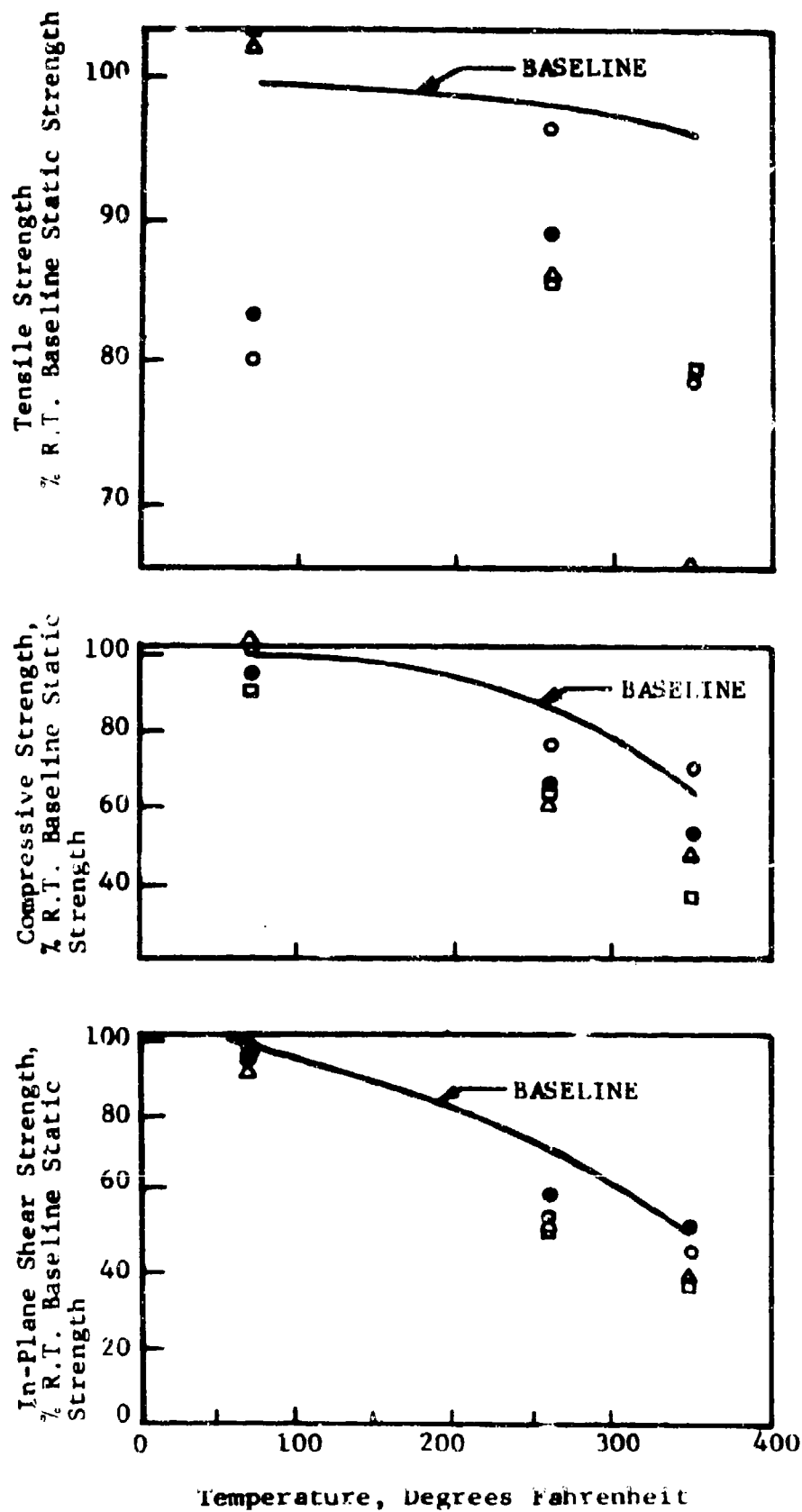


Fig. 11 EFFECT OF HUMIDITY CONDITIONING ON STRENGTHS OF AVCO 5505/BORON COMPOSITES - 0°

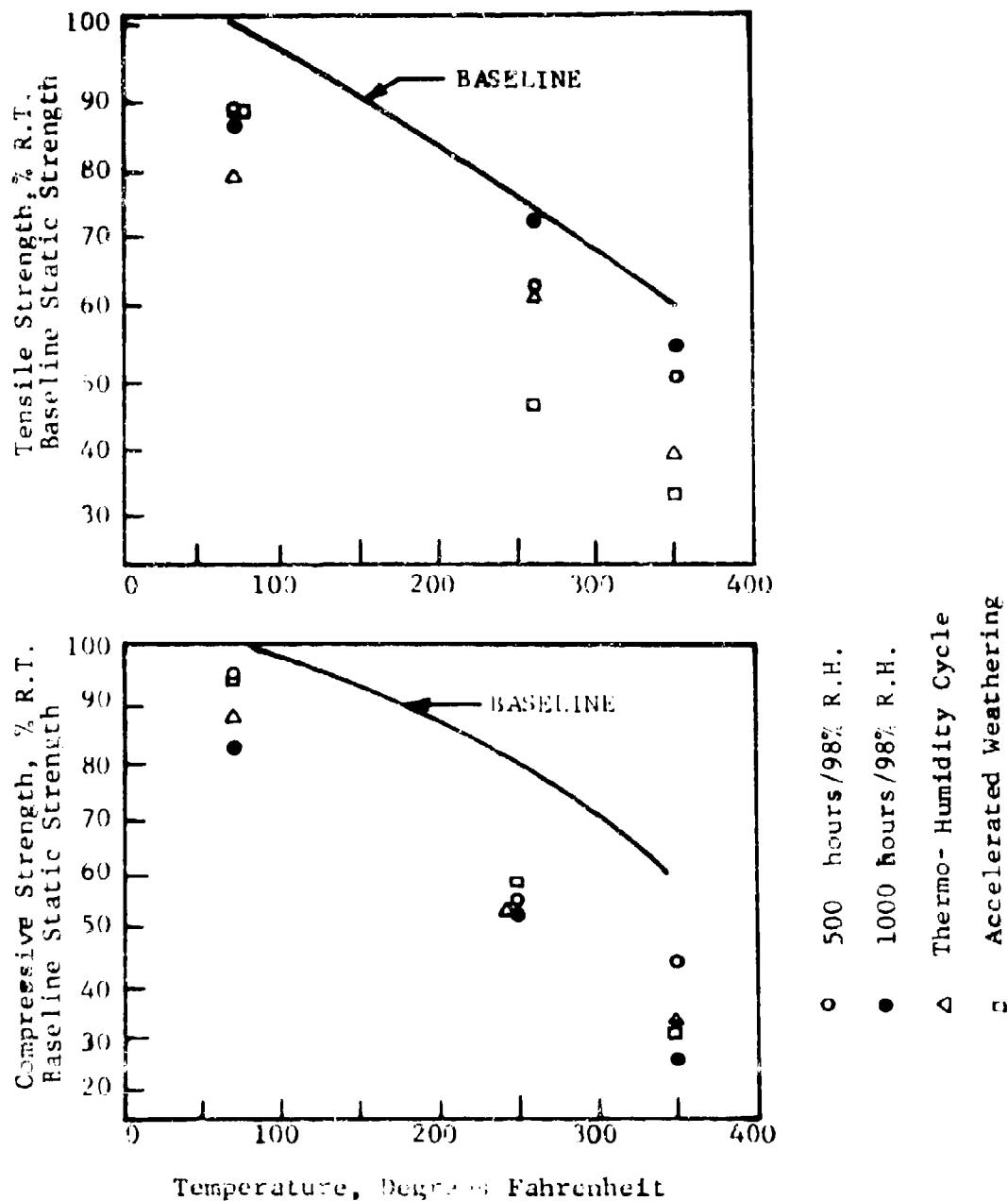


Fig. 12 EFFECT OF HUMIDITY CONDITIONING ON STRENGTHS OF AVCO 5505/BORON COMPOSITES - 90°

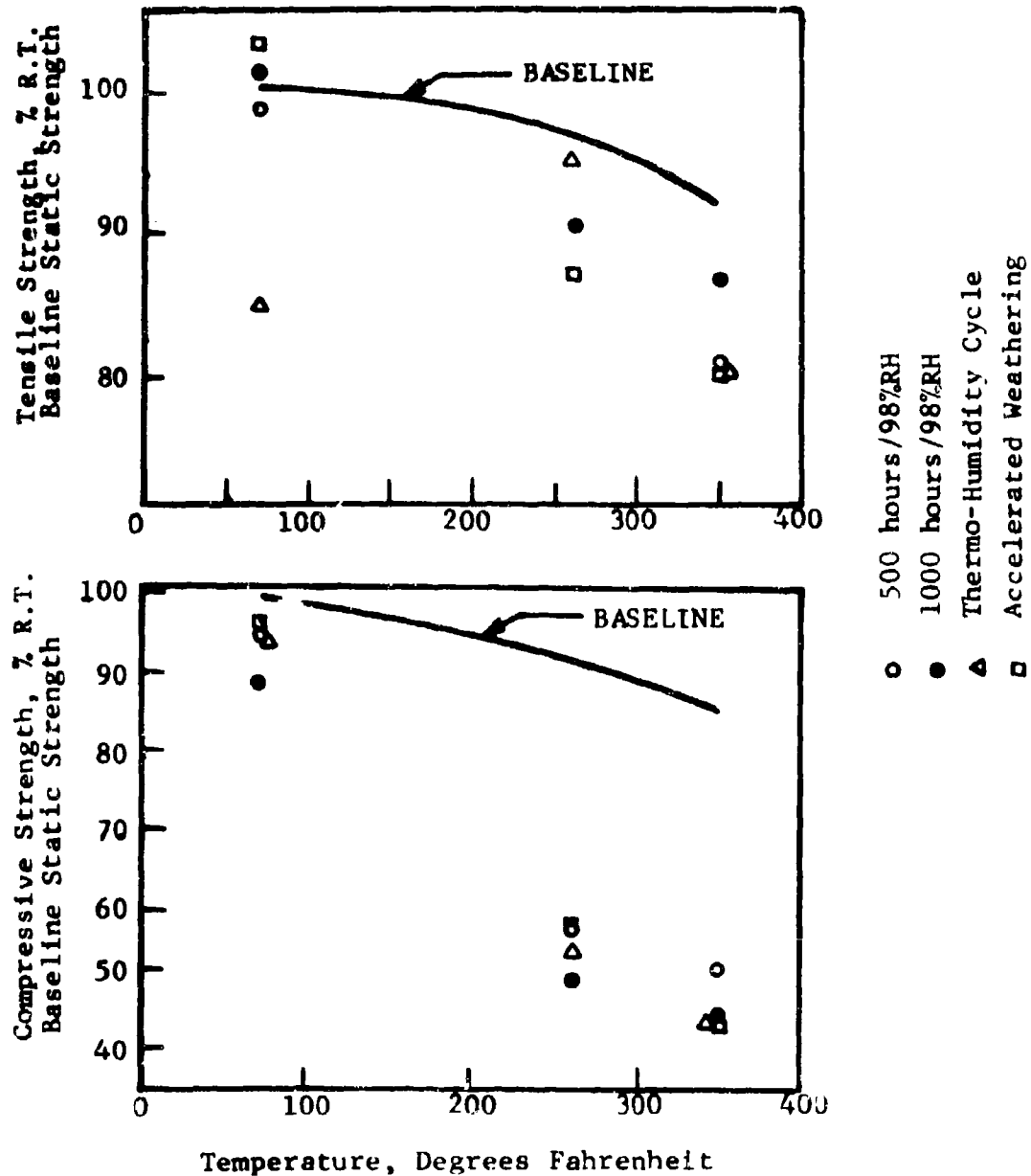


Fig. 13 EFFECT OF HUMIDITY CONDITIONING ON STRENGTHS OF AVCO 5505/BORON LAMINATES [0/45/135/0/90]_s

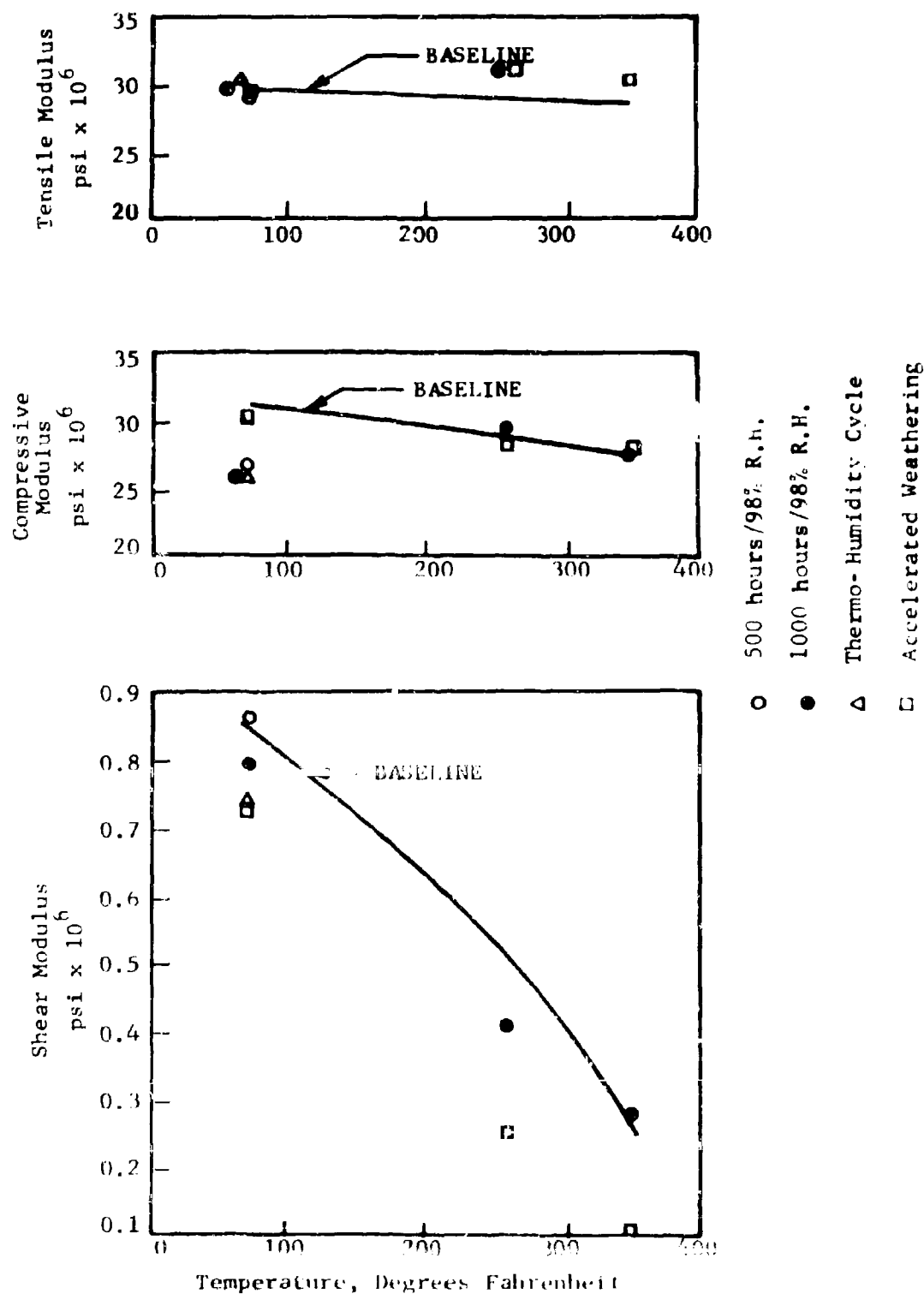


Fig. 14 EFFECT OF HUMIDITY CONDITIONING ON ELASTIC MODULUS OF AVCO 5505/BORON COMPOSITES-0

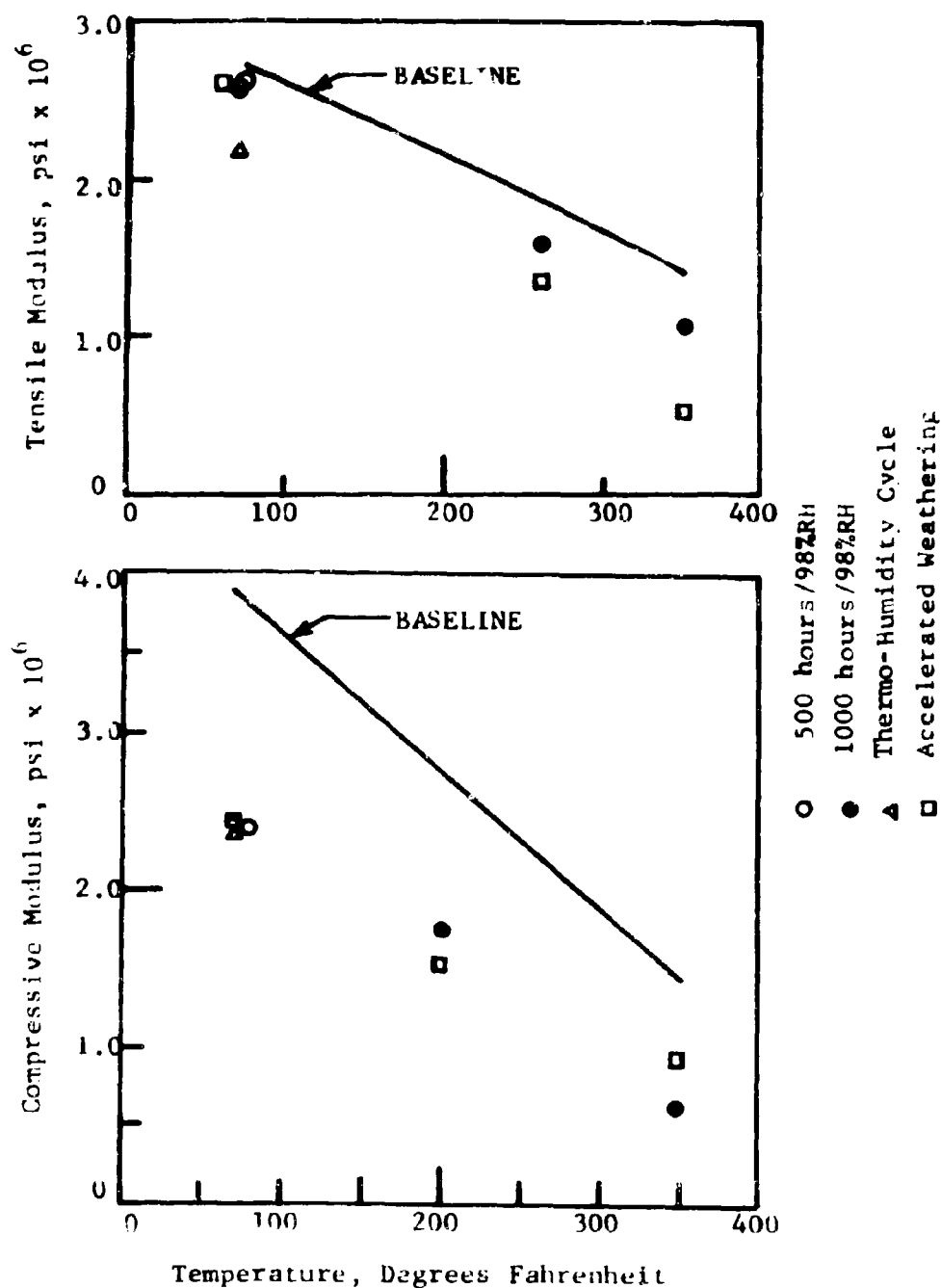


Fig. 15 EFFECT OF HUMIDITY CONDITIONING
ON ELASTIC MODULI OF AVCO 5505/BORON
COMPOSITES 90°

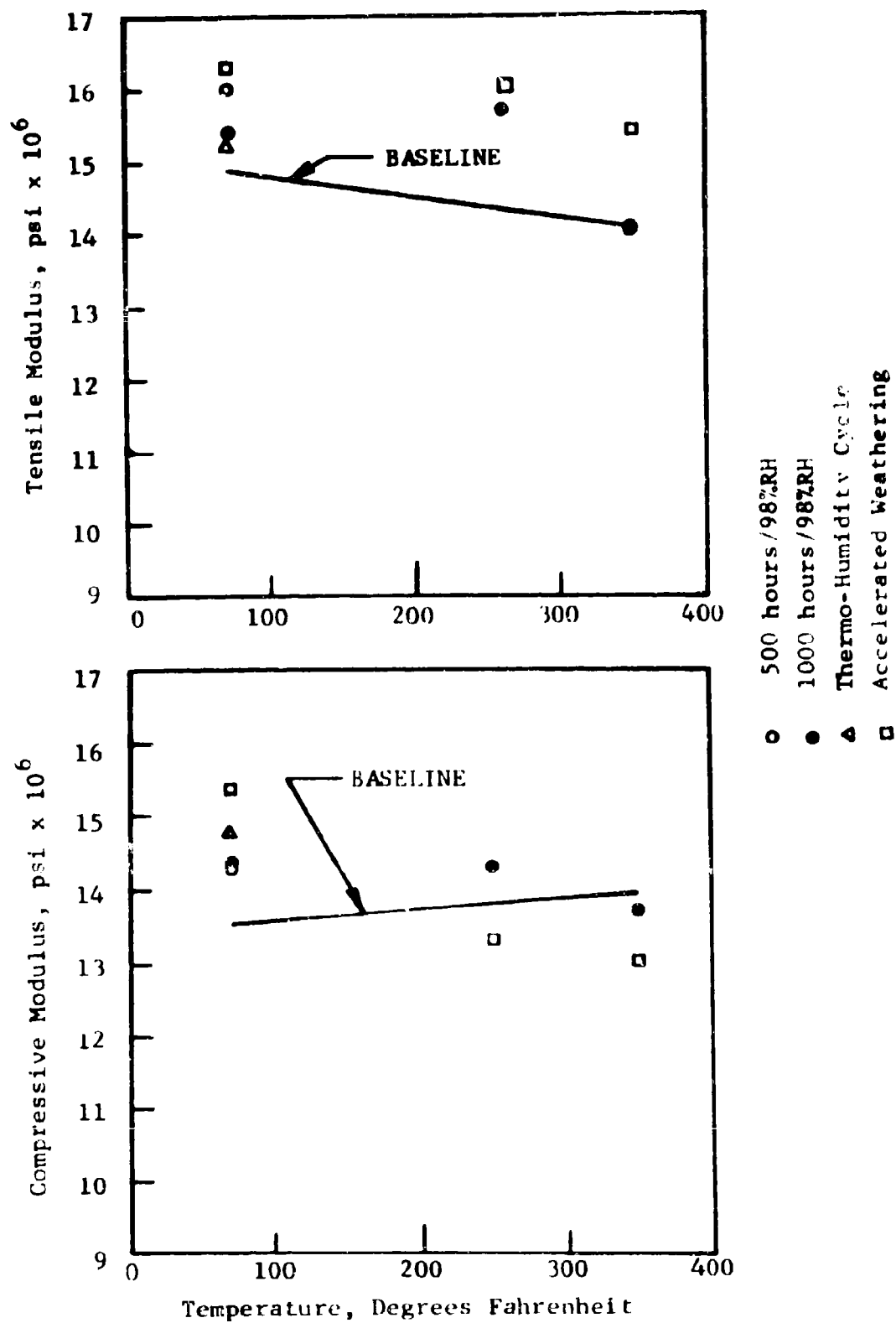


Fig. 16 EFFECT OF HUMIDITY CONDITIONING ON ELASTIC MODULI OF AVCO 55G5/BORON COMPOSITES [0/45/135/0/90]_s

strength reductions than did the steady state exposures. The transverse strengths are shown in Fig. 12a - c. Again the cyclic humidity exposures affected the tensile and compressive strengths more than did the constant humidity exposures.

The laminate strengths are plotted in Fig. 13. The elevated temperature compressive properties of the $[0/45/135/0/90]_g$ laminates were severely affected by both the steady state and cyclic humidity exposures.

The 0° elastic moduli were not as substantially affected by humidity environment (See Fig. 14) as were the 90° and laminate elastic moduli (See Figs. 15 and 16 respectively). The crossply laminate, $[0/45/135/0/90]_g$, stiffnesses increased over baseline values as a result of the humidity conditioning. The rate of stiffness decrease with temperature did not change for the 0° and 90° composites as it altered for the laminates.

With regard to the compression strength plots it should be noted that the coupon compressive values were used for these comparisons as in all following comparisons.

Similarly cross plots were made for Modmor II Graphite/Narmco 5206 composites (Figs. 17 - 22) and Courtaulds HMS Graphite/Hercules 3002M Composites (Fig. 23 - 28).

In several ways, the two graphite composites behaved similarly. The 0° tensile strength for both Modmor II/Narmco 5206 and Hercules 3002M/Courtaulds HMS Graphite Composites increased over the baseline 0° strength at room temperature although the latter's strengths at elevated temperatures fell below the baseline strengths. The inplane shear strengths for the two materials fell close to the baseline values over the entire temperature range. Furthermore, the inplane shear strengths

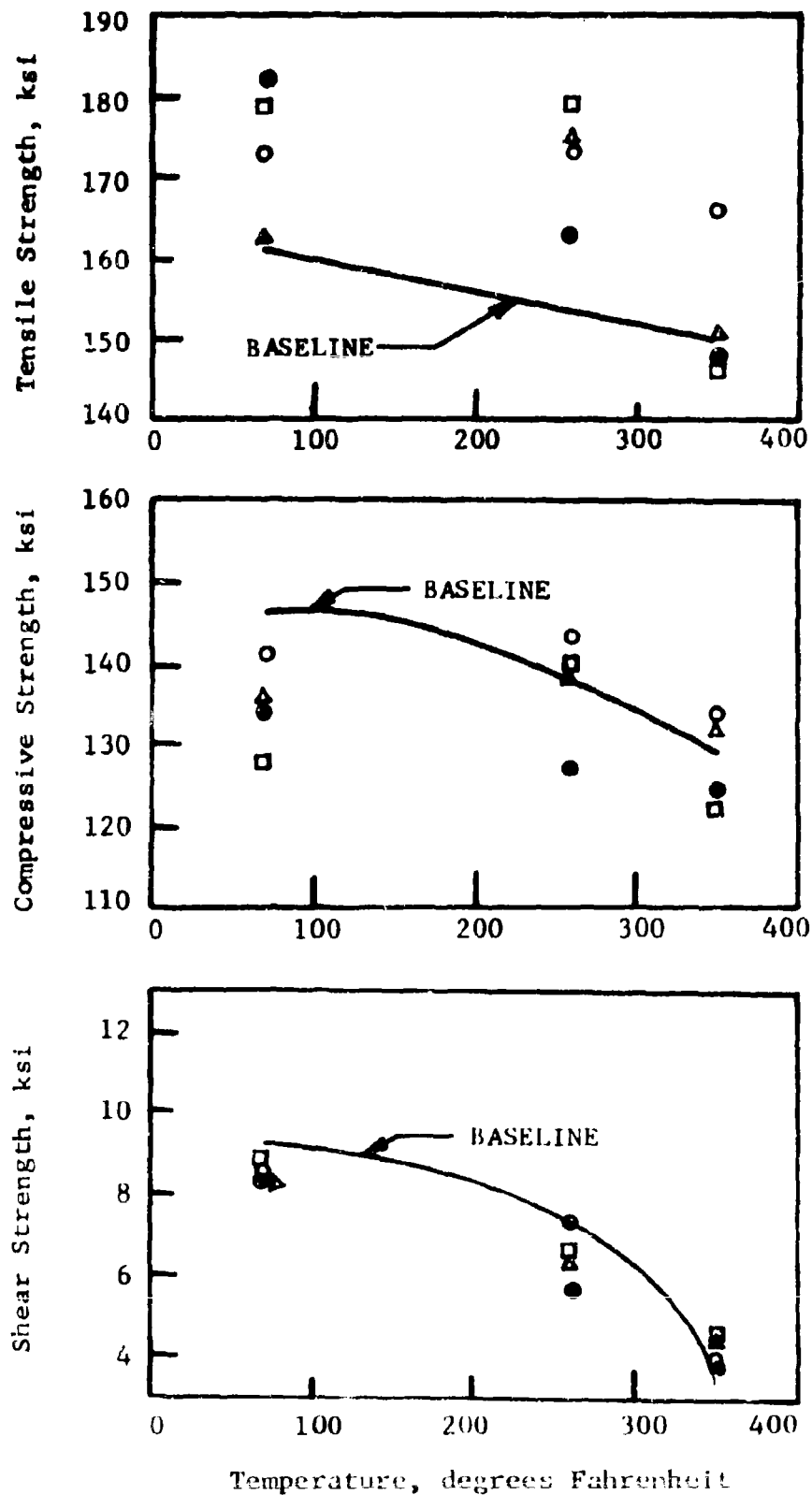


Fig. 17 EFFECT OF HUMIDITY CONDITIONING ON THE STRENGTHS OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES - 0°

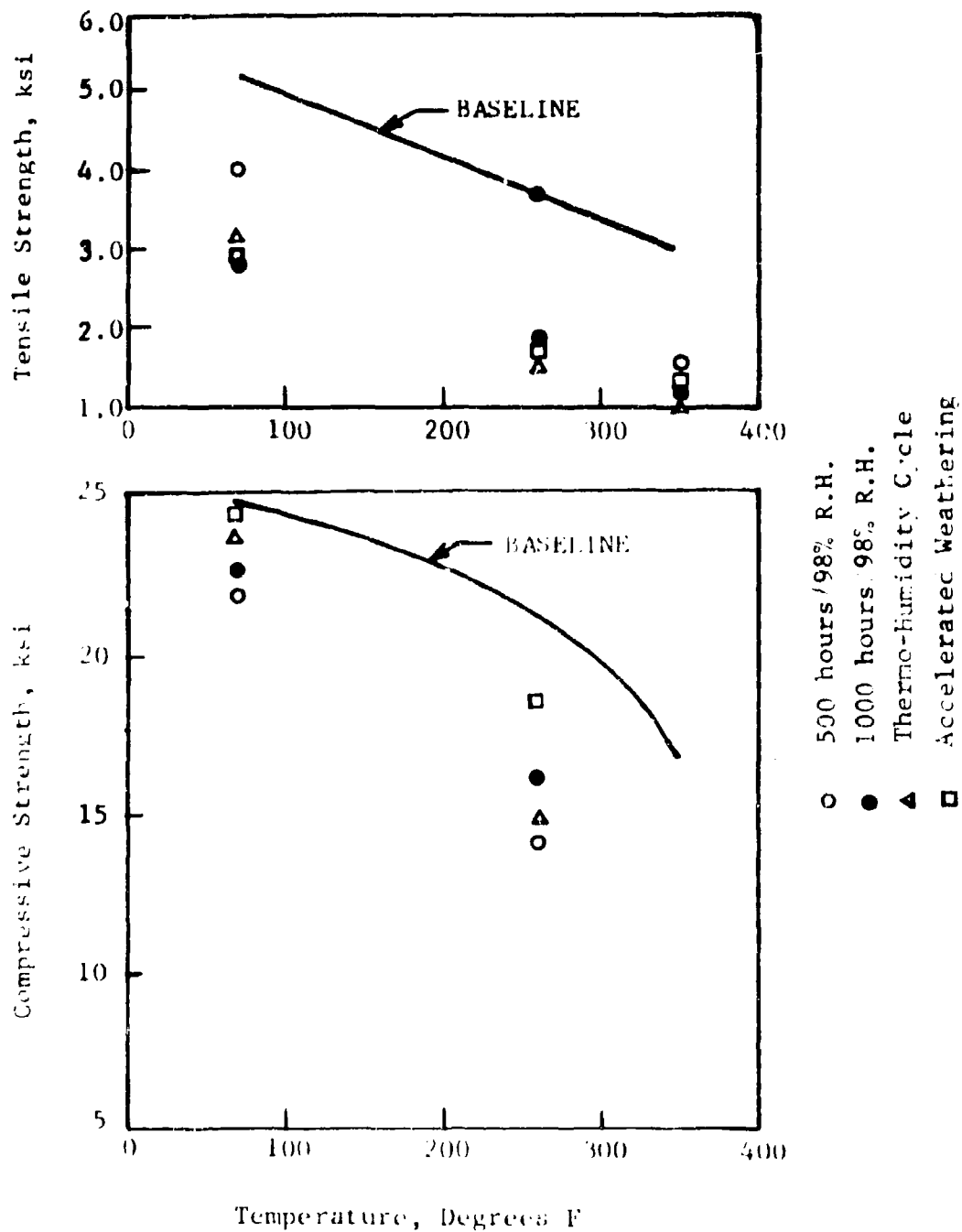


Fig. 18 EFFECT OF HUMIDITY CONDITIONING
ON THE STRENGTHS OF NARMCO 5206/MODMOR II
GRAPHITE COMPOSITES - 90°

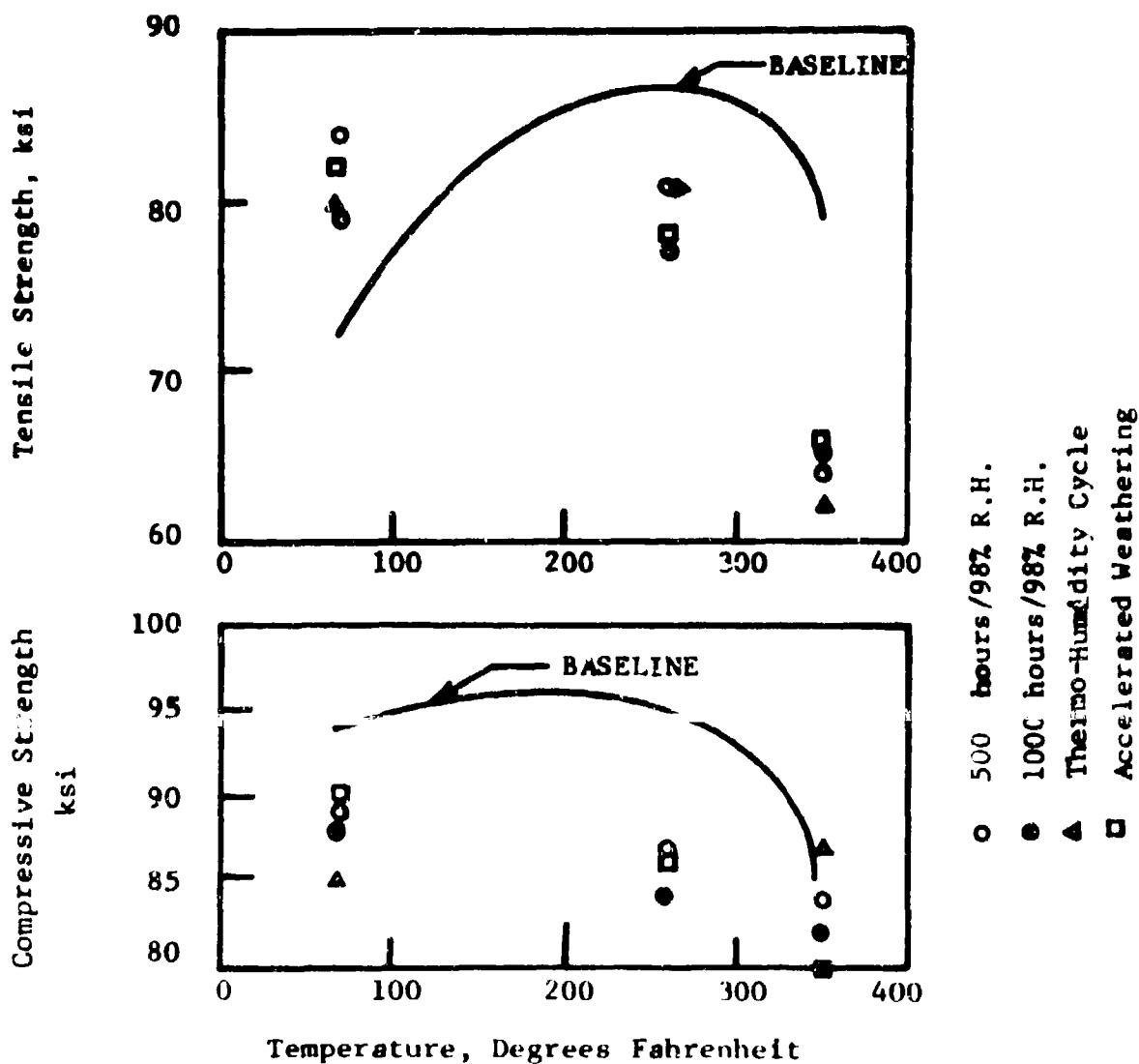


Fig. 19 EFFECT OF HUMIDITY CONDITIONING
ON THE STRENGTHS OF NARMCO 5206/MOIMOR II
GRAPHITE COMPOSITES - $[0^\circ/45/135/0^\circ/90^\circ]$

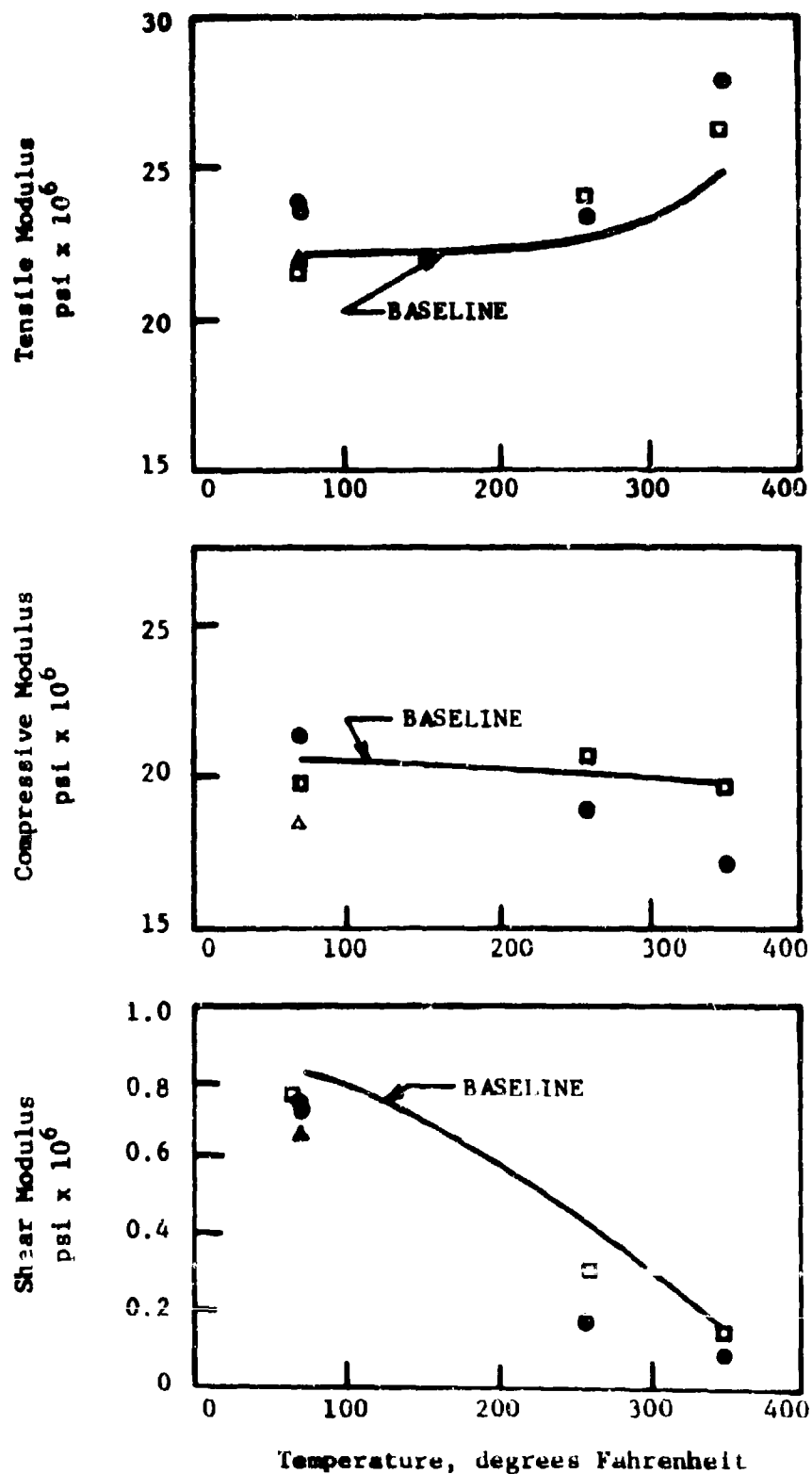


Fig. 20 EFFECT OF HUMIDITY CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MDMOR II GRAPHITE - 0° -48-

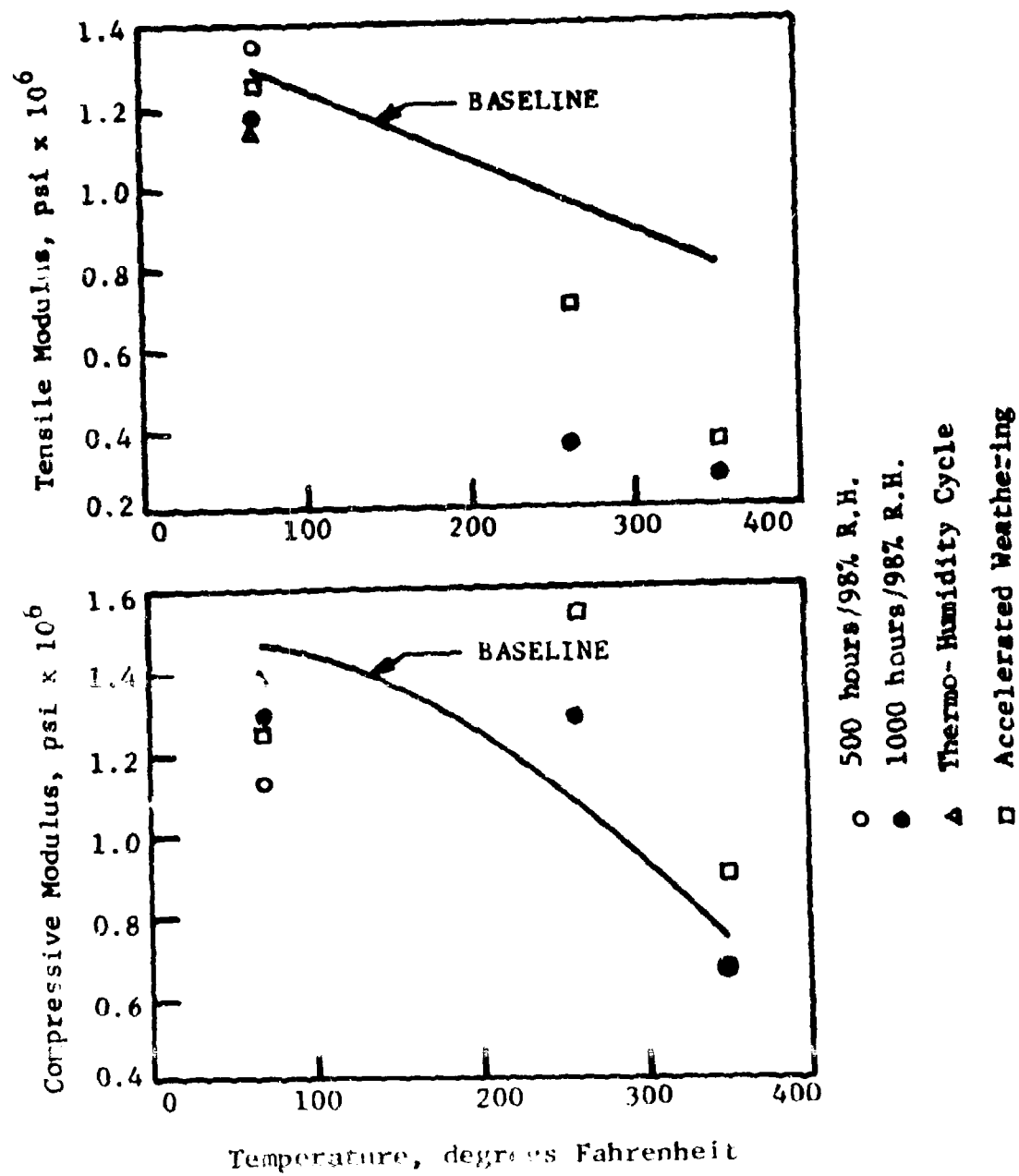


Fig. 21 EFFECT OF HUMIDITY CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MDMOR 11 GRAPHITE COMPOSITE - 90°

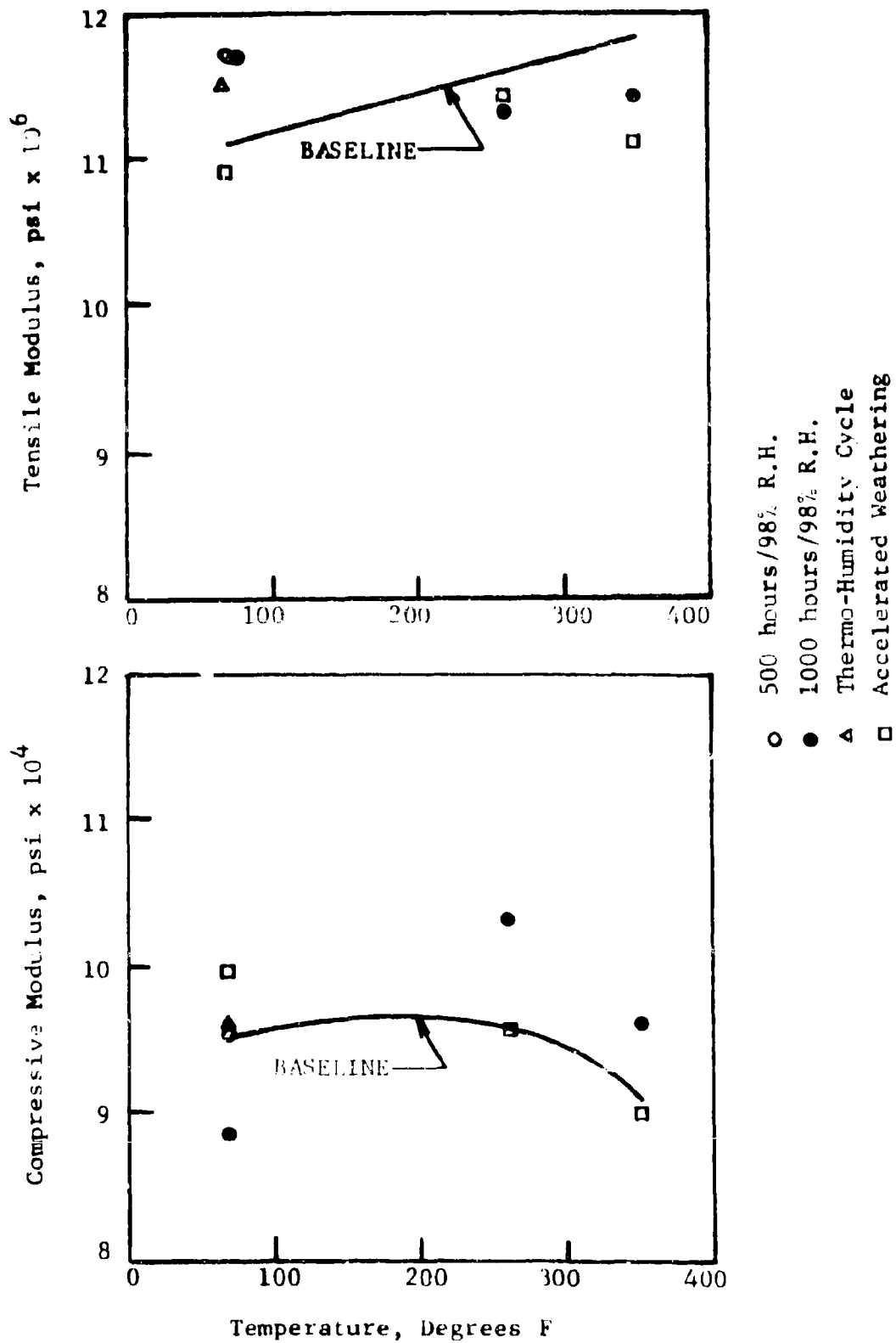


Fig. 22 EFFECT OF HUMIDITY CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MDMOR II GRAPHITE [0/45/135/0/90]

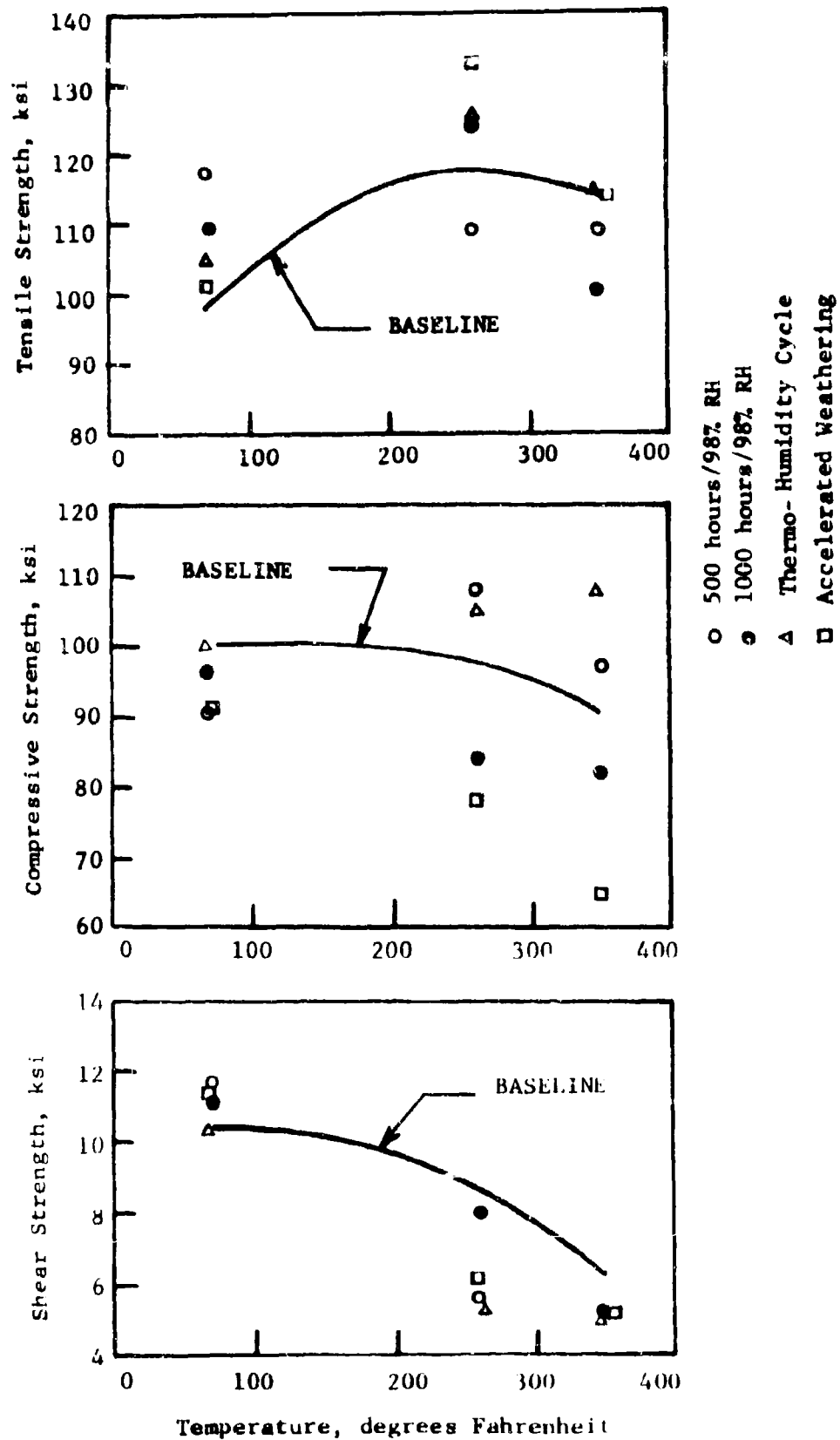


Fig 23 EFFECT OF HUMIDITY CONDITIONING ON THE STRENGTHS OF
HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 0°

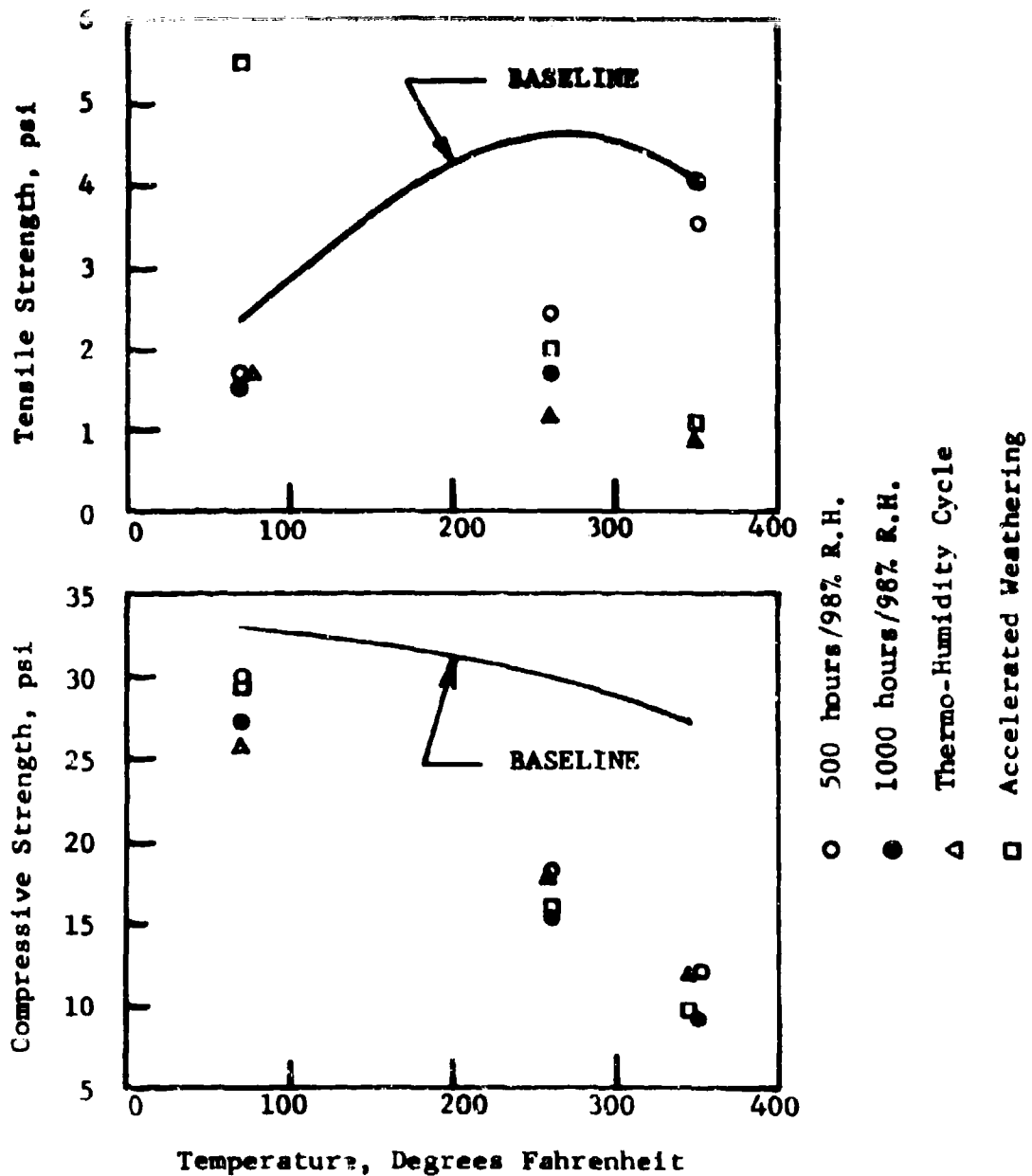


Fig. 24 EFFECTS OF HUMIDITY CONDITIONING
ON THE STRENGTHS OF HERCULES 3002M/
COURTAULDS HMS GRAPHITE COMPOSITES - 90°

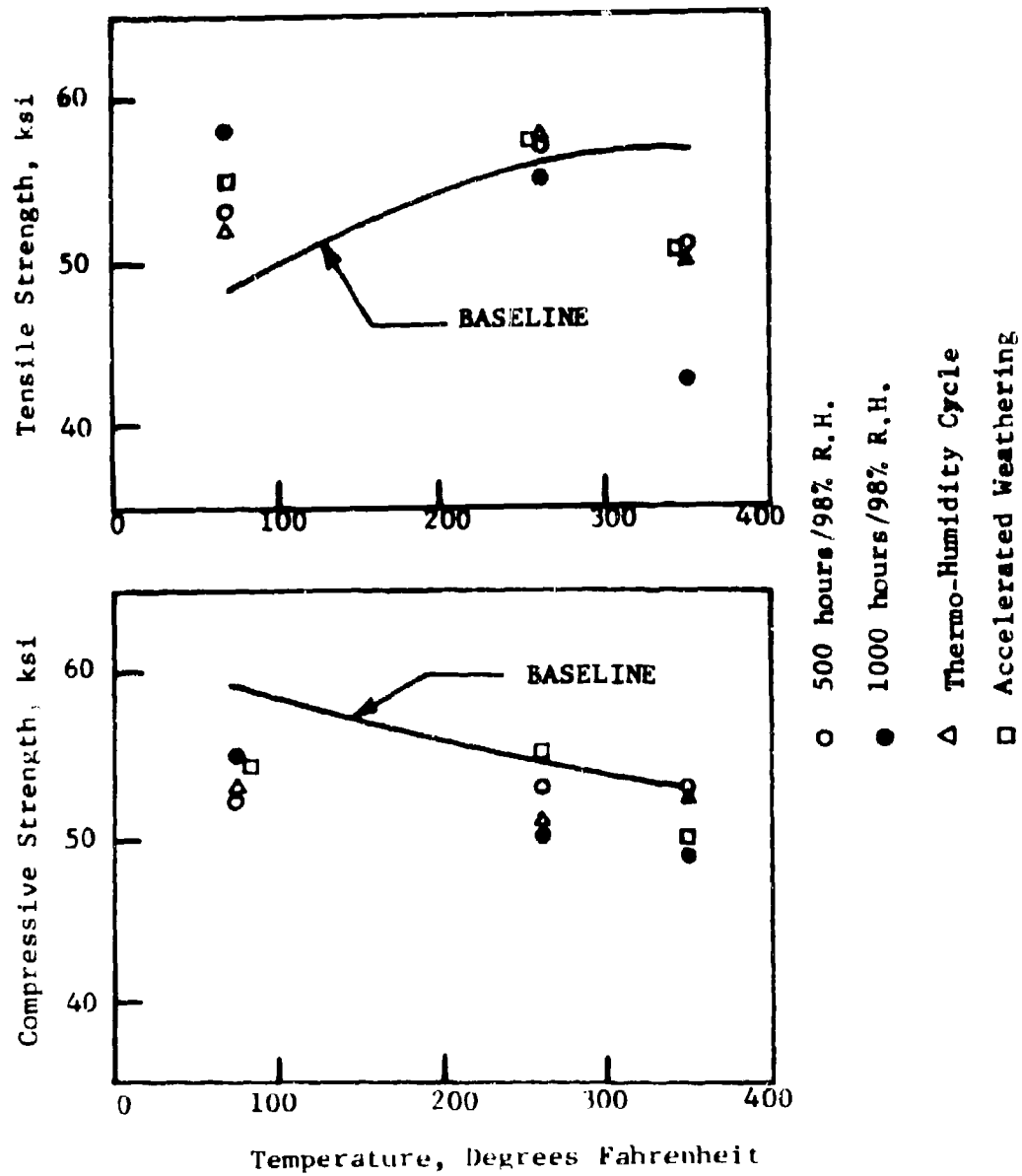


Fig. 25 EFFECTS OF HUMIDITY CONDITIONING ON THE STRENGTHS OF HERCULES 3002 M/COURTAULD'S HM'S GRAPHITE COMPOSITES - (0/45/135/0/90)s

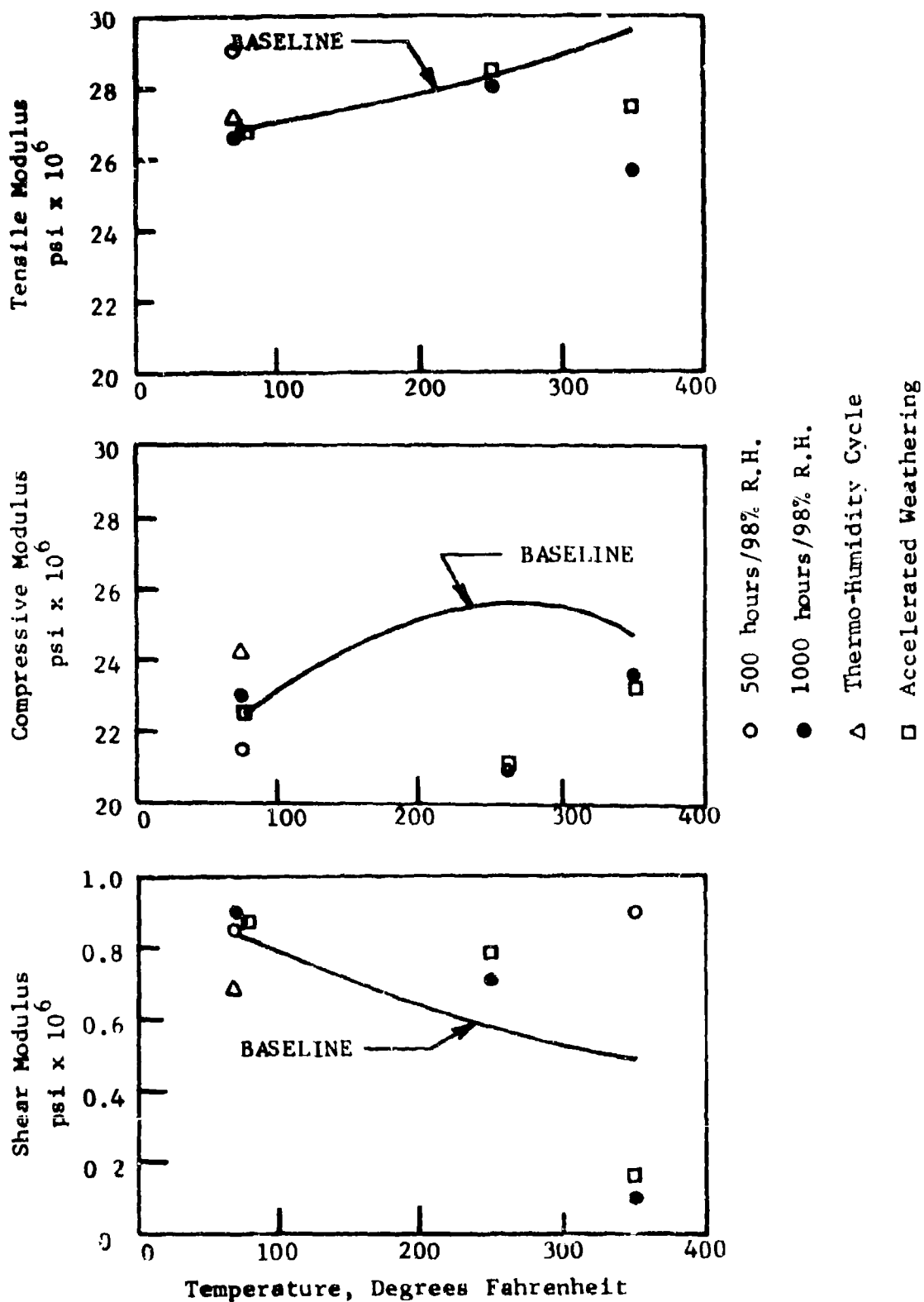


Fig. 26 EFFECTS OF HUMIDITY CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002 M/COURTAULDS HMS GRAPHITE COMPOSITES - 0°

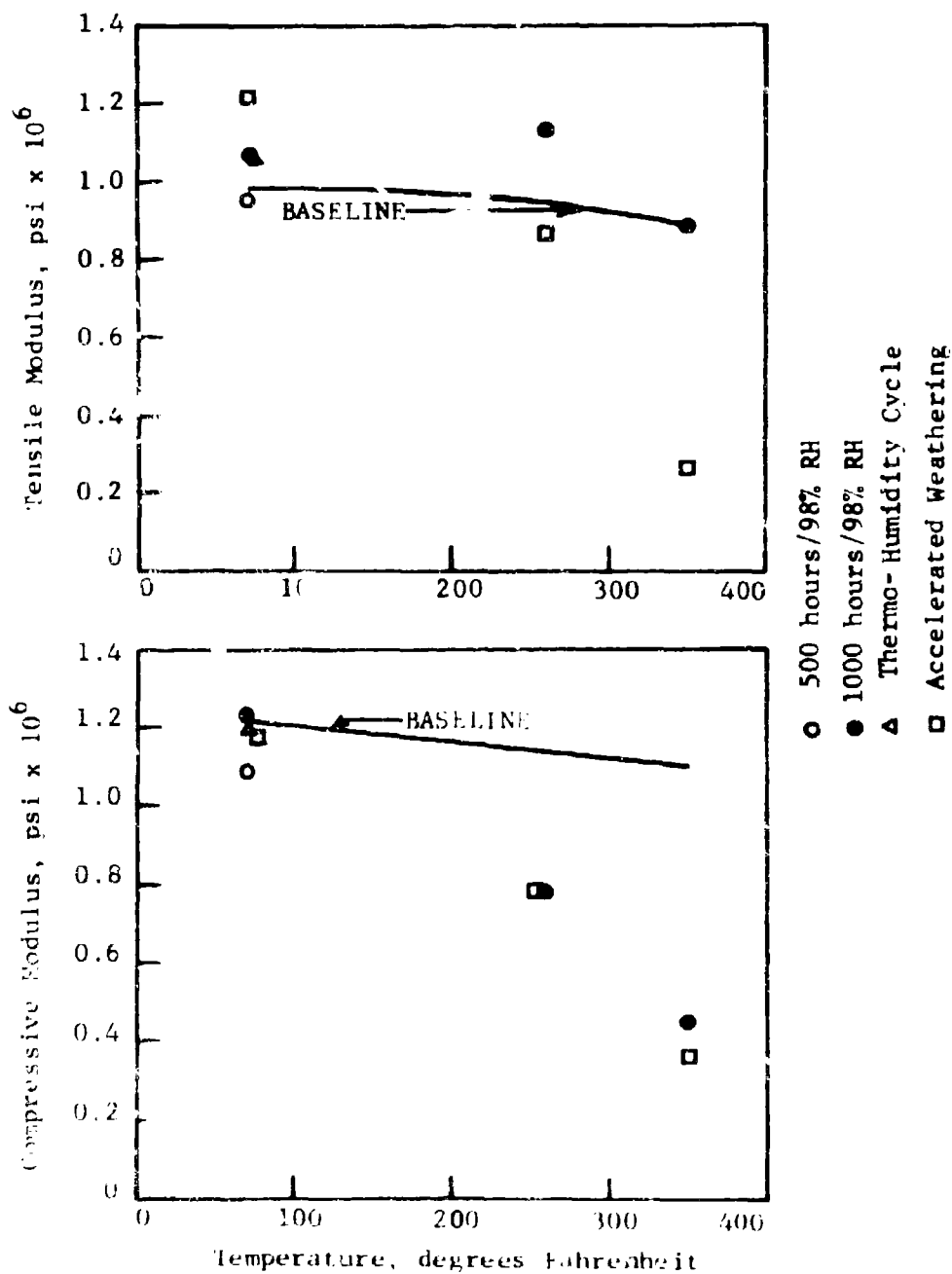


Fig. 27 EFFECT OF HUMIDITY CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/EPoxy RESIN GRAPHITE COMPOSITES - 90°

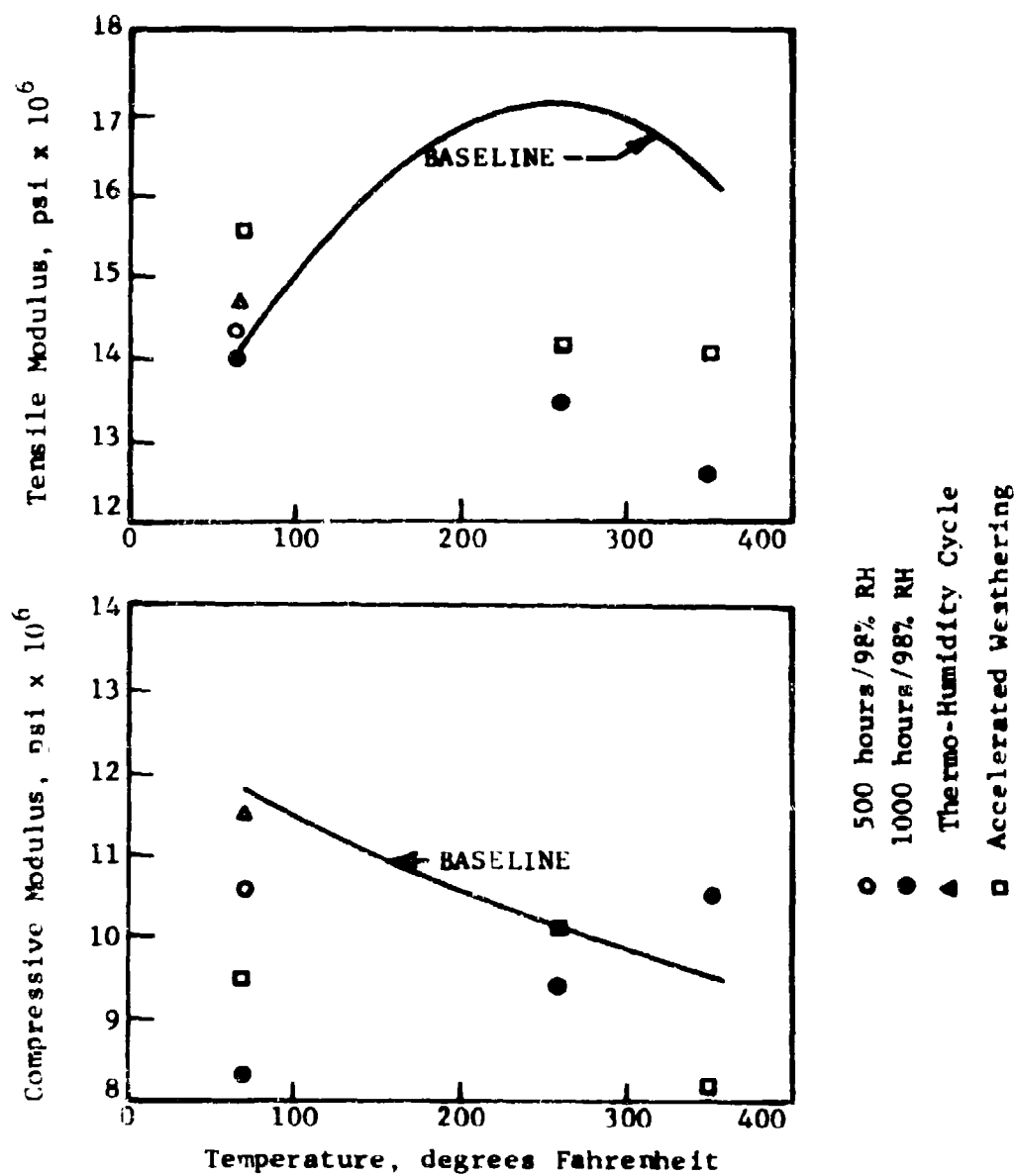


Fig. 28 EFFECT OF HUMIDITY CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - [0/45/135/0/90]

dropped rapidly with temperature increase. The 0° compressive strengths for both materials fell below the baseline values at room temperature but at elevated temperatures some of the conditioning treatments resulted in slight increases in the compressive strengths. Finally the laminate baseline tensile strengths of both materials increased with increasing temperature. The influence of the humidity conditioning on the laminate was to increase the tensile strengths at room temperature, show tensiles at 260°F fairly close to the baseline values and show a decrease at 350°F. The tensile strengths of the laminates showed an increase in the rate of change with temperature as a result of the humidity conditioning (See Figs. 19 and 25). This effect was previously noted for AVCO 5505/Eoron (See Fig. 13) but much less so than in the two graphite laminates. The 90° baseline compressive strengths of both graphite materials were affected by temperature and the rate of strength decrease with temperature was higher as a result of prior humidity conditioning. The compressive strengths of the two graphite/epoxy composites were not influenced substantially by either temperature or prior humidity conditioning. The Modmor II/Narmco 5206 Graphite laminate was affected proportionately less than was the Hercules 3002M/Courtaulds HMS Graphite laminates.

The moduli of the two graphite composite systems are shown in Figs. 20 - 22 and Figs. 26 - 28 for the Modmor II/Narmco 5206 and the Hercules 3002M/Courtaulds HMS Graphite respectively. The 0° tensile moduli of both systems increased with temperature. The baseline 0° compressive strength of Modmor II Graphite/Narmco 5206 remained constant over the temperature range but the Hercules 3002M/Courtaulds HMS Graphite 0° compressive strength increased with increasing temperature. The baseline inplane shear strength of both materials decreased

with temperature. Both the tensile and compressive baseline transverse moduli and the laminate compressive baseline moduli decreased with increasing temperatures. Similarly the baseline tensile moduli of the laminate, $[0/45/135/0/90]_s$, increased with increasing temperatures. Humidity conditioning did not substantially change the 0° moduli of either material. The 90° and $[0/45/135/0/90]_s$ moduli were affected substantially by the humidity conditioning. No real differences between steady state and cyclic humidity conditioning were noted for the graphites as they were in AVCO 5505/Boron as far as moduli alterations were concerned.

In summary, the prior humidity conditioning affected both unidirectional and laminate properties. In those cases where low residual stresses were present (as evidenced by a monotonic decreasing strength versus temperature curve), the presence of humidity conditioning generally decreased the strengths. In those cases where substantial residual stresses were present (as evidenced by a peaking or increasing strength versus temperature curve), the humidity conditioning frequently led to an increase in the strength of the composite. In addition it is evident that the amount of moisture absorbed by the composites depends on the total time exposure to high moisture, regardless of the intervening high temperature, low temperature, drying time or U.V. exposure.

On the basis of the static humidity results the Thermo-Humidity Cycle was selected for some additional studies. A limited test program was then initiated to ascertain the effect that moisture protective coatings might have on the static mechanical properties of composites subjected to this high humidity cycle.

Accordingly, aerospace companies were contacted to ascertain the most appropriate coatings for the composites. Air Force Spec. Mil-C-83286 and MACDAC Spec. MMS-420 were utilized to procure the coatings. A polyurethane coating was selected*. This particular system required a four hour drying period at 77°F and was fully cured in 7 days.

The coated samples were then statically tested. Table IX presents a summary of the test results. Unfortunately tape supplies of the system affected the most by the Thermo-Humidity cycle (namely Hercules 3002M/Courtaulds HMS Graphite) were exhausted and new supplies were unavailable in time for the coating tests.

2.1.6.3 Effects of Thermal Conditioning

The exposure of the resin matrix composites to steady state temperature affected the composites differently depending on the material. The Avco 5505/Boron composites appear in general to:

- 1) increase in stiffness slightly (in fact the entire stress-strain curve shifts slightly to the left)
- 2) increase in strength
- 3) have a slightly reduced ultimate strain capacity.

This behavior is illustrated in Figs. 29 and 30 for the laminae (90° tension and in-plane shear) which are most sensitive to prolonged exposure to elevated temperature. The steady-state temperature exposure would appear to be acting as an additional post cure to the AVCO 5505/Boron composite laminae. The laminate behavior is shown in Figs. 31 and 32 and appears to be less severe.

* Super Desothane, A product of DeSoto, Inc.

TABLE IX

SUMMARY OF TENSILE TESTS AT ROOM TEMPERATURE
ON VARIOUS COMPOSITES COATED WITH SUPER DESOTRHANE
POLYURETHANE AND SUBJECTED TO THE THERMO-HUMIDITY CYCLE

SYSTEM	ORIENTATION	CONDITION	σ_{ult} (ksi)	ϵ_{ult} (μ -in/in)	E (psi $\times 10^6$)	ν (in/in)
Avco 5505/ Boron	0°	Bare	183	6420	29.6	0.23
		Coated	185	6200	29.3	0.25
		Bare/Th-Hum Cycle	188	6360	29.6	0.17
		Coated/Th-Hum Cycle	186	6180	29.1	0.22
Narmco 5206/ Modmor II Graphite	0°	Bare	161	6920	22.5	0.30
		Coated	171	6840	21.9	0.27
		Bare/Th-Hum Cycle	163	7230	22.0	0.24
		Coated/Th-Hum Cycle	170	6960	22.0	0.26
Narmco 5206/ Modmor II Graphite	[0/45/135/0/90] _s	Bare	72	6610	11.1	0.38
		Coated	70	6580	10.8	0.32
		Bare/Th-Hum Cycle	80	6820	11.5	0.42
		Coated/Th-Hum Cycle	73	6950	11.1	0.43

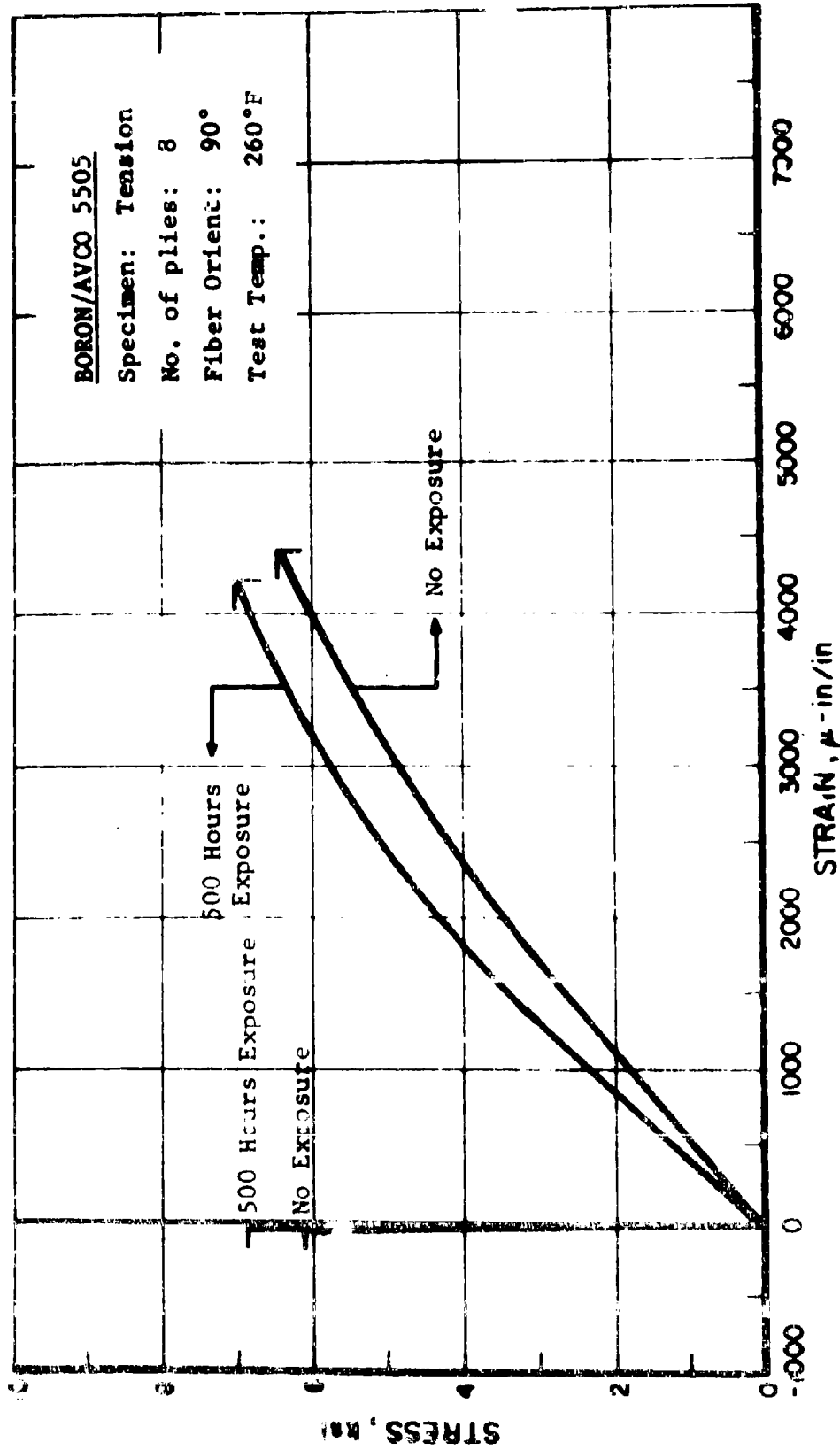


Fig. 29 COMPARATIVE TENSILE BEHAVIOR OF 90° BORON/AVCO 5505 COMPOSITE BEFORE AND AFTER 500 HOURS EXPOSURE TO 260°F WHEN TESTED AT 260°F

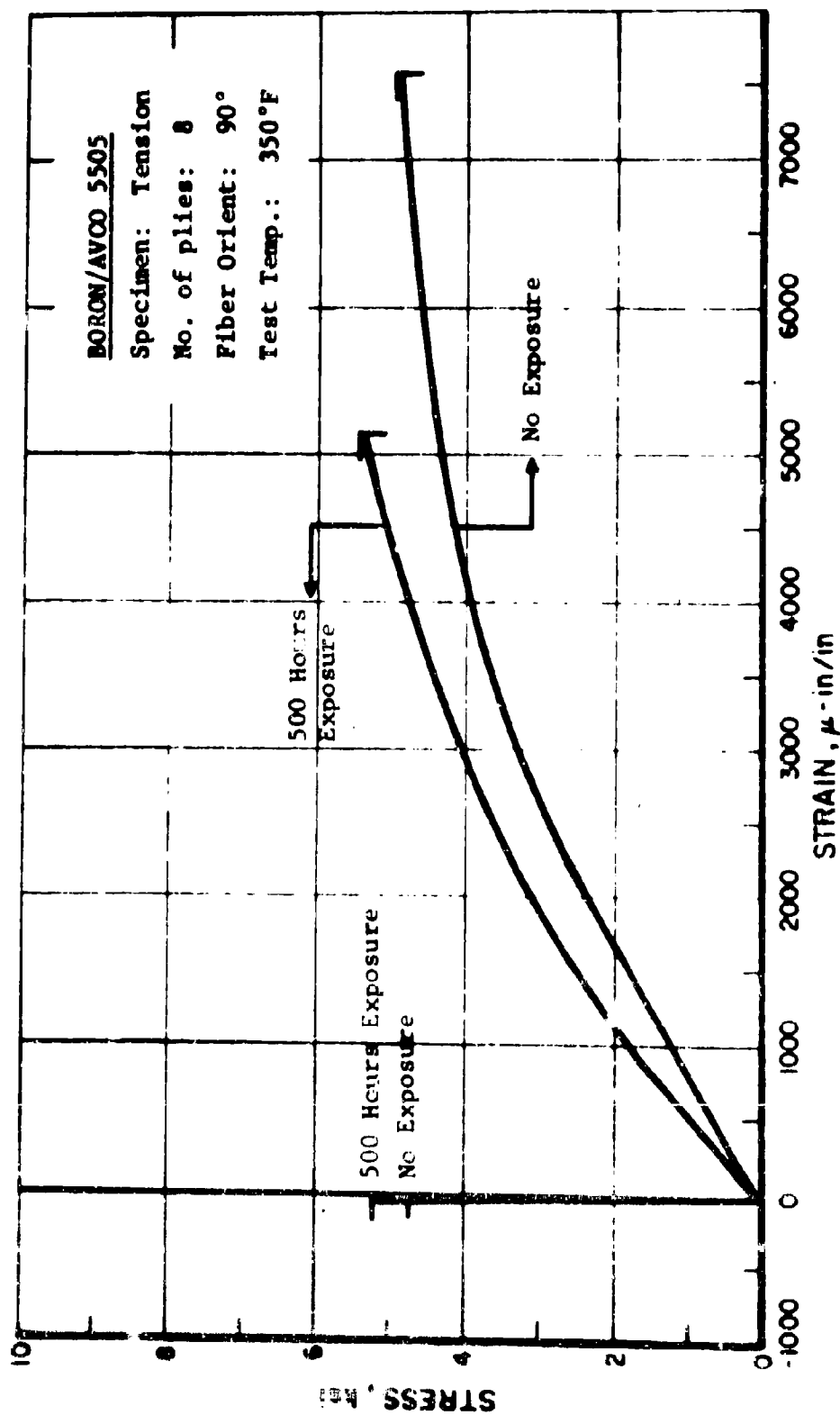


Fig. 30 COMPARATIVE TENSILE BEHAVIOR OF 90° BORON/AVCO 5505 COMPOSITE BEFORE AND AFTER 500 HOURS EXPOSURE TO 350°F WHEN TESTED AT 350°F

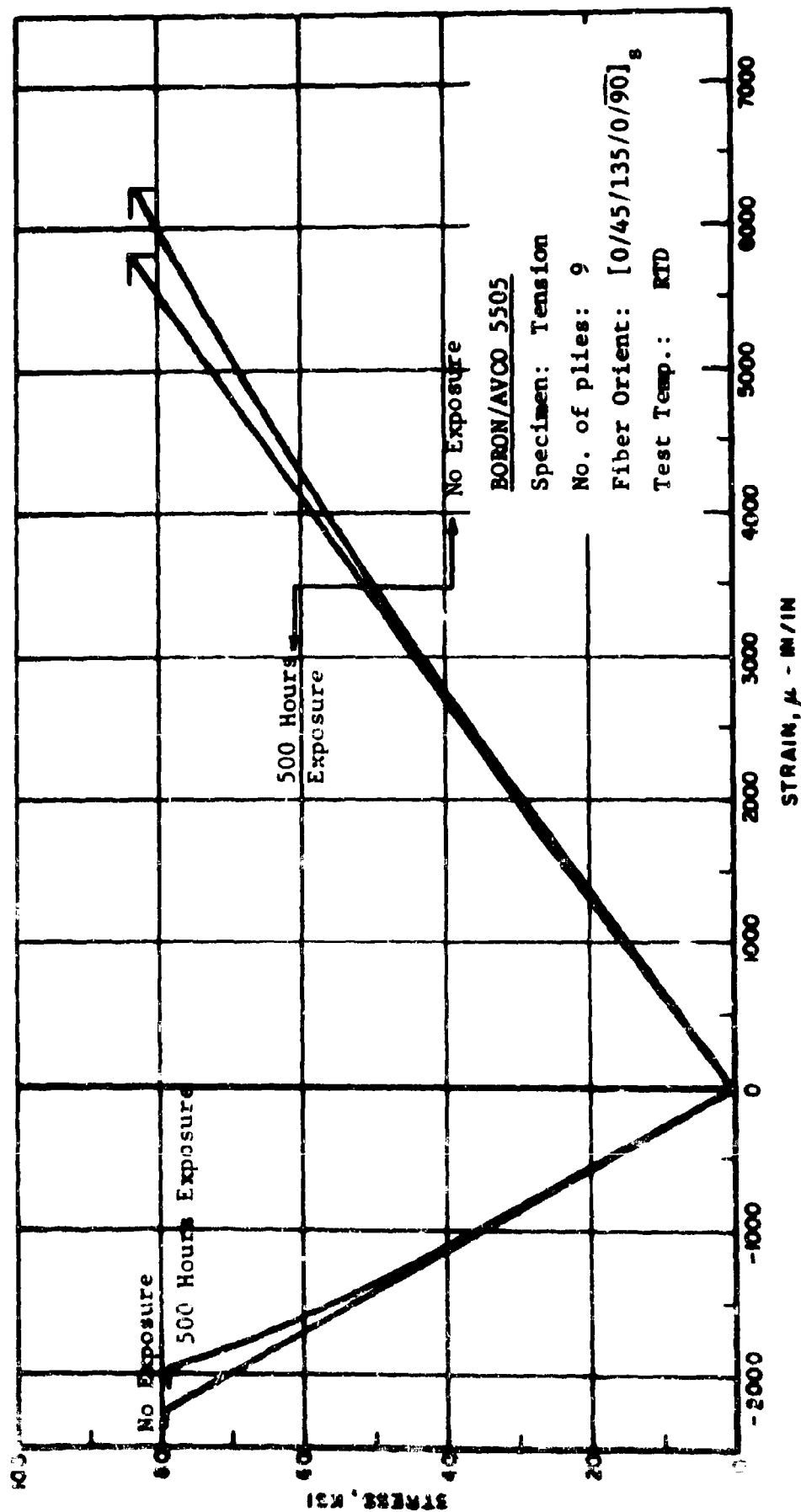


FIG. 31 COMPARATIVE TENSILE BEHAVIOR OF BORON/AVCO 5505 LAMINATE [0/45/135/0/90]_s BEFORE AND AFTER 500 HOURS EXPOSURE TO 260°F WHEN TESTED AT ROOM TEMPERATURE

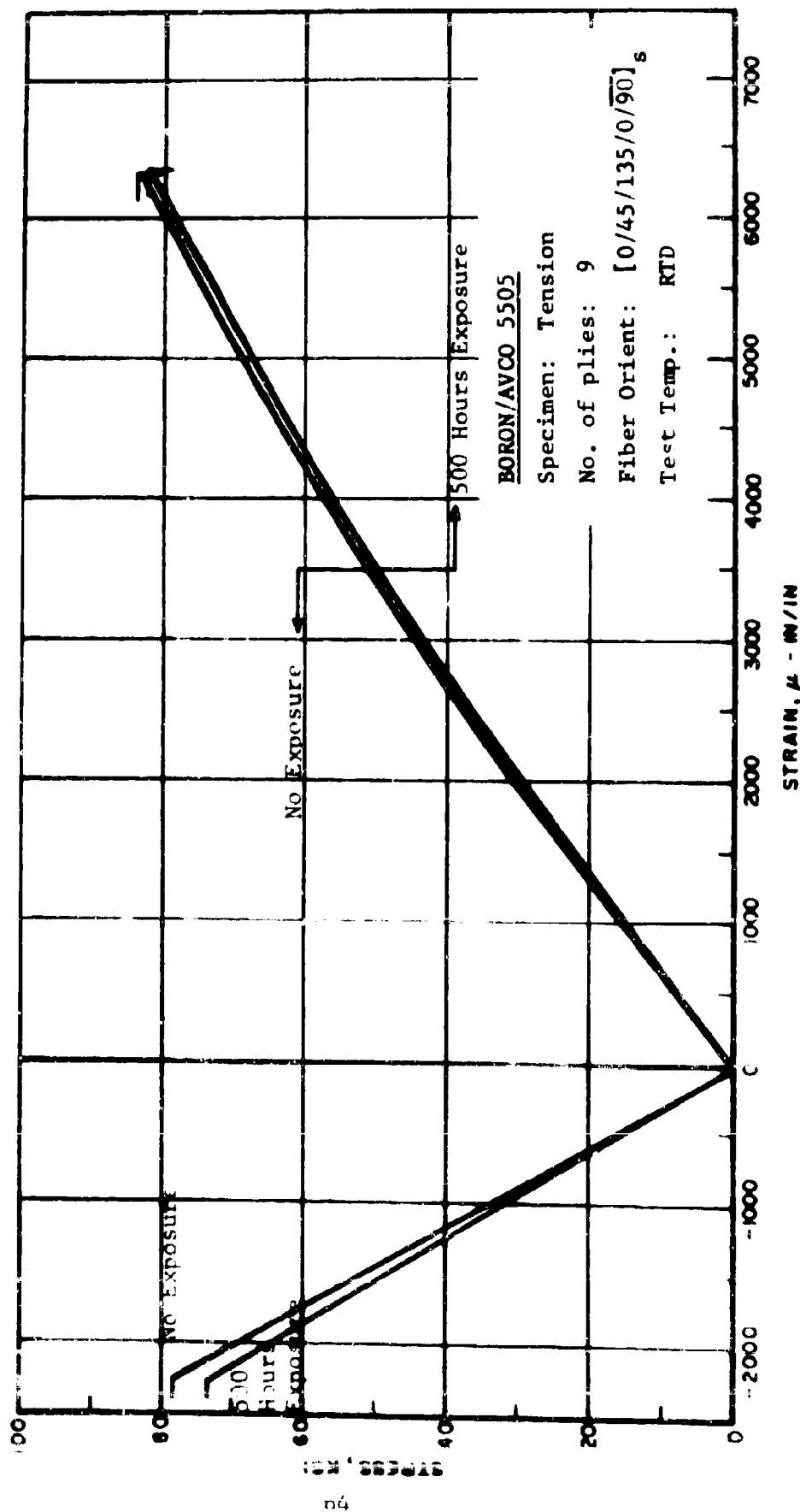


FIG. 32 COMPARATIVE TENSILE BEHAVIOR OF BORON/AVCO 5505 LAMINATE $[0/45/135/0/90]_s$ BEFORE AND AFTER 500 HOURS EXPOSURE TO 350°F WHEN TESTED AT ROOM TEMPERATURE

Prolonged exposure of Modmor II Graphite/Narmco 5206 epoxy laminae (see Figs. 33 and 34) to elevated temperature acts as a typical detrimental factor by decreasing transverse modulus, ultimate transverse strength and ultimate transverse strain capabilities of the lamina. The modulus reduction would appear to be primarily confined to the early portion of the exposure since after 100 hours and 500 hours the two stress-strain curves are coincident. However additional transverse strength and transverse strain capabilities were lost.

Several parametric cross plots are available for the purposes of illustrating the effects of steady-state thermal conditioning on the static properties of the three resin matrix composite materials. Thus Figs. 35 - 40 present the effects of steady state conditioning on the tensile compressive and shear strength and moduli of 0° , 90° and $[0/45/135/0/90]_S$ AVCO 5505/Boron composites. In Figs. 35 and 36 the tensile strength of the 0° and compressive strengths of the 90° and $[0/45/135/0/90]_S$ laminates showed a decrease after exposure to steady state thermal conditioning. The 0° compressive strength, the in-plane shear strength of the 0° composites, the tensile strengths of the 90° and $[0/45/135/0/90]_S$ showed increases in strength particularly at the elevated temperatures. These latter strengths are more resin sensitive than the former strengths. The steady-state thermal conditioning acts as an additional post-cure on the resin matrix.

The elastic moduli of the 0° AVCO 5505/Boron composites were increased slightly at the elevated temperatures (See Fig. 38) as a result of the steady-state thermal conditioning. In addition, the steady-state thermal conditioning produced moduli versus test temperatures more nearly equal between the tension

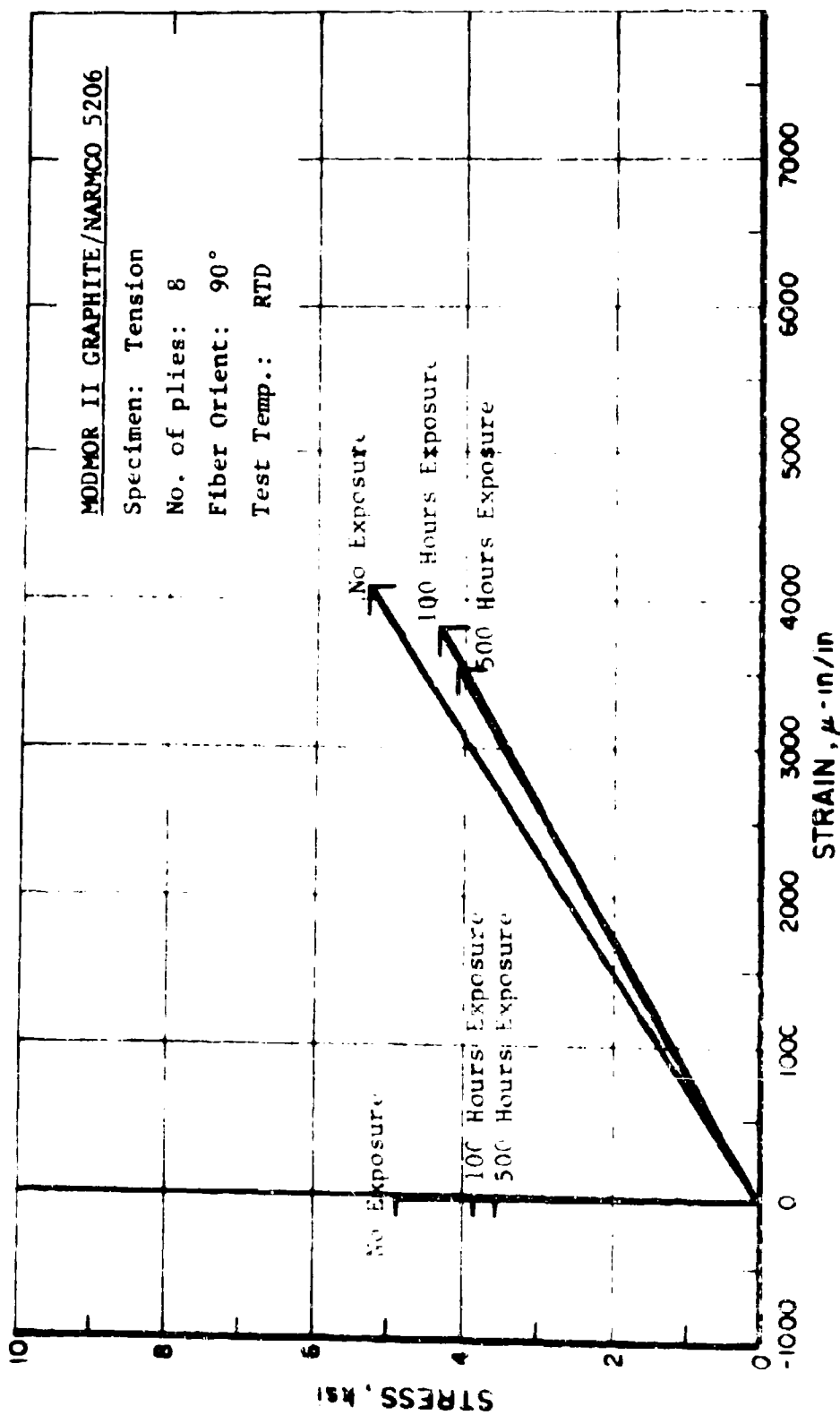


Fig. 33 COMPARATIVE TENSILE BEHAVIOR OF 90° MODMOR II GRAPHITE/NARMCO 5206 COMPOSITE BEFORE AND AFTER 100 AND 500 HOURS EXPOSURE TO 260°F WHEN TESTED AT ROOM TEMPERATURE

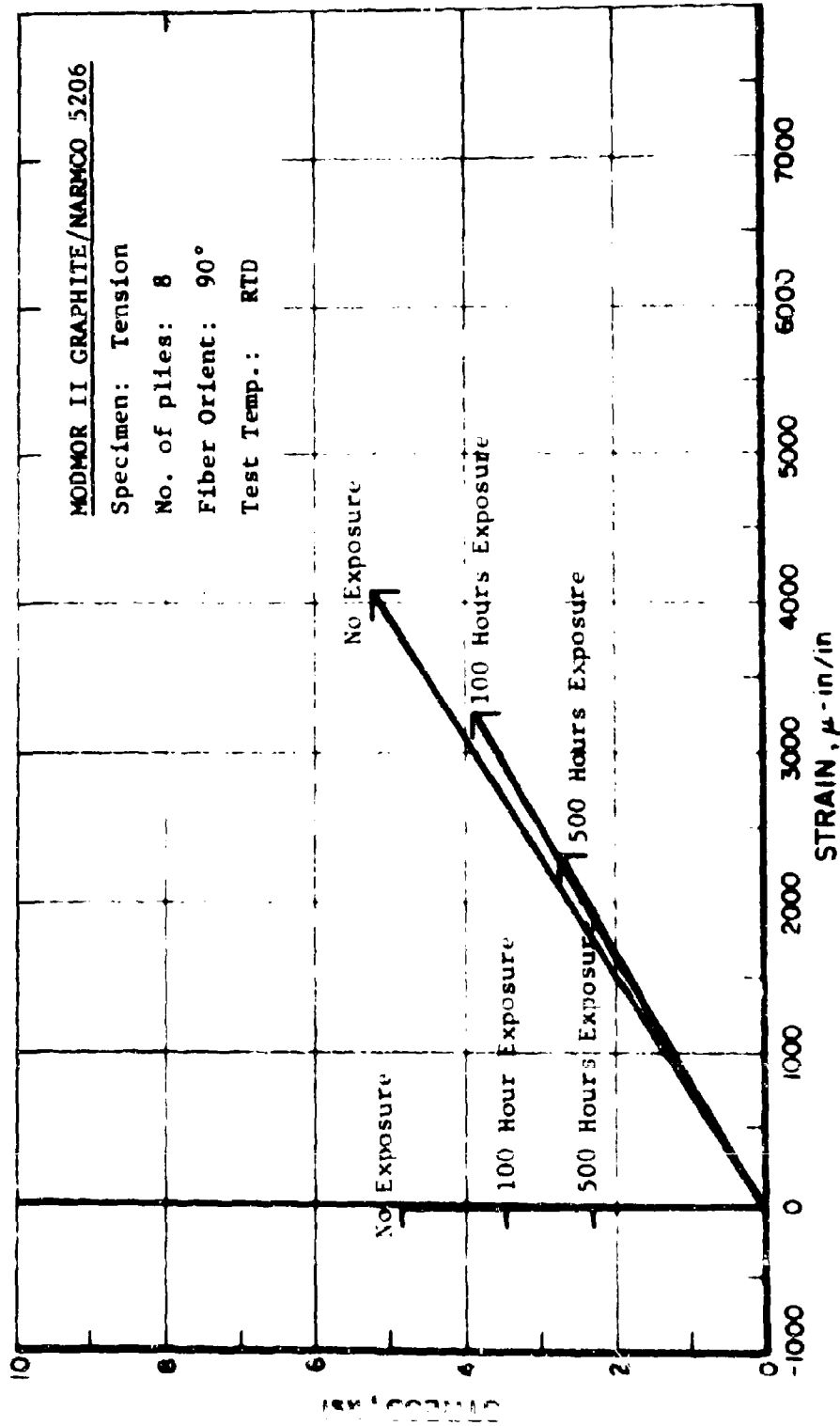


FIG. 34 COMPARATIVE TENSILE BEHAVIOR OF 90° MODMOR II GRAPHITE/NARMCO 5206 COMPOSITE BEFORE AND AFTER 100 AND 500 HOURS EXPOSURE TO 350°F WHEN TESTED AT ROOM TEMPERATURE

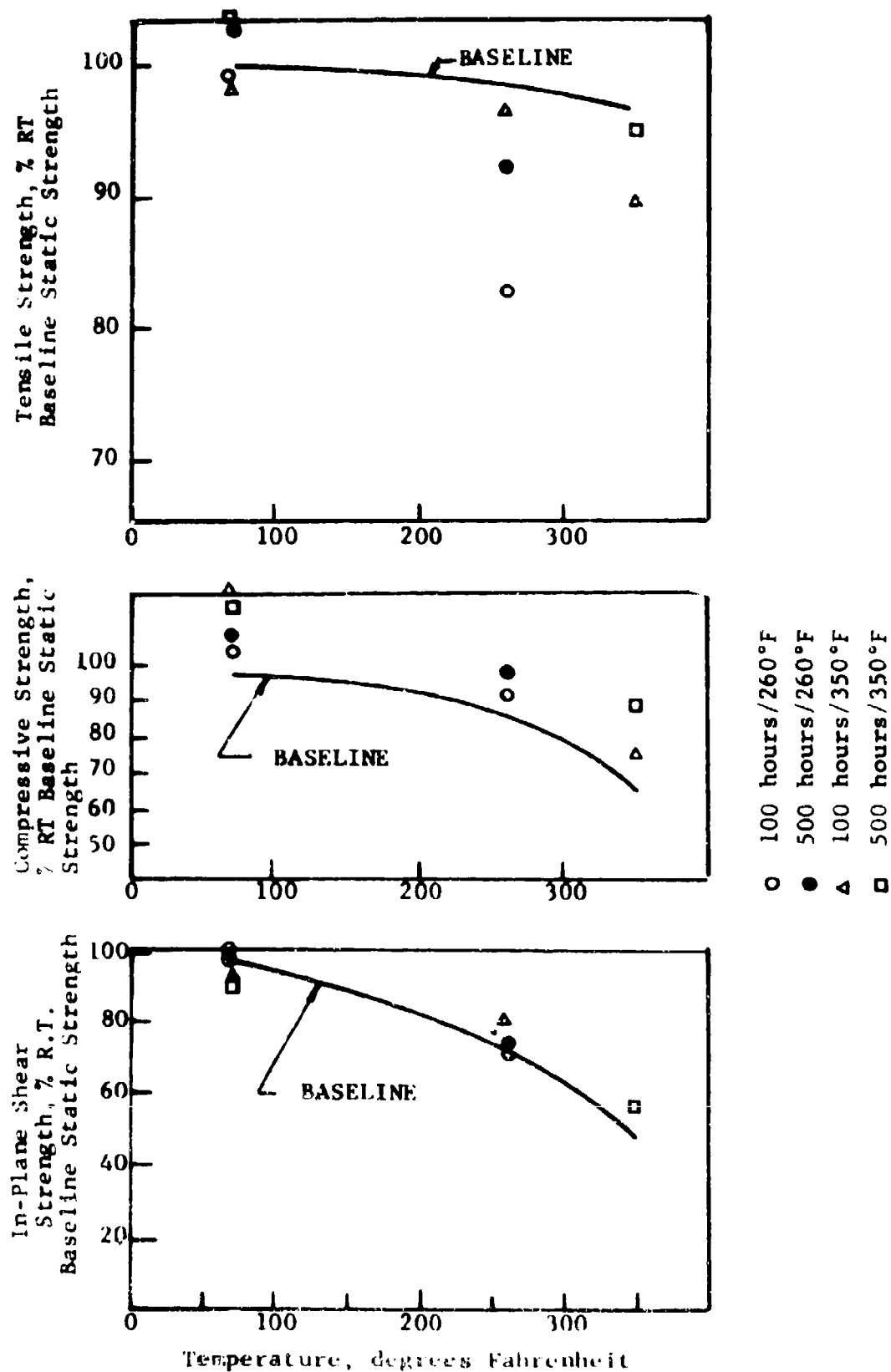


Fig. 35 EFFECTS OF STEADY STATE THERMAL CONDITIONING ON THE STRENGTHS OF AVCO 5105/BORON COMPOSITES - 67

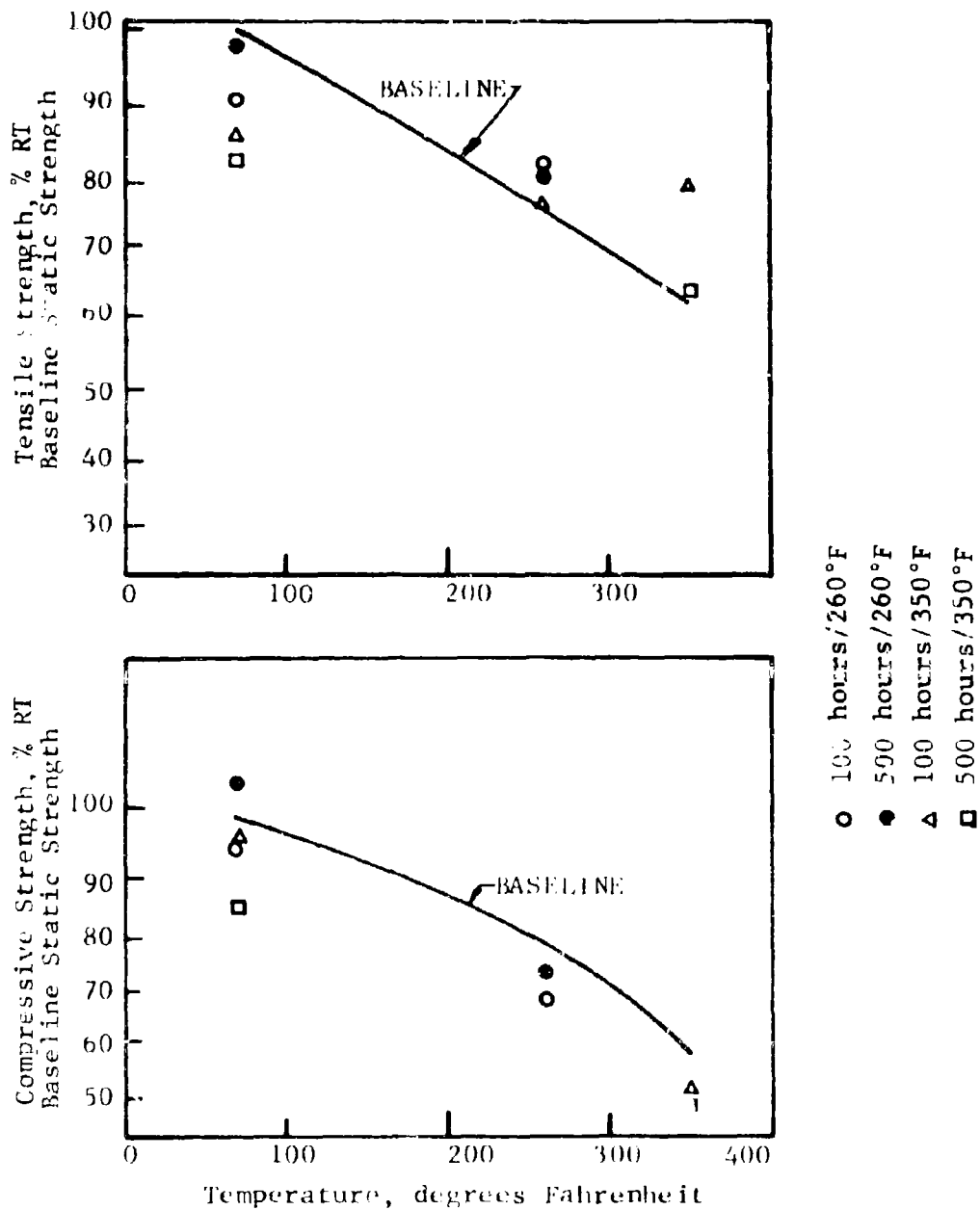


Fig. 36 EFFECTS OF STEADY STATE THERMAL CONDITIONING OF THE STRENGTHS OF AVCO 5505/BORON COMPOSITES - 90"

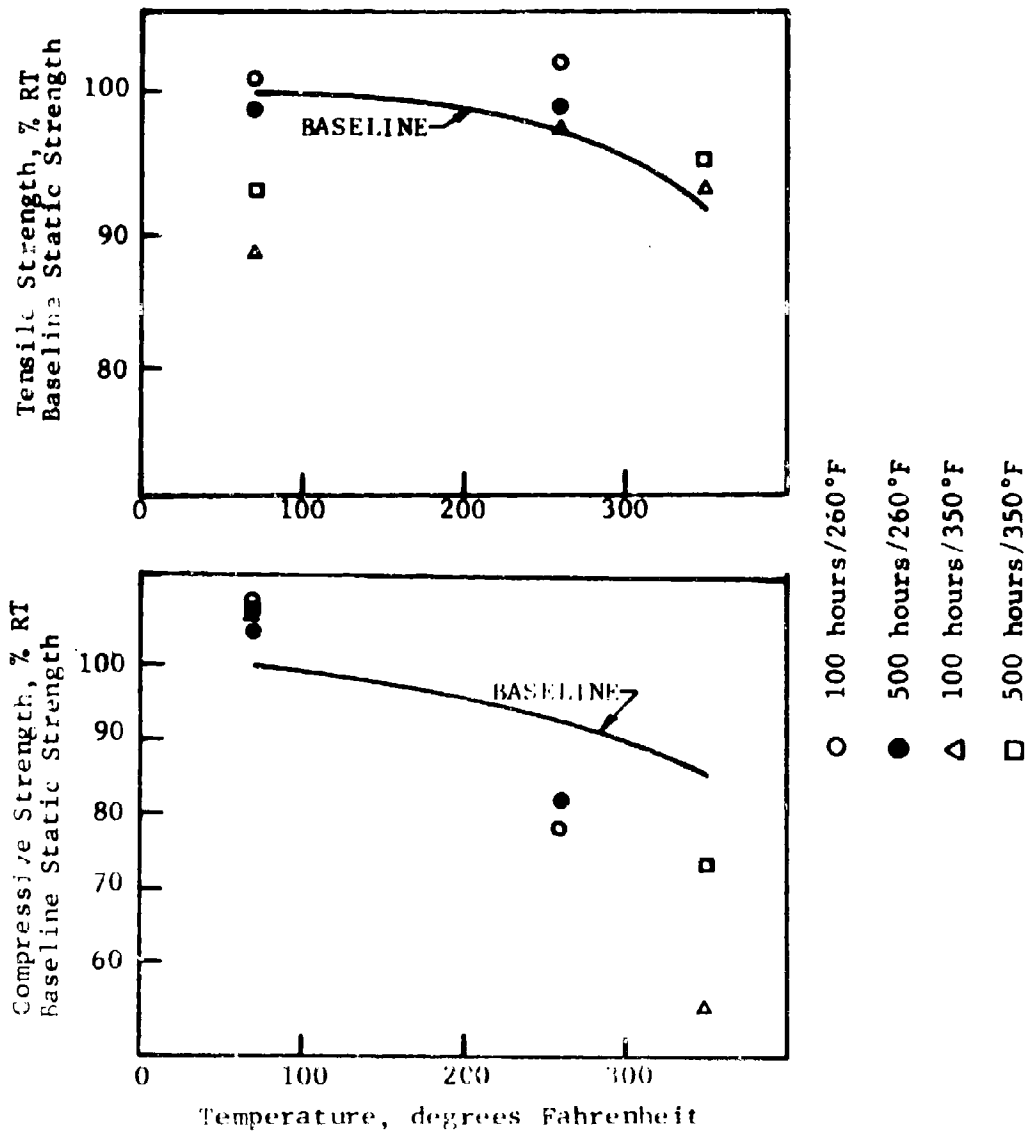
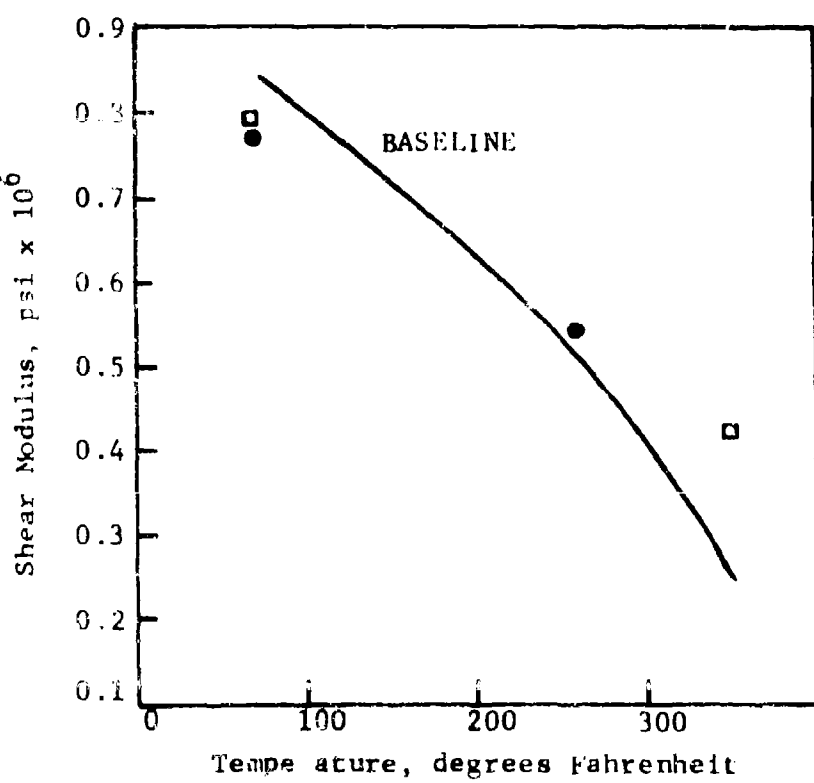
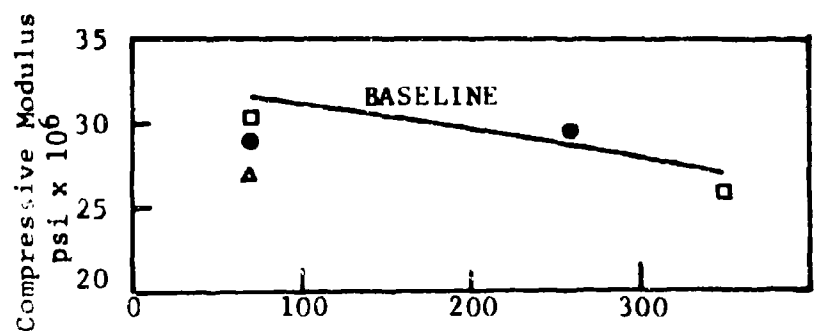
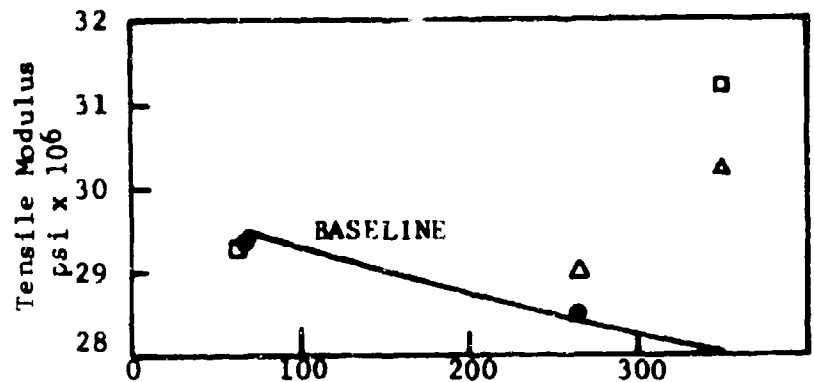


Fig. 37 EFFECTS OF STEADY-STATE THERMAL CONDITIONING ON THE STRENGTHS OF AVCO 5505/BORON COMPOSITE - $[0/45/135/0/90]_S$



- 100 hours/260°F
- 500 hours/260°F
- △ 100 hours/350°F
- 500 hours/350°F

Fig. 38 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE MODULI OF AVCO 5505/BORON COMPOSITES - 0°

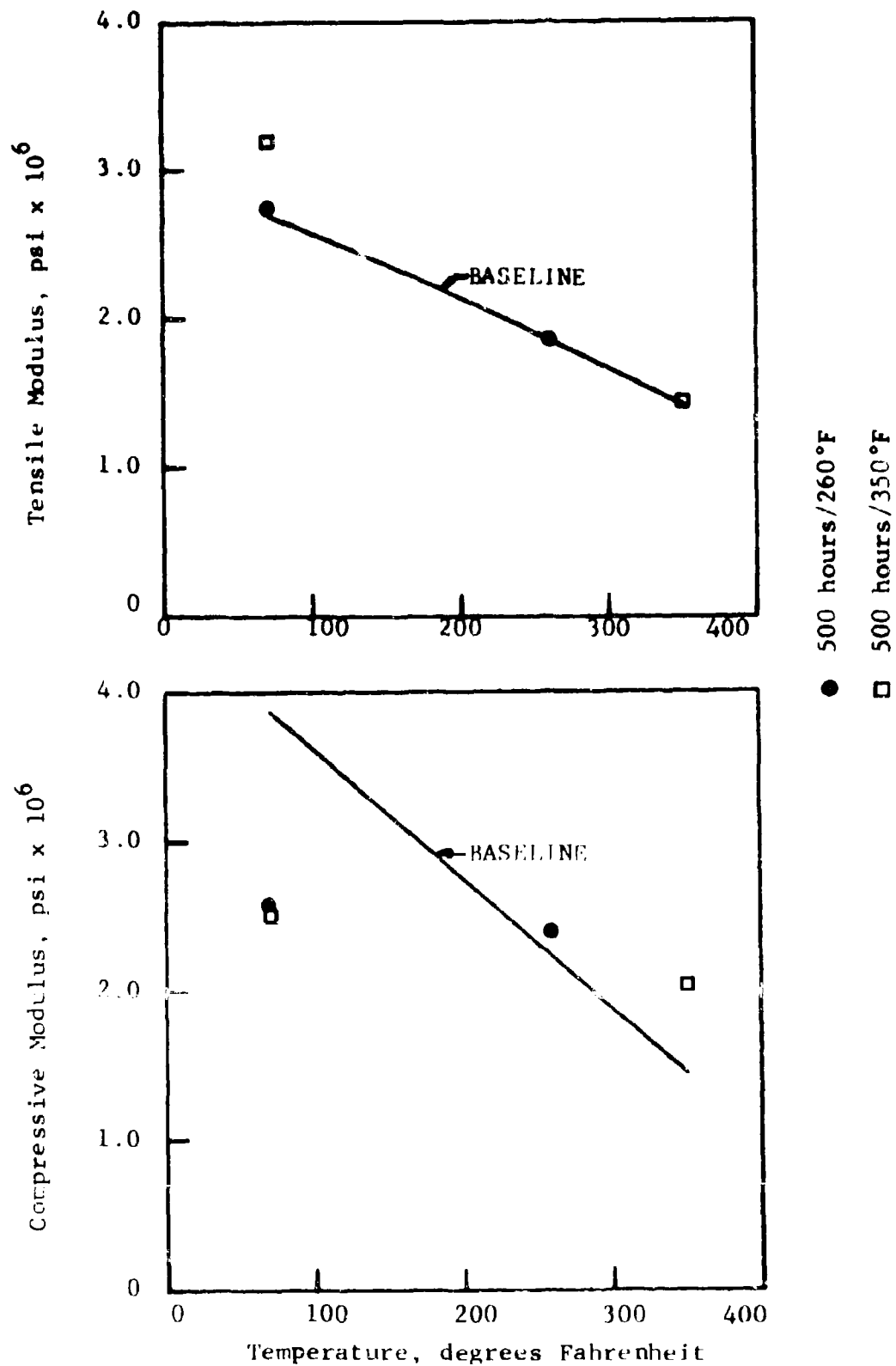


Fig. 39 EFFECT OF STEADY STATE THERMAL CONDITIONING ON
THE ELASTIC MODULI OF AVCO 5505/BORON COMPOSITES - 90°

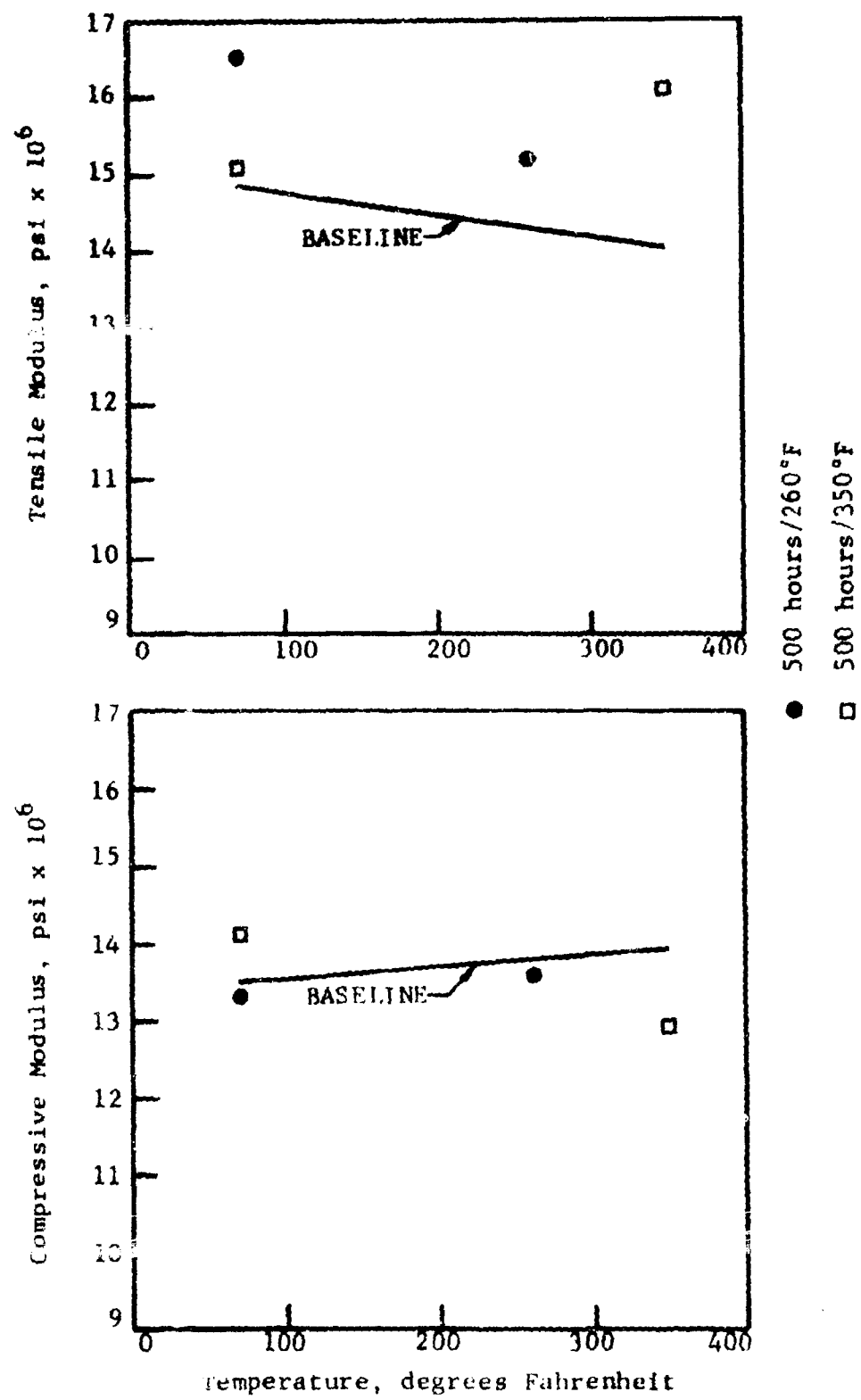


Fig. 40 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE ELASTIC MODULI OF AVCO 5505/BORON COMPOSITES - $[0/45/135/0/90]_8$

and compression modes (See Fig. 39). The tensile moduli of the [0/45/135/0/90]_s laminates increased over the entire temperature range as a result of prior thermal conditioning while the corresponding compressive moduli decreased at the higher test temperatures.

The effect of steady state thermal conditioning on the strength of Narmco 5206/Modmor II graphite composites is shown in Figs. 41-43. In general the strengths of this graphite/epoxy composite increased as a result of the steady-state thermal conditioning. The 260°F exposures resulted in small increases in strength or no change for almost all types of loading and composite orientations. The 350°F exposures showed lower exposed strengths than did the 260°F exposures and often times, as in the case of the 90° tensile strengths, a substantial reduction was detected.

The effect of steady state thermal conditioning on the elastic moduli of Narmco 5206/Modmor II graphite composites is shown in Figs. 44 to 46. The tensile and in-plane shear moduli were not affected substantially by steady state thermal conditioning. The compressive moduli were affected substantially; for all three orientations the 500 hours at 260°F was the worst culprit.

The effect of steady state thermal conditioning on the strengths of Hercules 3002M/Courtaulds HMS Graphite composites is shown in Figs. 47 to 49. In general, for the 0° and [0/45/135/0/90]_s composites, the tensile and compressive strengths increased above the baseline values at all temperatures. However the 90° tensile strengths were substantially lower, at all temperatures, than the baseline values.

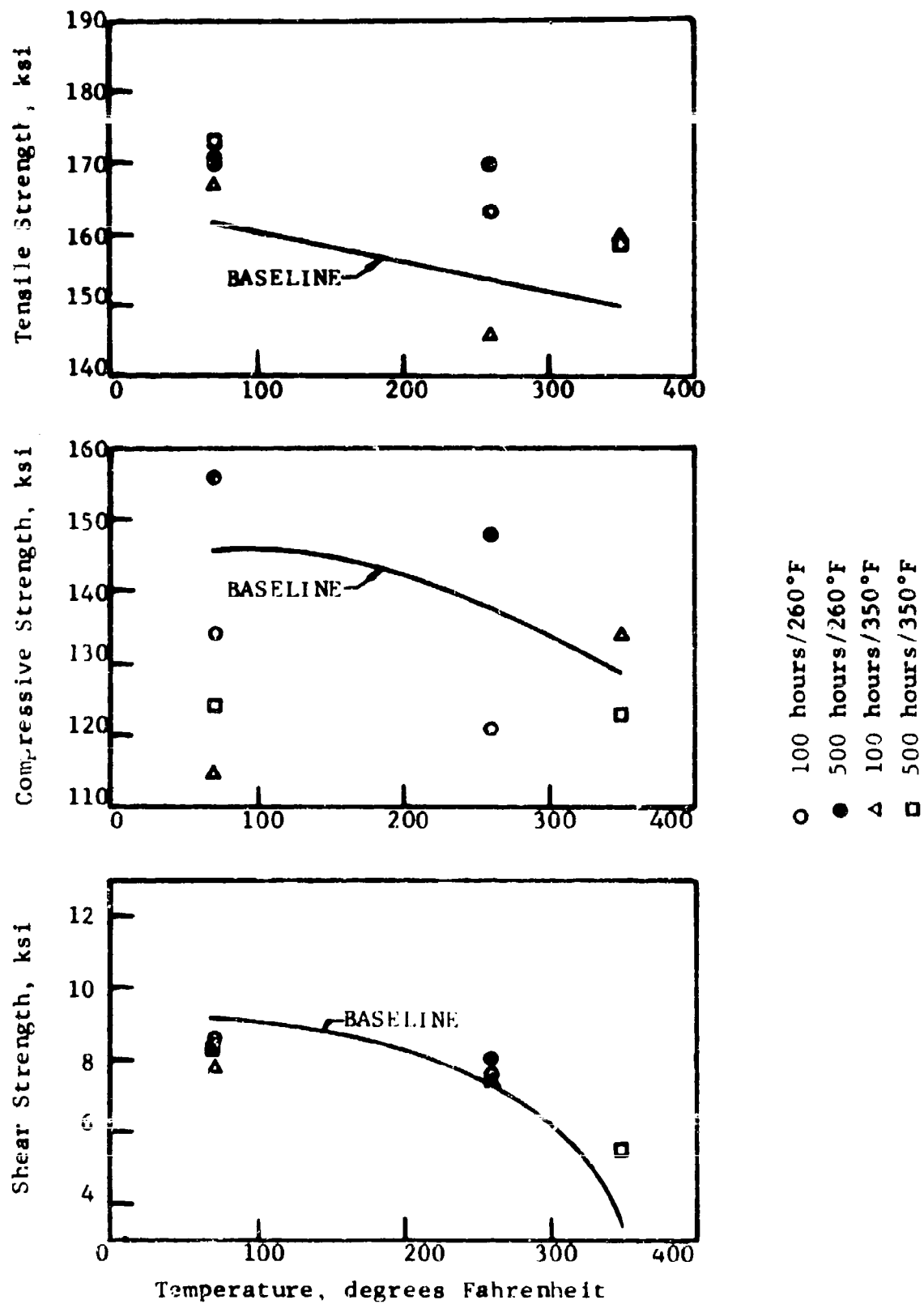


Fig. 41 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE STRENGTHS OF NARMCO 5266/RODMOR 11 GRAPHITE COMPOSITES - 0°

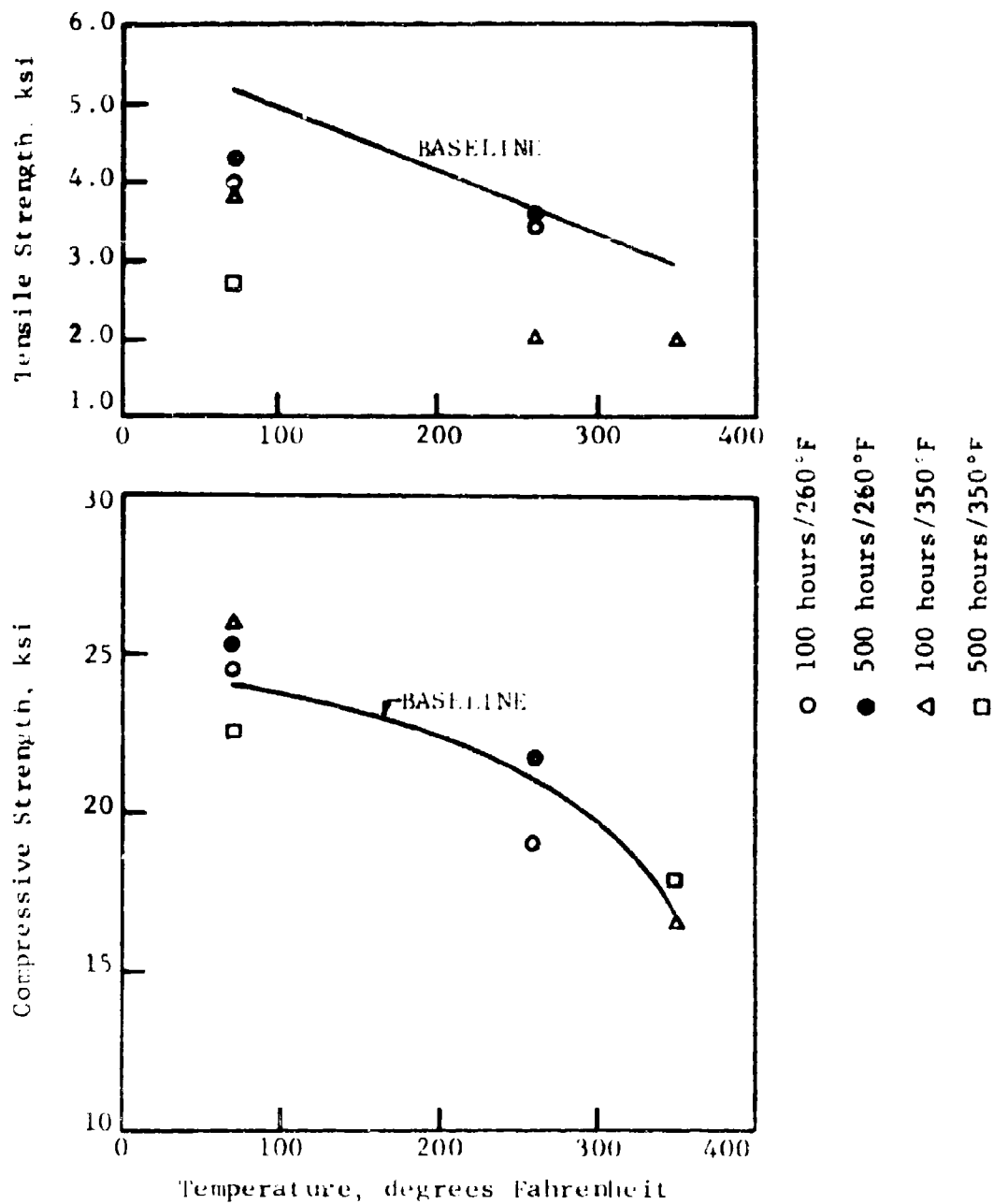


Fig. 42 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE STRENGTHS OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES - 90°

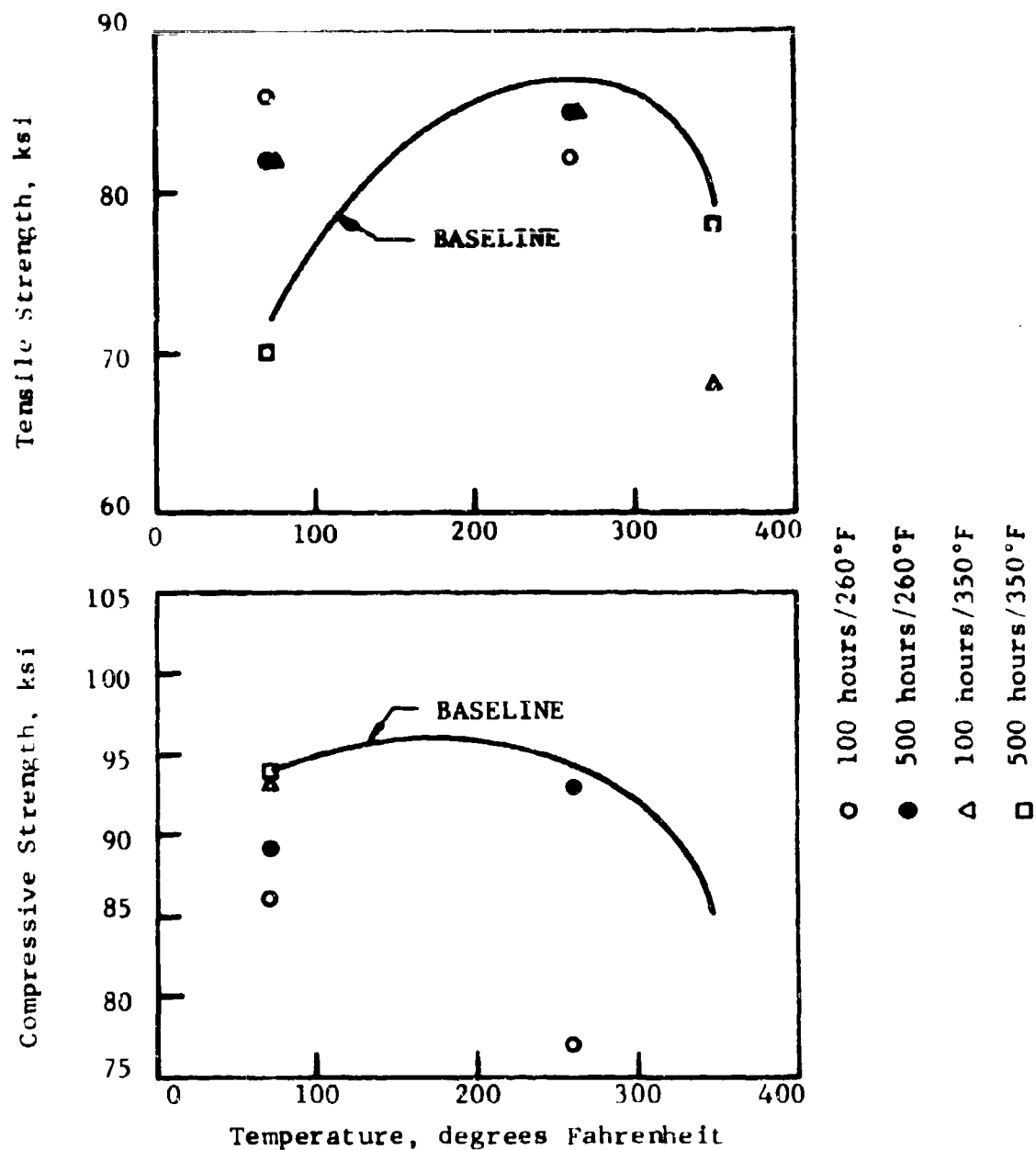


Fig. 43 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE STRENGTHS OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES - $[0/45/135/0/90]_s$

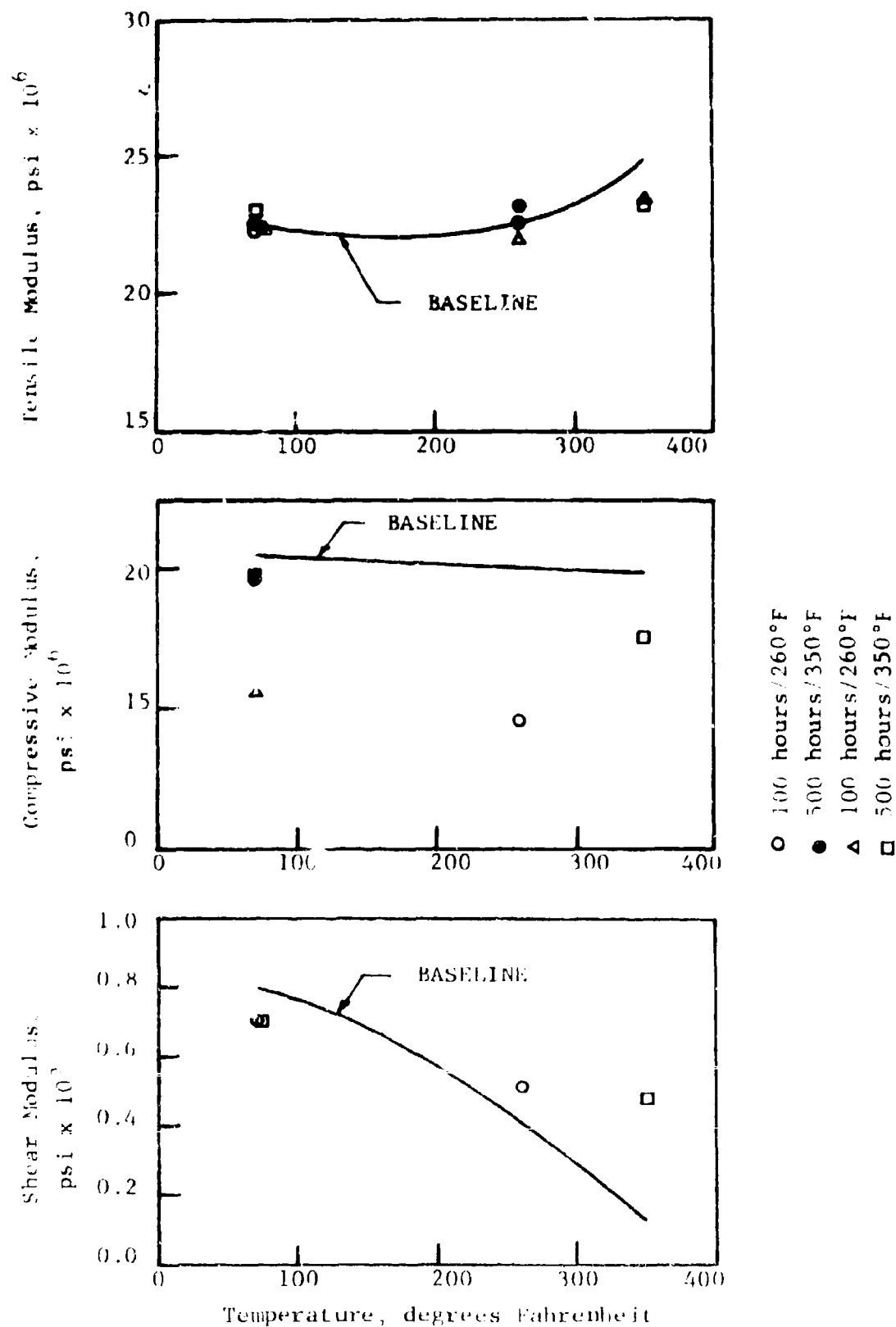


Fig. 44 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES - 0°

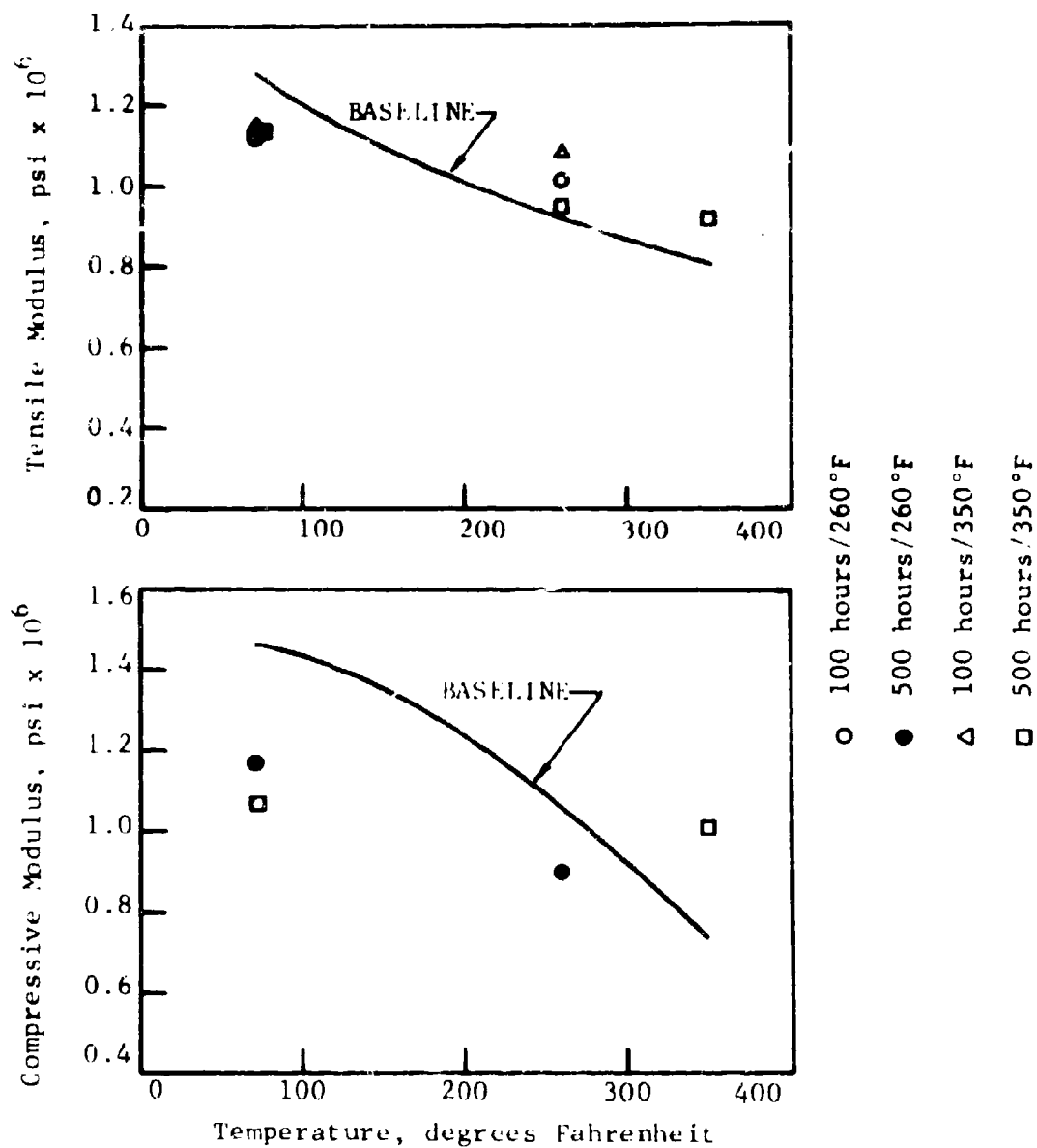


Fig. 40 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MDMOR 11 GRAPHITE COMPOSITES - 90°

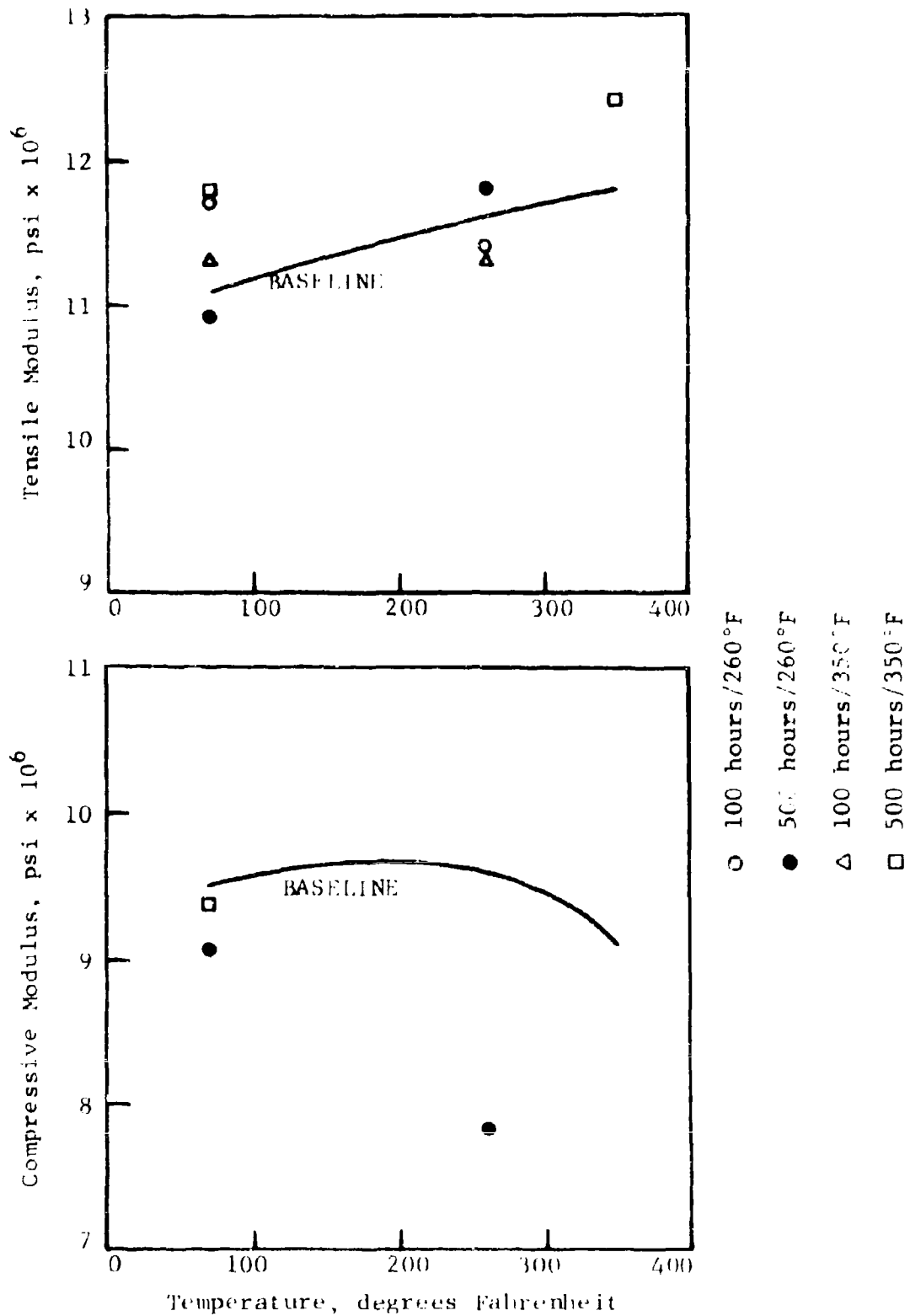


Fig. 46 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MODMOR II GRAPHITE COMPOSITES - $[0/45/135/0/90]_s$

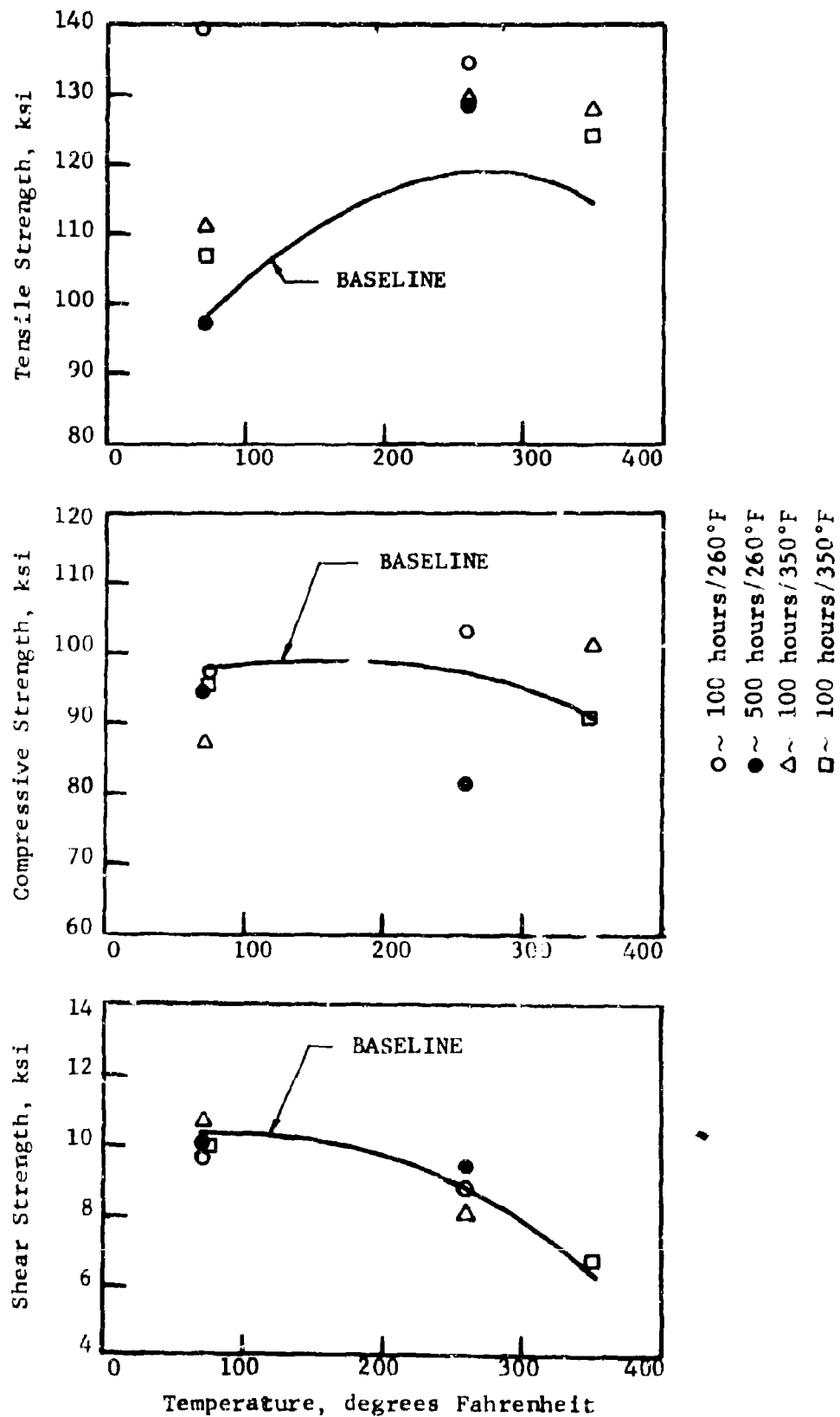


Fig. 47 EFFECTS OF STEADY STATE THERMAL CONDITIONING ON THE STRENGTHS OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 0°

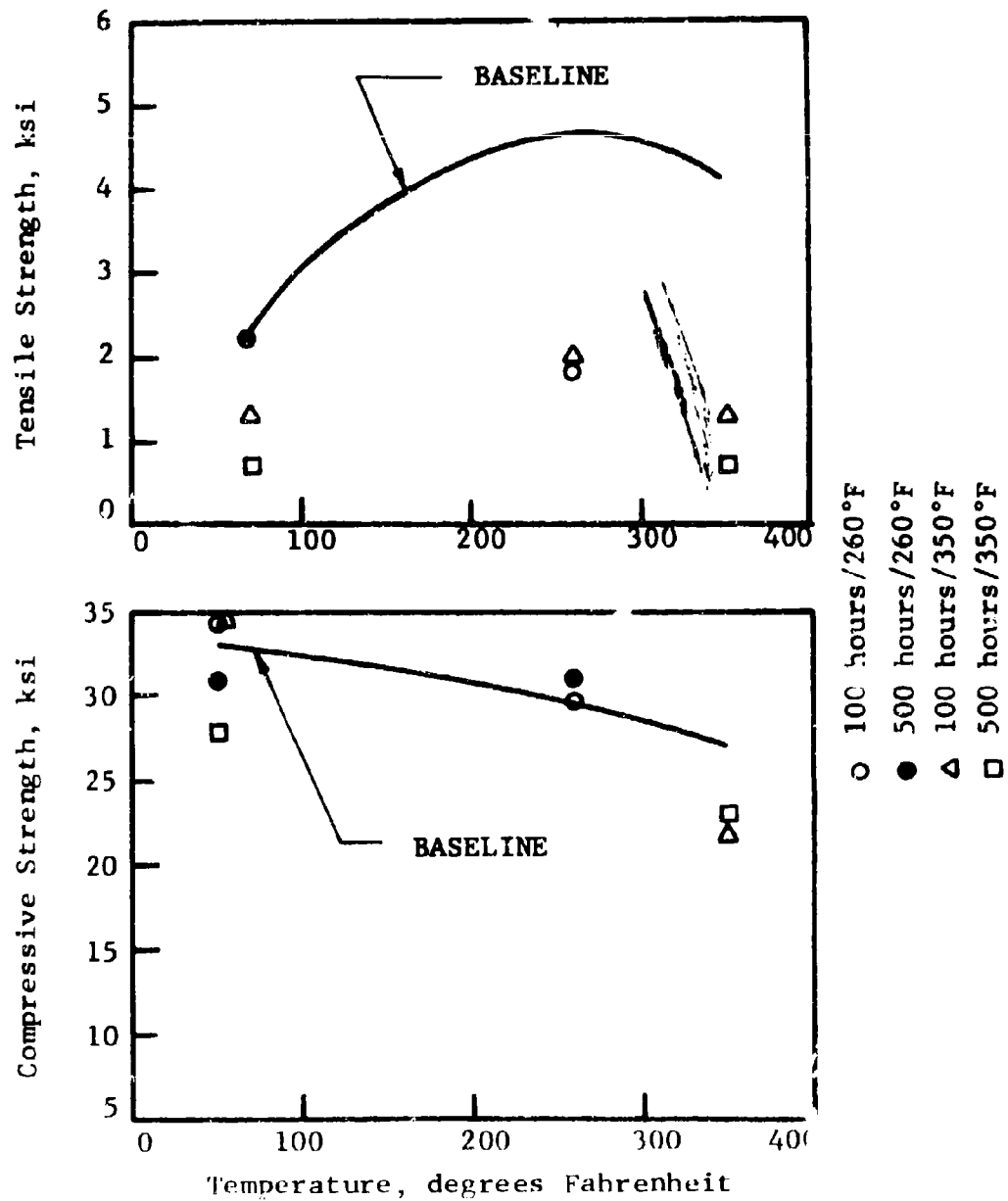


Fig. 48 EFFECTS OF STEADY-STATE THERMAL CONDITIONING ON THE STRENGTHS OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 90°

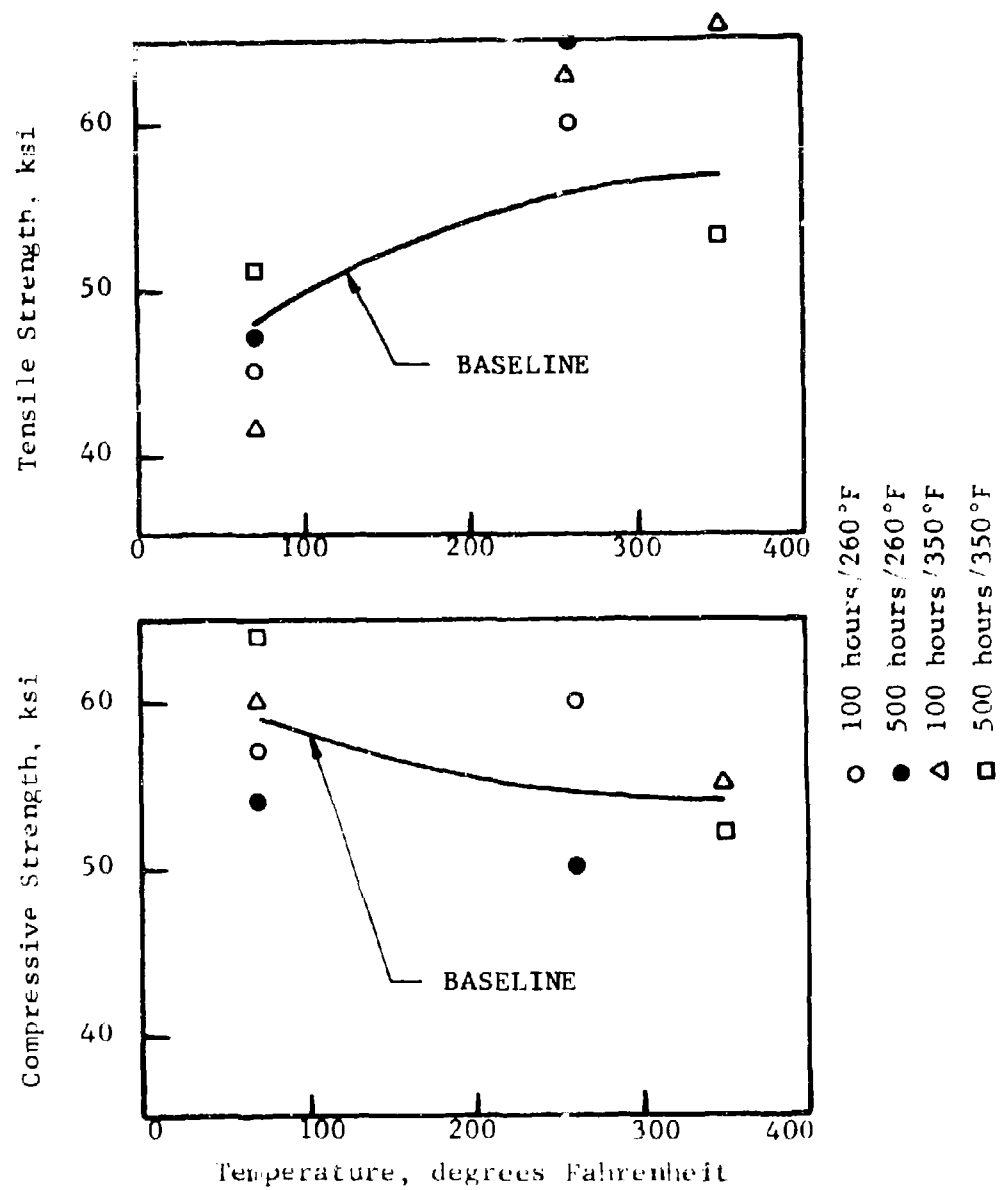


Fig. 49 EFFECTS OF STEADY STATE THERMAL CONDITIONING ON THE STRENGTHS OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - [0/45/135/0/90]

Figures 50 to 52 show the effect of thermal conditioning on the elastic moduli of Hercules 3002M/Courtaulds HMS graphite. Very little change in the elastic moduli of the 0° composites was evident. The [0/45/135/0/90]_s composites showed substantial modulus reduction in the compressive moduli for the 500 hour exposure at 260°F.

Cyclic thermal conditioning effects on the strengths of AVCO 5505/Boron are indicated in Figs. 53 to 55. The most substantial changes were in the 90° compression strengths, particularly, the room temperature strengths. In addition the 0° tensile strengths were reduced by cyclic thermal conditioning over the entire range of temperatures.

The effect of cyclic thermal conditioning on the elastic moduli of AVCO 5505/Boron composites is shown in Figs. 56 to 58. Most of the reduction in elastic moduli, from the baseline values took place at room temperature. The exception to this trend was for the compressive moduli of the [0/45/135/0/90]_s composites.

The effects of cyclic thermal conditioning on the strengths of Narmco 5206/Modmor II graphite are shown in Figs. 59 to 61. The in-plane shear strength of Narmco 5206/Modmor II graphite was altered so as to make the strength nearly constant over the entire range of temperatures. The 0° tensile strength were altered from the baseline strength levels so as to produce an increase in strength with temperature. The most scattered results were again shown for the [0/45/135/0/90]_s composites particularly the compressive strengths. The tensile strengths of the [0/45/135/0/90]_s laminates also became more constant over the entire range than were the baseline strengths.

Modulus changes in Narmco 5206/Modmor II graphite as a result of cyclic thermal conditioning are shown in Figs. 62 to 64.

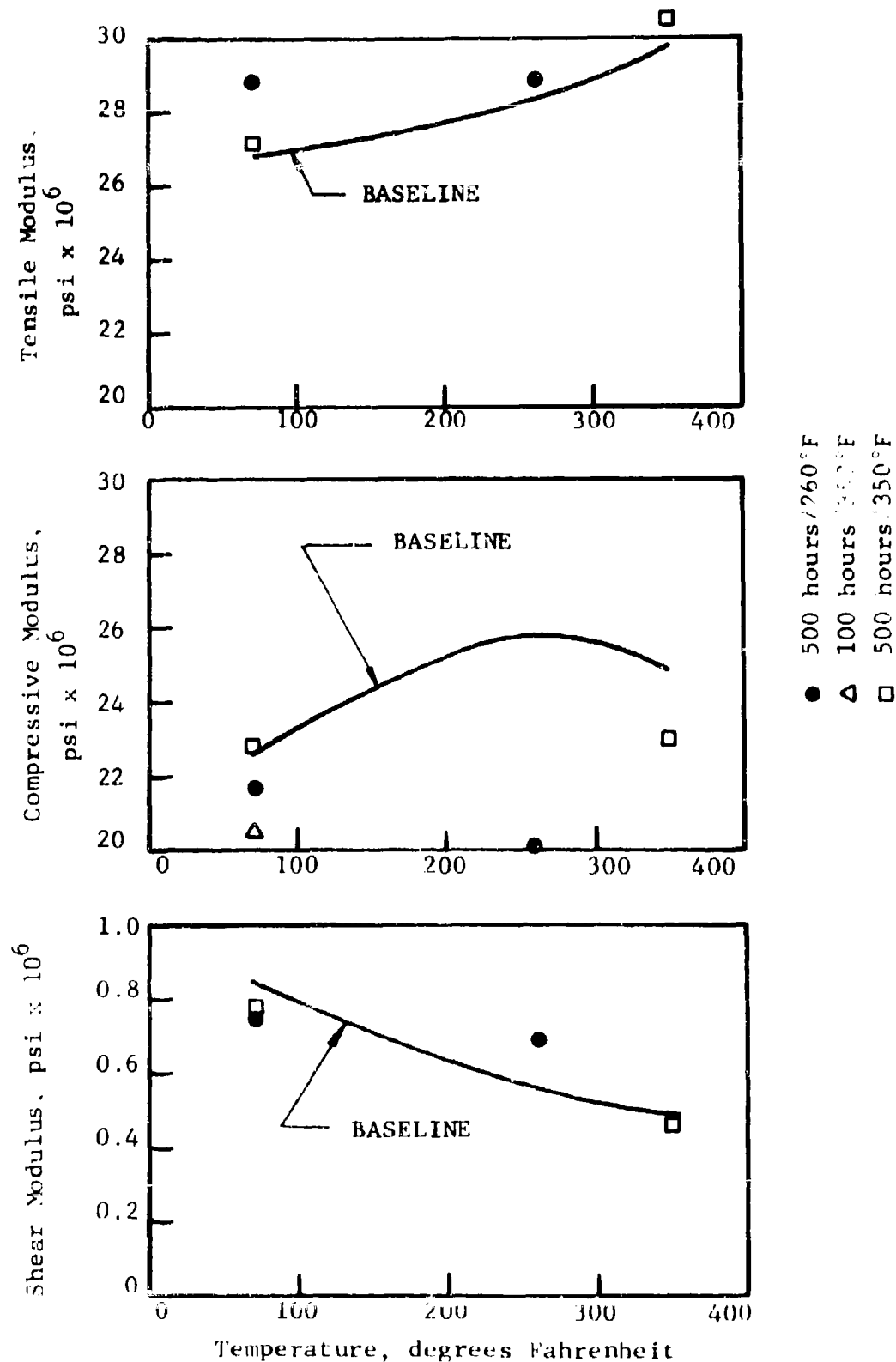


Fig. 50 EFFECTS OF STEADY-STATE THERMAL CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES- 0"

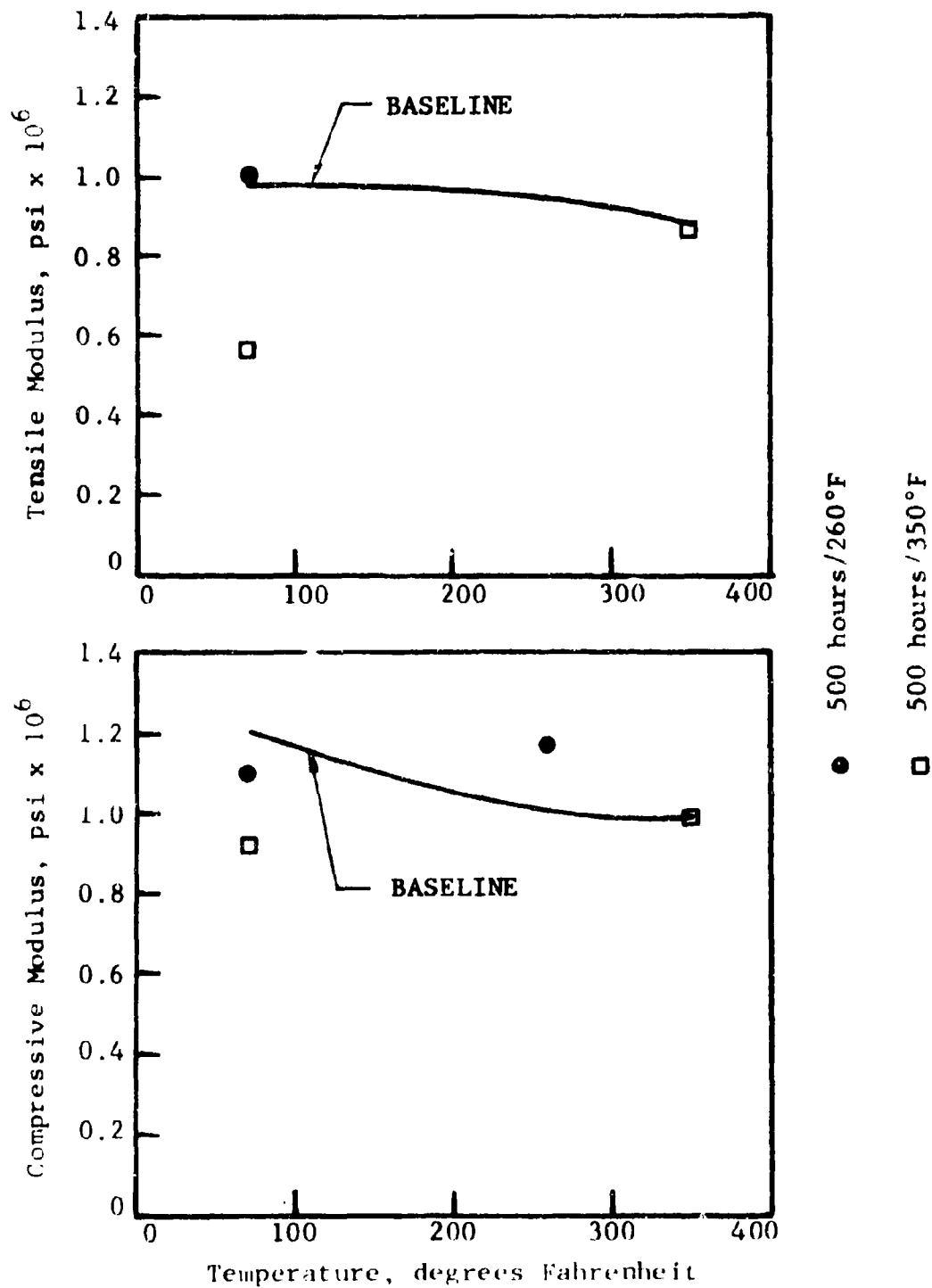


Fig. 51 EFFECTS OF STEADY STATE THERMAL CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 90°

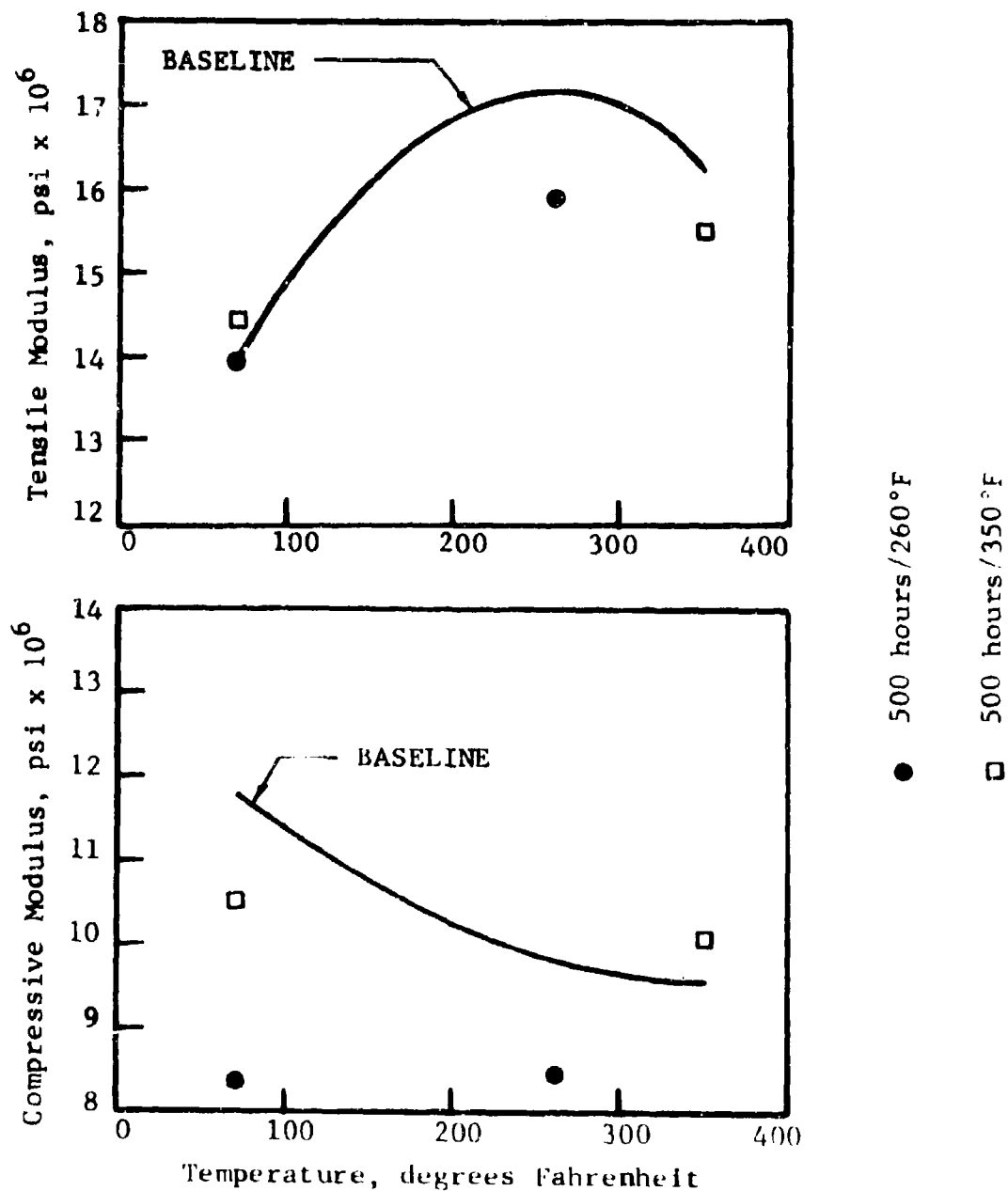


Fig. 52 EFFECT OF STEADY-STATE THERMAL CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - [0/45/135/0/90]₈

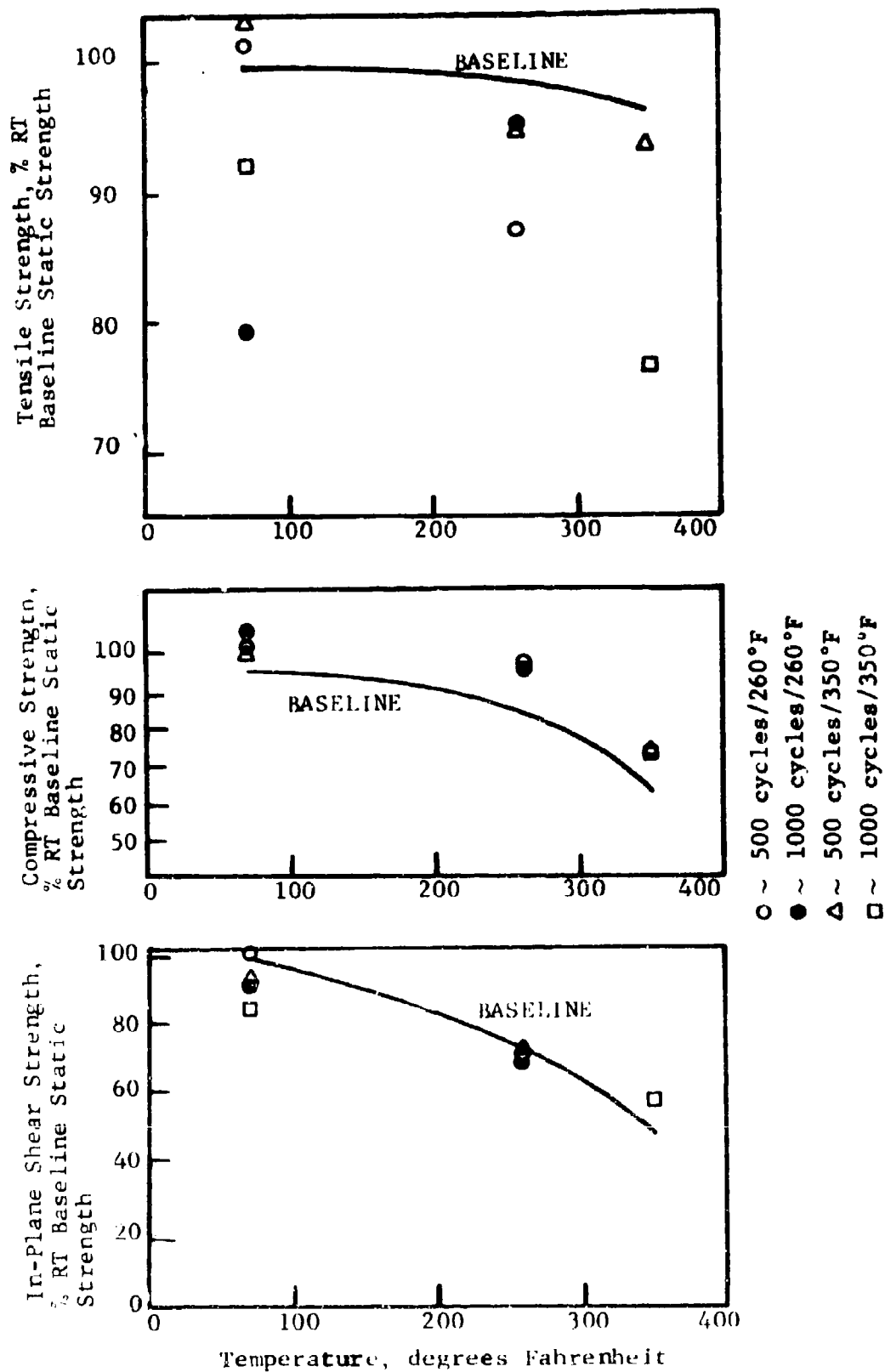


Fig. 53 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF AVCO 5505/BORON COMPOSITES - 0"

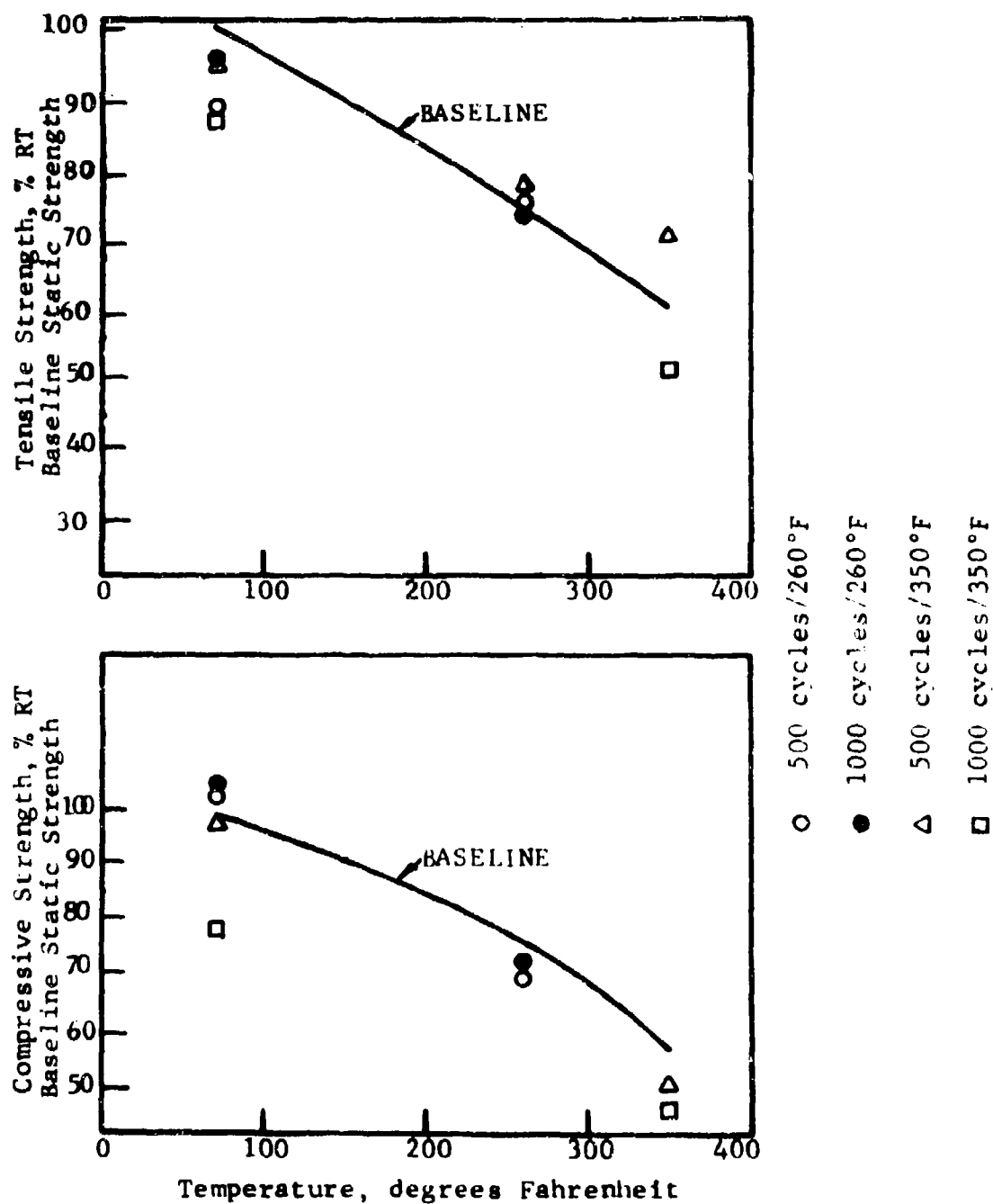


Fig. 54 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF AVCO 5505/BORON COMPOSITES - 90°

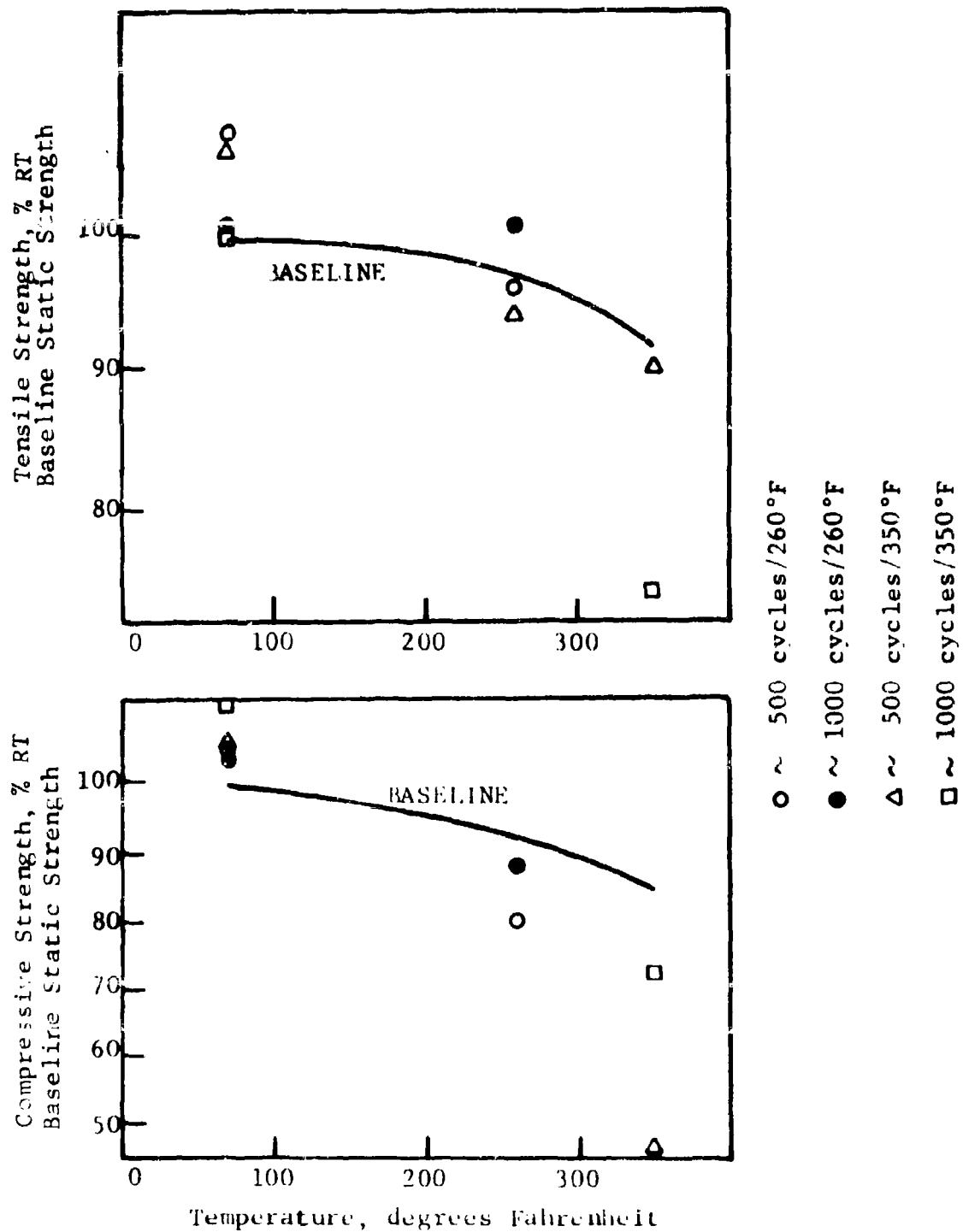


Fig. 55 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF AVCO 5505/BORON COMPOSITES - $[0/45/135/0/90]_s$

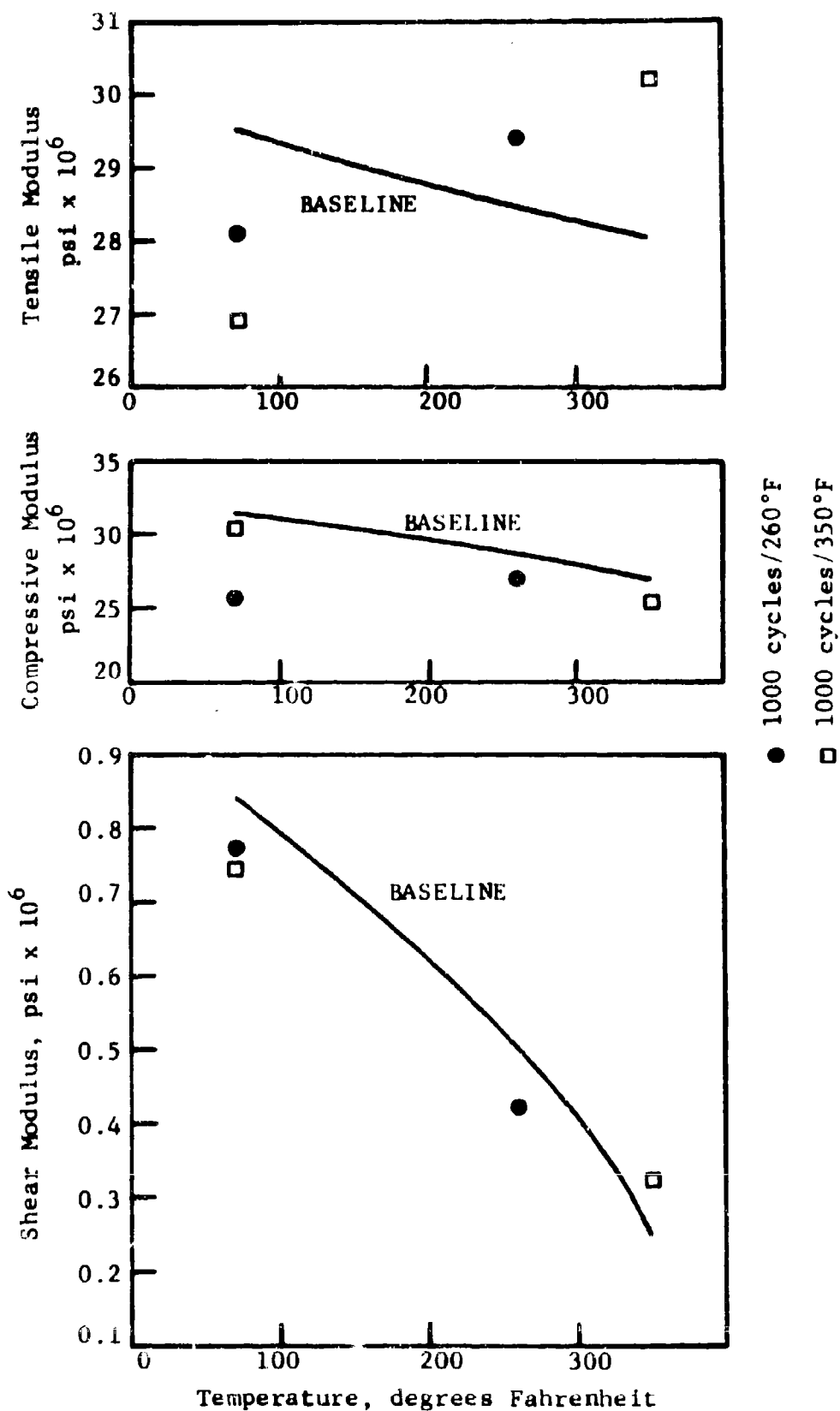


Fig. 56 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF AVCO 5505/BORON COMPOSITES - 0°

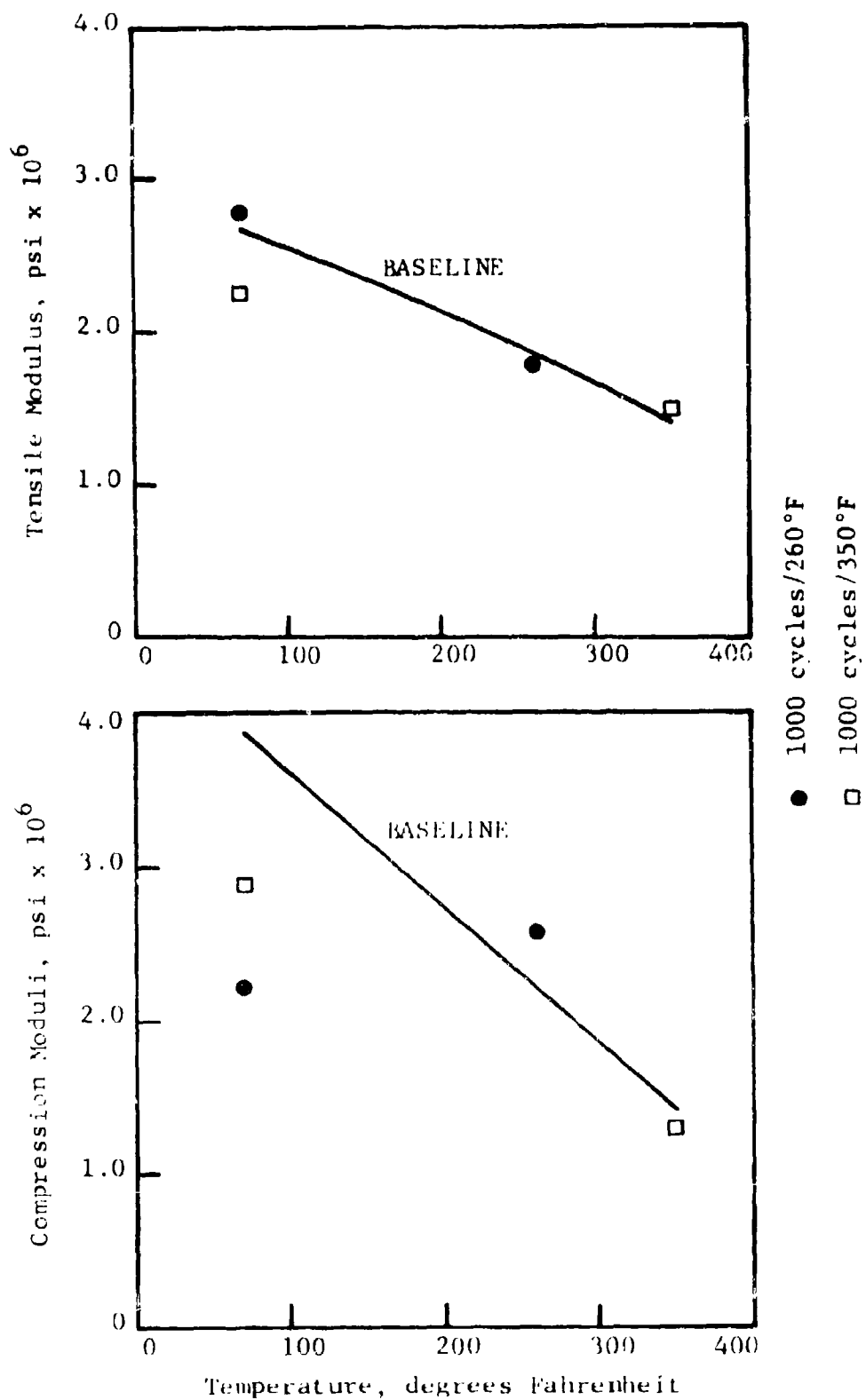


Fig. 57 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF AVCO 5505/BORON COMPOSITES - 90°

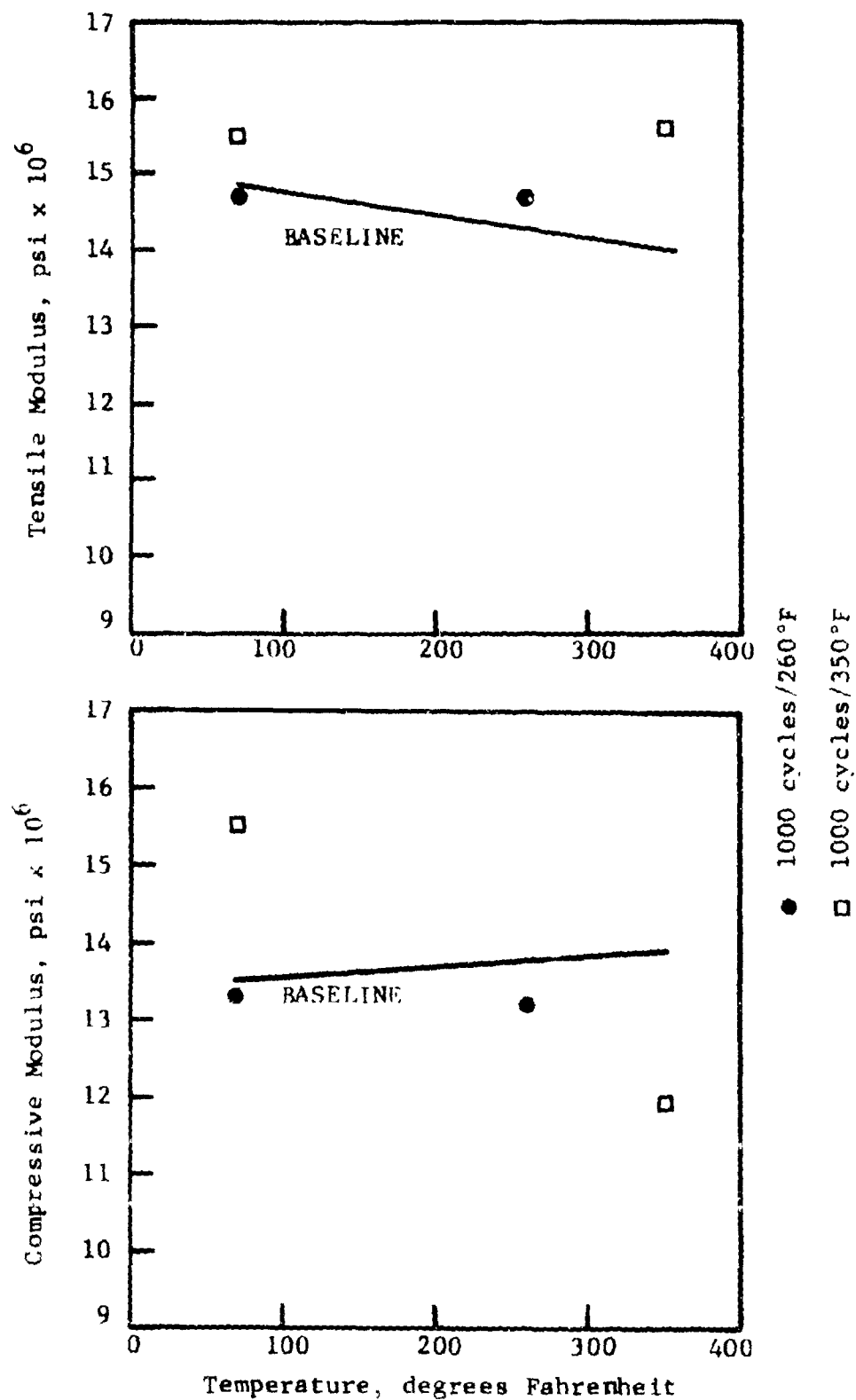


Fig. 58 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF AVCO 5505/BORON COMPOSITES - $[0/45/135/0/90]_s$

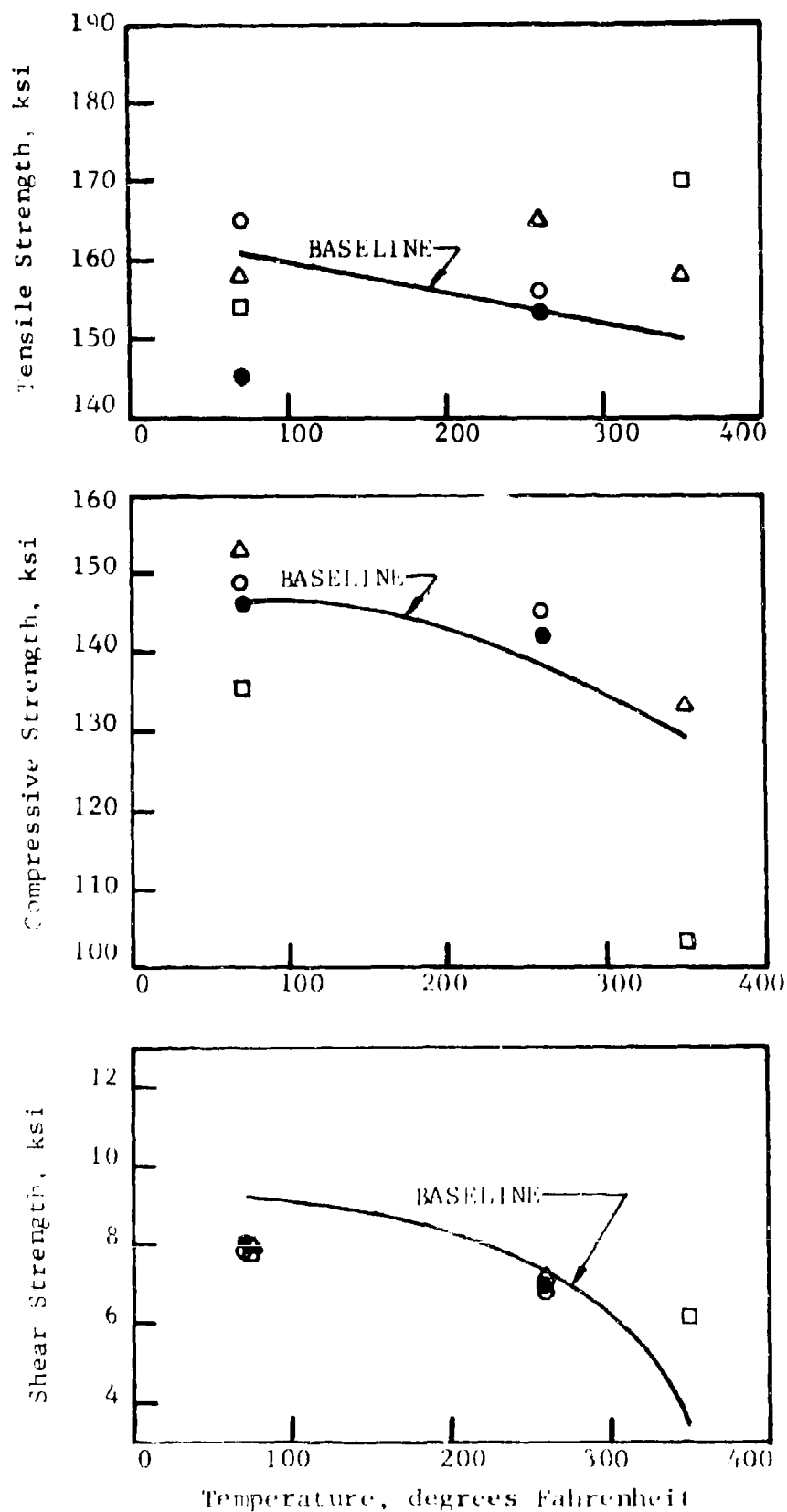


Fig. 59 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES 0°

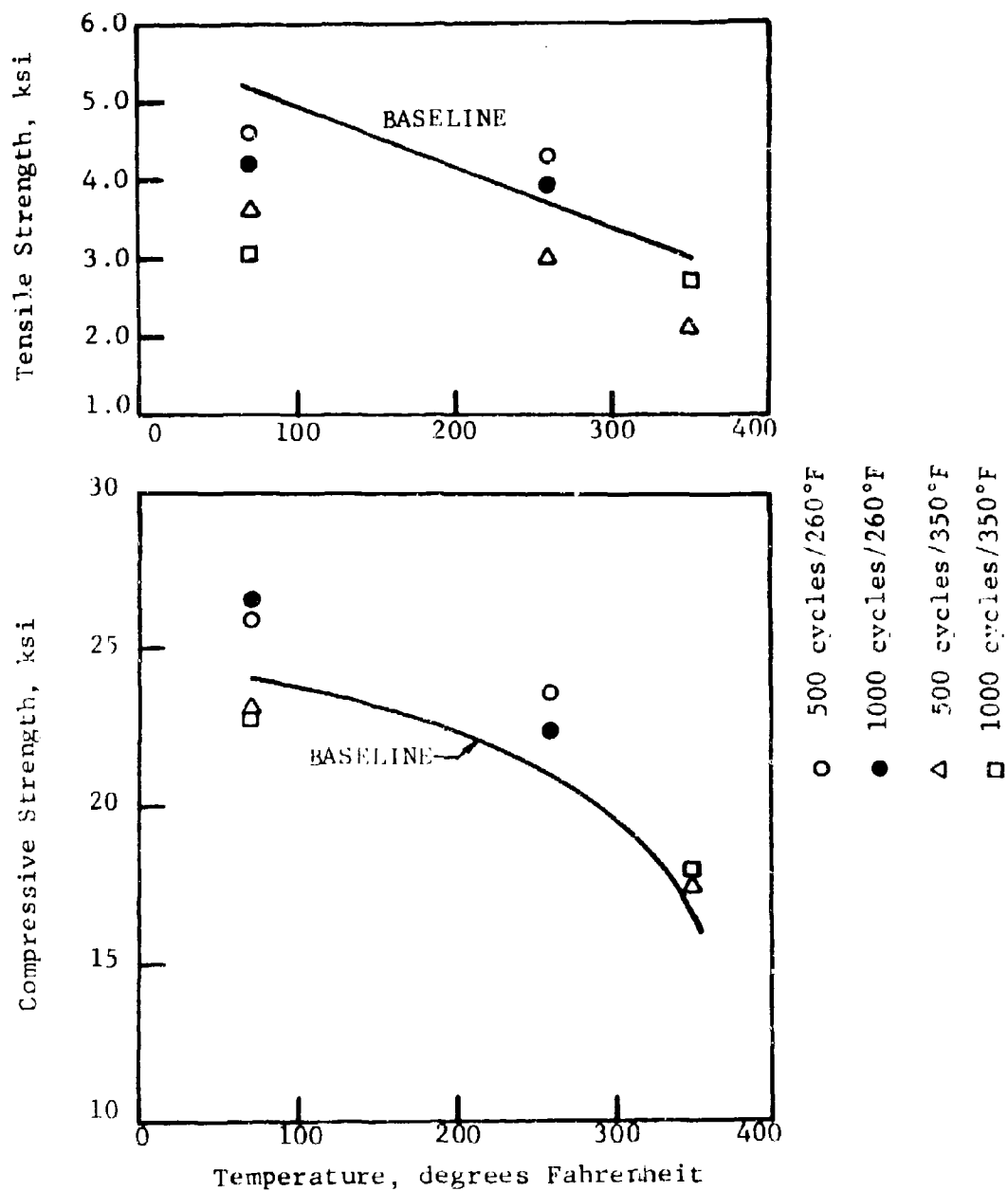


Fig. 60 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF NARMCO 5206/MDMOR 11 GRAPHITE COMPOSITES - 90°

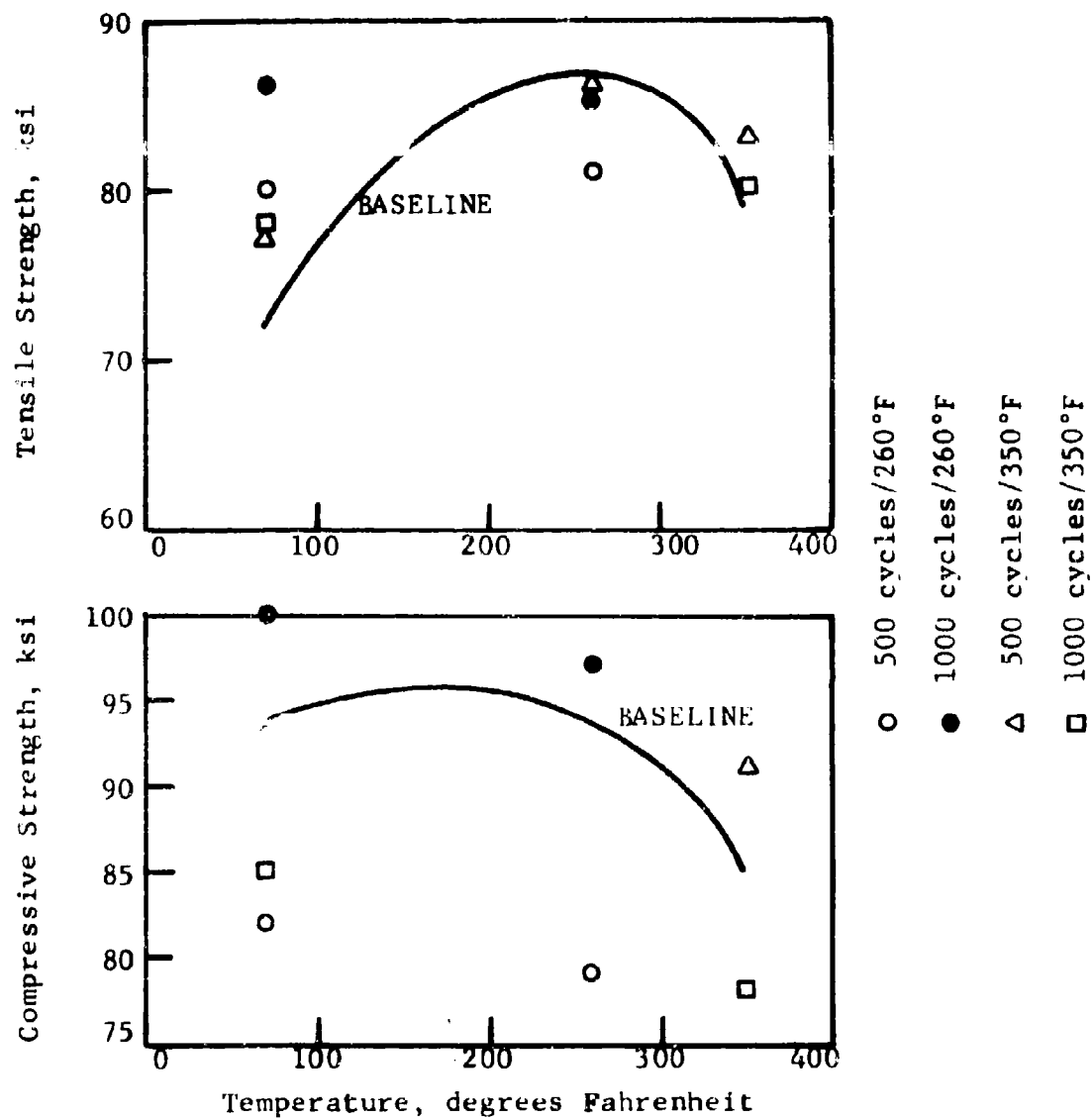


Fig. 61 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF NARMCO 5206/Modmor 11 GRAPHITE COMPOSITES - $[0/45/135/0/90]_s$

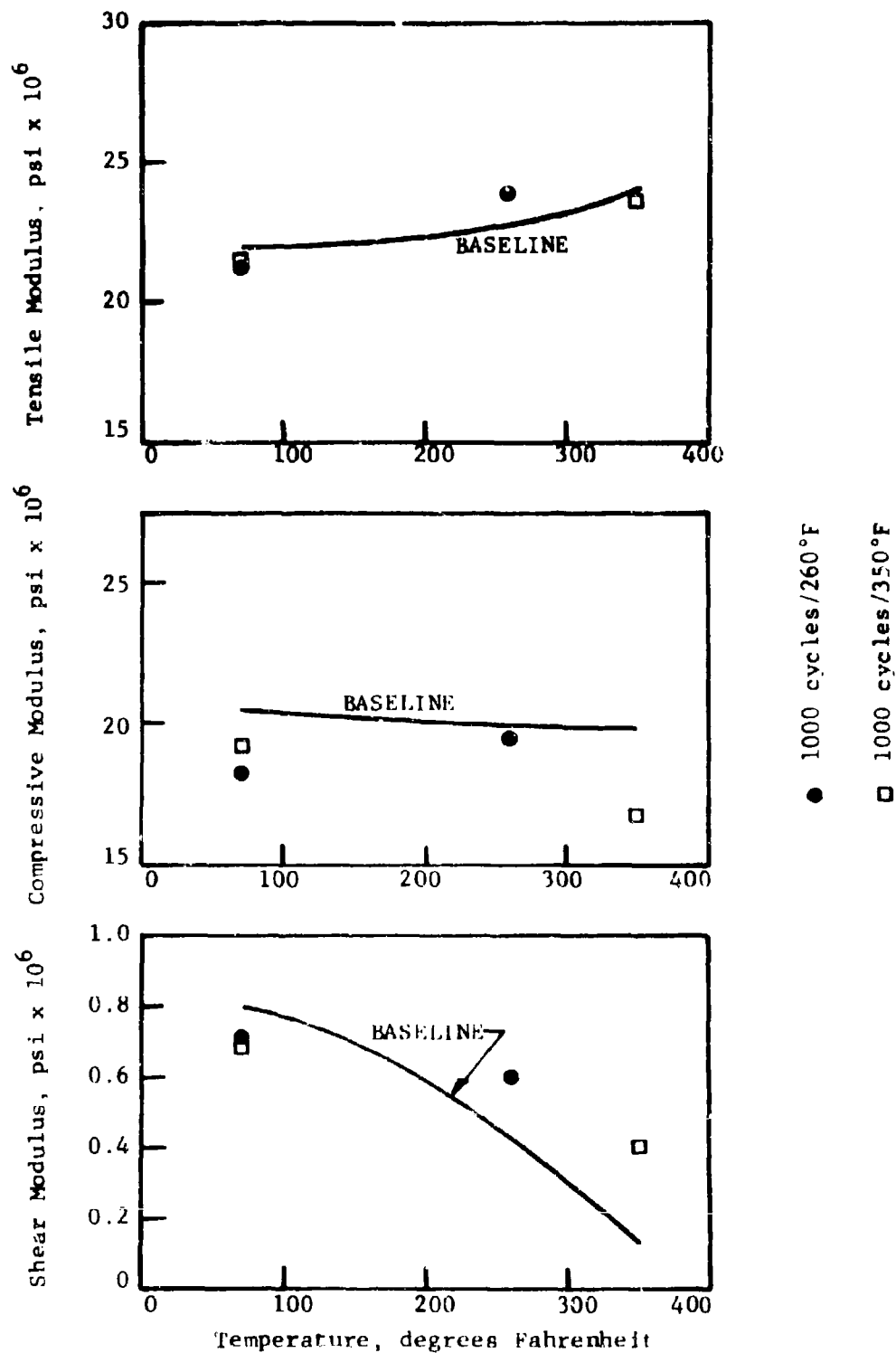


Fig. 62 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MDMOR 11 GRAPHITE COMPOSITES - 0°

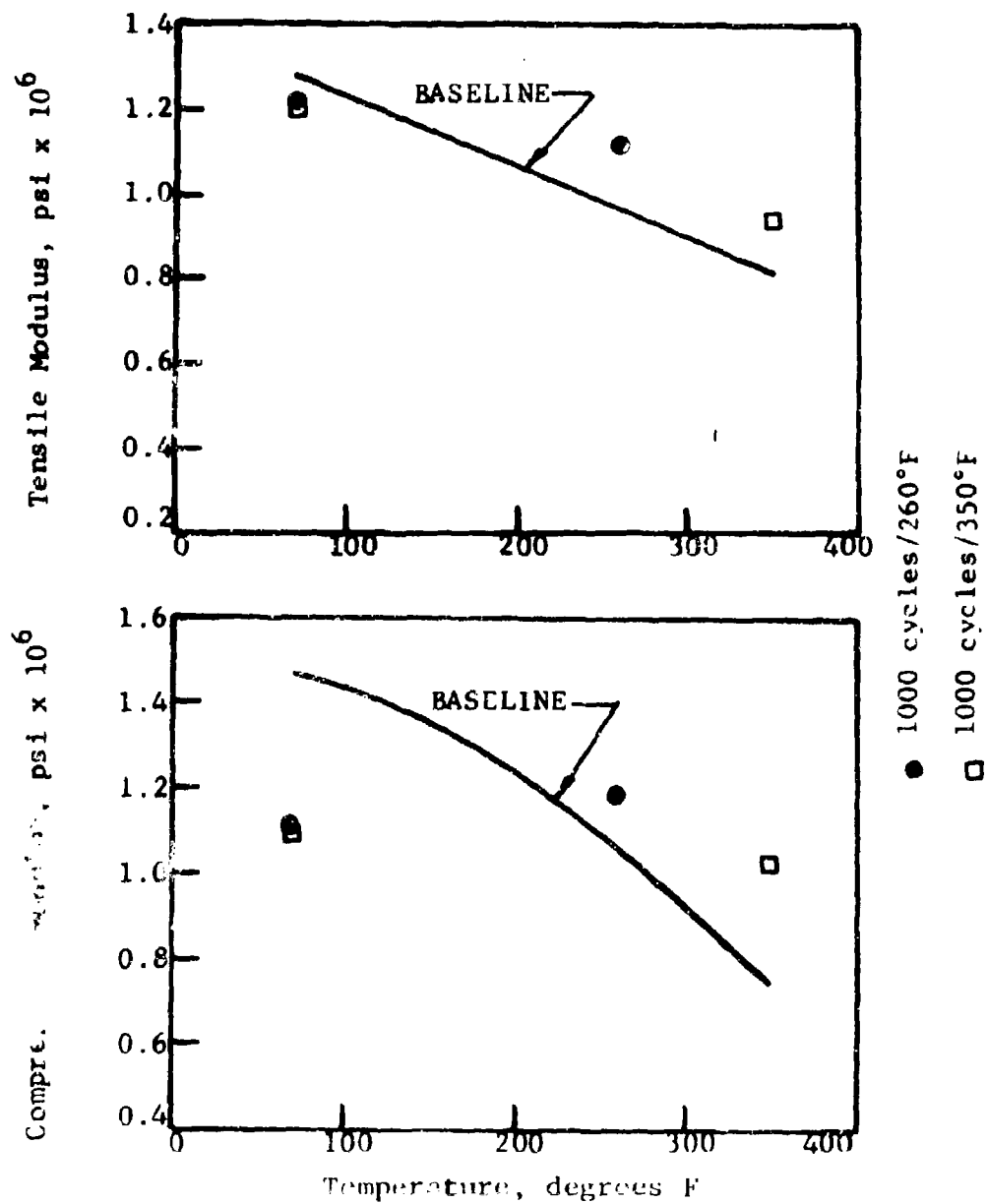


Fig. 63 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES - 90°

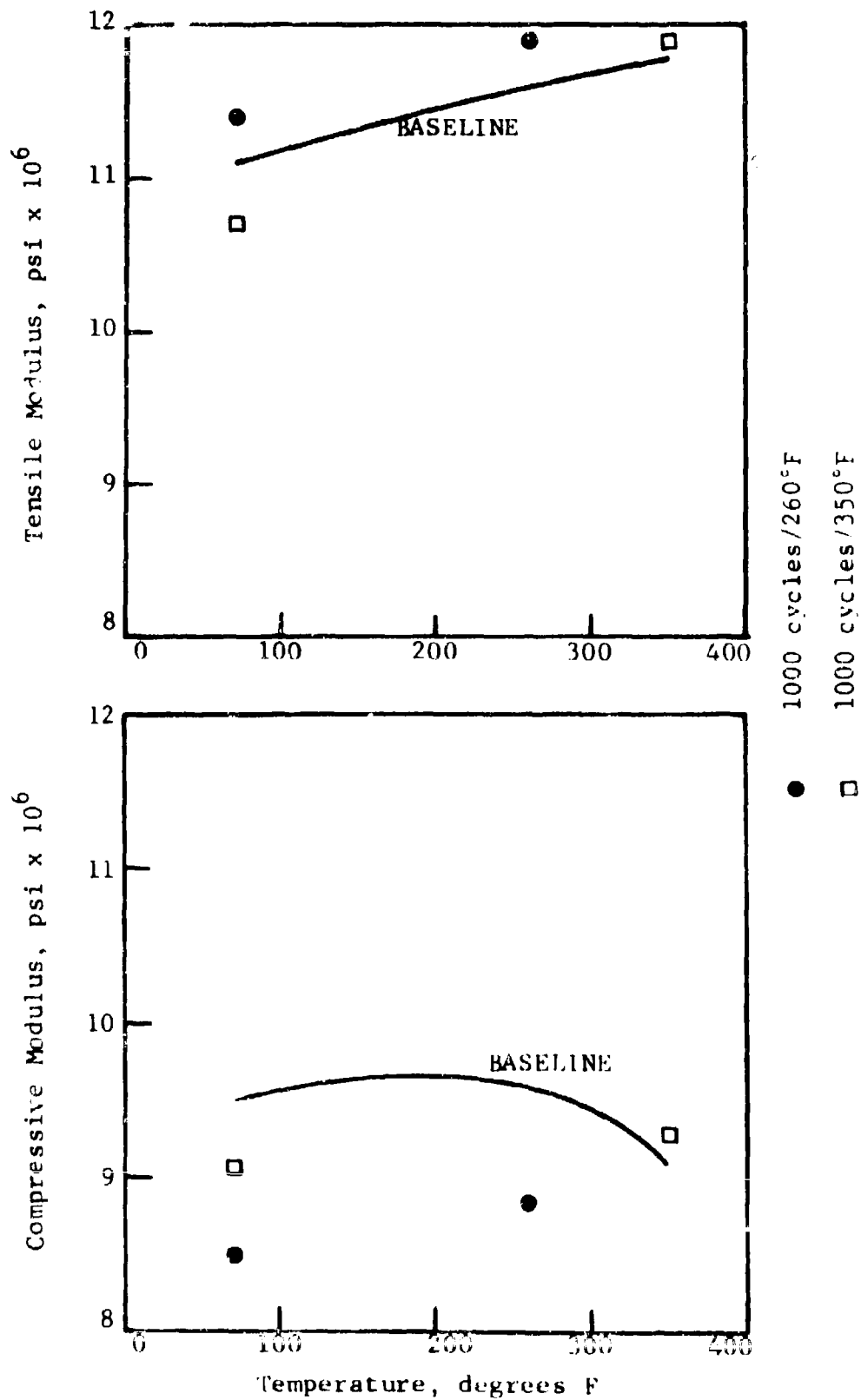


Fig. 64 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF NARMCO 5206/MDMOR 11 GRAPHITE COMPOSITES - [0/45/135/0/90]

The largest changes from the baseline behavior were evident in the 90° compressive room temperature behavior. In almost every case the elastic moduli became more constant over the temperature range than in the baseline or unconditioned state.

Figures 65 to 67 show the effect of cyclic thermal conditioning on the strengths of Hercules 3002M/Courtaulds HMS graphite composites. The greatest reduction in strength were evident for the 90° tensile strengths at elevated temperatures falling substantially below the baseline strengths. Increases in strengths were determined for the 0° and [0/45/135/0/90]_s tensile strengths and the laminate compressive strengths.

The elastic moduli of Hercules 3002M/Courtaulds HMS graphite were also affected by the cyclic thermal conditioning as is shown in Figs. 68 to 70. The tensile and compressive moduli of the [0/45/135/0/90]_s laminates were clearly affected substantially.

The steady state thermal conditioning generally increased the strength and stiffness of the unidirectional and [0/45/135/0/90]_s composites, decreasing the ultimate strain capabilities at the same time. The transverse strengths were decreased, transverse moduli increased and the strength versus temperature curves altered to a more constant value over the entire temperature range.

The cyclic thermal conditioning also made the variation of strengths and moduli with temperature more constant over the temperature range. The moduli were affected less than steady state exposures and were generally decreased.

2.1.6.4 Effect of Conditioning on Interlaminar Shear

The interlaminar shear strengths of the resin matrix composites are also affected by moisture and thermal conditioning, but to a lesser extent than other mechanical strengths.

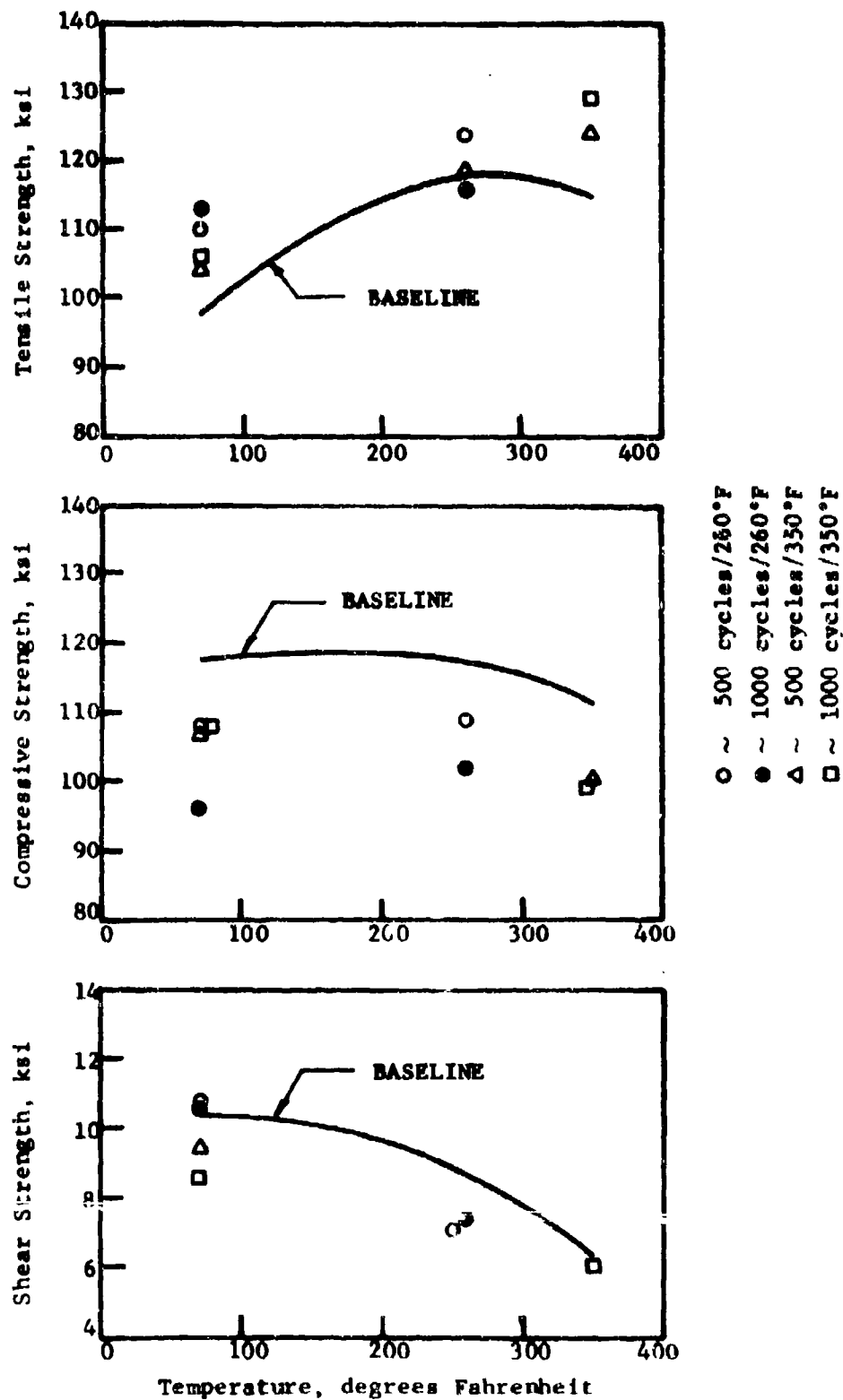


Fig. 65 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 0°

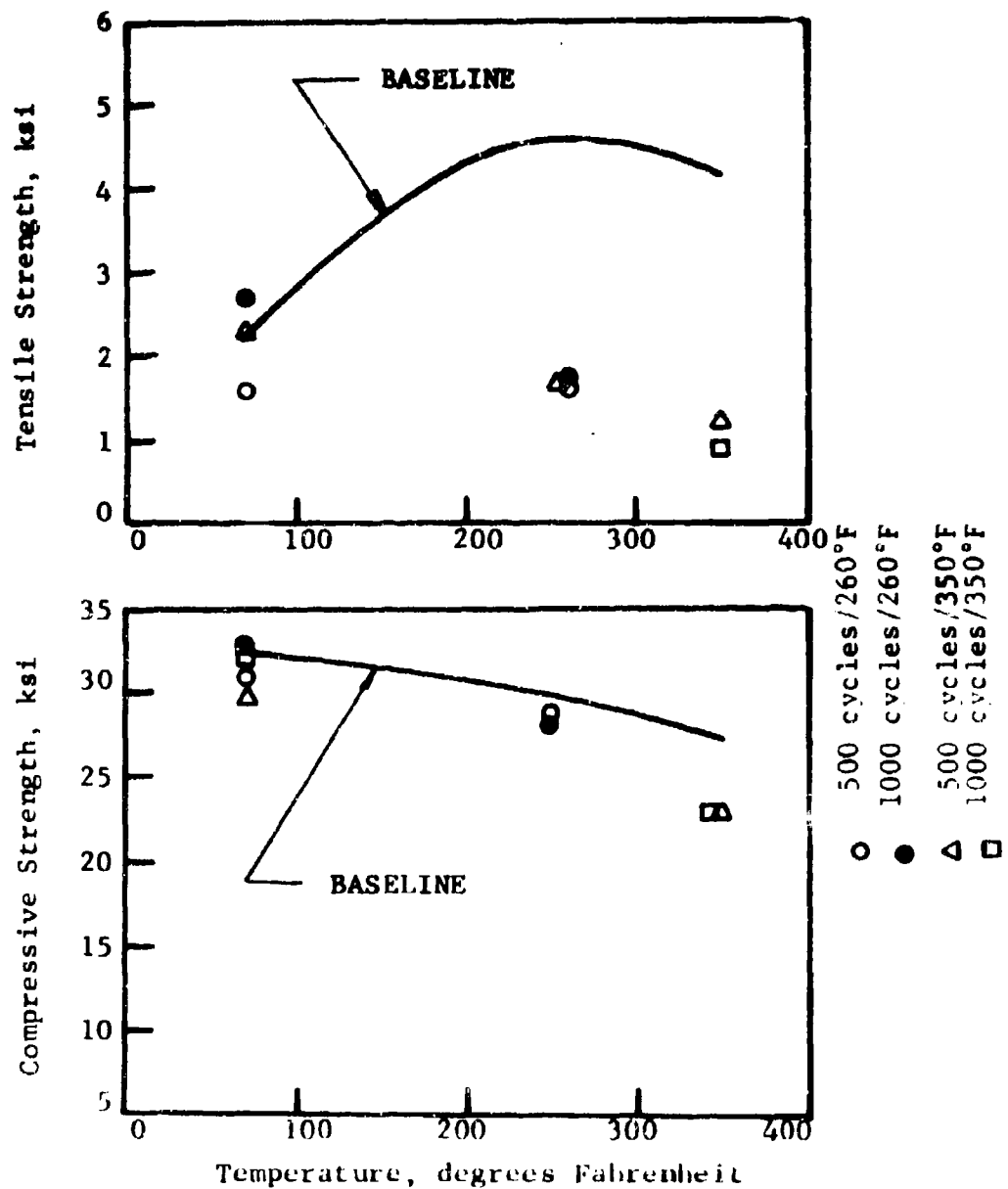


Fig. 66 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 90°

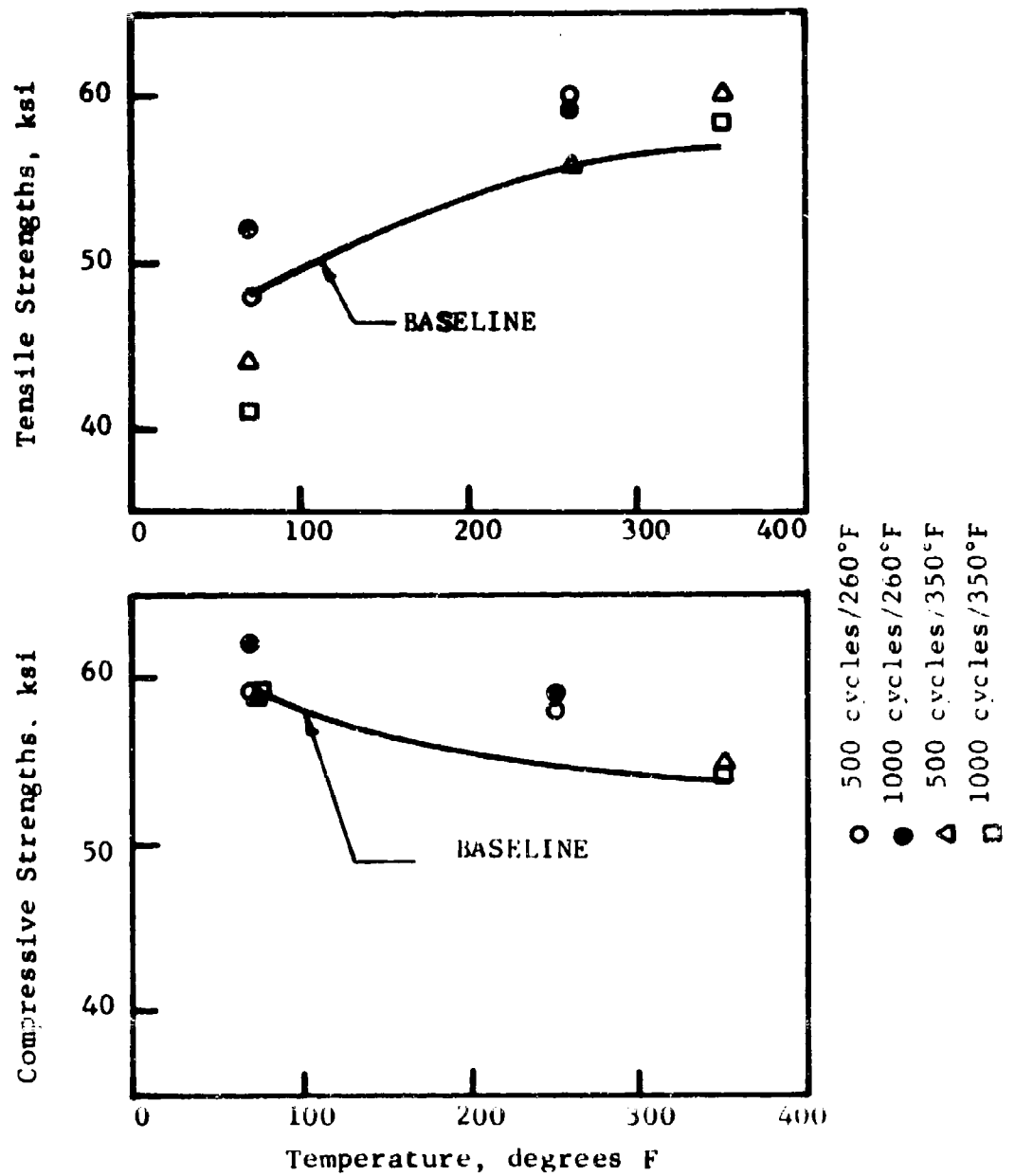


Fig. 67 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE STRENGTHS OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - $[0/45/135/0/90]_s$

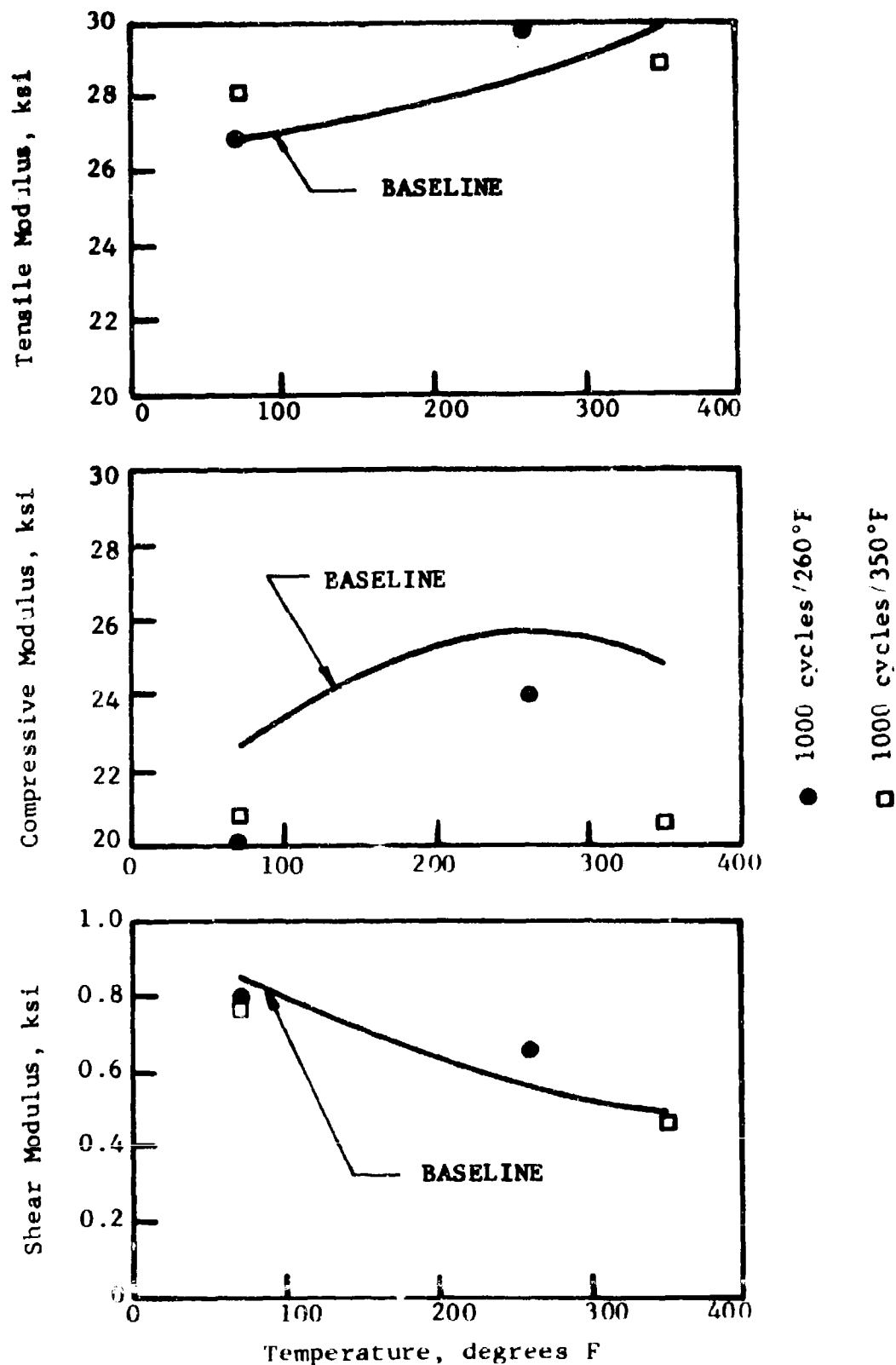


Fig. 68 EFFECTS OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/COURTAULDS HM₂ GRAPHITE COMPOSITES - 0°

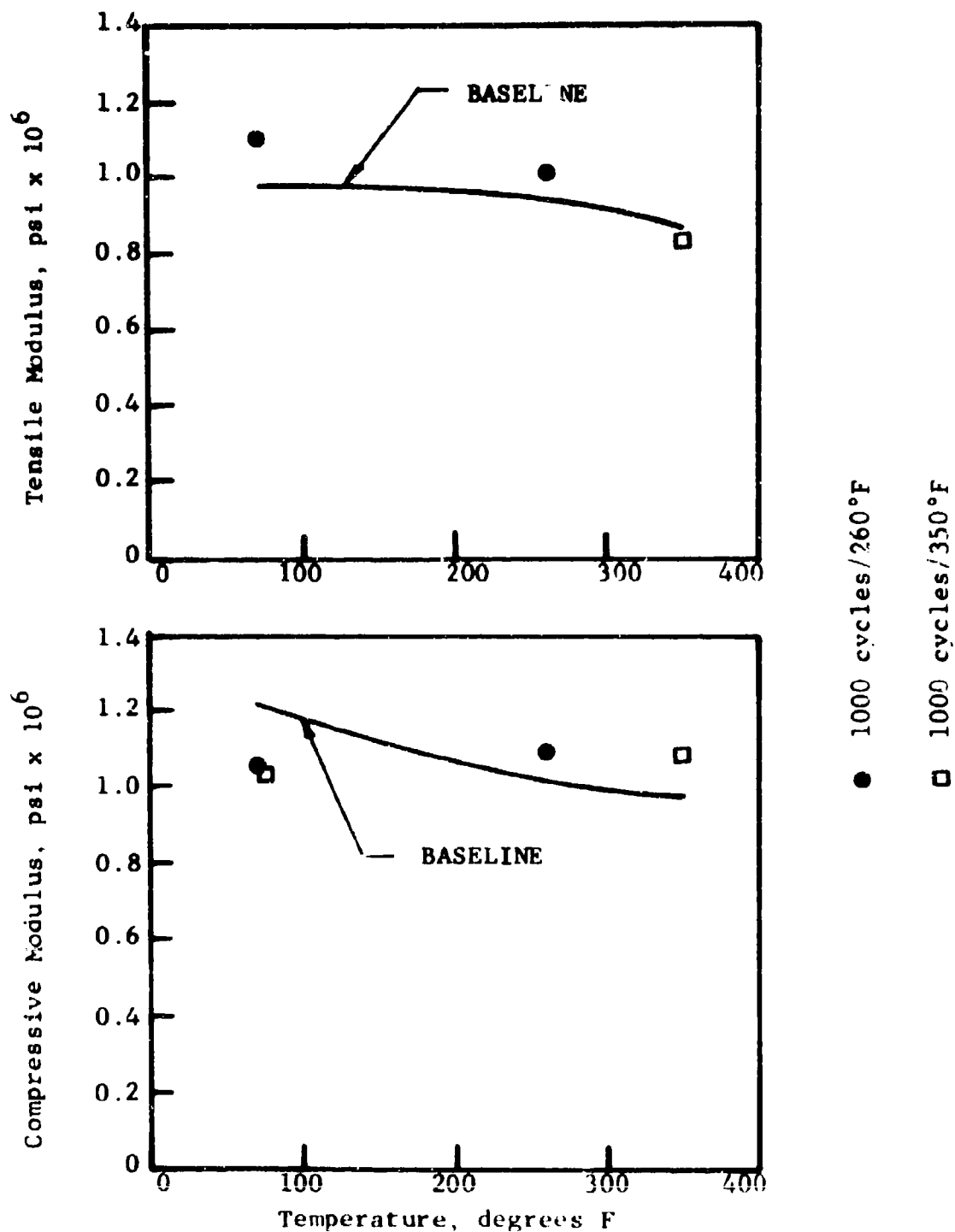


Fig. 69 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 90°

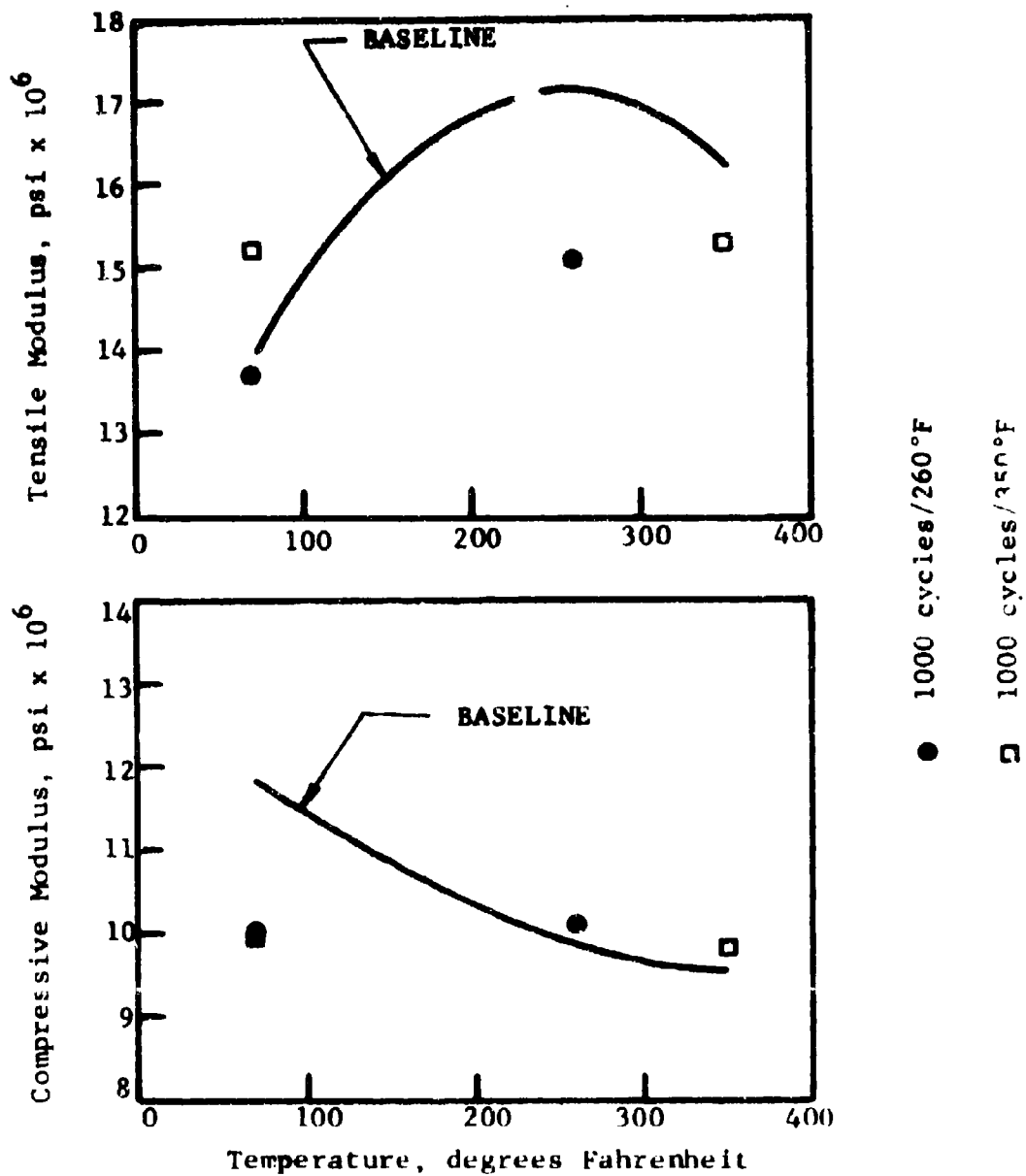


Fig. 70 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE ELASTIC MODULI OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - $[0/45/135/0/90]_s$

Figures 71, 72 and 73 show how the interlaminar shear strengths are affected by such prior exposures for AVCO 5505/Boron, Narmco 5206/Modmor II Graphite and Hercules 3002M/Courtaulds HMS Graphite composites respectively. All interlaminar shear strengths were obtained on the 0° fifteen-ply short beam specimens.

AVCO 5505/Boron composites show a loss of interlaminar shear strength with exposure to moisture (see Fig. 71a) and all environments result in practically the same loss of interlaminar shear strength.

Constant (noncyclic) temperature exposures (Fig. 71b) increased the interlaminar shear strength. The largest increases were for the least severe exposure (100 hours at 260°F), while the most severe exposure (500 hours at 350°F) increased the interlaminar shear strength the least. In fact the room temperature i.s.s. were least affected while the elevated temperature interlaminar shear strengths were affected substantially more.

Cyclic exposures affected the interlaminar shear strength of AVCO 5505/Boron differently, depending on the peak temperature per cycle. The shear strengths of specimens cycled to 260°F were relatively unaffected by the cyclic exposures whereas some increase or decrease in the interlaminar shear strength was noted for the specimens with 350°F upper temperatures per cycle.

Qualitatively the same effects were noted for the two graphite-epoxy composites (see Figs. 72 and 73) humidity generally decreasing the interlaminar shear strengths over the entire temperature range and mixed effects noted for the steady-state and cyclic thermal conditioning.

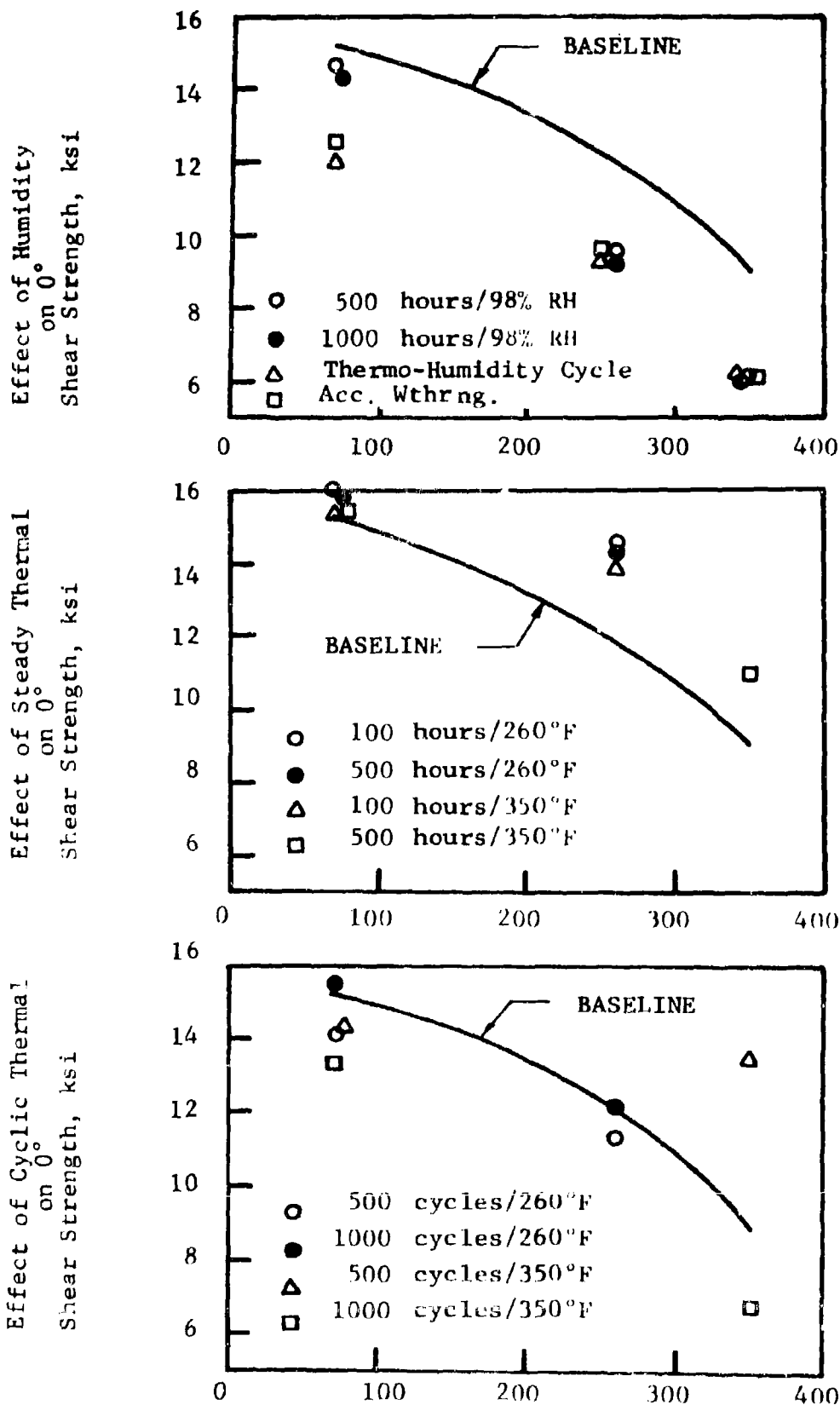


Fig. 71 EFFECT OF VARIOUS ENVIRONMENTAL CONDITIONING ON THE INTERLAMINAR SHEAR STRENGTH OF AVCO 5505/BORON COMPOSITES

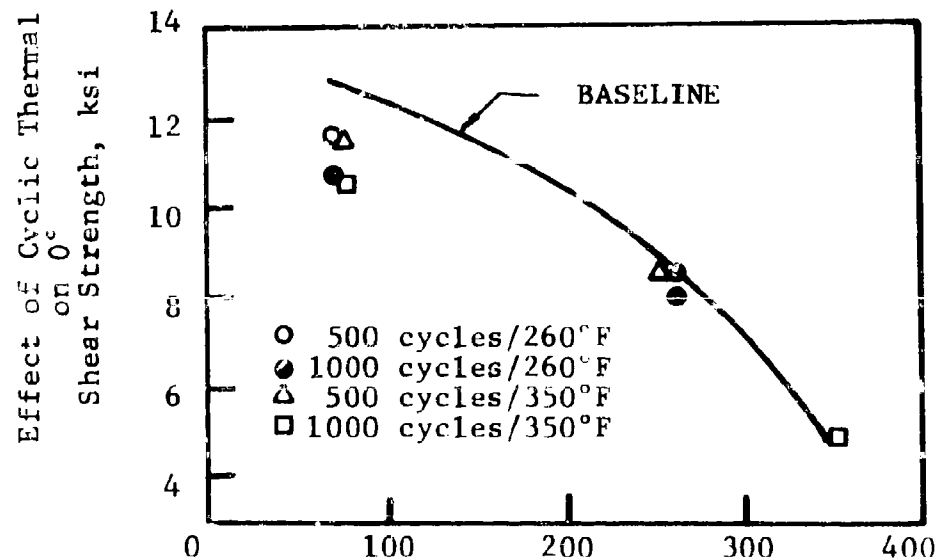
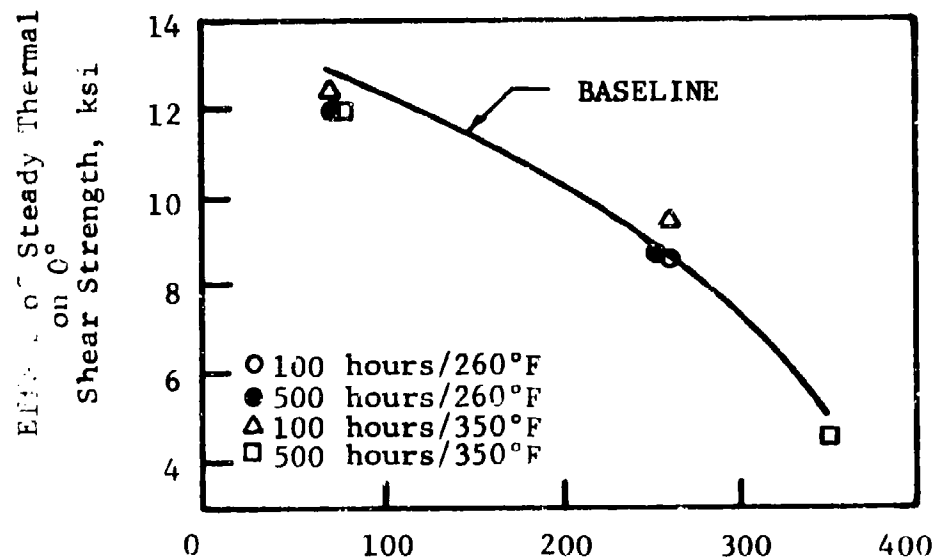
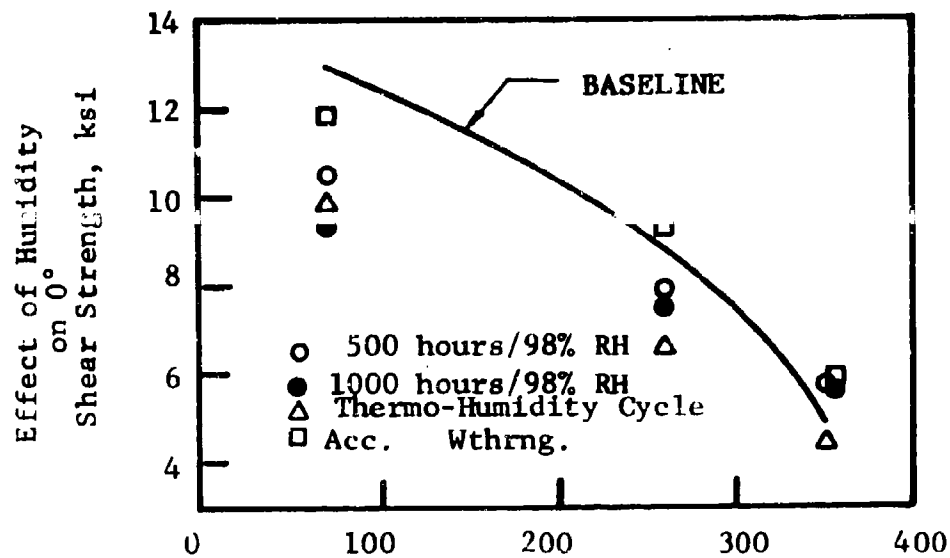


Fig. 72 EFFECT OF VARIOUS ENVIRONMENTAL CONDITIONING ON THE INTERLAMINAR SHEAR STRENGTH OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES 109

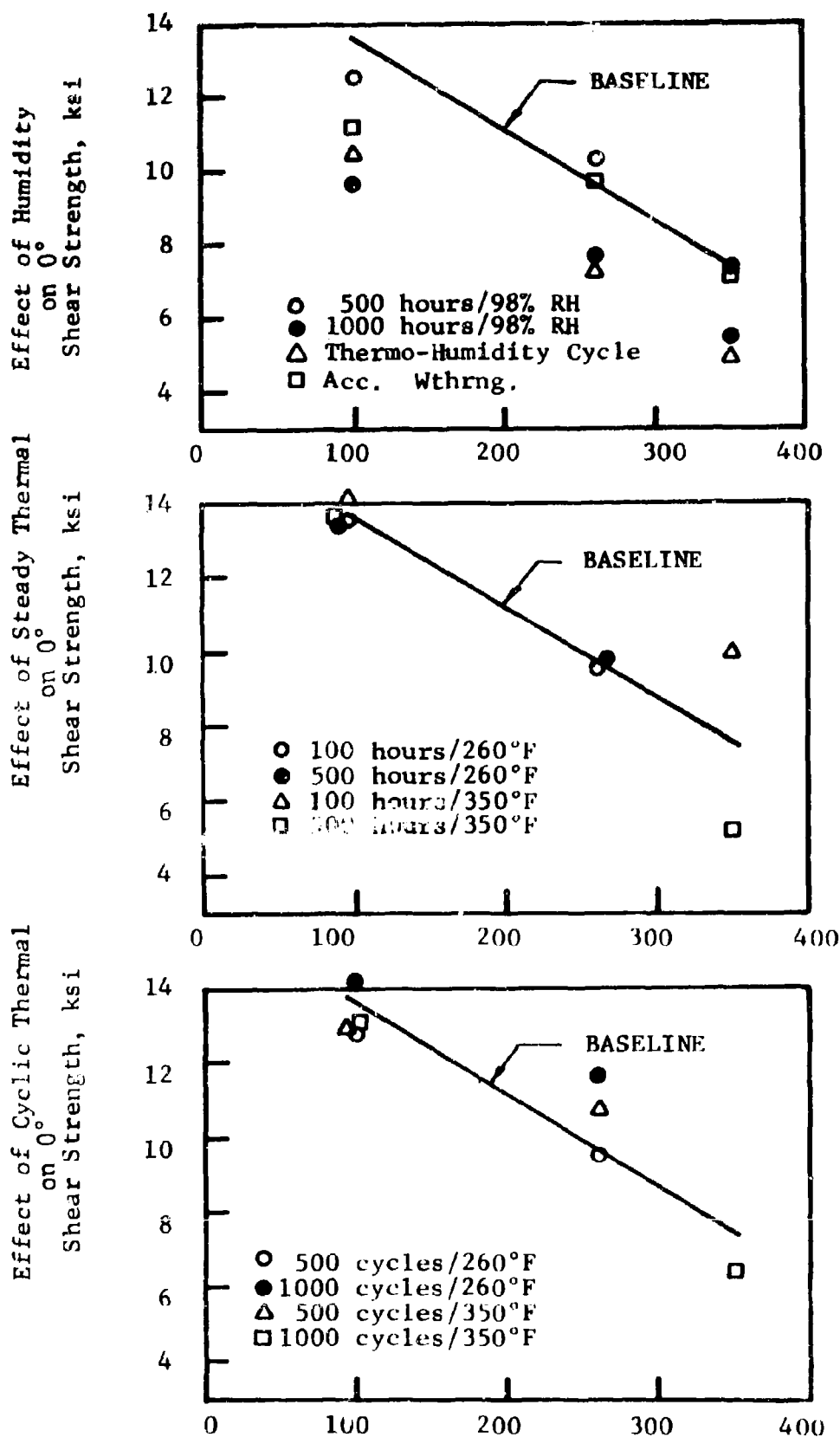


Fig. 73 EFFECT OF VARIOUS ENVIRONMENTAL CONDITIONING ON THE INTERLAMINAR SHEAR STRENGTHS OF HERCULES 3002M/COUNT AULDS HMS GRAPHITE COMPOSITES

2.1.7 Fatigue Test Results

2.1.7.1 Baseline Fatigue Data

The baseline fatigue data are presented in S-N plot form in Appendices I through III. It should be noted that there is a general decline in the fatigue resistance of all three composites with increasing temperature.

2.1.7.2 Effects of Humidity Conditioning on Fatigue Behavior

The parametric effects of humidity conditioning on the S-N fatigue behavior is shown in Figs. 74 and 75 for AVCO 5505/Boron unidirectional $[0/45/135/0/90]_s$ laminates respectively. The effects are shown at each of the three test temperatures (RT, 260°F and 350°F).

Note that the cyclic humidity conditioning treatments degraded the fatigue resistances of the AVCO 5505/Boron composites considerably more than did the steady-state humidity conditioning treatments.

Similarly the humidity effects on the graphite/epoxy composites are presented in Figs. 76 to 79.

With regard to the fatigue S-N behavior for Narmco 5206/Modmor II Graphite Composites, it is seen in Fig. 76 note that the ranking is (1) baseline, (2) 500 hours 98% RH, (3) Accelerated weathering, (4) 1000 hours 98% RH and (5) Thermo-Humidity cycle at room temperature. At higher temperatures the 500 and 1000 hours exposures degraded the fatigue behavior more than did the humidity cycles. Similar comments applied to the $[0/45/135/0/90]_s$ laminates as well (see Fig. 77).

The fatigue degradation due to high humidity conditions for Courtaulds HMS Graphite/Hercules 3002M composites are seen in Figs. 78 and 79. The behavior shown is complex. Some liberal

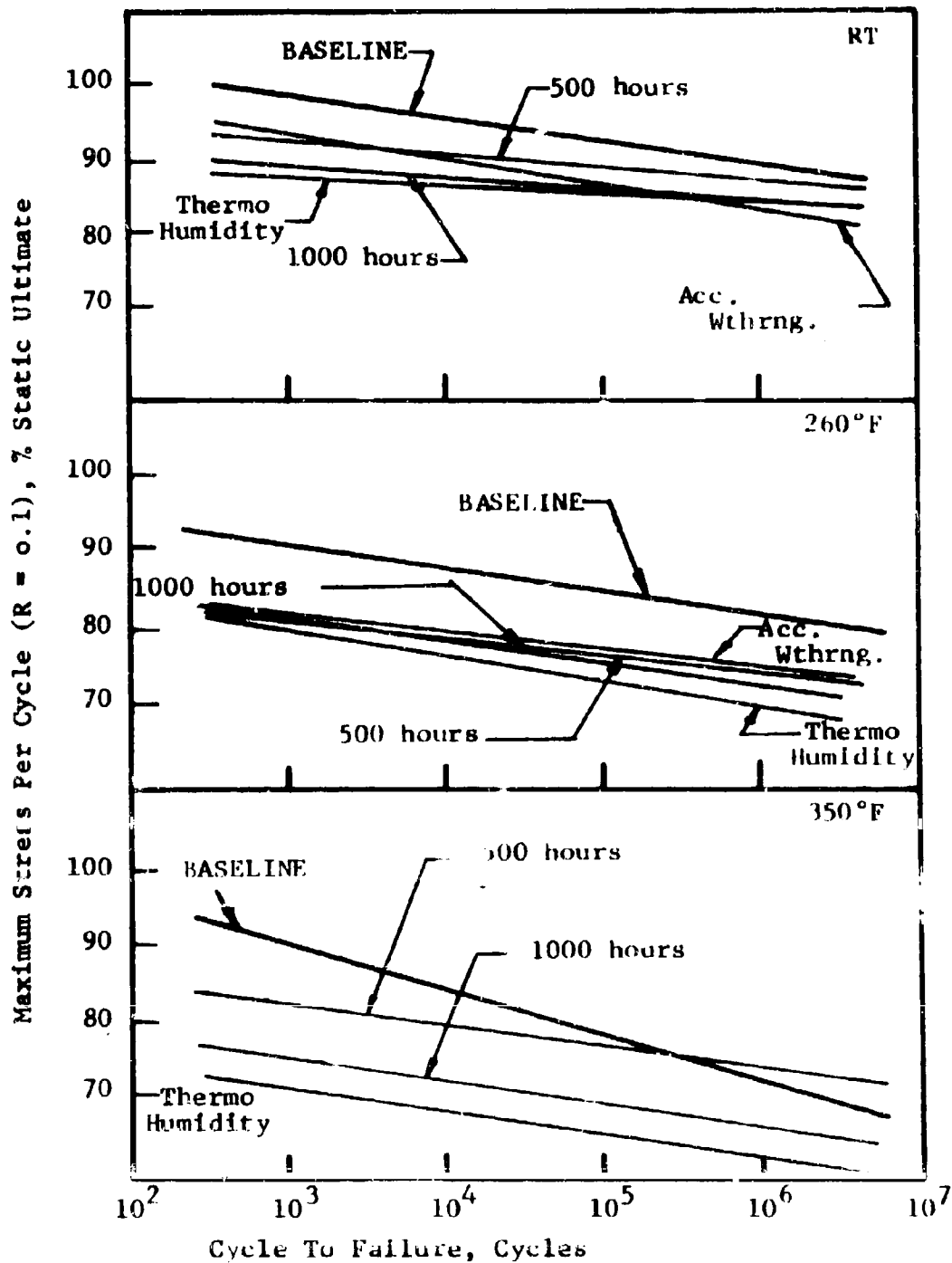


FIG. 7/ EFFECT OF HUMIDITY CONDITIONING ON THE FATIGUE SN CURVES FOR AVCO 5505/BORON COMPOSITES - 0°

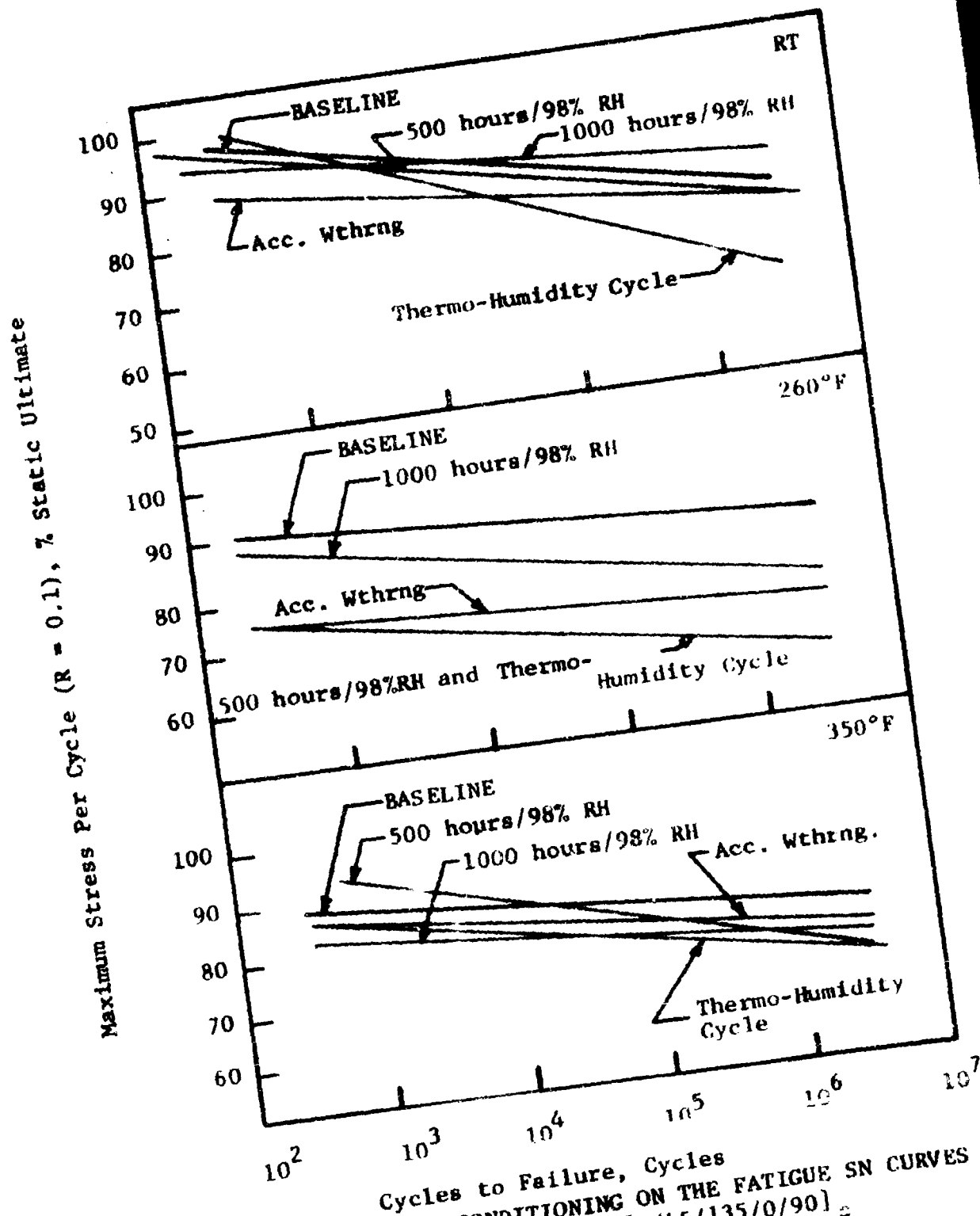


Fig. 75 EFFECT OF HUMIDITY CONDITIONING ON THE FATIGUE SN CURVES FOR AVCO 5505/BORON COMPOSITES [0/45/135/0/90]

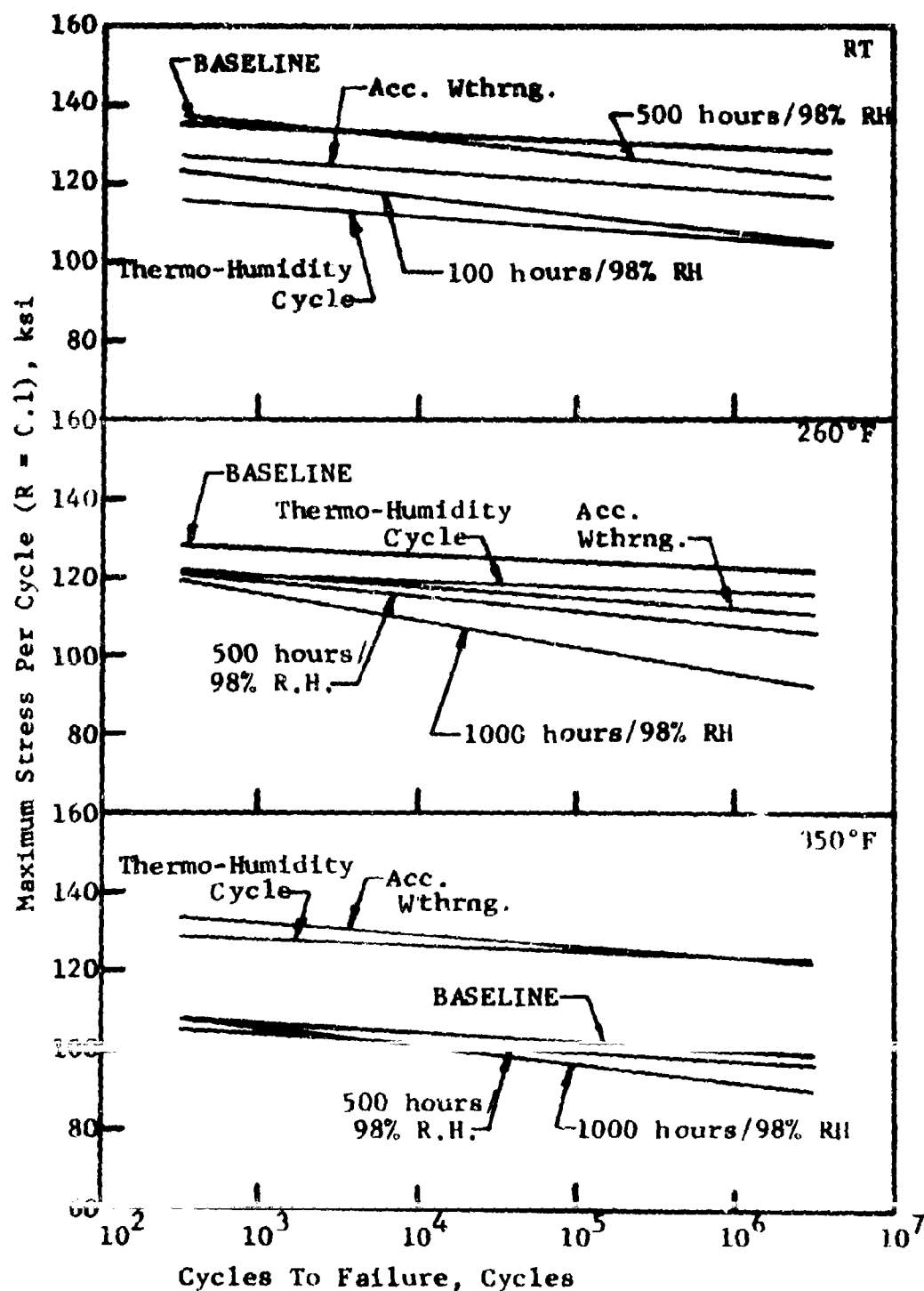


Fig. 76 EFFECT OF HUMIDITY CONDITIONING ON THE FATIGUE SN CURVES FOR NARMCO 5206/MODMOR II GRAPHITE COMPOSITES - 0°

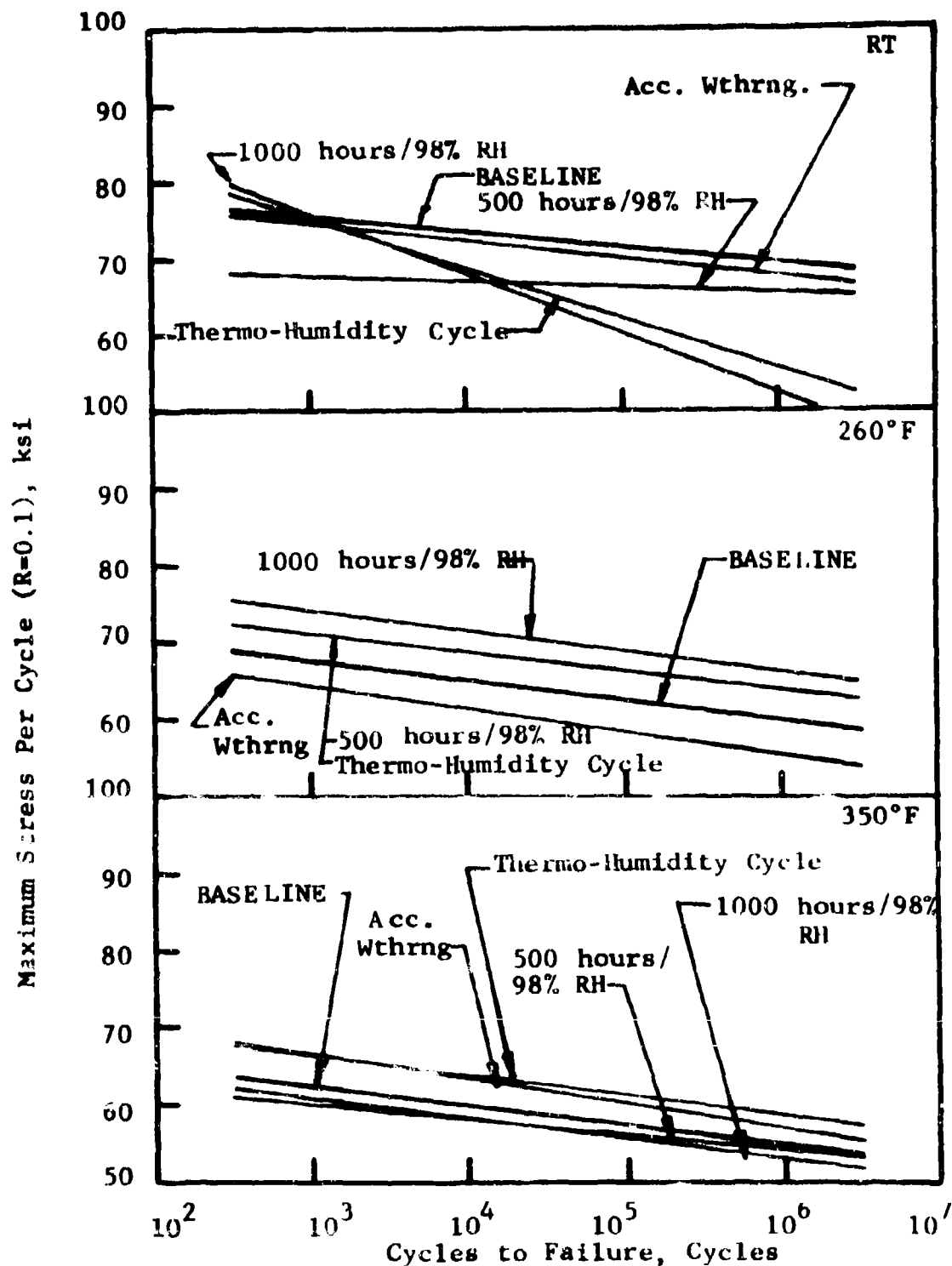


Fig. 77 EFFECT OF HUMIDITY CONDITIONING ON THE FATIGUE SN CURVES
FOR NARMCO 5206/MODMOD II GRAPHITE COMPOSITES - [0/45/135/0/90]_s

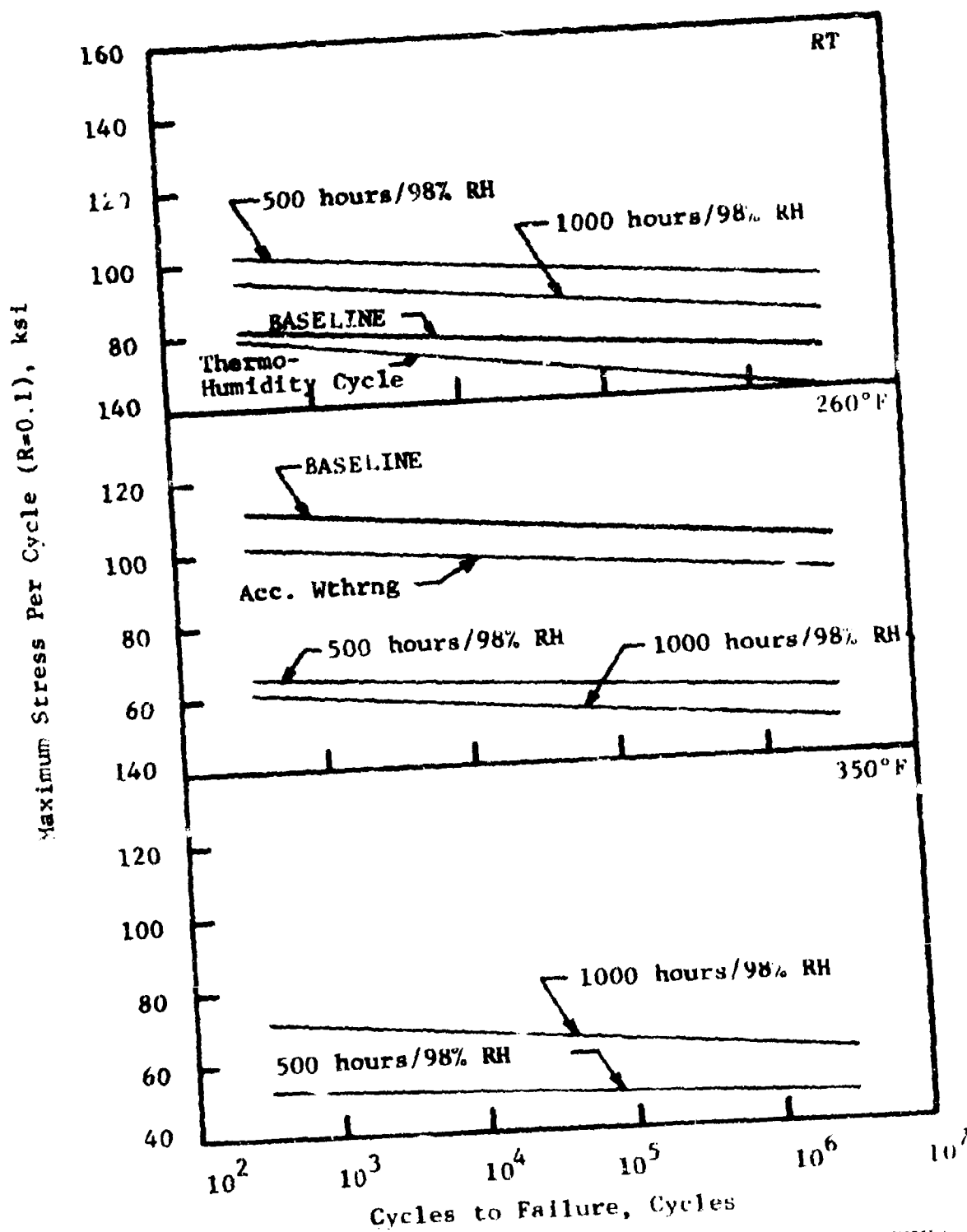


Fig. 78 EFFECT OF HUMIDITY CONDITIONING ON THE FATIGUE SN CURVES FOR HERCULES 3002M/COURTAULD'S HMS GRAPHITE COMPOSITES 0°

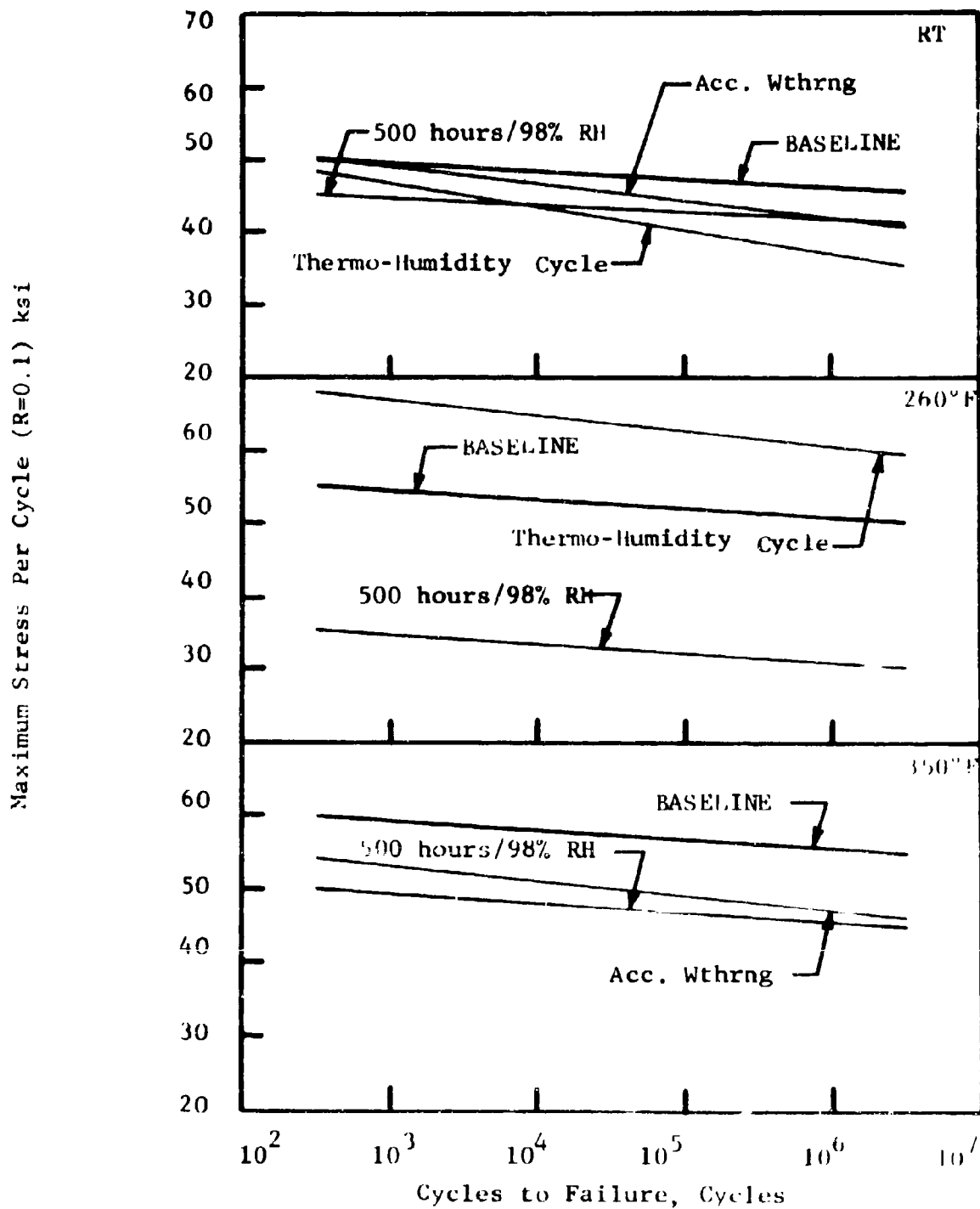


Fig. 79 EFFECT OF HUMIDITY CONDITIONING ON THE FATIGUE S-N CURVES FOR
HERCULES 3002 M COURTAULDS HMS GRAPHITE COMPOSITES [0/45/135/0/90]

interpretation must be applied to the room temperature baseline data which is probably shown too low in Fig. 78. On the other hand, the static strengths rose with temperature and it is possible that the fatigue S-N behavior mirrors this to some extent.

2.1.7.3 Effects of Thermal Conditioning on Fatigue Behavior

Several parametric cross plots on the effects of thermal conditioning on fatigue behavior were prepared. The effect of steady-state thermal conditioning are presented as follows:

AVCO 5505/Boron - Figs. 80 and 81

Modmor II Graphite/Narmco 5206 - Figs. 82 and 83

Courtaulds HMS Graphite/Hercules 3002M - Figs. 84 and 85

The classic degradation of the fatigue S-N behavior with prior steady-state thermal conditioning is seen in Fig. 80 for 0° AVCO 5505/Boron composites. More degradation at the higher cyclic lives is seen in Fig. 81 for the $[0/45/135/0/90]_s$ composites of AVCO 5505/Boron.

The Narmco 5206/Modmor II Graphite composites show more complex behavior. Both long term aging effects at the higher cyclic lives and some strengthening effects at the lower cyclic lives are seen in Fig. 82, for 0° composites, particular the room temperature fatigue behaviors. Similar behavior was noted in the case of the $[0/45/135/0/90]_s$ laminates although the strengthening was more uniform over the entire range of cyclic lives.

Similar effects are seen for the Hercules 3002M/Courtaulds HMS Graphite composites, (see Figs. 84 and 85).

Cyclic thermal conditioning effects on the fatigue behavior of the three resin matrix composites is shown as follows:

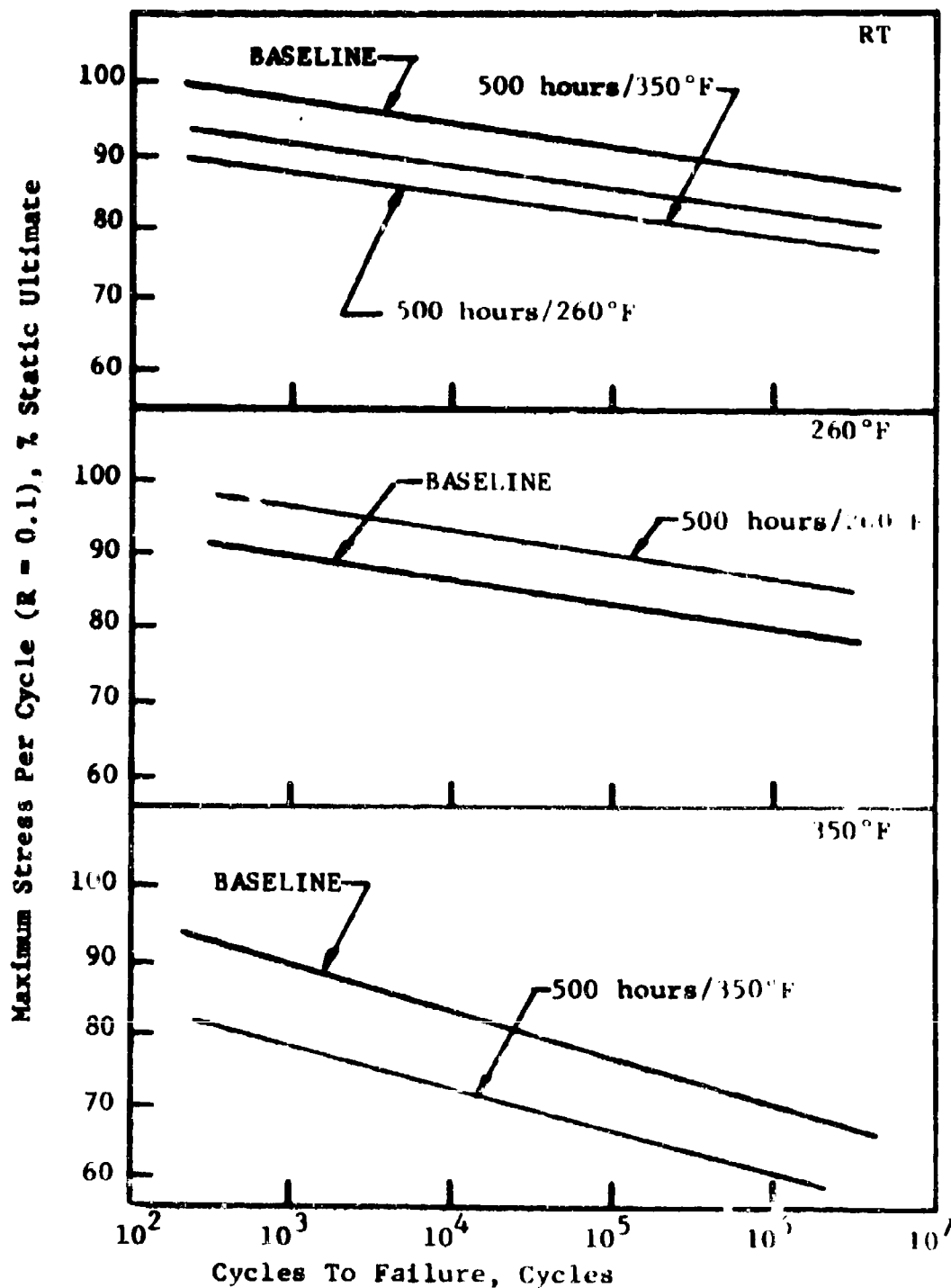


Fig. 80 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR AVCO 5505/BORON COMPOSITES-0°

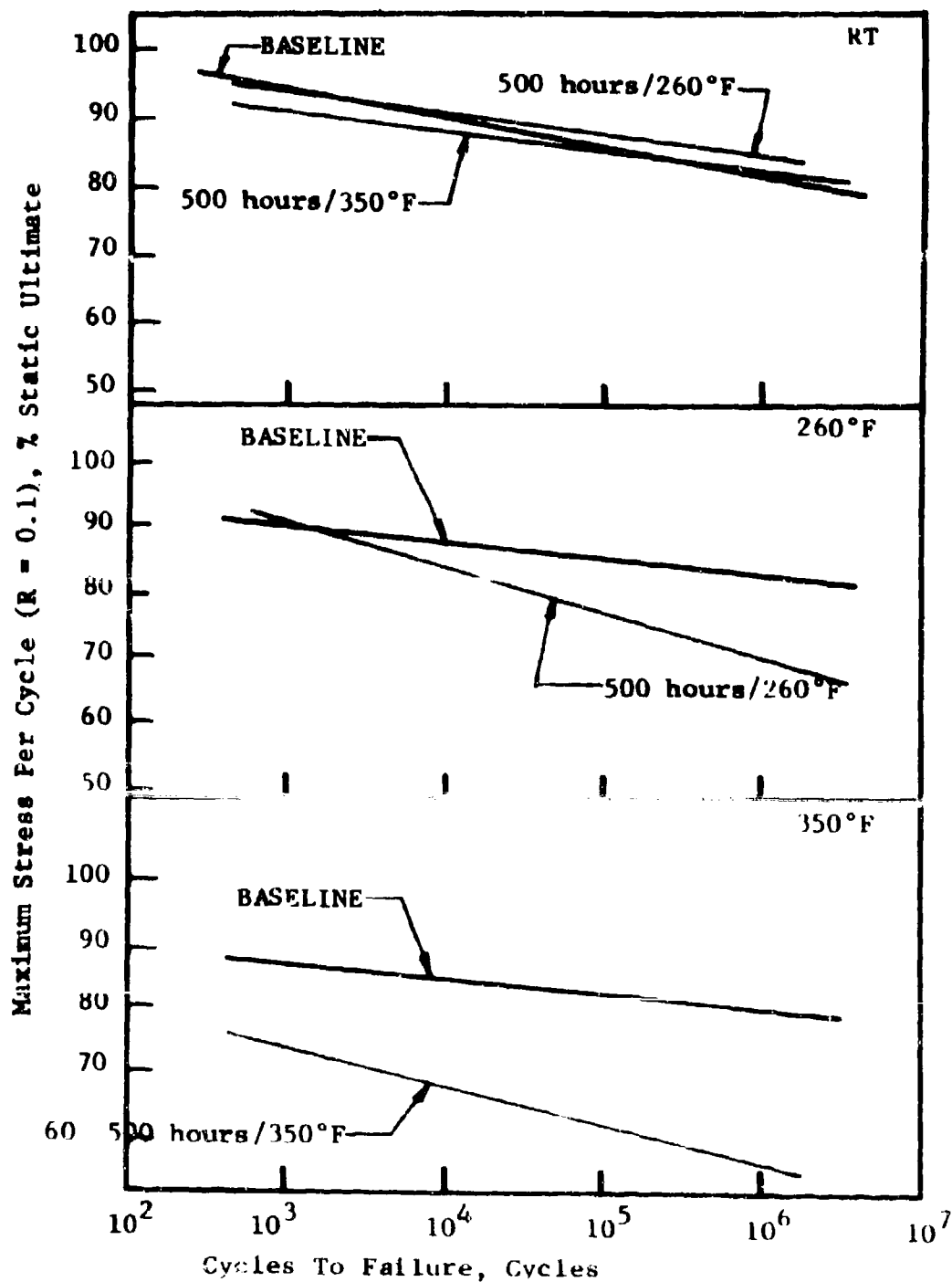


Fig. 81 EFFECT OF STEADY STATE THERMAL CONDITIONING
ON THE FATIGUE SN CURVES FOR AVCO 5505/BORON COMPOSITES
[0/45/135/0/90]_s

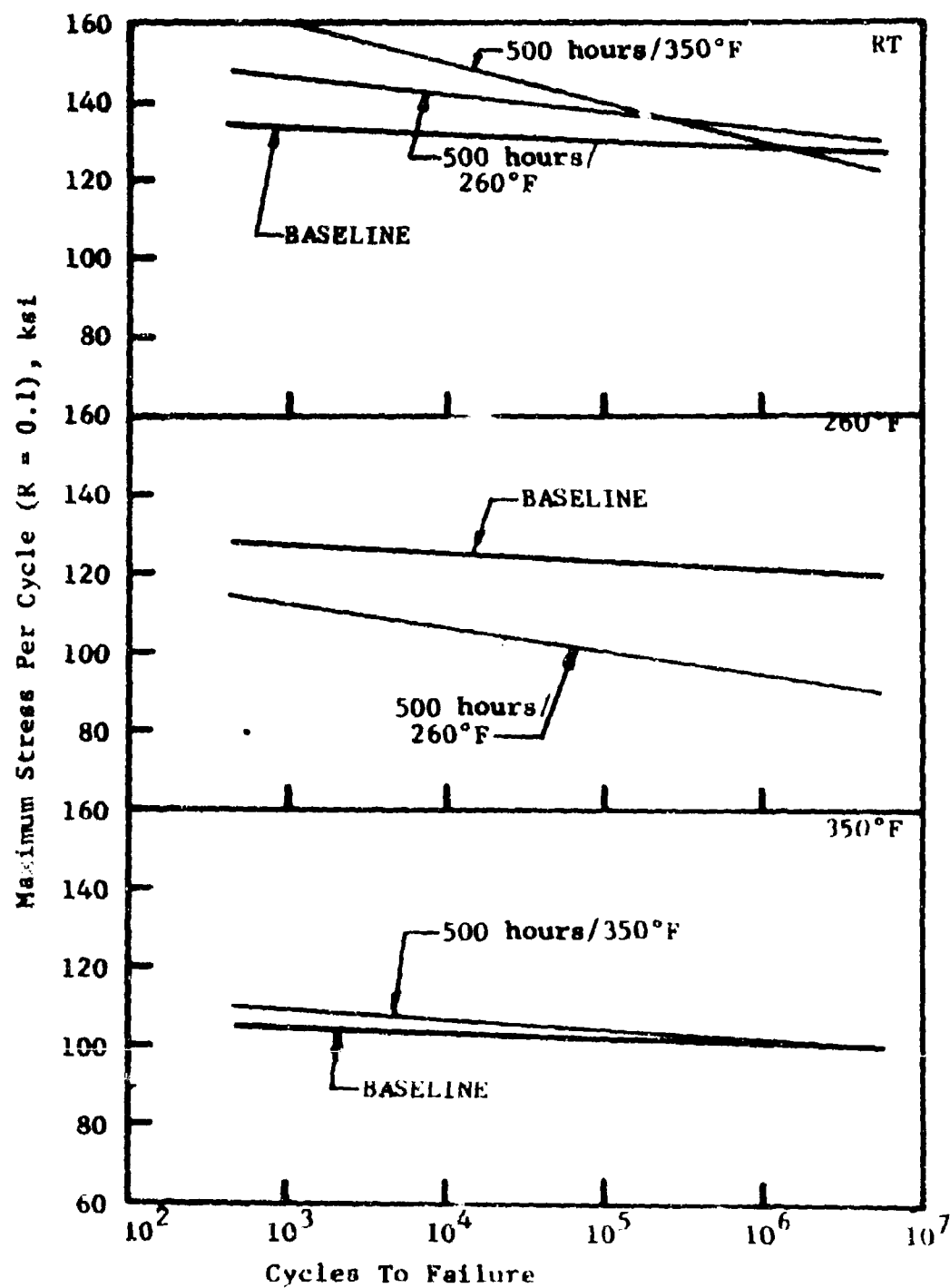


Fig. 82 EFFECT OF STEADY-STATE THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR MODMOR II/NARMCO 5206 COMPOSITES-0°

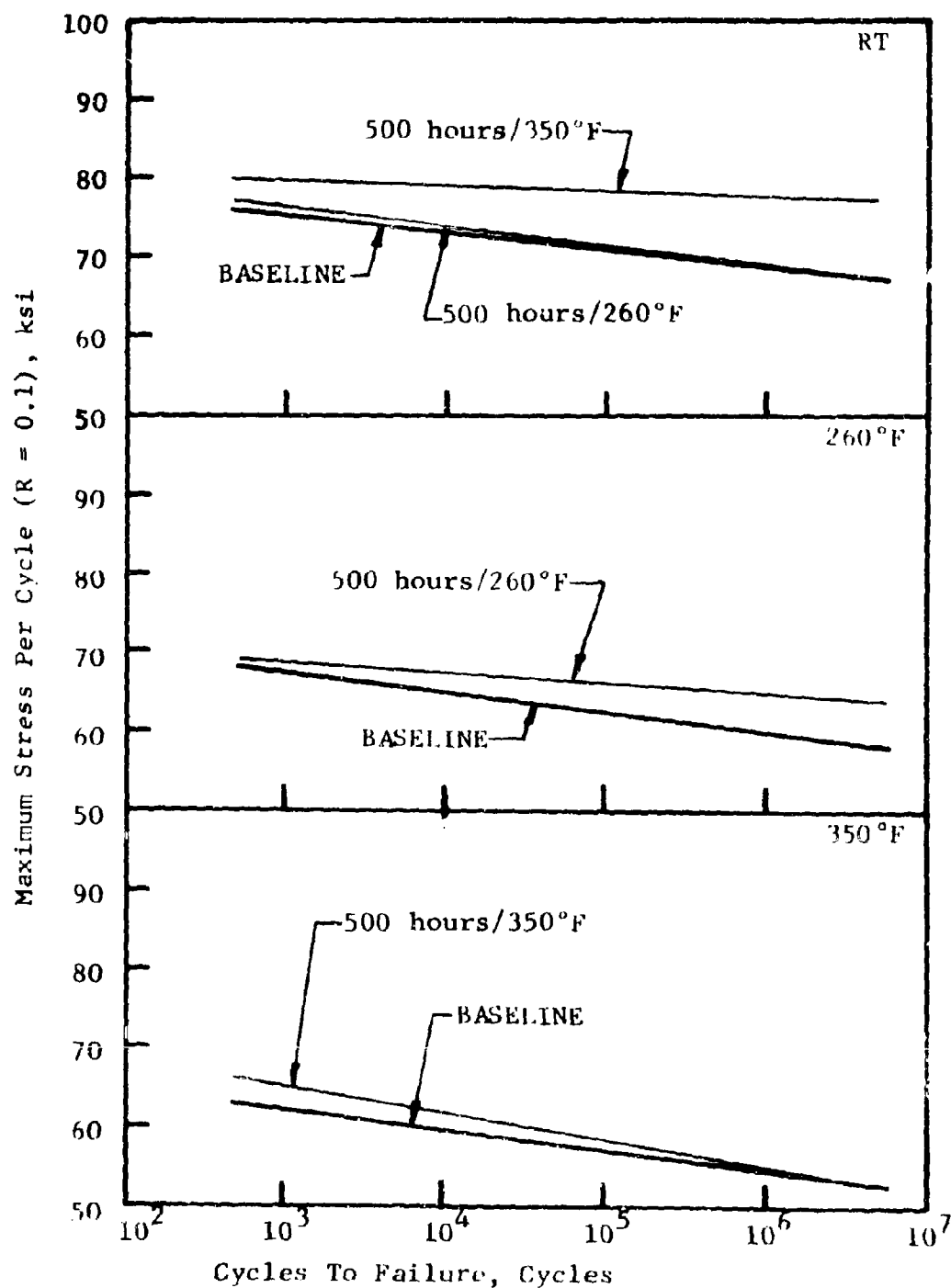


Fig. 83 EFFECT OF STEADY-STATE THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR MODMOR 11 GRAPHITE/NARMCO 5206 COMPOSITES - [0/45/135/0/90]_s

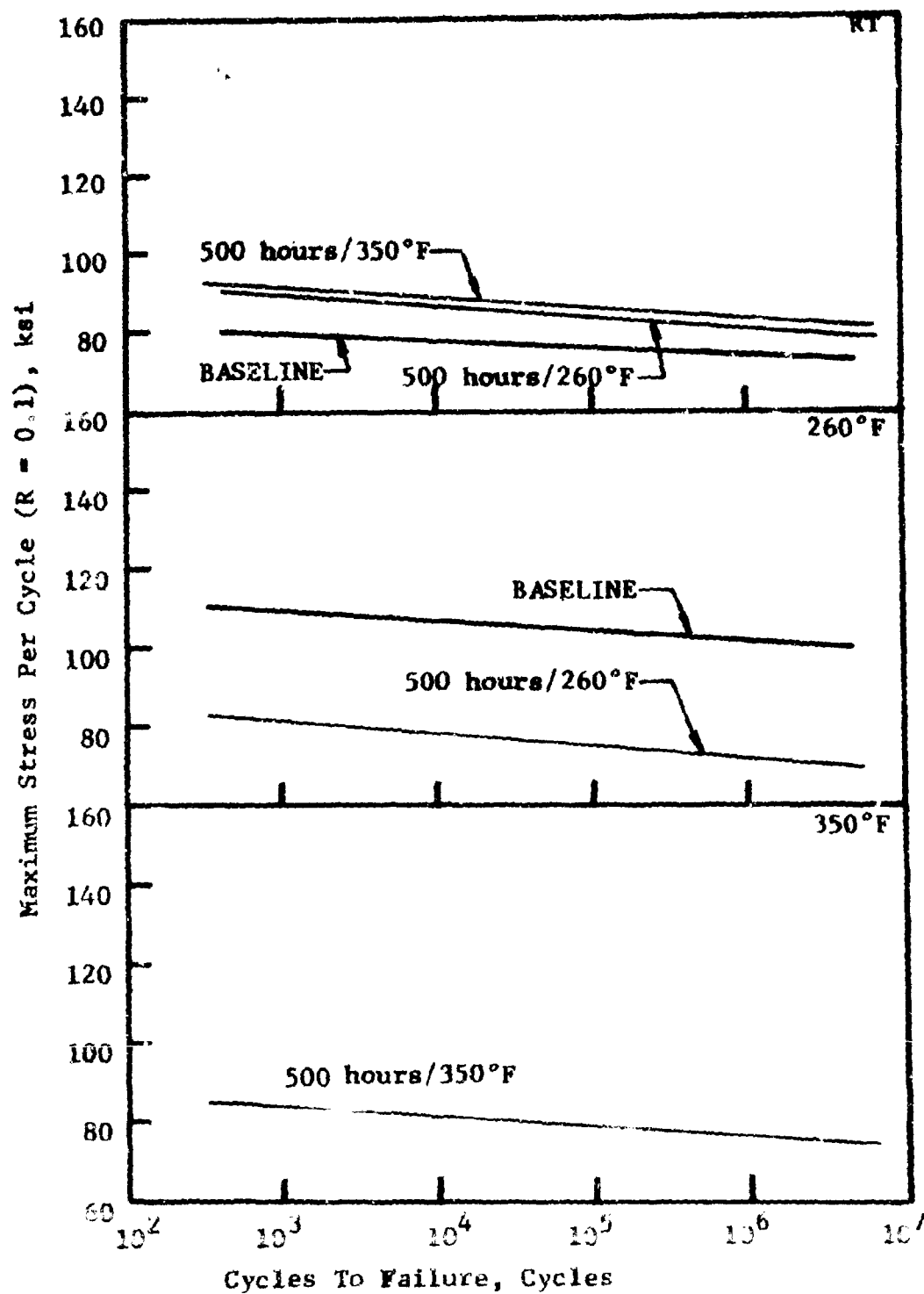


Fig. 84 EFFECT OF STEADY-STATE THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES - 0°₁₂₃

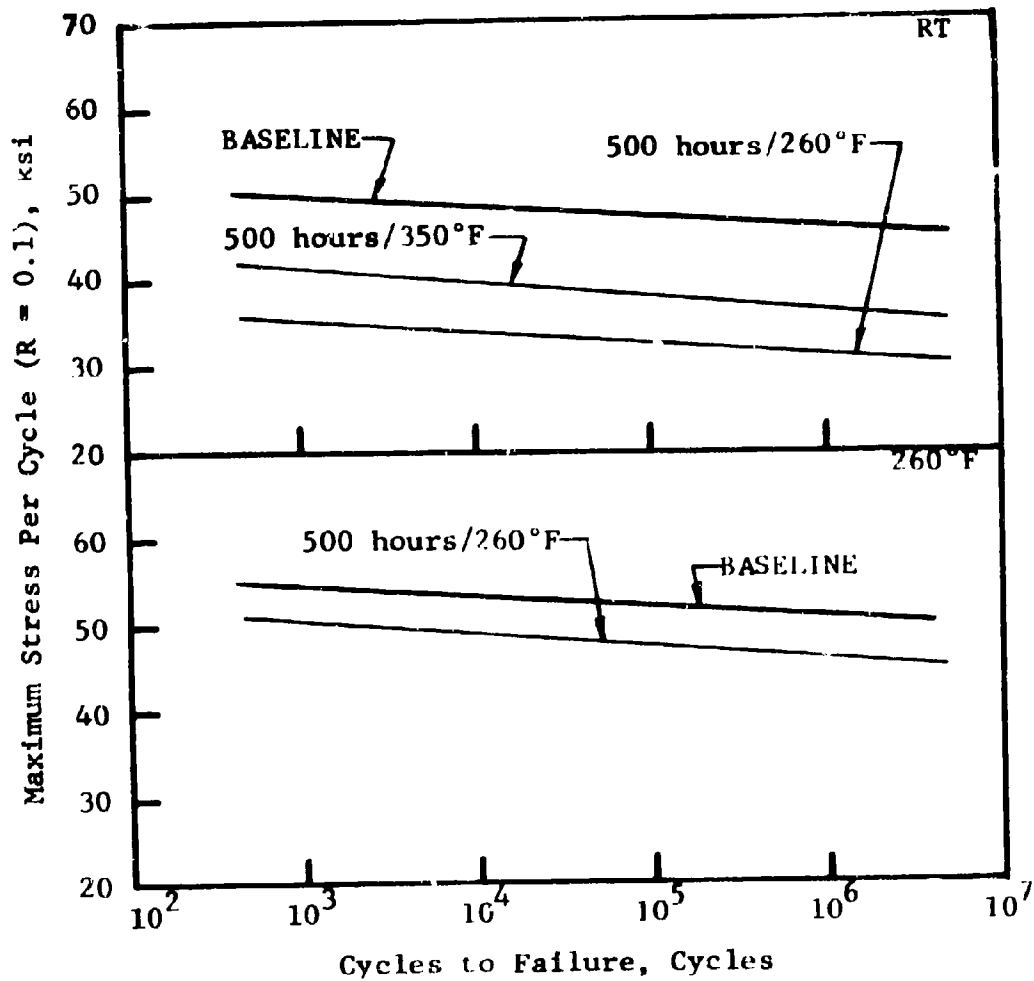


Fig. 85 EFFECT OF STEADY-STATE THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES [0/45/135/0/90]_s

AVCO 5505/Boron - Figs. 86 and 87

Narmco 5206/Modmor II Graphite - Figs. 88 and 89

Hercules 3002M/Courtaulds HMS Graphite - Figs. 90 and 91

The behavior shows consistent degradation in the following increasing order (1) 260°F for 500 cycles, (2) 260°F for 1000 cycles, (3) 350°F for 500 cycles and the worst (4) 350°F for 1000 cycles. The fatigue data indicates that the materials still retain satisfactory strengths at high temperature after thermal cycling.

2.1.8 Creep and Stress Rupture Test Results

2.1.8.1 Baseline Creep and Stress Rupture Data

All tests measured the response to prolonged tensile loads. Because of the greater creep susceptibility of resin matrix composites at elevated temperatures, the creep and stress rupture tests were conducted at elevated temperatures (260°F and 350°F) only. The creep test data were generated in the form of creep strain versus time curves at various percentages of average ultimate tensile stress of the particular material at that temperature. The stress versus time to rupture data was obtained for the composite materials at various percentages of the ultimate tensile stress levels at the two temperatures. Those tests which ran to 1000 hours were terminated at that time and the specimens removed from the test stands. The test results for individual specimens are shown in Appendices I to III. Both stress rupture versus time and creep-time curves are also presented.

Many specimens failed prior to the attainment of the intended load or "during loading." These specimens are so indicated in the tabular presentation of data. Where the majority of specimens for a given conditioning treatment fell into this category, no stress rupture curves were prepared for that particular condition. As this occasionally happened for

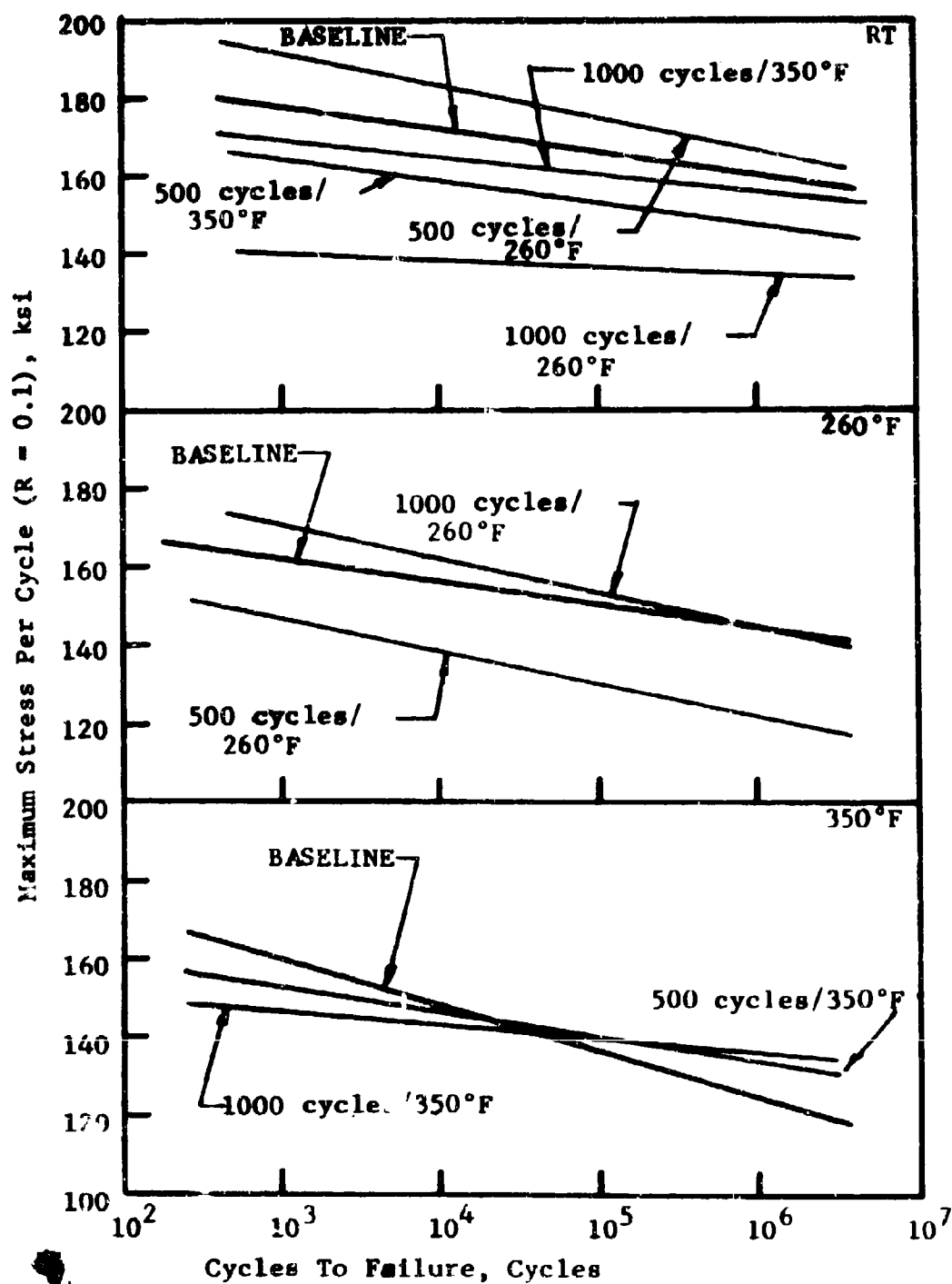


Fig. 86

EFFECT OF CYCLIC THERMAL CONDITIONING ON THE
FATIGUE SN CURVES FOR AVCO 5505/BORON COMPOSITES - 0°

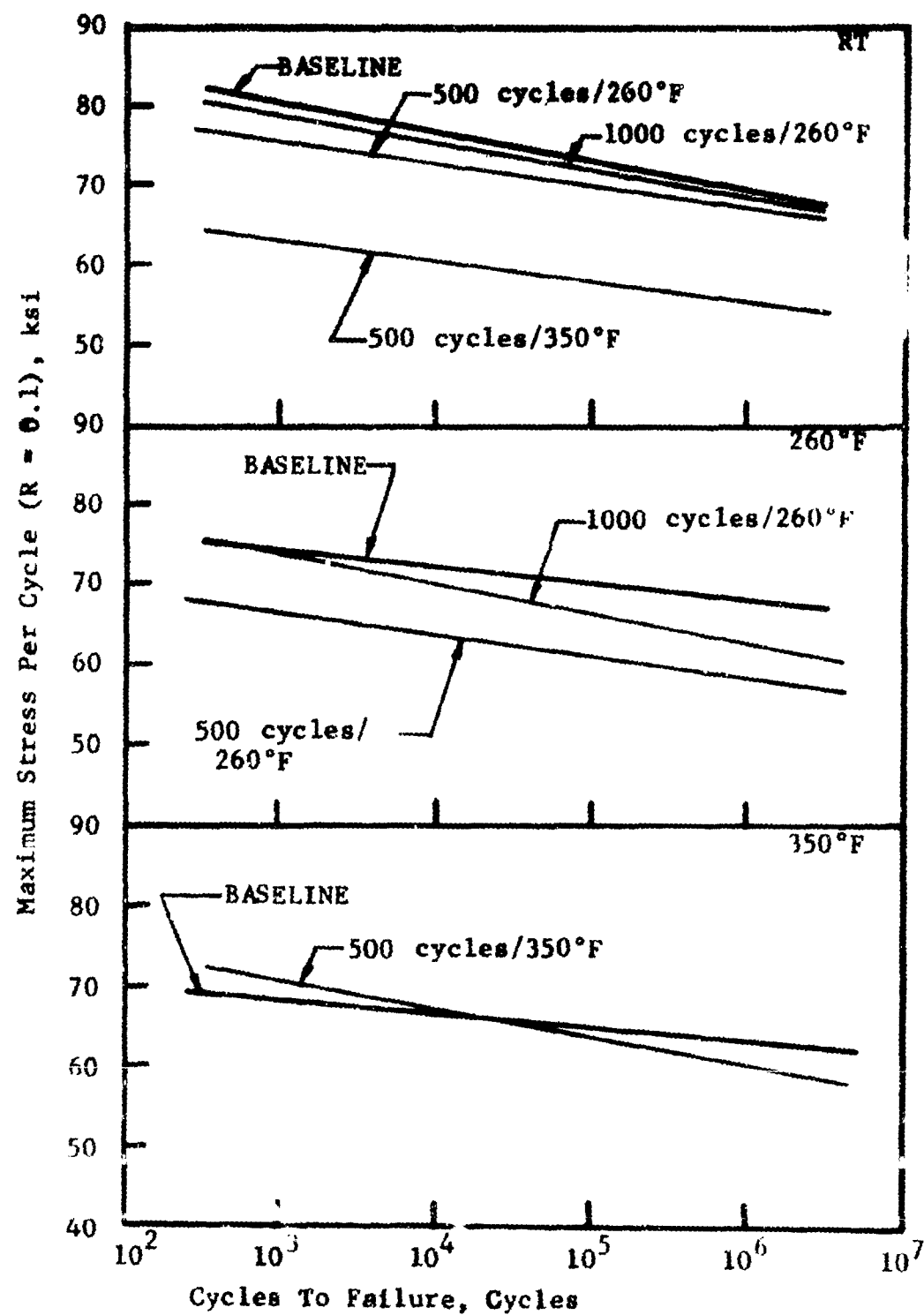


Fig. 87 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR AVCO 5505/BORON COMPOSITES [0/45/135/0/90]_s

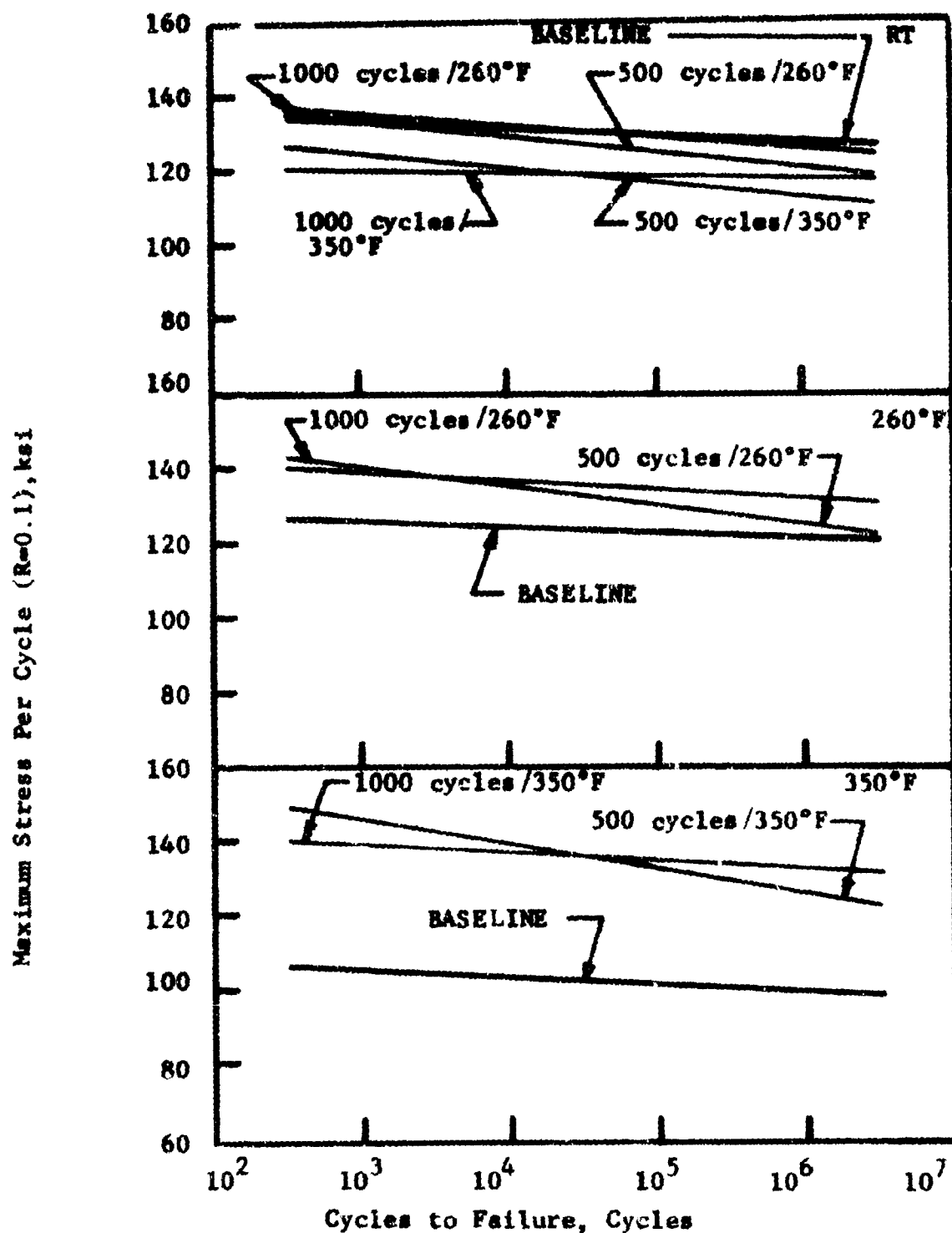


Fig. 88 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR NARMCO 5206/MODMOR II GRAPHITE COMPOSITES -0°.

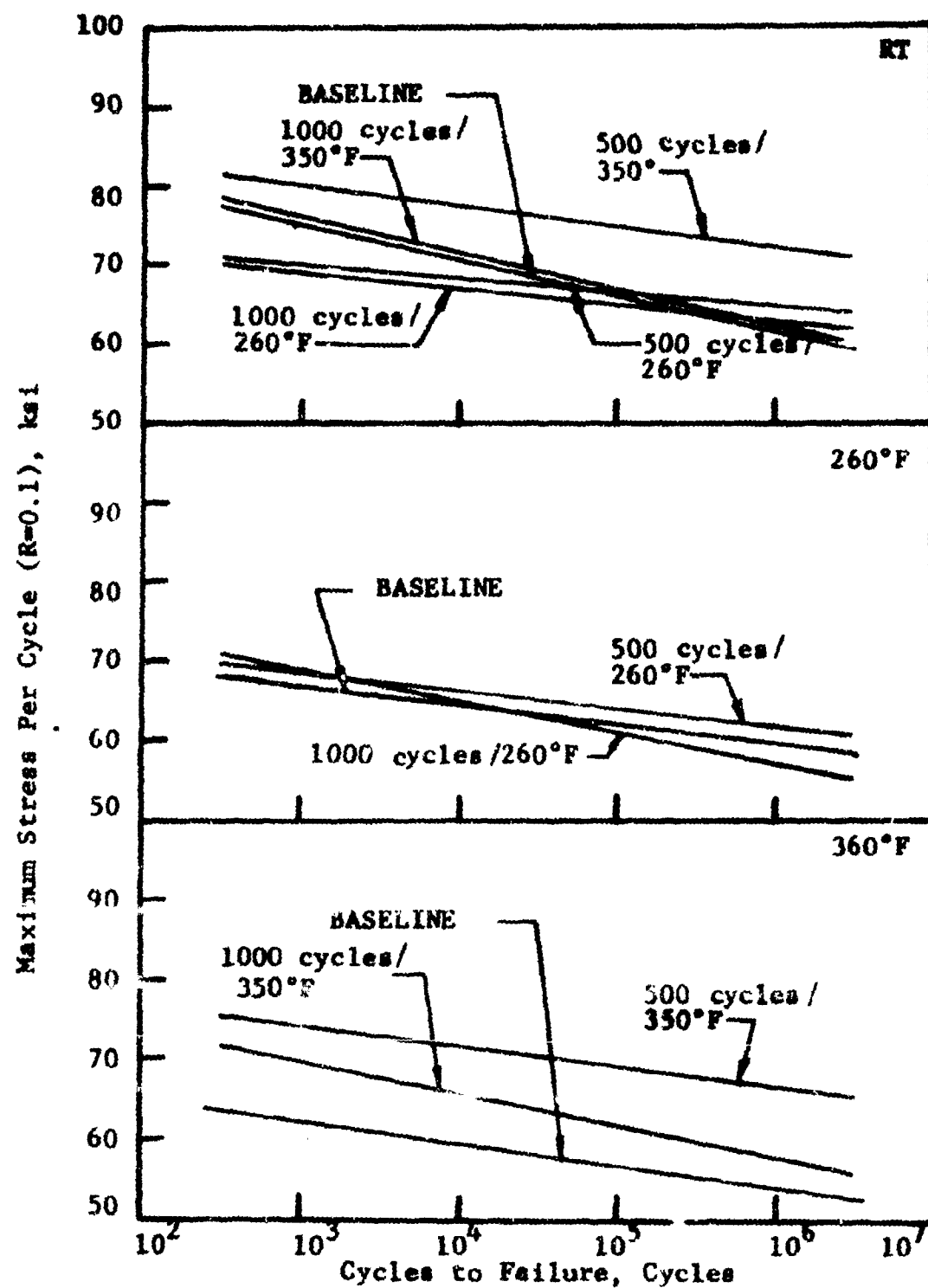


Fig. 89 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR NARMCO 5206/MODMOR II GRAPHITE COMPOSITES $-\{0/45/135/0/90\}_s$

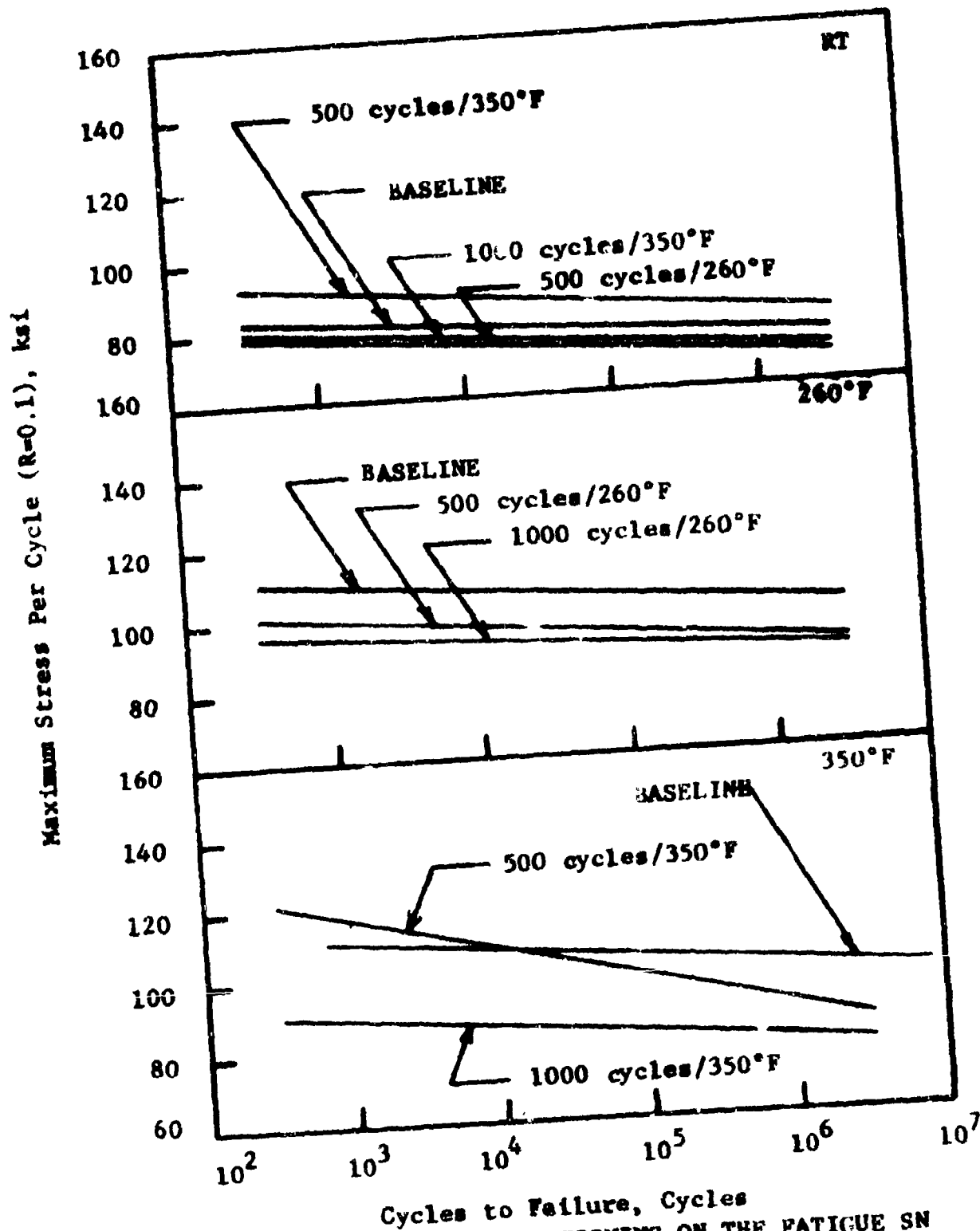


Fig. 90 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES 0°

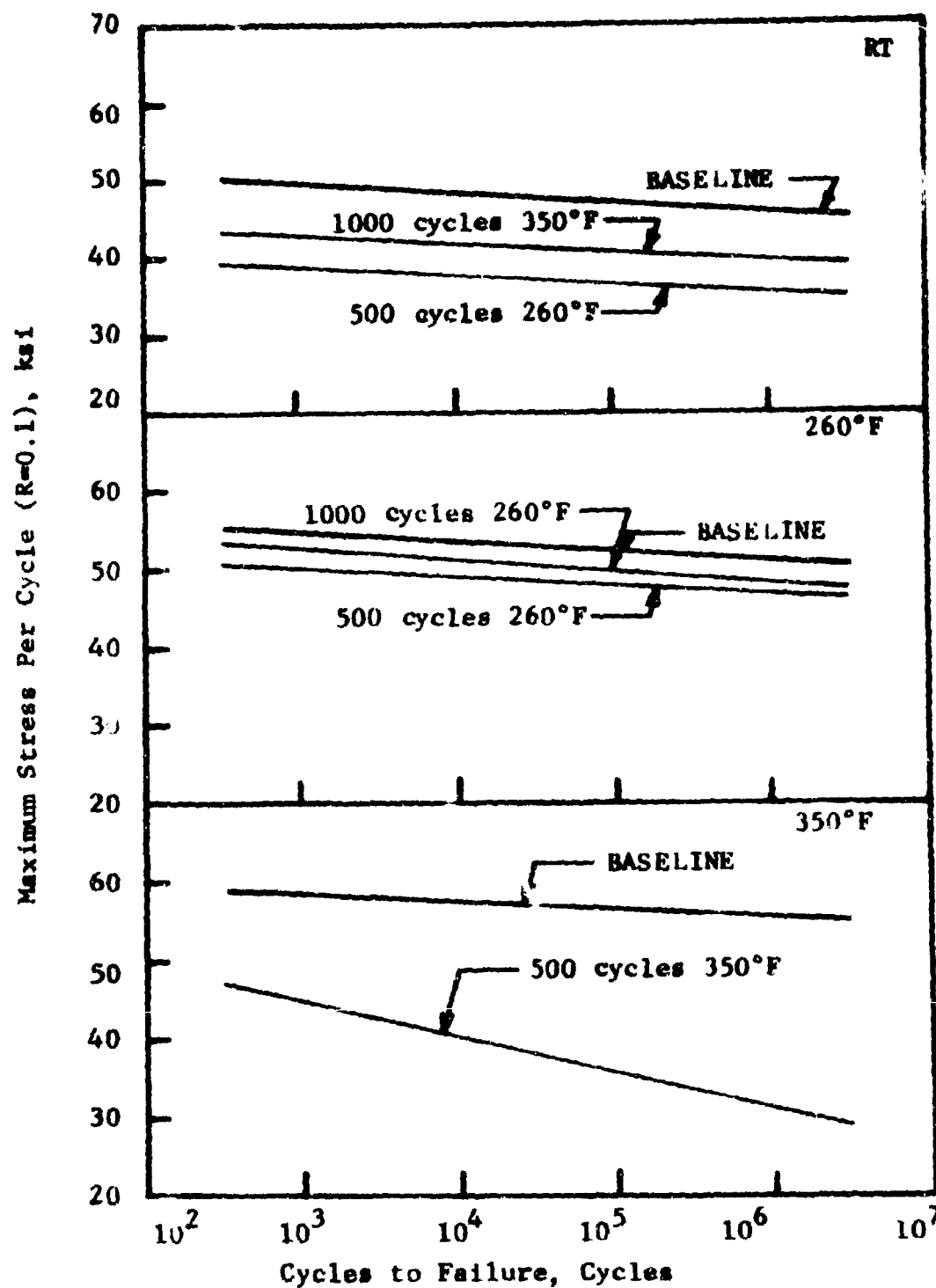


Fig. 91 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE FATIGUE SN CURVES FOR HERCULES 3002M COURTAULDS HMS GRAPHITE COMPOSITES-(10/45/135/0/90).

baseline data as well, some baseline stress-rupture versus time curves are also missing. Where data was obtained over a portion of the time range only, the stress versus time to rupture curves were so indicated.

2.1.8.2 Effects of Humidity Conditioning on the Creep and Stress Rupture Properties

The effect of humidity conditioning, treatments, both steady state exposure and cyclic humidity pretreatments on the creep and stress-rupture properties of AVCO 5505/Boron, Narmco 5206/Modmor II Graphite, and Hercules 3002M/Courtaulds HMS Graphite composites are presented in Figs. 92 and 93, Figs. 94 and 95, and Figs. 96 and 97 respectively. Both 0° and [0/45/135/0/90] composites were investigated.

Baseline data is not available to compare the effect of humidity conditioning on the stress rupture properties of 0° AVCO 5505/Boron composites at 260°F. Some reduction in the stress-rupture behavior of 0° AVCO 5505/Boron at 350°F is seen in Fig. 92. The stress rupture behavior of the [0/45/135/0/90] laminates at both 260°F and 350°F appears to be only slightly affected (and improved over baseline behavior) after steady state and cyclic humidity conditioning.

A similar set of humidity effects on the stress-rupture behavior of Narmco 5206/Modmor II Graphite Composites is shown in Figs. 94 and 95. All conditioning treatments increased the stress-rupture curves over the original baseline values. The 0° composites were affected the most while the [0/45/135/0/90] laminates were affected the least.

Figures 96 and 97 show the effect of prior humidity conditioning on the stress-rupture behavior of Hercules 3002M/Courtaulds HMS graphite. The only substantial reduction in the

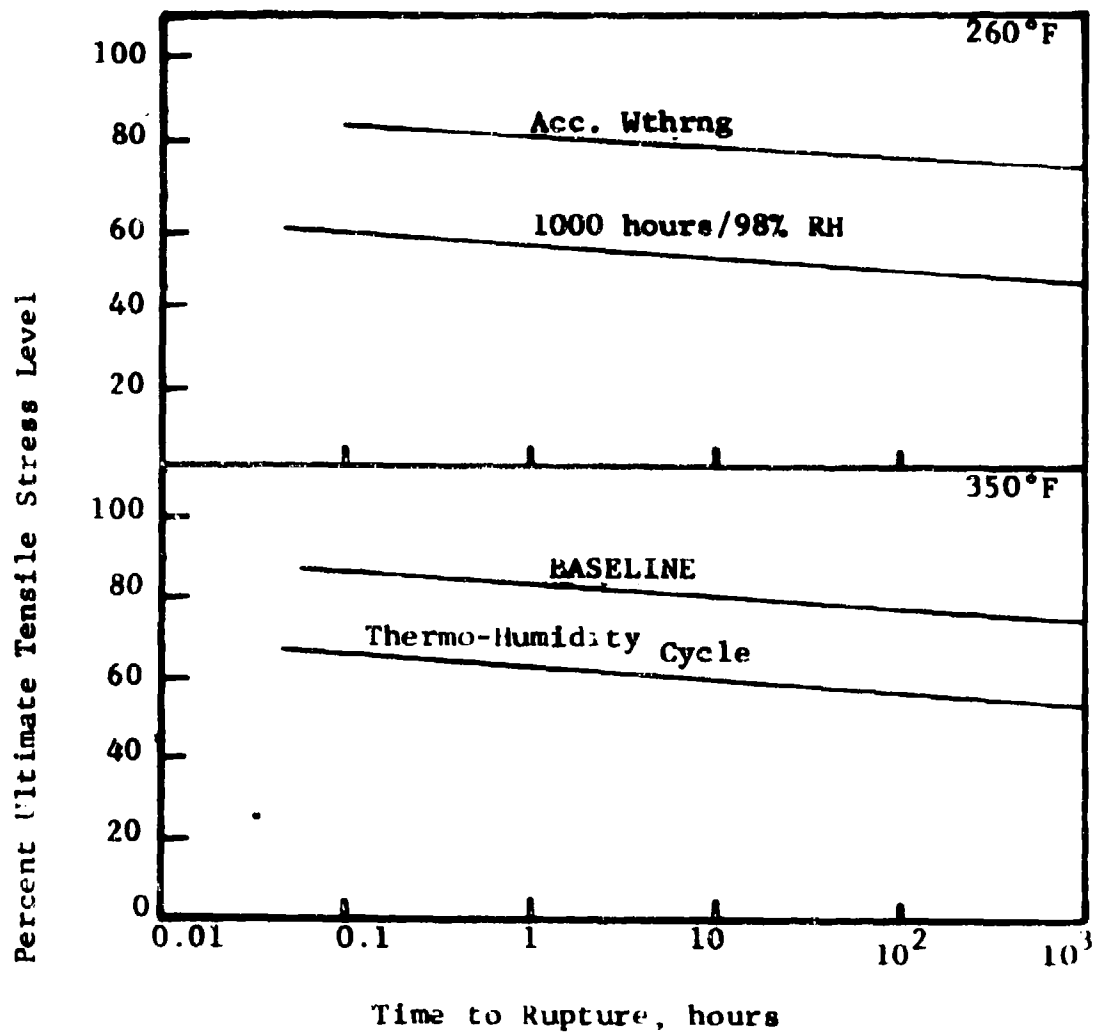


Fig. 92 EFFECT OF HUMIDITY CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF AVCO 5505/BORON COMPOSITES - 0°

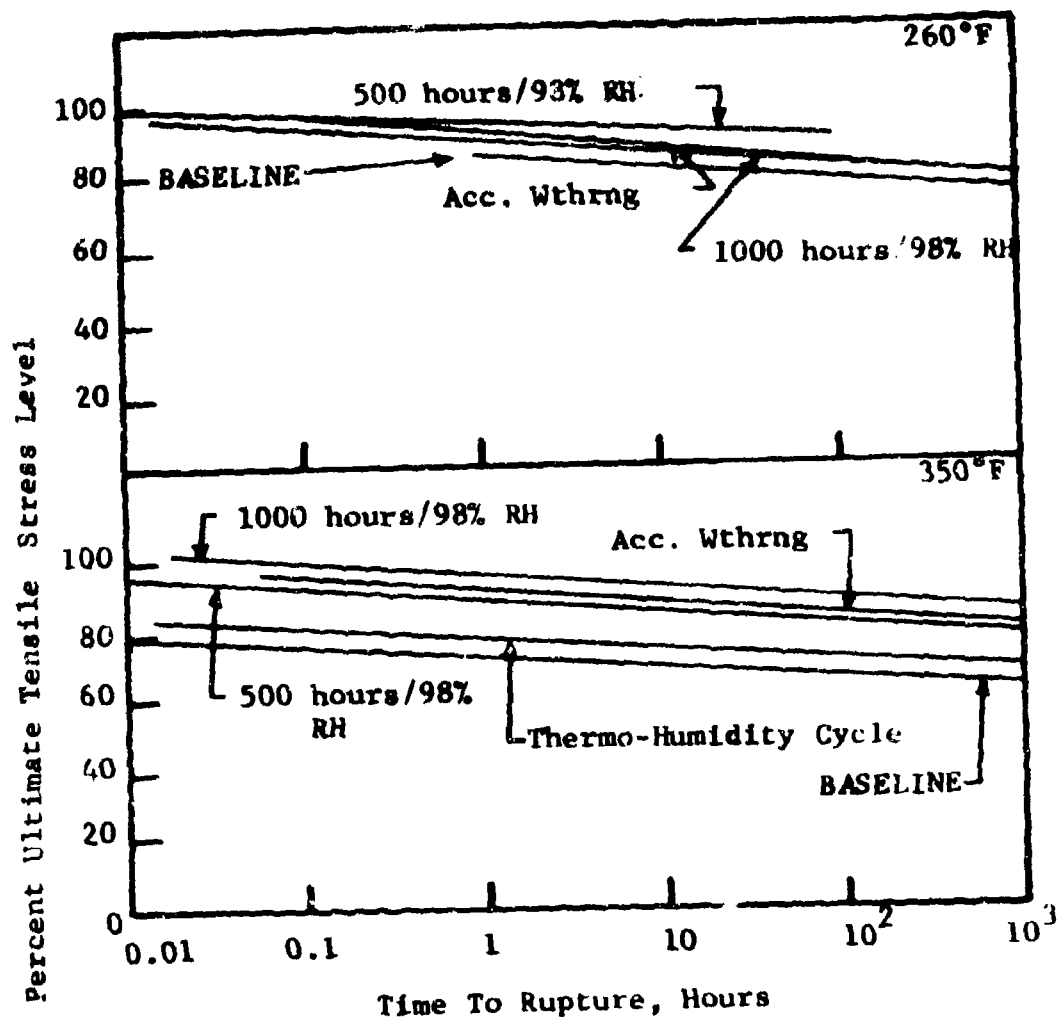


Fig. 93 EFFECT OF HUMIDITY CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF AVCO 3503/BORON COMPOSITES [0/45/135/0/90]_a

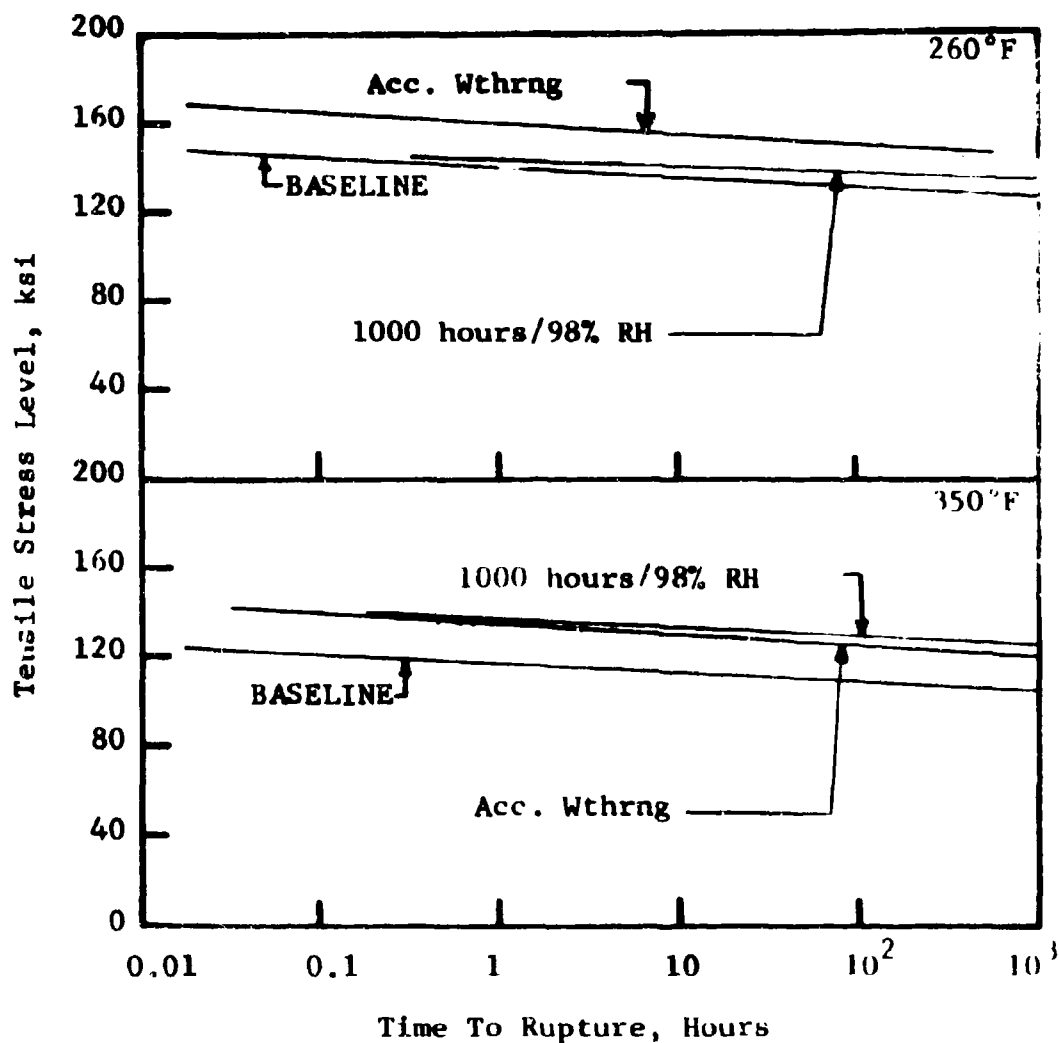


Fig. 94 EFFECT OF HUMIDITY CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF NARMCO 5206/MODMOR II GRAPHITE COMPOSITES - 0°

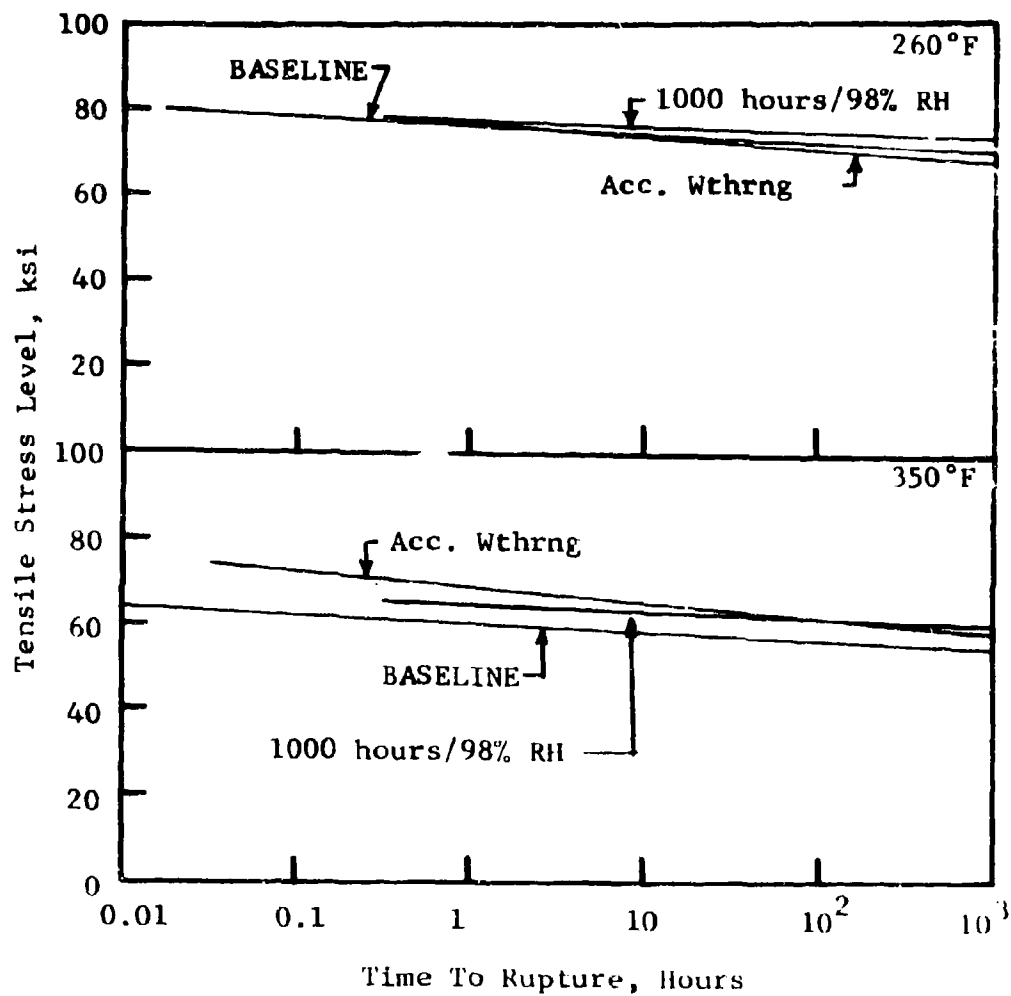


Fig. 95 EFFECT OF HUMIDITY CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF NARMCO 5206/MODMOR II GRAPHITE COMPOSITES - [0/45/135/0/90]_s

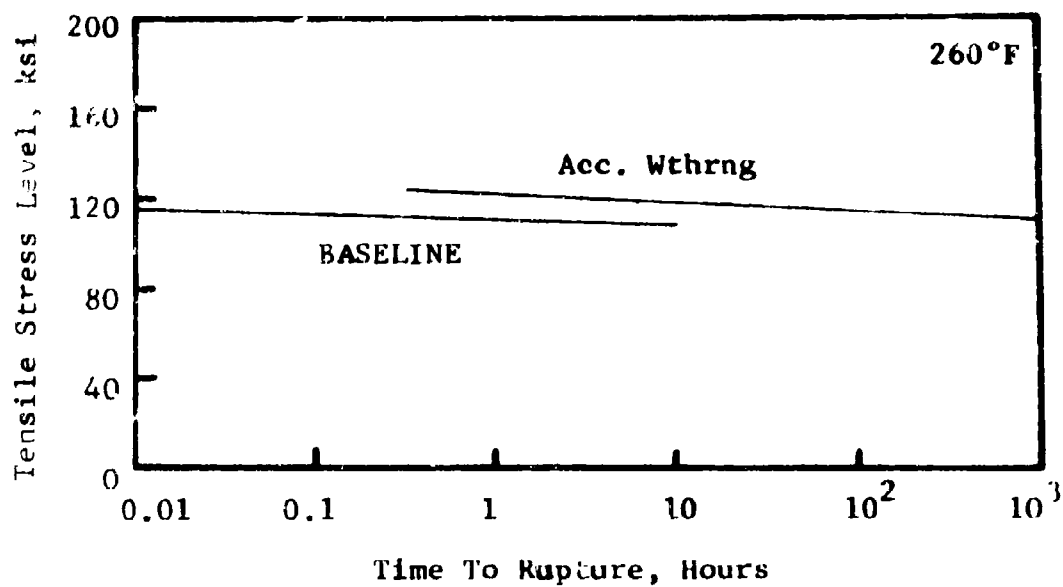


Fig. 96 EFFECT OF HUMIDITY CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF HERCULES 3002 M/COURTAULDS HMS GRAPHITE COMPOSITES - 0°

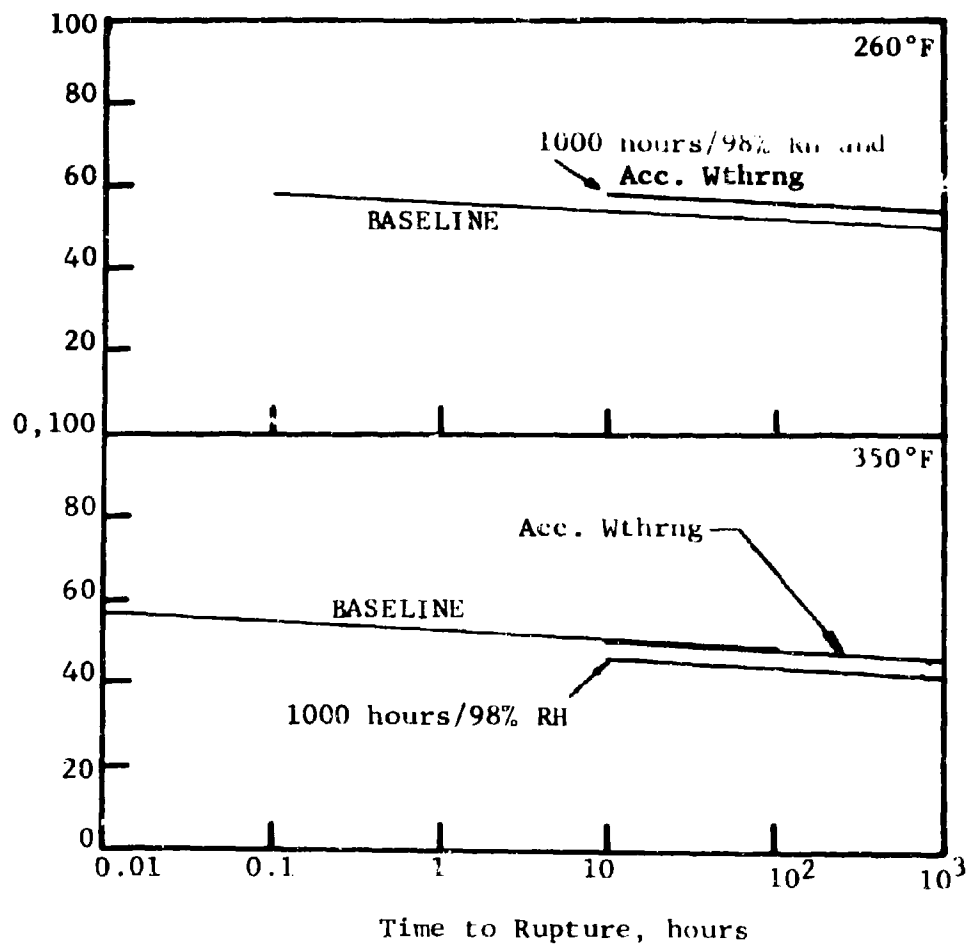


Fig. 97 EFFECTS OF HUMIDITY CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF HERCULES 3002M/COURTAULDS HNS GRAPHITE COMPOSITES - [0/45/135/0/90]_s

stress-rupture curves with humidity conditioning for all three materials was detected at 350°F for the [0/45/135/0/90]_g laminates. The accelerated weathering cycle stress-versus time to rupture curves shown in Fig. 97 at 350°F is coincident with the baseline behavior. However, the 1000 hour at 98% RH data showed a decrease from the baseline values.

Overall, the stress versus time to rupture behavior of the three resin matrix composites in the unidirectional as well as [0/45/135/0/90]_g laminates was either not affected by prior humidity conditioning or showed a slight improvement in the resistance to rupture under sustained stress.

2.1.8.3 Effects of Thermal Conditioning on the Creep and Stress Rupture Properties

The effects of steady state thermal conditioning on the stress-rupture behavior of the three resin matrix composites are shown in Figs. 98 to 102. Both 0° and [0/45/135/0/90]_g composites and two temperatures of testing (260°F and 350°F) are presented.

The effect of steady state thermal exposure on the stress versus time to rupture behavior of AVCO 5505/Boron composites is shown in Figs. 98 and 99. In general the exposure at 350°F for 500 hours enhanced the sustained stress properties while the 500 hour exposure to 260°F showed both degradatory and enhancement of the stress rupture properties relative to the unexposed baseline properties. From a logical point of view, it is reasonable to conclude that the thermal exposure may not have enhanced the stress rupture properties but that this conditioning had no adverse effects on the stress-rupture behavior.

The effect of steady-state thermal exposure on the stress versus time-to-rupture behavior of Narmco 5206/Modmor II graphite composites is presented in Figs. 100 and 101. Again the higher temperature exposure (350°F for 500 hours) increased the resistance to failure under sustained load above the 0° baseline

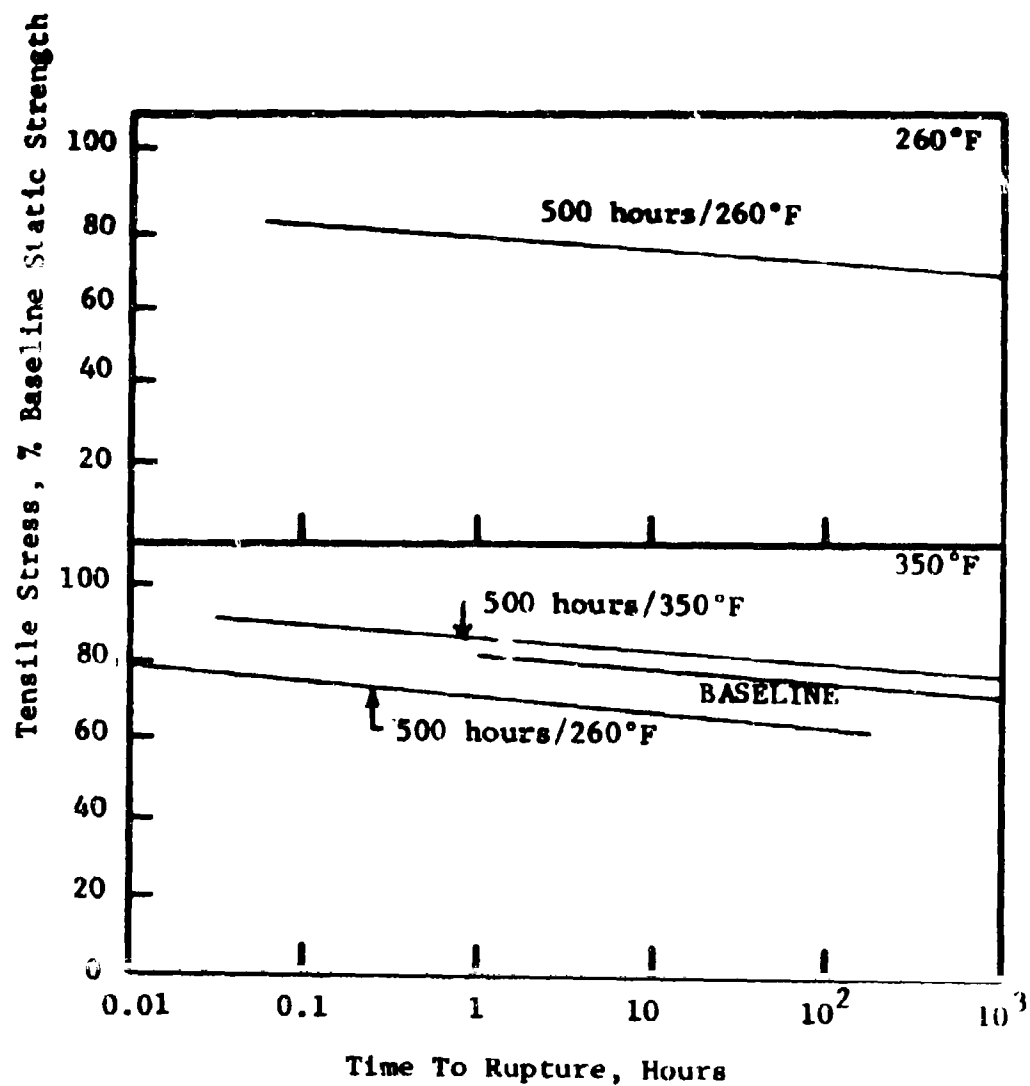


Fig. 98 EFFECTS OF STEADY-STATE THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF AVCO 5505/BORON COMPOS TES - 0°

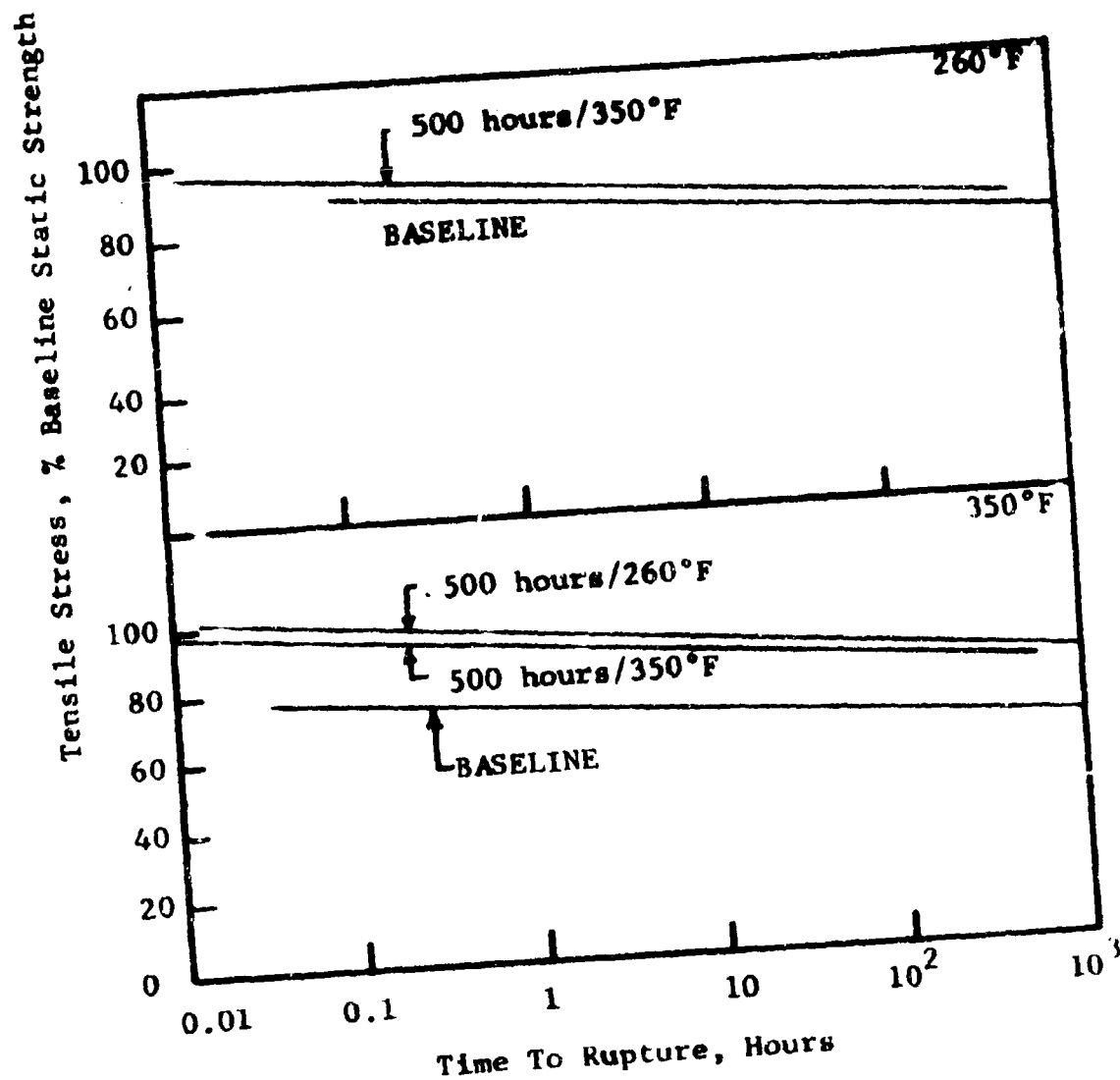


FIG. 99 EFFECTS OF STEADY-STATE THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF AVCO 5505/BORON COMPOSITES [0/45/135/0/90]_s

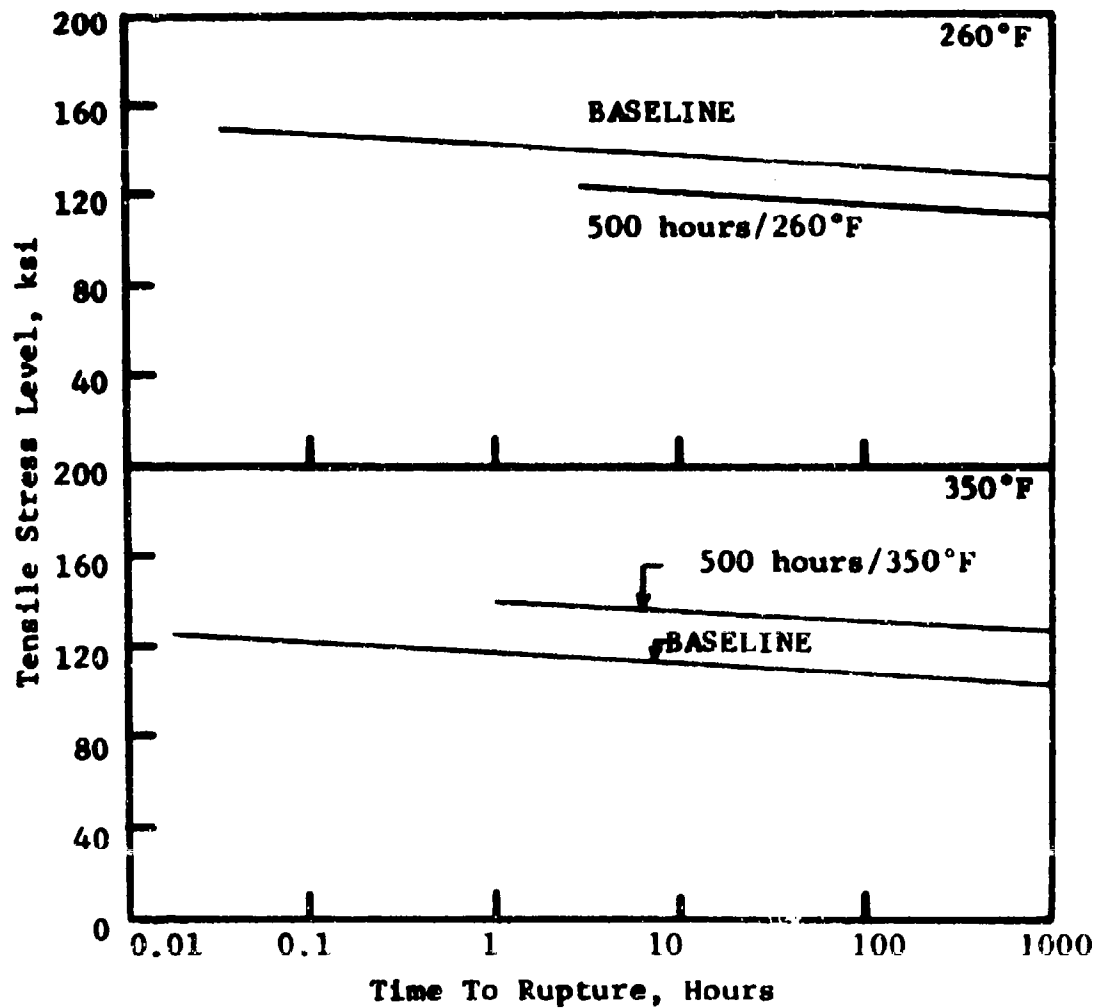


Fig. 100 EFFECT OF STEADY-STATE THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF NARMCO 5206/MODMOR II GRAPHITE COMPOSITE - 0°

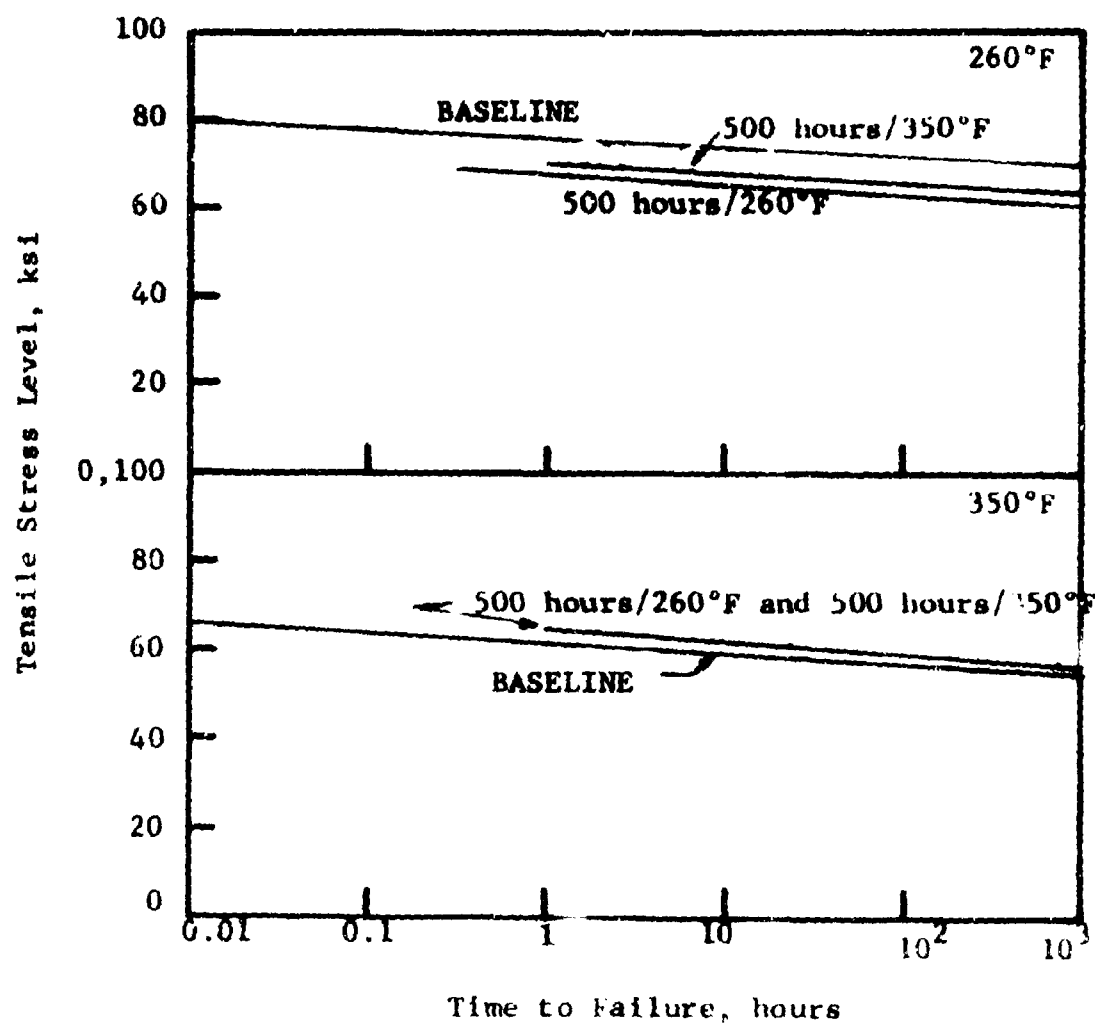


Fig. 101 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF NARMCO 5206/MDMOR 11 GRAPHITE COMPOSITES - [0/45/135/0/90]_s

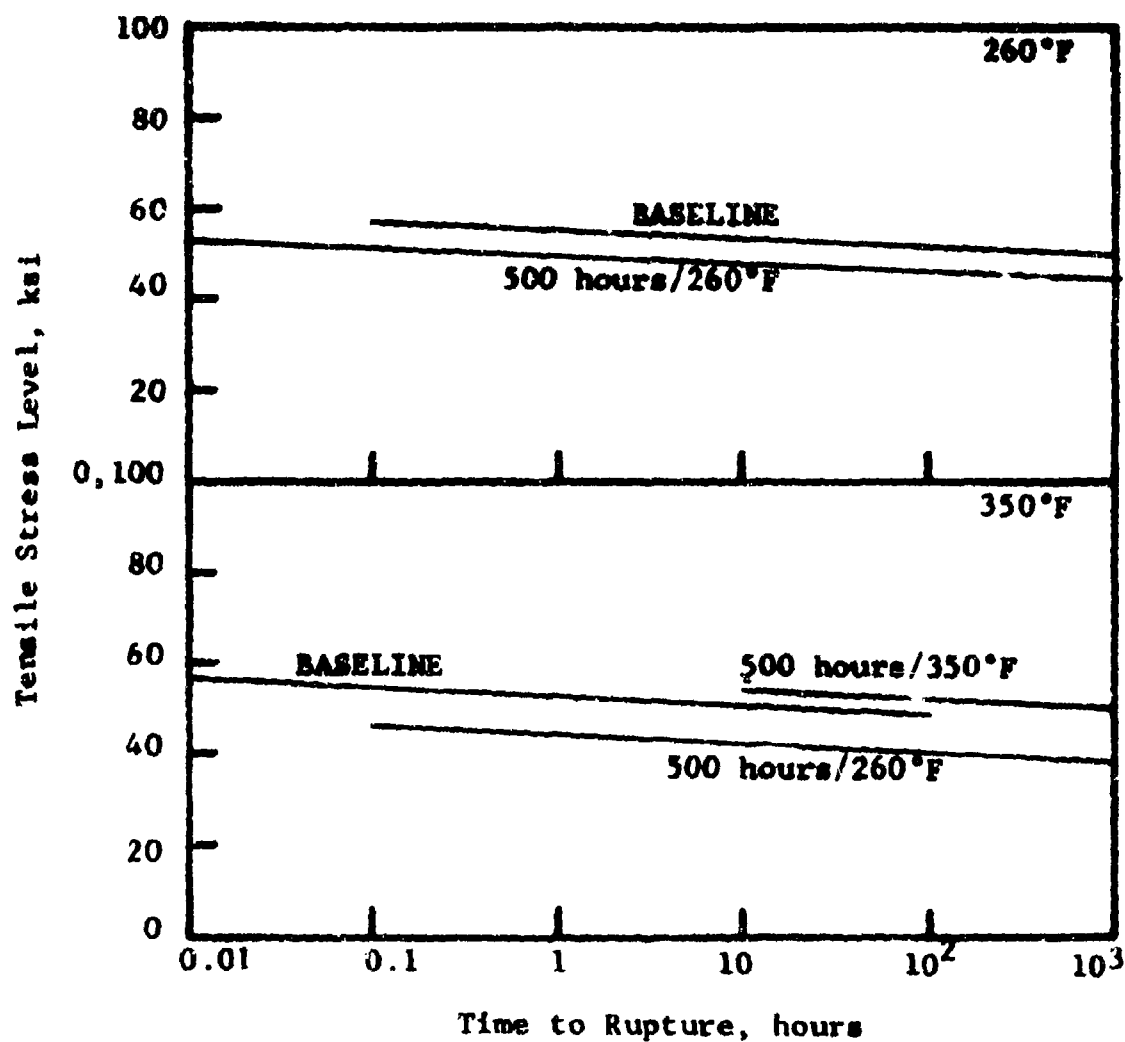


Fig. 102 EFFECT OF STEADY STATE THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF HERCULES 3002M/COURTAULDS HM3 GRAPHITE COMPOSITES - [0/45/135/0/90]

behavior at 350°F. The 500 hour exposure to 260°F resulted in minor degradation from the baseline behavior.

The 0° stress versus time to failure behavior of Hercules 3002M/Courtaulds HMS graphite is not shown because the data does not exist or all specimens were 1000 hour runouts. The laminate behavior is shown in Fig. 102. Again the 500 hour exposure to 350°F enhanced the stress-rupture behavior while the 260°F exposure for 500 hours degraded the stress-rupture behavior.

The effect of cyclic thermal conditioning on the stress-rupture behavior of AVCO 5505/Boron composites is shown in Figs. 103 and 104. The results showed behavior similar to that of the steady state thermal conditioning. The 500 hours exposure to 350°F showed better performance than both baseline and 500 hours exposure to 260°F. The exception was the [0/45/135/0/90]_s laminate creep-tested at 350°F. Baseline data at 260°F for the 0° composites were missing because all baseline coupons were 1000 hours runouts. (See Appendix I - Table XIV.).

Figures 105 and 106 show the effect of cyclic thermal conditioning on the stress versus time to rupture behavior of Narmco 5206/Modmor II graphite composites. The behavior is similar to that for AVCO 5505/Boron composites as discussed above. Finally the stress rupture behavior of the second graphite/epoxy system, Hercules 3002M/Courtaulds HMS graphite is shown in Figs. 107 and 108. No beneficial cyclic conditioning was indicated, all conditioning proving to be degradatory.

2.1.9 Thermo Physical Properties

2.1.9.1 Thermal Expansion

Thermal expansion measurements were made for the three resin matrix composite systems, AVCO 5505/Boron, Modmor II

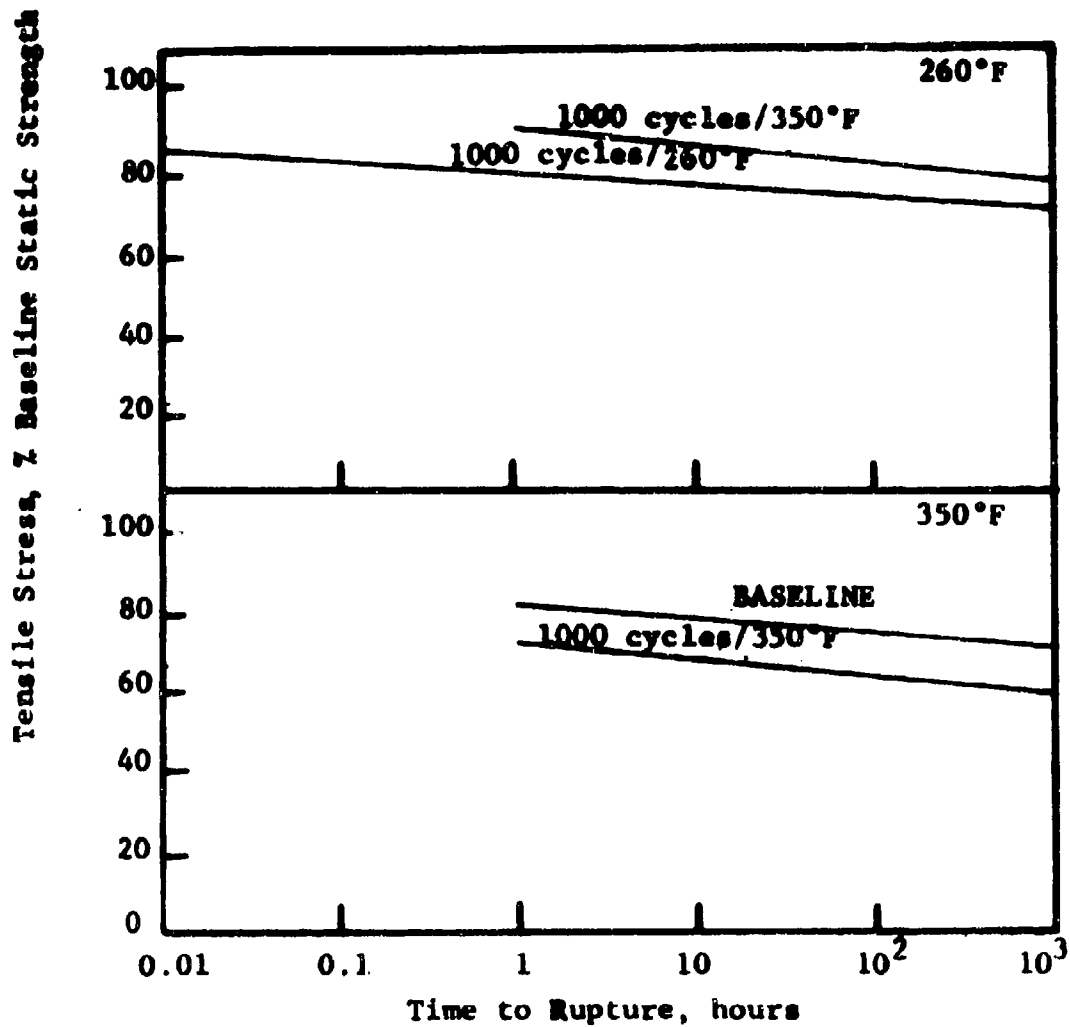


Fig. 103 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF AVCO 5505/BORON COMPOSITES - 0°

Tensile Stress, % Baseline Static Strength

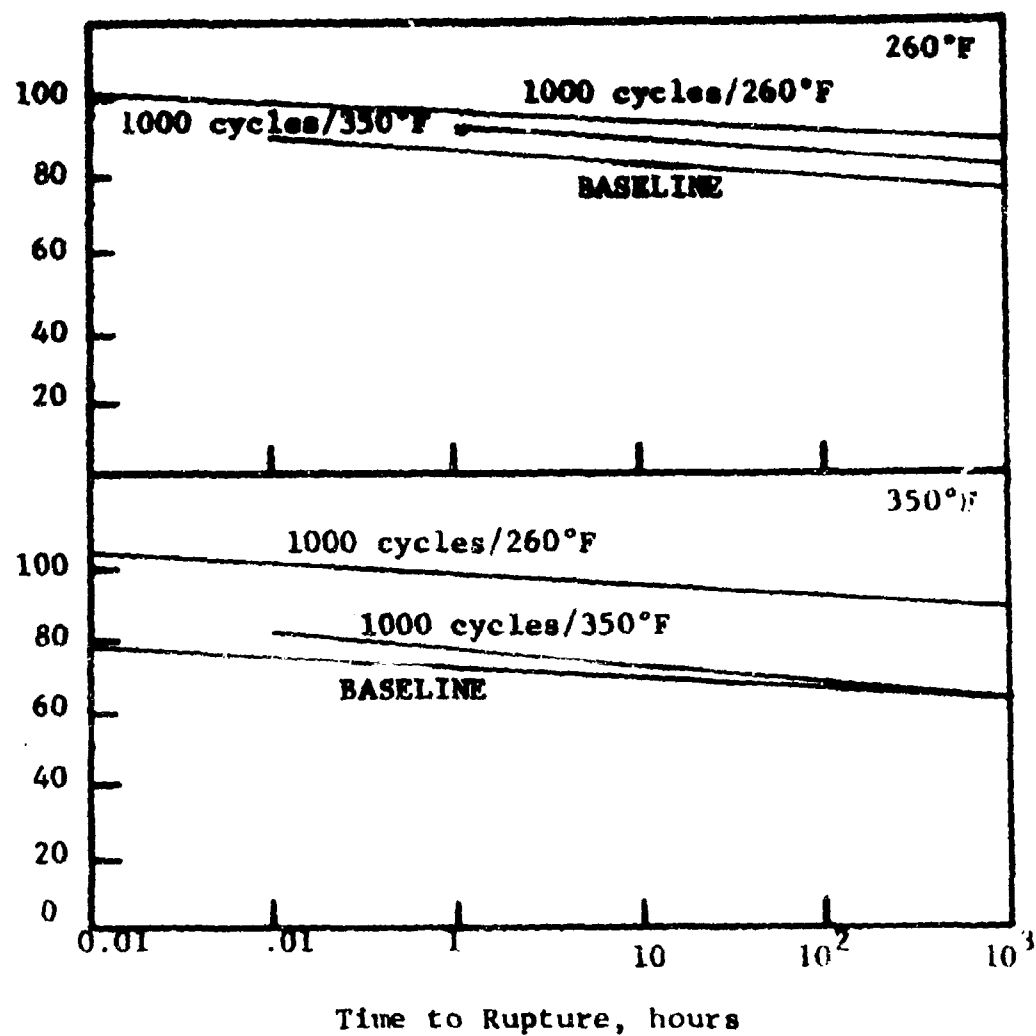


Fig. 104 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF AVCO 5505/BORON COMPOSITES - [0/45/135/0/90]_s

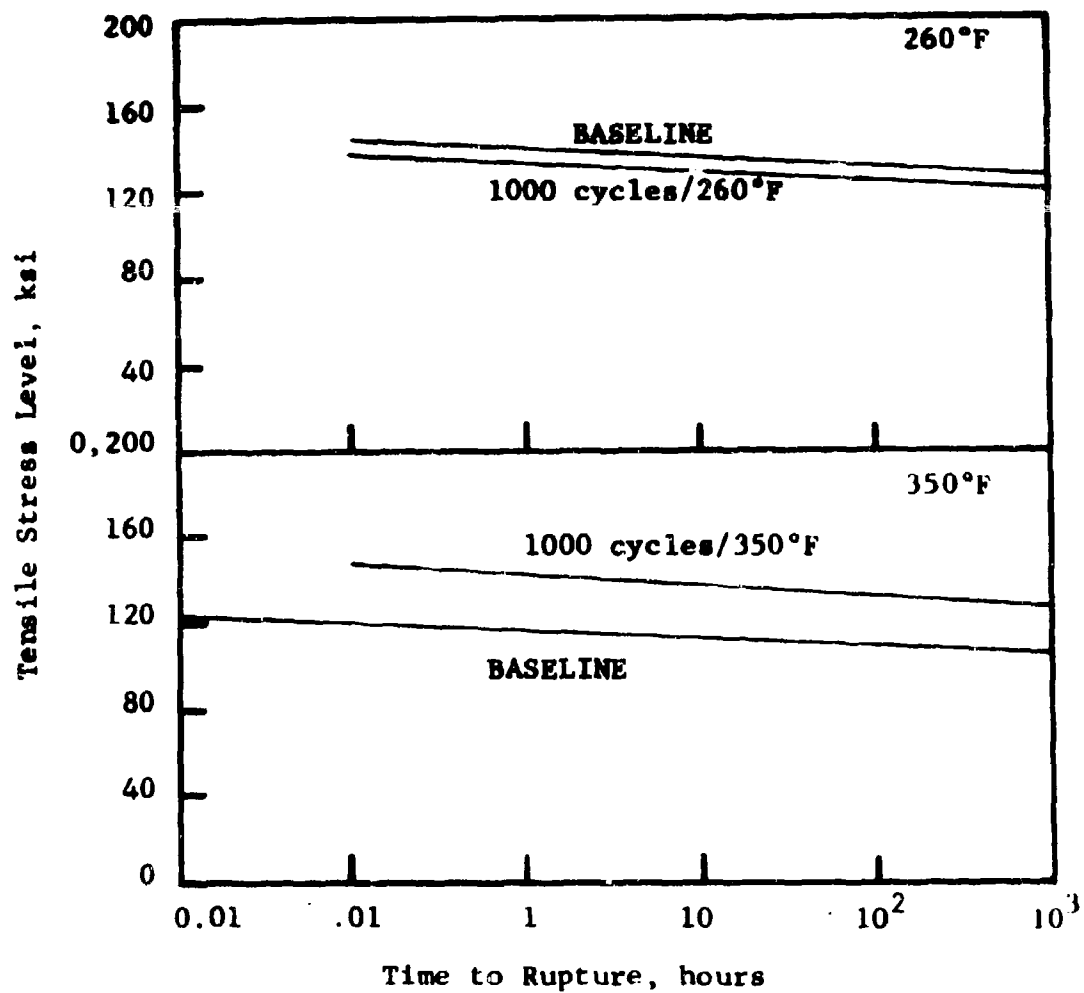


Fig. 105 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES - 0°

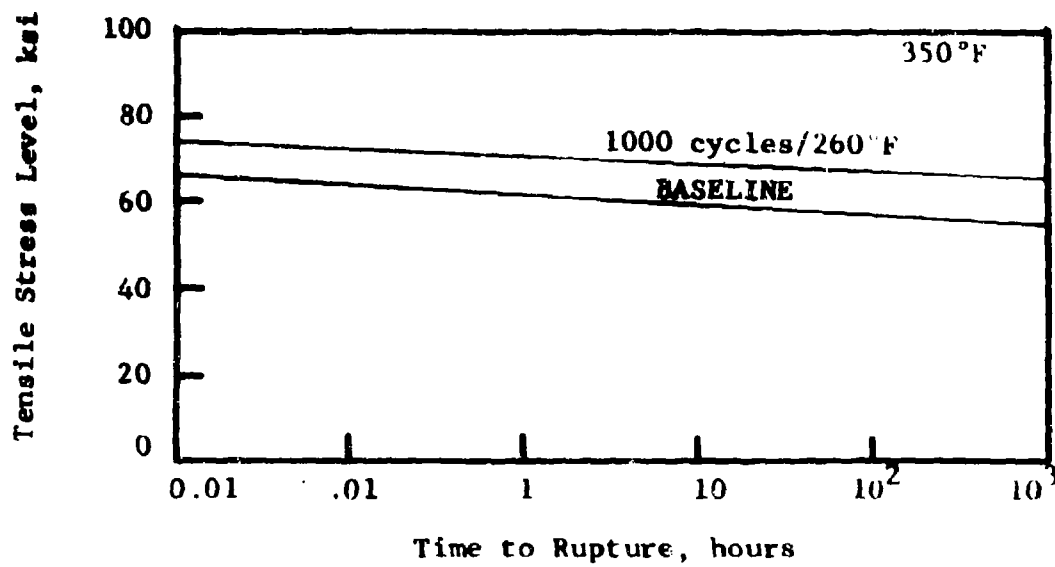


Fig. 106 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF NARMCO 5206/MODMOR 11 GRAPHITE COMPOSITES - [0/45/135/0/90]_s

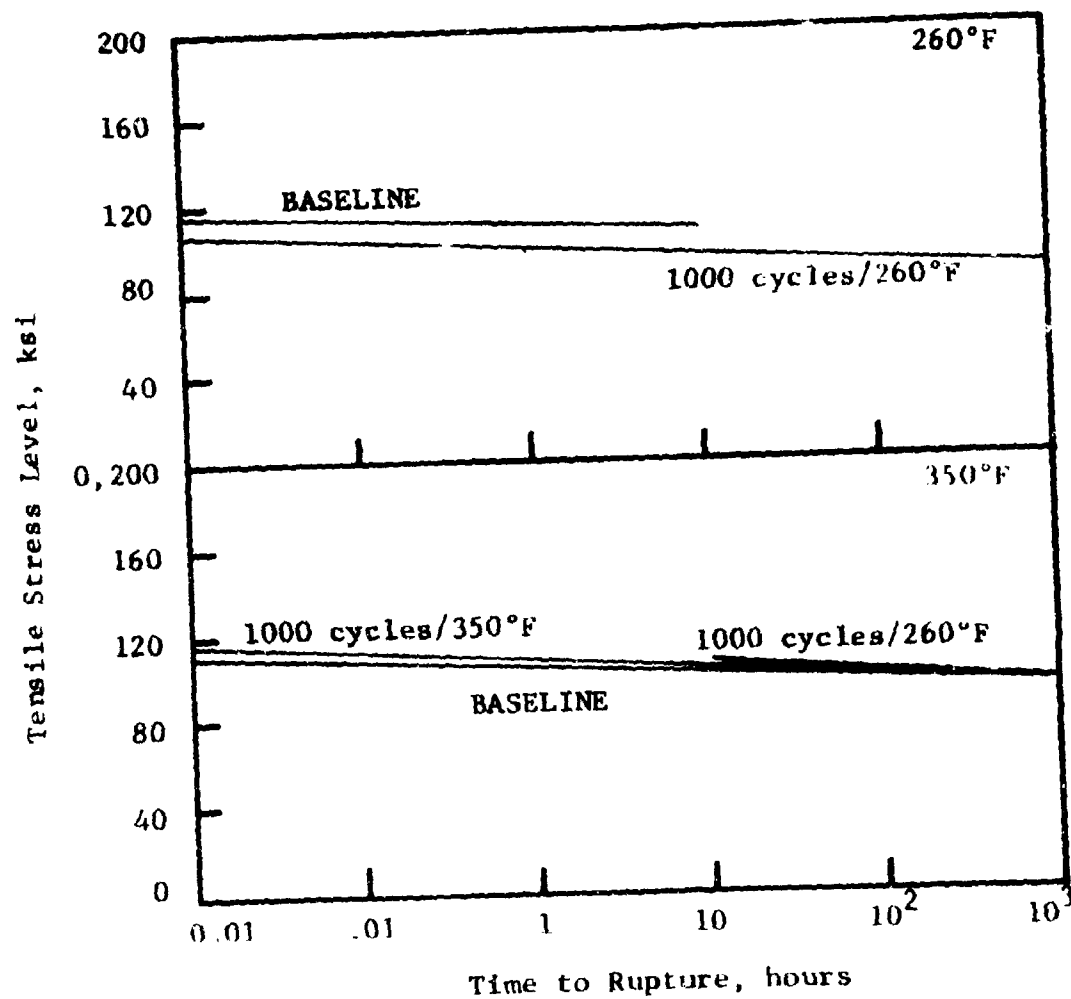


Fig. 107 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITE - 0°

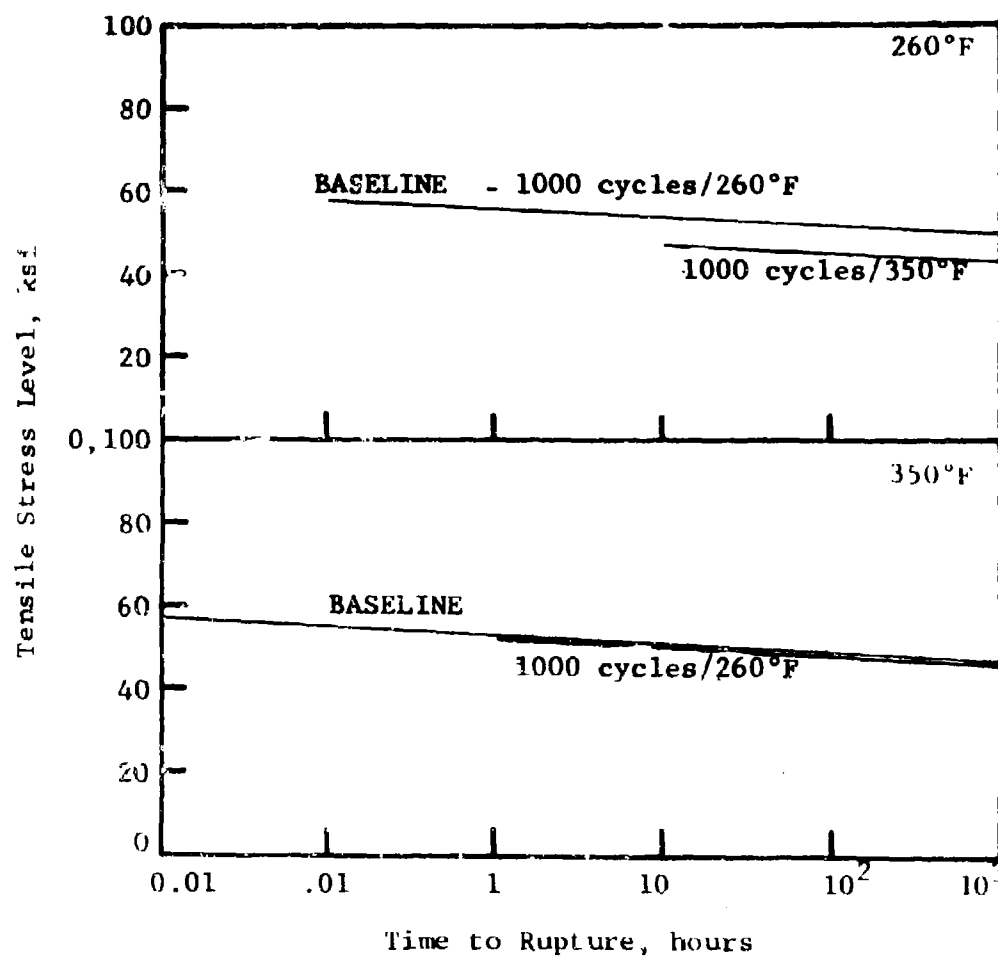


Fig. 103 EFFECT OF CYCLIC THERMAL CONDITIONING ON THE STRESS RUPTURE BEHAVIOR OF HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES [0/45/135/0/90]_g

Graphite/Narmco 5206, and Courtaulds HMS Graphite/Hercules 300M. Three samples in each of three fiber orientations (0° , 90° , and $[0/45/135/0/90]_s$ with respect to the expansion direction) were tested in air at $4^\circ\text{F}/\text{min.}$ from ambient RT to 350°F for each material system employing the NETZSCH Automatic recording push-rod dilatometer described previously (AFML-TR-72-205, Part I).

For the material tested in the transverse direction (90° fiber orientation) a 0.1 to 0.5 percent shrinkage was observed after the first heating/cooling cycle. Stable expansion behavior was observed during the subsequent cycles. This effect was also seen in the 0° and $[0/45/135/0/90]_s$ orientations. The thermal expansion behavior of material of this orientation is much lower. This effect is illustrated in Fig. 109, where percent expansion is plotted against temperature for both heating and cooling cycles for the Courtaulds HMS Graphite/Hercules 3002M material (typical of other materials). Materials experienced slight weight loss during testing, typical weight losses ranging from 0.1 to 0.3 percent.

The instantaneous coefficient of thermal expansion for each resin matrix material and fiber orientation tested was determined for the second cycle stable expansion behavior and is plotted as a function of temperature in Figs. 110 to 112, and tabulated in Table X.

The low expansion of the 0° (longitudinal) fiber orientation composites results from the high modulus fibers restricting the expansion of the low modulus matrix. Since the tensile moduli of the boron and graphite fibers are much higher than tensile moduli of the epoxy resin matrices, it can be predicted from strain compatibility considerations that the properties of the reinforcing fibers control the uniaxial (0°) expansion.

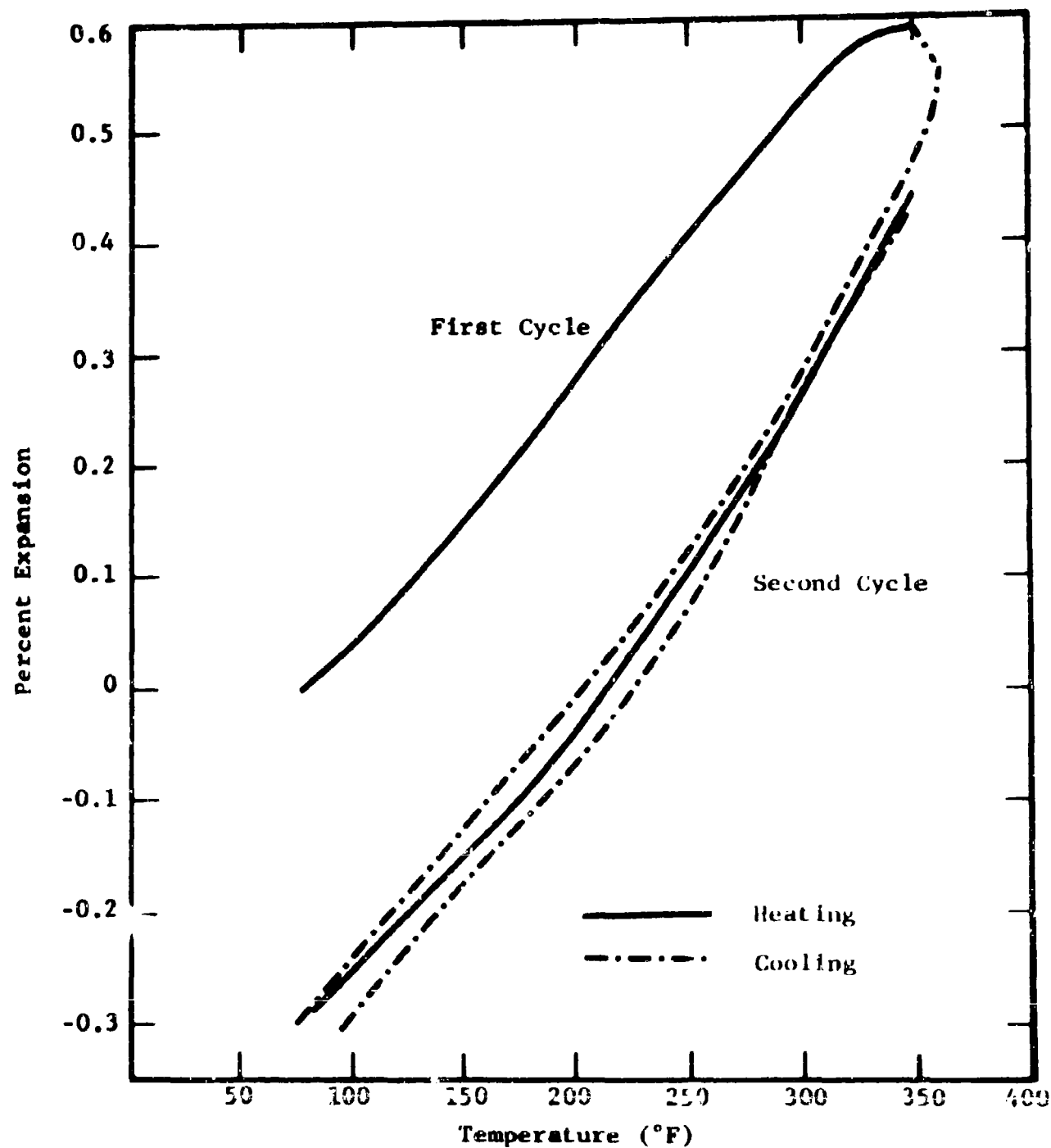


Fig. 109 THERMAL EXPANSION BEHAVIOR OF COURTAULDS HMS GRAPHITE/HERCULES 3002M IN THE 90° ORIENTATION

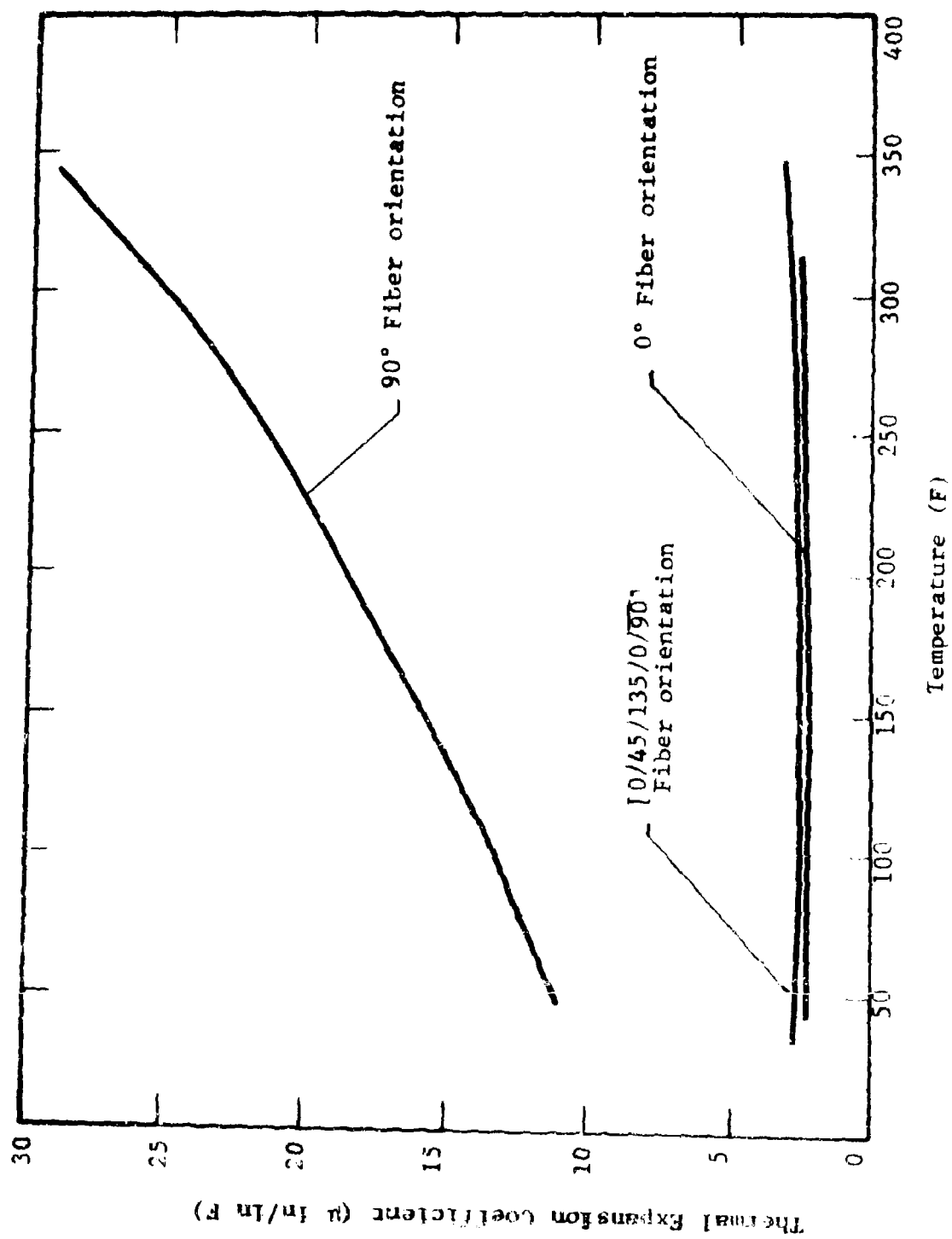


Fig. 110 COEFFICIENT OF THERMAL EXPANSION FOR
BORON/AVCO 5505 COMPOSITES

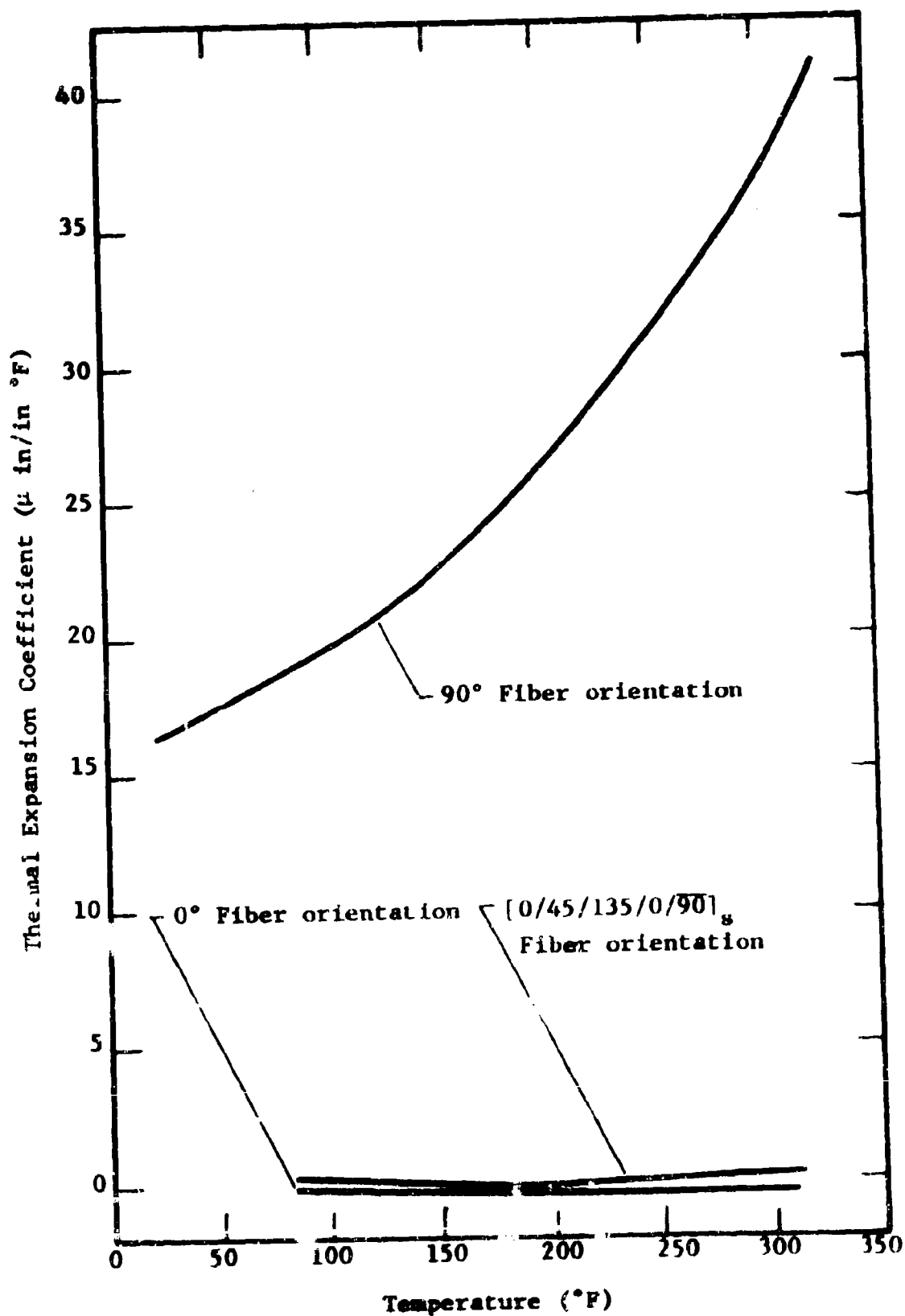


Fig. 111 COEFFICIENT OF THERMAL EXPANSION FOR COURTAULDS HMS GRAPHITE/HERCULES 3002M COMPOSITES

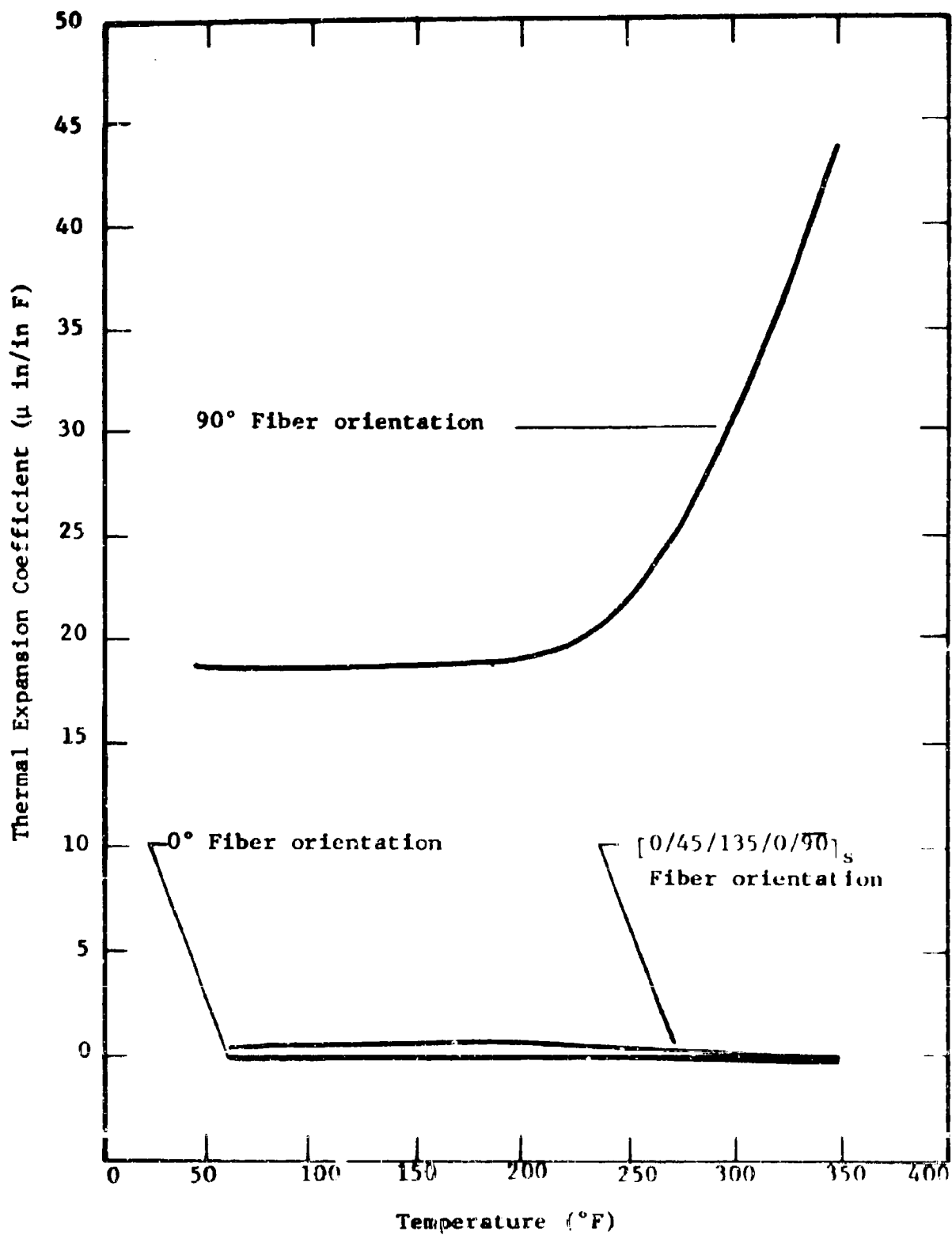


Fig. 112 COEFFICIENT OF THERMAL EXPANSION FOR MODMOR II GRAPHITE/NARMCO 5206 COMPOSITES

Table X

ERAGE INSTANTANEOUS COEFFICIENT OF EXPANSION DATA OF RESIN MATRIX COMPOSITES*

Temperature, °F	COEFFICIENT OF EXPANSION, μ in/in °F				
	RT**	100	200	300	350
Boron/AVCO 5505					
0° Orientation	2.4	2.4	2.5	2.8	3.0
[0/45/135/0/90] _s Orientation	2.6	2.6	2.75	2.95	3.2
90° Orientation	12.3	13.5	18.6	25.1	30
Modmor II Gr./Narmco 5206					
0° Orientation	-0.13	-0.13	-0.20	-0.18	-0.07
[0/45/135/0/90] _s Orientation	0.30	0.30	0.30	0.19	0.09
90° Orientation	18.9	18.9	18.9	30.6	43.7
Court. HVS Gr./Hercules 3002M					
0° Orientation	-0.13	-0.20	-0.27	-0.33	-0.42
[0/45/135/0/90] _s Orientation	0.20	0.23	0.27	0.32	.35
90° Orientation	18.6	19.5	25.9	36.3	42.2

* Based on 2nd cycle, stable behavior

** Extrapolated

behavior. This was found to occur as evidenced by the data in Table X. Boron fibers exhibit a uniaxial expansion coefficient of 2.7×10^{-6} in/in°F (14), and the AVCO 5505/Boron composite exhibited expansion coefficients ranging from 2.5 - 3.0 in/in°F (from ambient RT to 350°F) in the 0° direction.

Typical graphite fibers used in advanced graphite/epoxy composites exhibit negative expansion coefficients. Both graphite reinforced systems tested exhibited negative composite expansion coefficients in the 0° direction as seen in Table X. It was estimated that the high modulus graphite/epoxy system (Courtaulds HMS Graphite/Hercules 3002M) would have a lower uniaxial (0°) expansion coefficient than the high strength fiber system (Modmor II Graphite/Narmco 5206). This was also observed experimentally, the uniaxial expansion coefficient of the high modulus system being more negative than that of the high strength graphite reinforced material.

These data conform with composite thermal expansion data on boron - and graphite - reinforced epoxy systems found in the literature (14, 15).

The large expansion coefficients for the 90° fiber orientation (transverse) are mainly a result of matrix expansion without restraint effects produced by reinforcement. This increase in importance of the matrix expansion coefficient can be predicted from strain compatibility considerations, and is observed in the experimentally generated data summarized in Table X. Data for the transverse (90°) orientation exhibit the general magnitude and temperature dependence of typical epoxy materials as compared to the dependence of the expansion behavior on the reinforcement in the 0° orientation.

Considering both uniaxial and transverse expansion behavior, the reinforcing fibers alone more strongly control the uniaxial expansion behavior than does the matrix alone control the transverse expansion behavior. Thus the fibers have a stronger influence on transverse expansion behavior than the influence of the matrix on uniaxial expansion behavior. These observations are in concurrence with predictions based on stress equilibrium and strain compatibility analyses.

In the $[0/45/135/0/90]_8$ fiber orientation of each material tested the composite expansion coefficient is also low, indicating the few 0° plies present offer significant restraint to the composite. The angled plies also offer significant reinforcement according to literature data (16).

2.1.9.2 Effect of Absorbed Moisture on Thermal Expansion Behavior of Resin Matrix Composites

It has been demonstrated that each epoxy resin matrix composite investigated absorbs water vapor during shelf storage, as evidenced by weight gain, which results in unstable thermal expansion behavior upon initial heating and cooling, with more stable behavior in subsequent thermal cycles. This behavior has been observed in similar materials systems (15). In particular, the graphite/epoxy composites showed this behavior most clearly.

The unstable first cycle, stable second cycle expansion behavior for the transverse orientation Courtaulds HMS Graphite/Hercules 3002M material was presented before in Fig. 109. To indicate the role that absorbed water vapor has on this phenomenon, a sample, not previously tested, of the same material was exposed

to a 350°F environment for 63 hours. A thermal expansion test was then conducted on this material, the result of which is shown in Fig. 113. The prolonged temperature exposure has resulted in the elimination of the unstable first cycle behavior. This identical sample was then subjected to 98% R.H. (relative humidity) for 812 hours, until the sample regained its pre-350°F cure weight. Subsequent thermal expansion testing indicated unstable first cycle and a more stable second cycle expansion behavior as presented in Fig. 114. This behavior is similar to that shown in Fig. 109, indicating that the absorbed moisture is responsible for the observed unstable expansion behavior.

2.1.9.3 Thermal Conductivity Results

Thermal conductivity measurements were made on three reinforced epoxy systems, AVCO 5505/Boron, Modmor II graphite/Narmco 5206, and Courtaulds HMS graphite/Hercules 3002M. Three samples in each of three fiber orientations (0°, 90°, and [0/45/135/0/90], with respect to the heat flow direction) were tested from ambient RT to 350°F employing the guarded steady state longitudinal heat flow method previously described AFML-TR-72-205, Part I.

Thermal conductivity results for these resin matrix materials are presented as a function of temperature in Figs. 115 to 117. For all three materials systems the thermal conductivity in the 0° direction (parallel to fibers) is higher than in the transverse (90°) direction, with the mixed ply [0/45/135/0/90] orientation data falling in between. The straight-line representation of the data shown for each material orientation was derived from a linear least squares data analysis. Typical thermal conductivity data scatter for these composite

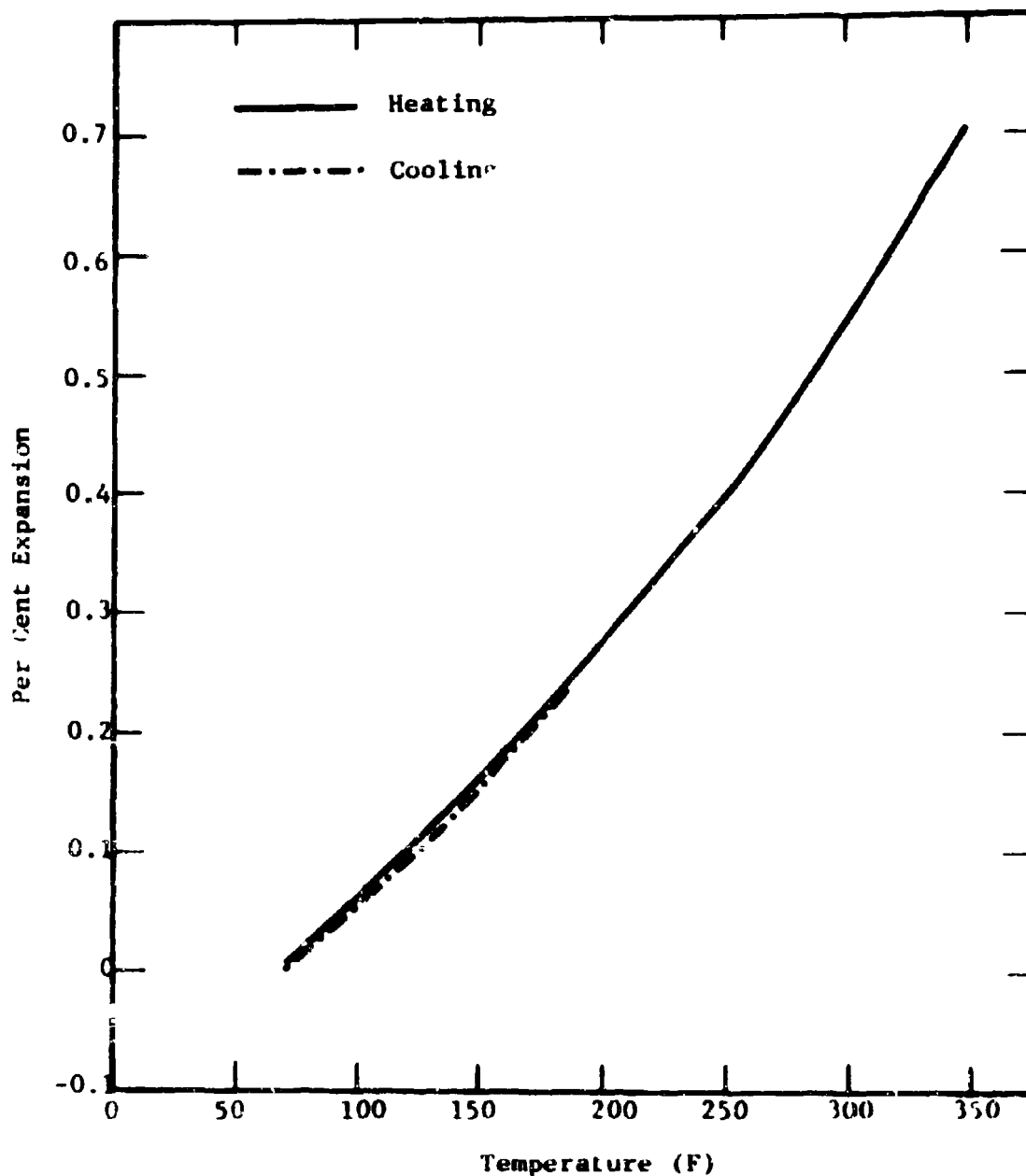


Fig. 113 THERMAL EXPANSION BEHAVIOR OF GRAPHITE REINFORCED RESIN COMPOSITE (COURTAULD'S HMS GRAPHITE/HERCULES 3002M, 90° ORIENTATION) CURED AT 350°F for 63 HOURS

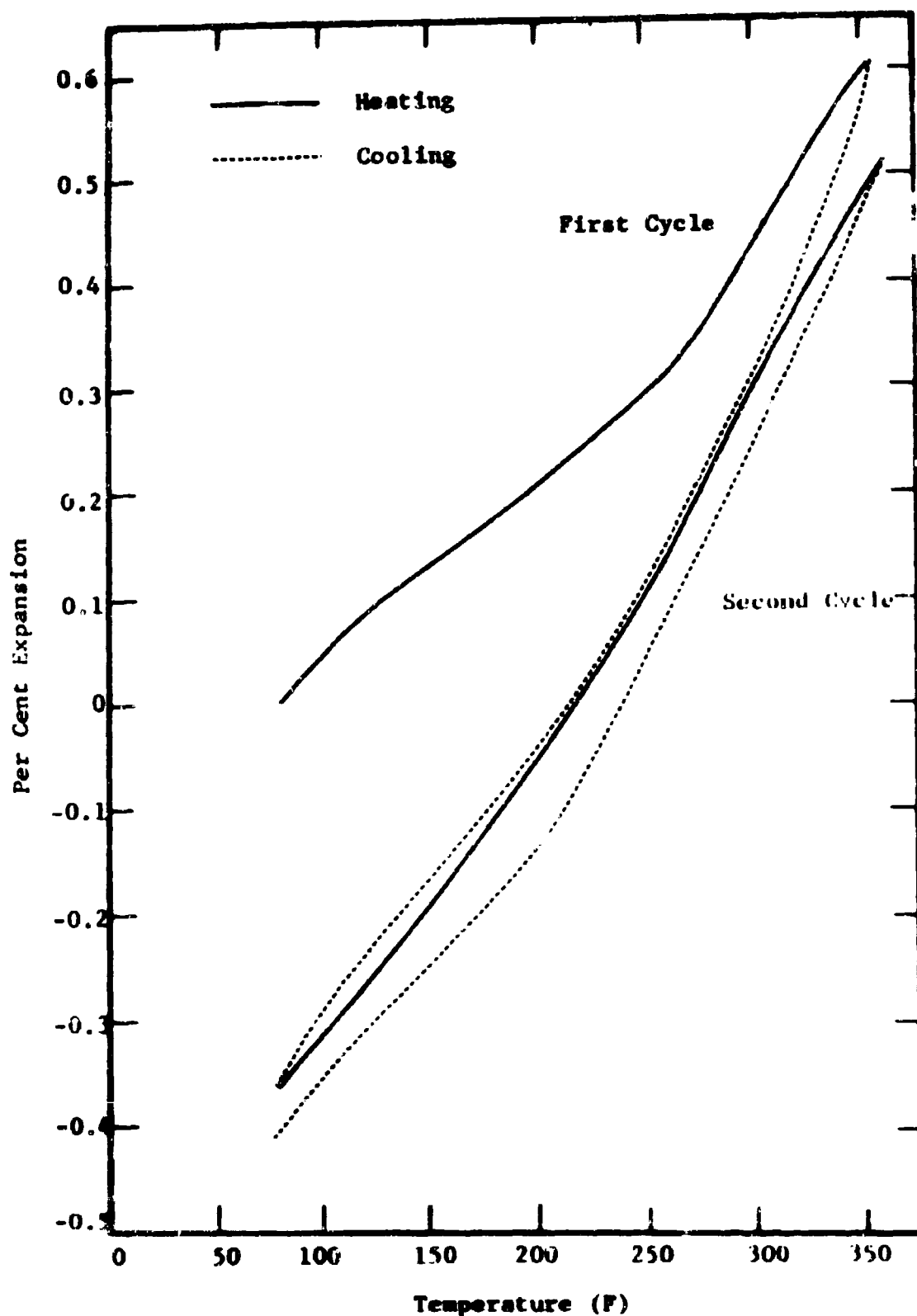


Fig. 114 THERMAL EXPANSION BEHAVIOR OF GRAPHITE REINFORCED RESIN COMPOSITE (COURTAULD'S HMS GRAPHITE/MERCULES 3002M, 90° ORIENTATION) EXPOSED TO 100% R.H. FOR 812 HOURS

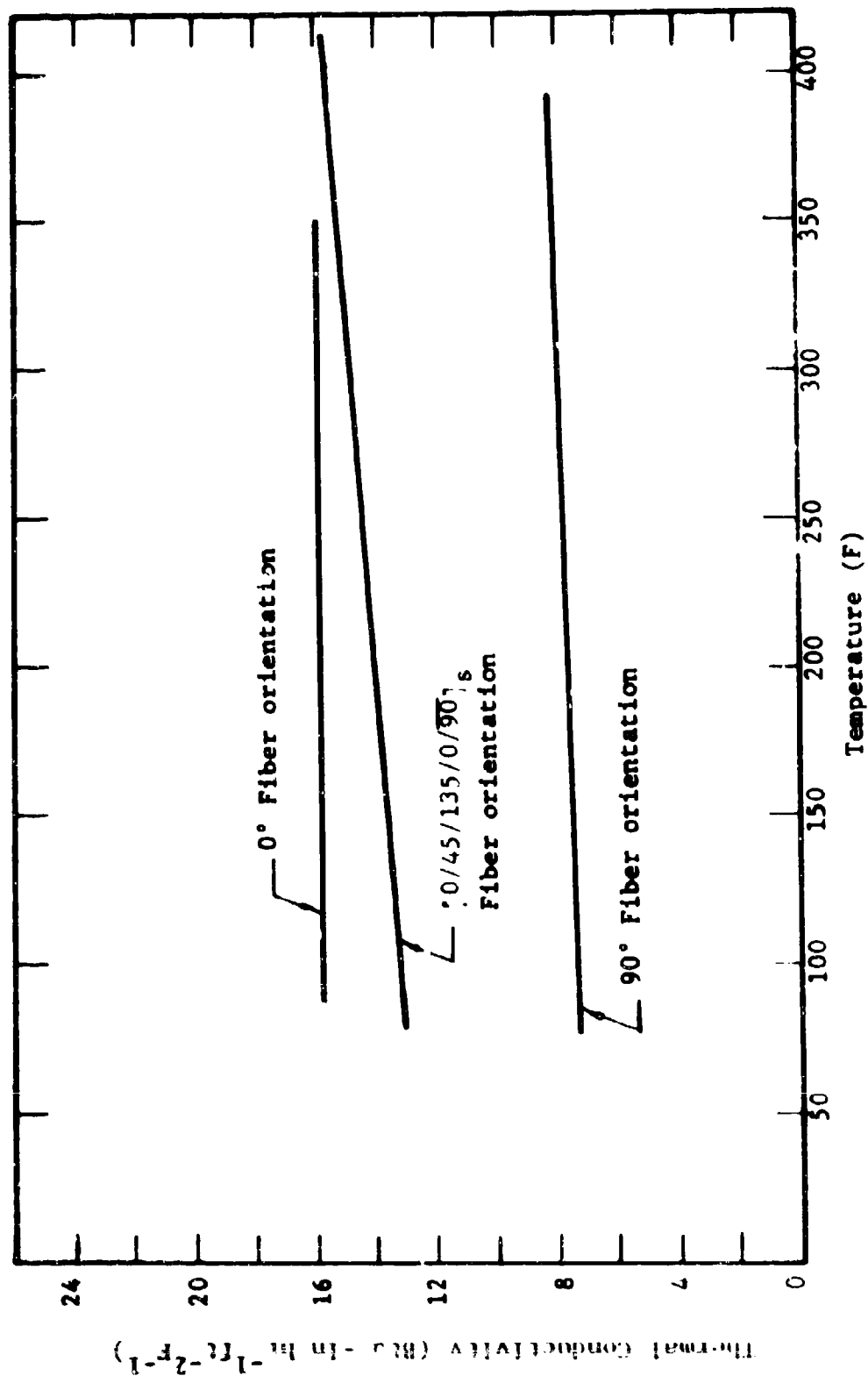


Figure 115 THERMAL CONDUCTIVITY OF BORON/AVCO 5505 COMPOSITES

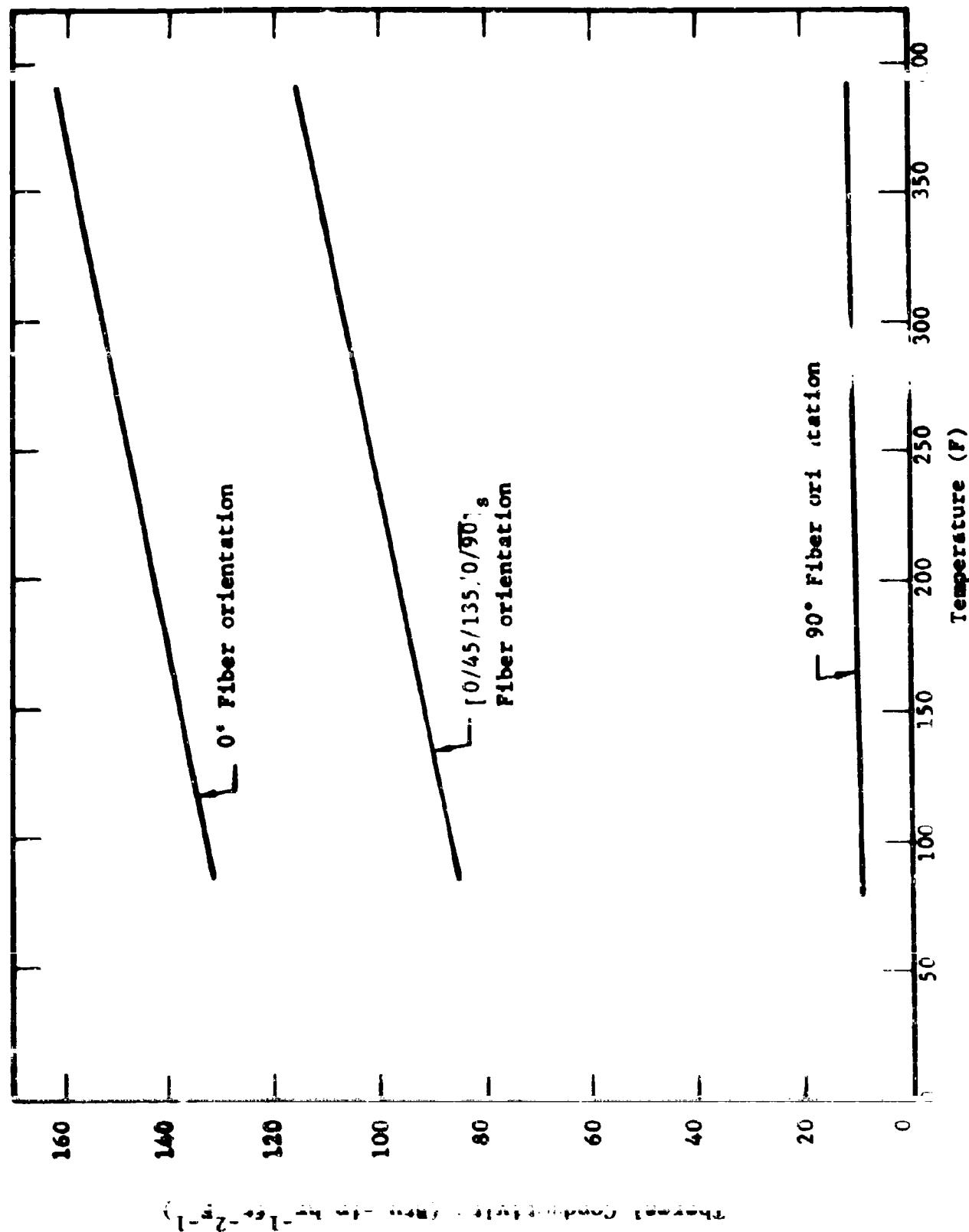


Figure 116 THERMAL CONDUCTIVITY OF MODMOR II GRAPHITE/NARMCO 5206 COMPOSITES

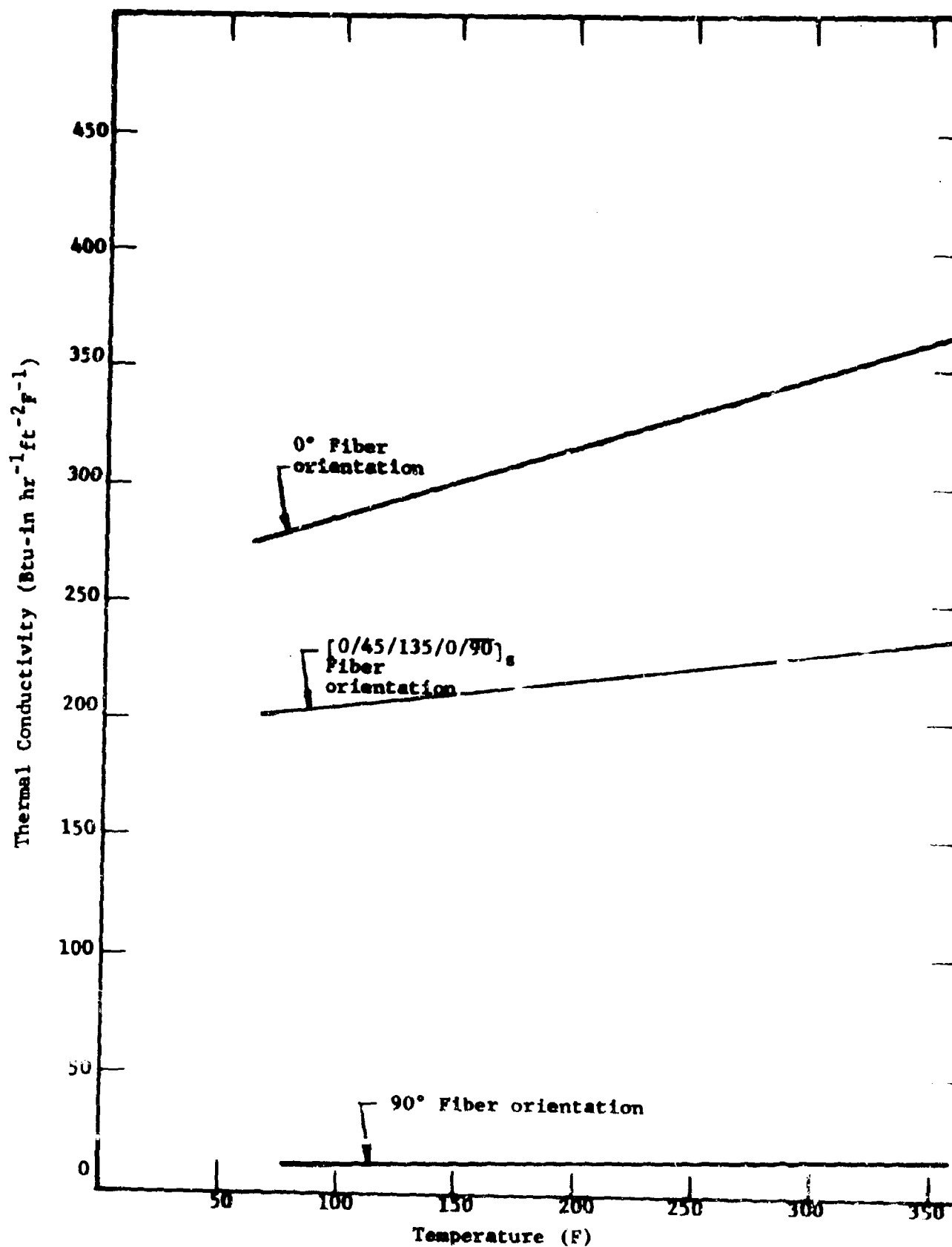


Figure 117 THERMAL CONDUCTIVITY OF COURTAULDS HHS GRAPHITE/BERGUELES 3002n COMPOSITES

materials ranged from ± 4 to $\pm 12\%$ maximum deviation from the linear representation shown. Data for the uniaxial Courtaulds HMS Graphite/Hercules 3002M material, however, exhibited $\pm 20\%$ variation from the linear representation, owing to sample variability.

The Courtaulds HMS Graphite/Hercules 3002M materials (high modulus fibers) exhibited thermal conductivity data substantially higher than the Modmor II Graphite/Narmco 5206 materials (high strength fibers). Although the properties of the Hercules 3002M and Narmco 5206 Matrices are not readily available, this result is possibly due to the increase in uniaxial fiber thermal conductivity with increasing uniaxial tensile modulus that has been observed in other graphite reinforced epoxy composites (17).

The AVCO 5505, Boron exhibited lower thermal conductivity than either of the two graphite reinforced composites studied. Although the properties of the respective matrix materials are not readily available, this result would not be unexpected owing to the lower thermal conductivity of boron fibers as compared to graphite fibers.

Both graphite reinforced materials exhibited substantially higher thermal conductivity directional anisotropy than the boron reinforced material. This is presumably due to the greater difference between fiber and matrix conductivity for the graphite reinforced materials as compared to the boron reinforced composites.

In general, good agreement was obtained in comparing the experimentally generated data for the 0° and 90° fiber orientations of the three resin matrix systems studied with data derived from analytical prediction techniques employing familiar parallel and series thermal analogies (16).

2.1.1.0 Fracture Modes

The failure patterns for 0° resin matrix composites depended upon mode and type of loading and on the prior conditioning to a lesser extent. Static tension of the AVCO 5505/Boron composites produced fractures which generally propagated fully or partially across the specimens in a straight path. The partial fractures also had straight smooth transverse fracture paths which were coupled with longitudinal fractures parallel to the filament directions thus resulting in an overall steplike fracture pattern. Fatigue fracture patterns of the 0° AVCO 5505/Boron composites contained more of such steps with many fibers involved in each transverse path. The creep fracture patterns of the 0° AVCO 5505/Boron were different from both static and fatigue patterns. The creep patterns in the 0° AVCO 5505/Boron composites showed many individual filaments pulled from the matrix in random locations so as to appear as a bundle of broken fibers of various lengths. Environmental conditioning modified these appearances only slightly. Humidity conditioning caused the fatigue and creep fractures to appear less fragmentary. Thermal conditioning caused the fracture surfaces to appear more fragmentary except in the case of fatigue and creep fracture surfaces where the fractures assumed a more straight or transverse crack direction. The two graphite composites behaved similarly to the AVCO 5505/Boron composites except that the fatigue fracture modes were more fragmentary than the corresponding AVCO 5505/Boron fractures.

The failure patterns for 90° composites showed practically no differences between the various fibers. Static tension failures were clear, flat and very nearly lay in plane perpendicular to the direction of loading. The 90° compression

failures (coupon specimens) consistently broke in a fracture plane inclined to the direction of loading. A wedge shaped piece was nearly always broken from the coupons after completion of the test specimens. The fatigue and creep fracture patterns were quite similar to the static tensile patterns for all three resin matrix composites except that the Hercules 3002M/Courtaulds HMS Graphite composites also delaminated.

Laminate $[0/45/135/0/90]_s$, composites generally failed in an irregular path, but straight across the specimens rather than in long steps as in the 0° static tensile patterns. Static compression patterns were so fragmentary that no analysis could be made of the origin and progress of the racking. The fatigue failures generally showed two fractures after testing, but one of these most likely occurred as a result of unrestrained compression followed by bending of the sample following initial specimen failure before the fatigue machine finally stops. Creep failures of the $[0/45/135/0/90]_s$ composites also showed double failures on a frequent basis. Considerable delamination of the static tensile, fatigue and creep specimens of Hercules 3002M/Courtaulds HMS graphite composites was evident after testing.

2.2 Metal Matrix Studies

2.2.1 Materials

Although the excellent specific strength and stiffness properties of certain metal-matrix composite materials have been known to the aerospace industry for some time, the application of these materials to structural components has been delayed because of high initial material cost and the lack of fabrication methods that are economical and capable of producing

panels of consistent quality. Two promising methods that are commercially used to fabricate metal-matrix composites were considered for this program.

1) Diffusion bonding in which the filaments are encapsulated by hot pressing of the matrix foils in an inert atmosphere.

2) Plasma spraying technique where matrix plasma is sprayed on filaments to form composite monolayers (or tapes). This method then requires further processing to produce multi-layer laminates.

A substantial number of aerospace applications for metal matrix composites utilize 6061 Aluminum together with the boron fiber. Therefore, this system (6061 aluminum/boron) was selected for characterization in this program.

The second metal matrix system selected was 6Al-4V-Titanium/BorSiC because of its utilization in turbine blade applications. A least two aerospace companies have shown an interest in this material.

2.2.2 Material Procurement

The maximum capability temperature of the aluminum matrix composites is generally defined as 600°F and the titanium matrix composites, 800°F. 5.6 mil boron and 5.7 mil BorSiC were used in the preparation of the laminates. Table IV in Section II presented the test program utilized for evaluation of the metal matrix composites.

Specifications for metal matrix composites did not exist at the time that these two materials were ordered for use on this program. The aluminum/boron composites fabricated contained 50 percent fiber volume. The titanium BorSiC composites contained 45 volume percent fibers. Preparation of the titanium composites was on a best efforts basis.

6061 Aluminum/Boron material was procured from Amercom Inc. The vendor fabricated the material in laminate form. The composite was diffusion-bonded in vacuum. It was initially assembled by winding boron filaments onto a thin foil of 6061 Aluminum. The filaments were held in place by a "Fugitive binder". The sheets of foil and filaments were then assembled to the requisite lamination, placed in a stainless steel vacuum bag and the bag was evacuated. The binder was eliminated at a low pressure and temperature under a dynamic vacuum. The heat was then raised to the pressing temperature and consolidation was carried out in the solid state under pressure. Following the consolidation the fully consolidated laminate was removed from the bag, trimmed and chemically cleaned prior to delivery.

6Al-4V - Titanium/BorSiC material was fabricated by TRW Inc. These laminates were prepared as follows.

BorSiC filaments were wound on a 16 inch diameter drum mounted in a filament-winding machine. The filament spacing was accurately maintained to provide the desired filament volume percent. The filaments were drawn through a glass nozzle in the process which added a polystyrene binder coating to the fiber. The collimated fiber mat is next cut and inserted between two titanium foils. This monolayer was then placed between two stainless steel or molybdenum separator which is coated with graphite and boron nitride antiadhesive coatings. The assembly

is then placed inside a stainless-steel capsule which is then evacuated. Following this the capsule is hot pressed which breaks down the polystyrene into gaseous decomposition products and these are removed by a dynamic vacuum. When the bonding temperature is reached, the pressure is increased and the assembly is bonded for a period of time. Following this the load is reduced the monolayer is removed and the surface is etched to a 50 fiber volume percent thickness. Then the monolayers were stacked between 20 mil thick doubler plates and the new assembly is subjected to pressure and elevated temperature. Thus two distinct diffusion bonding operations are used in the overall process.

2.2.3 Metal Matrix Material Test Specimens

Figure 118 presents the specimen geometries of the various metal matrix test specimens employed in this program.

Referring to the Fig. 118a the tension, and tensile fatigue and creep specimens were similar to the IITRI straight sided tab ended coupons used for the resin matrix studies with 2 in. gage lengths and 4 inches long. The specimen shape was arrived at by machining of the 20 mil doubler plates bonded during plate fabrication on top and bottom surfaces instead of bonding of a tab on the laminate as with resin matrix composite tests specimens. With the removal of 18 mil foil layer on either surface, the specimen thickness was approximately 44 mils.

Figure 118b shows the 15-ply compression and $R = -1$ and 10 fatigue coupon geometry which was obtained by machining in a manner similar to the tension specimens. The specimen had a gage length of 1/2 in. and with the removal of 18 mil cover on either side, the test section thickness came to about 110 mils.

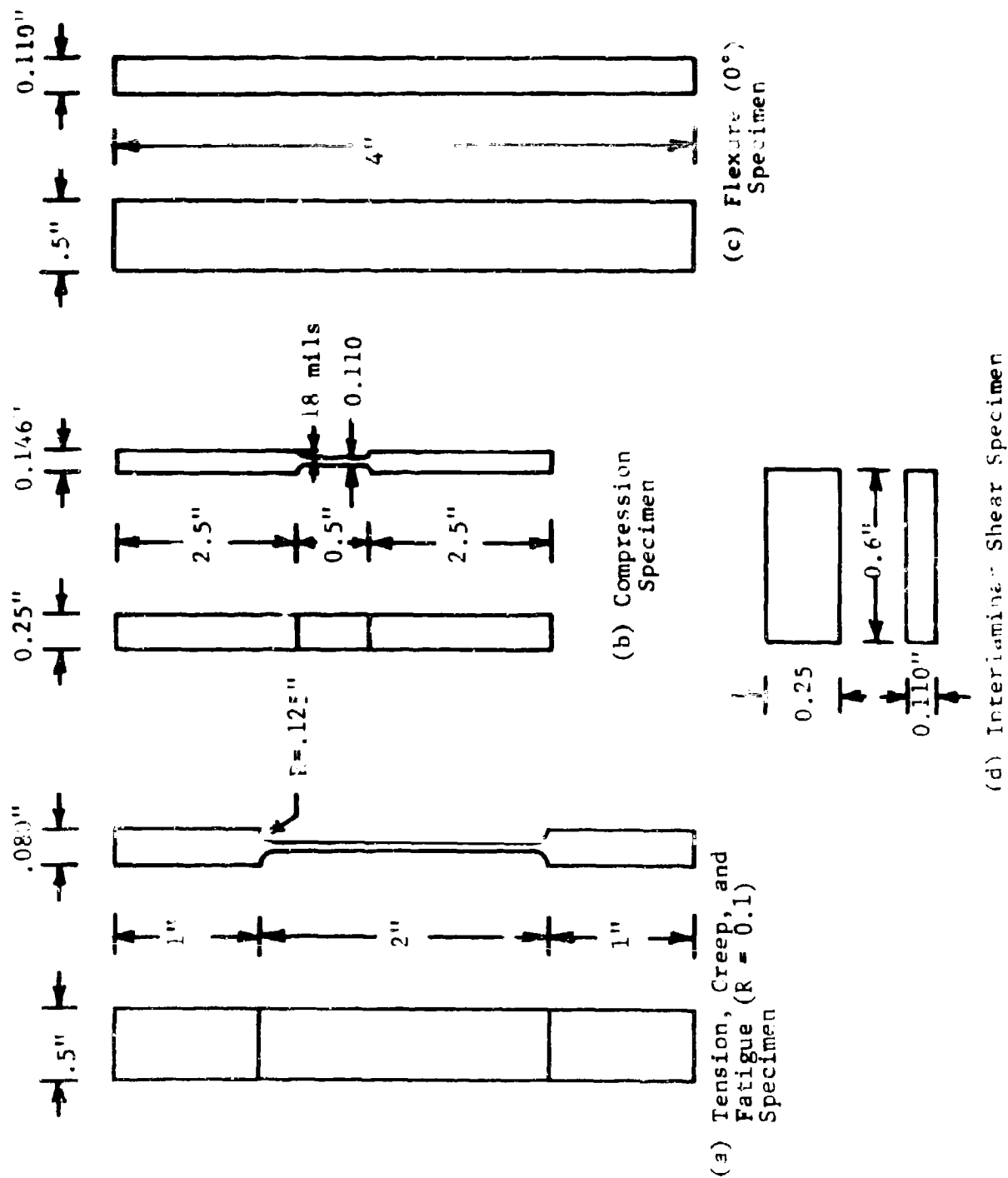


Fig. 118 METAL MATRIX TEST SPECIMENS

The flexural specimens of 0° and 90° fiber orientations were the same as those for the resin matrix composites. These specimens had 15 plies with a thicknesses of 110 mils after the removal of the cover. These specimens were tested in a manner similar to the testing of the resin matrix flexure specimens.

Interlaminar shear specimens were also 15 mils thick and they were 1/2 in. wide and 0.6 in. long. The test procedure was identical to that for the resin matrix specimens with three point loading.

Thermal conductivity and Thermal expansion specimens were 2 in. by 1/2 in. by 6 plies in thickness. For the former tests, several of these specimens were stacked together to a total thickness of 1 inch.

Density determinations were made on specimens similar in size to those used for thermal property tests. The fiber volume density was measured by gravimetric means.

2.2.3.1 General Specimen Machining Procedures

The 6061 Aluminum/boron panels fabricated by Amercom Inc. had a 20 mil thick 6061 aluminum doubler plates diffusion-bonded to both the top and bottom surfaces of the panels.

The tension and compression specimens required tabs at the grips. By machining away the doubler plates in the test section of the specimens (to a depth of 18 mils) we were left with 18 mil thick tabs on each end of the sample on both sides of the specimen. This provided a composite specimen with a uniform matrix covering the filaments throughout the entire test section. For specimens that did not require the tab thicknesses such as in flexure and interlaminar shear tests, the

doubler plates were machined to remove 18 mils uniformly over the full area of the specimen.

The actual machining work was done as described below:

The blank plates were held in a fixture on the surface grinder to permit two cuts in the longitudinal direction, using a 1/16" cutoff wheel. These two cuts removed the rough edges. The plates were then turned 90° and held in a similar clamping fixture to cut the plates to the specimen length. The reduced section was then ground in the plates using a grinding wheel with the corner radius dressed on both edges. At this point the plates were held in a fixture and the specimens were cut to the proper width with a cutoff wheel. After this operation the specimens were deburred.

A similar procedure was adapted for specimen fabrication from the 6Al-4V - Titanium/BorSiC material which also had a matrix foil cover of 20 mil thickness on either face.

2.2.3.2 Machining Procedure for Titanium/BorSiC Composite Specimens from Diffusion Bonded Plates

The edge condition of each blank plate was examined. If there was any doubtful edge sections, a predetermined amount was removed to assure a uniform density.

This whole operation was done in a steel hold down fixture in a surface grinder, (the clamp bar being 0.015" to 0.030" away from the cutoff wheel) to prevent fiber separation. The wheel utilized was an,

ALLISON, VA-602-M-RA, (1/16" x 3" x 12")
operated at 2800 RPM spindle speed.
A normal traverse, 0.001" downfeed--water
soluble coolant was employed.

Depending on the fiber orientation relative to the specimen geometry, the specimen blanks were removed in the following manner:

(A) Specimens that required the fibers in the longitudinal direction were cut in strips to the correct width and the full length of the plate. (Using the fixture described above).

(B) Specimens with transverse fibers were cut to the correct width from sections that were cut from the blank plate-- each section cut to the specimen length and parallel to the fiber direction. A smaller plate fixture of similar design was used to cut transverse specimens to the correct width. The wheel utilized was the same as above.

The reduced area was ground in a hold down fixture that accommodated twelve specimens and which clamped the specimens within 1/32" of the reduced section. Equal amounts were removed from each side. When the specimens were turned over for grinding, a suitable shim was placed in the original reduced area to prevent deflection and to act as a heat sink. The wheel used was a,

NORTON, 37C-60-JVK, (1" x 3" x 12")
operated at 2200 RPM spindle speed.
A normal traverse, 0.0005" downfeed--
soluble coolant was employed.

The radius was dressed on both edges of the wheel. The final grind, on both sides, was at 0.0001" to 0.00015" downfeed.

The amount of stock removed per pass was critical; any increase in the grinding cut caused excessive heat and tended to make the specimen deform upwards into the wheel, exposing the fibers.

Plain specimen blanks (no reduced section) were produced as described above for the specimen blanks.

The material removal of the entire surface of the plain blanks was done individually. A vise with "step jaws" was used to hold the specimens during the grinding operation. An equal amount of material was ground from each surface. The wheel used was as described above for removing material for tensile coupons.

The grinding of large sections resulted in deflection, due to the heat generated at the wheel contact point (even with coolant), and resulted in damaged areas with some fibers exposed. inspection was required.

2.2.4 Static Test Results for Metal Matrix Composites

2.2.4.1 Baseline Data

Baseline data were generated for both 6061 Aluminum/boron and 6Al-4V Titanium/BorSiC Composites for both 0° and 90° properties, in tension and compression at various temperatures: 70°F, 160°F, 400°F, 600°F and at 800°F for the Titanium/BorSiC. These results are presented in Appendices IV and V. Both tabularized data on strengths and moduli and stress-strain curves are shown there.

2.2.4.2 Effects of Thermal Conditioning on the Static Properties of Metal Matrix Composites

Both steady-state and cyclic thermal conditioning treatments were applied to the two metal matrix composites. The effects of these conditioning treatments are summarized in Figures 119 - 126. In general, the steady state treatments appeared to have a mixed effect on the tensile strengths of the two composites, while the cyclic thermal effects appeared to cause a general degradation of the tensile strengths. Both

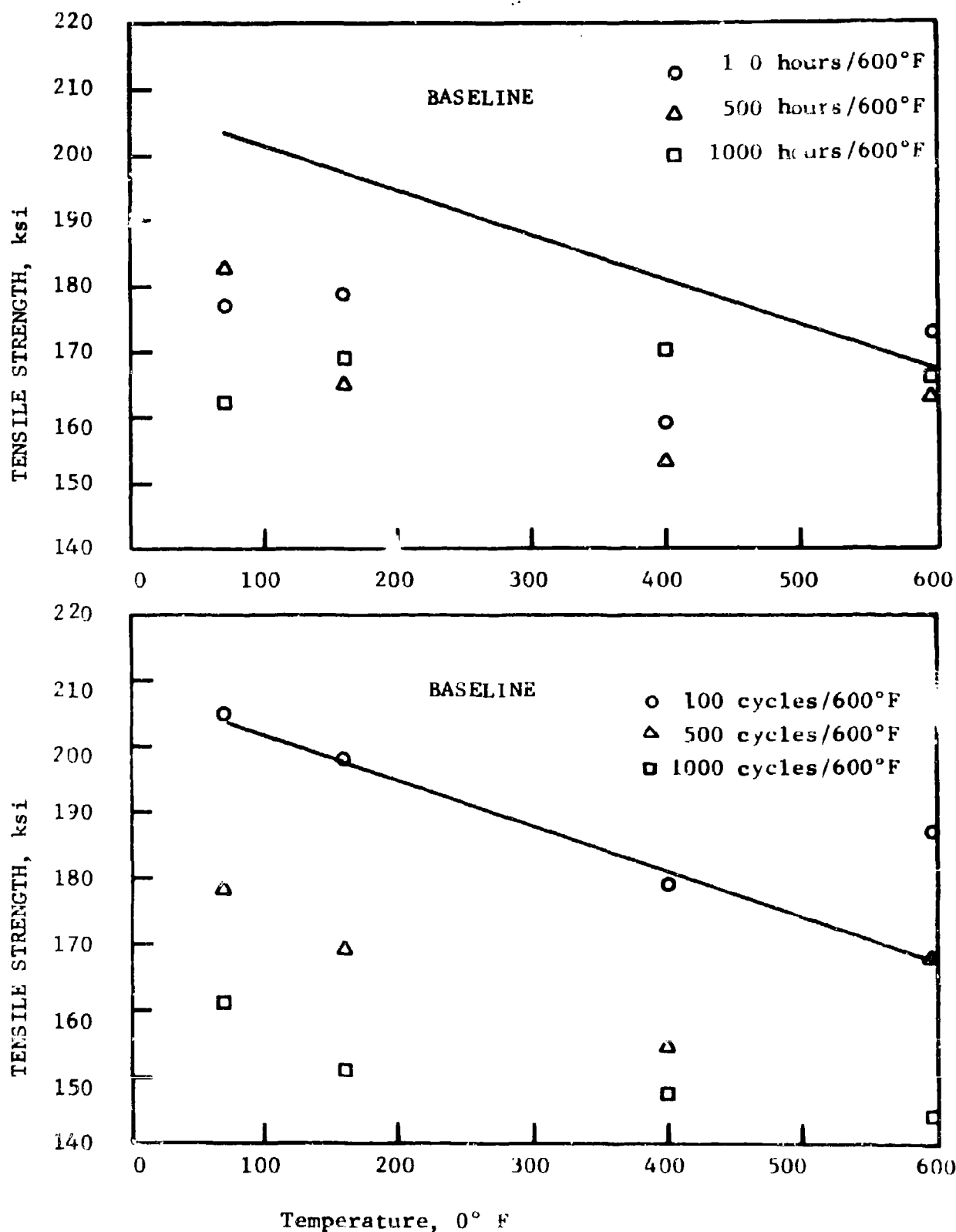


Fig. 119 EFFECT OF PRIOR THERMAL CONDITIONING ON THE TENSILE PROPERTIES OF BORON/6061 ALUMINUM COMPOSITES - 0°

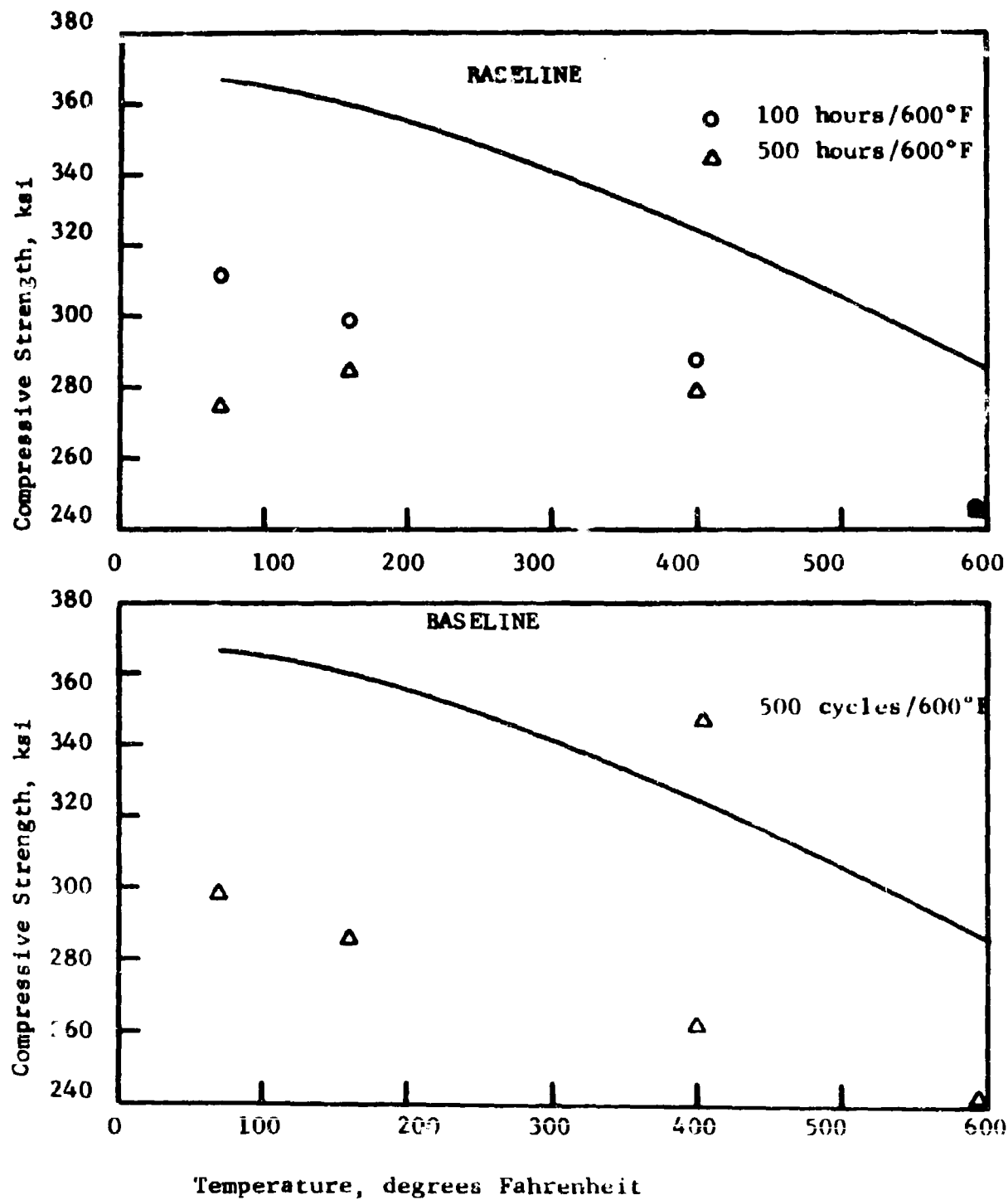


Fig. 120 EFFECT OF PRIOR THERMAL CONDITIONING ON THE COMPRESSIVE PROPERTIES OF BORON/6061 ALUMINUM COMPOSITES 0°

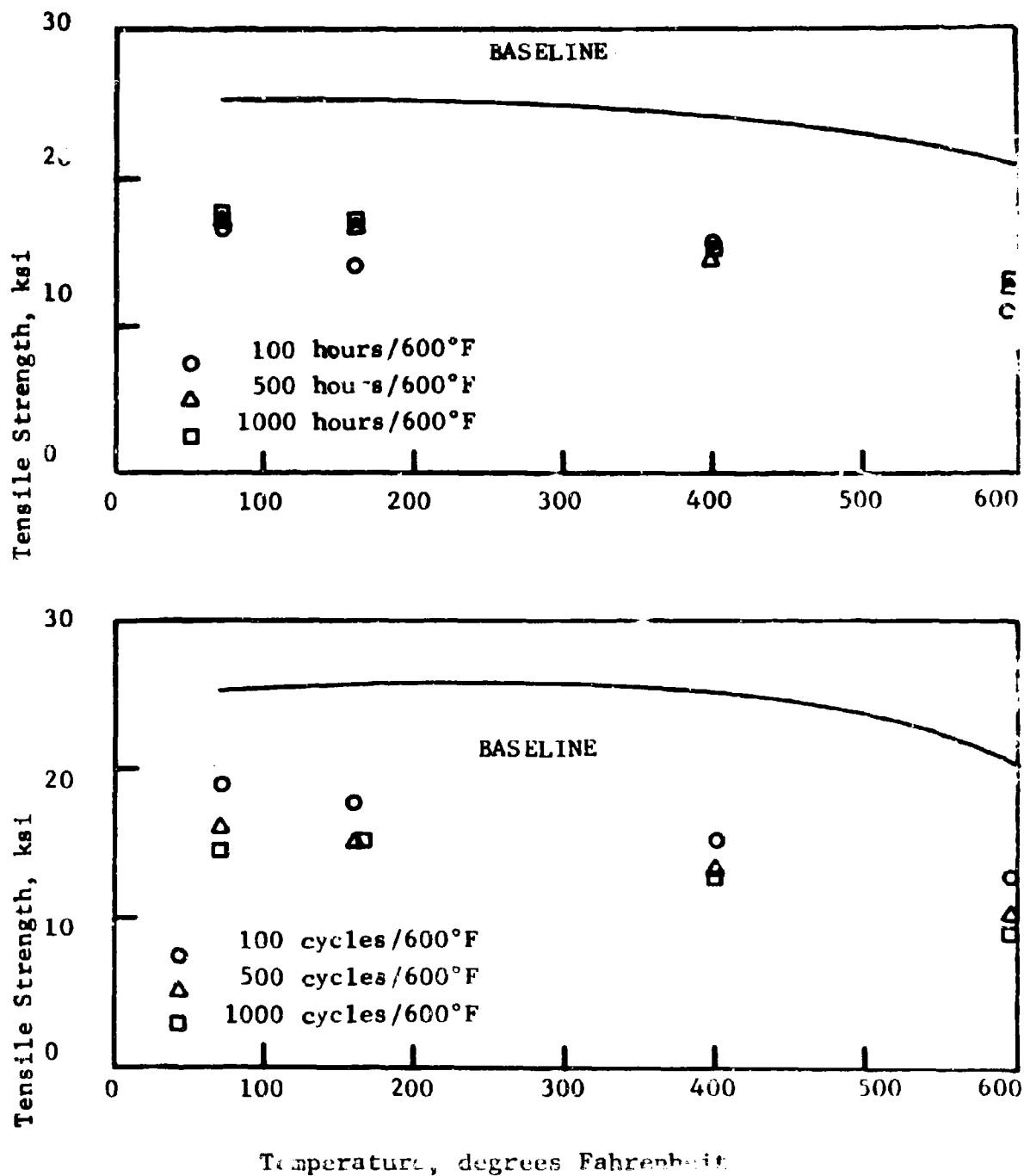


Fig. 121 EFFECT OF PRIOR THERMAL CONDITIONING ON THE TENSILE STRENGTHS OF 6061 ALUMINUM/BORON COMPOSITES 90°.

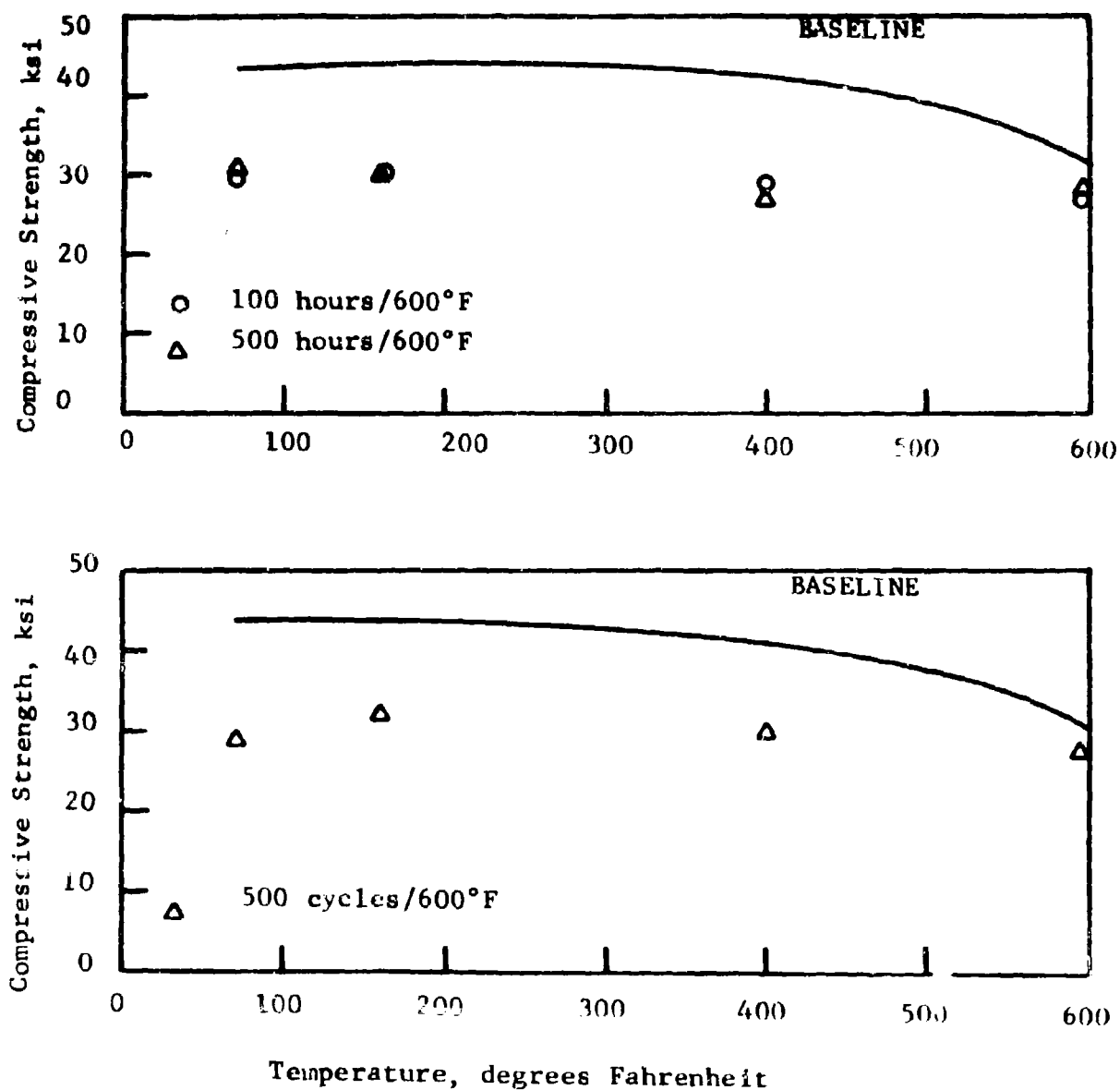


Fig. 122 EFFECTS OF PRIOR THERMAL CONDITIONING ON THE COMPRESSIVE STRENGTHS OF 6061 ALUMINUM/BORON COMPOSITES 90°.

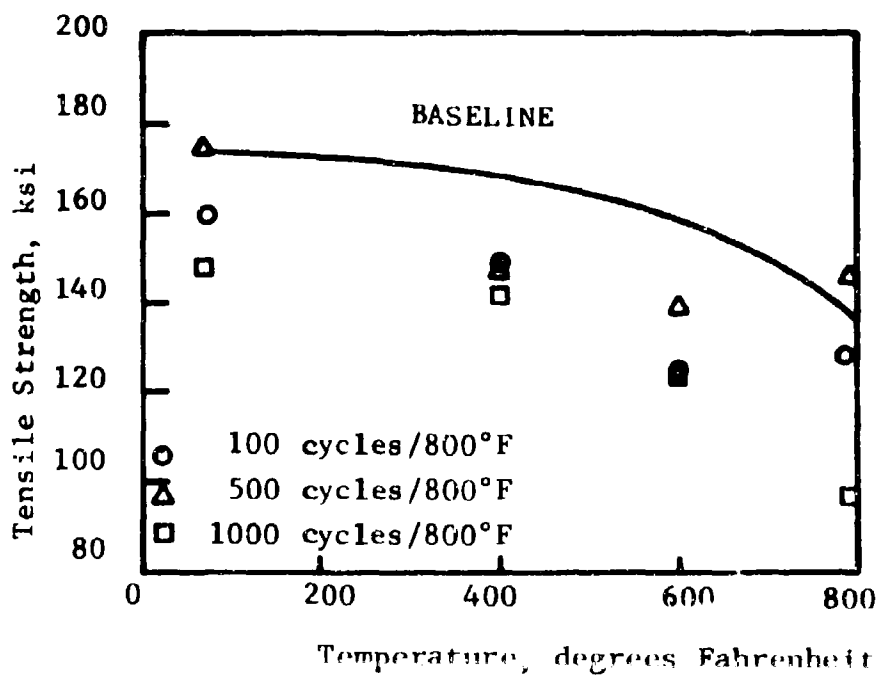
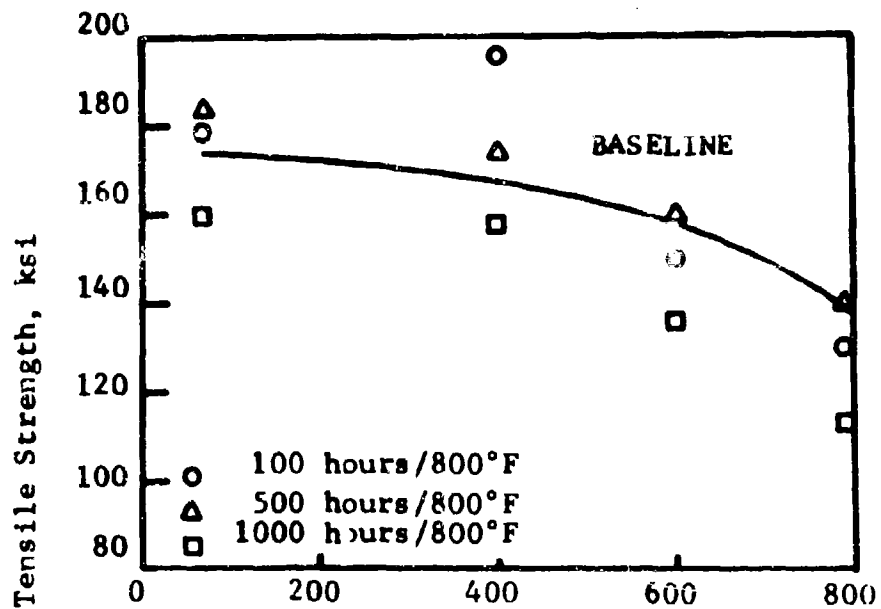


Fig. 123 EFFECT OF PRIOR THERMAL CONDITIONING ON THE TENSILE PROPERTIES OF 6Al-4V TITANIUM/BORSIC COMPOSITES 0°.

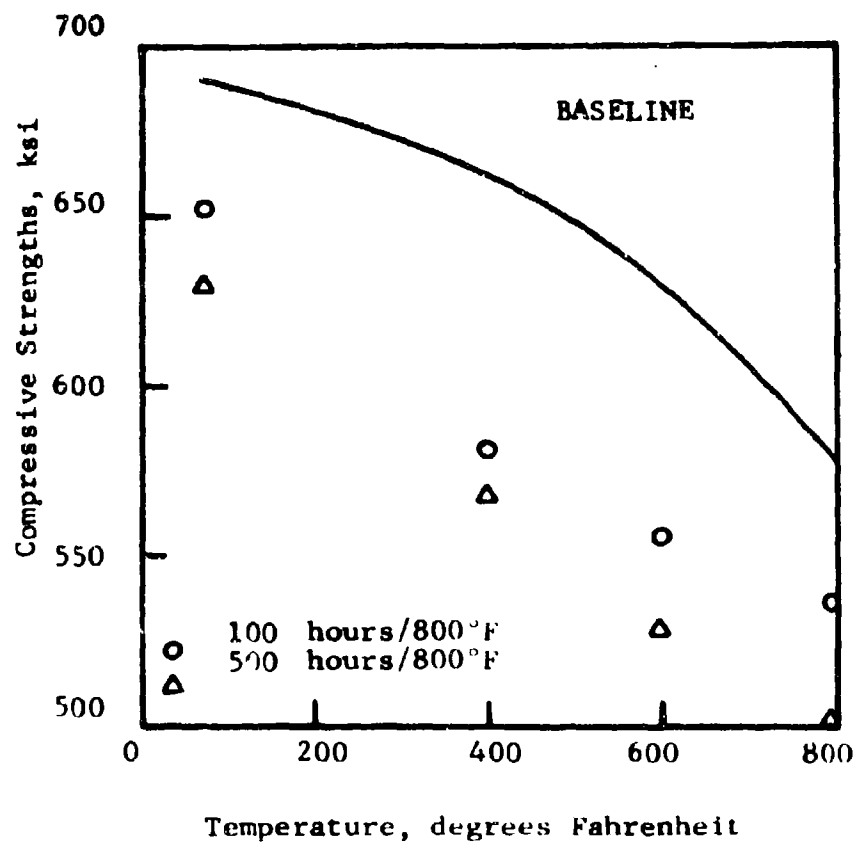


Fig. 124 EFFECT OF PRIOR THERMAL CONDITIONING ON THE COMPRESSIVE STRENGTHS OF 6Al-4V-TITANIUM/BORSIC COMPOSITES 0°.

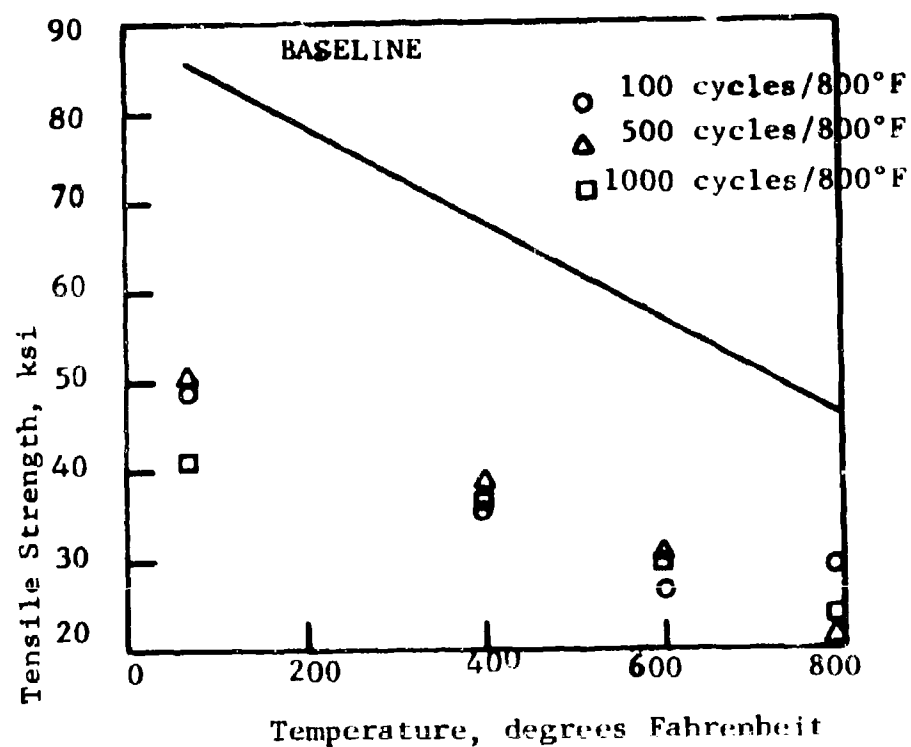
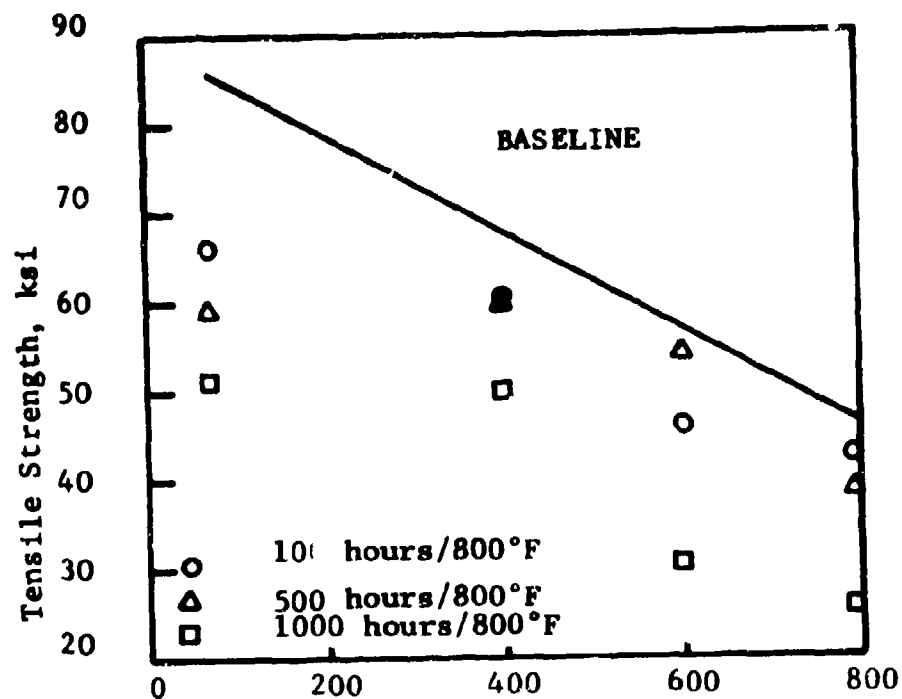


Fig. 125 EFFECT OF PRIOR THERMAL CONDITIONING ON THE TENSILE STRENGTHS OF 6Al-4V TITANIUM/BOR-SiC COMPOSITE 90°.

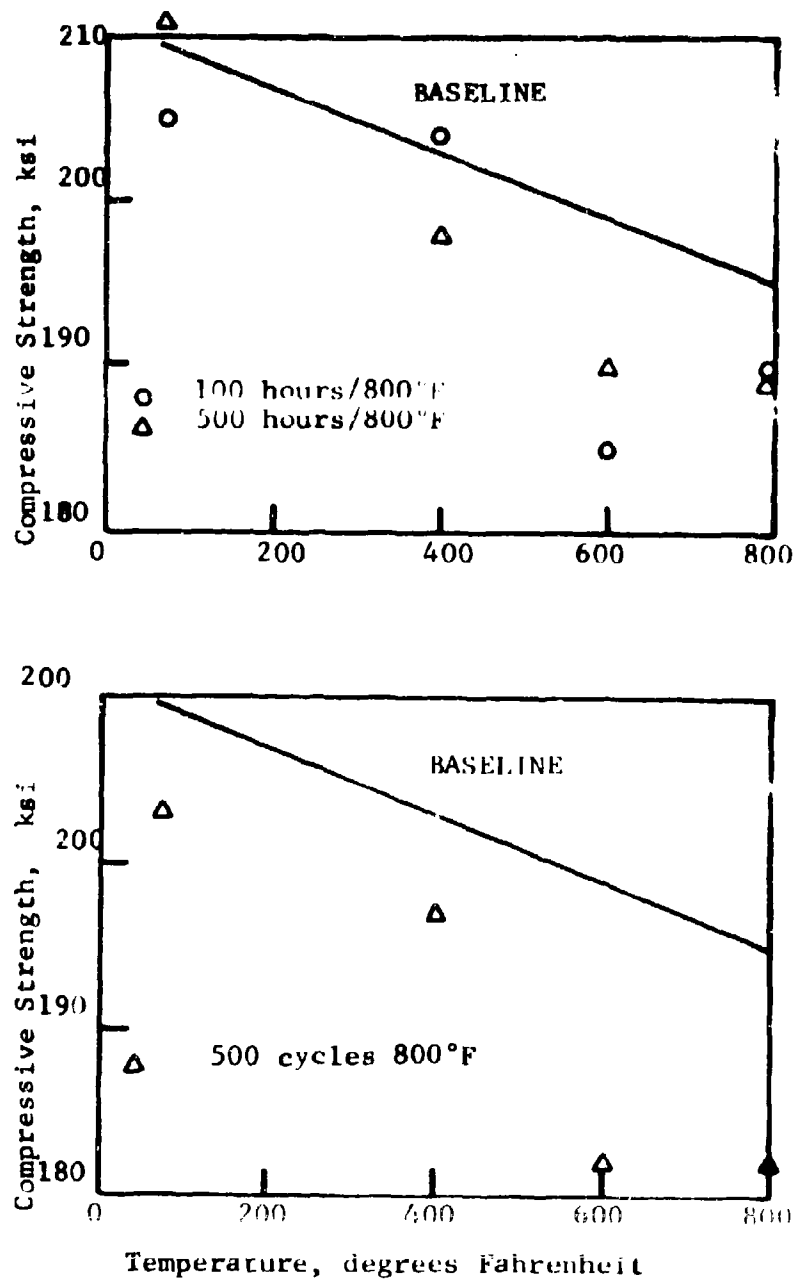


Fig. 126 EFFECT OF PRIOR THERMAL CONDITIONING ON THE COMPRESSIVE STRENGTHS OF 6Al-4V-TITANIUM/BORSIC COMPOSITES, 90°

conditioning treatments appeared to cause a degradation of the compressive strengths.

2.2.5 Fatigue Test Results

Both metal matrix composites were subjected to fatigue at various R ratios (R - 0.1, -1, and 10) at a cyclic frequency ϕ = 1800 rpm. No conditioning was applied to the metal matrix composites but the materials were tested at temperatures of 70°F, 160°F, 400°F, 600°F and at 800°F for the 6Al-4V-Titanium/BorSiC Composites. Fatigue in both the longitudinal (0°) and transverse (90°) directions was studied.

The results are presented in Appendices IV and V and in Figs. 551 to 556 and 588 to 593.

The 6061 Aluminum/Boron tensile fatigue (R - 0.1) results fell within a very narrow band for all temperatures, with only a slight degradation in strength with increasing temperature of the 0° composite. A much wider spread in the S-N curves was shown for the fully-reversed loading (R - -1) and considerable scatter in the compression fatigue (R = 1.0) results of the 0° composites. Similar results were evidenced for the 90° 6061 aluminum/boron composites.

The 6Al-4V - Titanium/BorSiC fatigue results show a greater reduction in strength with temperature and a greater scatter in the fully reversed and compression fatigue data for all temperatures and both longitudinal and transverse load-carrying capacities.

2.2.6 Creep And Stress Rupture Results

Both metal matrix composites were also subjected to long term tensile stress-rupture and creep testing. Both 0° and 90° composites were tested in creep at 70°F, 160°F, 400°F, 600°F

and 800°F. The results are presented in Appendices IV and V in tabular form, creep curves and stress versus time to rupture curves.

The test results indicate considerable scatter for the 6061 aluminum/boron composites and very little useful data for the 6Al-4V titanium matrix composites. The 6061 aluminum/boron stress versus time to rupture curves are extremely flat similar to the fatigue S-N curves. In addition it should be noted that the transverse creep strain versus time curves for the 6061 aluminum/boron composites showed a tendency to increase in growth rate at elevated temperatures similar to the familiar aluminum base metal creep curve performance. (The room temperature strains did not increase as quickly as those at the elevated temperatures). The 0° creep strain versus time curves were quite flat out to 1000 hours.

2.2.7 Physical and Thermophysical Properties of Metal Matrix Composites

2.2.7.1 Thermal Expansion Test Results

Thermal expansion measurements were made for the two fiber reinforced metal matrix systems, 6061 Aluminum/Boron and 6Al-4V-Titanium/BorSiC. Five samples in each of two fiber orientations (0° and 90° with respect to the expansion direction) were tested in air with the NETZSCH automatic recording pushrod dilatometer described previously. Testing was conducted from -320°F to 700°F for the 6061 Aluminum/Boron material, and from -320°F to 900°F for the 6Al-4V Titanium/BorSiC material.

Typical results for the 6061 Aluminum/Boron and 6Al-4V-Titanium/BorSiC materials are presented in Figs. 127 to 132, where percent expansion is plotted against temperature for both heating and cooling cycles above and below ambient RT. For the

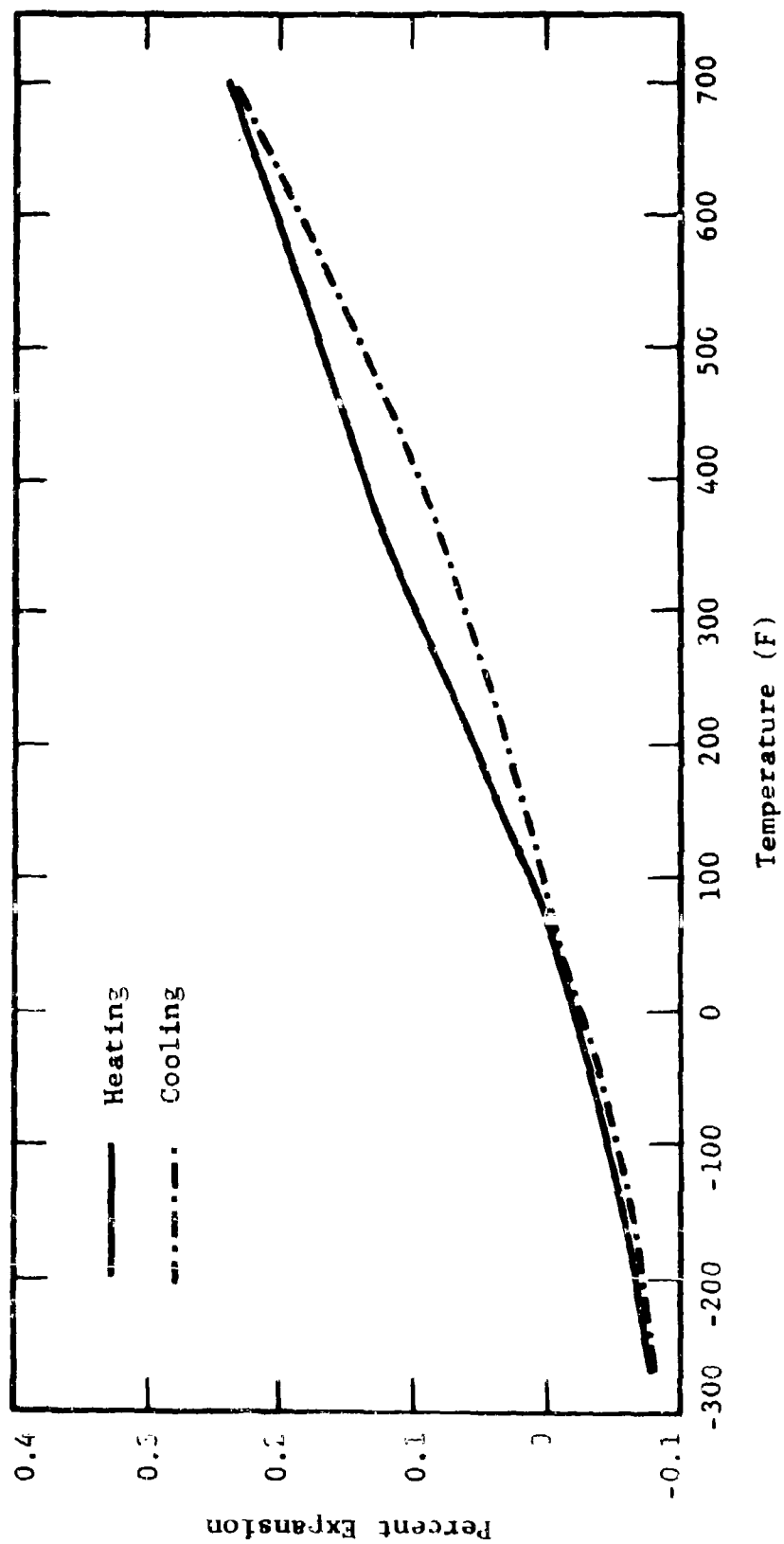


Fig. 127 THERMAL EXPANSION BEHAVIOR OF 6061 ALUMINUM/BORON MATERIAL IN THE 0° FIBER ORIENTATION

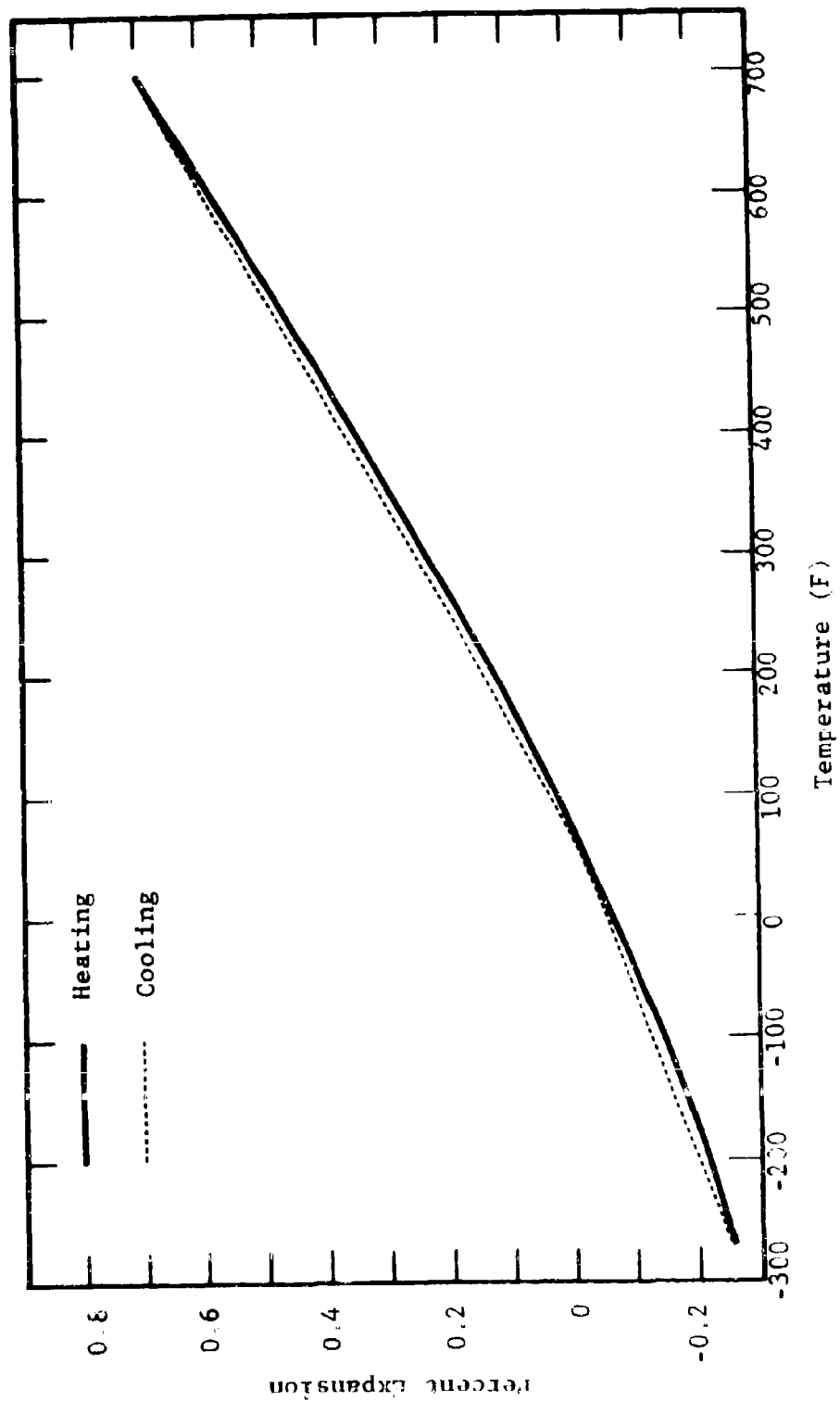


Fig. 128 THERMAL EXPANSION BEHAVIOR OF 6061 ALUMINUM/BORON MATERIAL IN THE 90° FIBER ORIENTATION

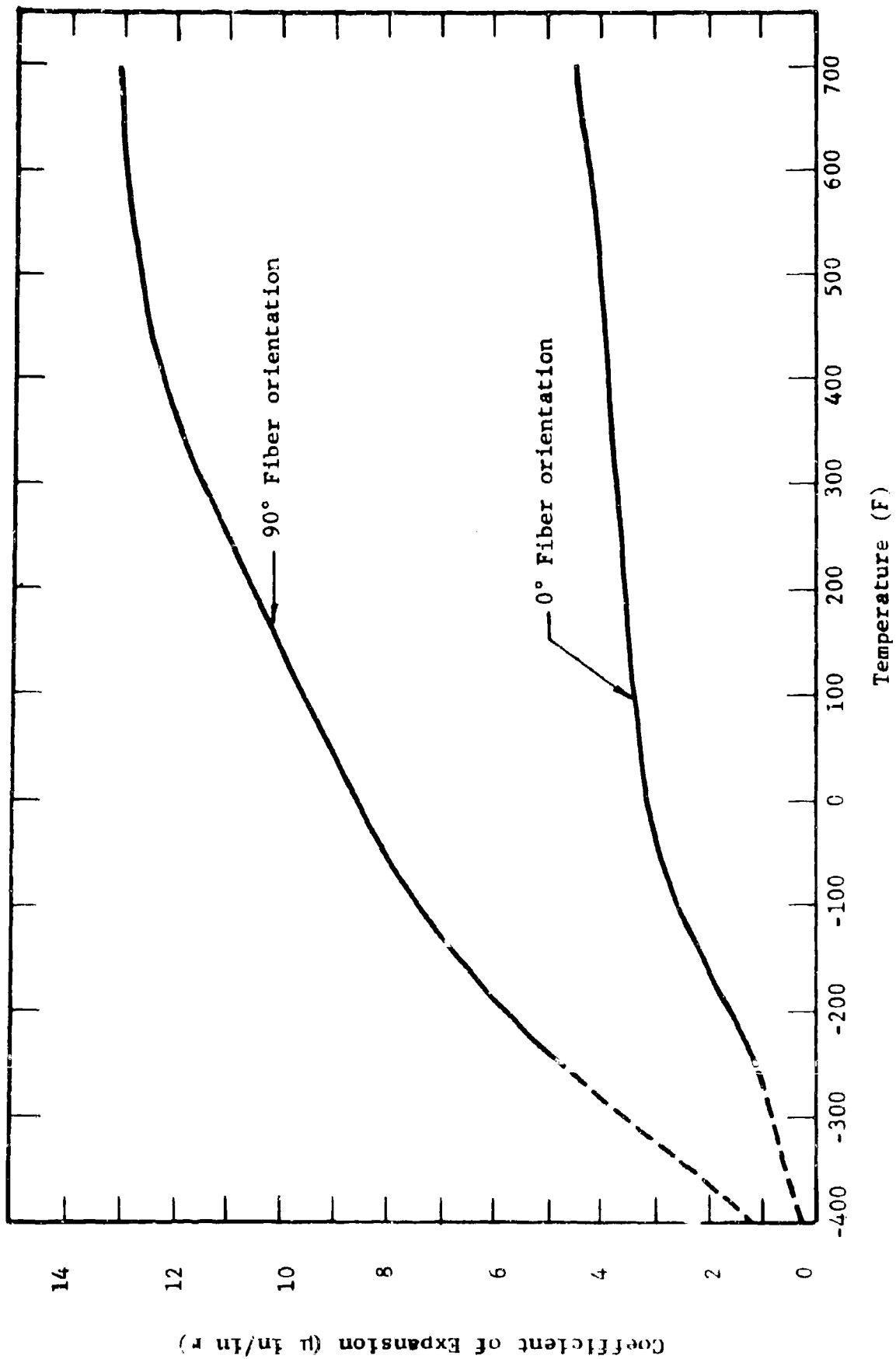


Fig. 129 COEFFICIENT OF THERMAL EXPANSION FOR
6061 ALUMINUM/BORON COMPOSITES

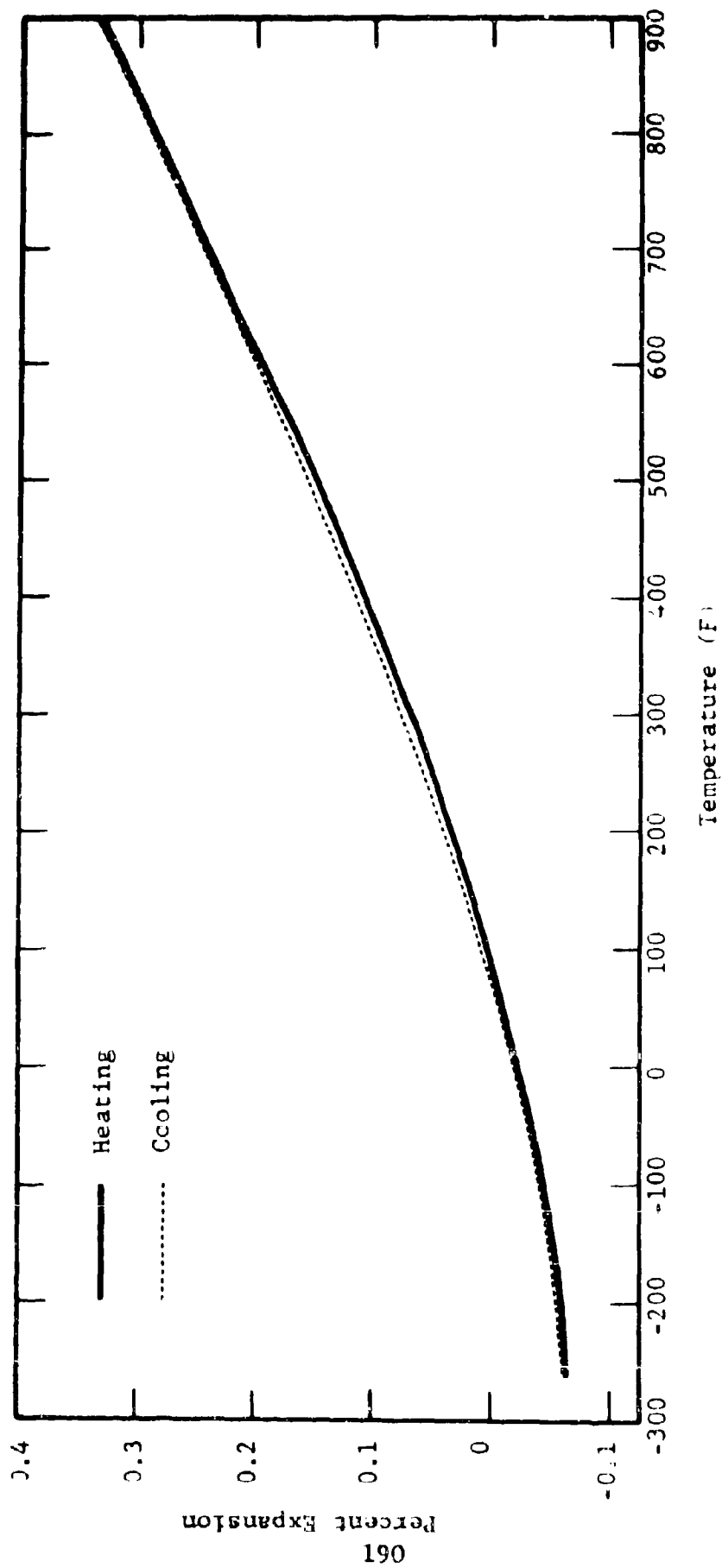


Fig.130 THERMAL EXPANSION BEHAVIOR OF 6Al-4V-TITANIUM/
BORSIC MATERIALS IN THE 0° FIBER ORIENTATION

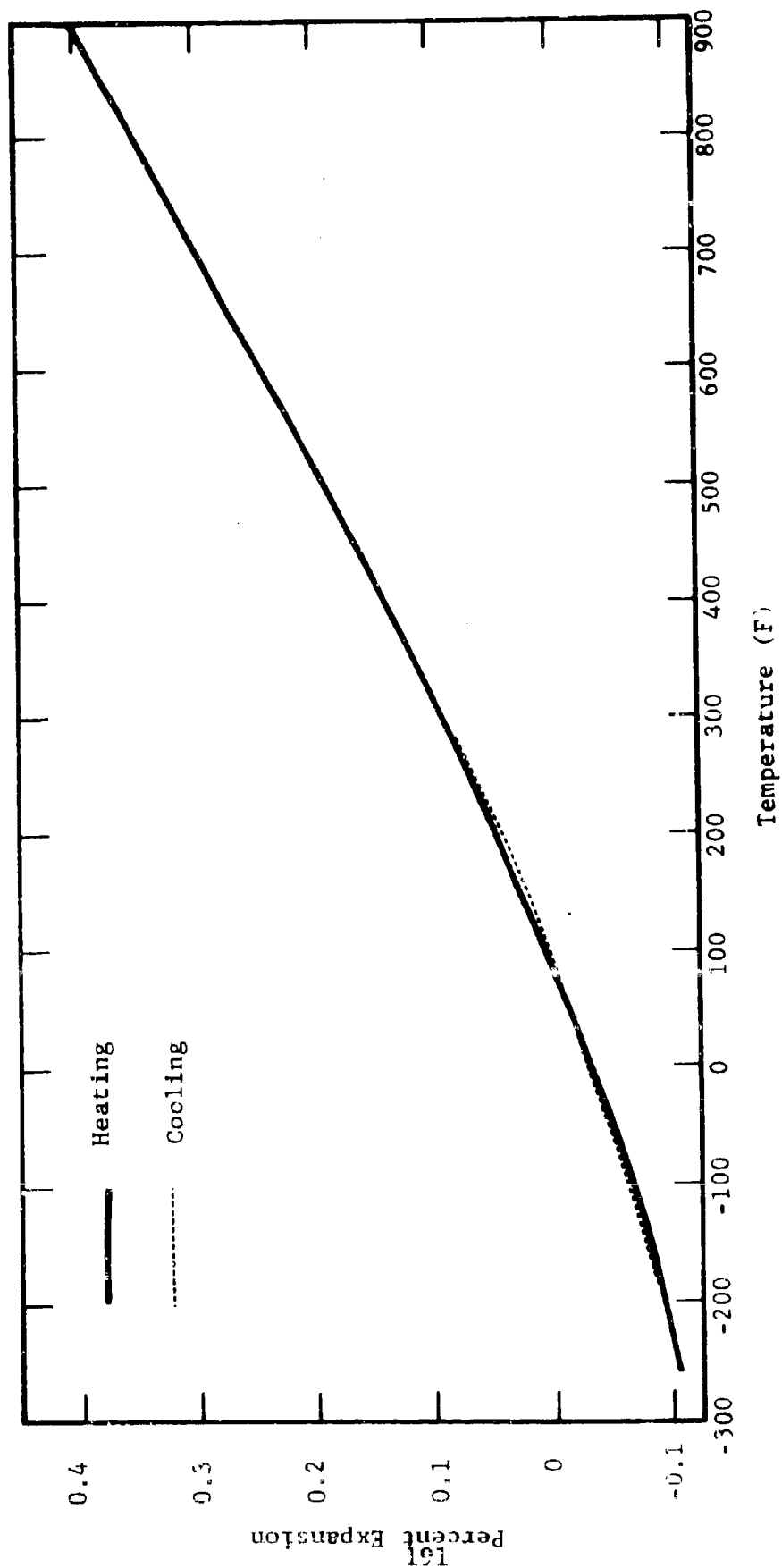


Fig. 13: THERMAL EXPANSION BEHAVIOR OF 6Al-4V-TITANIUM/
BorSiC MATERIALS IN THE 90° FIBER ORIENTATION

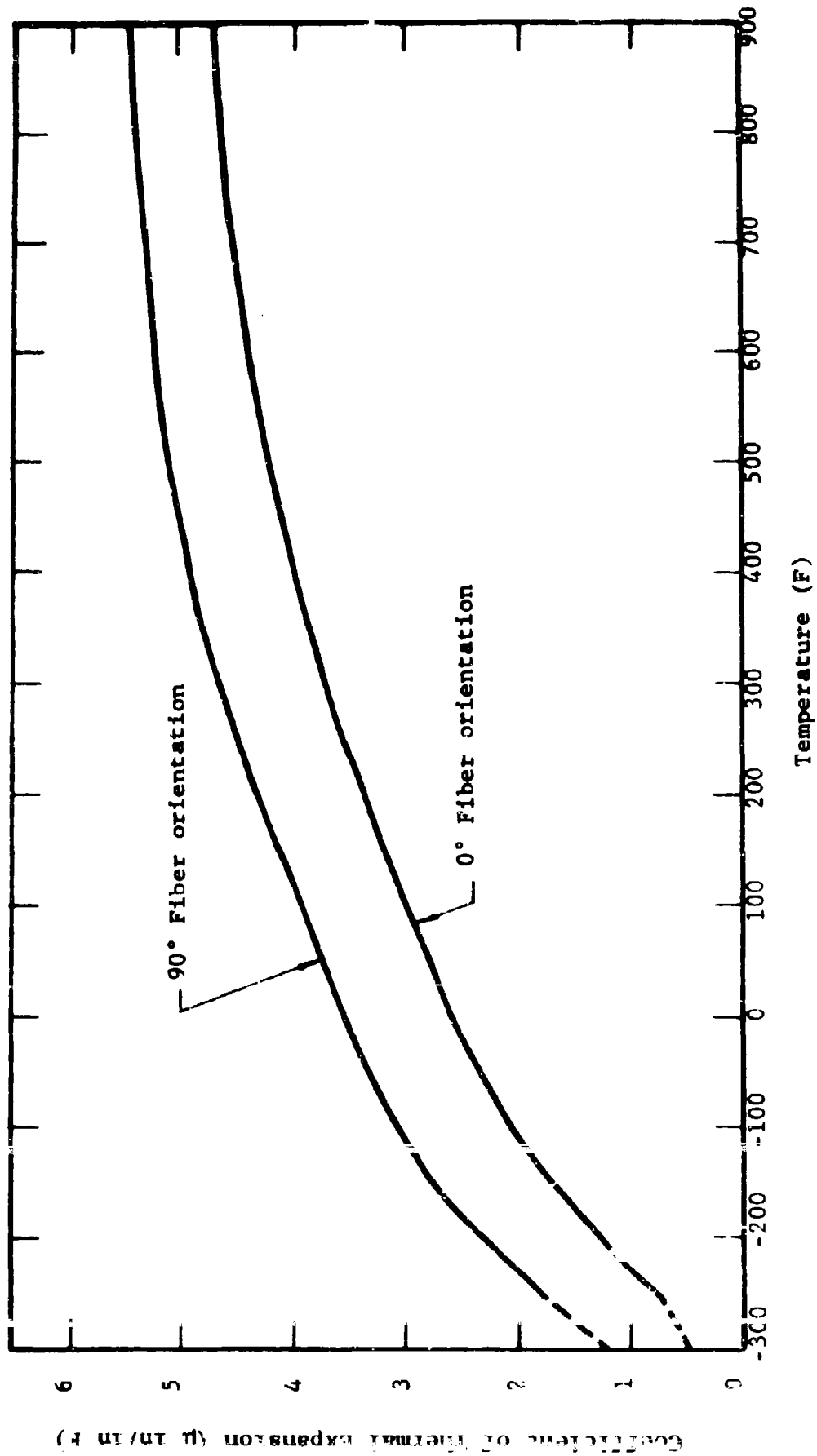


Fig. 132 COEFFICIENT OF THERMAL EXPANSION FOR 6Al-4V-TITANIUM/BORSIC COMPOSITES

6061 Aluminum/Boron system the overall expansion from -320°F to 700°F was 0.3 percent or the 0° direction and 0.95 percent or the 90° direction. Over the temperature range -320°F to 900°F the 6Al-4V Titanium/BorSiC materials exhibited 0.39 percent and 0.5 percent expansion in the longitudinal (0°) and transverse (90°) directions, respectively. For both metal matrix systems tested good sample-to-sample reproducibility was observed, with no unstable expansion behavior such as was obtained for the resin matrix materials.

The instantaneous coefficient of thermal expansion was determined for both metal matrix systems or the longitudinal and transverse directions and is presented as a function of temperature in Figs. 131 and 132 and is summarized in Table XI.

In the 0° direction (parallel to fibers) expansion coefficients are low due to fiber reinforcement effects. Expansion data for the uniaxial (0°) 6061 Aluminum/Boron metal matrix material are similar to the resin-matrix AVCO 5505/Boron system previously discussed. However, the boron fibers more strongly control the uniaxial expansion behavior in the resin matrix system. This can be predicted by considering the relative fiber and matrix moduli in both metal - and resin - matrix systems.

The uniaxial (0°) expansion coefficients of the 6Al-4V Titanium/BorSiC material were similar to those observed for the 6061 Aluminum/Boron system. Both materials were boron fiber reinforced which controlled the uniaxial expansion behavior.

The larger expansion coefficients for these metal matrix materials in the transverse (90°) direction represent relatively unrestrained matrix expansion, the boron fibers offering only minimal reinforcement. The transverse 6061 Aluminum/Boron material expansion coefficients are similar to those of the

Table XL

AVERAGE INSTANTANEOUS COEFFICIENT OF THERMAL EXPANSION
DATA FOR METAL MATRIX COMPOSITES

	COEFFICIENT OF EXPANSION, $\mu\text{in/in}^\circ\text{F}$						
TEMPERATURE, $^\circ\text{F}$	-300*	-100	100	300	500	700	900
6061 Aluminum/Boron							
0° orientation	0.85	2.55	3.38	3.75	4.00	4.20	--
90° orientation	3.55	7.33	9.70	11.50	12.70	13.10	--
6Al-4V-Titanium/BorSiC							
0° orientation	0.50	2.05	3.00	3.70	4.18	4.55	4.73
90° orientation	1.20	3.05	3.92	4.64	5.08	5.30	5.47

*extrapolated

6061 Aluminum matrix ($\sim 13 \mu\text{-in/in}^\circ\text{F}$ at RT), and the transverse expansion coefficients of the 6Al-4V-Titanium/BorSiC material are similar to those of titanium ($\sim 4.7 \mu\text{-in/in}^\circ\text{F}$ at RT). In both materials transverse expansion coefficients were slightly lower than for their respective matrix materials only, due to the contribution of the reinforcing fibers in the transverse direction.

The 6Al-4V titanium/BorSiC material exhibited less thermal expansion anisotropy than the 6061 Aluminum/Boron materials. This occurred presumably because the individual fiber and matrix component expansion coefficients were closer for the 6Al-4V-titanium/BorSiC system.

2.2.7.2 Thermal Conductivity of - Metal Matrix Composites

Thermal conductivity measurements were made on the two metal matrix composites: 6061 Aluminum/Boron and 6Al-4V-Titanium/BorSiC. Five samples in each of two fiber orientations, longitudinal (0°) and transverse (90°), were tested. Testing was conducted to 700°F and 900°F for the aluminum matrix and titanium matrix materials, respectively.

Thermal conductivity results are presented in Figs. 133 and 134, where the thermal conductivity is plotted as a function of temperature for both the longitudinal and transverse orientations. The thermal conductivity parallel to the fiber reinforcement was higher than in the transverse (normal to fibers) direction. The straight-line representations shown for each material/orientation are the result of linear least squares data fits. Data scatter for these metal matrix materials was roughly ± 4 to $\pm 12\%$ (maximum variation), with some evidence of sample-to-sample variability.

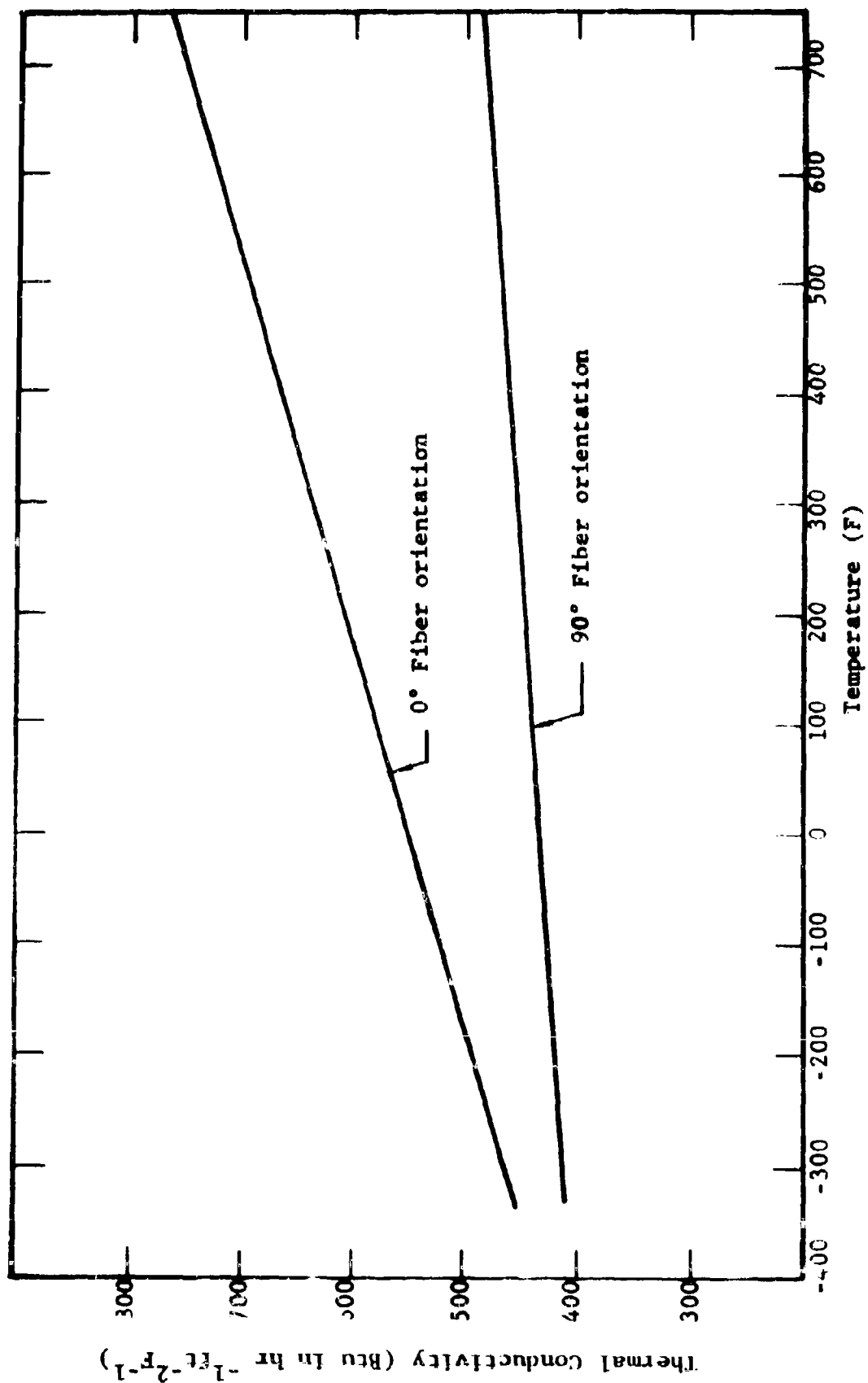


FIG. 133 THERMAL CONDUCTIVITY OF 6061 ALUMINUM/BORON COMPOSITES

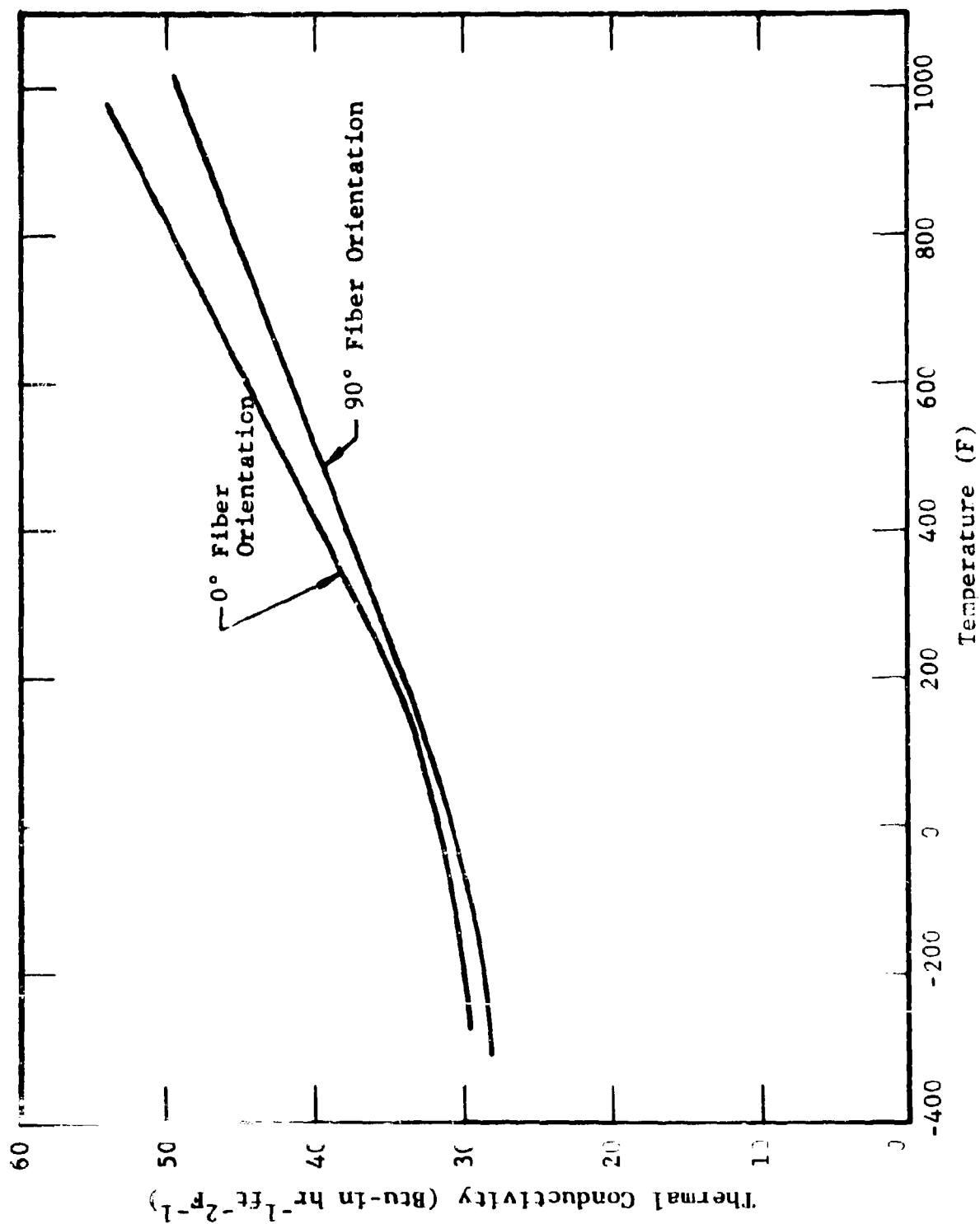


Fig. 134 THERMAL CONDUCTIVITY OF 6Al-4V-TITANIUM/BorSiC COMPOSITES

The thermal conductivity of the boron reinforced aluminum material was higher than for the boron (coated with Silicon carbide) reinforced titanium material due to the higher matrix thermal conductivity. A lower degree of directional anisotropy was observed for the 6Al-4V Titanium/BorSiC materials, which agrees with the thermal expansion results where lower directional anisotropy was also observed for the 6Al-4V Titanium/BorSiC material compared to the 6061 Aluminum/Boron material.

2.2.7.3 Densities

The densities of the metal matrix composites were also determined using gravimetric and leaching processes. These determinations were made to verify the fabricator's stated fiber densities. The average fiber density, from three plates of the 6061 aluminum/boron was 49 %. Similarly the average fiber density, from three determinations of the 6Al-4V-Titanium/BorSiC was 46 %.

2.2.8 Fracture Modes of Metal Matrix Composites

The 0° 6Al-4V-Titanium/BorSiC composites exhibited tensile fracture surfaces which were rough but lay in planes relatively transverse to the load direction. No steplike fractures were evident, as was the case for resin matrix composites, for the baseline data. Similar results were obtained for all levels of steady-state thermal exposure. However those samples which had been cyclically exposed to thermal conditioning showed both delamination and multiple step fractures particularly in the surface plies. The 0° compression failures of all 6Al-4V-Titanium composites were impossible to analyze because of severe crushing, multiple fractures, metal smearing and occasional delamination particularly those tested at elevated temperatures. Interlaminar shear and flexural failure modes at room temperature

appeared to be as is normally encountered for resin matrix composites.

At room temperature the 90° tension fracture in 6Al-4V-Titanium/BorSiC composites appeared similar for the baseline, steady-state thermal and cyclic thermal conditioning. Failures are transverse to the load direction, generally lie in a plane perpendicular to the load direction. There is often a shear lip on one side of the specimen if there was sufficient metal from the cover plates remaining after grinding of the surfaces. Compression failures of the 90° 6Al-4V-titanium/BorSiC composites were flat and lay in a plane always at 45° to the load direction. At room temperature little or no delamination was evident although metal smearing was present and may have hidden this delamination. At elevated temperatures (above 400°F) the failures were quite different. The fracture surfaces were generally out of plane but more perpendicular to the load direction and included some overall out-of-plane curvature to the gage section. This latter phenomenon may indicate buckling of the 90° 6Al-4V-titanium BorSiC composites at elevated temperature due to the combined effects of modulus reduction and some delamination which is partially evident looking at the side of the fractured samples. The prior cyclic thermal conditioning and steady state thermal conditioning did not alter this failure mode.

The 0° 6061 aluminum/boron tension failures at room temperature were closer to those encountered in the corresponding resin matrix tests. The fracture surfaces were very rough, did not lie in a plane and multiple stepping in the fracture patterns was clearly evident. Prior steady state and cyclic thermal conditioning resulted in a higher percentage of failures

close to the ends of the gage section near the tabs. 0° compressive failures of the baseline 6061 aluminum/boron composites at room temperature showed substantial flow present in the gage section, but whether this was encountered prior to failure or just after fracture is not known. Both steady-state and cyclic thermal conditioning caused less flow to be present as judged from post fracture examinations of the broken specimens.

Both baseline and steady state thermal conditioning of the 90° 6061 aluminum/boron composites resulted in fractures exhibiting considerable plastic flow as judged by post-fracture examinations and some curvature to the entire gage section of the sample. However the cyclic thermal conditioning resulted in room temperature compression failures of the 90° 6061 aluminum/boron composites which were generally flat, and at a 45° angle to the load direction. Occasionally some samples showed a double angle meeting at the center plane of the coupon. Tensile failures of the 90° 6061 aluminum/boron composites were similar to the failures of the 6Al-4V-Titanium/BorSiC composites except that many of the specimens exhibited a short (about 10 fiber diameters) steps in the failure surface.

The 6061 aluminum/boron composite fatigue failures were varied. Tensile fatigue ($R = 0.1$) of the 0° coupons appeared to follow the static fracture patterns. The compression fatigue ($R = 1.0$) failures, however, generally were different from the static tests with a short (approximately, 1/16 inch) segment of the 0° coupon broken away from the sample, thus resulting in three pieces after failure. Compression fatigue failure surfaces were normal to the load direction. The fully reversed 6061 aluminum/boron 0° composites frequently fractured into

Four or more pieces with the failure surfaces more like the tensile fatigue, i.e. irregular with some steplike appearance. The 90° 6061 aluminum/boron tensile fatigue ($R = 0.1$) failures contained some fiber failures resulting in a small step of a few fiber diameters on each failure surface. The compressive fatigue failures of the 90° composites frequently resulted in several post fracture pieces. Fully reversed failures were a mixture of these two modes.

The 0° 6Al-4V-titanium/BorSiC composites tested in tensile fatigue showed irregular fracture surfaces but a continuous non-stepped fracture path. The 0° compressive specimens invariably failed at the ends of gage section and considerable damage of the fracture surface took place after the initial fatigue failure. The 0° fully-reversed fractures more closely resembled the tensile fatigue failures. The 90° tensile fatigue failures were flat, planar and perpendicular to the load direction. The compression fatigue fracture surfaces of the 90° 6Al-4V-titanium composites were flat, planar and at 45° to the load direction.

SECTION III

3.0 CONCLUSIONS

In conclusion this program has demonstrated the capabilities of composites in retaining mechanical properties after exposure to various humidity and thermal environments. This data appears at a particularly appropriate time in the evolution of composite technology, when emphasis is being placed on composite reliability and durability. The effectiveness of composites in resisting environmental degradation has been demonstrated.

Several items of particular concern to aerospace designers and test engineers planning to utilize these materials in preliminary or advanced design were established during this program. These items can be summarized as follows:

The boron/epoxy system was particularly sensitive to moisture conditioning and moisture coupled with high/low temperature shocks. The boron/epoxy strengths were affected to a greater degree than were the moduli. Overall the results showed that the properties of the composite which depend largely on the resin constituent properties were affected the greatest. These included interlaminar shear strength, transverse strength and modulus and compressive strengths (the latter would appear to be a result of resin softening by plasticization which increases the tendency toward microbuckling). A somewhat similar properties loss in the transverse compressive strength was also observed for humidity coupled with ultraviolet radiation (accelerated weathering). Long term (high cyclic level) fatigue performance also was affected deleteriously by humidity coupled with thermal shocks.

The high-strength graphite/epoxy system were affected substantially by moisture and moisture/thermal shock conditioning. Again interlaminar shear strength, transverse strength and modulus and compressive strengths all properties sensitive to changes in the resin constituent properties, were affected the greatest.

The high-modulus graphite/epoxy exhibited less deleterious response to moisture than did the boron/epoxy or high strength graphite/epoxy systems. In fact, the presence of residual fabrication stresses in the high-modulus graphite/epoxy system led to some enhancement of the strengths from prior humidity conditioning. However the combined humidity/thermal conditioning radically affected the high-modulus graphite/epoxy transverse strength (losses up to 75%) and fatigue behaviors.

The metal matrix composites exhibited very improved transverse and compressive strength properties over the resin matrix composites. Losses in fatigue strength due to prior thermal conditioning were primarily confined to the transverse direction and were worse for cyclic (thermal) rather than steady-state conditioning.

Upon the introduction of these composite materials into an aerospace component design, the test engineer could obtain a rapid reading on the feasibility of their utilization by an examination of the above properties.

Certain portions of this program have led to other new questions such as the importance and characterization of residual fabrication stresses particularly in the graphite/epoxy systems.

The role of moisture in degrading (or enhancing) the mechanical properties of resin matrix composites is not entirely understood. The complimentary roles of simultaneous heat-cold cycles and ultraviolet are also vague. Although the data appear consistent, the frequently confusing nature of the qualitative and quantitative response implies that, to fully exploit these composites, further study of the fundamental nature of these causative factors would be in order.

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APPENDIX I

DATA SUMMARY FOR AVCO 5505/BORON COMPOSITES

MIT RESEARCH INSTITUTE

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APPENDIX I

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TABLE XII STATIC PROPERTIES
SANDWICH - ALCO
5505/ALUMINUM
COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
0°	Tension	None	RTD	29.6	0.23	183	6422
0°	Tension	None	260°F	28.6	0.21	181	6385
0°	Tension	None	350°F	28.5	0.22	177	6280
90°	Tension	None	RTD	2.69	0.04	8.85	3900
90°	Tension	None	260°F	1.84	0.03	6.56	4800
90°	Tension	None	350°F	1.40	0.03	5.32	7910
[0/45/135/0 (90)] _s	Tension	None	RTD	14.9	0.45	85.1	6280
[0/45/135/0 (90)] _s	Tension	None	260°F	13.9	0.42	82.6	6190
[0/45/13 / 0 (90)] _s	Tension	None	350°F	14.1	0.44	78.9	6190
0°	Compression	None	RTD ^a	31.5	0.49	362	11,270
0°	Compression	None	RTD ^a	26.6	0.20	196	8090
0°	Compression	None	260°F	27.1	0.30	172	6000
0°	Compression	None	350°F ^a	29.4	0.52	285	9530
0°	Compression	None	350°F ^a	29.4	0.17	126	4170
90°	Compression	None	RTD ^a	3.55	0.03	29.3	9620
90°	Compression	None	RTD ^a	3.89	0.0	35.5	13,620
90°	Compression	None	260°F	1.77	0.0	26.8	21,530
90°	Compression	None	350°F ^a	4.05	0.00	23.5	6560
90°	Compression	None	350°F ^a	2.15	0.0	19.9	16,500

^a Sandvich Beam Data

TABLE XII STATIC PROPERTIES
SUMMARY - ALCO
5505 BHRON
(CONT'D)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
[0/45/135/0/90] _s	Compression	None	RTD*	18.2	0.54	236	13,350
[0/45/135/0/90] _s	Compression	None	RTD*	13.5	0.46	178	14,280
[0/45/135/0/90] _s	Compression	None	260°F	13.9	0.45	164	13,430
[0/45/135/0/90] _s	Compression	None	350°F*	16.0	0.52	183	11,990
[0/45/135/0/90] _s	Compression	None	350°F*	13.9	0.44	151	10,790
0°	In-Plane Shear	None	RTD	0.84	-	9.7	26,000
0°	In-Plane Shear	None	260°F	0.50	-	7.1	32,000
0°	In-Plane Shear	None	350°F	0.25	-	4.9	17,000
0°	Int. Shear	None	RTD	-	-	15.2	-
0°	Int. Shear	None	260°F	-	-	12.0	-
0°	Int. Shear	None	350°F	-	-	9.1	-
[0/45/135/0/90] _s	Int. Shear	None	RTD	-	-	10.9	-
[0/45/135/0/90] _s	Int. Shear	None	260°F	-	-	7.9	-
[0/45/135/0/90] _s	Int. Shear	None	350°F	-	-	4.9	-
0°	Flex	None	RTD	-	-	263	-
0°	Flex	None	260°F	-	-	240	-
0°	Flex	None	350°F	-	-	218	-
90°	Flex	None	RTD	-	-	14.0	-
90°	Flex	None	260°F	-	-	12.5	-
90°	Flex	None	350°F	-	-	9.5	-
[0/45/135/0/90] _s	Flex	None	RTD	-	-	107	-
[0/45/135/0/90] _s	Flex	None	260°F	-	-	101	-
[0/45/135/0/90] _s	Flex	None	350°F	-	-	93	-

AD E 511 STANDARD SPECIFICATIONS
STANDARD - A-170
FOR RUBBER
COMPRESSION SPECIMENS

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in./in.)	σ_{ult} (ksi)	ϵ_{ult} (in.-in./in.)
0°	Tension	98% RH/500 Hrs.	RTD	28.7	0.20	147	5670
0°	Tension	98% RH/500 Hrs.	260°F	-	-	177	5670
0°	Tension	98% RH/500 Hrs.	350°F	-	-	144	-
0°	Tension	98% RH/1000 Hrs.	RTD	29.4	0.21	153	5960
0°	Tension	98% RH/1000 Hrs.	260°F	30.3	0.21	163	5540
0°	Tension	95% RH/1000 Hrs.	350°F	-	-	-	-
0°	Tension	Thermo-Humidity Cycle	RTD	29.6	0.17	188	6360
0°	Tension	Thermo-Humidity Cycle	260°F	-	-	158	-
0°	Tension	Thermo-Humidity Cycle	350°F	-	-	120	-
0°	Tension	Acc. Wthrg.	RTD	29.6	0.17	190	6710
0°	Tension	Acc. Wthrg.	260°F	30.7	0.27	157	4400
0°	Tension	Acc. Wthrg.	350°F	30.1	0.22	146	4880
90°	Tension	98% RH/500 Hrs.	RTD	2.58	0.01	7.8	3330
90°	Tension	98% RH/500 Hrs.	260°F	-	-	5.6	-
90°	Tension	98% RH/500 Hrs.	350°F	-	-	4.4	-
90°	Tension	98% RH/1000 Hrs.	RTD	2.55	0.02	7.6	3430
90°	Tension	98% RH/1000 Hrs.	260°F	1.56	0.01	6.4	4830
90°	Tension	98% RH/1000 Hrs.	350°F	1.06	0.00	4.8	6750
90°	Tension	Thermo-Humidity Cycle	RTD	2.18	0.0	6.9	3720
90°	Tension	Thermo-Humidity Cycle	260°F	-	-	5.4	-
90°	Tension	Thermo-Humidity Cycle	350°F	-	-	3.4	-

APP. A11 STATIC PROPERTIES
SPENNAR - AVCO
5505/BORON
COMPOSITES (cont'd)

Orientation	Test Load	Test Method	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	E_{ult} (ksi)	E_{ult} (psi x 10 ⁶)
90°	Tension	Acc. Wthrg	RTD	2.59	0.00	7.8	3490
90°	Tension	Acc. Wthrg	260°F	1.32	0.02	4.0	5980
90°	Tension	Acc. Wthrg	350°F	0.51	0.01	2.9	6340
0/45/135/0/90° s	Tension	98% RH/500 Hrs.	RTD	16.0	0.43	84	6060
0/45/135/0/90° s	Tension	98% RH/500 Hrs.	260°F	-	-	-	-
0/45/135/0/90° s	Tension	98% RH/500 Hrs.	350°F	-	-	69	-
0/45/135/0/90° s	Tension	98% RH/1000 Hrs.	RTD	15.4	0.44	86	6070
0/45/135/0/90° s	Tension	98% RH/1000 Hrs.	260°F	15.7	0.48	77	5820
0/45/135/0/90° s	Tension	98% RH/1000 Hrs.	350°F	14.1	0.38	74	5920
0/45/135/0/90° s	Tension	98% RH/1000 Hrs.	RTD	15.2	0.60	72	5070
0/45/135/0/90° s	Tension	Thermo-Humidity Cycle	260°F	-	-	81	-
0/45/135/0/90° s	Tension	Thermo-Humidity Cycle	350°F	-	-	68	-
0/45/135/0/90° s	Tension	Thermo-Humidity Cycle	RTD	16.3	0.42	88	5830
0/45/135/0/90° s	Tension	Acc. Wthrg	260°F	16.1	0.43	74	5020
0/45/135/0/90° s	Tension	Acc. Wthrg	350°F	15.4	0.56	68	4980

Orientation	Type Load	Plant Conditioning	Test Temp. (°F)	P (psi)	v (in ³ /in)	Stress (ksi)	Stress (ksi-in./in.)
0°	Compression	92% RH/100 Hrs.	RTD	26.8	0.23	199	8940
0°	Compression	72% RH/500 Hrs.	260°F	-	-	150	-
0°	Compression	92% RH/500 Hrs.	350°F	-	-	159	-
0°	Compression	92% RH/1000 Hrs.	RTD	25.7	0.17	186	8290
0°	Compression	92% RH/1000 Hrs.	260°F	29.5	0.25	129	4480
0°	Compression	92% RH/1000 Hrs.	350°F	27.5	0.14	106	4560
0°	Compression	Thermo-Humidity Cycle	RTD	25.8	0.15	207	8110
0°	Compression	Thermo-Humidity Cycle	260°F	-	-	119	-
0°	Compression	Thermo-Humidity Cycle	350°F	-	-	93	-
0°	Compression	Acc. Weibull	RTD	30.2	0.24	179	6790
0°	Compression	Acc. Weibull	260°F	26.1	0.28	123	4500
0°	Compression	Acc. Weibull	350°F	28.2	0.15	72	2560
90°	Compression	92% RH/500 Hrs.	RTD	2.39	0.0	33.2	17,580
90°	Compression	92% RH/500 Hrs.	260°F	-	-	18.9	-
90°	Compression	92% RH/500 Hrs.	350°F	-	-	15.0	-
90°	Compression	92% RH/1000 Hrs.	RTD	-	-	28.5	-
90°	Compression	92% RH/1000 Hrs.	260°F	1.75	0.0	17.9	21,980
90°	Compression	92% RH/1000 Hrs.	350°F	0.64	0.0	8.9	16,840
90°	Compression	Thermo-Humidity Cycle	RTD	2.33	0.01	30.4	17,630
90°	Compression	Thermo-Humidity Cycle	260°F	-	-	18.2	-
90°	Compression	Thermo-Humidity Cycle	350°F	-	-	11.4	-

Calculation	Tip Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	Δ (in/in)	T _{ult} (ksi)	E _{ult} (Δ-in./in.)
90°	Compression	Acc. Wthrg	RTD	2.45	0.0	33.0	15,340
90°	Compression	Acc. Wthrg	260°F	1.33	0.0	20.0	21,620
90°	Compression	Acc. Wthrg	350°F	0.93	0.0	10.5	19,650
0 45/135/0/90° s	Compression	96 RH/500 Hrs.	RTD	14.3	0.50	169	13,160
0 45/135/0/90° s	Compression	98% RH/500 Hrs.	350°F	-	-	96	-
0 45/135/0/90° s	Compression	98 RH/500 Hrs.	350°F	-	-	90	-
0 45/135/0/90° s	Compression	98% RH/1000 Hrs.	RTD	14.4	0.41	157	9670
0 45/135/0/90° s	Compression	98% RH/1000 Hrs.	260°F	14.0	0.54	86	6250
0 45/135/0/90° s	Compression	98% RH/1000 Hrs.	350°F	13.7	0.57	79	6000
0 45/135/0/90° s	Compression	Thermo-Humidity Cycle	RTD	14.8	0.50	169	10,360
0 45/135/0/90° s	Compression	Thermo-Humidity Cycle	260°F	-	-	92	-
0 45/135/0/90° s	Compression	Thermo-Humidity Cycle	350°F	-	-	78	-
0 45/135/0/90° s	Compression	Acc. Wthrg	RTD	15.4	0.50	171	13,160
0 45/135/0/90° s	Compression	Acc. Wthrg	260°F	13.3	0.57	100	7360
0 45/135/0/90° s	Compression	Acc. Wthrg	350°F	13.0	0.51	76	6320
0°	Ir-Plane Shear	98% RH/500 Hrs.	RTD	0.86	-	9.7	30,000
0°	Ir-Plane Shear	98% RH/500 Hrs.	260°F	-	-	5.4	-
0°	Ir-Plane Shear	98% RH/500 Hrs.	350°F	-	-	4.5	-
0°	Ir-Plane Shear	98% RH/1000 Hrs.	RTD	0.79	-	9.5	30,000 ^a
0°	Ir-Plane Shear	98% RH/1000 Hrs.	260°F	0.41	-	6.0	30,000
0°	Ir-Plane Shear	98% RH/1000 Hrs.	350°F	0.28	-	5.2	30,000

TABLE III STATIC PROPERTIES
SUMMARY - AVCO
3503/40RIN
COMPOSITES (cont'd)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksf)	ϵ_{ult} (in/in./in.)
0°	In-Plane Shear	Thermo-Humidity Cycle	RTD	0.74	-	9.1	30,000
0°	In-Plane Shear	Thermo-Humidity Cycle	260°F	-	-	5.1	-
0°	In-Plane Shear	Thermo-Humidity Cycle	350°F	-	-	3.8	-
0°	In-Plane Shear	Acc. Wehring	RTD	0.72	-	9.4	30,000
0°	In-Plane Shear	Acc. Wehring	260°F	0.25	-	5.0	30,000
0°	In-Plane Shear	Acc. Wehring	350°F	0.11	-	3.6	30,000
0°	Int. Shear	98% RH/500 Hrs.	RTD	-	-	14.6	-
0°	Int. Shear	98% RH/500 Hrs.	260°F	-	-	9.5	-
0°	Int. Shear	98% RH/500 Hrs.	350°F	-	-	6.0	-
0°	Int. Shear	98% RH/1000 Hrs.	RTD	-	-	14.3	-
0°	Int. Shear	98% RH/1000 Hrs.	260°F	-	-	9.1	-
0°	Int. Shear	98% RH/1000 Hrs.	350°F	-	-	5.9	-
0°	Int. Shear	Thermo-Humidity Cycle	RTD	-	-	12.0	-
0°	Int. Shear	Thermo-Humidity Cycle	260°F	-	-	9.2	-
0°	Int. Shear	Thermo-Humidity Cycle	350°F	-	-	6.1	-
0°	Int. Shear	Acc. Wehring	RTD	-	-	12.5	-
0°	Int. Shear	Acc. Wehring	260°F	-	-	9.5	-
0°	Int. Shear	Acc. Wehring	350°F	-	-	5.9	-

TABLE XII STATIC PROPERTIES
SUMMARY - AVCO
5505/BORON
COMPOSITES (Cont'd)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
0°	Tension	260°F/100 Hrs.	RTD	-	-	182	-
0°	Tension	260°F/100 Hrs.	260°F	-	-	152	-
0°	Tension	260°F/500 Hrs.	RTD	29.4	0.18	188	6530
0°	Tension	260°F/500 Hrs.	260°F	28.5	0.19	169	6210
0°	Tension	350°F/100 Hrs.	RTD	-	-	180	-
0°	Tension	350°F/100 Hrs.	260°F	29.0	0.16	177	6180
0°	Tension	350°F/100 Hrs.	350°F	30.2	0.13	164	5000
0°	Tension	350°F/500 Hrs.	RTD	29.3	0.19	190	6870
0°	Tension	350°F/500 Hrs.	350°F	31.2	0.13	174	6040
90°	Tension	260°F/100 Hrs.	RTD	-	-	8.0	-
90°	Tension	260°F/100 Hrs.	260°F	-	-	7.2	-
90°	Tension	260°F/500 Hrs.	RTD	2.75	0.3	8.7	3440
90°	Tension	260°F/500 Hrs.	260°F	1.84	0.0	7.1	4330
90°	Tension	350°F/100 Hrs.	RTD	-	-	7.6	-
90°	Tension	350°F/100 Hrs.	260°F	-	-	6.7	-
90°	Tension	350°F/100 Hrs.	350°F	-	-	6.9	-

TABLE XII
STATIC PROPERTIES
SUMMARY - AVCO
3305/BOKOR
(CONT'D)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in./in.)	σ_{ult} (ksi)	ϵ_{ult} (in.-in./in.)
90°	Tension	350°F/500 Hrs.	RTD	3.21	0.0	7.3	2560
90°	Tension	350°F/500 Hrs.	350°F	1.44	0.01	5.6	5140
[0/45/135/0/90]	Tension	260°F/100 Hrs.	RTD	-	-	86	-
[0/45/135/0/90]	Tension	260°F/100 Hrs.	260°F	-	-	87	-
[0/45/135/0/90]	Tension	260°F/500 Hrs.	RTD	16.5	0.45	84	5770
[0/45/135/0/90]	Tension	260°F/500 Hrs.	260°F	15.2	0.48	84	6000
[0/45/135/0/90]	Tension	350°F/100 Hrs.	RTD	-	-	75	-
[0/45/135/0/90]	Tension	350°F/100 Hrs.	260°F	-	-	83	-
[0/45/135/0/90]	Tension	350°F/100 Hrs.	350°F	-	-	79	-
[0/45/135/0/90]	Tension	350°F/500 Hrs.	RTD	15.1	0.43	79	5820
[0/45/135/0/90]	Tension	350°F/500 Hrs.	350°F	16.1	0.43	81	5660
0°	Compression	260°F/100 Hrs.	RTD	-	-	207	-
0°	Compression	260°F/100 Hrs.	260°F	-	-	183	-
0°	Compression	260°F/500 Hrs.	RTD	27.8	0.20	213	8640
0°	Compression	260°F/500 Hrs.	260°F	29.3	-	195	6710
0°	Compression	350°F/100 Hrs.	RTD	27.0	0.18	238	9190
0°	Compression	350°F/100 Hrs.	350°F	-	-	149	-
0°	Compression	350°F/500 Hrs.	RTD	30.6	0.20	232	8390
0°	Compression	350°F/500 Hrs.	350°F	26.9	0.24	172	7110

TABLE XII STATIC PROPERTIES
SUMMARY - AVCO
5505/BORON
COMPOSITES (Cont'd)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	v (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
90°	Compression	260°F/100 Hrs.	RTD	-	-	33.2	-
90°	Compression	260°F/100 Hrs.	260°F	-	-	23.7	-
90°	Compression	260°F/500 Hrs.	RTD	2.57	0.0	37.2	16,830
90°	Compression	260°F/500 Hrs.	260°F	2.40	0.01	25.2	19,350
90°	Compression	350°F/100 Hrs.	RTD	-	-	33.6	-
90°	Compression	350°F/100 Hrs.	350°F	-	-	18.1	-
90°	Compression	350°F/500 Hrs.	RTD	2.50	0.0	29.3	13,550
90°	Compression	350°F/500 Hrs.	350°F	2.05	0.0	17.9	17,370
90°	Compression	260°F/100 Hrs.	RTD	-	-	194	-
0/45/135/0/90° _s	Compression	260°F/100 Hrs.	260°F	-	-	137	-
0/45/135/0/90° _s	Compression	260°F/500 Hrs.	RTD	13.3	0.51	186	12,760
0/45/135/0/90° _s	Compression	260°F/500 Hrs.	260°F	13.6	0.51	144	11,390
0/45/135/0/90° _s	Compression	350°F/100 Hrs.	RTD	-	-	190	-
0/45/135/0/90° _s	Compression	350°F/100 Hrs.	350°F	-	-	93	-
0/45/135/0/90° _s	Compression	350°F/500 Hrs.	RTD	14.1	0.44	191	13,850
0/45/135/0/90° _s	Compression	350°F/500 Hrs.	350°F	12.9	0.38	128	9690

TABLE XII STATIC PROPERTIES
SUMMARY - AVCO
5505/BORON
COMPOSITES (Cont'd)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksf)	ϵ_{ult} (μ -in./in.)
0°	In-Plane Shear	260°F/100 Hrs.	RTD	-	-	9.9	-
0°	In-Plane Shear	260°F/100 Hrs.	260°F	-	-	7.1	-
0°	In-Plane Shear	260°F/500 Hrs.	RTD	0.77	-	9.8	24,000
0°	In-Plane Shear	260°F/500 Hrs.	260°F	0.54	-	7.4	30,030
0°	In-Plane Shear	260°F/100 Hrs.	RTD	-	-	9.2	-
0°	In-Plane Shear	260°F/100 Hrs.	260°F	-	-	8.0	-
0°	In-Plane Shear	330°F/500 Hrs.	RTD	0.79	-	9.1	21,870
0°	In-Plane Shear	330°F/500 Hrs.	330°F	0.42	-	5.6	30,030
0°	Int. Shear	260°F/100 Hrs.	RTD	-	-	16.7	-
0°	Int. Shear	260°F/100 Hrs.	260°F	-	-	14.6	-
0°	Int. Shear	260°F/500 Hrs.	RTD	-	-	15.1	-
0°	Int. Shear	260°F/500 Hrs.	260°F	-	-	14.3	-
0°	Int. Shear	330°F/100 Hrs.	RTD	-	-	15.4	-
0°	Int. Shear	330°F/100 Hrs.	260°F	-	-	13.8	-
0°	Int. Shear	330°F/500 Hrs.	RTD	-	-	15.3	-
0°	Int. Shear	330°F/500 Hrs.	330°F	-	-	11.0	-

TABLE XII STATIC PROPERTIES
SUMMARY - AVCO
5505 BORON
COMPOSITES (Cont'd)

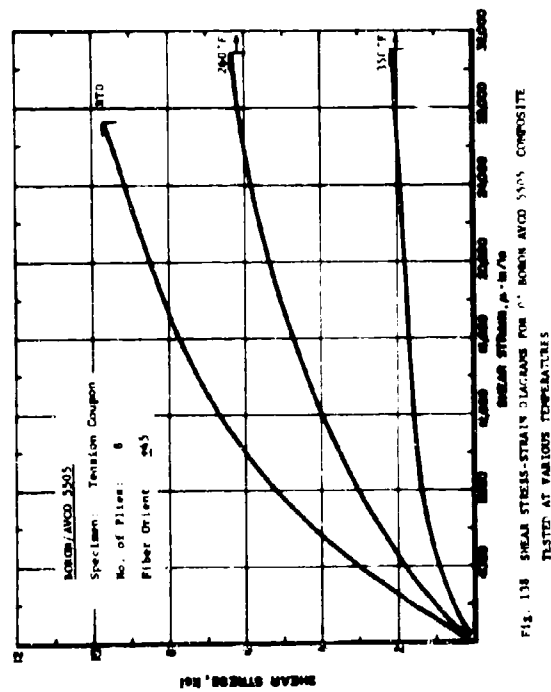
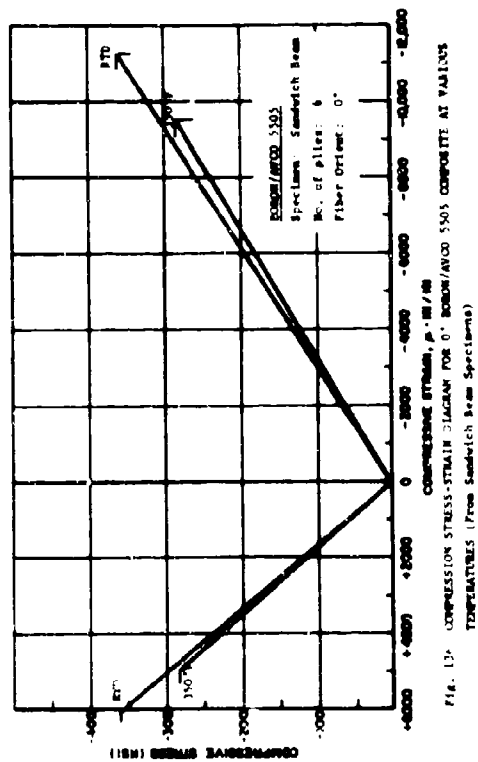
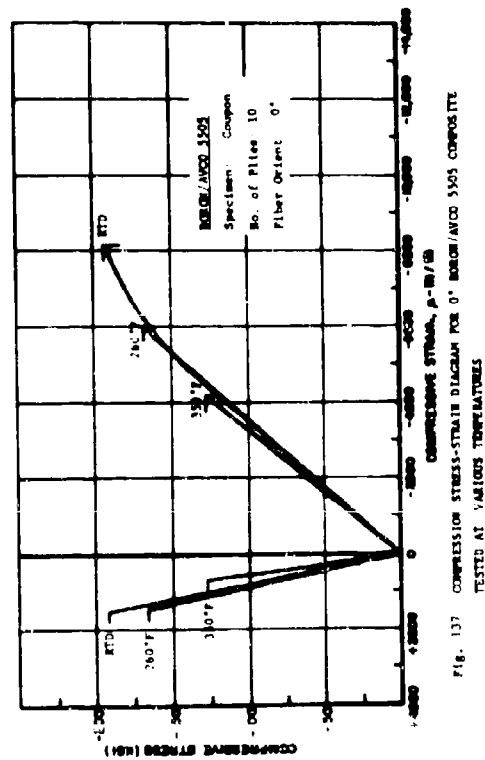
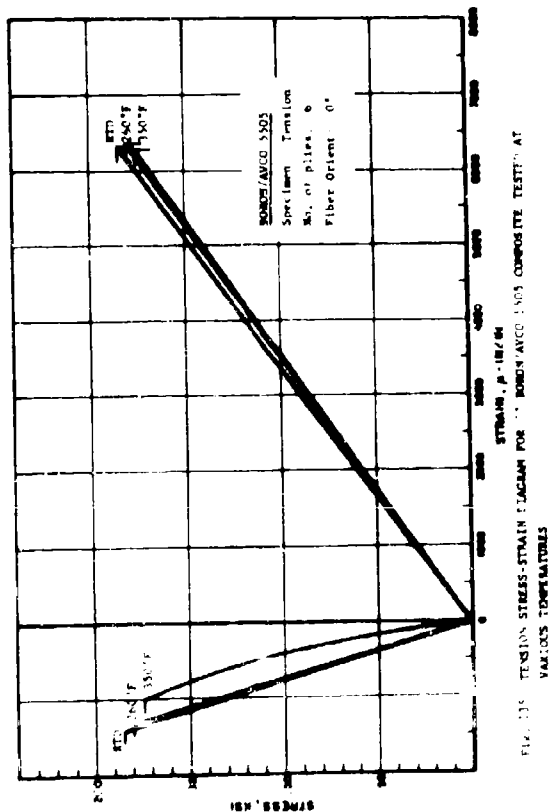
Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
0°	Tension	260°F/500 Cy.	RTD	-	-	186	-
0°	Tension	260°F/500 Cy.	260°F	-	-	160	-
0°	Tension	260°F/1000 Cy.	RTD	28.1	0.18	146	5460
0°	Tension	260°F/1000 Cy.	260°F	29.4	0.18	175	6010
0°	Tension	350°F/500 Cy.	RTD	-	-	189	-
0°	Tension	350°F/500 Cy.	260°F	-	-	174	-
0°	Tension	350°F/500 Cy.	350°F	-	-	172	-
0°	Tension	350°F/1000 Cy.	RTD	26.9	0.19	169	6290
0°	Tension	350°F/1000 Cy.	350°F	36.2	0.15	141	5540
90°	Tension	260°F/500 Cy.	RTD	-	-	7.9	-
90°	Tension	260°F/500 Cy.	260°F	-	-	6.7	-
90°	Tension	260°F/1000 Cy.	RTD	2.79	0.0	8.5	3410
90°	Tension	260°F/1000 Cy.	260°F	1.78	0.03	6.6	4300
90°	Tension	350°F/500 Cy.	RTD	-	-	8.4	-
90°	Tension	350°F/500 Cy.	260°F	-	-	6.9	-
90°	Tension	350°F/500 Cy.	350°F	-	-	6.3	-
90°	Tension	350°F/1000 Cy.	RTD	2.26	0.0	7.7	3150
90°	Tension	350°F/1000 Cy.	350°F	1.48	0.0	4.6	8000

TABLE VII
STATISTICAL DATA
TENSILE - VIDEO
5000 PSI
CROSS SECTION (in.²)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ϵ (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
[C/45/135/0/135]	Tension	260°F/500 Cy.	RTD	-	-	92	-
[C/45/135/0/135]	Tension	260°F/500 Cy.	260°F	-	-	82	-
[C/45/135/0/135]	Tension	260°F/1000 Cy.	RTD	14.7	0.40	86	6070
[C/45/135/0/135]	Tension	260°F/1000 Cy.	260°F	14.7	0.40	86	6070
[C/45/135/0/135]	Tension	350°F/500 Cy.	RTD	-	-	91	-
[C/45/135/0/135]	Tension	350°F/500 Cy.	260°F	-	-	80	-
[C/45/135/0/135]	Tension	350°F/500 Cy.	350°F	-	-	77	-
[C/45/135/0/135]	Tension	350°F/1000 Cy.	RTD	15.5	0.41	85	6110
[C/45/135/0/135]	Tension	350°F/1000 Cy.	350°F	15.6	0.43	62	4010
[C/45/135/0/135]	Tension	350°F/1000 Cy.	RTD	-	-	208	-
[C/45/135/0/135]	Compression	260°F/500 Cy.	260°F	-	-	199	-
[C/45/135/0/135]	Compression	260°F/1000 Cy.	RTD	25.5	0.19	215	8920
[C/45/135/0/135]	Compression	260°F/1000 Cy.	260°F	27.0	0.23	196	7360
[C/45/135/0/135]	Compression	350°F/500 Cy.	RTD	-	-	202	-
[C/45/135/0/135]	Compression	350°F/500 Cy.	350°F	-	-	149	-
[C/45/135/0/135]	Compression	350°F/1000 Cy.	RTD	30.3	0.20	231	8750
[C/45/135/0/135]	Compression	350°F/1000 Cy.	350°F	25.4	0.28	149	5670

TABLE XII
STATIC PROPERTIES
SUMMARY - AVCO
3305/BONOM
COMPOSITES (Cont'd)

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	σ_{ult} (ksi-in./in.)
90°	Compression	260°F/500 Gy.	RTD	-	-	34.1	-
90°	Compression	260°F/500 Gy.	260°F	-	-	24.7	-
90°	Compression	260°F/1000 Gy.	RTD	2.22	0.01	34.8	20,000
90°	Compression	260°F/1000 Gy.	260°F	2.57	0.01	25.6	10,980
90°	Compression	350°F/500 Gy.	RTD	-	-	34.3	-
90°	Compression	350°F/500 Gy.	350°F	-	-	17.9	-
90°	Compression	350°F/1000 Gy.	RTD	2.87	0.01	27.7	12,830
90°	Compression	350°F/1000 Gy.	350°F	1.30	0.0	16.3	12,360
[0/45/135/0/90] _g	Compression	260°F/500 Gy.	RTD	-	-	187	-
[0/45/135/0/90] _g	Compression	260°F/500 Gy.	260°F	-	-	142	-
[0/45/135/0/90] _g	Compression	260°F/1000 Gy.	RTD	13.3	0.44	184	14,330
[0/45/135/0/90] _g	Compression	260°F/1000 Gy.	260°F	13.2	0.37	156	12,600
[0/45/135/0/90] _g	Compression	350°F/500 Gy.	RTD	-	-	189	-
[0/45/135/0/90] _g	Compression	350°F/500 Gy.	350°F	-	-	82	-
[0/45/135/0/90] _g	Compression	350°F/1000 Gy.	RTD	15.5	0.49	199	15,140
[0/45/135/0/90] _g	Compression	350°F/1000 Gy.	350°F	11.9	0.53	128	11,830



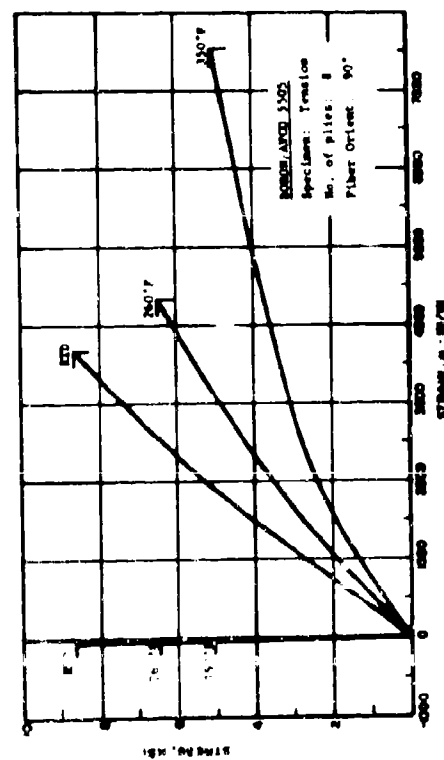


Fig. 1.1 TENSION STRESS-STRAIN DIAGRAM FOR 90° BMD/AMC 550 COMPOSITE, TESTED AT VARIOUS TEMPERATURES

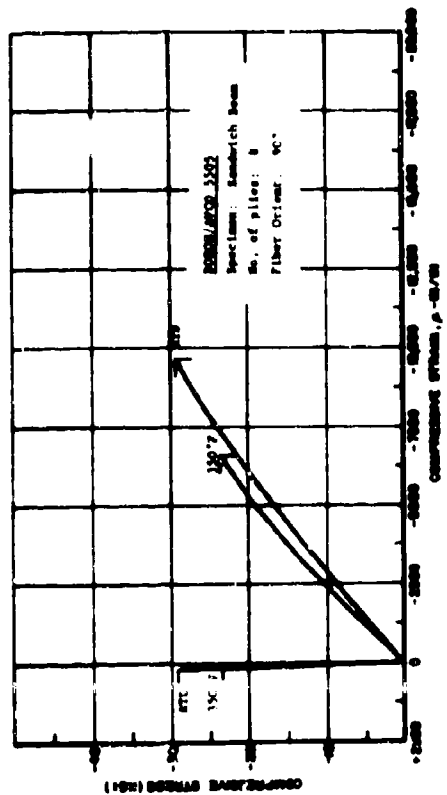


Fig. 1.2 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° BMD/AMC 550 COMPOSITE, TESTED AT VARIOUS TEMPERATURES

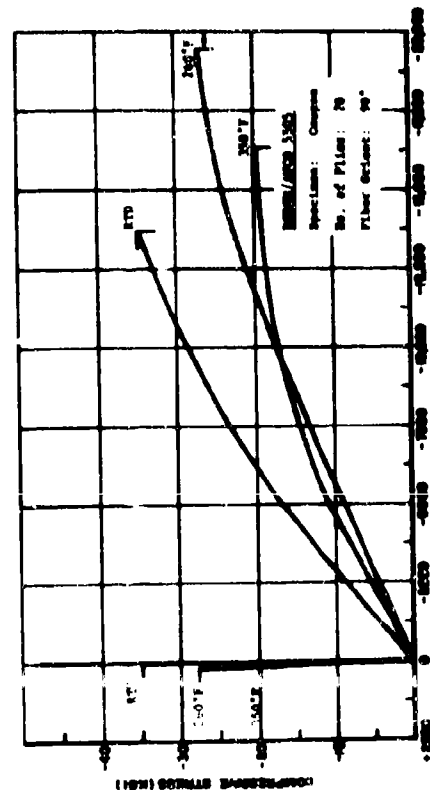


Fig. 1.3 TENSION STRESS-STRAIN DIAGRAM FOR 0/45/135/0 BMD/AMC 550 COMPOSITE, TESTED AT VARIOUS TEMPERATURES

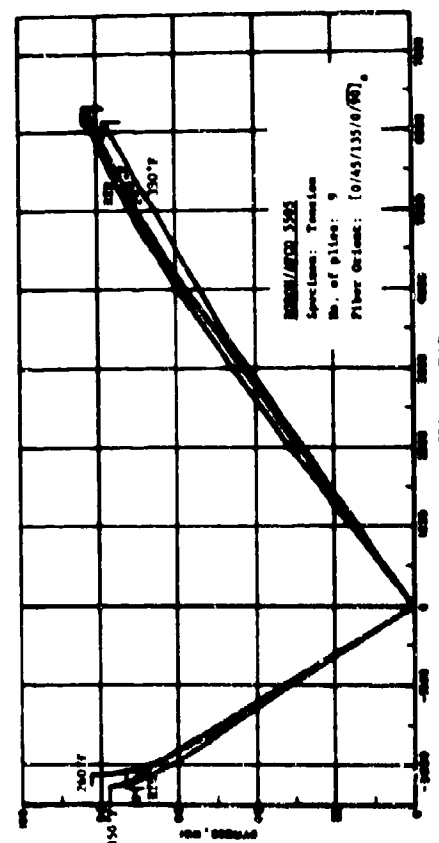


Fig. 1.4 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0/45/135/0 BMD/AMC 550 COMPOSITE, TESTED AT VARIOUS TEMPERATURES

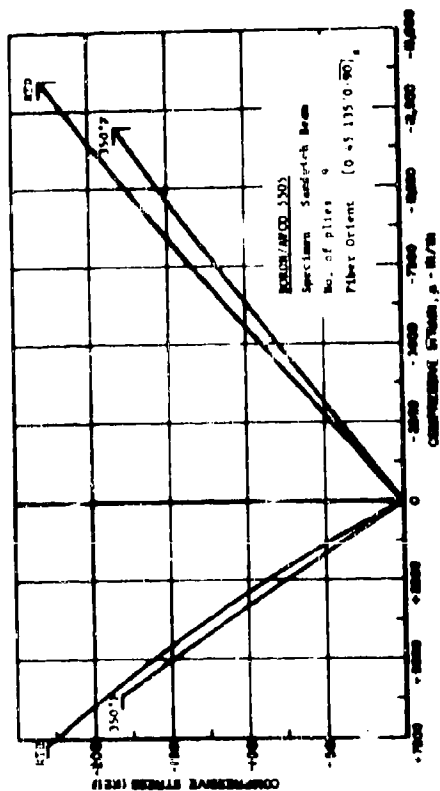


Fig. 143 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° BORDI/AFCD 5505 LAMINATE AT VARIOUS TEMPERATURES (Py = Sandwich Beam Specimens)

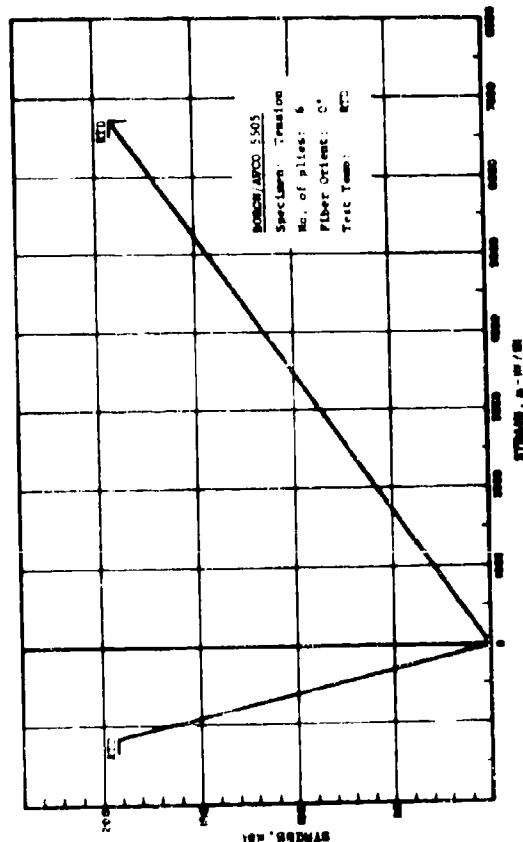


Fig. 145 TENSION STRESS-STRAIN DIAGRAM FOR 0° BORDI/AFCD 5505 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 90% R.H.

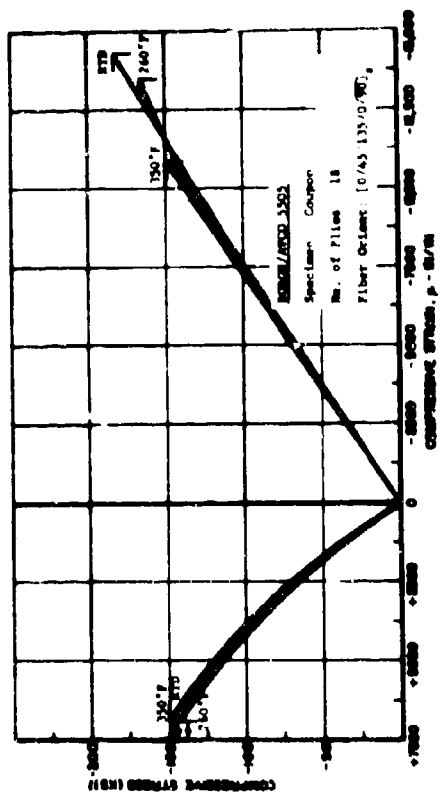


Fig. 146 TENSION STRESS-STRAIN DIAGRAM FOR 0° BORDI/AFCD 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

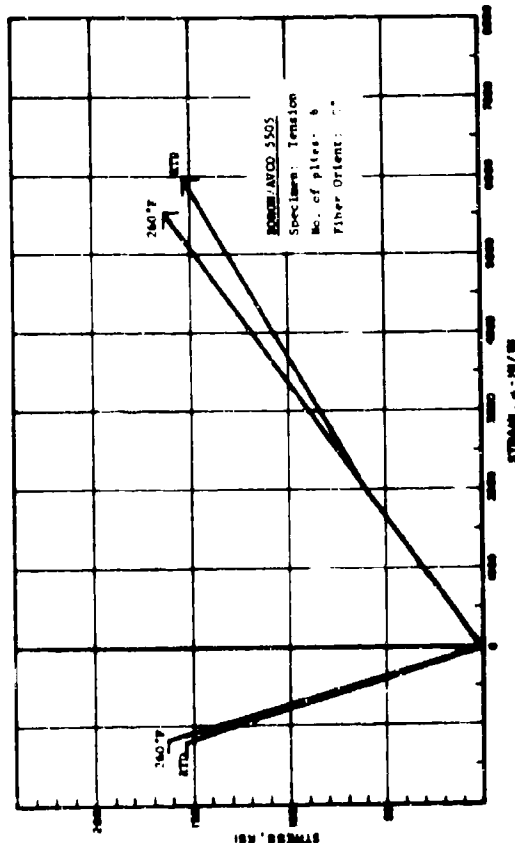


Fig. 146 TENSION STRESS-STRAIN DIAGRAM FOR 0° BORDI/AFCD 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

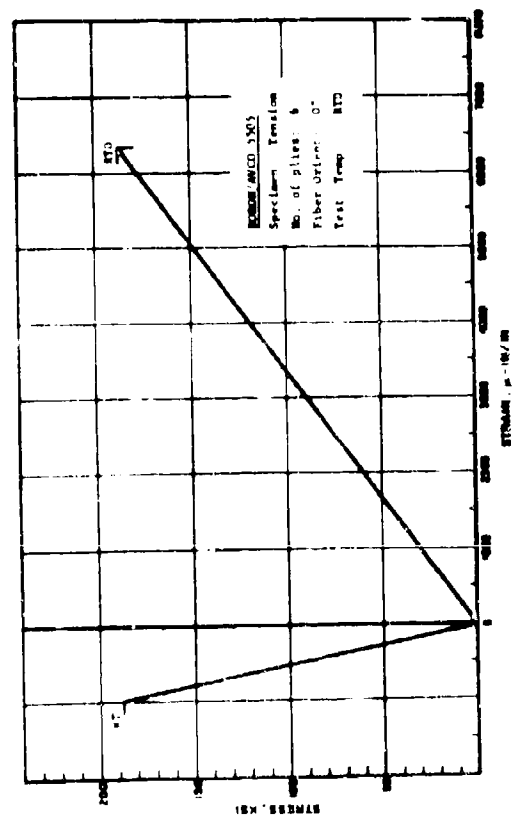


FIG. 147 T-S10 STRESS-STRAIN DIAGRAM FOR Kevlar/Aramid 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle)

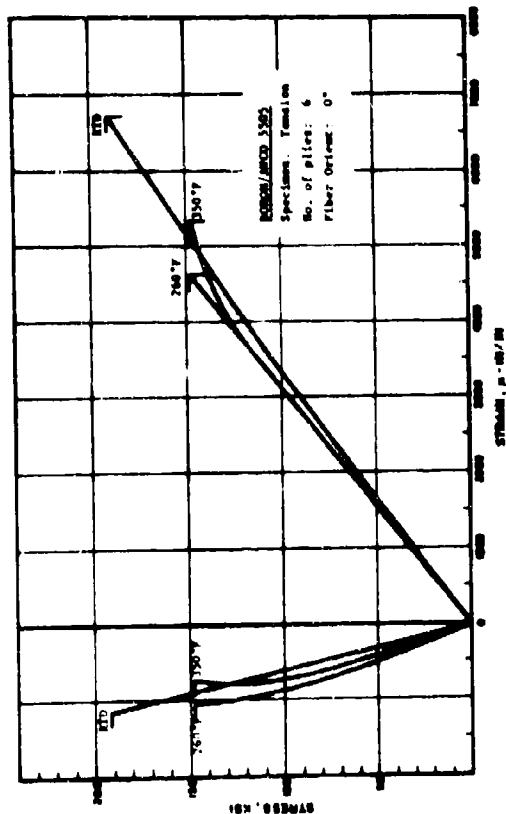


FIG. 148 T-S10 STRESS-STRAIN DIAGRAM FOR Kevlar/Aramid 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

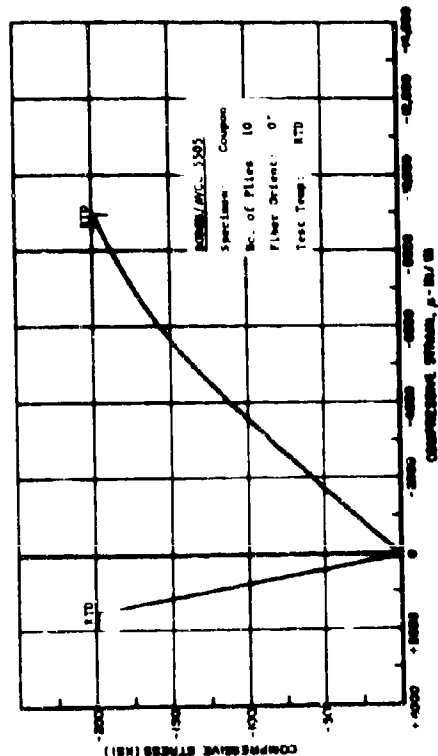


FIG. 149 COMPRESSION STRESS-STRAIN DIAGRAM FOR Kevlar/Aramid 5505 COMPOSITE TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 90% R.H.

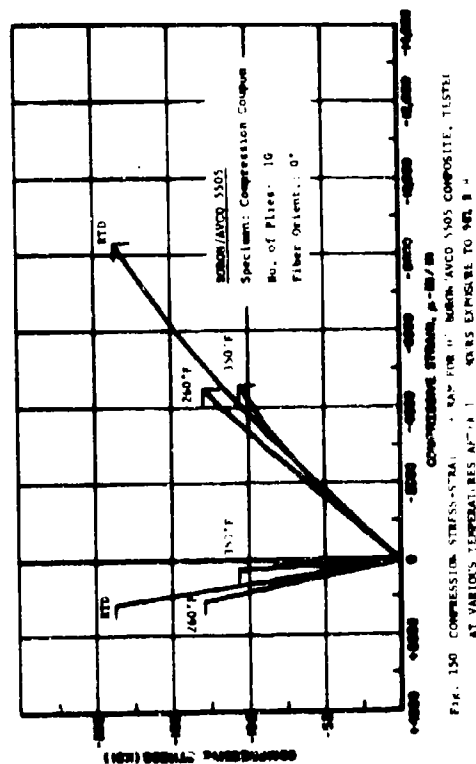


FIG. 150 COMPRESSION STRESS-STRAIN DIAGRAM FOR Kevlar/Aramid 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 90% R.H.

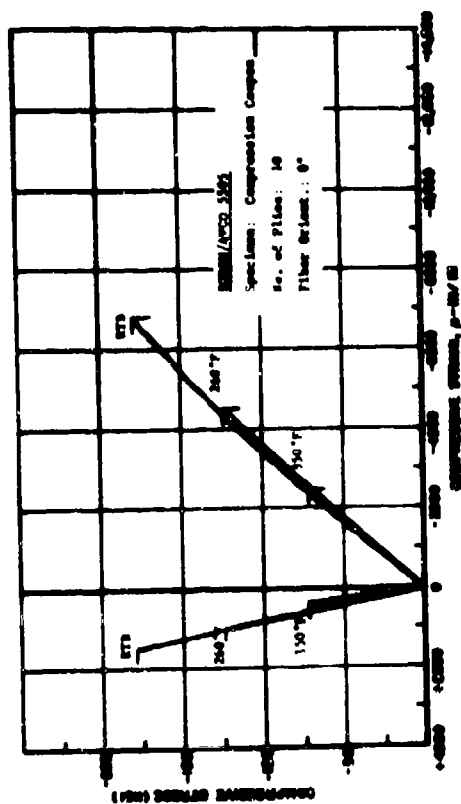


FIG. 132 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° BODIR/AMCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (ACCELERATED WEATHERING).

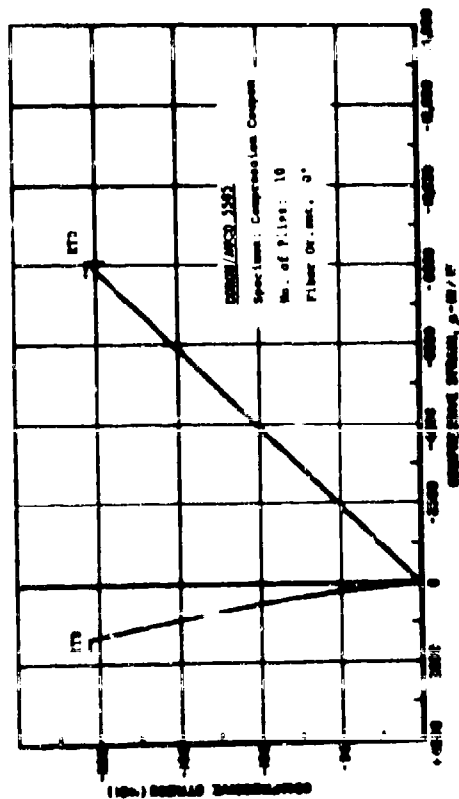


FIG. 133 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° BODIR/AMCO 5505 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER F/P-S-RE TO HUMIDITY CYCLE NO. 1 (Therm-Humidity Cycle)

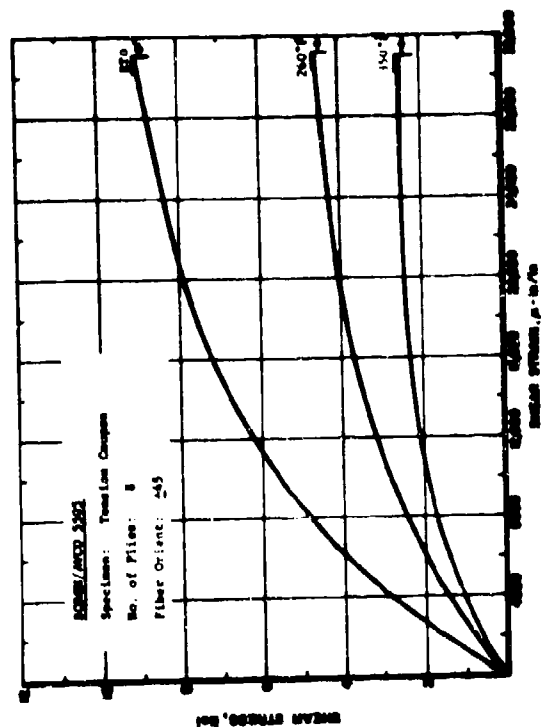


FIG. 134 5-BAR STRESS-STRAIN DIAGRAM FOR 0° BODIR/AMCO 5505 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 40% R.H.

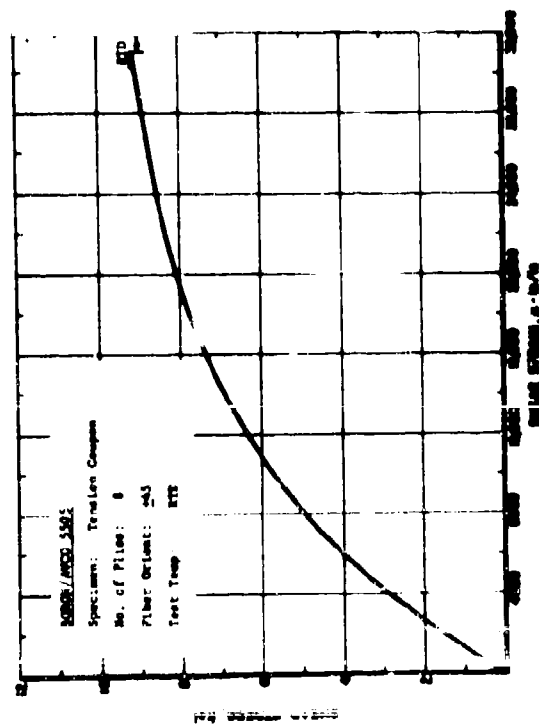


FIG. 135 5-BAR STRESS-STRAIN DIAGRAM FOR 0° BODIR/AMCO 5505 LAMINATE TESTED AT ROOM TEMPERATURE AFTER 550 HOURS EXPOSURE TO 40% R.H.

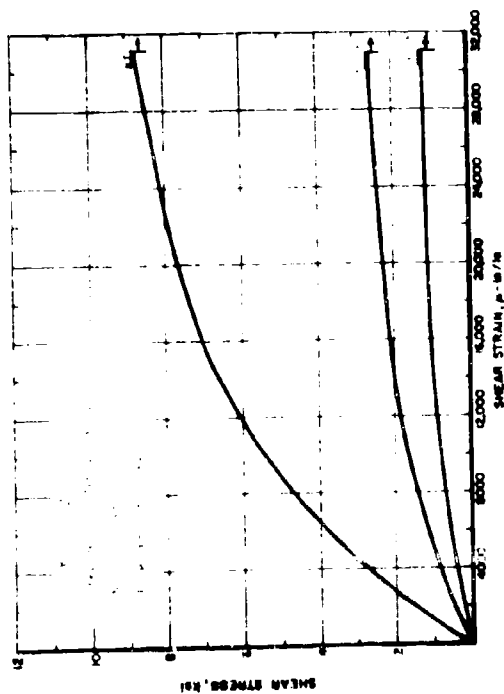


FIG. 124. TENSION-STRESS-STRAIN FOR Kevlar 49/epoxy COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 70 °F.

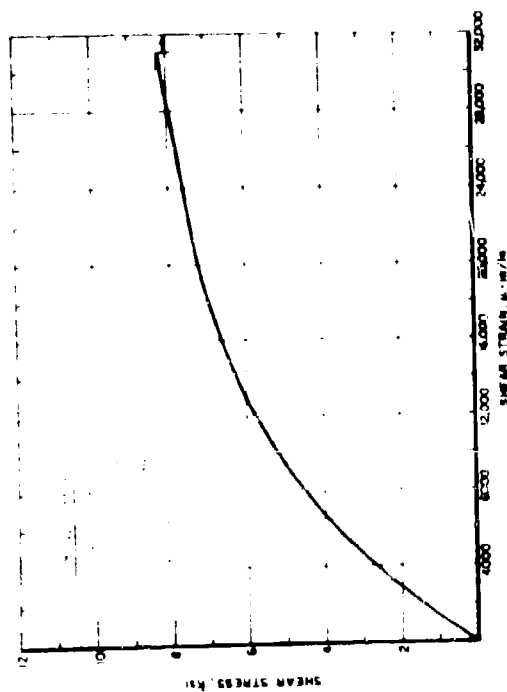


FIG. 125. TENSION-STRESS-STRAIN FOR Kevlar 49/epoxy COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 2000 HOURS EXPOSURE TO 70 °F.

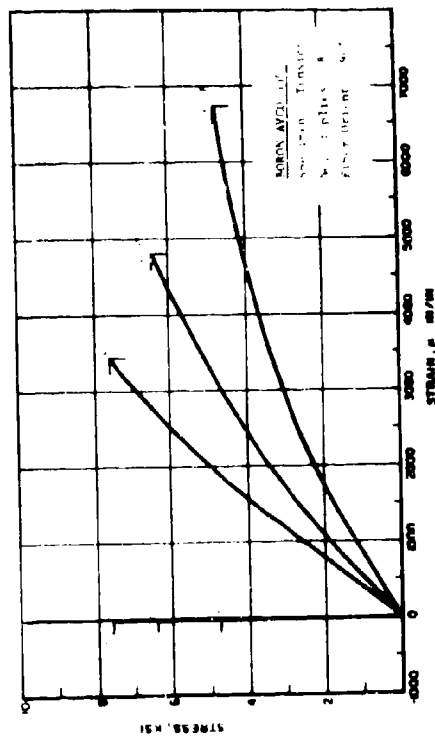


FIG. 126. TENSION-STRESS-STRAIN FOR Kevlar 49/epoxy COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 3000 HOURS EXPOSURE TO 70 °F.

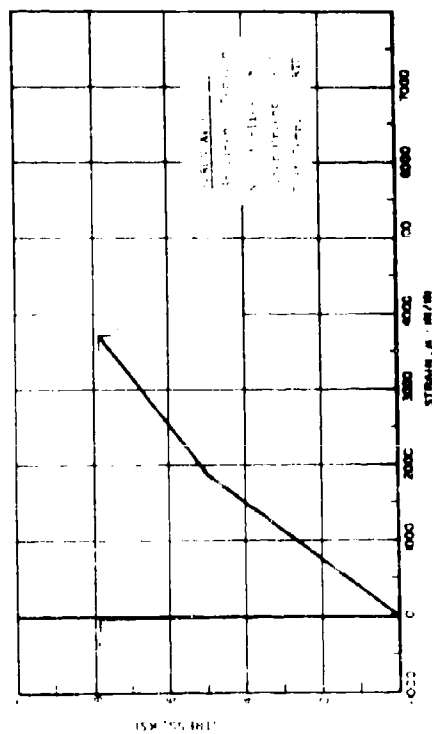


FIG. 127. TENSION-STRESS-STRAIN FOR Kevlar 49/epoxy COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 4000 HOURS EXPOSURE TO 70 °F.

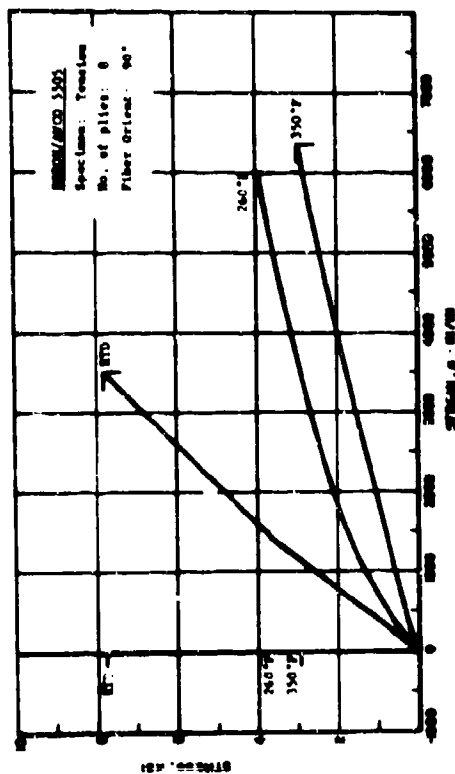


FIG. 159 TENSION STRESS-STRAIN DIAGRAM FOR 90° Kevlar/ARCO 5505 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle)

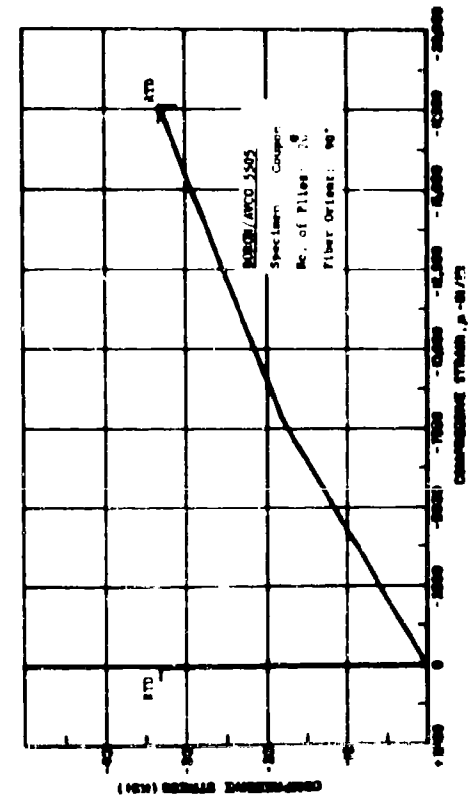


FIG. 161 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° Kevlar/ARCO 5505 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 90% R.H.

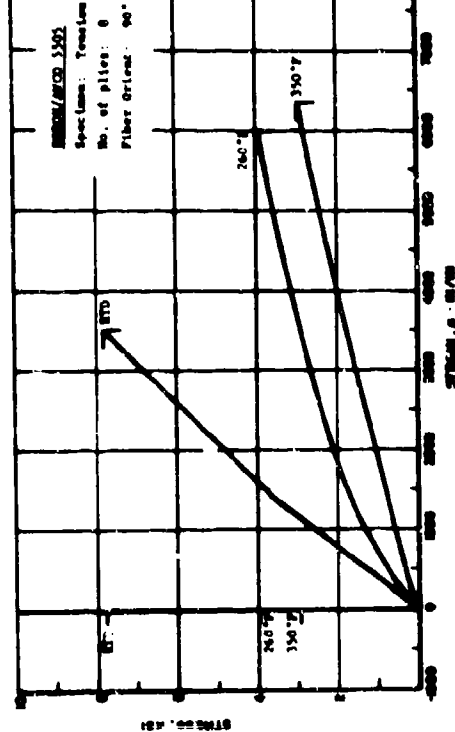


FIG. 160 TENSION STRESS-STRAIN DIAGRAM FOR 90° Kevlar/ARCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

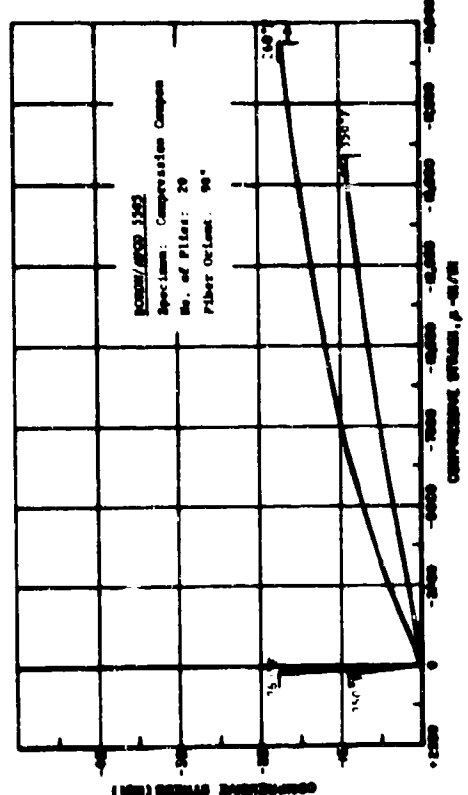


FIG. 162 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° Kevlar/ARCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

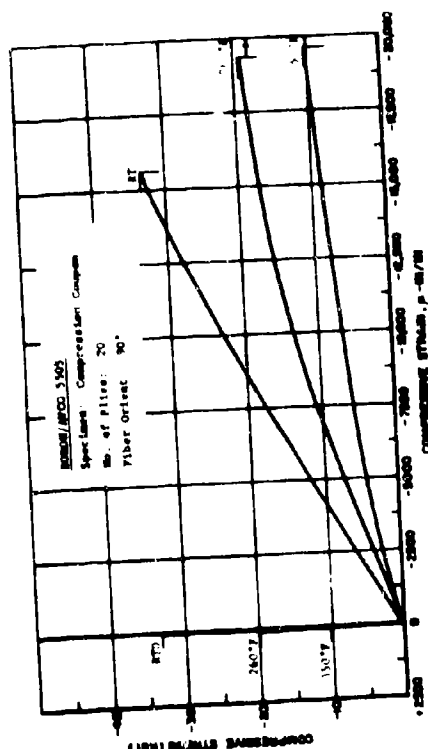


FIG. 164 COMPRESSION STRESS-STRAIN DIAGRAM FOR BORON/AFCO 5505 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

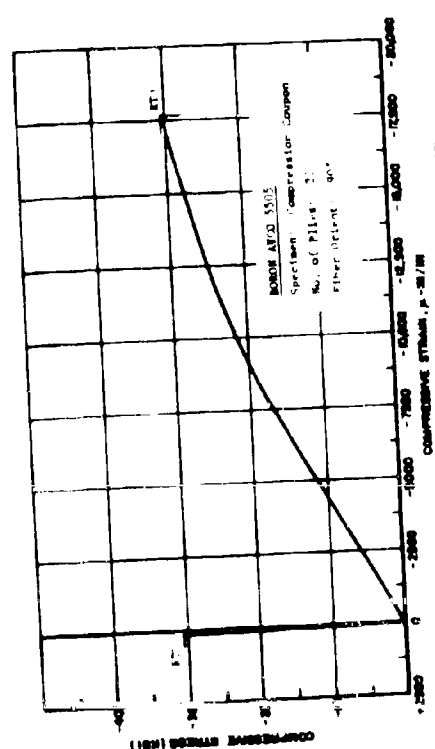


FIG. 163 COMPRESSION STRESS-STRAIN DIAGRAM FOR BORON/AFCO 5505 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (The Humidity Cycle)

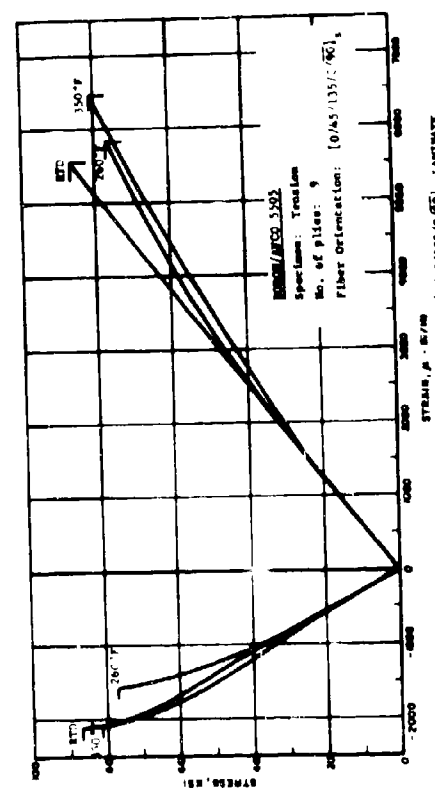


FIG. 165 TENSION STRESS-STRAIN DIAGRAM FOR BORON/AFCO 5505 [0/45/135/90]s LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

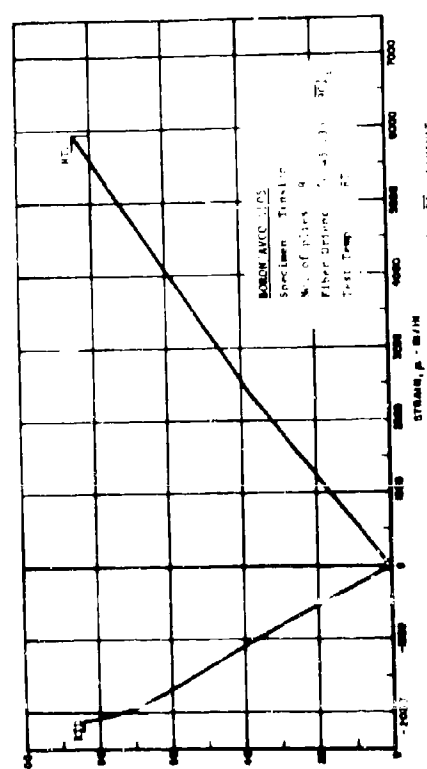


FIG. 166 TENSION STRESS-STRAIN DIAGRAM FOR BORON/AFCO 5505 [0/45/135/90]s LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 90% R.H.

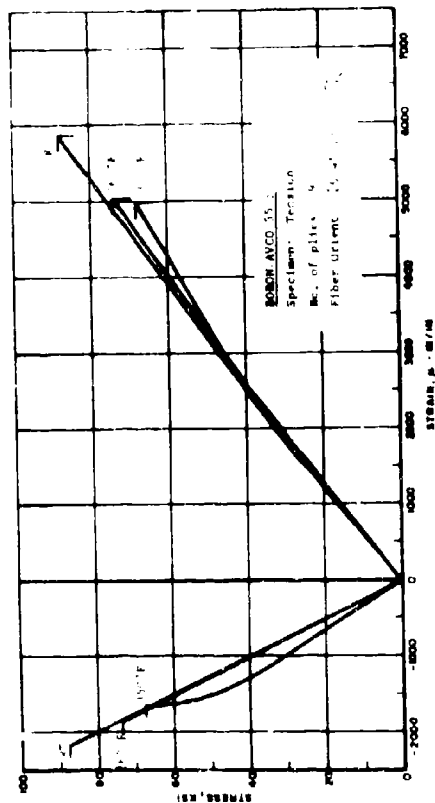


FIG. 16A TENSION STRESS-STRAIN DIAGRAM FOR BORD AVCO 5505 LAMINATE
TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE No. 1
Accelerating and Retarding

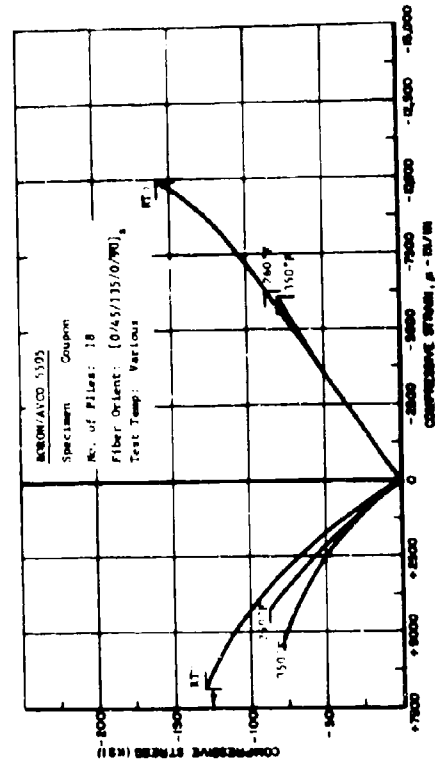


FIG. 170 COMPRESSION STRESS-STRAIN DIAGRAM FOR BORD AVCO 5505 LAMINATE
TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS
EXPOSURE TO 98% R.H.

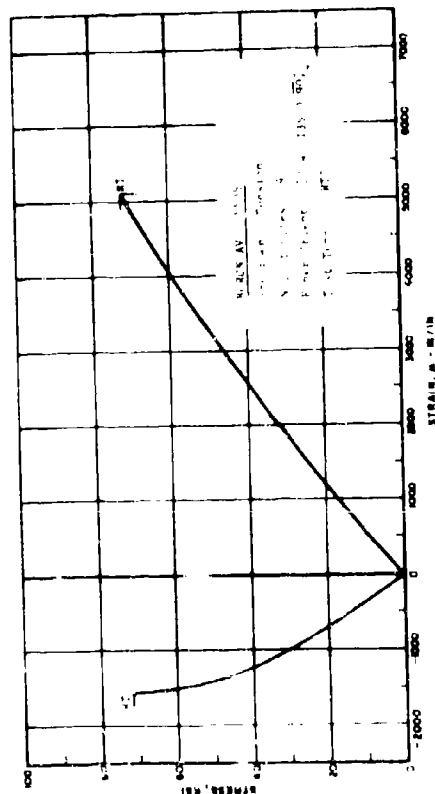


FIG. 167 TENSION STRESS-STRAIN DIAGRAM FOR BORD AVCO 5505 LAMINATE
TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE No. 1 (Specimen and Fiber)

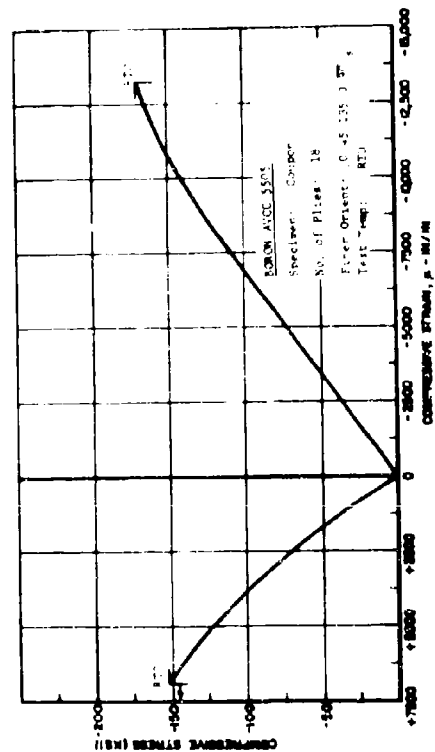


FIG. 169 COMPRESSION STRESS-STRAIN DIAGRAM FOR BORD AVCO 5505 LAMINATE
TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 98% R.H.

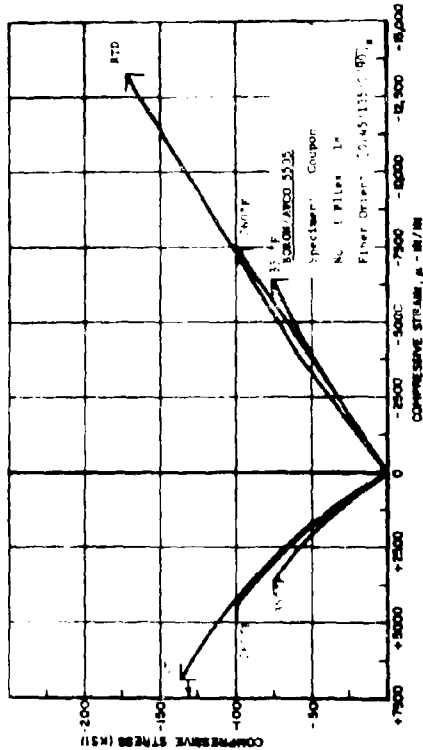


FIG. 16. COMPRESSION STRESS-STRAIN DIAGRAM FOR KEVLAR 4900 AT 150°F. SPECIMENS TESTED AT VARIOUS TEMPERATURES AFTER 50 HOURS EXPOSURE TO 160°F. ACCELERATED ANALOGUE.

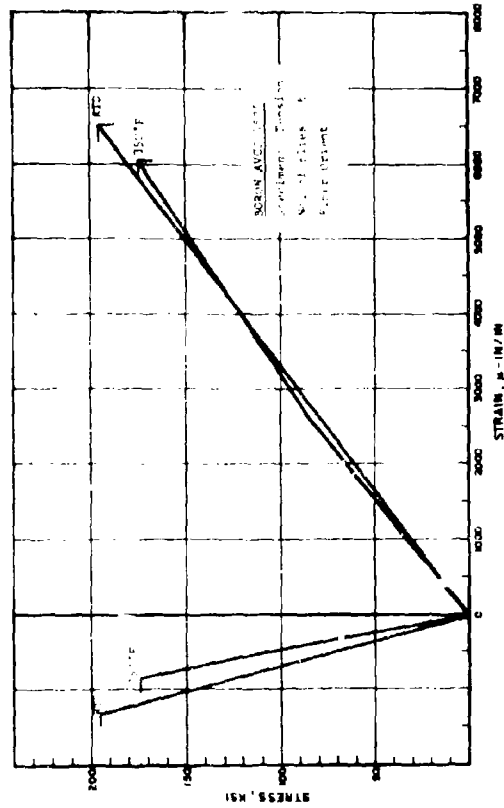


FIG. 17. TENSION STRESS-STRAIN DIAGRAM FOR KEVLAR 4900 AT 150°F. SPECIMENS TESTED AT VARIOUS TEMPERATURES AFTER 50 HOURS EXPOSURE TO 160°F.

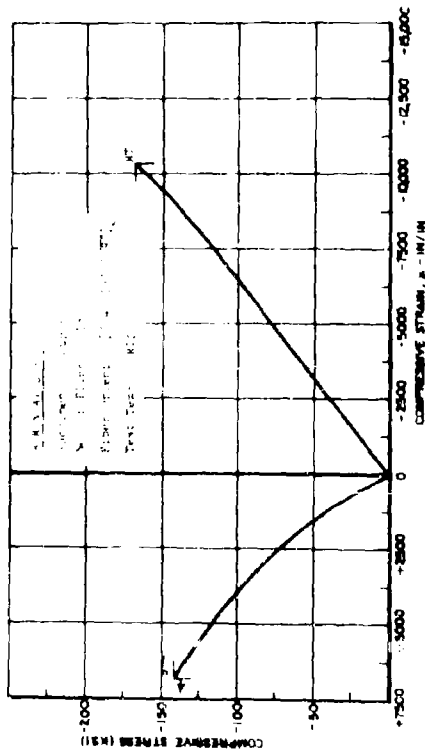


FIG. 18. COMPRESSION STRESS-STRAIN DIAGRAM FOR KEVLAR 4900 AT 160°F. SPECIMENS TESTED AT VARIOUS TEMPERATURES AFTER 50 HOURS EXPOSURE TO 160°F. ACCELERATED ANALOGUE.

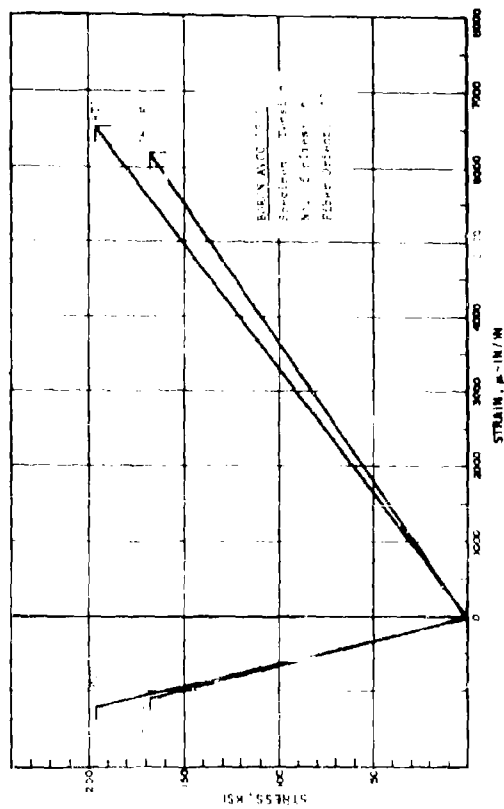


FIG. 19. TENSION STRESS-STRAIN DIAGRAM FOR KEVLAR 4900 AT 160°F. SPECIMENS TESTED AT VARIOUS TEMPERATURES AFTER 50 HOURS EXPOSURE TO 160°F.

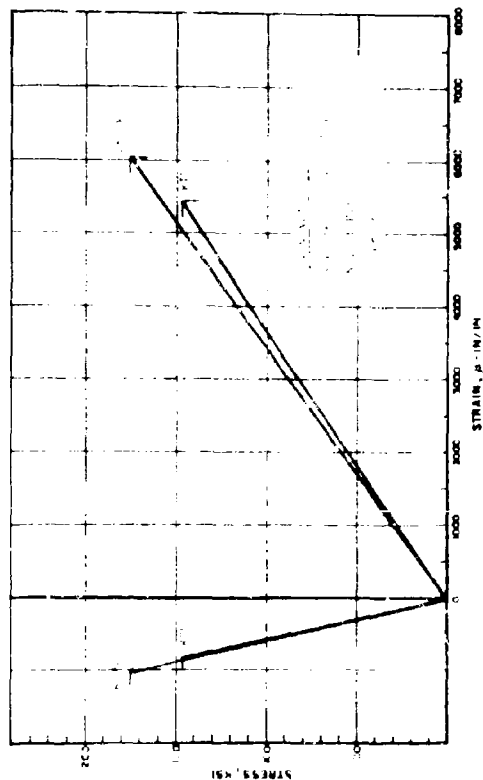


FIG. 1. STRESS-STRAIN CHARACTERISTICS OF CARBON AND GLASS COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSED TO 100°F

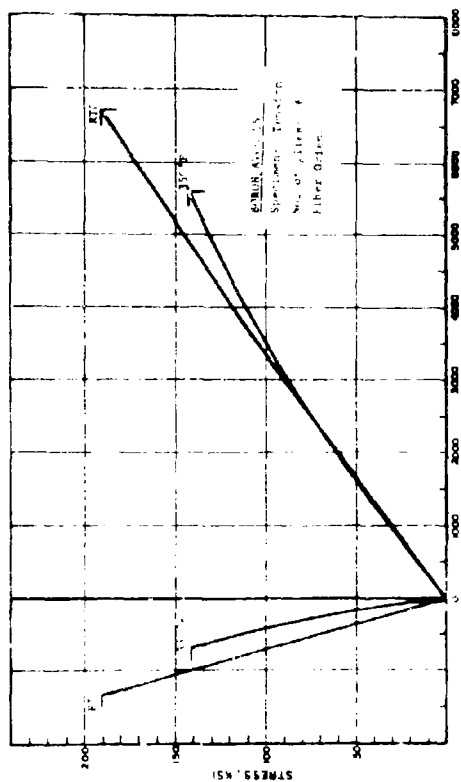


FIG. 2. STRESS-STRAIN CHARACTERISTICS OF CARBON AND GLASS COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSED TO 100°F

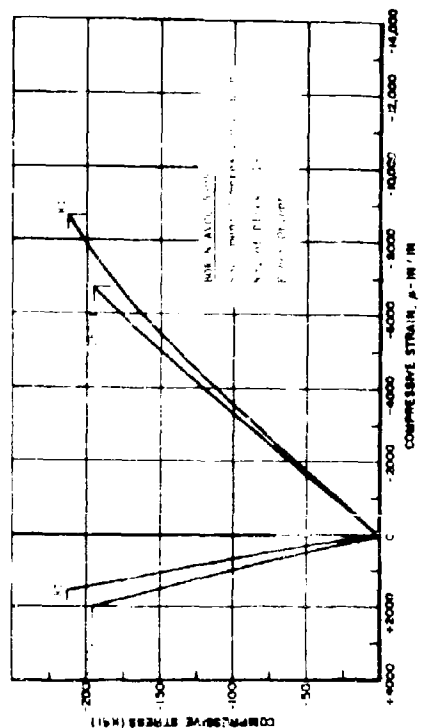


FIG. 3. COMPRESSIVE STRESS-STRAIN CHARACTERISTICS OF CARBON AND GLASS COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSED TO 100°F

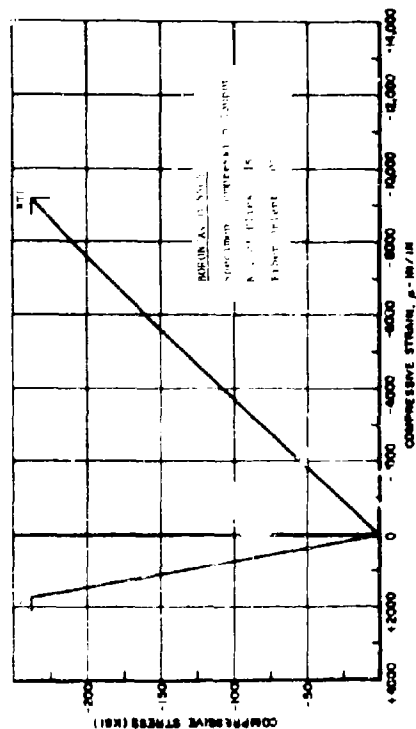


FIG. 4. COMPRESSIVE STRESS-STRAIN CHARACTERISTICS OF CARBON AND GLASS COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSED TO 100°F

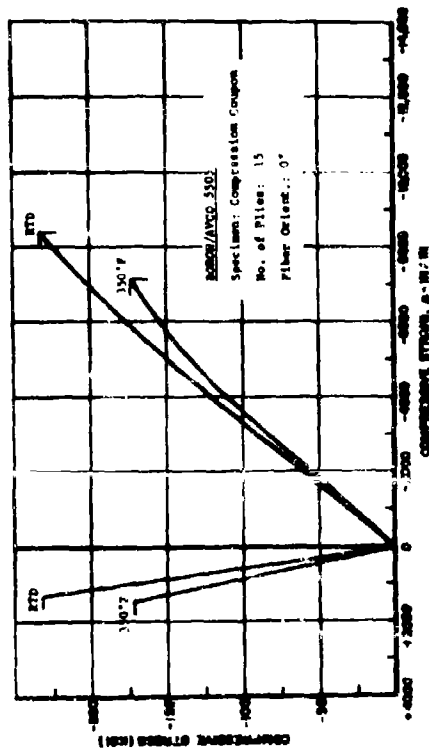


FIG. 175 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° BOND/AVCO 5503 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

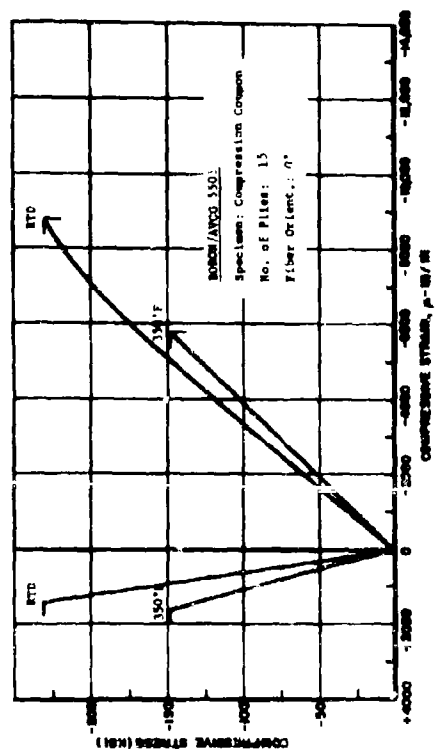


FIG. 181 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° BOND/AVCO 5503 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

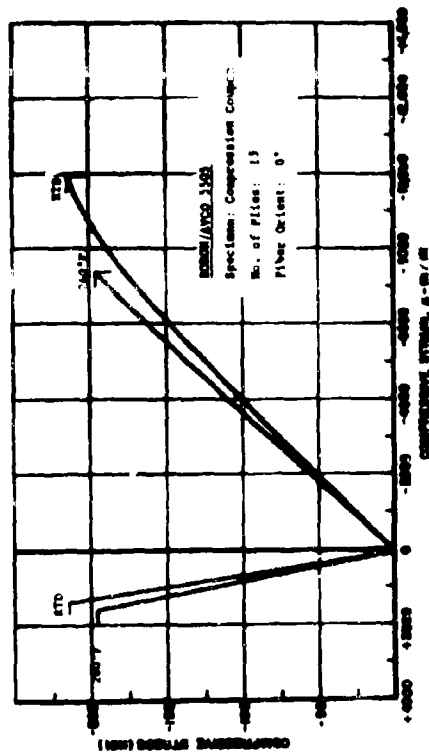


FIG. 180 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° BOND/AVCO 5503 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

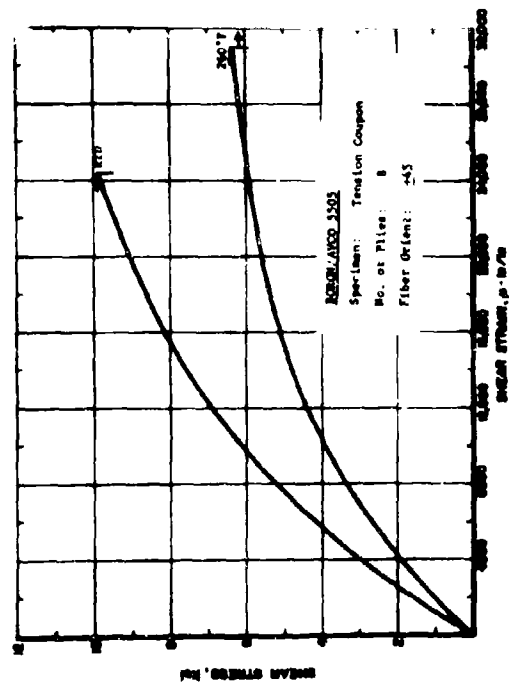


FIG. 182 SHEAR STRESS-STRAIN DIAGRAM FOR 0° BOND/AVCO 5503 LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

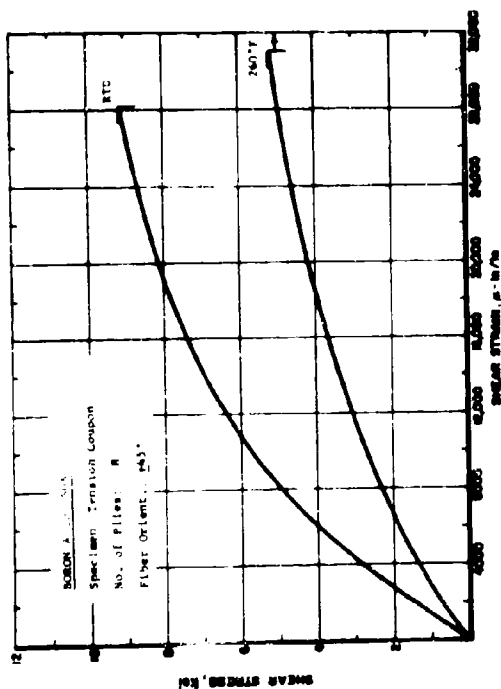


FIG. 16. SHEAR STRESS-STRAIN DIAGRAM FOR 0° BORON/AVCO 5505 LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

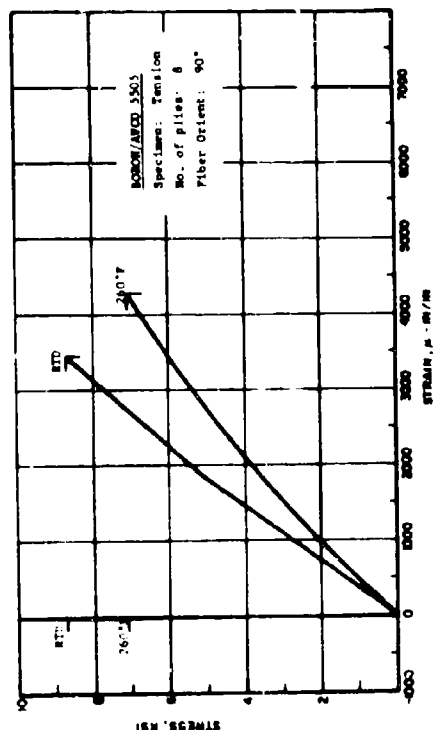


FIG. 18. TENSION STRESS-STRAIN DIAGRAM FOR 90° BORON/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 400 HOURS EXPOSURE TO 260°F

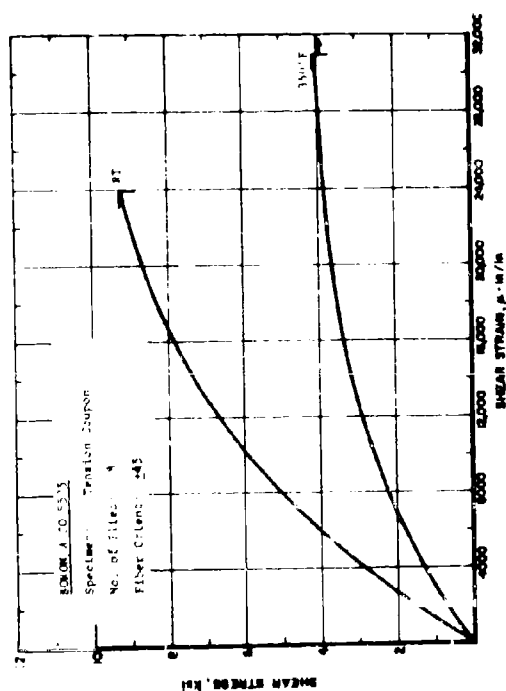


FIG. 13. SHEAR STRESS-STRAIN DIAGRAM FOR 0° BORON/AVCO 5505 LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 150°F

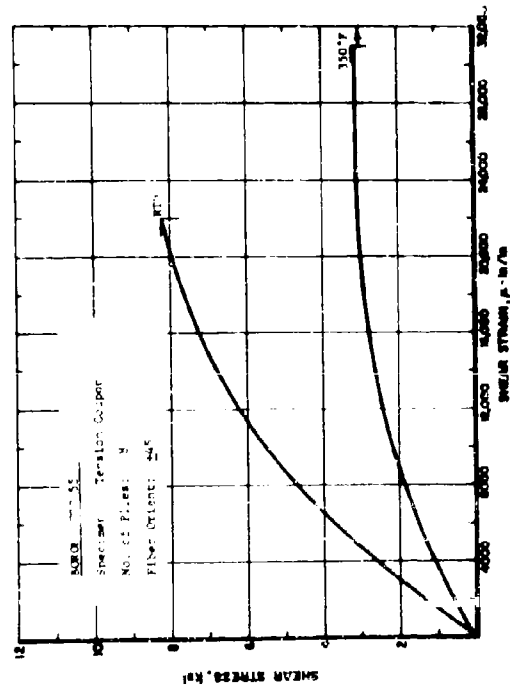


FIG. 14. SHEAR STRESS-STRAIN DIAGRAM FOR 0° BORON/AVCO 5505 LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 35°F

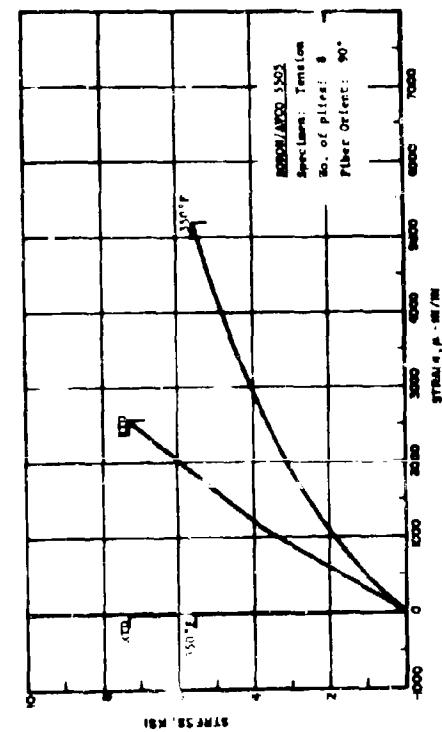


FIG. 187 TENSION STRESS-STRAIN DIAGRAM FOR 90° BORON/ARCO 3505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 260°F

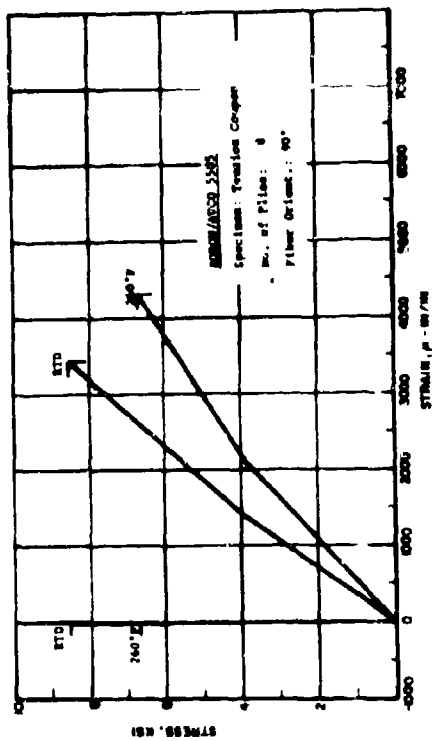


FIG. 188 TENSION STRESS-STRAIN DIAGRAM FOR 90° BORON/ARCO 3505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

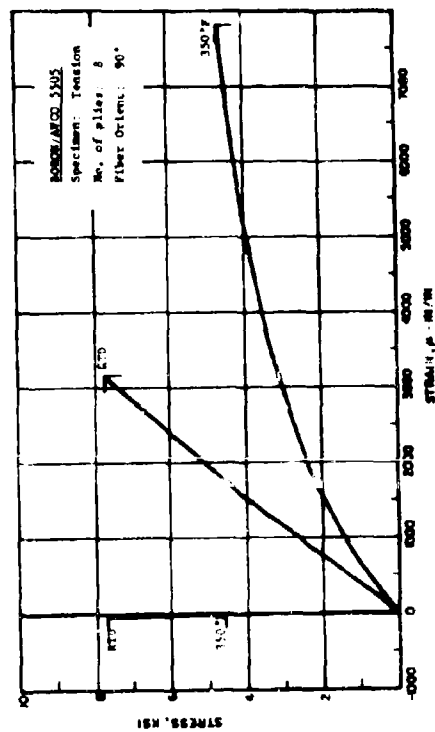


FIG. 189 TENSION STRESS-STRAIN DIAGRAM FOR 90° BORON/ARCO 3505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

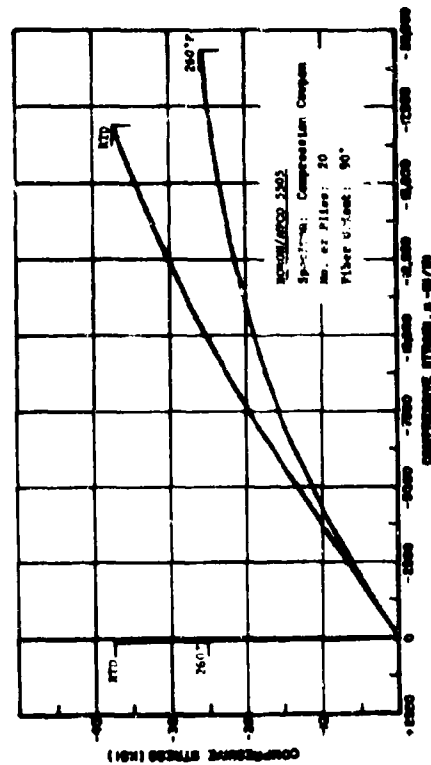
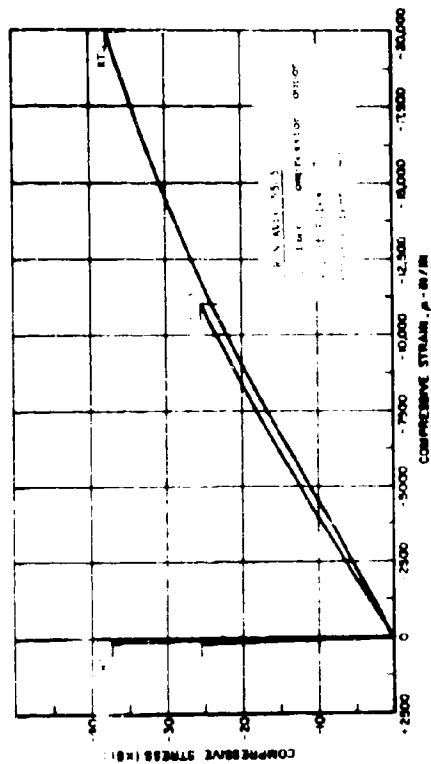
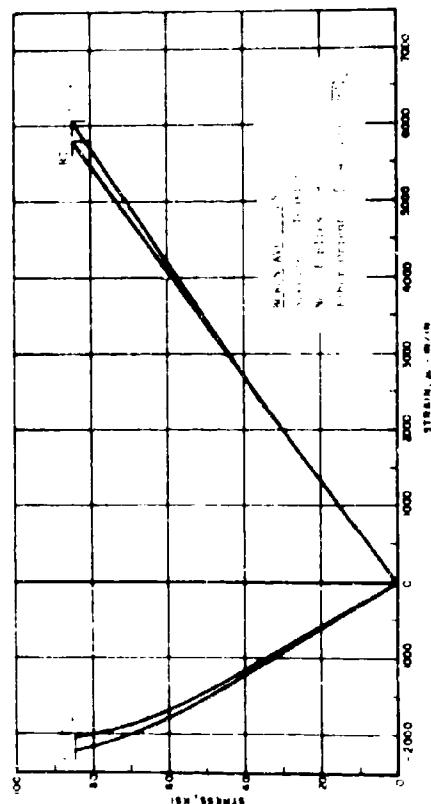


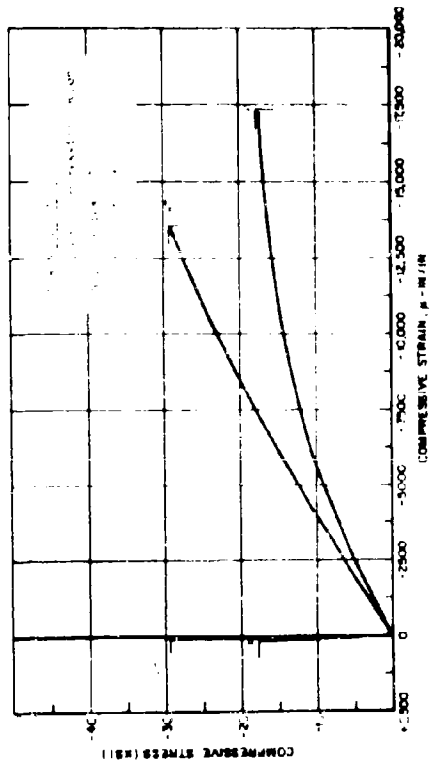
FIG. 190 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° BORON/ARCO 3505 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 260°F



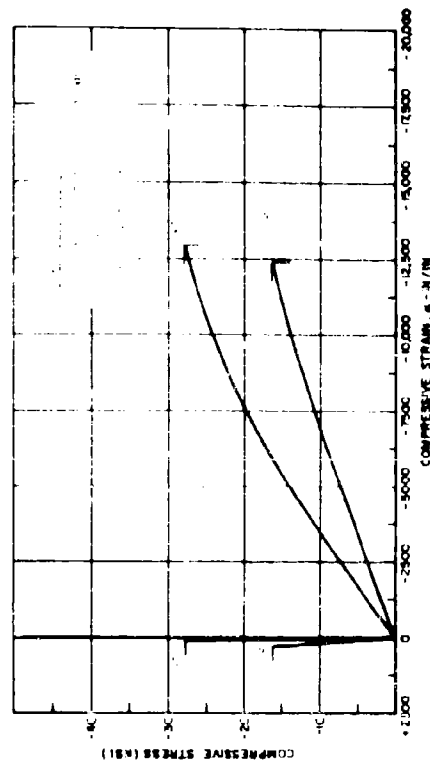
STRESS, KSI
 20
 10
 0



STRAIN, μ-IN/IN
 2000
 4000
 6000
 8000
 10000
 12000
 14000
 16000
 18000
 20000



STRESS, KSI
 20
 10
 0



STRAIN, μ-IN/IN
 2000
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 6000
 8000
 10000
 12000
 14000
 16000
 18000
 20000

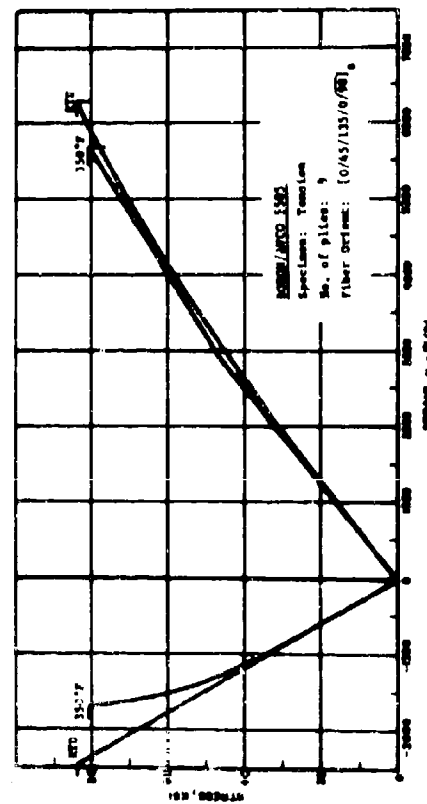


Fig. 195 TENSION STRESS-STRAIN DIAGRAM FOR BODI/APCO 5505 (0/AS/135/0/90)₂ LAMINATE,
TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

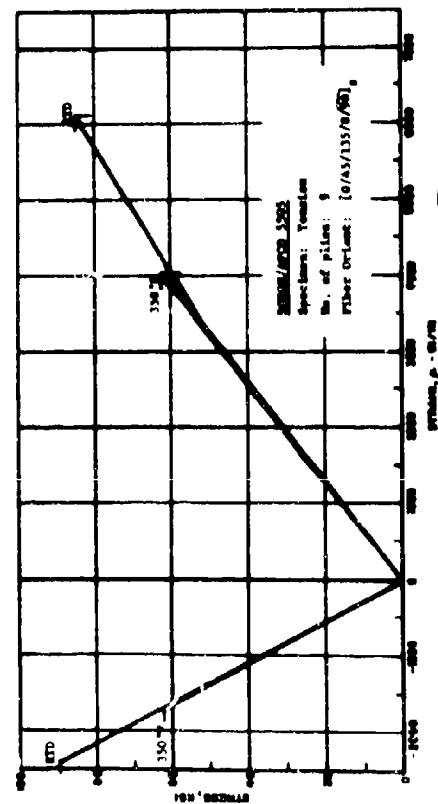


Fig. 196 COMPRESSION STRESS-STRAIN DIAGRAM FOR BODI/APCO 5505 (0/AS/135/0/90)₂ LAMINATE,
TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

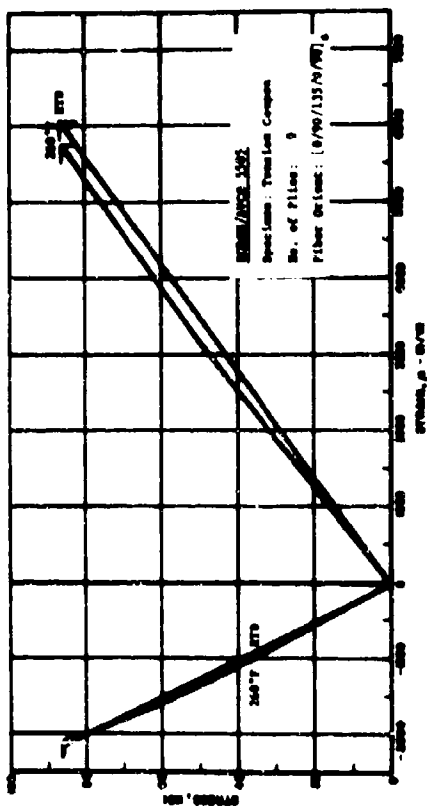


Fig. 197 TENSION STRESS-STRAIN DIAGRAM FOR BODI/APCO 5505 (0/AS/135/0/90)₂ LAMINATE,
TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

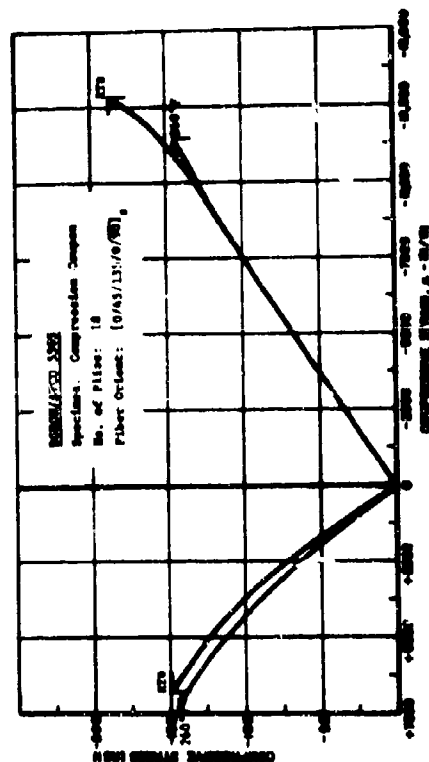


Fig. 198 COMPRESSION STRESS-STRAIN DIAGRAM FOR BODI/APCO 5505 (0/AS/135/0/90)₂ LAMINATE,
TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

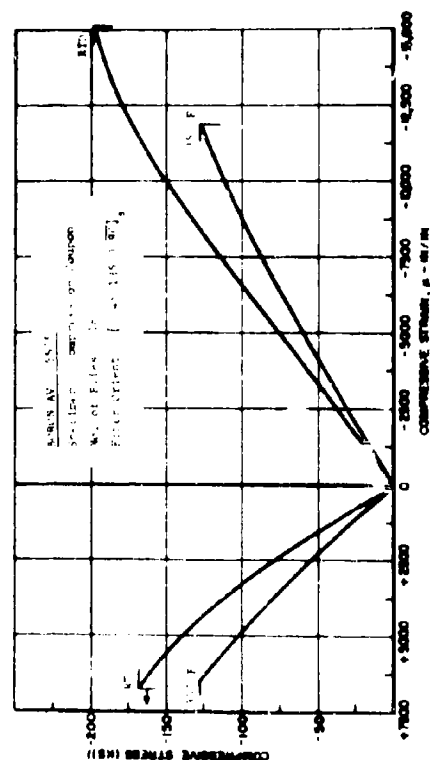
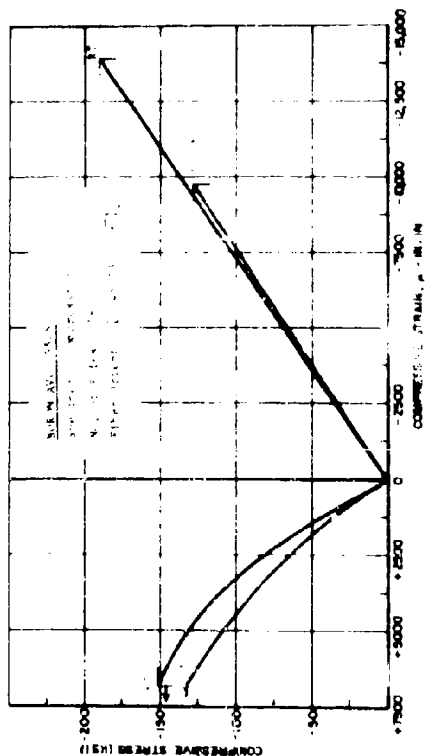
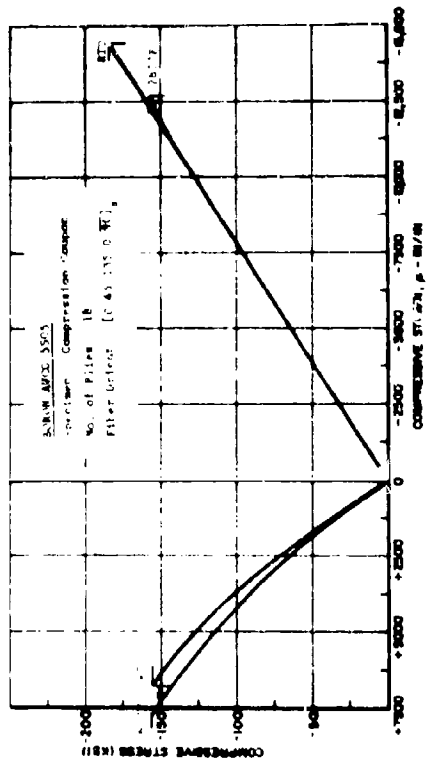


FIG. 10. COMPRESSION STRESS-STRAIN DIAGRAM FOR NIRM APC 3505 [0, 45, 135, 0, 90]₂
 (AFTER TESTS AT VARIOUS TEMPERATURES AFTER 1 HOUR EXPOSURE TO 140°F)

TABLE XIII FAILURE PROPERTIES SUMMARY -
AVCO 3305/GORDON COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	Prior Conditioning Type	Duration	Test Temp. (°F)	Stress Level (ksi) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
N1005A-E0	6 - 0.032	0°	None	-	RTD	164	710,000	-	-	-
N1005A-E1	6 - 0.032	0°	None	-	RTD	164.3	34,000	-	-	-
N1005A-E2	6 - 0.032	0°	None	-	RTD	160	90,000	-	-	-
N1005A-E3	6 - 0.032	0°	None	-	RTD	175	1,000	-	-	-
N1005A-E10	6 - 0.032	0°	None	-	RTD	160	1,354,000	-	-	-
N1005A-E11	6 - 0.032	0°	None	-	RTD	152	1,164,000	-	-	-
N1005A-E12	6 - 0.032	0°	None	-	RTD	175	34,000	-	-	-
N1005A-E13	6 - 0.032	0°	None	-	RTD	170	24,000	-	-	-
N1005A-E14	6 - 0.032	0°	None	-	RTD	170	207,000	-	-	-
N1005A-E1	6 - 0.032	0°	None	-	RTD	161	208,000	-	-	-
N1005A-E2	6 - 0.032	0°	None	-	RTD	156	3,229,000	-	-	-
N1005A-E3	6 - 0.032	0°	None	-	RTD	164	7,000	-	-	-
N1002-6	8 - 0.045	90°	None	-	RTD	6.0	8,000	-	-	-
N1002-7	8 - 0.044	90°	None	-	RTD	5.5	37,000	-	-	-
N1002-8	8 - 0.044	90°	None	-	RTD	5.0	33,000	-	-	-
N1002-9	8 - 0.044	90°	None	-	RTD	4.0	198,000	-	-	-
N1002-10	8 - 0.044	90°	None	-	RTD	4.5	423,000	-	-	-
N1002-11	8 - 0.044	90°	None	-	RTD	4.0	-	10,425,000	8.7	-
N1002-12	8 - 0.044	90°	None	-	RTD	5.5	18,000	-	-	-
N1002-13	8 - 0.044	90°	None	-	RTD	4.5	1,138,000	-	-	-
N1002-14	8 - 0.044	90°	None	-	RTD	5.0	61,000	-	-	-
N1002-15	8 - 0.044	90°	None	-	RTD	6.0	6,000	-	-	-
N1027A-6	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	68	363,000	-	-	Tab Area Failure
N1027A-7	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	78	6,000	-	-	-
N1027A-8	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	70	378,000	-	-	-
N1027A-9	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	75	13,000	-	-	-
N1027A-10	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	75	54,000	-	-	-
N1027A-11	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	80	-	-	-	Laminar Failure
N1027A-1	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	60	1,000	-	-	Tab Area Failure
N1027A-2	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	50	-	18,100,000	83.0	-
N1027A-3	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	70	889,000	-	-	-
N1027A-4	9 - 0.050	[0/45/135/0/90] _s	None	-	RTD	60	-	12,900,000	76.0	-

TABLE XIII FATIGUE PROPERTIES, UFGARY -
AFCO 5505, 6000, 60, 60, 60, 60

Specimen Number	Thickness (Plies) (in.)	Orientation	FLOR CONDITIONING		Test Temp. (°F)	Stress Level Sult (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1007A-11	6 - 0.033	0°	None	-	260°F	68	8,000	-	-	-
M1007A-12	6 - 0.033	0°	None	-	260°F	83	120,000	-	-	-
M1007A-13	6 - 0.033	0°	None	-	260°F	86	350,000	-	-	-
M1007A-14	6 - 0.033	0°	None	-	260°F	83	265,000	-	-	-
M1007A-15	6 - 0.033	0°	None	-	260°F	88	160	-	-	-
M1007A-16	6 - 0.033	0°	None	-	260°F	96	155	-	-	-
M1007A-17	6 - 0.033	0°	None	-	260°F	80	145	-	-	-
M1007A-E1	6 - 0.032	0°	None	-	260°F	87	157	-	-	Tab Area Failure
M1007A-19	6 - 0.032	0°	None	-	260°F	82	148	-	-	Tab Area Failure
M1007A-20	6 - 0.032	0°	None	-	260°F	77	140	-	-	-
M1013-11	8 - 0.045	90°	None	-	260°F	76	5	2,000	-	-
M1013-12	8 - 0.045	90°	None	-	260°F	76	5	1,000	-	-
M1013-13	8 - 0.045	90°	None	-	260°F	61	4	5,000	-	-
M1013-14	8 - 0.045	90°	None	-	260°F	61	4	11,000	-	-
M1013-15	8 - 0.045	90°	None	-	260°F	52	3.4	53,000	-	-
M1013-16	8 - 0.044	90°	None	-	260°F	53	3.5	23,000	-	-
M1013-17	8 - 0.044	90°	None	-	260°F	53	3.5	24,000	-	-
M1013-18	8 - 0.044	90°	None	-	260°F	50	3.3	229,000	-	-
M1014-1	8 - 0.045	90°	None	-	260°F	46	3	-	2.2 x 10 ⁶	Tab Area Failure
M1014-2	8 - 0.045	90°	None	-	260°F	49	3.2	1,451 x 10 ⁶	6.6	-
M1033B-2	9 - 0.049	[0/45/135/0/90]	None	-	260°F	85	70	11,000	-	-
M1033B-3	9 - 0.049	[0/45/135/0/90]	None	-	260°F	79	65	11,000	-	-
M1033B-4	9 - 0.049	[0/45/135/0/90]	None	-	260°F	85	70	2,000	-	-
M1033B-5	9 - 0.049	[0/45/135/0/90]	None	-	260°F	79	65	175,000	-	-
M1033B-6	9 - 0.049	[0/45/135/0/90]	None	-	260°F	91	75	2,000	-	-
M1033B-7	9 - 0.049	[0/45/135/0/90]	None	-	260°F	87	72	62,000	-	-
M1033B-8	9 - 0.049	[0/45/135/0/90]	None	-	260°F	87	72	186,000	-	-
M1033B-9	9 - 0.050	[0/45/135/0/90]	None	-	260°F	91	75	10,000	-	-
M1033B-10	9 - 0.049	[0/45/135/0/90]	None	-	260°F	82	68	738,000	-	-
M1033B-11	9 - 0.049	[0/45/135/0/90]	None	-	260°F	82	68	1,265,000	-	-

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Tear Temp. (°F)	Stress Level (% ^{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
N10078-1	6 - 0.033	0°	None	-	350°F	90	3,000	-	-	-
N10078-2	6 - 0.033	0°	None	-	350°F	90	2,000	-	-	-
N10078-3	6 - 0.033	0°	None	-	350°F	88	4,000	-	-	-
N10078-4	6 - 0.033	0°	None	-	350°F	88	155	-	-	Immediate tab failure
N10078-5	6 - 0.033	0°	None	-	350°F	85	2,000	-	-	-
N10078-6	6 - 0.033	0°	None	-	350°F	82	13,000	-	-	-
N10078-7	6 - 0.033	0°	None	-	350°F	94	1	-	-	-
N10078-8	6 - 0.033	0°	None	-	350°F	85	-	-	-	Immediate tab failure
N10078-9	6 - 0.033	0°	None	-	350°F	79	6,000	-	-	-
N10078-10	6 - 0.033	0°	None	-	350°F	73	511,000	-	-	-
N1014-3	8 - 0.044	90°	None	-	350°F	75	4	-	-	-
N1014-4	8 - 0.044	90°	None	-	350°F	75	3,000	-	-	-
N1014-5	8 - 0.044	90°	None	-	350°F	56	3	-	-	-
N1014-6	8 - 0.044	90°	None	-	350°F	53	268,000	-	-	-
N1014-7	8 - 0.044	90°	None	-	350°F	66	1,789,000	-	-	-
N1014-8	8 - 0.043	90°	None	-	350°F	69	3.5	-	-	-
N1014-9	8 - 0.043	90°	None	-	350°F	60	8,000	-	-	-
N1014-10	8 - 0.043	90°	None	-	350°F	62	3.2	-	-	-
N1014-11	8 - 0.043	90°	None	-	350°F	62	3.3	-	-	-
N1014-12	8 - 0.044	90°	None	-	350°F	66	11,000	-	-	-
N1034A-1	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	80	2,000	-	-	-
N1034A-2	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	63	668,000	-	-	-
N1034A-3	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	82	554,000	-	-	-
N1034A-4	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	82	10,000	-	-	-
N1034A-5	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	89	7,000	-	-	-
N1034A-6	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	89	7,000	-	-	-
N1034A-7	9 - 0.050	[0/45/135/0/90] _g	None	-	350°F	85	4,000	-	-	-
N1034A-8	9 - 0.050	[0/45/135/0/90] _g	None	-	350°F	96	9,000	-	-	-
N1034A-9	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	85	10,000	-	-	-
N1034A-10	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	86	13,000	-	-	-
N1034A-11	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	84	16,000	-	-	-
N1034A-12	9 - 0.049	[0/45/135/0/90] _g	None	-	350°F	84	24,000	-	-	-

Excess epoxy not taken off. Spec. broke while mounting

TABLE XIII FATIGUE PROPERTIES SUMMARY -
AVCO 5505/BORON COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PLATE COMPOSITION	Type	Duration	Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
M1005B-7	6 - 0.033	0°	987 RH	/	500 Hrs.	RTD	86	165	1,000		Tab Area Failure
M1005B-8	6 - 0.033	0°	987 RH	/	500 Hrs.	RTD	82	158	210,000		(Specimens broke during fabrication)
M1005B-9	6 - -	0°	987 RH	/	500 Hrs.	RTD					Immediate Failure
M1005B-10	6 - -	0°	987 RH	/	500 Hrs.	RTD					Immediate Failure
M1005B-11	6 - -	0°	987 RH	/	500 Hrs.	RTD					Immediate Failure
M1008B-15	6 - 0.033	0°	987 RH	/	500 Hrs.	260°F	85	150			
M1008B-16	6 - 0.033	0°	987 RH	/	500 Hrs.	260°F	82	145			
M1008B-17	6 - 0.033	0°	987 RH	/	500 Hrs.	260°F	79	140			
M1008B-18	6 - 0.033	0°	987 RH	/	500 Hrs.	260°F	76	135			
M1008B-19	6 - 0.033	0°	987 RH	/	500 Hrs.	260°F	72	127			
M1009A-15	6 - 0.032	0°	987 RH	/	500 Hrs.	350°F	104	150			
M1009A-16	6 - 0.033	0°	987 RH	/	500 Hrs.	350°F	90	130			
M1009A-17	6 - 0.032	0°	987 RH	/	500 Hrs.	350°F	101.5	145			
M1009A-18	6 - 0.032	0°	987 RH	/	500 Hrs.	350°F	97.5	140			
M1009A-19	6 - 0.032	0°	987 RH	/	500 Hrs.	350°F	94	135			
M1005B-12	6 - 0.033	0°	987 RH	/	1000 Hrs.	RTD	104.5	160			
M1005B-13	6 - 0.033	0°	987 RH	/	1500 Hrs.	RTD	101.0	155			
M1005B-14	6 - 0.033	0°	987 RH	/	1000 Hrs.	RTD	98	150			
M1005B-15	6 - 0.033	0°	987 RH	/	1000 Hrs.	RTD	100	153			
M1005B-16	6 - 0.033	0°	987 RH	/	1000 Hrs.	RTD	99	151			
M1008B-20	6 - 0.033	0°	987 RH	/	1000 Hrs.	260°F	92	150			
M1009A-1	6 - 0.033	0°	987 RH	/	1000 Hrs.	260°F	85	145			
M1009A-2	6 - 0.033	0°	987 RH	/	1000 Hrs.	260°F	86	140			
M1009A-3	6 - 0.033	0°	987 RH	/	1000 Hrs.	260°F	83	135			
M1009A-4	6 - 0.033	0°	987 RH	/	1000 Hrs.	260°F	77	125			
M1009A-20	6 - 0.032	0°	987 RH	/	1000 Hrs.	350°F	*	140			
M1009B-1	6 - 0.033	0°	987 RH	/	1000 Hrs.	350°F	*	135			
M1009B-2	6 - 0.032	0°	987 RH	/	1000 Hrs.	350°F	*	128			
M1009B-3	6 - 0.033	0°	987 RH	/	1000 Hrs.	350°F	*	120			
M1009B-4	6 - 0.033	0°	987 RH	/	1000 Hrs.	350°F	*	115			

* σ_{ult} data not available

TABLE XIII
Tensile Properties of Epoxy Resin

Specimen Number	Thickness (plies) (in.)	Orientation	PRIME CONDITIONING		Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1028A - 6	9 - 0.050	[0/45/135/0/90] ₂	987 RH	500 Hrs.	RTD	89	51,000	-	-	-
M1028A - 7	9 - 0.050		987 RH	500 Hrs.	RTD	92	2,000	-	-	-
M1028A - 8	9 - 0.050		987 RH	500 Hrs.	RTD	83	197,000	-	-	-
M1028A - 9	9 - 0.050		987 RH	500 Hrs.	RTD	86	73	-	-	-
M1028A - 10	9 - 0.050		987 RH	500 Hrs.	RTD	80.5	68	-	-	-
M1035B - 1	9 - 0.051		987 RH	500 Hrs.	260°F	-	-	-	-	-
M1035B - 2	9 - 0.051		987 RH	500 Hrs.	260°F	62	19,000	-	-	-
M1035B - 3	9 - 0.051		987 RH	500 Hrs.	260°F	66	5,000	-	-	-
M1035B - 4	9 - 0.051		987 RH	500 Hrs.	260°F	58	429,000	-	-	-
M1035B - 5	9 - 0.051		987 RH	500 Hrs.	260°F	64	549,000	-	-	-
M1036B - 1	9 - 0.050	[0/45/135/0/90] ₂	987 RH	500 Hrs.	350°F	86	60	-	-	-
M1036B - 2	9 - 0.050		987 RH	500 Hrs.	350°F	93.5	65	-	-	-
M1036B - 3	9 - 0.050		987 RH	500 Hrs.	350°F	101	70	-	-	-
M1036B - 4	9 - 0.050		987 RH	500 Hrs.	350°F	95	66	-	-	-
M1036B - 5	9 - 0.050		987 RH	500 Hrs.	350°F	81	56	-	-	-
M1028A - 11	9 - 0.050		987 RH	1000 Hrs.	RTD	93	80	-	-	-
M1028B - 1	9 - 0.050		987 RH	1000 Hrs.	RTD	88	76	-	-	-
M1028B - 2	9 - 0.050		987 RH	1000 Hrs.	RTD	86	74	-	-	-
M1028B - 3	9 - 0.051		987 RH	1000 Hrs.	RTD	87	75	-	-	-
M1028B - 4	9 - 0.050		987 RH	1000 Hrs.	RTD	88	76	-	-	-
M1035B - 6	9 - 0.051	[0/45/135/0/90] ₂	987 RH	1000 Hrs.	260°F	91	70	-	-	-
M1035B - 7	9 - 0.051		987 RH	1000 Hrs.	260°F	84.5	65	-	-	-
M1035B - 8	9 - 0.051		987 RH	1000 Hrs.	260°F	87	67	-	-	-
M1035B - 9	9 - 0.051		987 RH	1000 Hrs.	260°F	80.5	62	-	-	-
M1035B - 10	9 - 0.051		987 RH	1000 Hrs.	260°F	86	66	-	-	-
M1036B - 6	9 - 0.050		987 RH	1000 Hrs.	350°F	87	65	-	-	-
M1036B - 7	9 - 0.050		987 RH	1000 Hrs.	350°F	81	60	-	-	-
M1036B - 8	9 - 0.050		987 RH	1000 Hrs.	350°F	77	57	-	-	-
M1036B - 9	9 - 0.050		987 RH	1000 Hrs.	350°F	85	63	-	-	-
M1036B - 10	9 - 0.050		987 RH	1000 Hrs.	350°F	79	59	-	-	-

* σ_{ult} data not available

TABLE XIII
RESULTS OF TESTS

Specimen Number	Thickness (in.)	Orientation	Prior Conditioning		Test Temp. (°F)	Stress Level (%Yield) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
N1005B-17	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	85	2,000			
N1005B-18	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	82.5	90,000			
N1005B-19	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	84	27,000			
N1005B-20	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	81.5	2,000			
N1005B-21	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	79	3,000			
N1009A-5	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	98	2,000			
N1009A-6	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	92	5,000			
N1009A-7	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	87.5	5,000			
N1009A-8	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	82.5	6,000			
N1009A-9	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	76	120	2.1 x 10 ⁶	154.3	
N1009B-5	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	108	12,000			Tab Failure
N1009B-6	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	104	8,000			
N1009B-7	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	100	12,000			
N1009B-8	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	96	13,000			Tab Failure
N1009B-9	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	92.5	314,000			Tab Failure
N1005C-1	6 - 0.033	0°	Acc. Wthrg.		RTD	84	30,000			
N1005C-2	6 - 0.033	0°	Acc. Wthrg.		RTD	82.5	45,000			
N1005C-3	6 - 0.033	0°	Acc. Wthrg.		RTD	87	9,000			
N1005C-4	6 - 0.033	0°	Acc. Wthrg.		RTD	80	176,000			
N1005C-5	6 - 0.033	0°	Acc. Wthrg.		RTD	78	9,000			
N1009A-10	6 - 0.032	0°	Acc. Wthrg.		260°F	92.5	4,000			
N1009A-11	6 - 0.032	0°	Acc. Wthrg.		260°F	89	4,000			
N1009A-12	6 - 0.033	0°	Acc. Wthrg.		260°F	83	51,000			
N1009A-13	6 - 0.032	0°	Acc. Wthrg.		260°F	79.5	125	2.25 x 10 ⁶	189.8	
N1009A-14	6 - 0.033	0°	Acc. Wthrg.		260°F	81.5	128	2.791 x 10 ⁶	183.1	
N1009B-10	6 - 0.033	0°	Acc. Wthrg.		350°F	82	1,000			Tab Failure
N1009B-11	6 - 0.033	0°	Acc. Wthrg.		350°F	79	115			Tab Failure
N1009B-12	6 - 0.032	0°	Acc. Wthrg.		350°F	72	236,000			Immediate Failure
N1009B-13	6 - 0.033	0°	Acc. Wthrg.		350°F	75.5	110			
N1009B-14	6 - 0.033	0°	Acc. Wthrg.		350°F	68.5	100			

TABLE VIII. TENSILE PROPERTIES REPORT
 A-10 1500 15000 15000 15000

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (7.5 unit) (ksi)	Cycles to Failure (cycles)	Cycles Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
N10283-5	9 - 0.031	0 - 45° 135° 90°	Thermo-Humidity Cycle		RTD	104	6,000			Tab Area Failure
N10283-6	9 - 0.031	"	Thermo-Humidity Cycle		RTD	97	20,000			
N10283-7	9 - 0.031	"	Thermo-Humidity Cycle		RTD	93	136,000			
N10283-8	9 - 0.031	"	Thermo-Humidity Cycle		RTD	90	74,000			Tab Area Failure
N10283-9	9 - 0.031	"	Thermo-Humidity Cycle		RTD	83	764,000			Tab Area Failure
N1036A-1	9 - 0.031	"	Thermo-Humidity Cycle		260°F	80.5	65			
N1036A-2	9 - 0.031	"	Thermo-Humidity Cycle		260°F	62	50	2.42 x 10 ⁶	79.2	Immediate Failure
N1036A-3	9 - 0.031	"	Thermo-Humidity Cycle		260°F	68.5	55			
N1036A-4	9 - 0.031	"	Thermo-Humidity Cycle		260°F	74.5	60			
N1036A-5	9 - 0.031	"	Thermo-Humidity Cycle		260°F	66	53			
N1037A-1	9 - 0.031	"	Thermo-Humidity Cycle		350°F	74	50			
N1037A-2	9 - 0.031	"	Thermo-Humidity Cycle		350°F	69.5	50			
N1037A-3	9 - 0.031	"	Thermo-Humidity Cycle		350°F	97	65			
N1037A-4	9 - 0.031	"	Thermo-Humidity Cycle		350°F	92.5	82			
N1037A-5	9 - 0.031	"	Thermo-Humidity Cycle		350°F	96.5	58	2.062 x 10 ⁶	58.0	
N1038A-1	9 - 0.031	"	Acc. Wthrg.		RTD	80	70			
N1038A-2	9 - 0.031	"	Acc. Wthrg.		RTD	74	65			Tab Failure
N1038A-3	9 - 0.031	"	Acc. Wthrg.		RTD	77.5	68			
N1038A-4	9 - 0.031	"	Acc. Wthrg.		RTD	83.5	73			
N1038A-5	9 - 0.031	"	Acc. Wthrg.		RTD	80	70			Tab Failure
N1038A-6	9 - 0.031	"	Acc. Wthrg.		260°F	81.5	60			
N1038A-7	9 - 0.031	"	Acc. Wthrg.		260°F	74.5	55			Immediate Failure
N1038A-8	9 - 0.031	"	Acc. Wthrg.		260°F	72	53			
N1038A-9	9 - 0.031	"	Acc. Wthrg.		260°F	77.5	56			
N1038A-10	9 - 0.031	"	Acc. Wthrg.		260°F	76	56			
N1037A-1	9 - 0.031	"	Acc. Wthrg.		350°F	88	60			
N1037A-2	9 - 0.031	"	Acc. Wthrg.		350°F	95	65			
N1037A-3	9 - 0.031	"	Acc. Wthrg.		350°F	83.5	57			Tab Failure
N1037A-4	9 - 0.031	"	Acc. Wthrg.		350°F	90.5	62			
N1037A-5	9 - 0.031	"	Acc. Wthrg.		350°F	98	67			

TABLE VIII

Specimen Temp.	Thickness (Plies) (in.)	Orientation	PRIORITY CONDITIONING		Test Temp. (°F)	Stress Level (% of σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1006A-1	h - 0.033	0°	Steady 260°F	500 Hrs.	RTD	42.5	1,000	-	-	Tab Area Failure
M1006A-10	h - 0.033	0°	Steady 260°F	500 Hrs.	RTD	20	20,000	-	-	Tab Area Failure
M1006A-11	h - 0.033	0°	Steady 260°F	500 Hrs.	RTD	40	530,000	-	-	-
M1006A-12	h - 0.033	0°	Steady 260°F	500 Hrs.	RTD	88	2,000	-	-	-
M1006A-14	h - 0.033	0°	Steady 260°F	500 Hrs.	RTD	83	66,000	-	-	-
M1006A-14	h - 0.032	0°	Steady 330°F	500 Hrs.	RTD	89.5	1,000	-	-	Tab Area Failure
M1006A-15	h - 0.032	0°	Steady 450°F	500 Hrs.	RTD	84	1,000	-	-	Tab Area Failure
M1006A-16	h - 0.032	0°	Steady 350°F	500 Hrs.	RTD	79	58,000	-	-	Tab Area Failure
M1006A-17	h - 0.032	0°	Steady 350°F	500 Hrs.	RTD	74	5,671 x 10 ⁴	-	-	Tab Area Failure
M1006A-18	h - 0.032	0°	Steady 350°F	500 Hrs.	RTD	76	15,000	-	-	Tab Area Failure
M1006A-19	h - 0.034	0°	Cyclic 260°F	500 Cyc.	RTD	86	1,400,000	-	-	-
M1006A-10	h - 0.034	0°	Cyclic 260°F	500 Cyc.	RTD	97	110,000	-	-	-
M1006A-20	h - 0.033	0°	Cyclic 260°F	500 Cyc.	RTD	102	3,000	-	-	-
M1006A-21	h - 0.033	0°	Cyclic 260°F	500 Cyc.	RTD	86.5	1,000	-	-	-
M1006A-22	h - 0.033	0°	Cyclic 260°F	500 Cyc.	RTD	91.5	206,000	-	-	-
M1006A-23	h - 0.033	0°	Cyclic 260°F	500 Cyc.	RTD	91.5	170	-	-	Immediate failure
M1006A-24	h - 0.034	0°	Cyclic 260°F	1000 Cyc.	RTD	86	160	-	-	Immediate failure
M1006A-25	h - 0.034	0°	Cyclic 260°F	1000 Cyc.	RTD	70	130	-	-	Tab failure
M1006A-26	h - 0.034	0°	Cyclic 260°F	1000 Cyc.	RTD	75.5	140	-	-	Tab failure
M1006A-27	h - 0.033	0°	Cyclic 260°F	1000 Cyc.	RTD	80.5	150	-	-	Immediate Tab Failure
M1006A-28	h - 0.033	0°	Cyclic 350°F	500 Cyc.	RTD	90	1,000	-	-	-
M1006A-29	h - 0.034	0°	Cyclic 350°F	500 Cyc.	RTD	85	4,000	-	-	-
M1006A-30	h - 0.033	0°	Cyclic 350°F	500 Cyc.	RTD	82	292,000	-	-	-
M1006A-31	h - 0.033	0°	Cyclic 350°F	500 Cyc.	RTD	83.5	3,000	-	-	-
M1006A-32	h - 0.034	0°	Cyclic 350°F	500 Cyc.	RTD	80.5	52,000	-	-	-
M1006A-33	h - 0.034	0°	Cyclic 350°F	500 Cyc.	RTD	42	890,000	-	-	-
M1006A-34	h - 0.033	0°	Cyclic 350°F	1000 Cyc.	RTD	94.5	137,000	-	-	-
M1006A-35	h - 0.033	0°	Cyclic 350°F	1000 Cyc.	RTD	57.5	8,000	-	-	-
M1006A-36	h - 0.033	0°	Cyclic 350°F	1000 Cyc.	RTD	57.5	165	-	-	-
M1006A-37	h -	0°	Cyclic 350°F	1000 Cyc.	RTD	Specimen Broke During Fabrication	-	-	-	-
M1006A-38	h -	0°	Cyclic 350°F	1000 Cyc.	RTD	Specimen Broke During Fabrication	-	-	-	-

2.021x10⁶

185.4

TAB XIII FATHOM'S SUMMARY
AVG. STRESS (ksi) = 100

Specimen Number	Thickness (Piles) (In.)	Orientation	Pilot Conditioning		Test Temp. (°F)	Stress Level (°ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1011A-5	6 - 0.033	0°	Steady 260°F	/ 500 Hrs.	260°F	106	180	1,000		Tab Area Failure
M1011A-6	6 - 0.033	0°	Steady 260°F	/ 500 Hrs.	260°F	103	175	2,000		
M1011A-7	6 - 0.033	0°	Steady 260°F	/ 500 Hrs.	260°F	95	160	445,000		
M1011A-8	6 - 0.033	0°	Steady 260°F	/ 500 Hrs.	260°F	101	170	7,000		
M1011A-9	6 - 0.033	0°	Steady 260°F	/ 500 Hrs.	260°F	97.5	165	11,000		Immediate Failure
M1011A-10	6 - 0.034	0°	Cyclic 260°F	/ 500 Cyc.	260°F	92	150	-		
M1011A-11	6 - 0.033	0°	Cyclic 260°F	/ 500 Cyc.	260°F	86	140	5,000		
M1011A-12	6 - 0.033	0°	Cyclic 260°F	/ 500 Cyc.	260°F	90	135	23,000		
M1011A-13	6 - 0.033	0°	Cyclic 260°F	/ 500 Cyc.	260°F	87.5	130	1,739,000		Immediate Failure
M1011A-14	6 - 0.034	0°	Cyclic 260°F	/ 500 Cyc.	260°F	81.5	133	21,000		
M1011A-15	6 - 0.033	0°	Cyclic 260°F	/ 1000 Cyc.	260°F	80	140	1,451,000		
M1011A-16	6 - 0.034	0°	Cyclic 260°F	/ 1000 Cyc.	260°F	88.5	155	88,000		
M1011A-17	6 - 0.034	0°	Cyclic 260°F	/ 1000 Cyc.	260°F	87.5	153	124,000		Immediate Failure
M1011A-18	6 - 0.033	0°	Cyclic 260°F	/ 1000 Cyc.	260°F	91.5	160	14,000		
M1011A-19	6 - 0.034	0°	Cyclic 260°F	/ 1000 Cyc.	260°F	83	145	142,000		
M1011B-1	6 - 0.033	0°	Steady 350°F	/ 500 Hrs.	350°F	89	155	-		
M1011B-2	6 - 0.033	0°	Steady 350°F	/ 500 Hrs.	350°F	80.5	140	2,000		Immediate Failure
M1011B-3	6 - 0.033	0°	Steady 350°F	/ 500 Hrs.	350°F	75	130	4,000		
M1011B-4	6 - 0.032	0°	Steady 350°F	/ 500 Hrs.	350°F	72	125	65,000		
M1011B-5	6 - 0.032	0°	Steady 350°F	/ 500 Hrs.	350°F	69	120	34,000		
M1011B-6	6 - 0.034	0°	Cyclic 350°F	/ 500 Cyc.	350°F	75.5	130	682,000		Immediate Failure
M1011B-7	6 - 0.033	0°	Cyclic 350°F	/ 500 Cyc.	350°F	81.5	140	191,000		
M1011B-8	6 - 0.033	0°	Cyclic 350°F	/ 500 Cyc.	350°F	87	150	5,000		
M1011B-9	6 - 0.033	0°	Cyclic 350°F	/ 500 Cyc.	350°F	84.5	145	467,000		
M1011B-10	6 - 0.034	0°	Cyclic 350°F	/ 500 Cyc.	350°F	86	148	3,000		Immediate Failure
M1011B-11	6 - 0	0°	Cyclic 350°F	/ 1000 Cyc.	350°F	99	140	159,000		
M1011B-12	6 - 0.033	0°	Cyclic 350°F	/ 1000 Cyc.	350°F	106	150	9,000		
M1011B-13	6 - 0.033	0°	Cyclic 350°F	/ 1000 Cyc.	350°F	92	130	862,000		
M1011B-14	6 - 0.033	0°	Cyclic 350°F	/ 1000 Cyc.	350°F	103	145	18,000		Immediate Failure
M1011B-15	6 - 0.033	0°	Cyclic 350°F	/ 1000 Cyc.	350°F	96.5	135	280,000		

Specimen Number	Thickness (P in.) (In.)	Orientation	Prior Conditions		Test Temp. (°F)	Stress Level (ksi) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Time	Duration						
W 0304 - 1	- 0.050	[1/4]	260°F / 500 Hrs.		RTD	93	1,000	-	-	-
W 0304 - 2	- 0.051		260°F / 500 Hrs.		RTD	84	261,000	-	-	-
W 0304 - 3	- 0.051		260°F / 500 Hrs.		RTD	92.5	2,000	-	-	-
W 0304 - 4	- 0.051		260°F / 500 Hrs.		RTD	90	34,000	-	-	-
W 0304 - 5	- 0.051		260°F / 500 Hrs.		RTD	85.5	14,000	-	-	-
W 0304 - 6	- 0.050		350°F / 500 Hrs.		RTD	84	468,000	-	-	-
W 0304 - 7	- 0.050		350°F / 500 Hrs.		RTD	80	8,000	-	-	-
W 0304 - 8	- 0.050		350°F / 500 Hrs.		RTD	92.5	39,000	-	-	-
W 0304 - 9	- 0.050		350°F / 500 Hrs.		RTD	92	1,000	-	-	-
W 0304 - 10	- 0.050		350°F / 500 Hrs.		RTD	84	-	2.0 x 10 ⁶	80.0	-
W 0314 - 1	- 0.050		260°F / 500 Cyc		RTD	76	12,000	-	-	Tab Failure
W 0314 - 2	- 0.050		260°F / 500 Cyc		RTD	60	-	2.418x10 ⁶	79.4	Tab Area Failure
W 0314 - 3	- 0.050		260°F / 500 Cyc		RTD	60	-	2.573x10 ⁶	83.6	Tab Area Failure
W 0314 - 4	- 0.050		260°F / 500 Cyc		RTD	82	2,000	-	-	Tab Area Failure
W 0314 - 5	- 0.050		260°F / 500 Cyc		RTD	74	1,504,000	-	-	Tab Area Failure
W 0314 - 6	- 0.051		260°F / 1000 Cyc		RTD	83.8	4,000	-	-	Tab Area Failure
W 0314 - 7	- 0.051		260°F / 1000 Cyc		RTD	74	3,719,000	-	-	Tab Area Failure
W 0314 - 8	- 0.050		260°F / 1000 Cyc		RTD	74	2,743,000	-	-	Tab Area Failure
W 0314 - 9	- 0.050		260°F / 1000 Cyc		RTD	87	3,000	-	-	Tab Failure
W 0314 - 10	- 0.050		260°F / 1000 Cyc		RTD	85	178,000	-	-	Tab Failure
W 0304 - 8	- 0.051		350°F / 500 Cyc		RTD	77	2,000	-	-	Tab Failure
W 0304 - 9	- 0.051		350°F / 500 Cyc		RTD	66	10,000	-	-	Tab Failure
W 0304 - 10	- 0.051		350°F / 500 Cyc		RTD	60.5	5,000	-	-	Tab Failure
W 0314 - 1	- 0.051		350°F / 500 Cyc		RTD	58	-	2.0 x 10 ⁶	75.3	-
W 0314 - 2	- 0.051		350°F / 500 Cyc		RTD	60.5	-	2.468 x 10 ⁶	77.9	-
W 0314 - 3	- 0.050		350°F / 1000 Cyc		RTD	82.5	2,000	-	-	-
W 0314 - 4	- 0.050		350°F / 1000 Cyc		RTD	76.5	413,000	-	-	-
W 0314 - 5	- 0.050		350°F / 1000 Cyc		RTD	80	10,000	-	-	-
W 0314 - 6	- 0.050		350°F / 1000 Cyc		RTD	78	421,000	-	-	-
W 0314 - 7	- 0.051	[0.75/1.75/0.75] ₆	350°F / 1000 Cyc		RTD	74	7,000	-	-	-

TABLE VIII FATIGUE PROPERTIES SUMMARY -
AUG 5505 KODIN COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
N1040A - 1	9 - 0.051	[0/5/135/0/90]	Steady 260°F/500 Hrs.		260°F	89	75	3,000		
N1040A - 2	9 - 0.051	[0/5/135/0/90]	Steady 260°F/500 Hrs.		260°F	83	70	9,000		
N1040A - 3	9 - 0.051	[0/5/135/0/90]	Steady 260°F/500 Hrs.		260°F	77	65	25,000		
N1040A - 4	9 - 0.051	[0/5/135/0/90]	Steady 260°F/500 Hrs.		260°F	71	60	195,000		
N1040A - 5	9 - 0.051	[0/5/135/0/90]	Steady 260°F/500 Hrs.		260°F	66	57	-	2.014 x 10 ⁶	70.7
N1040A - 6	9 - 0.051	[0/5/135/0/90]	Cyclic 260°F/500 Cyc.		260°F	73	60	445,000		
N1040A - 7	9 - 0.051	[0/5/135/0/90]	Cyclic 260°F/500 Cyc.		260°F	79	65	-		
N1040A - 8	9 - 0.051	[0/5/135/0/90]	Cyclic 260°F/500 Cyc.		260°F	76.5	63	6,000		
N1040A - 9	9 - 0.051	[0/5/135/0/90]	Cyclic 260°F/500 Cyc.		260°F	69.5	57	490,000		
N1040A - 10	9 - 0.051	[0/5/135/0/90]	Cyclic 260°F/500 Cyc.		260°F	73.5	62	99,000		
N1040B - 1	9 - 0.050	[0/5/135/0/90]	Cyclic 260°F/1000 Cyc.		260°F	75.5	65	210,000		
N1040B - 2	9 - 0.049	[0/5/135/0/90]	Cyclic 260°F/1000 Cyc.		260°F	87.5	75	47,000		
N1040B - 3	9 - 0.049	[0/5/135/0/90]	Cyclic 260°F/1000 Cyc.		260°F	99	85	5,000		
N1040B - 4	9 - 0.050	[0/5/135/0/90]	Cyclic 260°F/1000 Cyc.		260°F	64	55	-	4.344 x 10 ⁶	63.2
N1040B - 5	9 - 0.050	[0/5/135/0/90]	Cyclic 260°F/1000 Cyc.		260°F	81.5	70	11,000		
N1040B - 6	9 - 0.049	[0/5/135/0/90]	Steady 350°F/500 Hrs.		350°F	74.5	60	5,000		
N1040B - 7	9 - 0.049	[0/5/135/0/90]	Steady 350°F/500 Hrs.		350°F	68	55	3,000		
N1040B - 8	9 - 0.050	[0/5/135/0/90]	Steady 350°F/500 Hrs.		350°F	62	50	7,000		
N1040B - 9	9 - 0.049	[0/5/135/0/90]	Steady 350°F/500 Hrs.		350°F	49.5	40	1,158,000		
N1040B - 10	9 - 0.049	[0/5/135/0/90]	Steady 350°F/500 Hrs.		350°F	56	45	818,000		
N1041A - 1	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/500 Cyc.		350°F	91	70	3,000		
N1041A - 2	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/500 Cyc.		350°F	84.5	65	82,000		
N1041A - 3	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/500 Cyc.		350°F	76	60	1,416,000		
N1041A - 4	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/500 Cyc.		350°F	82	63	54,000		
N1041A - 5	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/500 Cyc.		350°F	88.5	68	204,000		
N1041A - 6	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/1000 Cyc.		350°F	96	60	-	2.0 x 10 ⁶	80.0 Tab Failure
N1041A - 7	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/1000 Cyc.		350°F	103	65	382,000		
N1041A - 8	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/1000 Cyc.		350°F	112	70	22,000		
N1041A - 9	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/1000 Cyc.		350°F	109	68	295,000		
N1041A - 10	9 - 0.049	[0/5/135/0/90]	Cyclic 350°F/1000 Cyc.		350°F	117	73	14,000		

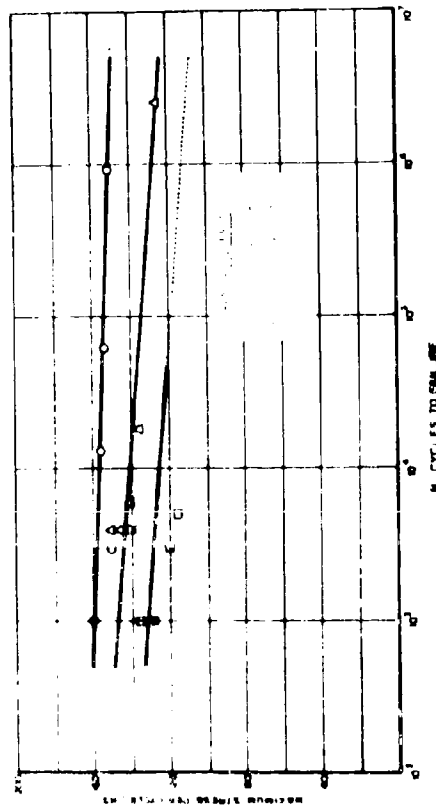
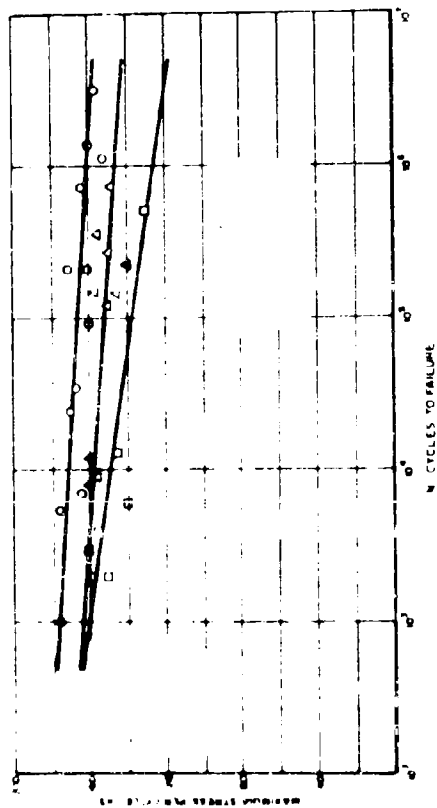
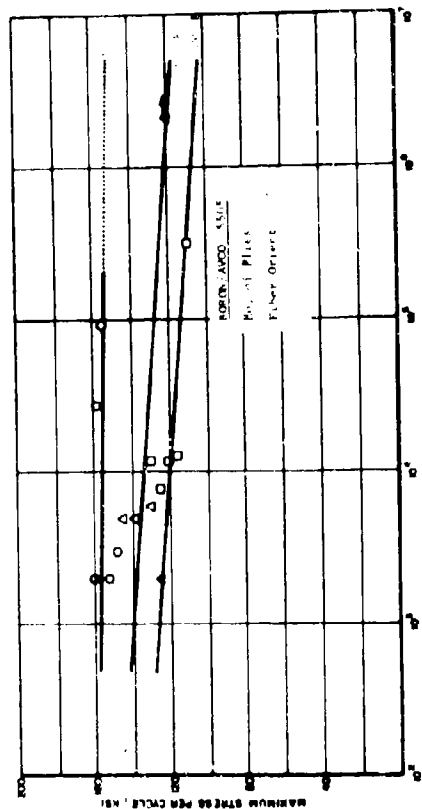
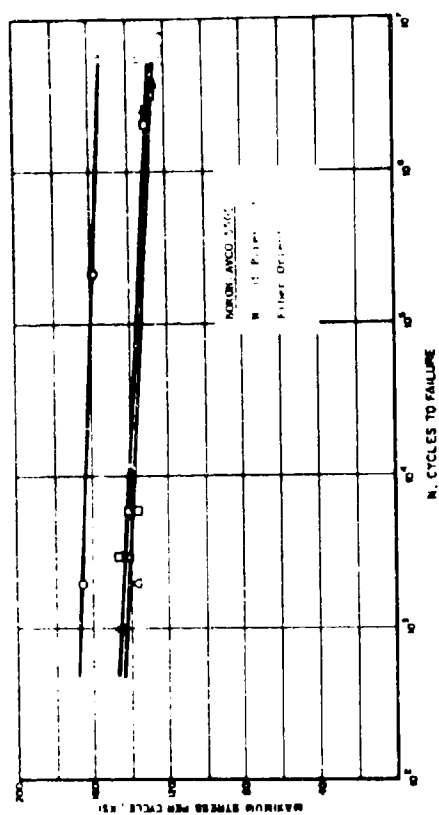


TABLE 1. GLASSMAN FOR 100% AND 150% COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE No. 1 (Thermo-Humidity Cycle)
 $R = 0.1$
 $R = 0.1$ (PM)

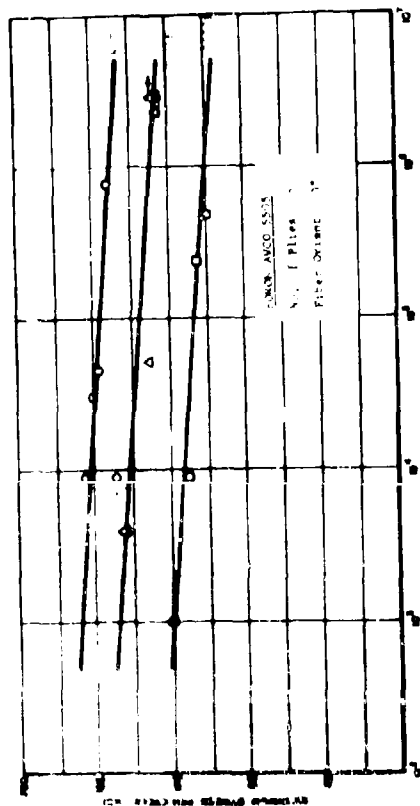


FIG. 207 FATIGUE S-N DIAGRAM FOR 0° KEVLAR/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO 260°F (R = 0.1, f = 1500 cpm)

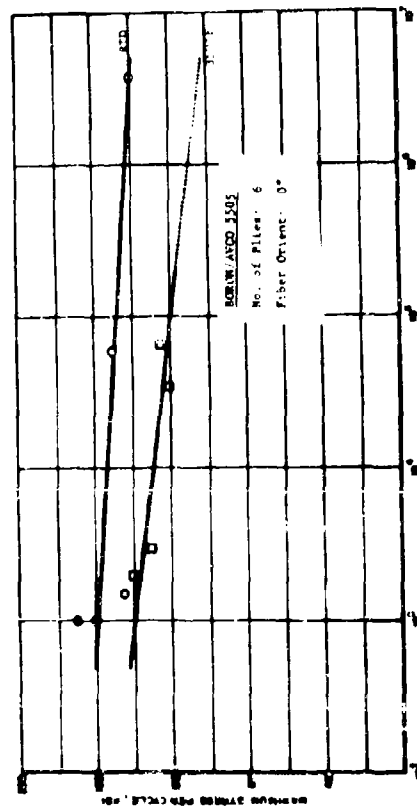


FIG. 208 FATIGUE S-N DIAGRAM FOR 0° KEVLAR/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO 350°F (R = 0.1, f = 1500 cpm)

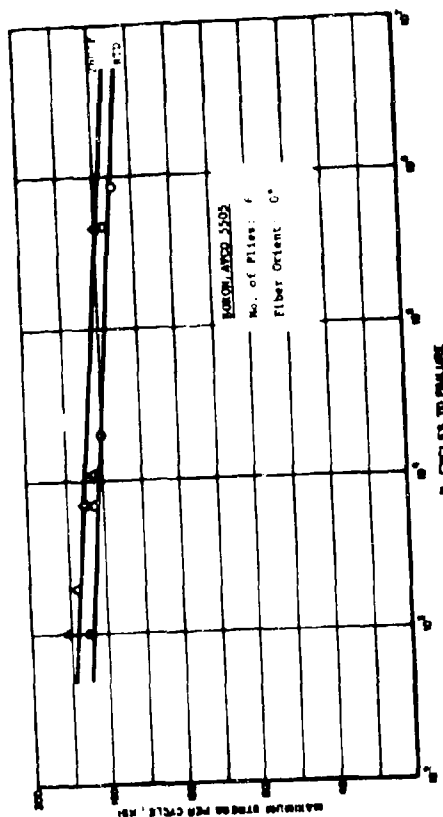


FIG. 209 FATIGUE S-N DIAGRAM FOR 0° KEVLAR/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 260°F (R = 0.1, f = 1500 cpm)

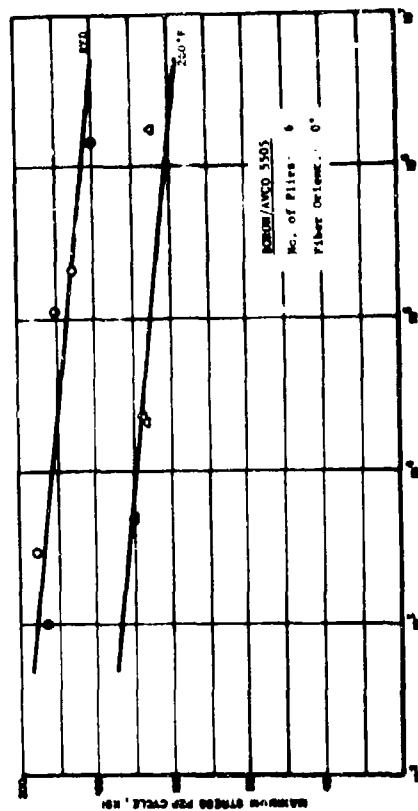


FIG. 210 FATIGUE S-N DIAGRAM FOR 0° KEVLAR/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 260°F (R = 0.1, f = 1500 cpm)

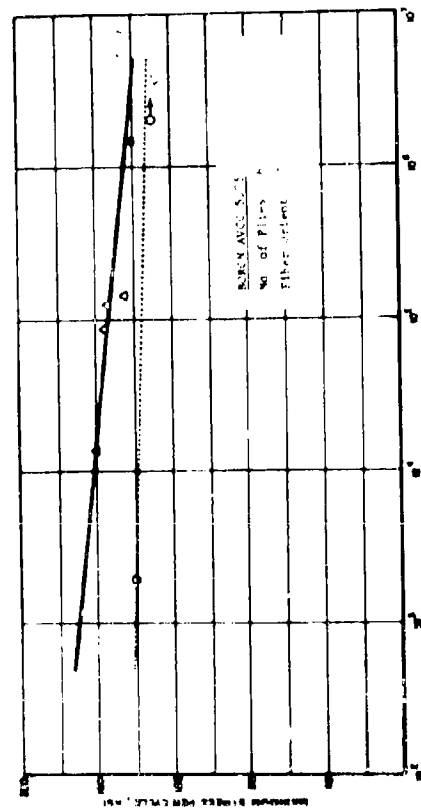


FIG. 210 FATIGUE S-N DIAGRAM FOR 90° BORON/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 350°F (N = 0.1).

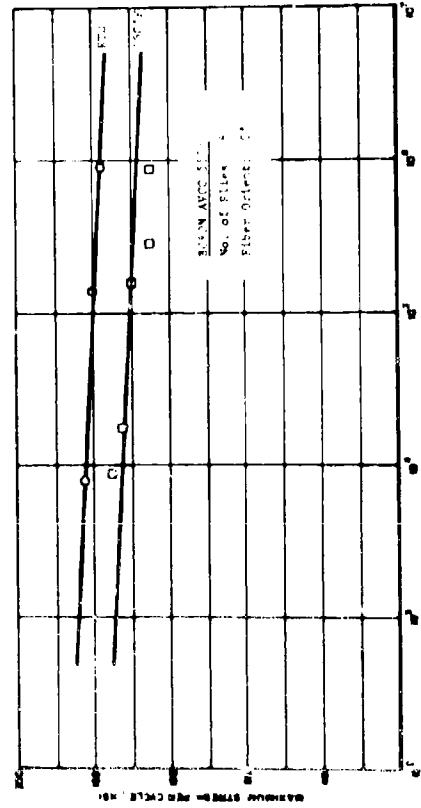


FIG. 211 FATIGUE S-N DIAGRAM FOR 90° BORON/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F (N = 0.1).

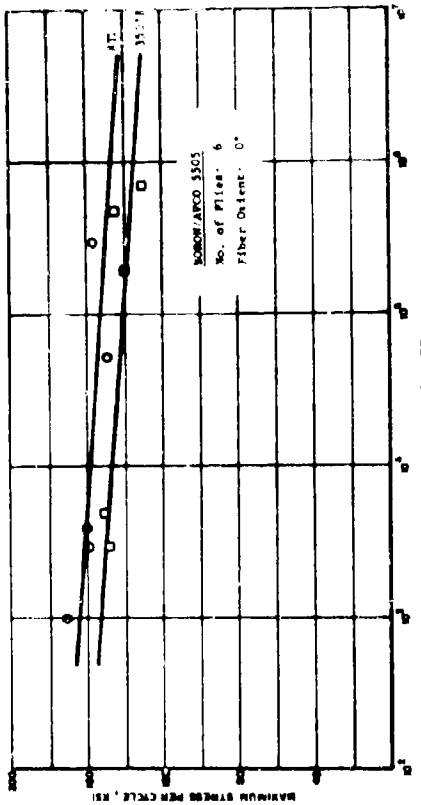


FIG. 212 FATIGUE S-N DIAGRAM FOR 0° BORON/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 350°F (N = 0.1).

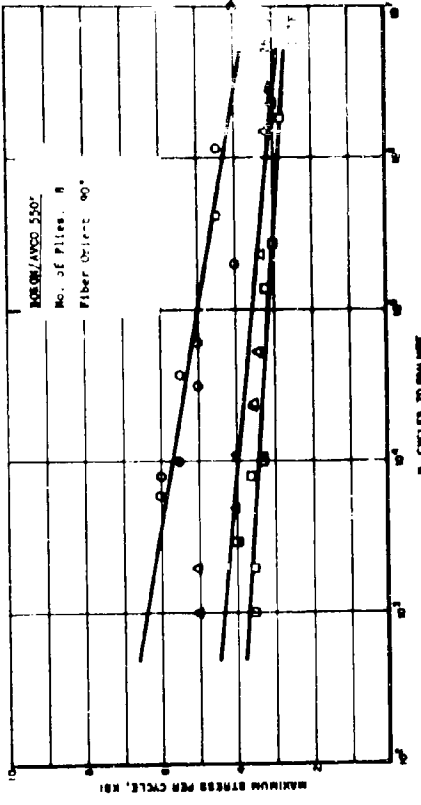


FIG. 213 FATIGUE S-N DIAGRAM FOR 0° BORON/AVCO 5505 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F (N = 0.1).

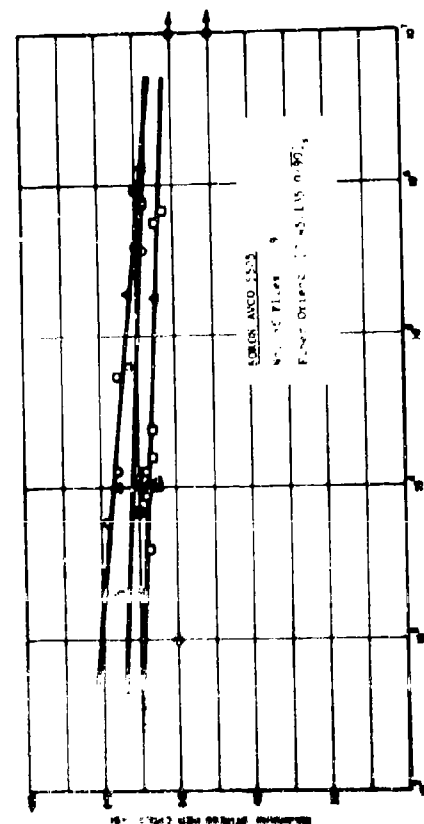


FIG. 215 FATIGUE S-N DIAGRAM FOR BORON/AVCO 5505 (0.45/135/0/90)₄ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 98% R.H. ($R = 0.1$; $\theta = 1000$ CPM)

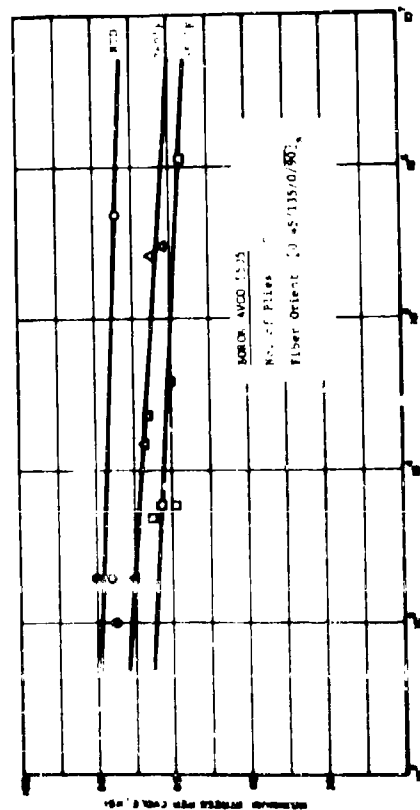


FIG. 216 FATIGUE S-N DIAGRAM FOR BORON/AVCO 5505 (0.45/135/0/90)₄ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 98% R.H. ($R = 0.1$; $\theta = 1000$ CPM)

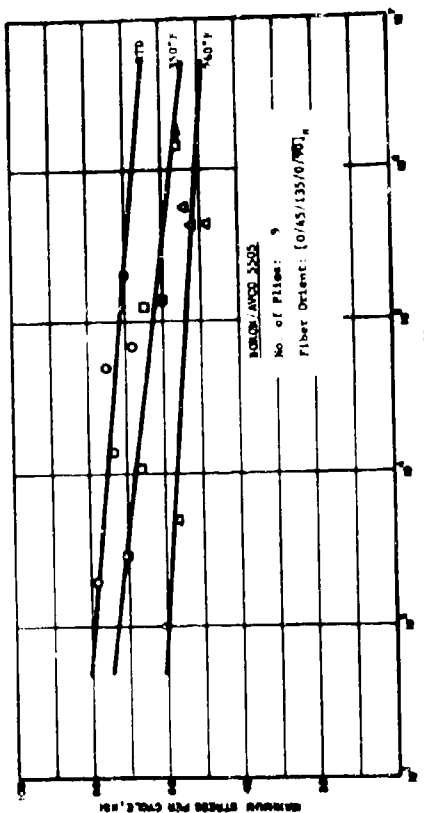


FIG. 217 FATIGUE S-N DIAGRAM FOR BORON/AVCO 5505 (0.45/135/0/90)₄ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 98% R.H. ($R = 0.1$; $\theta = 1000$ CPM)

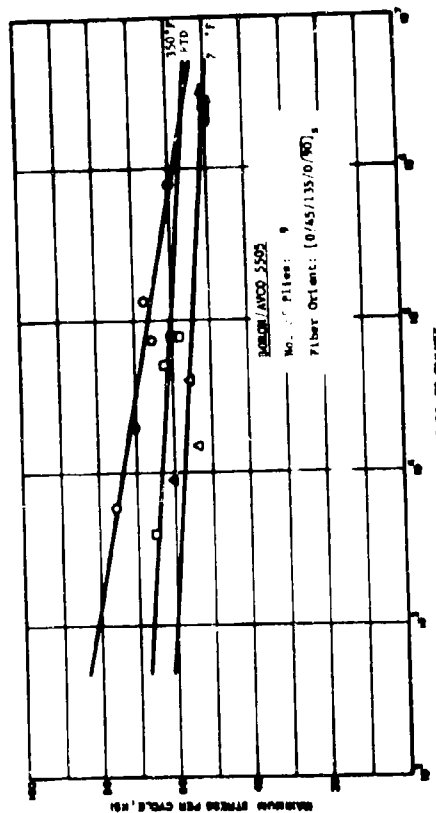


FIG. 218 FATIGUE S-N DIAGRAM FOR BORON/AVCO 5505 (0.45/135/0/90)₄ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle) ($R = 0.1$; $\theta = 1000$ CPM)

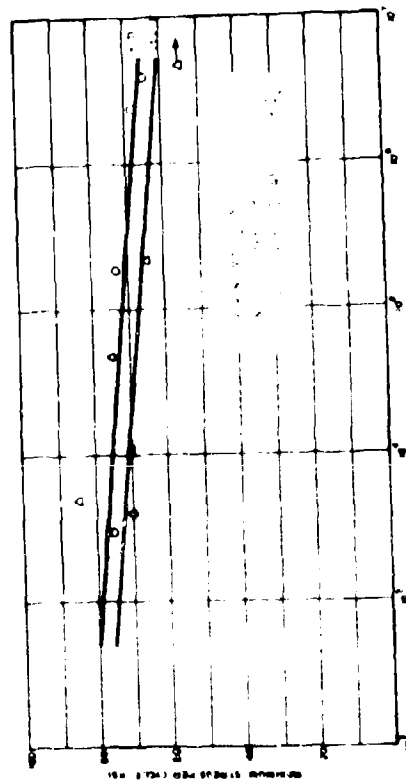
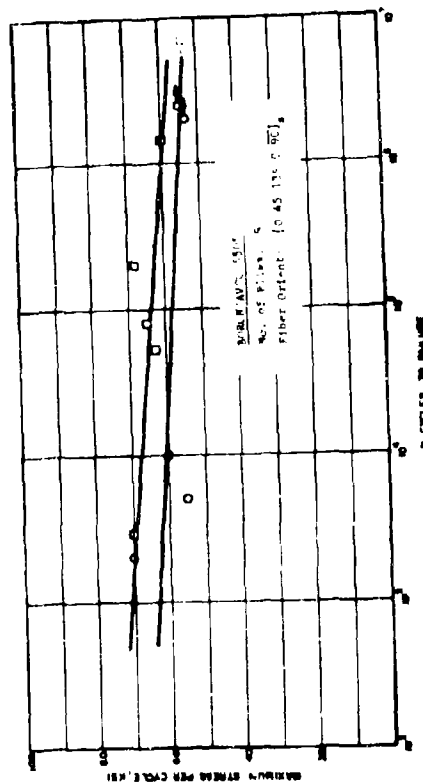


TABLE XIV CREEP AND STRESS RUPTURE PROPERTIES OF
AVCO 5505/BORON COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PULSE CONDITIONING		Test Temp. (°F)	Stress level (% UTS) (ksi)	Time to Failure (hours)	Time Applied without Failure (hours)	Comment
			Type	Duration					
N10078-11	0.031	0°	None		250°F	80	145	1001	
N10078-12	0.031	0°	None		260°F	41	74.3	1000	
N10078-13	0.031	0°	None		260°F	42	74.9	1000	
N10078-14	0.031	0°	None		260°F	41	73.2	1000	
N10078-15	0.030	0°	None		260°F	42	74.6	1000	
N10078-16	0.031	0°	None		260°F	70	127	-	Instantaneous Failure
N10078-17	0.031	0°	None		260°F	43	78.1	1000	
N10078-18	0.031	0°	None		260°F	42	75.6	1000	
N10078-19	0.031	0°	None		260°F	43.3	76.4	1000	
N10078-20	0.031	0°	None		260°F	75	134	-	Failed during loading
N1008A-1	0.031	0°	None		350°F	38	67	1000	
N1008A-2	0.031	0°	None		350°F	38	68.3	1000	
N1008A-3	0.031	0°	None		350°F	75	133	231	
N1008A-4	0.031	0°	None		350°F	80	143	-	1001.4
N1008A-5	0.031	0°	None		350°F	34	64	1000	
N1008A-6	0.031	0°	None		350°F	70	124	-	
N1008A-7	0.031	0°	None		350°F	80	147	6.1	
N1008A-8	0.031	0°	None		350°F	85	151	534	
N1008A-9	0.031	0°	None		350°F	80	143	267	
N1008A-10	0.031	0°	None		350°F	90	154	-	
N1008A-11	0.031	0°	None		350°F	85	150	-	Failed during loading
N1008A-12	0.031	0°	None		350°F	80	142	-	Broke during loading
N1008A-13	0.031	0°	None		350°F	60	104	-	Broke during loading

0.25V

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EXPERIMENTAL STRESS RUPTURE PROPERTIES SUMMARY
AVCO 2205 BORON COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comments
			Type	Duration					
M117-13	8 0.045	90°	None		260°F	70	4.59	-	Failed during loading
M117-14	8 0.044	40°	None		260°F	90	5.90	.033	Tab area failed
M117-15	8 0.043	40°	None		260°F	90	5.90	.016	Tab area failed
M117-16	8 0.045	40°	None		260°F	60	3.93	.413	Strain gage failed
M117-17	8 0.045	90°	None		260°F	80	5.25	-	Failed during loading
M117-18	8 0.045	40°	None		260°F	88	5.72	-	Load applied too quickly
M118-1	8 0.045	90°	None		260°F	85	5.58	-	Failed during loading
M118-2	8 0.043	90°	None		260°F	93	5.45	0.10	-
M118-3	8 0.045	90°	None		260°F	78	5.11	0.008	-
M118-4	8 0.045	90°	None		260°F	75	4.92	15.6	-
M1179-14	8 0.045	90°	None		260°F	55	3.6	1005.3	Lost Strain Gage on Load
M1178-15	8 0.045	90°	None		260°F	65	4.3	1005.1	Lost Strain Gage on Load
M1178-5	8 0.045	90°	None		350°F	70	2.13	-	Failed during loading
M1178-6	8 0.045	90°	None		350°F	70	2.13	110	-
M1178-7	8 0.045	90°	None		350°F	75	2.28	541	-
M1178-8	8 0.045	90°	None		350°F	75	2.28	498	-
M1178-9	8 0.045	90°	None		350°F	80	2.44	387	-
M1178-10	8 0.044	90°	None		350°F	80	2.44	607	-
M1178-11	8 0.045	90°	None		350°F	85	2.58	64	-
M118-12	8 0.045	90°	None		350°F	85	2.58	154.3	-
M118-13	8 0.045	90°	None		350°F	90	2.74	126.8	-
M118-14	8 0.044	90°	None		350°F	90	2.74	14.8	-

Strain gage failed after 193 hrs.

Specimen Number	Thickness Piles) (In.)	Orientation	EXPOSURE CONDITIONING		Test Temp. (°F)	Stress Level (ksi)	Time to Failure (hours)	Applied Without Failure (hours)	Comment
			Type	Duration					
N1048-1	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-2	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-3	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-4	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-5	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-6	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-7	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-8	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-9	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-10	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-11	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-12	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-13	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-14	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-15	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-16	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-17	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-18	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-19	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-20	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-21	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-22	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-23	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-24	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-25	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-26	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-27	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-28	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-29	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-30	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-31	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-32	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-33	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-34	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-35	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-36	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-37	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-38	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-39	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-40	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-41	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-42	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-43	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-44	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-45	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-46	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-47	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-48	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-49	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-50	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-51	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-52	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-53	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-54	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-55	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-56	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-57	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-58	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-59	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-60	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-61	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-62	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-63	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-64	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-65	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-66	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-67	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-68	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-69	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-70	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-71	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-72	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-73	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-74	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-75	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-76	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-77	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-78	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-79	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-80	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-81	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-82	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-83	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-84	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-85	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-86	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-87	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-88	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-89	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-90	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-91	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-92	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-93	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-94	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-95	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-96	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-97	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-98	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-99	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load
N1048-100	0.031	0	48 RH	500 hrs.	20 F	4	-	-	Tab failure - broke during load

TABLE XIV. CARBON FIBER REINFORCED POLYESTER COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	Prior Conditioning		Test Temp. (°F)	Stress Level (% ult) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
N1048-16	6	0°	Thermo-Humidity Cycle		350°F	65	114.0	1.50	Tab failure
N1048-17	6	0°	Thermo-Humidity Cycle		350°F	64	112.8	0.82	Broke during loading - near middle
N1048-18	6	0°	Thermo-Humidity Cycle		350°F	63	110.4	0.47	Broke during loading - near middle
N1048-19	6	0°	Thermo-Humidity Cycle		350°F	61	108.0	320	Broke 1/2" from tab
N1048-20	6	0°	Thermo-Humidity Cycle		350°F	67	117.6	-	Tab failure - broke during loading
N1048-31	6	0°	Thermo-Humidity Cycle		350°F	34.5	68.3	-	1000
N1048-39	6	0°	Thermo-Humidity Cycle		350°F	38	67	-	1000
N1048-34	6	0°	Thermo-Humidity Cycle		350°F	36	63	117.6	-
N10098-20	6	0°	Acc. Wthrg.		260°F	91	143	419	-
N1010A-1	6	0°	Acc. Wthrg.		260°F	89	139	921	-
N1010A-2	6	0°	Acc. Wthrg.		260°F	87	136	-	1000
N1010A-3	6	0°	Acc. Wthrg.		260°F	85	130	-	1000
N1010A-4	6	0°	Acc. Wthrg.		260°F	83	130	11.4	-
N1010A-10	6	0°	Acc. Wthrg.		350°F	90	131	-	Failed during loading
N1010A-11	6	0°	Acc. Wthrg.		350°F	92	134	-	Failed during loading
N1010A-12	6	0°	Acc. Wthrg.		350°F	94	137	-	Failed during loading
N1010A-13	6	0°	Acc. Wthrg.		350°F	96	140	-	Failed during loading
N1010A-14	6	0°	Acc. Wthrg.		350°F	98	143	-	Failed during loading
N1049-1	9	[0/45/135/0/90] _g	98% R _g / 500 Hrs.		260°F	98	79	.016	Broke at tab
N1049-2	9	"	98% R _g / 500 Hrs.		260°F	97	78	2	Broke at Tab
N1049-3	9	"	98% R _g / 500 Hrs.		260°F	98	79	-	Broke during loading
N1049-4	9	"	98% R _g / 500 Hrs.		260°F	98	79	1	Broke at tab
N1049-5	9	"	98% R _g / 500 Hrs.		260°F	98	79	1	Broke at tab
N1049-6	9	"	98% R _g / 500 Hrs.		350°F	98	61.1	252.2	Tab failure - slipped 1/8"
N1049-7	9	"	98% R _g / 500 Hrs.		350°F	90	62.5	183.2	-
N1049-8	9	"	98% R _g / 500 Hrs.		350°F	93	64.6	5.1	-
N1049-9	9	"	98% R _g / 500 Hrs.		350°F	95	66.0	239.8	-
N1049-10	9	[0/45/135/0/90] _g	98% R _g / 500 Hrs.		350°F	98	68.1	168.9	-

TABLE XIV CREEP AND STRESS RUPTURE PROPERTIES - SUMMARY
AVCO 5505 BORON CARBIDES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING Type	Duration	Test Temp. (°F)	Stress Level (% ult) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
N1037B-1	9	0.051	[0/45/135/0/90] _s	98% RH	260°F	92	70.6	-	
N1037B-2	9	0.052	"	98% RH / 1000 Hrs.	260°F	90	69.2	51.5	
N1037B-3	9	0.052	"	98% RH / 1000 Hrs.	260°F	86	66.1	-	Oven overheated
N1037B-4	9	0.051	"	98% RH / 1000 Hrs.	260°F	80	61.5	1000	
N1037B-5	9	0.051	"	98% RH / 1000 Hrs.	260°F	-	-	-	Spec. broke during fabrication
N1038A-1	9	0.051	"	98% RH / 1000 Hrs.	350°F	96	71.4	96.3	
N1038A-2	9	0.051	"	98% RH / 1000 Hrs.	350°F	98	72.9	0.134	
N1038A-3	9	0.050	"	98% RH / 1000 Hrs.	350°F	93	69.2	336	
N1038A-4	9	0.051	"	98% RH / 1000 Hrs.	350°F	91	67.7	-	1000
N1038A-5	9	0.050	[0/45/135/0/90] _s	98% RH / 1000 Hrs.	350°F	88	65.4	-	1001
N1049-11	9	0.048	[0/45/135/0/90] _s	Thermo-Humidity Cycle	260°F	95	76.5	1	Tab failure
N1049-12	9	0.049	"	Thermo-Humidity Cycle	260°F	98	78	-	Specimen broke during loading
N1049-13	9	0.048	"	Thermo-Humidity Cycle	260°F	90	71.5	-	Specimen broke during loading
N1049-14	9	0.048	"	Thermo-Humidity Cycle	260°F	85	67.6	-	Specimen broke during loading
N1049-15	9	0.049	"	Thermo-Humidity Cycle	260°F	90	71.5	-	Specimen broke during loading
N1049-21	9	0.048	"	Thermo-Humidity Cycle	260°F	99	79.8	-	Broke during loading
N1049-34	9	0.048	"	Thermo-Humidity Cycle	260°F	98	79.0	-	Broke during loading
N1049-35	9	0.047	[0/45/135/0/90] _s	Thermo-Humidity Cycle	260°F	97	78.2	-	Broke during loading
N1049-16	9	0.048	[0/45/135/0/90] _s	Thermo-Humidity Cycle	350°F	86	58.3	335	
N1049-17	9	0.048	"	Thermo-Humidity Cycle	350°F	89	60.3	1.0	
N1049-18	9	0.048	"	Thermo-Humidity Cycle	350°F	88	52.6	27 min	
N1049-19	9	0.048	"	Thermo-Humidity Cycle	350°F	95	64.4	-	Broke during loading
N1049-20	9	0.048	"	Thermo-Humidity Cycle	350°F	98	66.3	-	Broke during loading
N1049-22	9	0.048	"	Thermo-Humidity Cycle	350°F	90	60.9	8 min	
N1049-38	9	0.047	[0/45/135/0/90] _s	Thermo-Humidity Cycle	350°F	87	58.9	-	Broke during loading

TABLE XIV CREEP AND STRESS RUPTURE PROPERTIES SUMMARY
AVCO 5505/BORON COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (Z _{ult})	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
1037B-6	9	0.051	[0.45/135/0/90] _B	Acc. Wthrg.	260°F	94	167.9	-	Strain gage failed
1037B-7	9	0.051	"	Acc. Wthrg.	260°F	96	31.6	-	Strain gage failed
1037B-8	9	0.051	"	Acc. Wthrg.	260°F	98	14.4	-	
1037B-9	9	0.051	"	Acc. Wthrg.	260°F	90	66.2	1001	
1037B-10	9	0.051	"	Acc. Wthrg.	260°F	92	66.7	1001	
1038A-6	9	0.050	"	Acc. Wthrg.	350°F	93	53.6	1001	
1038A-7	9	0.050	"	Acc. Wthrg.	350°F	95	65	1001	
1038A-8	9	0.050	"	Acc. Wthrg.	350°F	98	67	116	
1038A-9	9	0.050	"	Acc. Wthrg.	350°F	90	61.5	1001	
1038A-10	9	0.050	[0.45/135/0/90] _S	Acc. Wthrg.	350°F	88	60.1	1000	
1011B-16	6	0.032	0°	Steady 260°F/500 Hrs.	260°F	70	118	198	
1011B-17	6	0.034	0°	Steady 260°F/500 Hrs.	260°F	75	127	-	1001
1011B-18	6	0.033	0°	Steady 260°F/500 Hrs.	260°F	80	135	4.0	
1011B-19	6	0.033	0°	Steady 260°F/500 Hrs.	260°F	85	134	-	1000
1011B-20	6	0.033	0°	Steady 260°F/500 Hrs.	260°F	90	152	-	Failed in loading
1012A-1	6	0.034	0°	Steady 260°F/500 Hrs.	350°F	95	144	-	Failed in loading
1012A-2	6	0.034	0°	Steady 260°F/500 Hrs.	350°F	92	140	.014	
1012A-3	6	0.033	0°	Steady 260°F/500 Hrs.	350°F	90	137	.05	
1012A-4	6	0.034	0°	Steady 260°F/500 Hrs.	350°F	88	134	.067	
1012A-5	6	0.034	0°	Steady 260°F/500 Hrs.	350°F	85	129	1.0	
1012A-16	6	0.033	0°	Steady 350°F/500 Hrs.	260°F	93	167	-	Failed during loading
1012A-17	6	0.033	0°	Steady 350°F/500 Hrs.	260°F	94	169	-	Failed during loading
1012A-18	6	0.033	0°	Steady 350°F/500 Hrs.	260°F	90	161	-	Failed during loading
1012A-19	6	0.033	0°	Steady 350°F/500 Hrs.	260°F	91	163	-	Immediate failure
1012A-20	6	0.033	0°	Steady 350°F/500 Hrs.	260°F	89	160	-	Failed during loading
1012B-1	6	0.035	0°	Steady 350°F/500 Hrs.	350°F	93	162	-	Immediate failure
1012B-2	6	0.035	0°	Steady 350°F/500 Hrs.	350°F	80	139	1000	Strain gage failed after .25 hr.
1012B-3	6	0.033	0°	Steady 350°F/500 Hrs.	350°F	92	161	-	Immediate failure
1012B-4	6	0.033	0°	Steady 350°F/500 Hrs.	350°F	88	153	-	Immediate failure
1012B-5	6	0.033	0°	Steady 350°F/500 Hrs.	350°F	90	157	0.6	

TABLE XIV CREEP AND STRESS RUPTURE PROPERTIES SUMMARY
AV-19 5505 BORON COMPOSITES

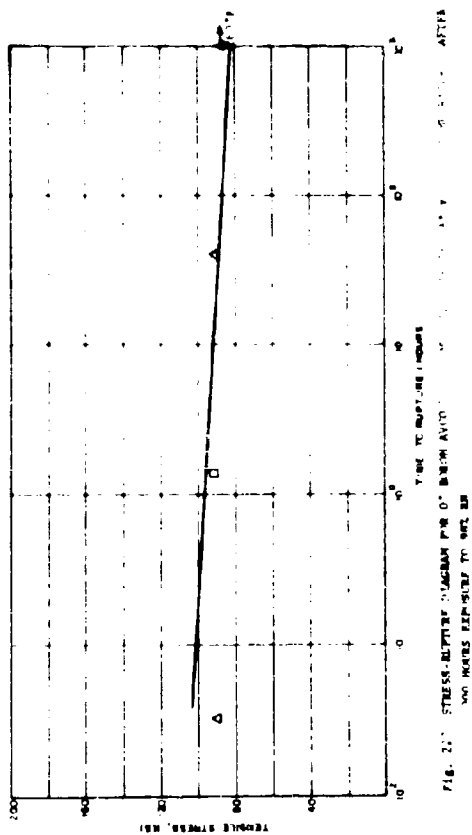
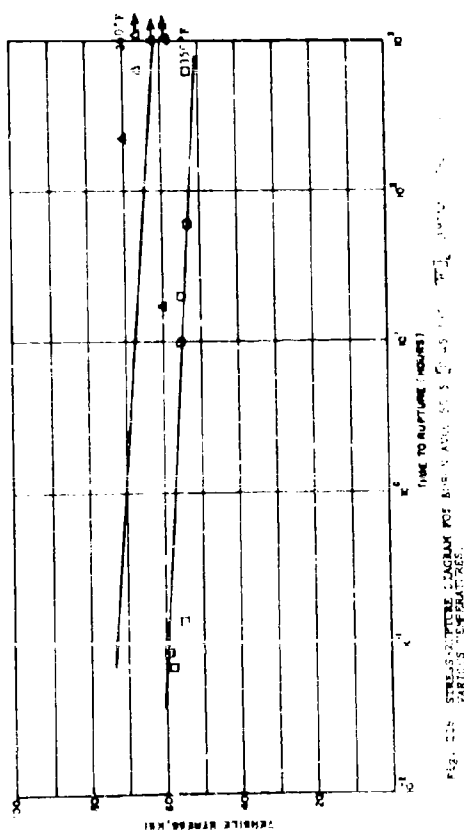
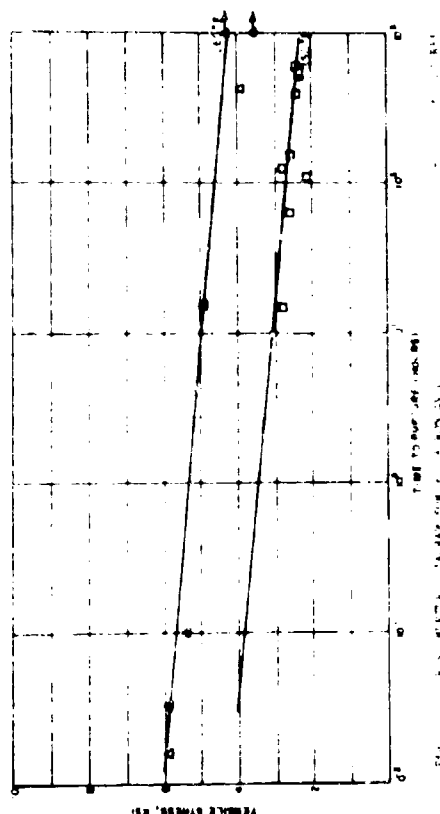
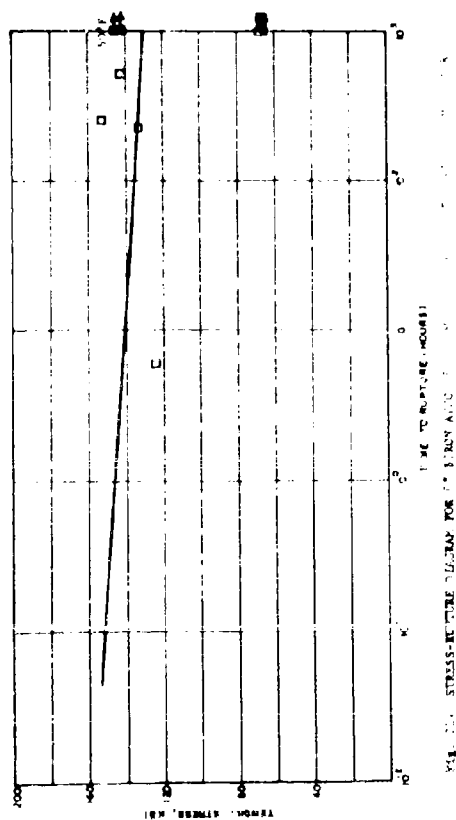
Specimen Number	Thickness (plies) (in.)	Orientation	PRIME CONDITIONING		Test Temp. (°F)	Stress Level (% ult) (ksi)	Time to Failure (Hours)	Time Applied Without Failure (Hours)	Comment
M1041B-1	9 0.050	[0/45/135/0/90] _g	Steady	260°F/500 Hrs.	260°F	70	58.9	-	Ovens overheated, spec. delaminated
M1041B-2	9 0.049	"	Steady	260°F/500 Hrs.	260°F	75	61.1	-	
M1041B-3	9 0.049	"	Steady	260°F/500 Hrs.	260°F	80	67.3	3.7	
M1041B-4	9 0.050	"	Steady	260°F/500 Hrs.	260°F	85	71.6	-	1012
M1041B-5	9 0.049	"	Steady	260°F/500 Hrs.	260°F	90	75.8	-	Immediate failure
M1041B-6	9 0.051	"	Steady	260°F/500 Hrs.	350°F	94	79	.016	
M1041B-7	9 0.050	"	Steady	260°F/500 Hrs.	350°F	90	75.6	.1	
M1041B-8	9 0.051	"	Steady	260°F/500 Hrs.	350°F	88	74	.33	Strain Gage Failed
M1041B-9	9 0.050	"	Steady	260°F/500 Hrs.	350°F	85	71.4	.51	Strain Gage Failed
M1041B-10	9 0.051	[0/45/135/0/90] _g	Steady	260°F/500 Hrs.	350°F	80	67.2	49.4	Strain Gage Failed
M1042B-1	9 0.052	[0/45/135/0/90] _g	Steady	350°F/500 Hrs.	260°F	95	75.6	.01	
M1042B-2	9 0.052	"	Steady	350°F/500 Hrs.	260°F	92	73.2	102	
M1042B-3	9 0.051	"	Steady	350°F/500 Hrs.	260°F	94	74.8	.016	
M1042B-4	9 0.051	"	Steady	350°F/500 Hrs.	260°F	88	70.0	24.6	
M1042B-5	9 0.051	"	Steady	350°F/500 Hrs.	260°F	90	71.6	.25	Strain gage failed
M1042B-6	9 0.052	"	Steady	350°F/500 Hrs.	350°F	94	75.7	.016	
M1042B-7	9 0.051	"	Steady	350°F/500 Hrs.	350°F	90	72.5	.25	Strain gage failed
M1042B-8	9 0.051	"	Steady	350°F/500 Hrs.	350°F	88	70.9	16.5	
M1042B-9	9 0.050	"	Steady	350°F/500 Hrs.	350°F	84	67.7	42.6	Strain gage failed after .05 hr.
M1042B-10	9 0.050	[0/45/135/0/90] _g	Steady	350°F/500 Hrs.	350°F	80	64.4	96.4	Strain gage failed after 1 hour

TABLE XIV CRACK AND DISCONTINUITY DEVELOPMENT SUMMARY
FOR 1000 PSI STRESS

Specimen Number	Thickness (Plies) (In.)	Orientation	Prior Conditioning Type	Duration	Test Temp. (°F)	Stress Level (ksi) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
N1012A-6	6	0°	Cyclic 260°F / 1000 cye.		260°F	70	123	1000	
N1012A-7	6	0°	Cyclic 260°F / 1000 cye.		260°F	75	131	-	Oven overheated
N1012A-8	6	0°	Cyclic 260°F / 1000 cye.		260°F	80	140	384	
N1012A-9	6	0°	Cyclic 260°F / 1000 cye.		260°F	85	149	316	
N1012A-10	6	0°	Cyclic 260°F / 1000 cye.		260°F	90	158	-	Failed in Loading
N1012A-11	-	0°	Cyclic 260°F / 1000 cye.		350°F	-----	OVEN OVERHEATED DURING PRECONDITIONING	-----	-----
N1012A-12	-	0°	Cyclic 260°F / 1000 cye.		350°F	-----	OVEN OVERHEATED DURING PRECONDITIONING	-----	-----
N1012A-13	-	0°	Cyclic 260°F / 1000 cye.		350°F	-----	OVEN OVERHEATED DURING PRECONDITIONING	-----	-----
N1012A-14	-	0°	Cyclic 260°F / 1000 cye.		350°F	-----	OVEN OVERHEATED DURING PRECONDITIONING	-----	-----
N1012A-15	-	0°	Cyclic 260°F / 1000 cye.		350°F	-----	OVEN OVERHEATED DURING PRECONDITIONING	-----	-----
N1012B-6	6	0°	Cyclic 350°F / 1000 cye.		260°F	102	153	-	Failed in Loading
N1012B-7	6	0°	Cyclic 350°F / 1000 cye.		260°F	98	147	409	
N1012B-8	6	0°	Cyclic 350°F / 1000 cye.		260°F	97	145	495.4	
N1012B-9	6	0°	Cyclic 350°F / 1000 cye.		260°F	93	140	-	1003
N1012B-10	6	0°	Cyclic 350°F / 1000 cye.		260°F	90	135	385	
N1012B-11	6	0°	Cyclic 350°F / 1000 cye.		350°F	70	98.7	-	1000
N1012B-12	6	0°	Cyclic 350°F / 1000 cye.		350°F	75	106	905	Strain gage failed
N1012B-13	6	0°	Cyclic 350°F / 1000 cye.		350°F	80	113	-	1004
N1012B-14	6	0°	Cyclic 350°F / 1000 cye.		350°F	85	120	22.6	-
N1012B-15	6	0°	Cyclic 350°F / 1000 cye.		350°F	90	127	-	1000
N1042A-1	9	[0/45/135/0/90]	Cyclic 260°F / 1000 cye.		260°F	90	77.3	103	Strain gage failed
N1042A-2	9	"	Cyclic 260°F / 1000 cye.		260°F	85	73	439	-
N1042A-3	9	"	Cyclic 260°F / 1000 cye.		260°F	97	83.3	008	-
N1042A-4	9	"	Cyclic 260°F / 1000 cye.		260°F	94	80.7	18	Strain gage failed
N1042A-5	9	"	Cyclic 260°F / 1000 cye.		260°F	80	68.7	-	1000
N1042A-6	9	"	Cyclic 260°F / 1000 cye.		350°F	94	80.6	008	Strain gage failed
N1042A-7	9	"	Cyclic 260°F / 1000 cye.		350°F	90	77.2	24.8	-
N1042A-8	9	"	Cyclic 260°F / 1000 cye.		350°F	88	75.5	91.4	-
N1042A-9	9	"	Cyclic 260°F / 1000 cye.		350°F	84	72	201	-
N1042A-10	9	[0/45/135/0/90]	Cyclic 260°F / 1000 cye.		350°F	80	68.6	304	Strain gage failed

TABLE CIV CREEP AND STRESS RUTTING TESTS
AVCO 5505 BORON CARBIDE

Specimen Number	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
N1041C-1	9 0.050	[0/45/135/0/90] _s	Cyclic	350°F / 1000 cye.	260°F	90 96.3	-	1000	
N1041C-2	9 0.050	"	Cyclic	350°F / 1000 cye.	260°F	95 70	488	-	
N1041C-3	9 0.050	"	Cyclic	350°F / 1000 cye.	260°F	98 72.2	-	-	Broke during loading
N1041C-4	9 0.050	"	Cyclic	350°F / 1000 cye.	260°F	96 70.7	-	-	Broke during loading
N1041C-5	9 0.050	"	Cyclic	350°F / 1000 cye.	260°F	93 68.5	-	-	Broke during loading
N1041C-6	9 0.051	"	Cyclic	350°F / 1000 cye.	350°F	85 53.1	25.7	-	
N1041C-7	9 0.051	"	Cyclic	350°F / 1000 cye.	350°F	83 51.8	-	1000	
N1041C-8	9 0.050	"	Cyclic	350°F / 1000 cye.	350°F	88 55	-	-	Oven overheated
N1041C-9	9 0.050	"	Cyclic	350°F / 1000 cye.	350°F	90 56.2	-	-	
N1041C-10	9 0.050	[0/45/135/0/90] _s	Cyclic	350°F / 1000 cye.	350°F	90 56.2	3.4	-	



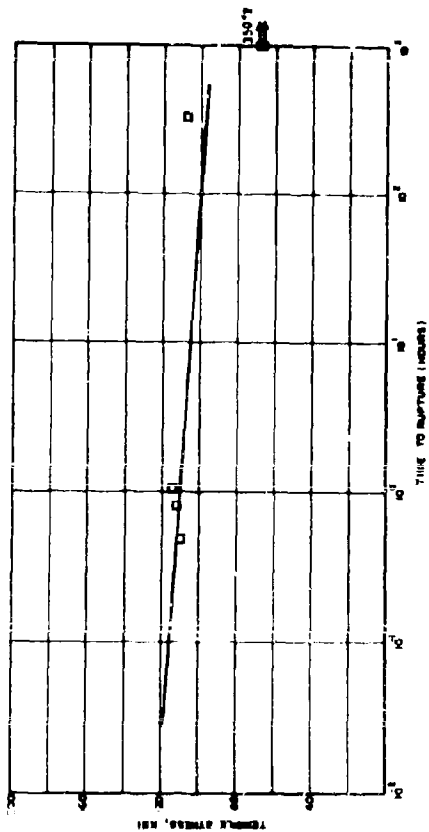


FIG. 220 STRESS-STRAIN DIAGRAM FOR 0.4 INCH/AVO 550 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Therm-Humidity Cycle)

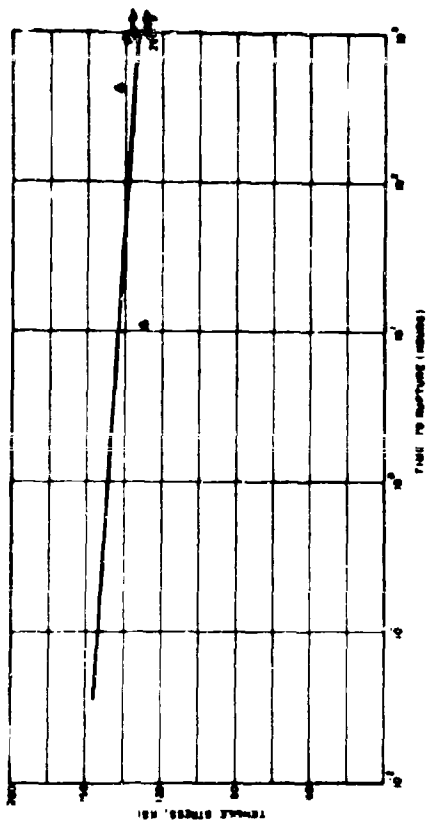


FIG. 224 STRESS-STRAIN DIAGRAM FOR 0.4 INCH/AVO 550 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

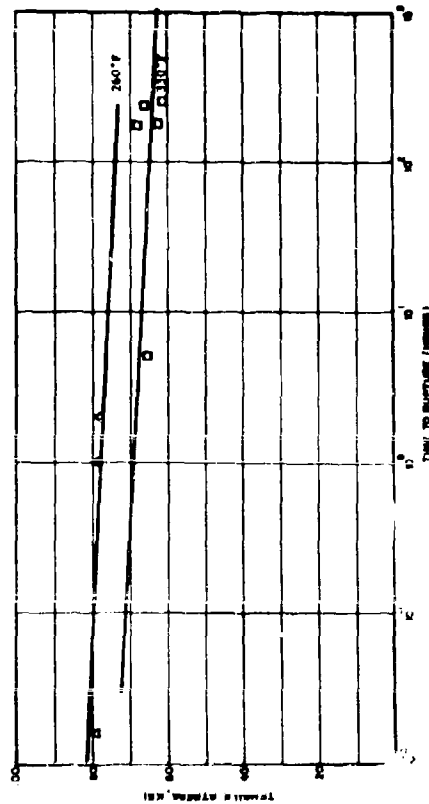


FIG. 230 STRESS-STRAIN DIAGRAM FOR 0.4 INCH/AVO 550 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO WET AIR

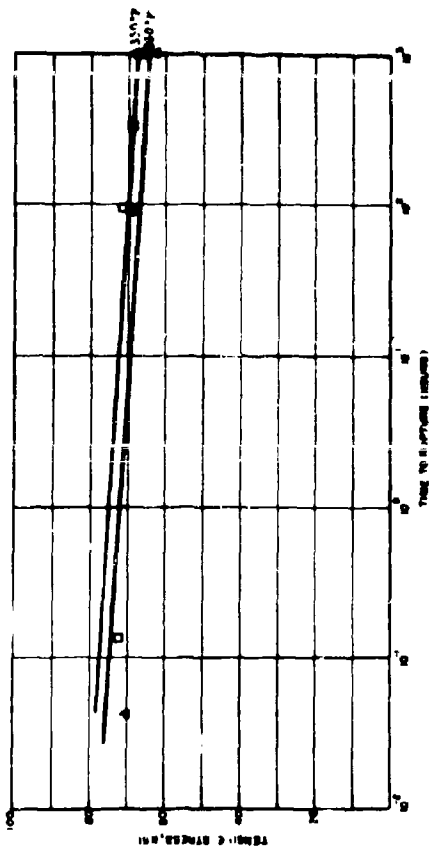


FIG. 231 STRESS-STRAIN DIAGRAM FOR 0.4 INCH/AVO 550 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO WET AIR

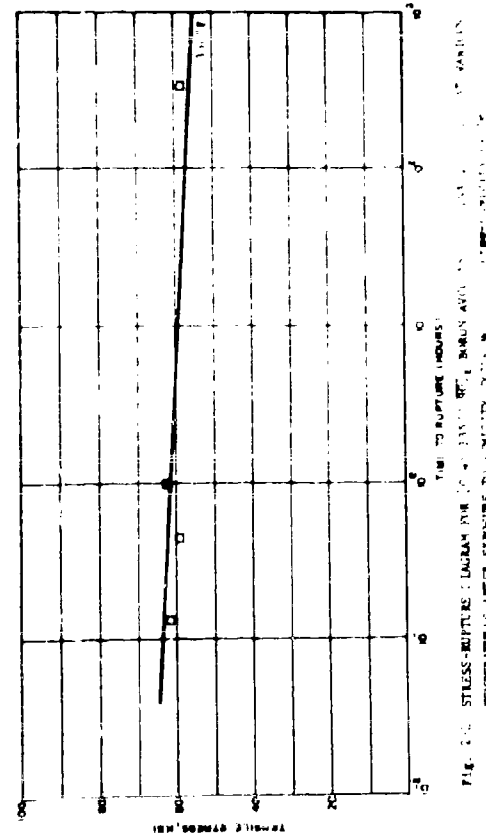


FIG. 2-6 STRESS-RUPTURE DIAGRAM FOR 100% HUMIDITY AT 100°C. (STRESS IN KILOGRAMS PER SQUARE CENTIMETER)

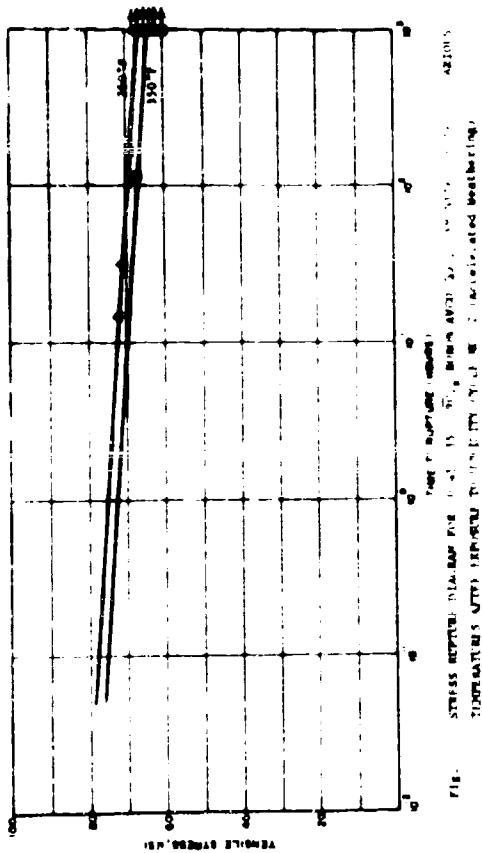


FIG. 2-7 STRESS-RUPTURE DIAGRAM FOR 100% HUMIDITY AT 125°C. (STRESS IN KILOGRAMS PER SQUARE CENTIMETER)

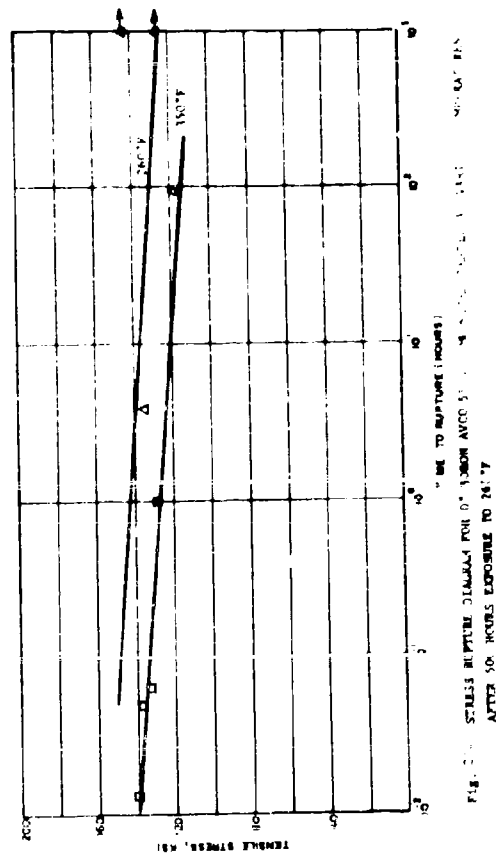


FIG. 2-8 STRESS-RUPTURE DIAGRAM FOR 100% HUMIDITY AT 150°C. (STRESS IN KILOGRAMS PER SQUARE CENTIMETER)

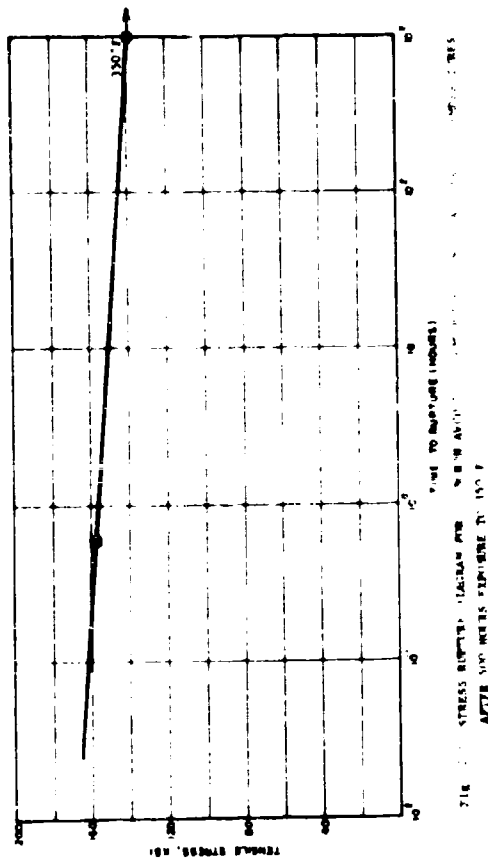


FIG. 2-9 STRESS-RUPTURE DIAGRAM FOR 100% HUMIDITY AT 175°C. (STRESS IN KILOGRAMS PER SQUARE CENTIMETER)

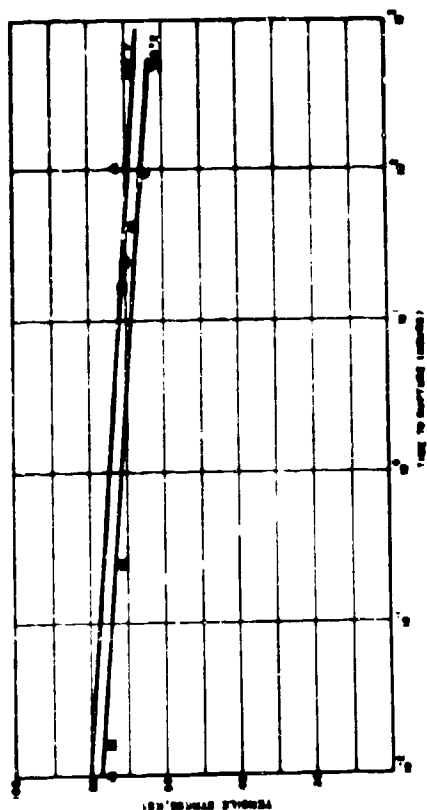


FIG. 21 STRESS-RUPTURE DIAGRAM FOR 0.45/135/0/80% BORON/ARCOS 5405 LAMINATES TESTED AT 350°F

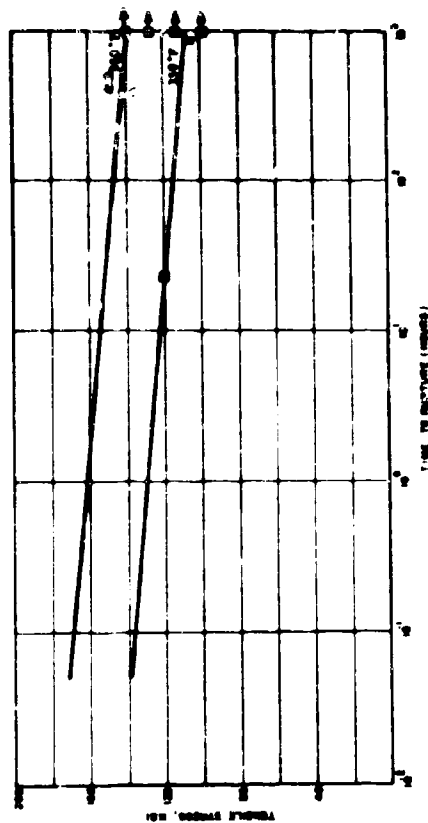


FIG. 21a STRESS-RUPTURE DIAGRAM FOR 0.45/135/0/80% BORON/ARCOS 5405 LAMINATES TESTED AT 350°F AFTER 1000 CYCLES EXPOSURE TO 350°F

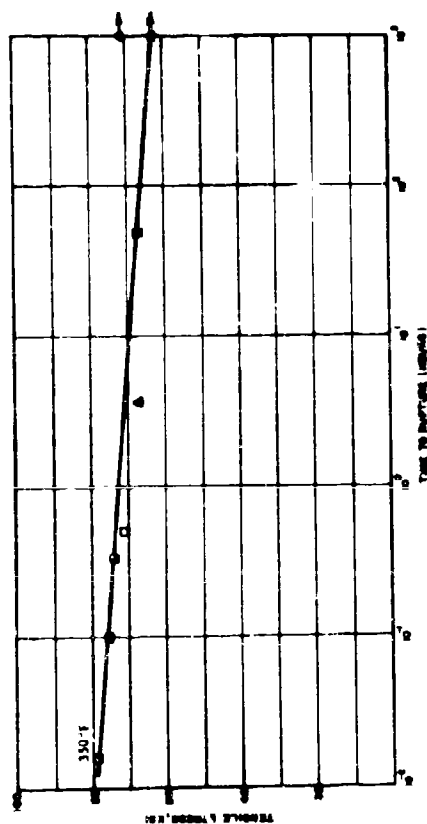


FIG. 22 STRESS-RUPTURE DIAGRAM FOR 0.45/135/0/80% BORON/ARCOS 5405 LAMINATES TESTED AT 260°F

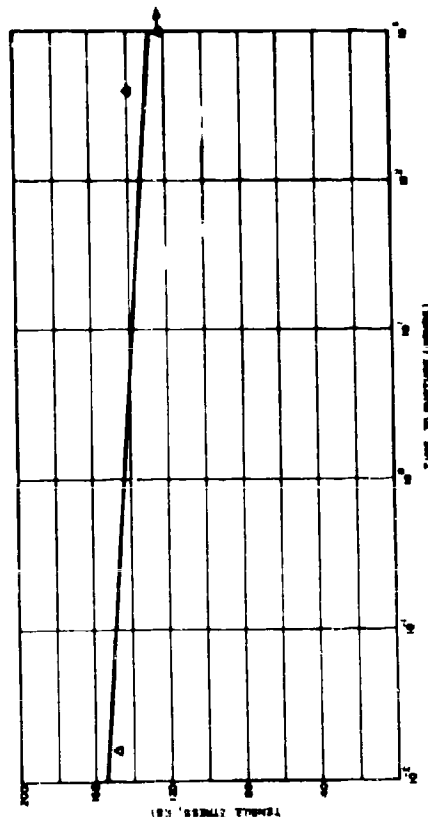


FIG. 22a STRESS-RUPTURE DIAGRAM FOR 0.45/135/0/80% BORON/ARCOS 5405 LAMINATES TESTED AT 260°F AFTER 1000 CYCLES EXPOSURE TO 260°F

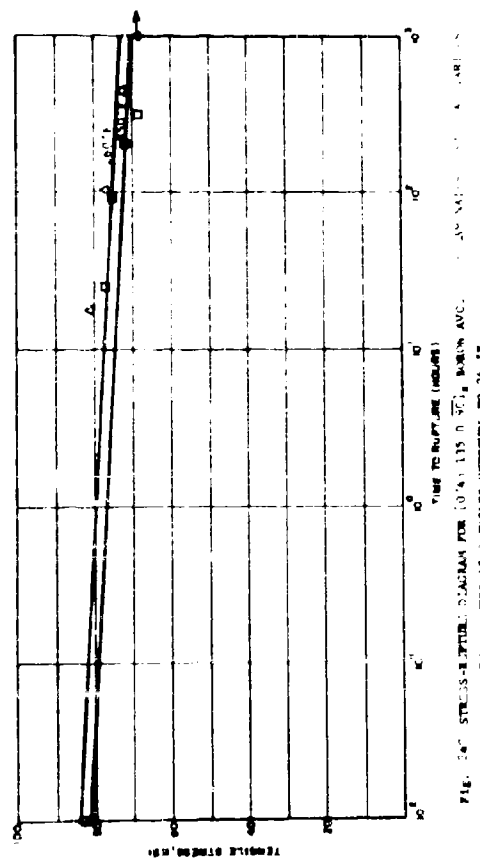


FIG. 240 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR J-AY-20 5505 NKRON COMPOSITES TESTED AT 260°F

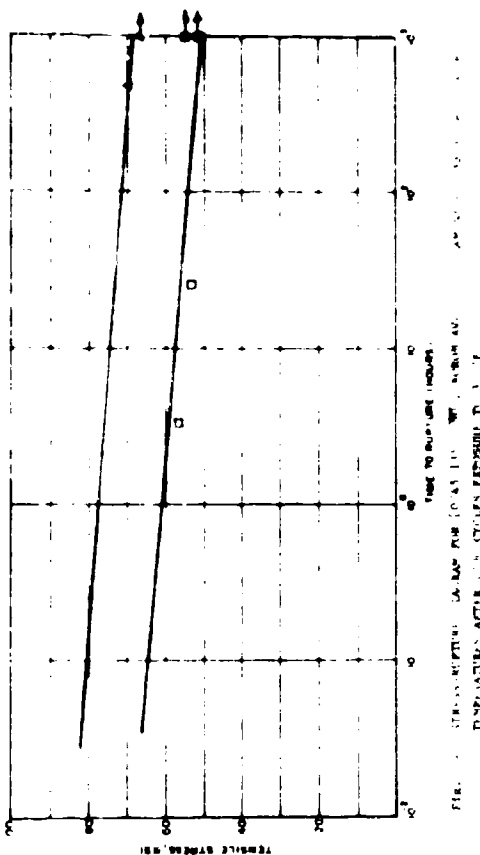


FIG. 241 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR J-AY-20 5505 NKRON COMPOSITES TESTED AT 260°F

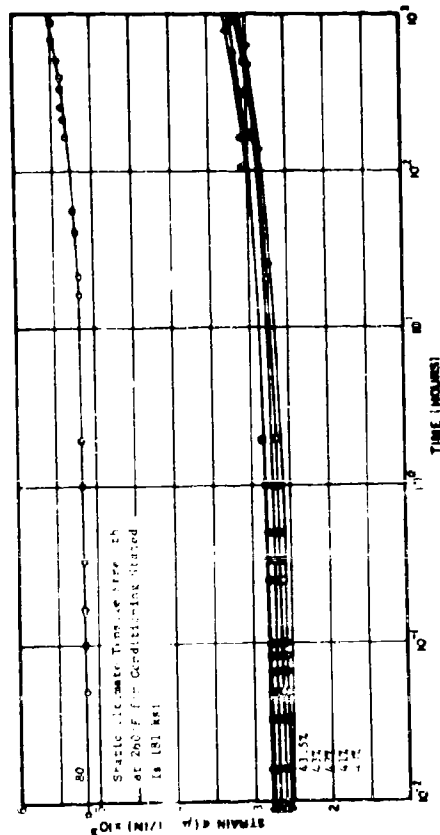


FIG. 242 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR J-AY-20 5505 NKRON COMPOSITES TESTED AT 260°F

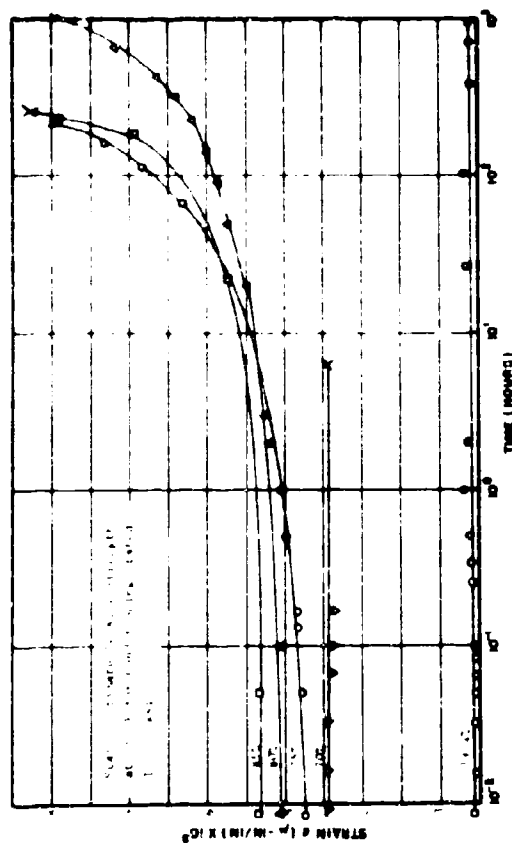


FIG. 243 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR J-AY-20 5505 NKRON COMPOSITES TESTED AT 260°F

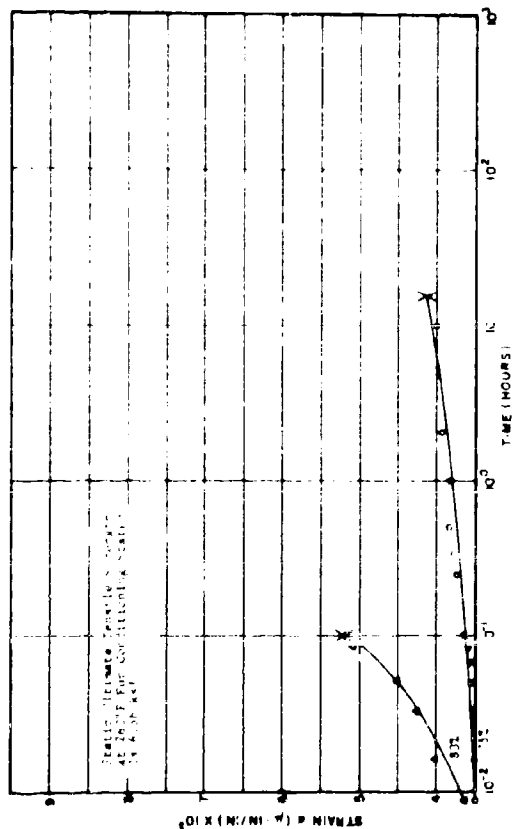


FIG. 1. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 90° AND 135° BULK SPECIMENS TESTED AT 260°F

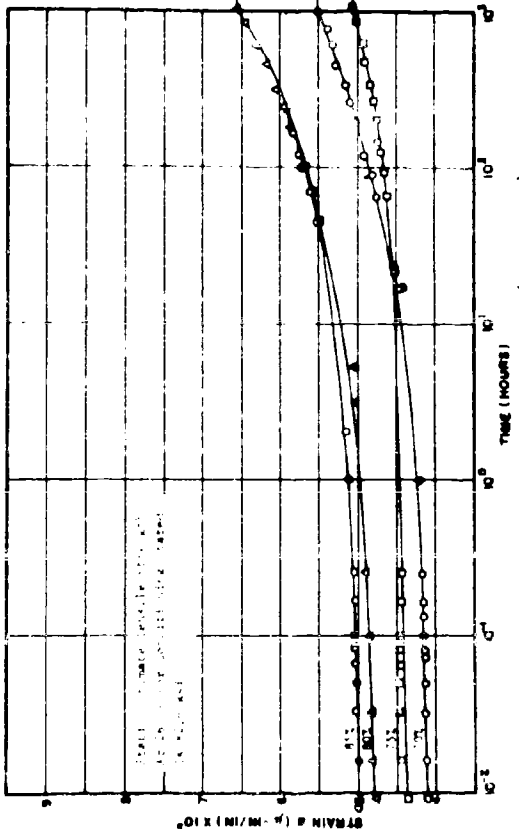
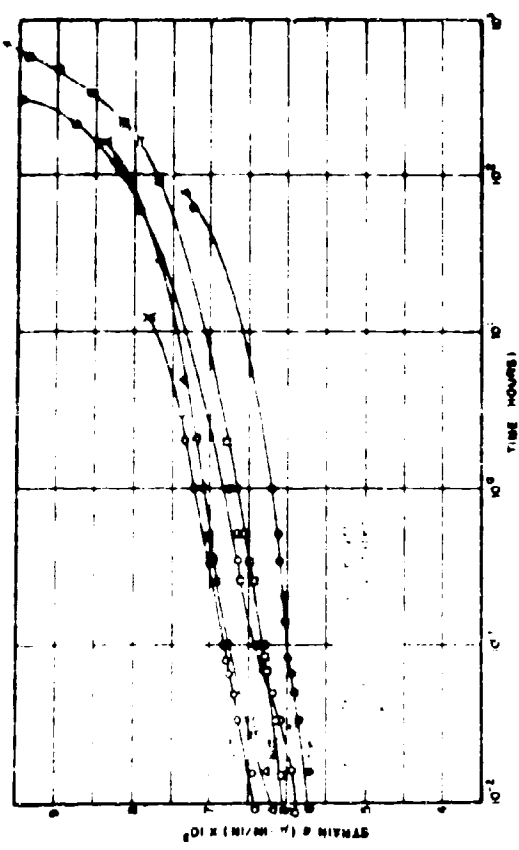


FIG. 2. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AND 45° BULK SPECIMENS TESTED AT 260°F

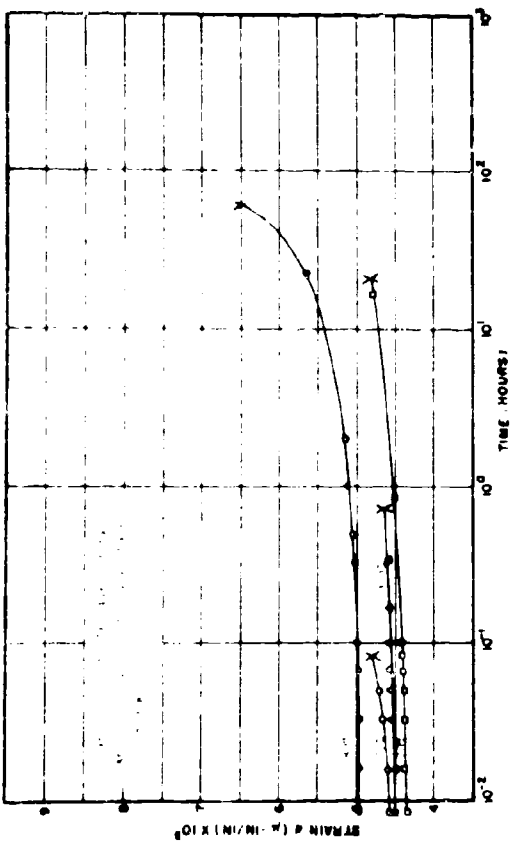


FIG. 3. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AND 45° BULK SPECIMENS TESTED AT 260°F

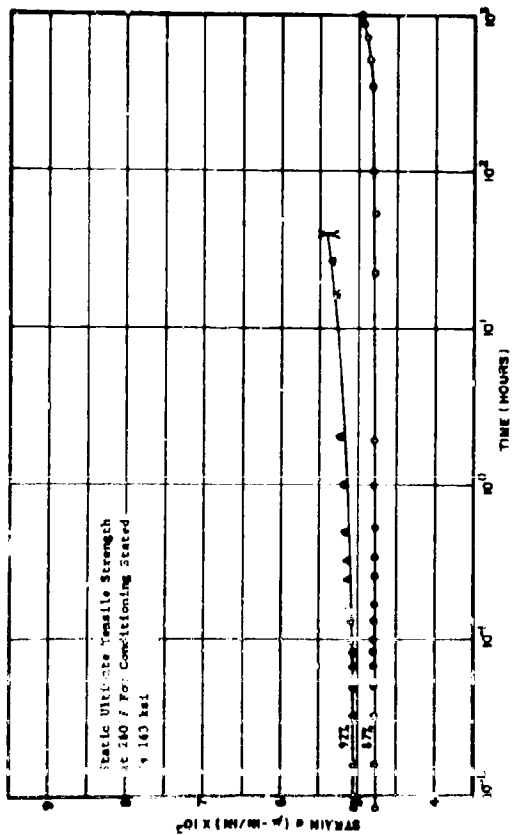


FIG. 24a. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AVCO 5505/BORON COMPOSITES TESTED AT 240°F AFTER 1000 HOURS EXPOSURE TO 98% RH

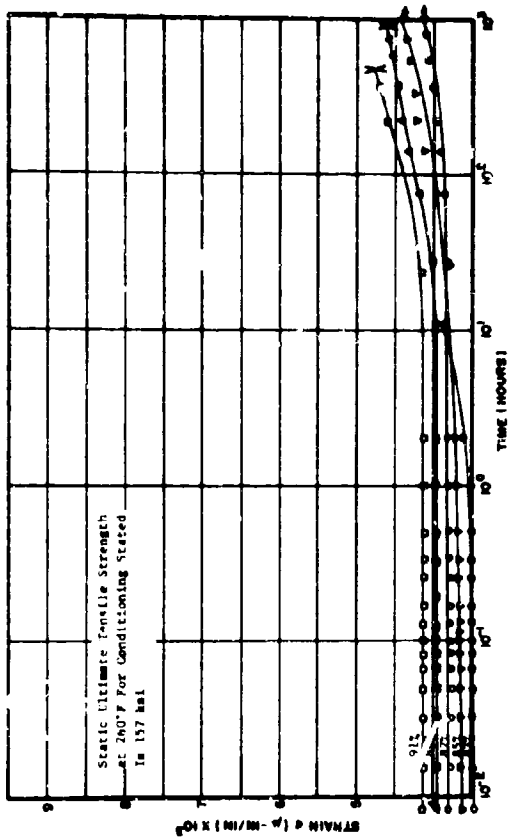


FIG. 24b. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AVCO 5505/BORON COMPOSITES TESTED AT 240°F AFTER EXPOSURE TO HUMIDITY CYCLE #2 (Accelerated Weathering)

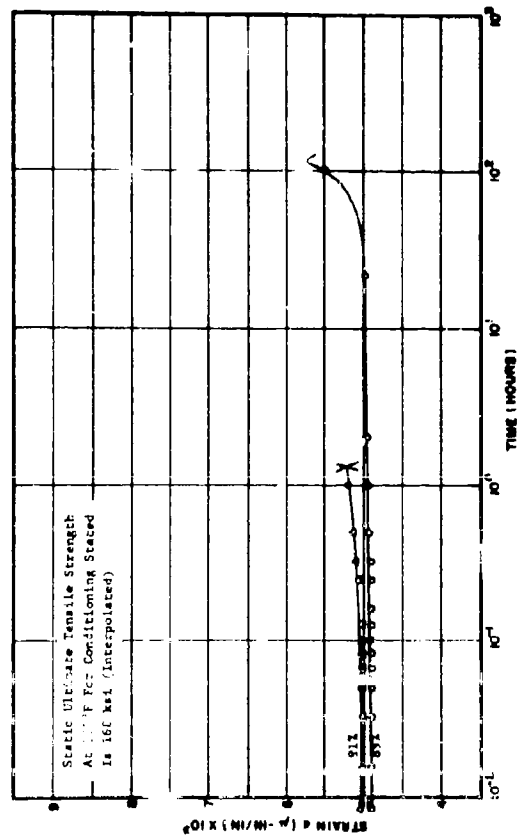


FIG. 24c. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AVCO 5505/BORON COMPOSITES TESTED AT 240°F AFTER 1000 HOURS EXPOSURE TO 98% RH

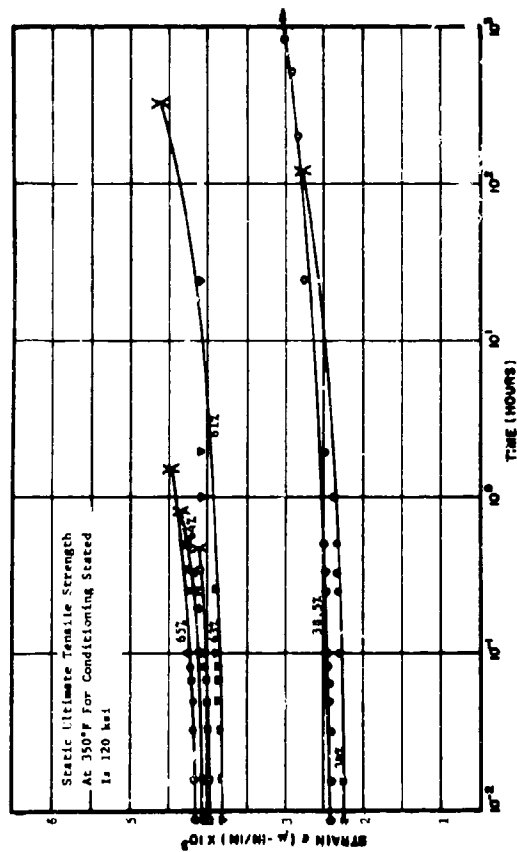


FIG. 25. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AVCO 5505/BORON COMPOSITES TESTED AT 350°F AFTER EXPOSURE TO HUMIDITY CYCLE #1 (Thermo-Humidity Cycle)

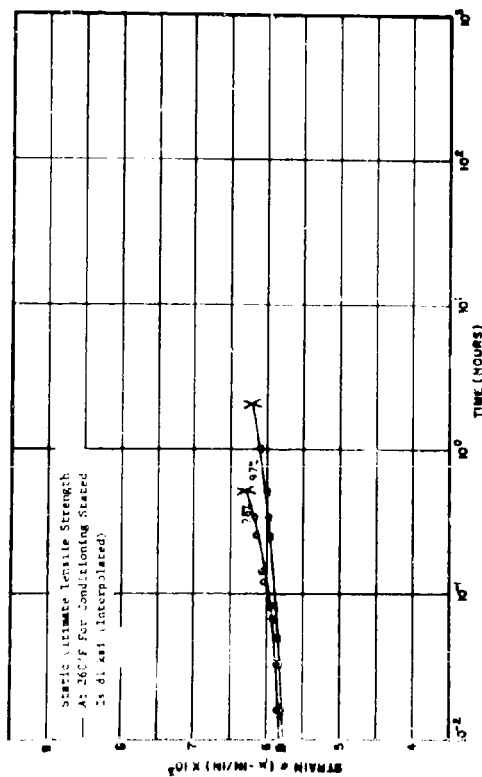


FIG. 250 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.45/135/0/90° AVCO 5505 BORON LAMINATE TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 4000 PSI

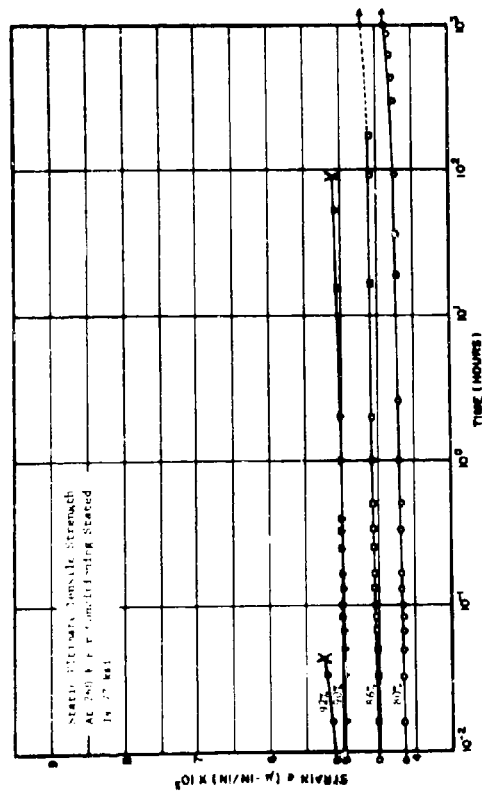


FIG. 251 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.45/135/0/90° AVCO 5505 BORON LAMINATE TESTED AT 260°F AFTER 1000 HOURS EXPOSURE TO 4800 PSI

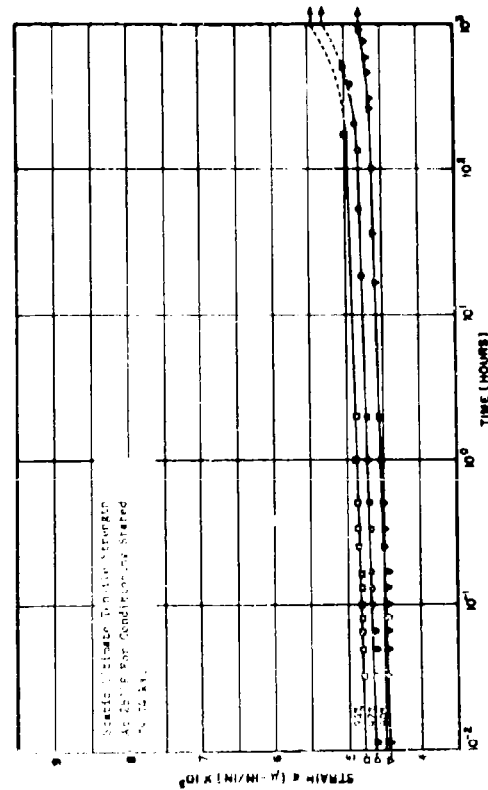


FIG. 252 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.45/135/0/90° AVCO 5505 BORON LAMINATE TESTED AT 260°F AFTER EXPOSURE TO 4000 PSI (4000 PSI ACCELERATED WEATHERING)

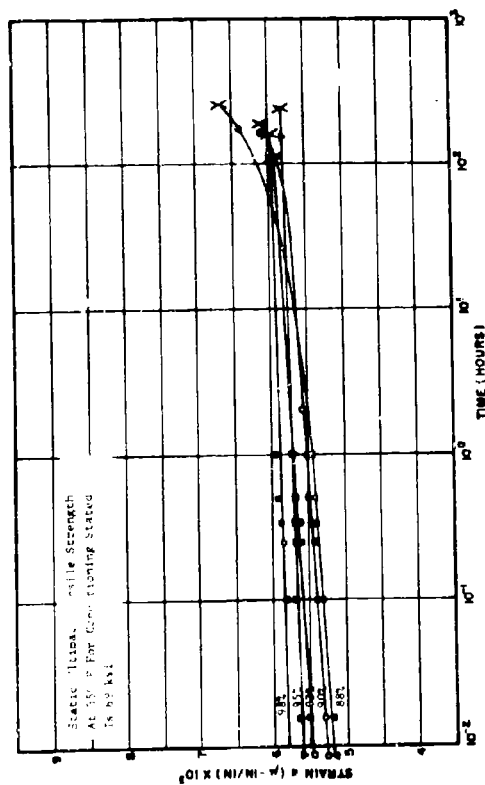


FIG. 253 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.45/135/0/90° AVCO 5505 BORON LAMINATE TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 4800 PSI

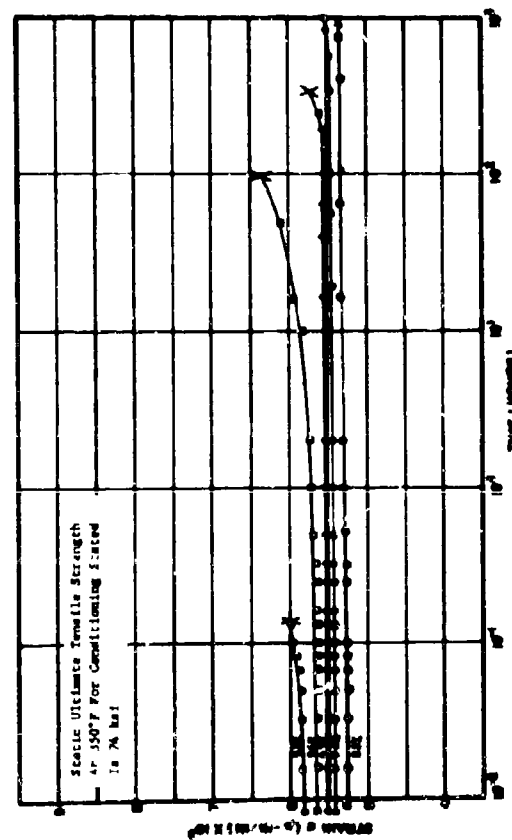


FIG. 256 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90]_s AVCO 5505/7000 COMPOSITE LAMINATE TESTED AT 350°F AFTER 1000 HOURS EXPOSURE AT 982 MI

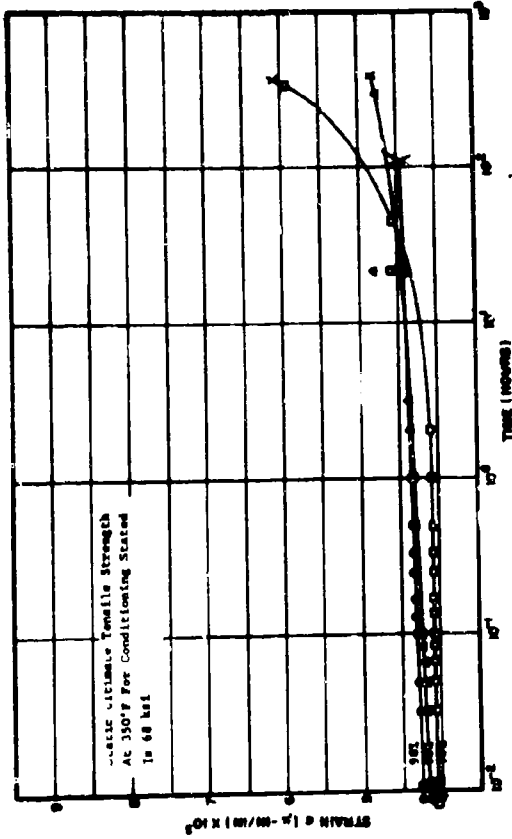


FIG. 257 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90]_s AVCO 5505/7000 COMPOSITE LAMINATE TESTED AT 350°F AFTER EXPOSURE TO HUMIDITY CYCLE #2 (Accelerated Weathering)

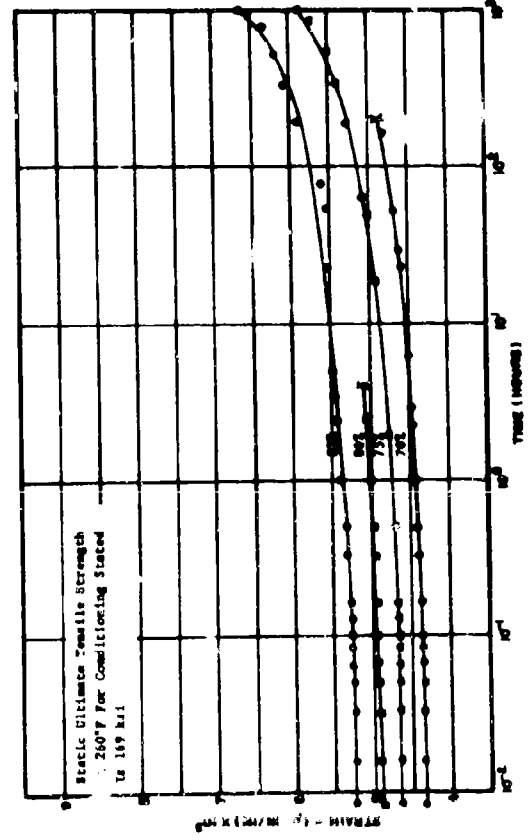


FIG. 258 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0°] AVCO 5505/7000 COMPOSITE TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 260°F

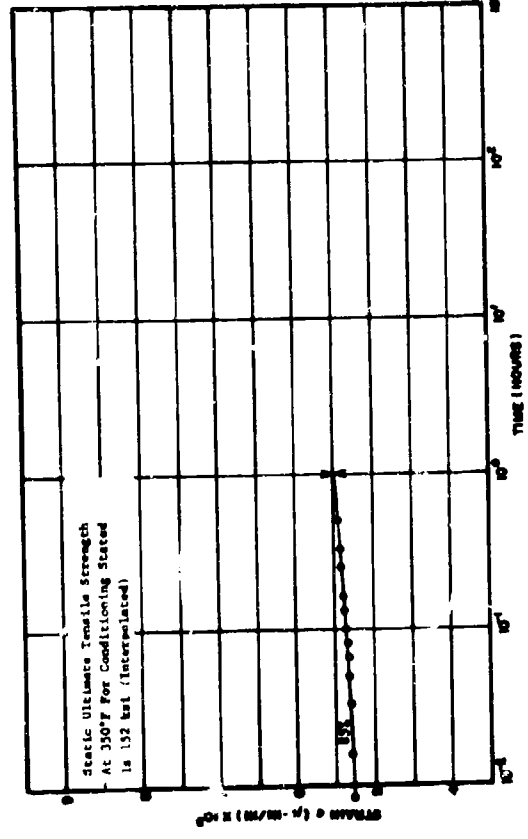


FIG. 259 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0°] AVCO 5505/7000 COMPOSITE TESTED AT 350°F AFTER 900 HOURS EXPOSURE TO 260°F

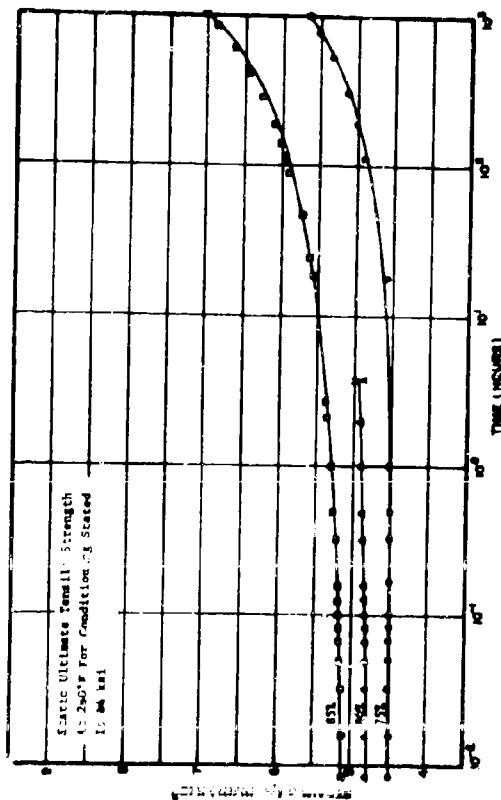


FIG. 260. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90], AWC 5505/MODM LAMINATE TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 260°F

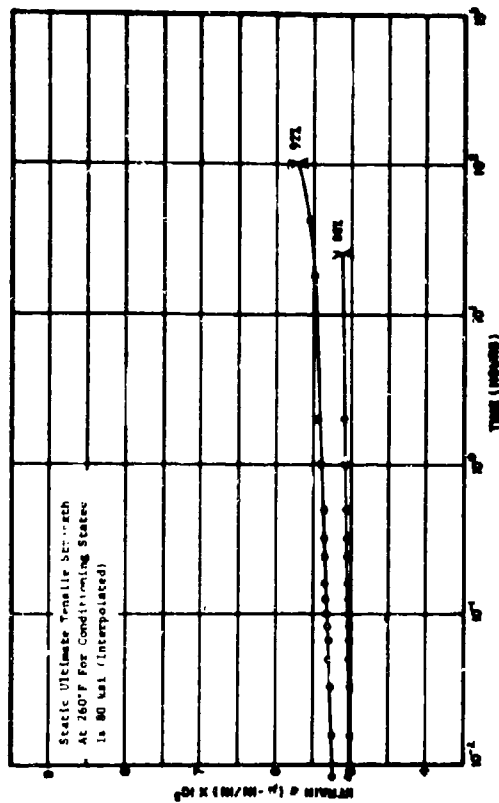


FIG. 261. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90], AWC 5505/MODM LAMINATE TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 260°F

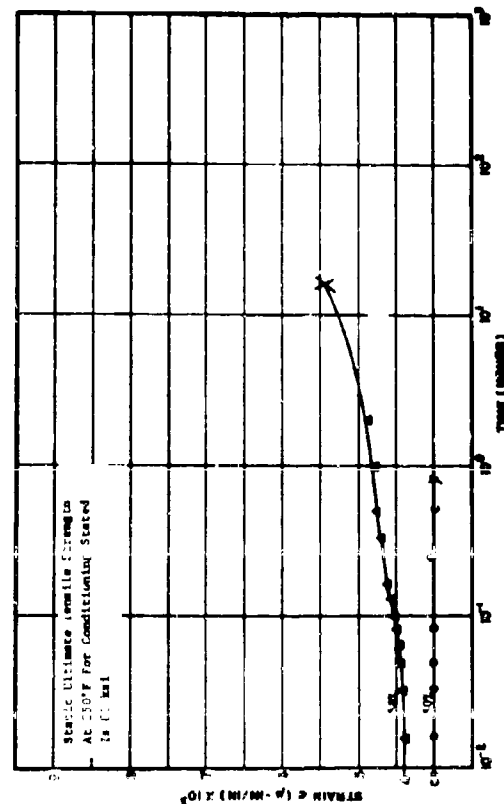


FIG. 262. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90], AWC 5505/MODM LAMINATE TESTED AT 350°F AFTER 500 HOURS EXPOSURE AT 350°F

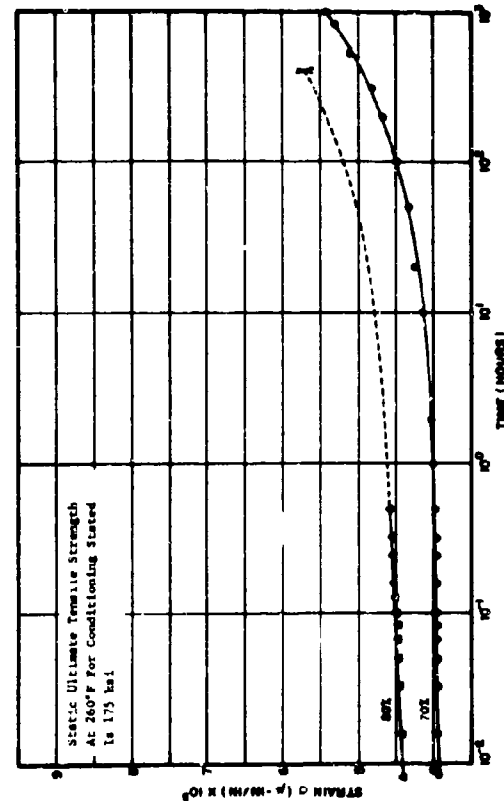


FIG. 263. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0°] AWC 5505/MODM COMPOSITE TESTED AT 260°F AFTER 1000 CYCLES EXPOSURE TO 260°F

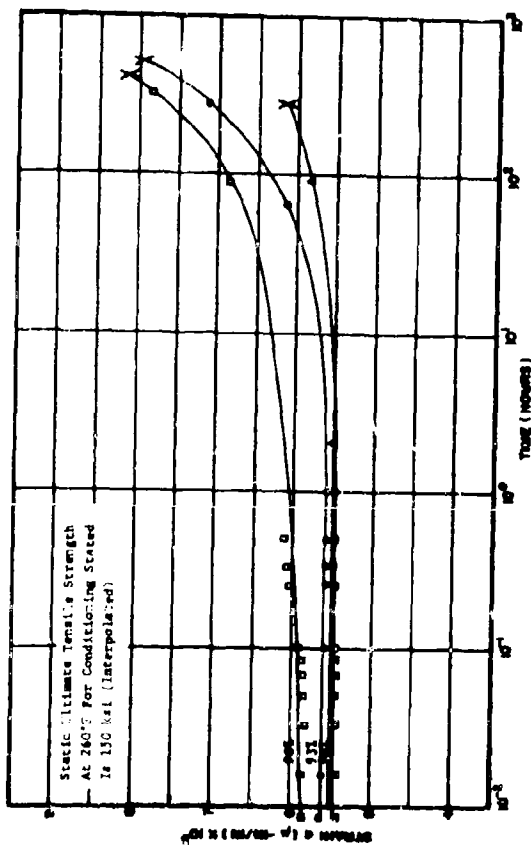


FIG. 264 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AWC 5505/MBON COMPOSITES TESTED AT 260°F AFTER 1000 CYCLE EXPOSURE TO 350°F

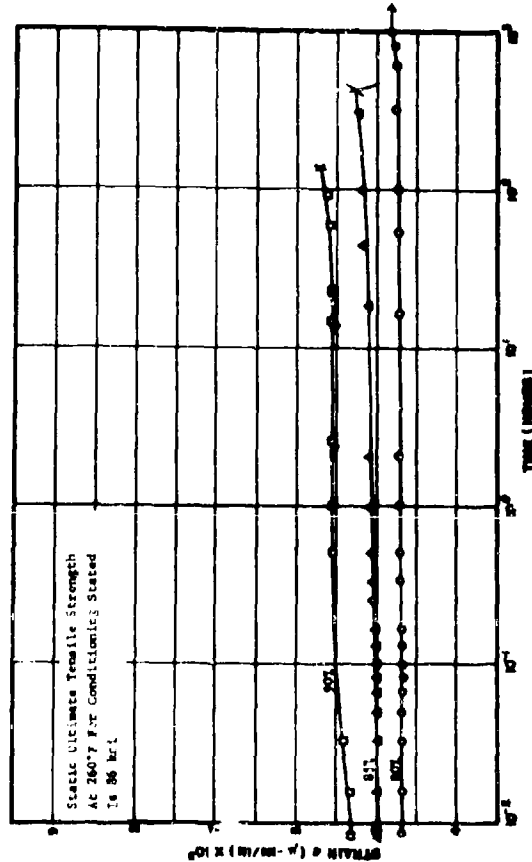


FIG. 266 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AWC 5505/MBON LAMINATE TESTED AT 260°F AFTER 1000 CYCLE EXPOSURE TO 350°F

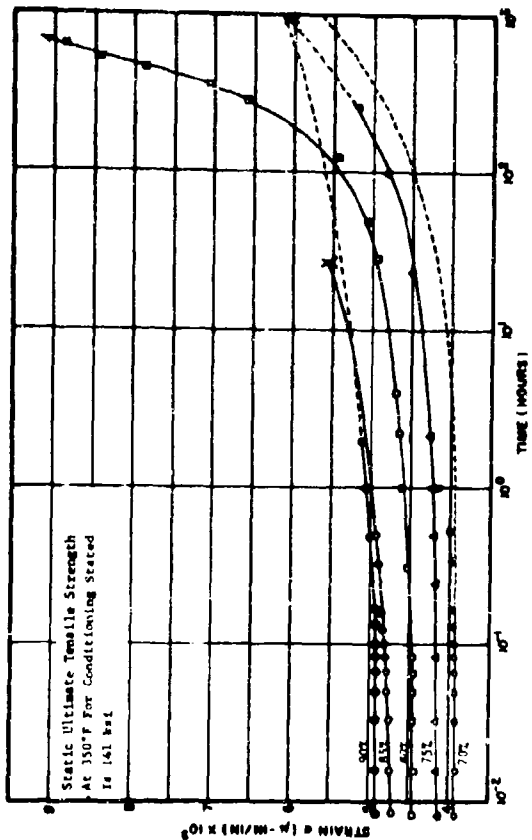


FIG. 265 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AWC 5505/MBON COMPOSITES TESTED AT 350°F AFTER 1000 CYCLE EXPOSURE TO 350°F

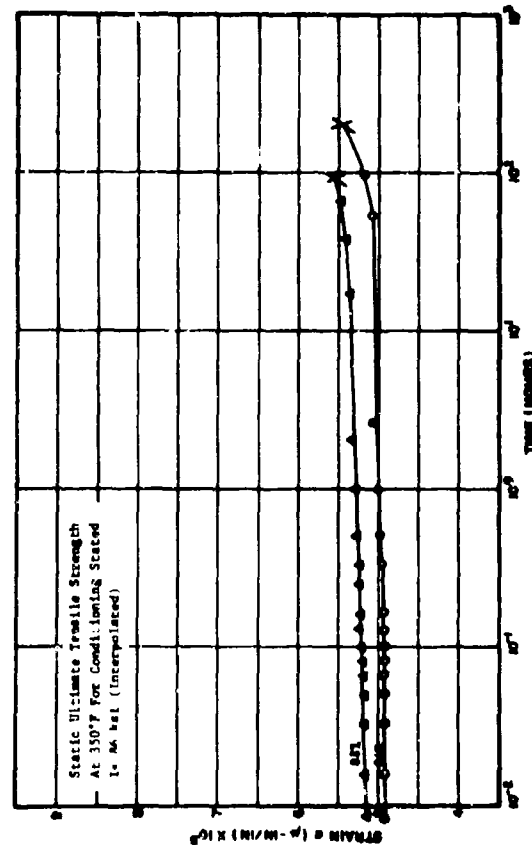


FIG. 267 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° AWC 5505/MBON LAMINATE TESTED AT 350°F AFTER 1000 CYCLE EXPOSURE TO 350°F

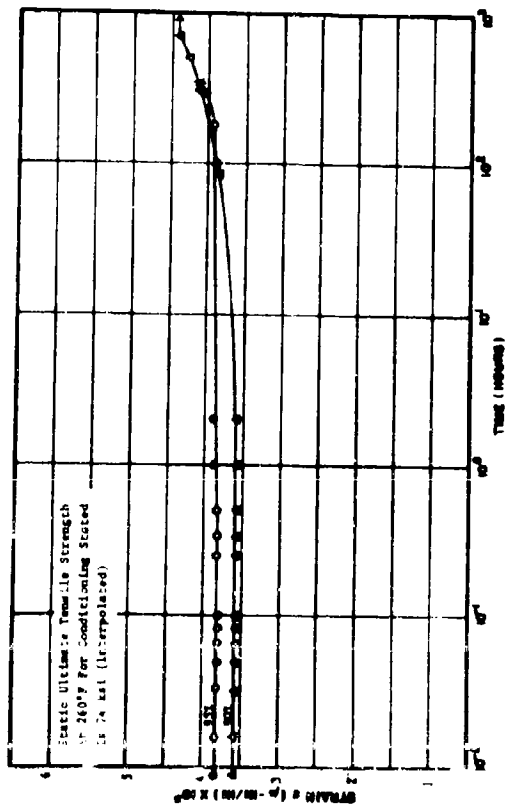


FIG. 26: TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.45/115/0/90, AVOO 5505/8000 LAMINATE TESTED AT 260°F AFTER 1000 CYCLES EXPOSURE TO 350°F

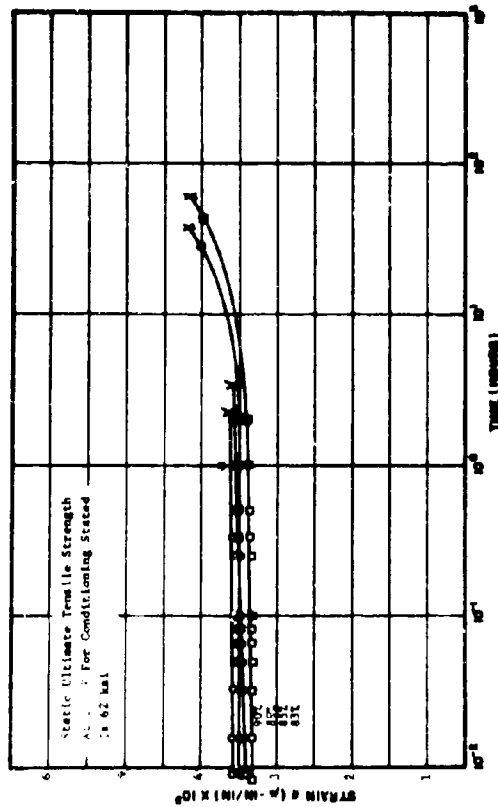


FIG. 26: TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.45/115/0/90, AVOO 5505/8000 LAMINATE TESTED AT 350°F AFTER 1000 CYCLES EXPOSURE TO 350°F

APPENDIX II

DATA SUMMARY FOR MOI MOR II GRAPHITE/NARMCO 5206 COMPOSITES

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APPENDIX II

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STATIC PROPERTIES
MARINCO 5206/ANODIZED
GRAPHITE COMPOSITE

Orientation	Type Load	Conditioning	Test Temp. (°F)	ϵ (10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
0°	Tension	None	RTD	22.5	0.30	161	6,920
0°	Tension	None	260°F	22.5	0.26	150	6,780
0°	Tension	None	350°F	25.0	0.23	150	6,040
90°	Tension	None	RTD	1.28	0.05	5.2	4,950
90°	Tension	None	260°F	0.42	0.05	3.1	3,130
90°	Tension	None	350°F	0.81	0.05	3.0	4,510
0/45/135/0/90°s	Tension	None	RTD	11.1	0.38	72	6,610
10/45/135/0/90°s	Tension	None	260°F	11.6	0.45	87	7,200
10/45/135/0/90°s	Tension	None	350°F	11.8	0.45	79	7,090
0°	Compression	None	RTD*	19.6	0.75	141	7,610
0°	Compression	None	RTD*	20.5	0.24	146	7,830
0°	Compression	None	260°F	20.0	0.37	138	7,570
0°	Compression	None	350°F*	18.9	0.66	123	6,790
0°	Compression	None	350°F*	19.8	0.25	129	6,150
90°	Compression	None	RTD*	1.71	0.03	24.7	20,340
90°	Compression	None	RTD*	1.47	0.01	24.9	16,970
90°	Compression	None	260°F	1.06	0.01	21.1	>30,000
90°	Compression	None	350°F*	1.20	0.00	17.3	>30,000
40°	Compression	None	350°F*	0.74	0.00	16.8	>30,000

*Sandwich Beam Data

Orientation	Type Load	Defining	Test Temp. (°F)	σ (ksi)	ν (in./in.)	ϵ_{ult} (μ -in./in.)
[0/45/135/0/90] _s	Compression	None	RTD*	99	0.53	10,080
[0/45/135/0/90] _s	Compression	None	RTD*	94	0.41	11,730
[0/45/135/0/90] _s	Compression	None	260°F	95	0.49	9,320
[0/45/135/0/90] _s	Compression	None	350°F*	84	0.46	8,780
[0/45/135/0/90] _s	Compression	None	350°F*	65	0.40	9,320
0°	In-Plane Shear	None	RTD	42	-	-
0°	In-Plane Shear	None	260°F	73	-	-
0°	In-Plane Shear	None	350°F	34	-	-
0°	Int. Shear	None	RTD	129	-	-
0°	Int. Shear	None	260°F	88	-	-
0°	Int. Shear	None	350°F	51	-	-
[0/45/135/0/90] _s	Int. Shear	None	RTD	89	-	-
[0/45/135/0/90] _s	Int. Shear	None	260°F	66	-	-
[0/45/135/0/90] _s	Int. Shear	None	350°F	46	-	-
0°	Flexural	None	RTD	188	-	-
0°	Flexural	None	260°F	151	-	-
0°	Flexural	None	350°F	48	-	-
90°	Flexural	None	RTD	77	-	-
90°	Flexural	None	260°F	66	-	-
90°	Flexural	None	350°F	30	-	-
[0/45/135/0/90] _s	Flexural	None	RTD	104	-	-
[0/45/135/0/90] _s	Flexural	None	260°F	48	-	-
[0/45/135/0/90] _s	Flexural	None	350°F	21	-	-

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Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	τ_{ult} (ksf)	ϵ_{ult} (in/in. %)
0°	Tension	98% RH 500 Hrs	RTD	23.5	0.25	173	7,220
0°	Tension	98% RH 500 Hrs	260°F	-	-	173	-
0°	Tension	98% RH 500 Hrs	350°F	-	-	166	-
0°	Tension	98% RH 1000 Hrs	RTD	23.9	0.25	182	7,350
0°	Tension	98% RH 1000 Hrs	260°F	23.3	0.44	163	6,710
0°	Tension	98% RH 1000 Hrs	350°F	17.9	0.48	148	5,350
0°	Tension	Thermo-Humidity Cycle	RTD	22.0	0.2-	163	7,230
0°	Tension	Thermo-Humidity Cycle	260°F	-	-	175	-
0°	Tension	Thermo-Humidity Cycle	350°F	-	-	151	-
0°	Tension	Acc. Wthrg.	RTD	21.9	0.28	179	7,870
0°	Tension	Acc. Wthrg.	260°F	24.0	0.25	146	5,520
90°	Tension	98% RH 500 Hrs	RTD	1.35	-	4.0	3,010
90°	Tension	98% RH 500 Hrs	260°F	-	-	3.7	-
90°	Tension	98% RH 500 Hrs	350°F	-	-	1.6	-
90°	Tension	96% RH 1000 Hrs	RTD	1.17	0.00	2.8	2,350
90°	Tension	98% RH 1000 Hrs	260°F	0.36	0.00	1.9	4,500
90°	Tension	98% RH 1000 Hrs	350°F	0.28	0.00	1.2	5,680
90°	Tension	Thermo-Humidity Cycle	RTD	1.13	0.00	3.2	2,830
90°	Tension	Thermo-Humidity Cycle	260°F	-	-	1.5	-
90°	Tension	Thermo-Humidity Cycle	350°F	-	-	1.0	-

TABLE XV STATIC PROPERTIES SUMMARY -
NARMCO 5206/MODHUR II
GRAPHITE COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
90	Tension	Acc. Wthrg.	RTD	1.25	0.01	2.9	2,380
90	Tension	Acc. Wthrg.	260°F	0.71	0.00	1.7	2,870
90	Tension	Acc. Wthrg.	350°F	0.36	0.00	1.3	5,090
[0/45/135/0/90] ₈	Tension	98% RH/500 Hrs	RTD	11.7	0.39	84	7,140
[0/45/135/0/90] ₈	Tension	98% RH/500 Hrs	260°F	-	-	81	-
[0/45/135/0/90] ₈	Tension	98% RH/500 Hrs	350°F	-	-	64	-
[0/45/135/0/90] ₈	Tension	98% RH/1000 Hrs	RTD	11.7	0.40	79	6,830
[0/45/135/0/90] ₈	Tension	98% RH/1000 Hrs	260°F	11.3	0.48	77	6,710
[0/45/135/0/90] ₈	Tension	98% RH/1000 Hrs	350°F	11.4	0.38	65	6,160
[0/45/135/0/90] ₈	Tension	Thermo-Humidity Cycle	RTD	11.5	0.42	80	6,820
[0/45/135/0/90] ₈	Tension	Thermo-Humidity Cycle	260°F	-	-	81	-
[0/45/135/0/90] ₈	Tension	Thermo-Humidity Cycle	350°F	-	-	62	-
[0/45/135/0/90] ₈	Tension	Acc. Wthrg.	RTD	10.9	0.45	82	7,630
[0/45/135/0/90] ₈	Tension	Acc. Wthrg.	260°F	11.4	0.42	78	6,940
[0/45/135/0/90] ₈	Tension	Acc. Wthrg.	350°F	11.1	0.49	66	6,150

TABLE XV
 STATIC PROPERTIES SUMMARY -
 NARCO 5206/MODCOR II
 GRAPHITE COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	v (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
0°	Compression	98% RH/500 Hrs	RTD	-	-	141	-
0°	Compression	98% RH/500 Hrs	260°F	-	-	143	-
0°	Compression	98% RH/500 Hrs	350°F	-	-	134	-
0°	Compression	98% RH/1000 Hrs	RTD	21.2	0.26	134	9,450
0°	Compression	98% RH/1000 Hrs	260°F	18.8	0.28	127	6,400
0°	Compression	98% RH/1000 Hrs	350°F	17.1	0.34	125	7,420
0°	Compression	Thermo-Humidity Cycle	RTD	18.4	0.22	136	8,000
0°	Compression	Thermo-Humidity Cycle	260°F	-	-	138	-
0°	Compression	Thermo-Humidity Cycle	350°F	-	-	132	-
0°	Compression	Acc. Wthrg.	RTD	19.8	-	128	6,660
0°	Compression	Acc. Wthrg.	260°F	20.6	0.31	140	8,850
0°	Compression	Acc. Wthrg.	350°F	19.6	0.34	122	7,070
90°	Compression	98% RH/500 Hrs	RTD	1.12	0.00	23.1	21,630
90°	Compression	98% RH/500 Hrs	260°F	-	-	13.8	-
90°	Compression	98% RH/500 Hrs	350°F	-	-	7.6	-
90°	Compression	98% RH/1000 Hrs	RTD	1.30	0.00	22.4	24,600
90°	Compression	98% RH/1000 Hrs	260°F	1.28	0.01	15.2	20,260
90°	Compression	98% RH/1000 Hrs	350°F	**	**	**	**
90°	Compression	Thermo-Humidity Cycle	RTD	1.38	0.00	23.5	19,260
90°	Compression	Thermo-Humidity Cycle	260°F	-	-	14.6	-
90°	Compression	Thermo-Humidity Cycle	350°F	-	-	8.1	-

**Specimen Broken During Handling

TABLE XV STATIC PROPERTIES SUMMARY -
NARMCO 5206/MODMOR II
GRAPHIC COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
90°	Compression	Acc. Wthrg.	RTD	1.25	0.00	24.1	21,320
90°	Compression	Acc. Wthrg.	260°F	1.63	0.00	18.0	21,040
90°	Compression	Acc. Wthrg.	350°F	0.66	0.00	9.2	28,420
{0/45/135/0/90} _s	Compression	98% RH/500 Hrs	RTD	9.54	0.42	89	10,100
	Compression	98% RH/500 Hrs	260°F	-	-	87	-
	Compression	98% RH/500 Hrs	350°F	-	-	84	-
{0/45/135/0/90} _s	Compression	98% RH/1000 Hrs	RTD	8.86	0.37	88	10,080
	Compression	98% RH/1000 Hrs	260°F	10.32	0.48	84	9,590
	Compression	98% RH/1000 Hrs	350°F	9.62	0.45	82	9,880
{0/45/135/0/90} _s	Compression	98% RH/1000 Hrs	RTD	9.60	0.43	85	11,030
	Compression	Thermo-Humidity Cycle	260°F	-	-	94	-
	Compression	Thermo-Humidity Cycle	350°F	-	-	87	-
{0/45/135/0/90} _s	Compression	Acc. Wthrg.	RTD	9.86	0.46	90	11,100
	Compression	Acc. Wthrg.	260°F	9.55	0.39	86	10,170
	Compression	Acc. Wthrg.	350°F	9.01	0.37	80	10,200
0°	In-Plane Shear	98% RH/500 Hrs	RTD	0.72	-	8.6	18,330
0°	In-Plane Shear	98% RH/500 Hrs	260°F	-	-	7.3	-
0°	In-Plane Shear	98% RH/500 Hrs	350°F	-	-	4.0	-
0°	In-Plane Shear	98% RH/1000 Hrs	RTD	0.74	-	8.4	23,000
0°	In-Plane Shear	98% RH/1000 Hrs	260°F	0.17	-	5.6	> 30,000
0°	In-Plane Shear	98% RH/1000 Hrs	350°F	0.08	-	3.8	> 30,000

TABLE IV STATIC PROPERTIES SUMMARY -
 5206 SENSOR II
 5206 PROPERTIES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	G (psi x 10 ⁶)	τ_{ult} (ksi)	ϵ_{ult} (in./in.)
0°	In-Plane Shear	Thermo-Humidity Cycle	RTD	0.66	8.4	26,730
0°	In-Plane Shear	Thermo-Humidity Cycle	260°F	-	6.4	-
0°	In-Plane Shear	Thermo-Humidity Cycle	350°F	-	4.4	-
0°	In-Plane Shear	Acc. Wthrg.	RTD	0.76	8.8	23,870
0°	In-Plane Shear	Acc. Wthrg.	260°F	0.31	6.6	>30,000
0°	In-Plane Shear	Acc. Wthrg.	350°F	0.14	4.5	>30,000
0°	Int. Shear	98% RH/500 Hrs	RTD	-	10.4	-
0°	Int. Shear	98% RH/500 Hrs	50°F	-	7.9	-
0°	Int. Shear	98% RH/500 Hrs	350°F	-	5.6	-
0°	Int. Shear	98% RH/1000 Hrs	RTD	-	9.3	-
0°	Int. Shear	98% RH/1000 Hrs	260°F	-	7.4	-
0°	Int. Shear	98% RH/1000 Hrs	350°F	-	5.5	-
0°	Int. Shear	Thermo-Humidity Cycle	RTD	-	9.8	-
0°	Int. Shear	Thermo-Humidity Cycle	260°F	-	6.5	-
0°	Int. Shear	Thermo-Humidity Cycle	350°F	-	4.3	-
0°	Int. Shear	Acc. Wthrg.	RTD	-	11.8	-
0°	Int. Shear	Acc. Wthrg.	260°F	-	9.2	-
0°	Int. Shear	Acc. Wthrg.	350°F	-	5.8	-

TABLE XV STATIC PROPERTIES SUMMARY -
NARMCO 5206/MODMOR II
GRAPHITE COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
0°	Tension	260°F/100 Hrs	RTD	22.5	0.25	171	7,500
0°	Tension	260°F/100 Hrs	260°F	23.0	0.32	170	7,340
0°	Tension	260°F/500 Hrs	RTD	22.4	0.28	170	7,330
0°	Tension	260°F/500 Hrs	260°F	22.6	0.27	163	7,120
0°	Tension	350°F/100 Hrs	RTD	22.2	0.28	167	7,180
0°	Tension	350°F/100 Hrs	260°F	22.0	0.28	146	6,570
0°	Tension	350°F/100 Hrs	350°F	23.5	0.24	160	6,630
0°	Tension	350°F/500 Hrs	RTD	23.0	0.26	173	7,410
0°	Tension	350°F/500 Hrs	350°F	23.4	0.21	159	6,450
90°	Tension	260°F/100 Hrs	RTD	1.12	0.00	4.3	3,770
90°	Tension	260°F/100 Hrs	260°F	1.02	0.02	3.6	3,360
90°	Tension	260°F/500 Hrs	RTD	1.15	0.01	4.0	3,590
90°	Tension	260°F/500 Hrs	260°F	1.09	0.02	3.4	3,280
90°	Tension	350°F/100 Hrs	RTD	1.14	0.0	3.8	3,370
90°	Tension	350°F/100 Hrs	260°F	0.95	0.01	2.0	2,190
90°	Tension	350°F/100 Hrs	350°F	0.92	0.02	2.0	2,120

TABLE XV STATIC PROPERTIES SUMMARY -
NARMCO 7000MOR II
GRAPHITE FIBRITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
90°	Tension	350°F/500 Hrs	RTD	1.14	0.01	2.7	2,310
90°	Tension	350°F/500 Hrs	350°F	1.05	0.02	1.8	1,790
[0/45/135/0/90] _s	Tension	260°F/100 Hrs	RTD	10.9	0.36	82	7,300
[0/45/135/0/90] _s	Tension	260°F/100 Hrs	260°F	11.8	0.41	85	7,340
[0/45/135/0/90] _s	Tension	260°F/500 Hrs	RTD	11.7	0.40	86	7,330
[0/45/135/0/90] _s	Tension	260°F/500 Hrs	260°F	11.4	0.37	82	7,130
[0/45/135/0/90] _s	Tension	350°F/100 Hrs	RTD	11.3	0.41	82	7,210
[0/45/135/0/90] _s	Tension	350°F/100 Hrs	260°F	11.3	0.43	85	7,380
[0/45/135/0/90] _s	Tension	350°F/100 Hrs	350°F	-	-	68	-
[0/45/135/0/90] _s	Tension	350°F/500 Hrs	RTD	11.8	0.44	70	5,930
[0/45/135/0/90] _s	Tension	350°F/500 Hrs	350°F	12.4	0.51	78	6,060
0°	Compression	260°F/100 Hrs	RTD	-	-	156	-
0°	Compression	260°F/100 Hrs	260°F	-	-	148	-
0°	Compression	260°F/500 Hrs	RTD	19.3	0.32	134	7,950
0°	Compression	260°F/500 Hrs	260°F	16.0	0.29	121	8,900
0°	Compression	350°F/100 Hrs	RTD	16.2	0.31	115	7,740
0°	Compression	350°F/100 Hrs	350°F	-	-	134	-
0°	Compression	350°F/500 Hrs	RTD	19.2	0.30	124	7,290
0°	Compression	350°F/500 Hrs	350°F	17.5	0.27	123	7,390

TABLE XV
STATIC PROPERTIES SUMMARY -
WARMED 5206/MX/MOR II
GRAPHIC COMPOSITE

Orientation	Type Load	Prior Conditioning	Temp. Test	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
90°	Compression	260°F/100 Hrs	RTD	-	-	25.6	-
90°	Compression	260°F/100 Hrs	260°F	-	-	21.8	-
90°	Compression	260°F/500 Hrs	RTD	1.17	0.01	24.7	22,920
90°	Compression	260°F/500 Hrs	260°F	0.90	0.00	19.1	26,330
90°	Compression	350°F/100 Hrs	RTD	-	-	26.0	-
90°	Compression	350°F/100 Hrs	350°	-	-	16.5	-
90°	Compression	350°F/500 Hrs	RTD	1.07	0.01	22.5	16,610
90°	Compression	350°F/500 Hrs	350°F	1.01	0.01	17.9	25,970
[0/45/135/0/90] _s	Compression	260°F/100 Hrs	RTD	-	-	89	-
[0/45/135/0/90] _s	Compression	260°F/100 Hrs	260°F	-	-	93	-
[0/45/135/0/90] _s	Compression	260°F/500 Hrs	RTD	9.07	0.46	86	10,480
[0/45/135/0/90] _s	Compression	260°F/500 Hrs	260°F	7.84	0.40	77	11,500
[0/45/135/0/90] _s	Compression	350°F/100 Hrs	RTD	-	-	93	-
[0/45/135/0/90] _s	Compression	350°F/100 Hrs	350°F	9.38	0.42	94	10,610
[0/45/135/0/90] _s	Compression	350°F/500 Hrs	RTD	-	-	-	-
[0/45/135/0/90] _s	Compression	350°F/500 Hrs	350°F	-	-	-	-

TABLE XV STATIC PROPERTIES SUMMARY -
NARX 5706/MODMOR II
GRAPHIC COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	G (psi x 10 ⁶)	τ_{ult} (psi)	ϵ_{ult} (μ -in./in.)
C°	In-Plane Shear	260°F/100 Hrs	RTD	-	8.4	-
C°	In-Plane Shear	260°F/100 Hrs	260°F	-	8.1	-
C°	In-Plane Shear	260°F/500 Hrs	RTD	0.70	8.6	22,000
C°	In-Plane Shear	260°F/500 Hrs	260°F	0.51	7.6	>30,000
C°	In-Plane Shear	350°F/100 Hrs	RTD	-	7.8	-
C°	In-Plane Shear	350°F/100 Hrs	260°F	-	7.4	-
C°	In-Plane Shear	350°F/500 Hrs	RTD	0.70	8.3	25,500
C°	In-Plane Shear	350°F/500 Hrs	350°F	0.47	5.5	>30,000
C°	Int. Shear	260°F/100 Hrs	RTD	-	11.1	-
C°	Int. Shear	260°F/100 Hrs	260°F	-	8.6	-
C°	Int. Shear	260°F/500 Hrs	RTD	-	11.9	-
C°	Int. Shear	260°F/500 Hrs	260°F	-	8.7	-
C°	Int. Shear	350°F/100 Hrs	RTD	-	12.4	-
C°	Int. Shear	350°F/100 Hrs	260°F	-	9.4	-
C°	Int. Shear	350°F/500 Hrs	RTD	-	11.9	-
C°	Int. Shear	350°F/500 Hrs	350°F	-	6.5	-

TABLE XV STATIC PROPERTIES SUMMARY -
NARMCO 5266/MUMOR II
GRAPHIC CONSTITUTES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
0°	Tension	260°F/500 Cy.	RTD	-	-	145	-
0°	Tension	260°F/500 Cy.	260°F	-	-	153	-
0°	Tension	260°F/1000 Cy.	RTD	21.2	0.30	165	7,440
0°	Tension	260°F/1000 Cy.	260°F	23.7	0.19	156	6,470
0°	Tension	350°F/500 Cy.	RTD	-	-	158	-
0°	Tension	350°F/500 Cy.	260°F	-	-	165	-
0°	Tension	350°F/500 Cy.	350°F	-	-	158	-
0°	Tension	350°F/1000 Cy.	RTD	21.3	0.27	154	7,150
0°	Tension	350°F/1000 Cy.	350°F	23.6	0.24	170	7,160
90°	Tension	260°F/500 Cy.	RTD	-	-	4.2	-
90°	Tension	260°F/500 Cy.	260°F	-	-	3.9	-
90°	Tension	260°F/1000 Cy.	RTD	1.22	0.00	4.6	3,680
90°	Tension	260°F/1000 Cy.	260°F	1.12	0.00	4.3	3,830
90°	Tension	350°F/500 Cy.	RTD	-	-	3.6	-
90°	Tension	350°F/500 Cy.	260°F	-	-	3.0	-
90°	Tension	350°F/500 Cy.	350°F	-	-	2.2	-
90°	Tension	350°F/1000 Cy.	RTD	1.20	0.0	3.0	2,630
50°	Tension	350°F/1000 Cy.	350°F	0.94	0.0	2.7	2,913

TABLE XV STATIC PROPERTIES SUMMARY
NARMCO 5000 FIBER II
GRAPHIC COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in./in.)
[0/45/155/0/90] _s	Tension	260°F/500 Cy.	RTD	-	-	86	-
[0/45/155/0/90] _s	Tension	260°F/500 Cy.	260°F	-	-	85	-
[0/45/155/0/90] _s	Tension	260°F/1000 Cy.	RTD	11.4	0.42	80	7,290
[0/45/155/0/90] _s	Tension	260°F/1000 Cy.	260°F	11.9	0.42	81	6,830
[0/45/155/0/90] _s	Tension	350°F/500 Cy.	RTD	-	-	77	-
[0/45/155/0/90] _s	Tension	350°F/500 Cy.	260°F	-	-	86	-
[0/45/155/0/90] _s	Tension	350°F/500 Cy.	350°F	-	-	83	-
[0/45/155/0/90] _s	Tension	350°F/1000 Cy.	RTD	10.7	0.47	78	7,380
[0/45/155/0/90] _s	Tension	350°F/1000 Cy.	350°F	11.9	0.46	80	6,640
[0/45/155/0/90] _s	Compression	260°F/500 Cy.	RTD	-	-	146	-
[0/45/155/0/90] _s	Compression	260°F/500 Cy.	260°F	-	-	142	-
[0/45/155/0/90] _s	Compression	260°F/1000 Cy.	RTD	18.3	0.32	149	9,260
[0/45/155/0/90] _s	Compression	260°F/1000 Cy.	260°F	19.5	0.39	145	8,350
[0/45/155/0/90] _s	Compression	350°F/500 Cy.	RTD	-	-	153	-
[0/45/155/0/90] _s	Compression	350°F/500 Cy.	350°F	-	-	133	-
[0/45/155/0/90] _s	Compression	350°F/1000 Cy.	RTD	17.9	0.20	135	9,280
[0/45/155/0/90] _s	Compression	350°F/1000 Cy.	350°F	16.6	0.28	103	5,750

TABLE XV STA 1C PROPERTIES SUMMARY -
W-860 3206 MONOR II
GRAPHIC COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
90°	Compression	260°F/500 Cy.	RTD	-	-	26.4	-
90°	Compression	260°F/500 Cy.	260°F	-	-	22.2	-
90°	Compression	260°F/1000 Cy.	RTD	1.11	0.01	25.9	26,160
90°	Compression	260°F/1000 Cy.	260°F	1.18	0.00	23.6	23,450
90°	Compression	350°F/500 Cy.	RTD	-	-	23.1	-
90°	Compression	350°F/500 Cy.	350°F	-	-	17.4	-
90°	Compression	350°F/1000 Cy.	RTD	1.09	0.01	23.3	22,520
90°	Compression	350°F/1000 Cy.	350°F	1.02	0.00	17.9	24,170
[0/45/135/0/90] _s	Compression	260°F/500 Cy.	RTD	-	-	100	-
[0/45/135/0/90] _s	Compression	260°F/500 Cy.	260°F	-	-	97	-
[0/45/135/0/90] _s	Compression	260°F/1000 Cy.	RTD	8.48	0.42	82	9,930
[0/45/135/0/90] _s	Compression	260°F/1000 Cy.	260°F	8.83	0.42	79	10,910
[0/45/135/0/90] _s	Compression	350°F/500 Cy.	RTD	-	-	93	-
[0/45/135/0/90] _s	Compression	350°F/500 Cy.	350°F	-	-	91	-
[0/45/135/0/90] _s	Compression	350°F/1000 Cy.	RTD	9.04	0.42	85	12,030
[0/45/135/0/90] _s	Compression	350°F/1000 Cy.	350°F	9.26	0.44	78	12,370

TABLE XV STATIC PROPERTIES SUMMARY -
NARMCO 5276 MODMOR II
GRAPHIC COMPOSITES

Orientation	Typ. Load	Prior Conditioning	Test Temp. (°F)	G (psi x 10 ⁶)	τ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
0°	In-Plane Shear	260°F/500 Cy.	RTD	-	8.0	-
0°	In-Plane Shear	260°F/500 Cy.	260°F	-	6.9	-
0°	In-Plane Shear	260°F/1000 Cy.	RTD	0.71	7.9	18,070
0°	In-Plane Shear	260°F/1000 Cy.	260°F	0.60	6.8	>30,000
0°	In-Plane Shear	350°F/500 Cy.	RTD	-	7.9	-
0°	In-Plane Shear	350°F/500 Cy.	260°F	-	7.1	-
0°	In-Plane Shear	350°F/1000 Cy.	RTD	0.69	7.9	17,300
0°	In-Plane Shear	350°F/1000 Cy.	350°F	0.40	6.1	>30,000
0°	Int. Shear	260°F/500 Cy.	RTD	-	11.6	-
0°	Int. Shear	260°F/500 Cy.	260°F	-	8.6	-
0°	Int. Shear	260°F/1000 Cy.	RTD	-	10.7	-
0°	Int. Shear	260°F/1000 Cy.	260°F	-	8.0	-
0°	Int. Shear	350°F/500 Cy.	RTD	-	11.5	-
0°	Int. Shear	350°F/500 Cy.	260°F	-	8.5	-
0°	Int. Shear	350°F/1000 Cy.	RTD	-	10.6	-
0°	Int. Shear	350°F/1000 Cy.	350°F	-	4.8	-

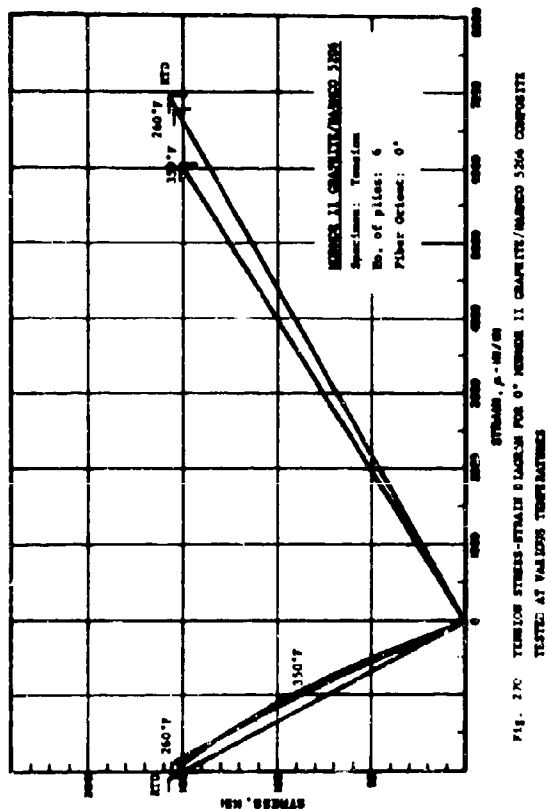


Fig. 270. TENSILE STRESS-STRAIN DIAGRAM FOR 0° MONOCLINIC GRAPHITE/MATRIX 5204 COMPOSITE TESTED AT VARIOUS TEMPERATURES

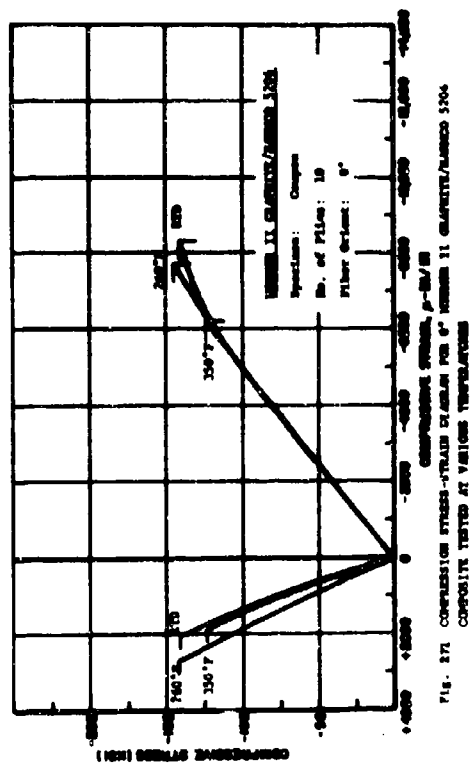


Fig. 271. COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° MONOCLINIC GRAPHITE/MATRIX 5204 COMPOSITE TESTED AT VARIOUS TEMPERATURES

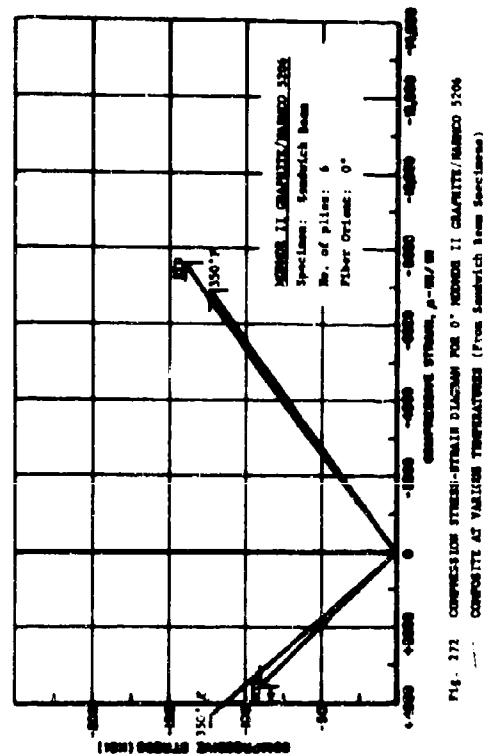


Fig. 272. COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° MONOCLINIC GRAPHITE/MATRIX 5204 COMPOSITE AT VARIOUS TEMPERATURES (From Sandwich Beam Specimens)

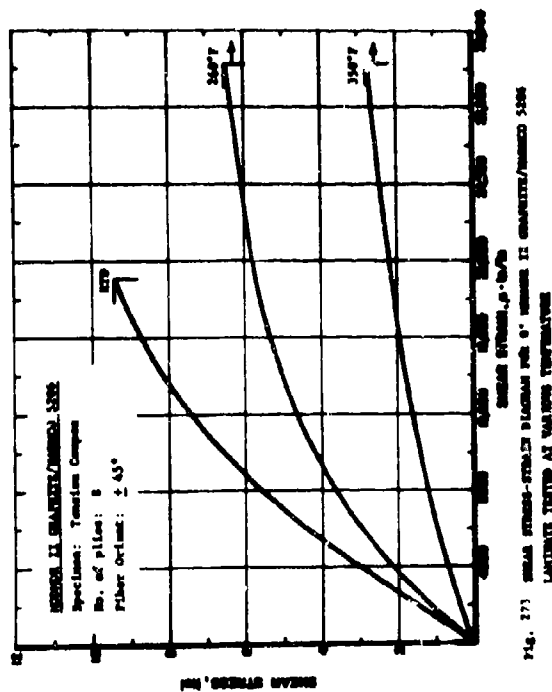


Fig. 273. SHEAR STRESS-STRAIN DIAGRAM FOR 0° MONOCLINIC GRAPHITE/MATRIX 5204 LAMINATE TESTED AT VARIOUS TEMPERATURES

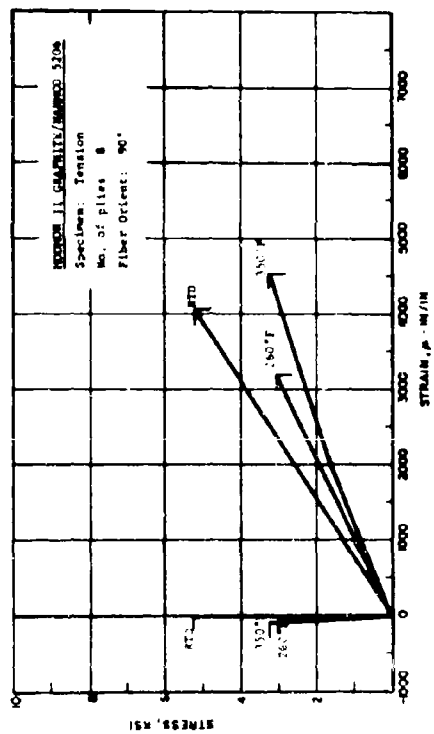


Fig. 27. TENSION STRESS-STRAIN DIAGRAM FOR 90° KEVLAR II GRAPHITE/MARISCO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES

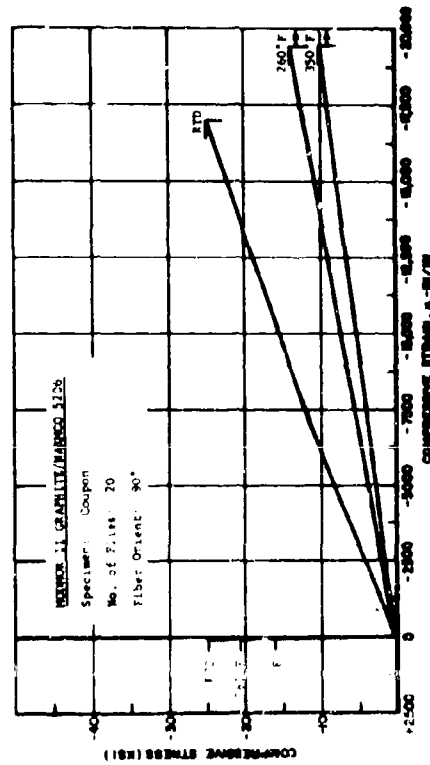


Fig. 276. COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° KEVLAR II GRAPHITE/MARISCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES

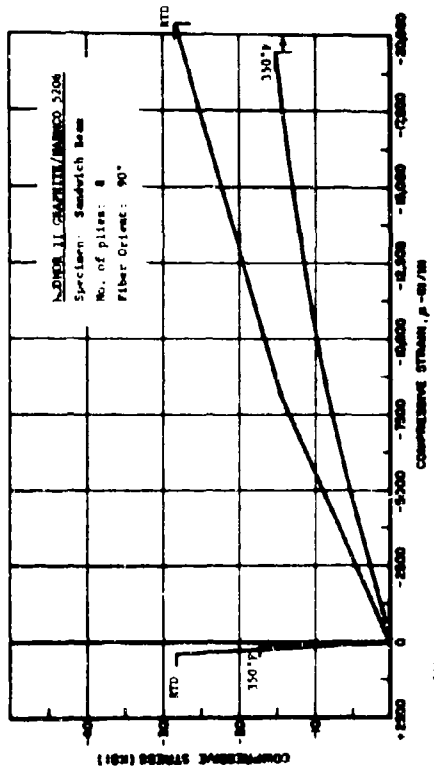


Fig. 274. COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° KEVLAR II GRAPHITE/MARISCO 5206 COMPOSITE AT VARIOUS TEMPERATURES (From Sandwich Beam Specimens)

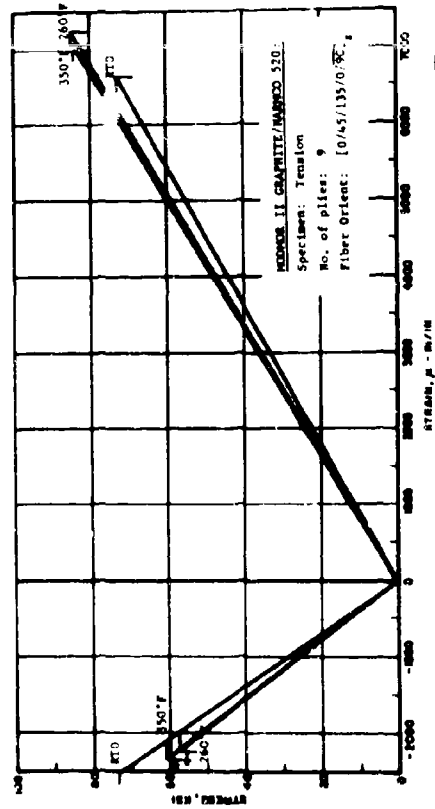


Fig. 277. TENSION STRESS - STRAIN DIAGRAM FOR KEVLAR II GRAPHITE/MARISCO 5206 [0/45/135/0/90]s LAMINATE TESTED AT VARIOUS TEMPERATURES

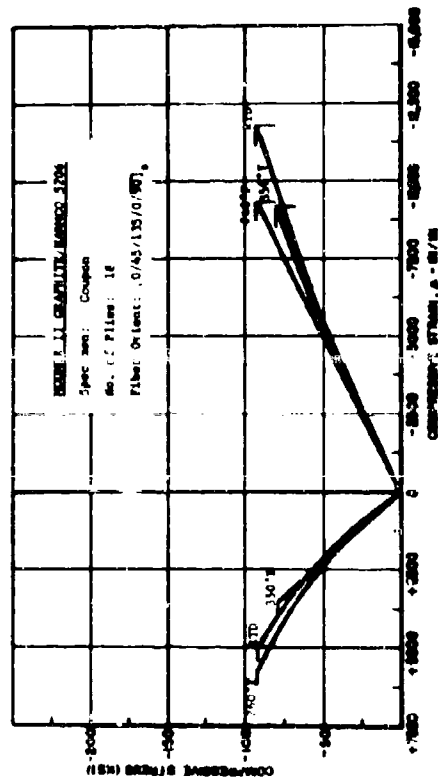


FIG. 278 COMPRESSION STRESS-STRAIN DIAGRAM FOR Kevlar II Graphite/IMR 5704 0°/45°/135°/0°/90° LAMINATE TESTED AT VARIOUS TEMPERATURES

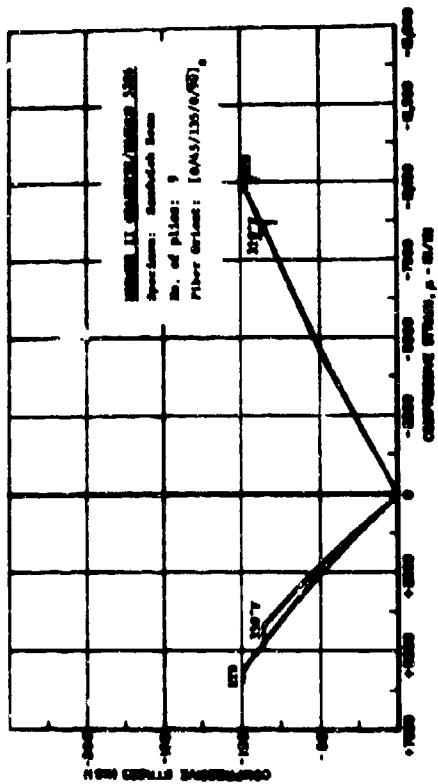


FIG. 279 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0°/45°/135°/0°/90° Kevlar II Graphite/IMR 5206 LAMINATE AT VARIOUS TEMPERATURES (From Sandwich Beam Test Results)

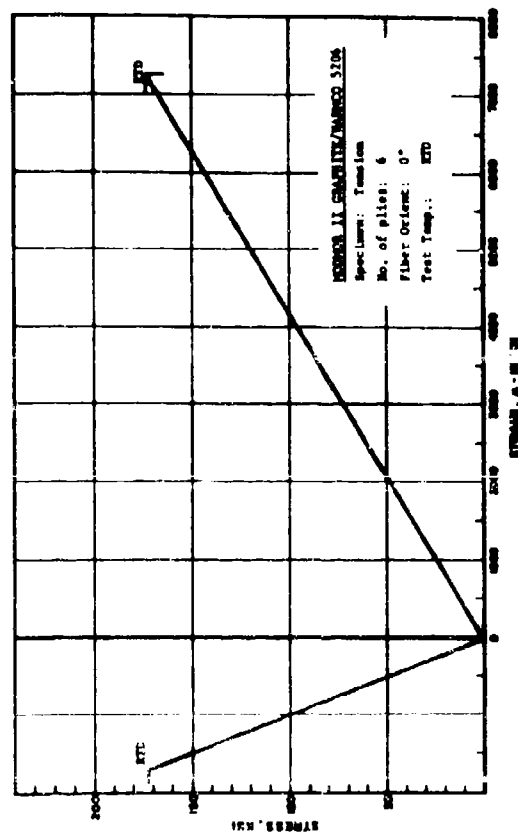


FIG. 280 TENSION STRESS-STRAIN DIAGRAM FOR 0° Kevlar II Graphite/IMR 5206 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 98% R.H.

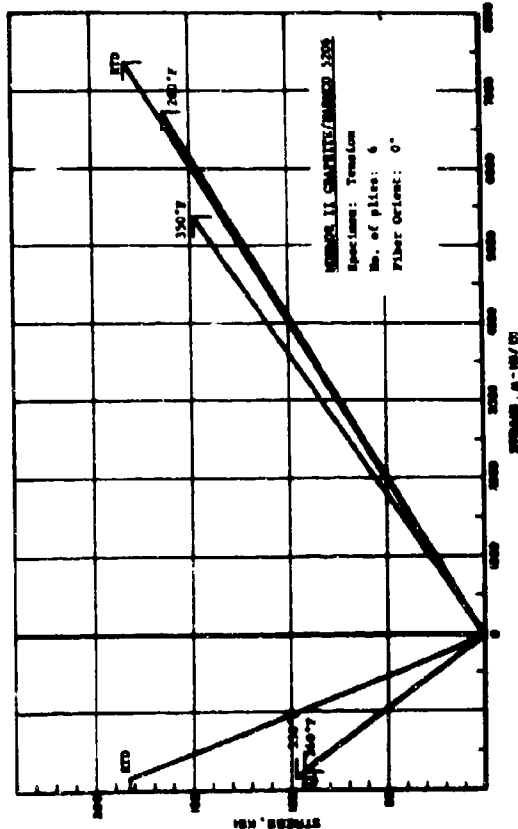


FIG. 281 TENSION STRESS-STRAIN DIAGRAM FOR 0° Kevlar II Graphite/IMR 5206 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER 1000 HOURS EXPOSURE TO 98% R.H.

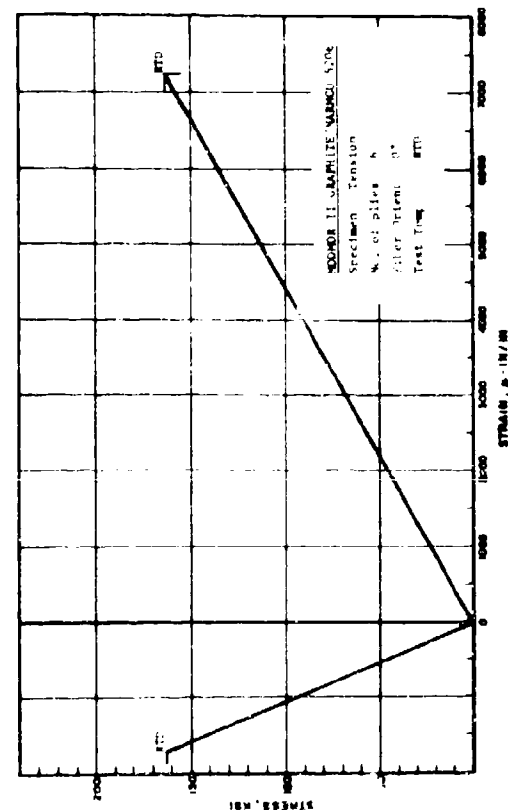


FIG. 282 TENSION STRESS-STRAIN DIAGRAM FOR 0° NOMEX II GRAPHITE MARKED 570 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Therm-Humidity Cycle)

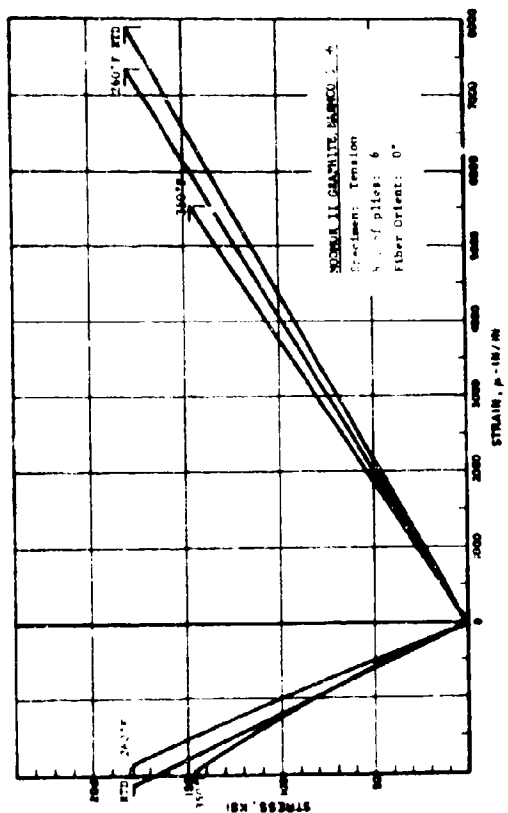


FIG. 283 TENSION STRESS-STRAIN DIAGRAM FOR 0° NOMEX II GRAPHITE MARKED 570 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Therm-Humidity Cycle)

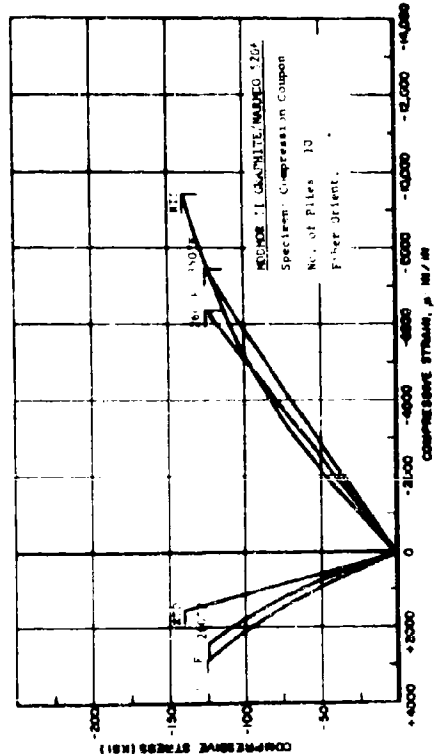


FIG. 284 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° NOMEX II GRAPHITE MARKED 570 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Therm-Humidity Cycle)

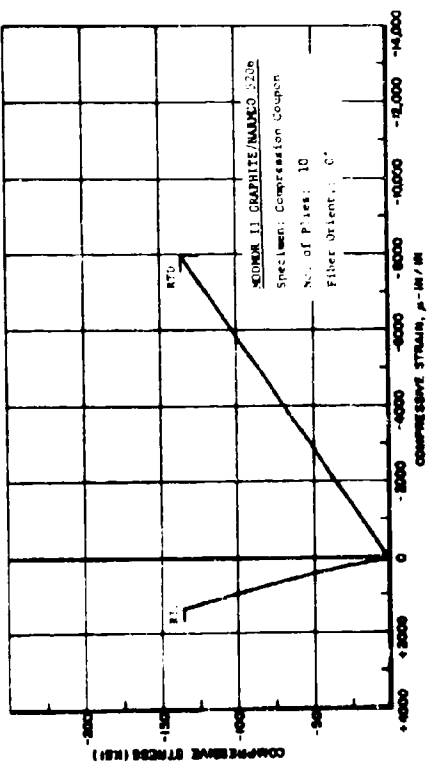


FIG. 285 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° NOMEX II GRAPHITE MARKED 570 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Therm-Humidity Cycle)

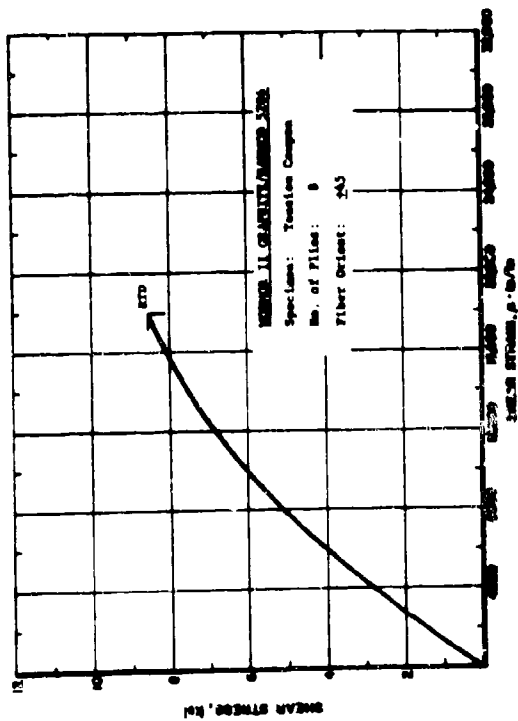


FIG. 287 SHEAR STRESS-STRAIN DIAGRAM FOR 0° HOOPER II GRAPHITE/MARISCO 5206 LAMINATE TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 90% R.H.

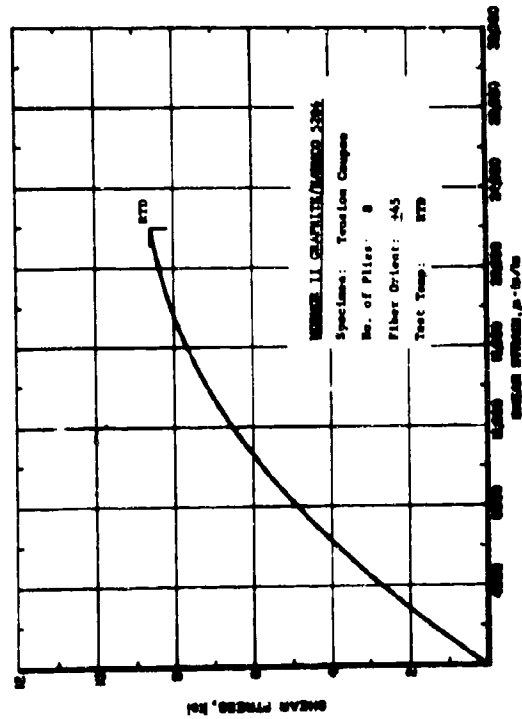


FIG. 289 SHEAR STRESS-STRAIN DIAGRAM FOR 0° HOOPER II GRAPHITE/MARISCO 5206 LAMINATE TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermal-Humidity Cycle)

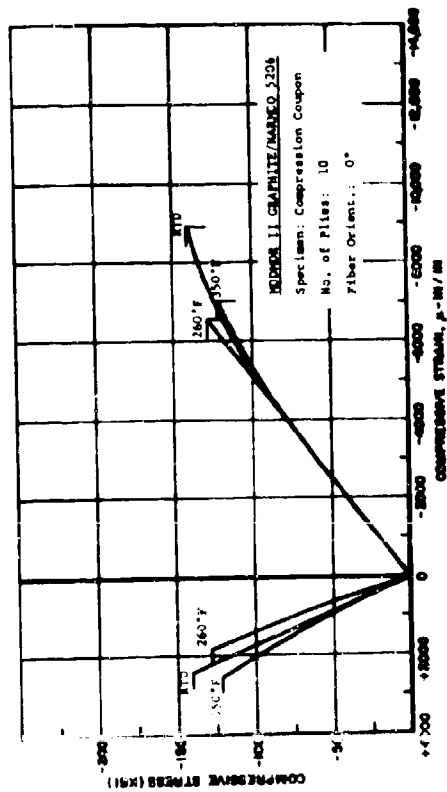


FIG. 286 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° HOOPER II GRAPHITE/MARISCO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

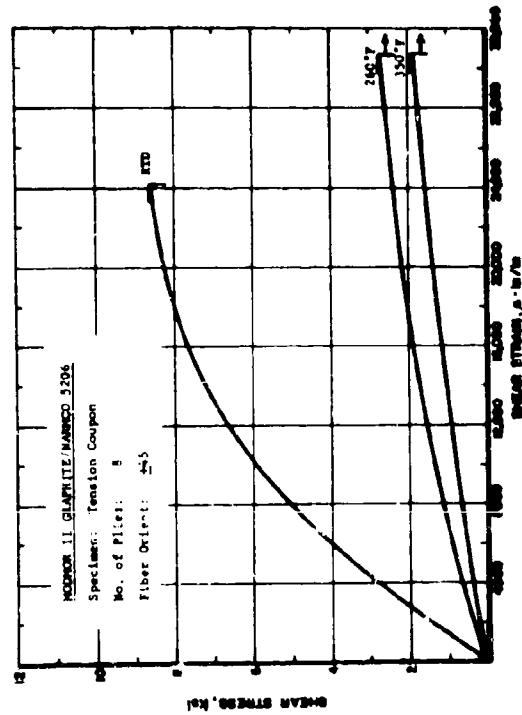


FIG. 288 SHEAR STRESS-STRAIN DIAGRAM FOR 0° HOOPER II GRAPHITE/MARISCO 5206 LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

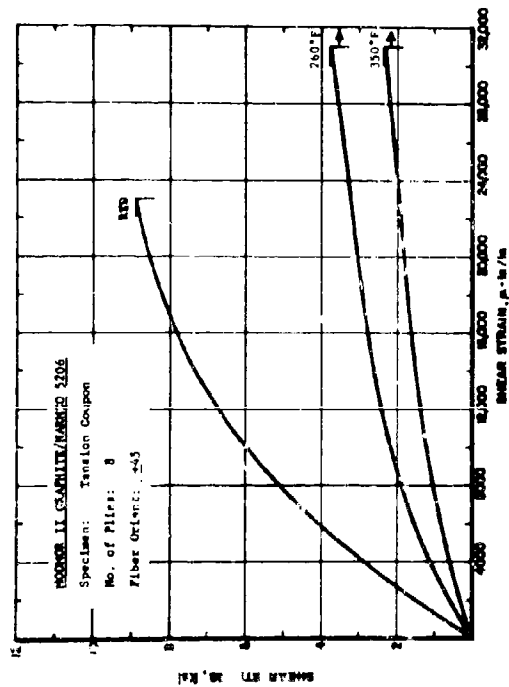


Fig. 290 SHEAR STRESS-STRAIN DIAGRAM FOR 0° MONOR II GRAPHITE/MARNO 5206 LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

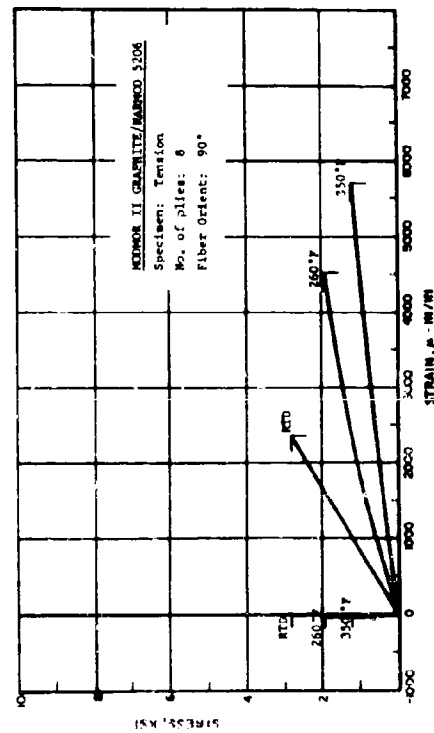


Fig. 292 TENSION STRESS-STRAIN DIAGRAM FOR 90° MONOR II GRAPHITE/MARNO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 95% R.H.

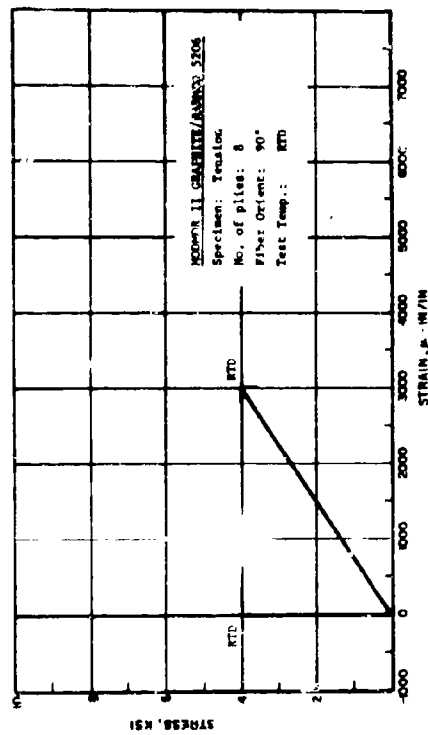


Fig. 291 TENSION STRESS-STRAIN DIAGRAM FOR 90° MONOR II GRAPHITE/MARNO 5206 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 95% R.H.

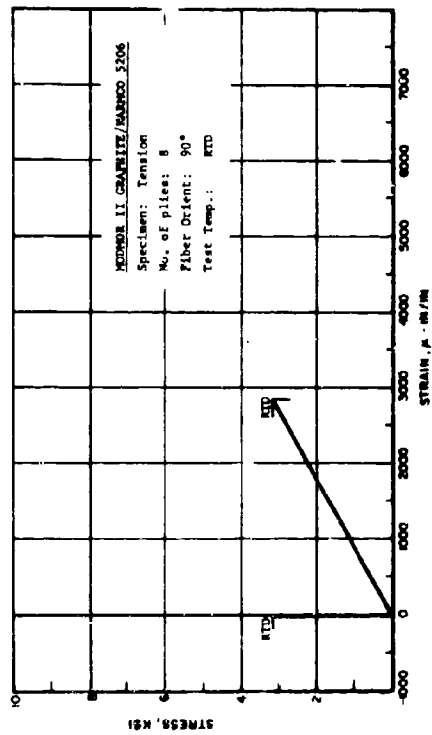


Fig. 293 TENSION STRESS-STRAIN DIAGRAM FOR 90° MONOR II GRAPHITE/MARNO 5206 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle)

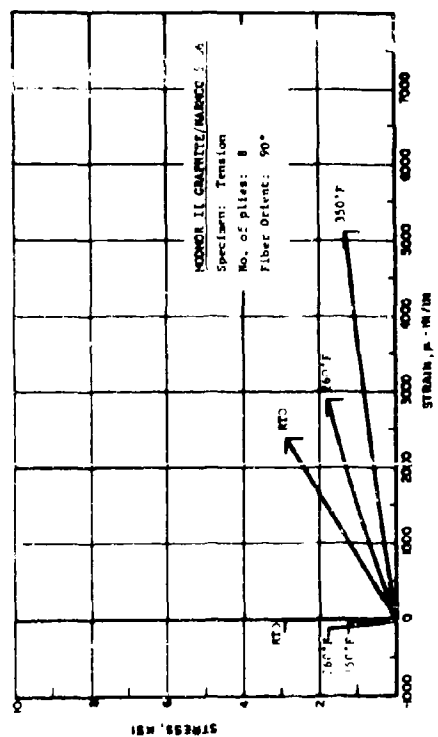


FIG. 294 TENSION STRESS-STRAIN DIAGRAM FOR 90° KODOR II GRAPHITE/MANCO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

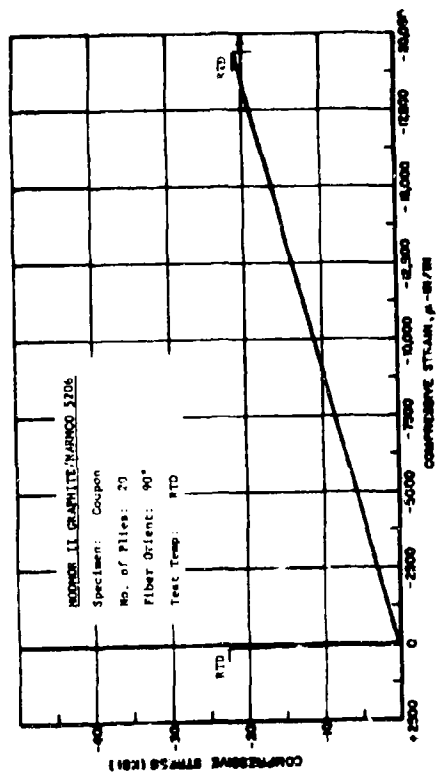


FIG. 295 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° KODOR II GRAPHITE/MANCO 5206 COMPOSITE TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 98% R.H.

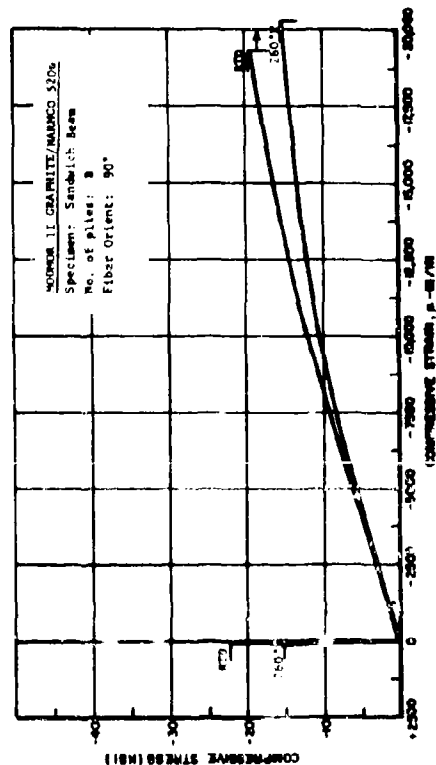


FIG. 296 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° KODOR II GRAPHITE/MANCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 98% R.H.

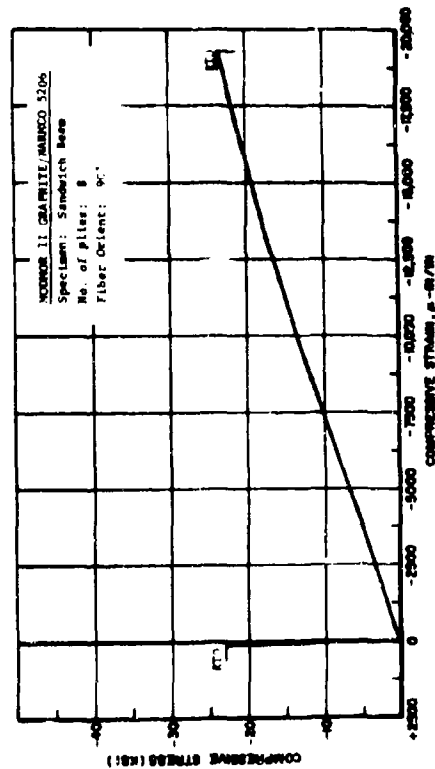


FIG. 297 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° KODOR II GRAPHITE/MANCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Two-Humidity Cycle)

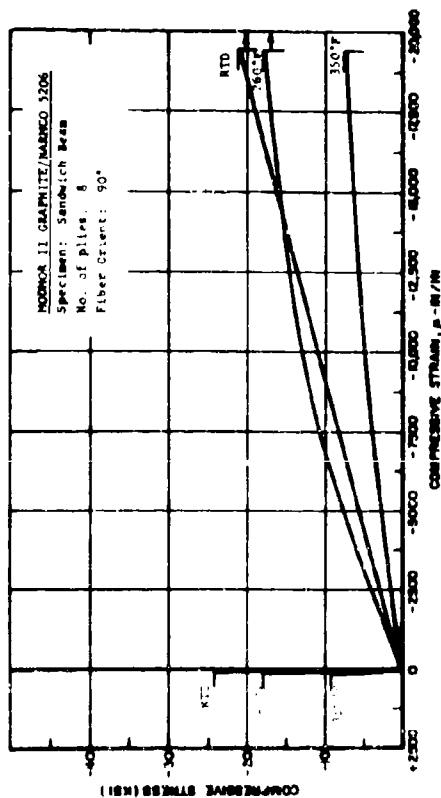


Fig. 299 COMPRESSION STRESS-STRAIN DIAGRAM FOR MOHOM II GRAPHITE/MANCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (After etched weathering)

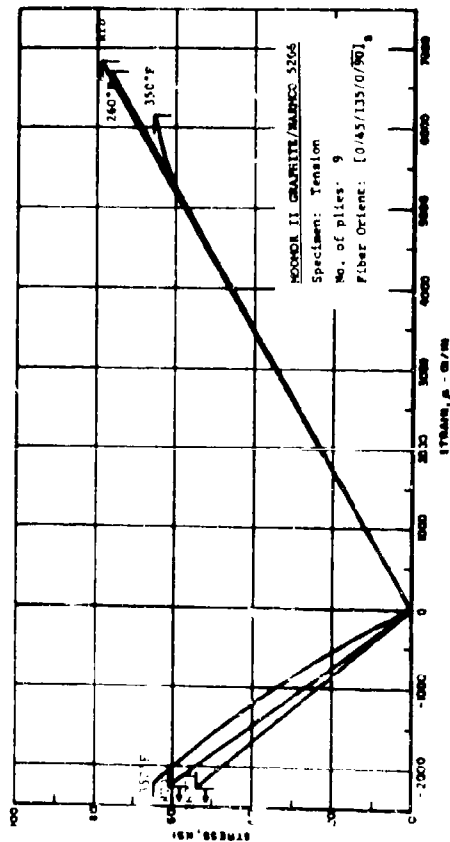


Fig. 300 TENSION STRESS-STRAIN DIAGRAM FOR MOHOM II GRAPHITE/MANCO 5206 LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

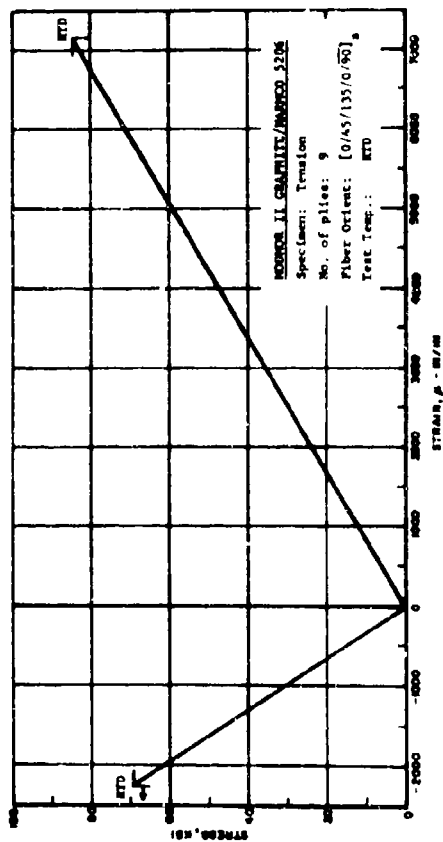


Fig. 298 TENSION STRESS-STRAIN DIAGRAM FOR MOHOM II GRAPHITE/MANCO 5206 LAMINATE, TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 90% R.H.

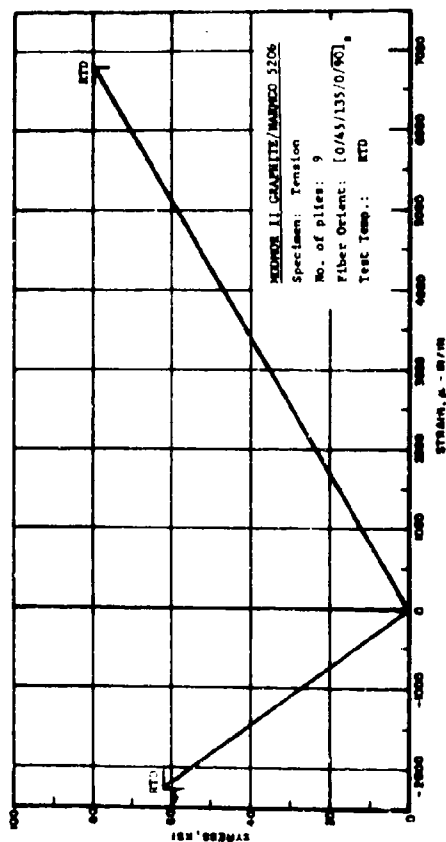


Fig. 301 TENSION STRESS-STRAIN DIAGRAM FOR MOHOM II GRAPHITE/MANCO 5206 LAMINATE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle)

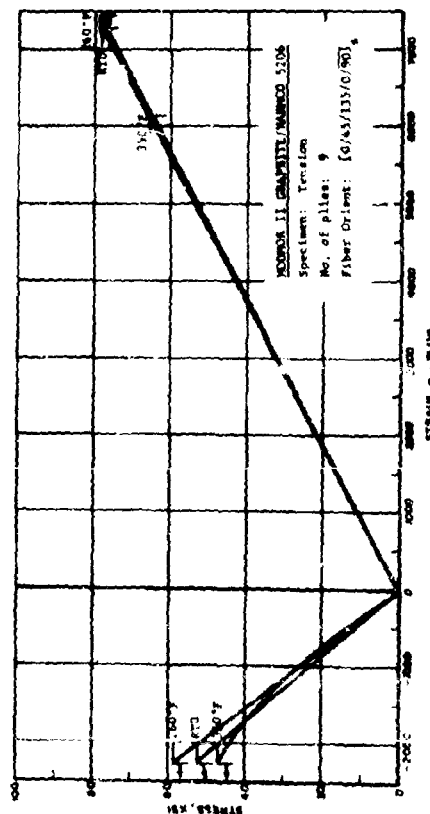


FIG. 302 TENSION STRESS-STRAIN DIAGRAM FOR NOMOR II GRAPHITE/MARISCO 5206 [0/45/135/0/90]₉ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

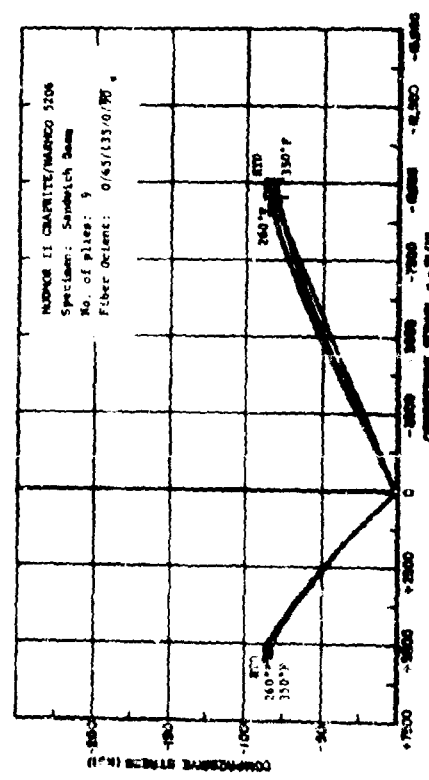


FIG. 304 COMPRESSION STRESS-STRAIN DIAGRAM FOR NOMOR II GRAPHITE/MARISCO 5206 [0/45/135/0/90]₉ LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% RH

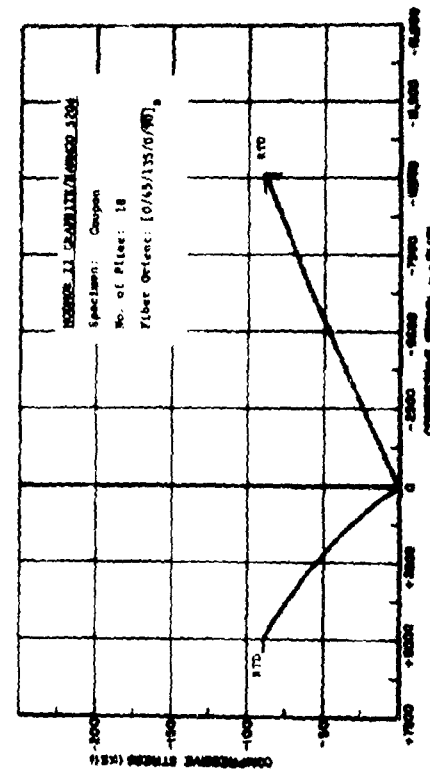


FIG. 303 COMPRESSION STRESS-STRAIN DIAGRAM FOR NOMOR II GRAPHITE/MARISCO 5206 [0/45/135/0/90]₁₈ LAMINATE TESTED AT ROOM TEMP AFTER 500 HOURS EXPOSURE TO 90% RH

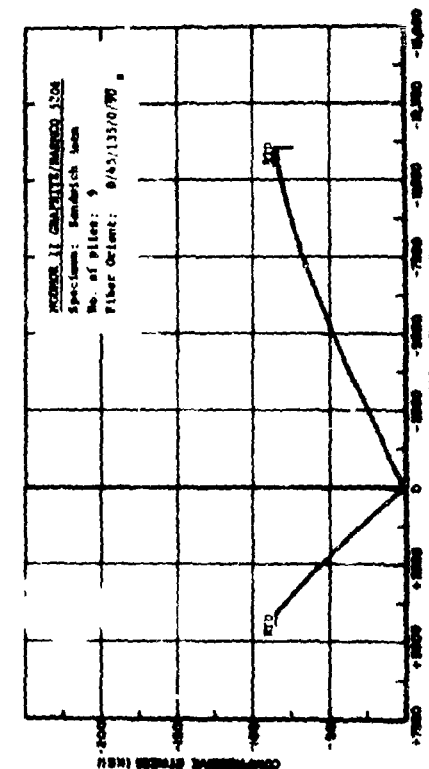


FIG. 305 COMPRESSION STRESS-STRAIN DIAGRAM FOR NOMOR II GRAPHITE/MARISCO 5206 [0/45/135/0/90]₉ LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle)

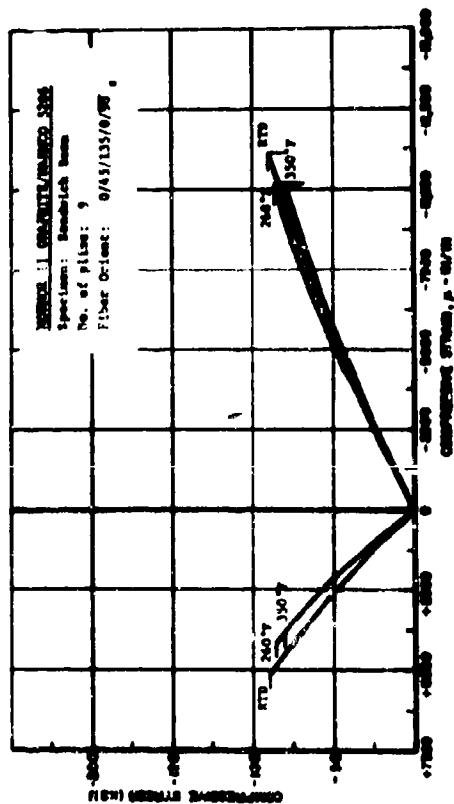


Fig. 306 COMPRESSION STRESS-STRAIN DIAGRAM FOR NOMEX II GRAPHITE/MAJCO 5306 LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

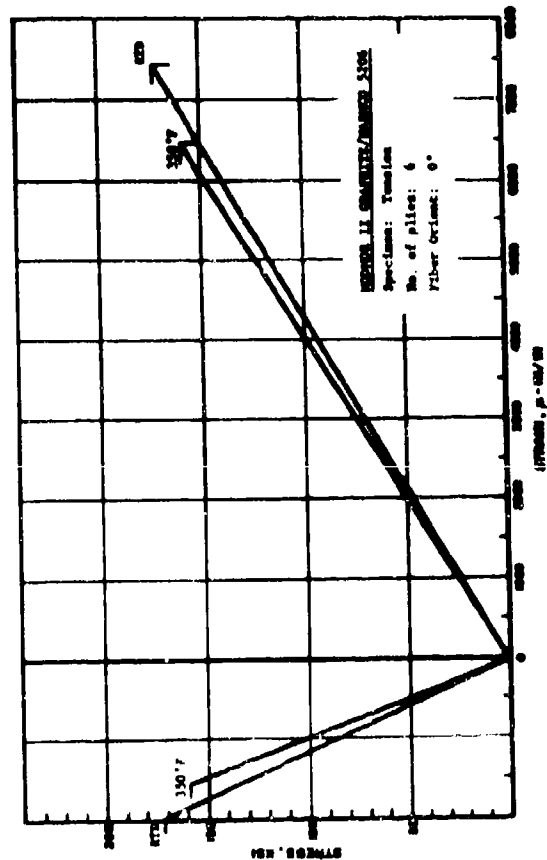


Fig. 308 TENSION STRESS-STRAIN DIAGRAM FOR 0° NOMEX II GRAPHITE/MAJCO 5306 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 340 HOURS EXPOSURE TO 350°F

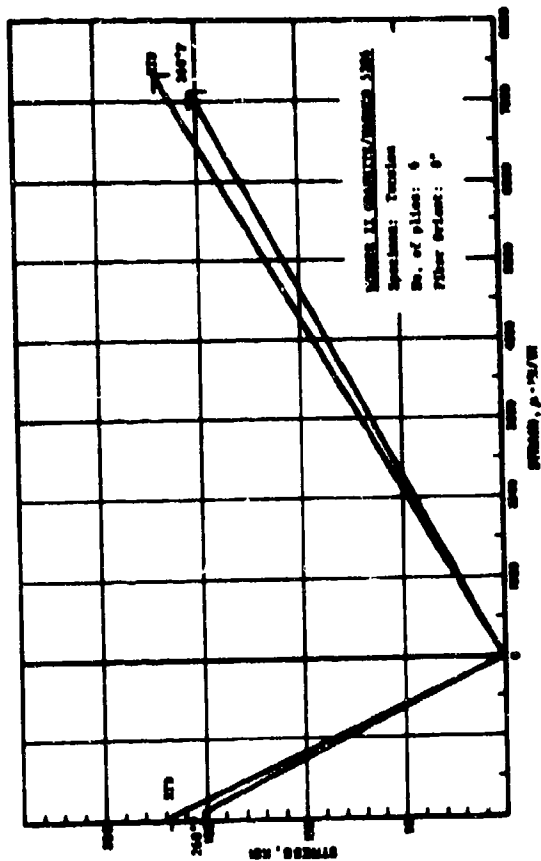


Fig. 307 TENSION STRESS-STRAIN DIAGRAM FOR 0° NOMEX II GRAPHITE/MAJCO 5306 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 340 HOURS EXPOSURE TO 350°F

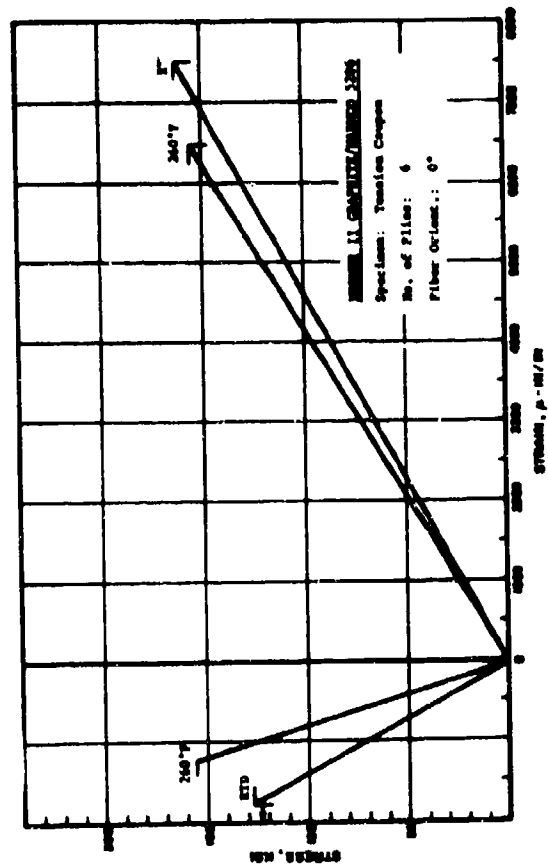


Fig. 309 TENSION STRESS-STRAIN DIAGRAM FOR 0° NOMEX II GRAPHITE/MAJCO 5306 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

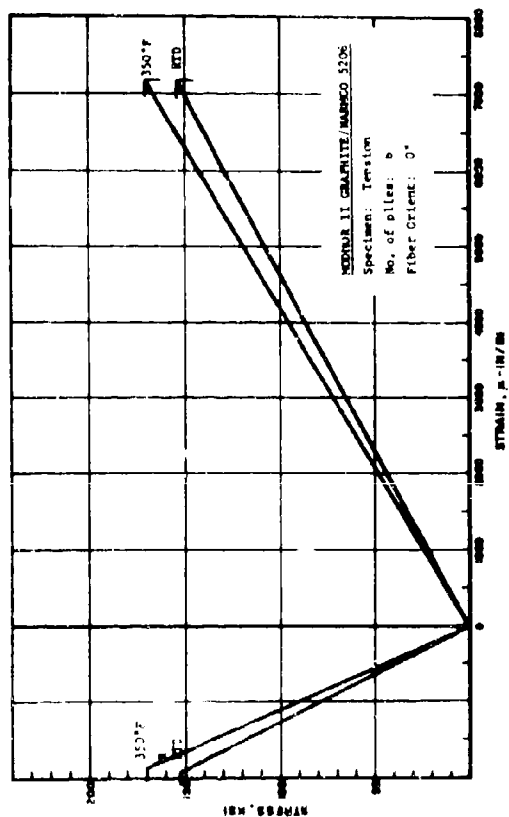


FIG. 311 TENSION STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARICO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

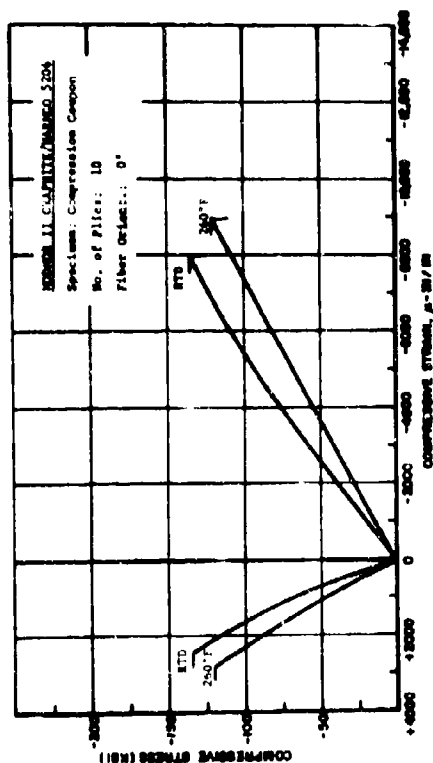


FIG. 312 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARICO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

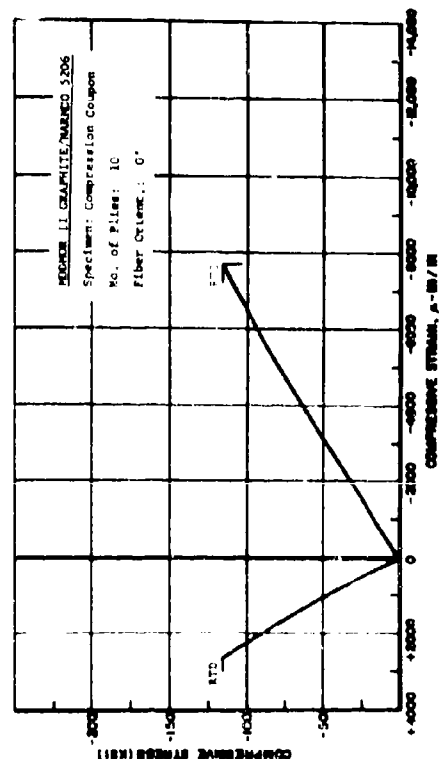


FIG. 313 TENSION STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARICO 5206 COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER 100 HOURS EXPOSURE TO 350°F

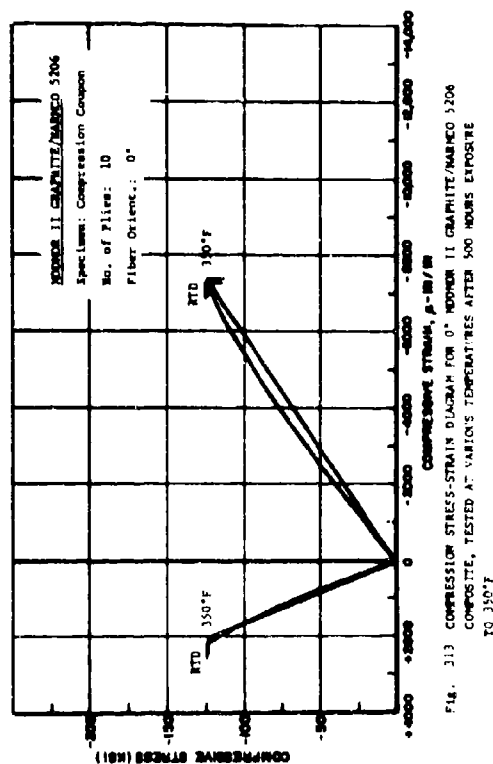


FIG. 314 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARICO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

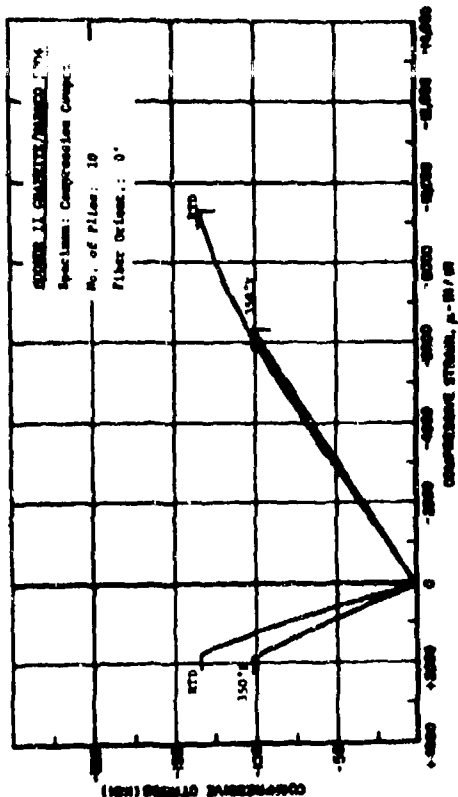


Fig. 313 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARBLE 5204 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 150°F

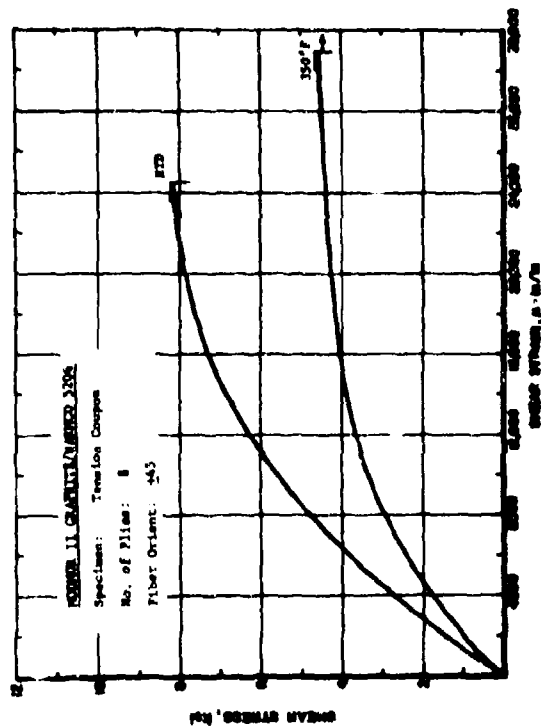


Fig. 317 SHEAR STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARBLE 5204 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

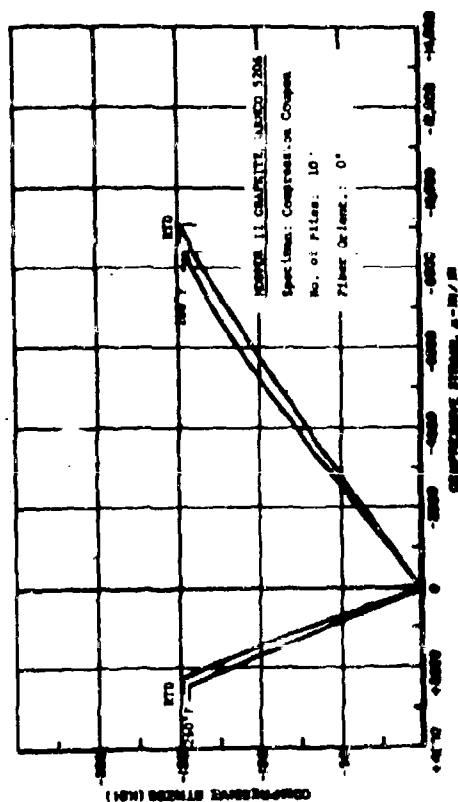


Fig. 314 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARBLE 5204 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 740°F

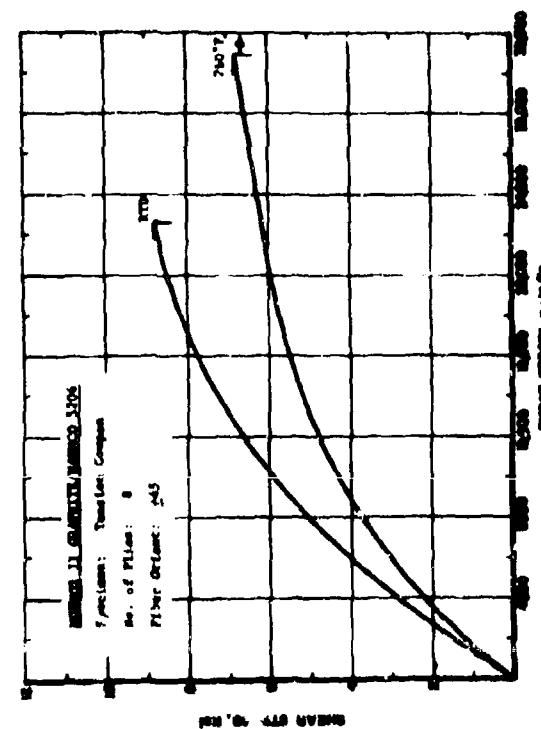


Fig. 316 SHEAR STRESS-STRAIN DIAGRAM FOR 0° KEVLAR II GRAPHITE/MARBLE 5204 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 740°F

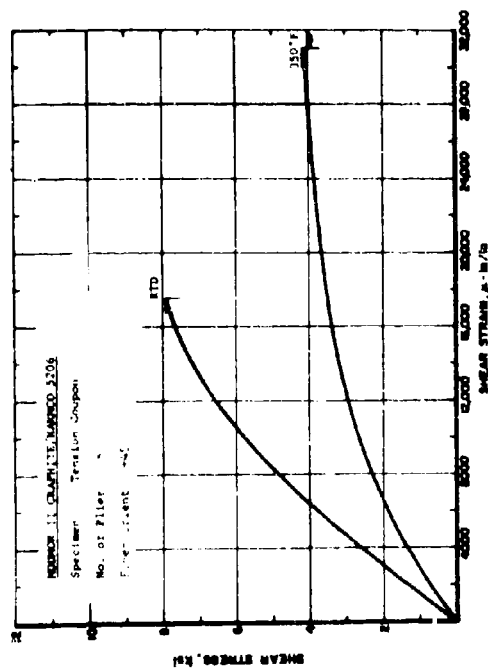


FIG. 11a SHEAR STRESS-STRAIN DIAGRAM FOR 90° MONOMER II GRAPHITE/MARMO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 350°F

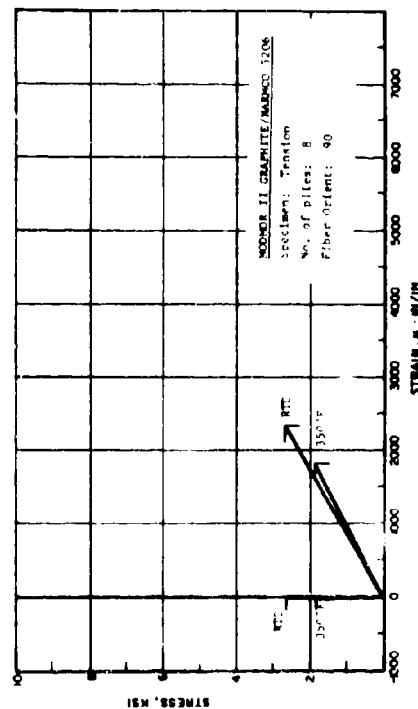


FIG. 11b TENSION STRESS-STRAIN DIAGRAM FOR 90° MONOMER II GRAPHITE/MARMO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 300-HOUR EXPOSURE TO 350°F

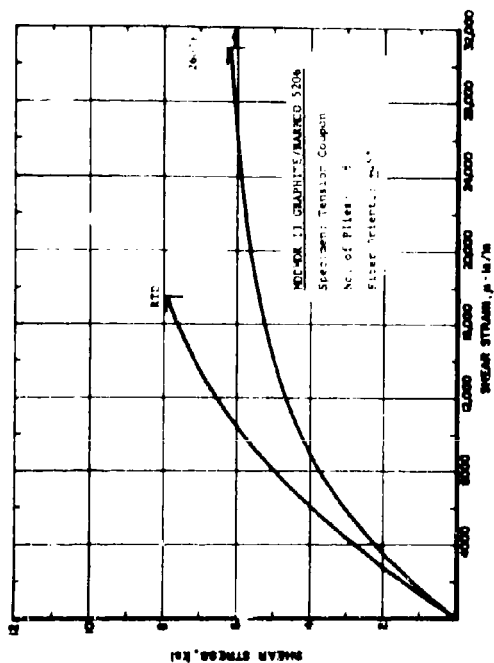


FIG. 12a SHEAR STRESS-STRAIN DIAGRAM FOR 90° MONOMER II GRAPHITE/MARMO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

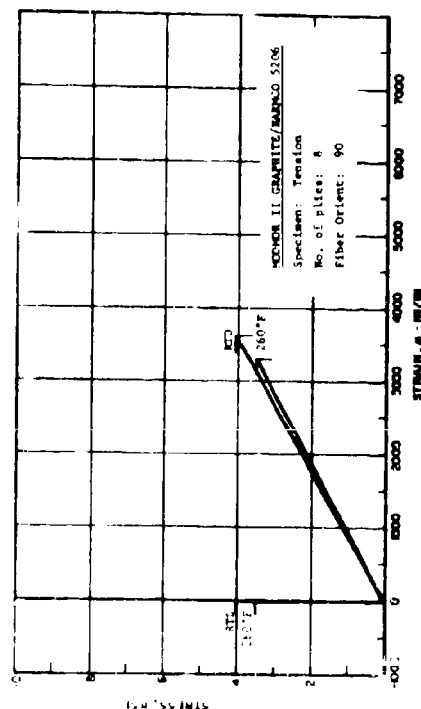


FIG. 12b TENSION STRESS-STRAIN DIAGRAM FOR 90° MONOMER II GRAPHITE/MARMO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 260°F

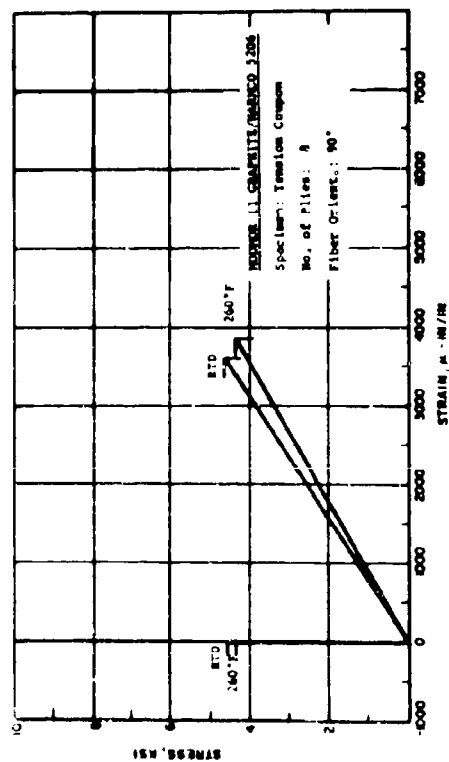


Fig. 322 TENSION STRESS-STRAIN DIAGRAM FOR 90° KEVLAR II GRAPHITE/MARISCO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 240°F

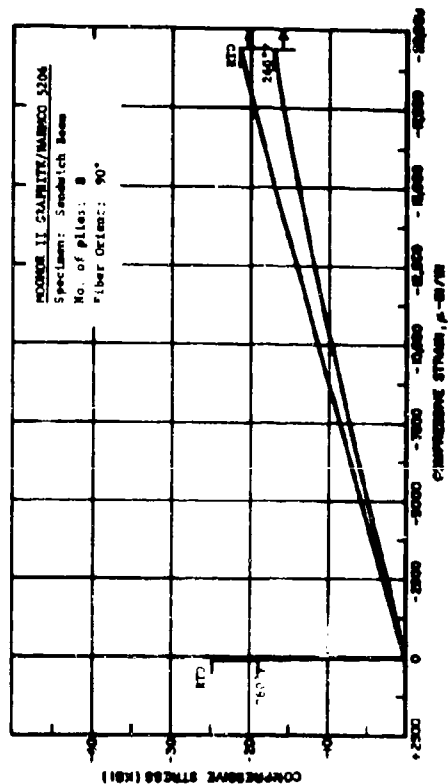


Fig. 324 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° KEVLAR II GRAPHITE/MARISCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE

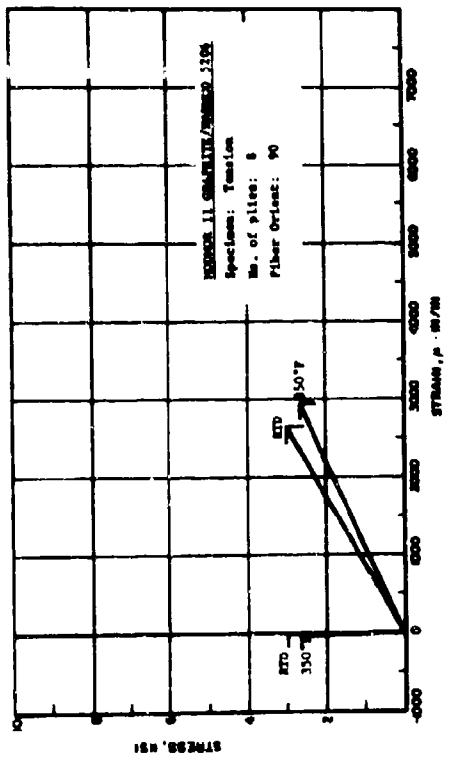


Fig. 323 TENSION STRESS-STRAIN DIAGRAM FOR 90° KEVLAR II GRAPHITE/MARISCO 5206 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

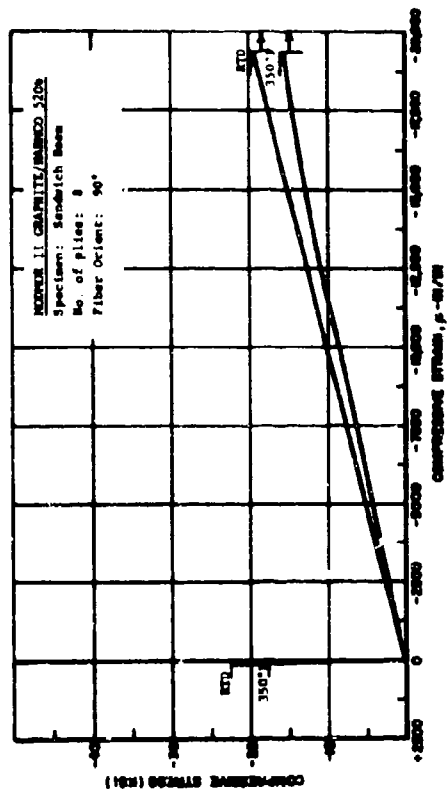


Fig. 325 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° KEVLAR II GRAPHITE/MARISCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE AT 350°F

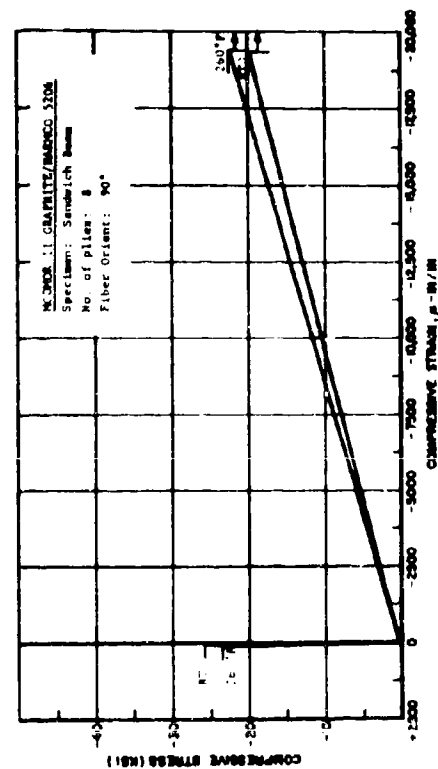


FIG. 11- COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° MONOR II GRAPHITE/MARCO 5206 LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

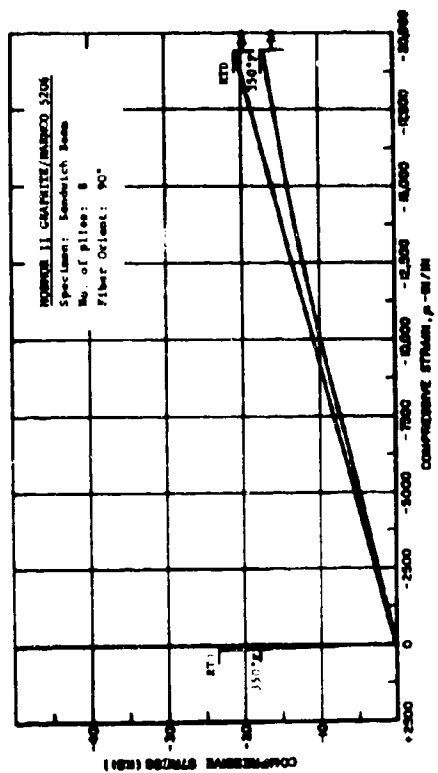


FIG. 12- COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° MONOR II GRAPHITE/MARCO 5206 LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 350°F

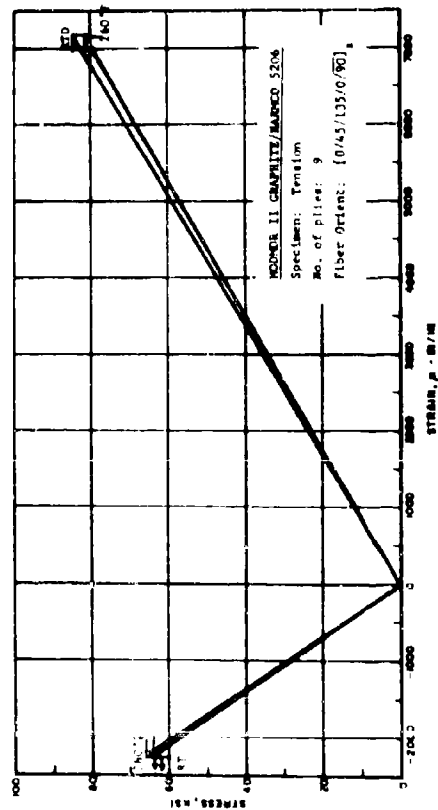


FIG. 13- TENSION STRESS-STRAIN DIAGRAM FOR MONOR II GRAPHITE/MARCO 5206 [0/45/135/0/90] LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 280°F

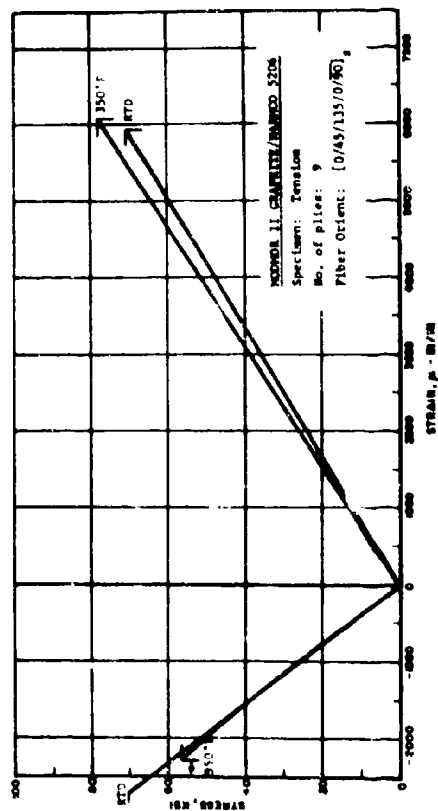


FIG. 14- TENSION STRESS-STRAIN DIAGRAM FOR MONOR II GRAPHITE/MARCO 5206 [0/45/135/0/90] LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

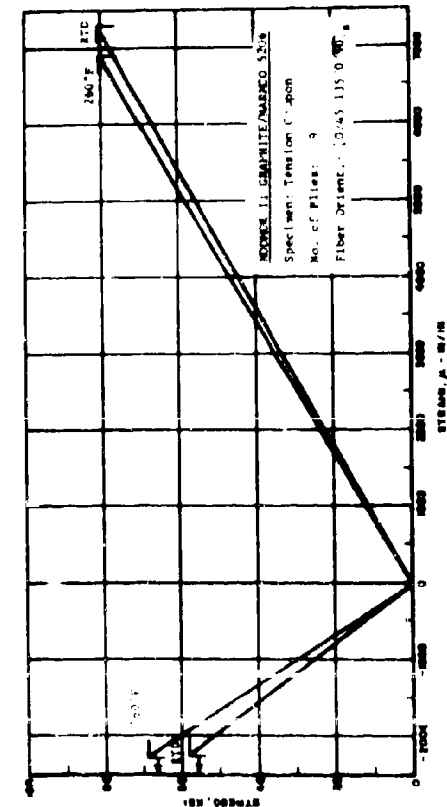


FIG. 131 TENSION STRESS-STRAIN DIAGRAM FOR MONOR II GRAPHITE/MARCO 5206 [0/45/135/0/90]° LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

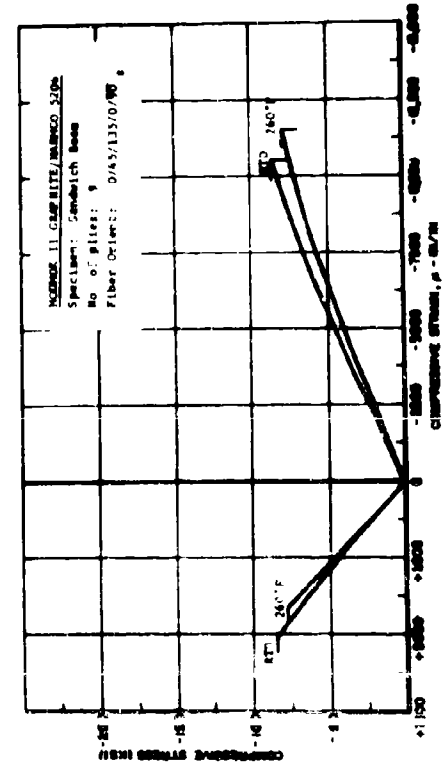


FIG. 132 COMPRESSION STRESS-STRAIN DIAGRAM FOR MONOR II GRAPHITE/MARCO 5206 [0/45/135/0/90]° LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 260°F

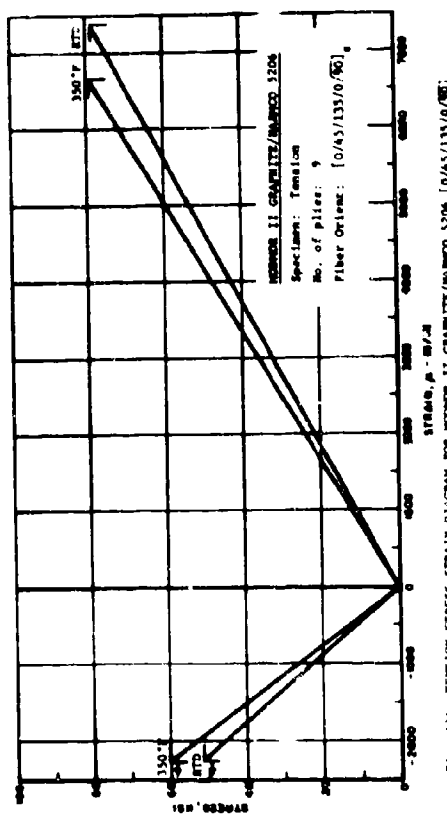


FIG. 133 TENSION STRESS-STRAIN DIAGRAM FOR MONOR II GRAPHITE/MARCO 5206 [0/45/135/0/90]° LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

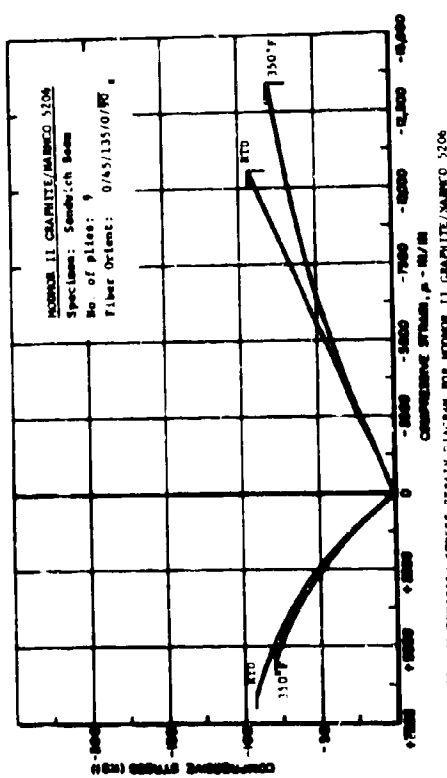


FIG. 134 COMPRESSION STRESS-STRAIN DIAGRAM FOR MONOR II GRAPHITE/MARCO 5206 [0/45/135/0/90]° LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

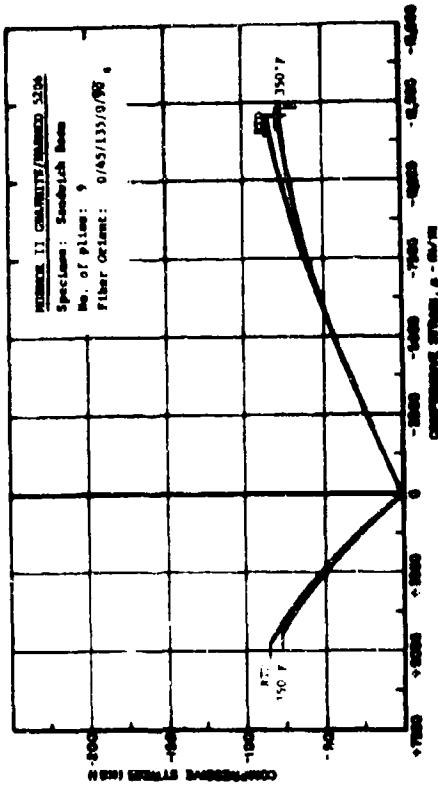
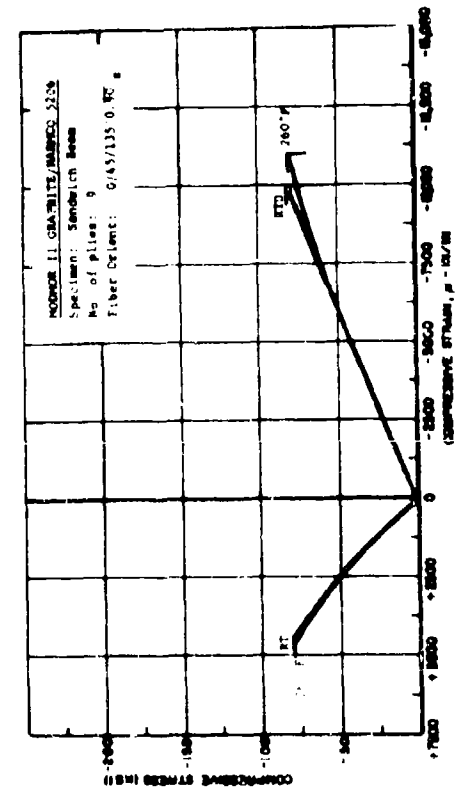


FIG. 135 COMPRESSION STRESS-STRAIN DIAGRAM FOR MODER II CARBONITE/MARKED 5704
 (0/45/135 0.9%) LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES
 EXPOSURE TO 150°F

COMPRESSION STRESS-STRAIN DIAGRAM FOR MODER II CARBONITE/MARKED 5704
 (0/45/135 0.9%) LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES
 EXPOSURE TO 150°F

TABLE XVI
STRESS-TO-FAILURE DATA FOR COMPOSITE

Specimen Number	Thickness (Plies) (in.)	Orientation	PRIORITY CONDITIONING		Test Temp. (°F)	Stress Level (%ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1105A-6	6 - 0.032	0°	None	-	RTD	87	1,000	-	-	Tab Area Failure
M1105A-7	6 - 0.032	0°	None	-	RTD	78	1,000	-	-	-
M1105A-8	6 - 0.033	0°	None	-	RTD	84	7,000	-	-	-
M1105A-9	6 - 0.033	0°	None	-	RTD	82	106,000	-	-	-
M1105A-10	6 - 0.033	0°	None	-	RTD	81	4,000	-	-	Tab Area Failure
M1105A-11	6 - 0.033	0°	None	-	RTD	81	848,000	-	-	-
M1105A-12	6 - 0.032	0°	None	-	RTD	87	1,000	-	-	Tab Area Failure
M1105A-13	6 - 0.032	0°	None	-	RTD	83	13,000	-	-	Tab Area Failure
M1105A-14	6 - 0.032	0°	None	-	RTD	83	2,000	-	-	Tab Area Failure
M1105A-15	6 - 0.032	0°	None	-	RTD	78	5,678,000	-	-	Tab Area Failure
M1102-6	8 - 0.042	90°	None	-	RTD	91	-	-	-	Immediate Tab Failure
M1102-7	8 - 0.042	90°	None	-	RTD	52	1,000	-	-	Tab Area Failure
M1102-8	8 - 0.042	90°	None	-	RTD	52	2,000	-	-	Tab Area Failure
M1102-9	8 - 0.043	90°	None	-	RTD	39	6,569,000	-	-	Tab Area Failure
M1102-10	8 - 0.043	90°	None	-	RTD	26	881,000	-	-	-
M1102-11	8 - 0.043	90°	None	-	RTD	48	1,000	-	-	-
M1102-12	8 - 0.043	90°	None	-	RTD	49	2,000	-	-	-
M1102-13	8 - 0.043	90°	None	-	RTD	46	2,351,000	-	-	-
M1102-14	8 - 0.042	90°	None	-	RTD	47	3,000	-	-	Tab Area Failure
M1102-15	8 - 0.042	90°	None	-	RTD	47	5,818,000	-	-	-
M1127A-6	9 - 0.047	[0/45/135/C/90] ^a	None	-	RTD	84	60	10 x 10 ⁶	83.2	-
M1127A-7	9 - 0.047	[0/45/135/C/90] ^a	None	-	RTD	98	324,000	-	-	Immediate Tab Failure
M1127A-8	9 - 0.046	[0/45/135/C/90] ^a	None	-	RTD	112	80	2,000	-	-
M1127A-9	9 - 0.046	[0/45/135/C/90] ^a	None	-	RTD	105	75	-	-	Immediate Tab Failure
M1127A-10	9 - 0.048	[0/45/135/C/90] ^a	None	-	RTD	100.5	72	-	-	Immediate Tab Failure
M1127A-11	9 - 0.046	[0/45/135/C/90] ^a	None	-	RTD	91	65	10,200,000	-	-
M1127A-12	9 - 0.048	[0/45/135/C/90] ^a	None	-	RTD	98	70	-	-	Immediate Tab Failure
M1127A-13	9 - 0.047	[0/45/135/C/90] ^a	None	-	RTD	102	73	3,000	-	Tab Area Failure
M1127A-14	9 - 0.046	[0/45/135/C/90] ^a	None	-	RTD	103	74	-	-	Immediate Tab Failure
M1127A-15	9 - 0.048	[0/45/135/C/90] ^a	None	-	RTD	100.5	72	1,366,000	-	-

TABLE XVI FAILURE PROPERTIES SUMMARY -
NARCO 2206 MODERN II GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (σ _{ult})	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1107A-11	6 - C.038	0°	None	-	260°F	90	1,000	-	-	Immediate Failure
M1107A-12	6 - C.038	0°	None	-	260°F	87	-	-	-	-
M1107A-13	6 - C.038	0°	None	-	260°F	83.5	6,000	-	-	-
M1107A-14	6 - C.038	0°	None	-	260°F	80	-	2.113 x 10 ⁶	179.0	-
M1107A-15	6 - C.039	0°	None	-	260°F	82	3,000	-	-	Tab Failure
M1107A-16	6 - C.038	0°	None	-	260°F	81	1,000	-	-	Tab Failure
M1107A-17	6 - C.036	0°	None	-	260°F	80	-	-	-	Immediate Tab Failure
M1107A-18	6 - C.038	0°	None	-	260°F	81	-	-	-	Immediate Tab Failure
M1107A-19	6 - C.039	0°	None	-	260°F	82	-	-	-	Immediate Tab Failure
M1107A-20	6 - C.038	0°	None	-	260°F	83.5	-	-	-	Immediate Tab Failure
M1113-11	8 - 0.044	90°	None	-	260°F	65	2	70,000	-	Failed under static load while coming up to temperature
M1113-12	8 - 0.043	90°	None	-	260°F	98	3	-	-	Tab Area Failure
M1113-13	8 - 0.041	90°	None	-	260°F	82	2,000	-	-	-
M1113-14	8 - 0.044	90°	None	-	260°F	65	2	8,000	-	-
M1113-15	8 - 0.042	90°	None	-	260°F	82	2.5	30,000	-	-
M1113-16	8 - 0.043	90°	None	-	260°F	59	1.8	261,000	-	-
M1113-17	8 - 0.043	90°	None	-	260°F	75	2.3	5,000	-	-
M1113-18	8 - 0.042	90°	None	-	260°F	91.5	2.8	-	-	Failed under static load while coming up to temperature
M1114-1	8 - 0.043	90°	None	-	260°F	49	1.5	-	3.4	Tab Area Failure
M1114-2	8 - 0.043	90°	None	-	260°F	98	3	-	-	Failed under static load while coming up to temperature
M1133B-2	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	80	70	14,000	-	Immediate Failure
M1133B-3	9 - 0.049	[0/45/135/0/90] _s	None	-	260°F	83.5	73	-	-	Tab Failure
M1133B-4	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	80	70	1,000	-	-
M1133B-5	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	74.5	65	4,000	-	-
M1133B-6	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	74.5	65	10,000	-	-
M1133B-7	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	68.5	60	6,000	-	-
M1133B-8	9 - 0.049	[0/45/135/0/90] _s	None	-	260°F	63	55	-	2.362 x 10 ⁶	78.4
M1133B-9	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	68.5	60	8,000	-	-
M1133B-10	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	66.5	58	-	2.377 x 10 ⁶	76.7
M1133B-11	9 - 0.048	[0/45/135/0/90] _s	None	-	260°F	72	63	-	2.08 x 10 ⁶	71.9

TABLE XVI FATIGUE PROPERTIES SUMMARY -
NARMCO 5500/5400 RIM (T) CARBIDE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1107B-1	6 - 0.039	0°	None	-	350°F	67	2,000	-	-	Tab Failure
M1107B-2	6 - 0.039	0°	None	-	350°F	63.5	-	-	-	Immediate Failure
M1107B-3	6 - 0.037	0°	None	-	350°F	60	-	2.619 x 10 ⁶	139.2	Tab Failure
M1107B-4	6 - 0.037	0°	None	-	350°F	67	-	2.421 x 10 ⁶	140.5	Tab Failure
M1107B-5	6 - 0.038	0°	None	-	350°F	70	17,000	-	-	Tab Failure
M1107B-6	6 - 0.038	0°	None	-	350°F	70	2,000	-	-	
M1107B-7	6 - 0.037	0°	None	-	350°F	73.5	1,000	-	-	
M1107B-8	6 - 0.037	0°	None	-	350°F	68.5	5,000	-	-	
M1107B-9	6 - 0.034	0°	None	-	350°F	63.5	1,930,000	-	-	
M1107B-10	6 - 0.037	0°	None	-	350°F	67.5	1,000	-	-	Defective Tab
M1114-3	8 - 0.041	90°	None	-	350°F	30	23,000	-	-	Failed under static load while coming up to temperature
M1114-4	8 - 0.043	90°	None	-	350°F	98	-	-	-	Failed under static load while coming up to temperature
M1114-5	8 - 0.043	90°	None	-	350°F	30	2,000	-	-	Failed under static load while coming up to temperature
M1114-6	8 - 0.043	90°	None	-	350°F	67	-	-	-	
M1114-7	8 - 0.044	90°	None	-	350°F	23	4,000	-	-	
M1114-8	8 - 0.043	90°	None	-	350°F	16.5	-	7.0 x 10 ⁶	3.7	
M1114-9	8 - 0.044	90°	None	-	350°F	23	8,000	-	-	
M1114-10	8 - 0.043	90°	None	-	350°F	21	-	7.0 x 10 ⁶	3.7	
M1114-11	8 - 0.043	90°	None	-	350°F	33	3,000	-	-	
M1114-12	8 - 0.043	90°	None	-	350°F	33	1,000	-	-	
M1134A-1	9 - 0.050	[0/45/135/0/90] _s	None	-	350°F	82	-	-	-	Spec. slipped in grips
M1134A-2	9 - 0.049	[0/45/135/0/90] _s	None	-	350°F	82	2,000	-	-	
M1134A-3	9 - 0.049	[0/45/135/0/90] _s	None	-	350°F	63	-	2.332 x 10 ⁶	60.0	
M1134A-4	9 - 0.050	[0/45/135/0/90] _s	None	-	350°F	69.5	-	2.033 x 10 ⁶	72.2	
M1134A-5	9 - 0.050	[0/45/135/0/90] _s	None	-	350°F	69.5	-	2.000 x 10 ⁶	73.3	
M1134A-6	9 - 0.049	[0/45/135/0/90] _s	None	-	350°F	76	2,000	-	-	
M1134A-7	9 - 0.049	[0/45/135/0/90] _s	None	-	350°F	76	6,000	-	-	
M1134A-8	9 - 0.048	[0/45/135/0/90] _s	None	-	350°F	72	2,000	-	-	
M1134A-9	9 - 0.049	[0/45/135/0/90] _s	None	-	350°F	73.5	20,000	-	-	Tab Failure
M1134A-10	9 - 0.049	[0/45/135/0/90] _s	None	-	350°F	73.5	18,000	-	-	

TABLE XVI
TENSILE PROPERTIES SUMMARY -
CARBO FIBER REINFORCED GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	Failure Conditioning Type	Duration	Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
M1105B-7	6 -	0°	98° RH	500 Hrs.	RTD					-(Specimen broke during fabrication)
M1105B-8	6 -	0°	98° RH	500 Hrs.	RTD					Immediate failure
M1105B-9	6 - 0.032	0°	98° RH	500 Hrs.	RTD	78	2,000			Immediate failure
M1105B-10	6 - 0.032	0°	98° RH	500 Hrs.	RTD	75				Immediate failure
M1105B-11	6 - 0.032	0°	98° RH	500 Hrs.	RTD	70.5				Immediate failure
M1108B-15	6 - 0.038	0°	98° RH	500 Hrs.	260°F	69.5	1,000			Tab Failure
M1108B-16	6 - 0.037	0°	98° RH	500 Hrs.	260°F	66.5	18,000			Tab Failure
M1108B-17	6 - 0.037	0°	98° RH	500 Hrs.	260°F	68	2,000			Tab Failure
M1108B-18	6 - 0.036	0°	98° RH	500 Hrs.	260°F	63.5	11,900			Tab Failure
M1108B-19	6 - 0.037	0°	98° RH	500 Hrs.	260°F	61		2.033 x 10 ⁶	166.7	Tab Failure
M1109A-15	6 - 0.033	0°	98° RH	500 Hrs.	350°F	63.5	5,000			Tab Failure
M1109A-16	6 - 0.033	0°	98° RH	500 Hrs.	350°F	60	4,000			Tab Failure
M1109A-17	6 - 0.031	0°	98° RH	500 Hrs.	350°F	57		2.34 x 10 ⁶	134.9	Tab Failure
M1109A-18	6 - 0.033	0°	98° RH	500 Hrs.	350°F	59	7,000			Tab Failure
M1109A-19	6 - 0.032	0°	98° RH	500 Hrs.	350°F	58	13,000			Tab Failure
M1105B-12	6 - 0.032	0°	98° RH	1000 Hrs.	RTD	56	2,000			Tab Failure
M1105B-13	6 - 0.032	0°	98° RH	1000 Hrs.	RTD	63				Immediate Tab Failure
M1105B-14	6 - 0.033	0°	98° RH	1000 Hrs.	RTD	60.5	2,000			Tab Failure
M1105B-15	6 - 0.032	0°	98° RH	1000 Hrs.	RTD	58	4,631,000			Tab Failure
M1105B-16	6 - 0.033	0°	98° RH	1000 Hrs.	RTD	59	51,000			Tab Failure
M1108B-20	6 - 0.033	0°	98° RH	1000 Hrs.	260°F	70.5	3,000			Tab Failure
M1109A-1	6 - 0.033	0°	98° RH	1000 Hrs.	260°F	67.5	2,000			Tab Failure
M1109A-2	6 - 0.035	0°	98° RH	1000 Hrs.	260°F	61.5	11,000			Tab Failure
M1109A-3	6 - 0.033	0°	98° RH	1000 Hrs.	260°F	55		2.26 x 10 ⁶	201	Tab Failure
M1109A-4	6 - 0.033	0°	98° RH	1000 Hrs.	260°F	58.5		2.83 x 10 ⁶	144.6	Tab Failure
M1109A-20	6 - 0.032	0°	98° RH	1000 Hrs.	350°F	64		4,766,000		Tab Failure
M1109B-1	6 - 0.031	0°	98° RH	1000 Hrs.	350°F	71		1,000		Tab Failure
M1109B-2	6 - 0.033	0°	98° RH	1000 Hrs.	350°F	67.5		14,000		Immediate Tab Failure
M1109B-3	6 - 0.032	0°	98° RH	1000 Hrs.	350°F	66				Failed under static load while coming up to temperature
M1109B-4	6 - 0.033	0°	98° RH	1000 Hrs.	350°F	66				

TABLE XVI
FATIGUE TESTS SUMMARY
NACA 64-206 AIRFOIL COMPOSITES

Specimen Number	Thickness (In.)	Orientation	Prior Conditioning		Test Temp. (°F)	Stress Level (%ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
M1105B-17	6 - 0.032	0°	Thermo-Humidity Cycle	Duration	RTD	73.5	1,000			Tab Failure
M1105B-18	6 - 0.032	0°	Thermo-Humidity Cycle		RTD	67.5	621,000			Tab Failure
M1105B-19	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	70.5	1,000			Tab Failure
M1105B-20	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	64.5	3,000			
M1105B-21	6 - 0.033	0°	Thermo-Humidity Cycle		RTD	63	102	2 x 10 ⁶	141.7	
M1109A-5	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	66	115	2.246 x 10 ⁶	155.2	
M1109A-6	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	71.5	125			
M1109A-7	6 - 0.032	0°	Thermo-Humidity Cycle		260°F	68.5	120	4,000		Tab Failure
M1109A-8	6 - 0.033	0°	Thermo-Humidity Cycle		260°F	67.5	118	1,000		Tab Failure
M1109A-9	6 - 0.032	0°	Thermo-Humidity Cycle		260°F	66.5	116	12,000		Tab Failure
M1109B-5	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	79.5	120	2.329 x 10 ⁶	170.0	Immediate Failure
M1109B-6	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	89.5	135			
M1109B-7	6 - 0.032	0°	Thermo-Humidity Cycle		350°F	86	130	17,000		
M1109B-8	6 - 0.032	0°	Thermo-Humidity Cycle		350°F	83	125	1,000		Tab Failure
M1109B-9	6 - 0.033	0°	Thermo-Humidity Cycle		350°F	81.5	123	2.28 x 10 ⁶	155.2	
M1105C-1	6 - 0.031	0°	Acc. Wehring.		RTD	61.5	110	2.335 x 10 ⁶	169.4	
M1105C-2	6 - 0.032	0°	Acc. Wehring.		RTD	67	120	41,000		
M1105C-3	6 - 0.031	0°	Acc. Wehring.		RTD	70	125	6,000		Tab Failure
M1105C-4	6 - 0.031	0°	Acc. Wehring.		RTD	64.5	115	27,000		
M1105C-5	6 - 0.031	0°	Acc. Wehring.		RTD	63	113		188.4	
M1109A-10	6 - 0.033	0°	Acc. Wehring.		260°F	61.5	110	2.442 x 10 ⁶	171.8	Immediate Failure
M1109A-11	6 - 0.033	0°	Acc. Wehring.		260°F	67	120			
M1109A-12	6 - 0.033	0°	Acc. Wehring.		260°F	64.5	115	21,000		
M1109A-13	6 - 0.032	0°	Acc. Wehring.		260°F	63	113	1,357,000		
M1109A-14	6 - 0.033	0°	Acc. Wehring.		260°F	65.5	117	5,000		
M1109B-10	6 - 0.033	0°	Acc. Wehring.		350°F	89	130	2,000		
M1109B-11	6 - 0.033	0°	Acc. Wehring.		350°F	85.5	125	272,000		
M1109B-12	6 - 0.033	0°	Acc. Wehring.		350°F	87.5	128	5,000		
M1109B-13	6 - 0.033	0°	Acc. Wehring.		350°F	87	127	1,000		
M1109B-14	6 - 0.032	0°	Acc. Wehring.		350°F	83	121	2.477 x 10 ⁶	158.1	

TABLE XVI
TENSILE STRENGTH AND ELONGATION OF ALUMINUM
SPECIMENS

Specimen Number	Thickness (Plies) (in.)	Orientation	Prior Conditioning		Test Temp. (°F)	Stress Level (T _{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1128A-1	6 - 0.048	0-45/135/0/90°	98° RH /	500 Hrs.	RTD	89	-	-	-	Immediate tab failure
M1128A-2	6 - 0.048	"	98° RH /	500 Hrs.	RTD	84.5	28,000	-	-	Immediate tab failure
M1128A-3	6 - 0.048	"	98° RH /	500 Hrs.	RTD	84.5	-	-	-	Immediate tab failure
M1128A-4	6 - 0.048	"	98° RH /	500 Hrs.	RTD	85	1,08 x 10 ⁶	-	-	Immediate tab failure
M1135B-1	6 - 0.050	"	98° RH /	500 Hrs.	260°F	74.5	-	1.632 x 10 ⁶	82.2	-
M1135B-2	6 - 0.050	"	98° RH /	500 Hrs.	260°F	87	7,000	-	-	-
M1135B-3	6 - 0.048	"	98° RH /	500 Hrs.	260°F	80.5	191,000	-	-	-
M1135B-4	6 - 0.047	"	98° RH /	500 Hrs.	260°F	83	1,174,000	-	-	-
M1135B-5	6 - 0.048	"	98° RH /	500 Hrs.	260°F	84	388,000	-	-	-
M1136B-1	6 - 0.049	"	98° RH /	500 Hrs.	350°F	102	1,000	-	-	-
M1136B-2	6 - 0.051	"	98° RH /	500 Hrs.	350°F	94	1,000	-	-	-
M1136B-3	6 - 0.049	"	98° RH /	500 Hrs.	350°F	89.5	9,000	-	-	-
M1136B-4	6 - 0.050	"	98° RH /	500 Hrs.	350°F	83	-	2.25 x 10 ⁶	77.5	-
M1136B-5	6 - 0.049	"	98° RH /	500 Hrs.	350°F	86	10,000	-	-	-
M1128A-1	6 - 0.048	"	98° RH /	1000 Hrs.	RTD	101	1,000	-	-	Tab Failure
M1128B-1	6 - 0.048	"	98° RH /	1000 Hrs.	RTD	94.5	1,000	-	-	Tab Failure
M1128B-2	6 - 0.047	"	98° RH /	1000 Hrs.	RTD	88.5	6,000	-	-	Immediate Failure
M1128B-3	6 - 0.048	"	98° RH /	1000 Hrs.	RTD	84.5	119,000	-	-	Tab Failure
M1128B-4	6 - 0.046	"	98° RH /	1000 Hrs.	RTD	75.5	-	-	-	-
M1135B-6	9 - 0.049	"	98° RH /	1000 Hrs.	260°F	78	-	2.01 x 10 ⁶	81.7	-
M1135B-7	9 - 0.050	"	98° RH /	1000 Hrs.	260°F	91	-	1 x 10 ⁶	79.7	-
M1135B-8	9 - 0.050	"	98° RH /	1000 Hrs.	260°F	98	5,000	-	-	-
M1135B-9	9 - 0.049	"	98° RH /	1000 Hrs.	260°F	94	7,000	-	-	-
M1135B-10	9 - 0.049	"	98° RH /	1000 Hrs.	260°F	92.5	-	-	-	-
M1136B-1	9 - 0.049	"	98° RH /	1000 Hrs.	350°F	107	1,000	-	-	-
M1136B-2	9 - 0.049	"	98° RH /	1000 Hrs.	350°F	92	2,000	-	-	-
M1136B-3	9 - 0.048	"	98° RH /	1000 Hrs.	350°F	77	-	2.261 x 10 ⁶	78.6	-
M1136B-4	9 - 0.049	"	98° RH /	1000 Hrs.	350°F	84.5	47,000	-	-	-
M1136B-5	9 - 0.050	[0/45/135/0/90]°	98° RH /	1000 Hrs.	350°F	81.5	-	2.0 x 10 ⁶	78.1	-

TABLE XVI FAILURE PROPERTIES SUMMARY -
CARBON FIBRE EPOXY THERMO-SET COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	Prior Conditioning		Test Temp. (°F)	Stress Level (% ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1128F-5	9 - 0.049	0 - 5 / 135 0/30°	Thermo-Humidity Cycle		RTD	94	1,000			Tab Failure
M1128F-6	9 - 0.048	"	Thermo-Humidity Cycle		RTD	88	-			Immediate Tab Failure
M1128F-7	9 - 0.046	"	Thermo-Humidity Cycle		RTD	75.5	3,000			Tab Failure
M1128F-8	9 - 0.049	"	Thermo-Humidity Cycle		RTD	63	-	2.515 x 10 ⁶	70.4	Tab Failure
M1128F-9	9 - 0.048	"	Thermo-Humidity Cycle		RTD	69	-	2.421 x 10 ⁶	80.9	Tab Failure
M1136A-1	9 - 0.049	"	Thermo-Humidity Cycle		260°F	87.5	1,000			
M1136A-2	9 - 0.048	"	Thermo-Humidity Cycle		260°F	74	-	2.5 x 10 ⁶	81.6	
M1136A-3	9 - 0.049	"	Thermo-Humidity Cycle		260°F	80	-	2.226 x 10 ⁶	82.7	
M1136A-4	9 - 0.049	"	Thermo-Humidity Cycle		260°F	88.5	7,000			
M1136A-5	9 - 0.049	"	Thermo-Humidity Cycle		260°F	84	5,000			
M1137A-1	9 - 0.047	"	Thermo-Humidity Cycle		350°F	112.5	1,000			
M1137A-2	9 - 0.048	"	Thermo-Humidity Cycle		350°F	104.5	3,000			
M1137A-3	9 - 0.048	"	Thermo-Humidity Cycle		350°F	88.5	-	2.361 x 10 ⁶	83.0	
M1137A-4	9 - 0.047	"	Thermo-Humidity Cycle		350°F	96.5	89,000			
M1137A-5	9 - 0.048	"	Thermo-Humidity Cycle		350°F	103	2,000			
M1128E-10	9 - 0.049	"	Acc. Wthrg.		RTD	91	2,000			Tab Failure
M1128E-11	9 - 0.048	"	Acc. Wthrg.		RTD	85	179,000			Tab Failure
M1129A-1	9 - 0.048	"	Acc. Wthrg.		RTD	88.5	2,000			Tab Failure
M1129A-2	9 - 0.048	"	Acc. Wthrg.		RTD	87.5	1,000			Tab Failure
M1129A-3	9 - 0.048	"	Acc. Wthrg.		RTD	79	-	2.03 x 10 ⁶	83.3	
M1136A-6	9 - 0.048	"	Acc. Wthrg.		260°F	83	3,000			
M1136A-7	9 - 0.048	"	Acc. Wthrg.		260°F	77	6,000			
M1136A-8	9 - 0.047	"	Acc. Wthrg.		260°F	64	-	2.186 x 10 ⁶	78.3	Tab Failure
M1136A-9	9 - 0.048	"	Acc. Wthrg.		260°F	70.5	-	2.667 x 10 ⁶	81.7	Tab Failure
M1136A-10	9 - 0.049	"	Acc. Wthrg.		260°F	74.5	-	2.398 x 10 ⁶	78.2	
M1137A-6	9 - 0.048	"	Acc. Wthrg.		350°F	91.5	34,000			
M1137A-7	9 - 0.048	"	Acc. Wthrg.		350°F	79.9	-	2.178 x 10 ⁶	102.4	Tab Failure
M1137A-8	9 - 0.048	"	Acc. Wthrg.		350°F	96	14,000			
M1137A-9	9 - 0.047	"	Acc. Wthrg.		350°F	90	56,000			
M1137A-10	9 - 0.047	10/45/135 0/30°	Acc. Wthrg.		350°F	99	2,000			Tab Failure

TABLE XVI
THERMAL STRESS CRACKING TESTS

Specimen Number	Thickness (Plis) (in.)	Orientation	Pre-Conditioning Type	Duration	Test Temp. (°F)	Stress Level (ksi) (ult)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
W1106A-9	6 - 0.031	0°	260°F / 500 Hrs.	RTD	53	90	-	2.012 x 10 ⁶	174.8	Tab Area Failure
W1106A-10	6 - 0.031	0°	260°F / 500 Hrs.	RTD	82.5	140	75,000	-	-	Tab Area Failure
W1106A-11	6 - 0.031	0°	260°F / 500 Hrs.	RTD	82.5	145	2,000	-	-	Tab Area Failure
W1106A-12	6 - 0.031	0°	260°F / 500 Hrs.	RTD	84	143	4,000	-	-	Tab Area Failure
W1106A-13	6 - 0.031	0°	260°F / 500 Hrs.	RTD	81	137	11,000	-	-	Tab Area Failure
W1106A-14	6 - 0.031	0°	350°F / 500 Hrs.	RTD	84	145	17,000	-	-	Tab Area Failure
W1106A-15	6 - 0.031	0°	350°F / 500 Hrs.	RTD	69.5	130	-	10.09 x 10 ⁶	175.9	Tab Failure
W1106A-16	6 - 0.031	0°	350°F / 500 Hrs.	RTD	81	140	245,000	-	-	Tab Failure
W1106A-17	6 - 0.031	0°	350°F / 500 Hrs.	RTD	82.5	160	1,000	-	-	Tab Failure
W1106A-18	6 - 0.031	0°	350°F / 500 Hrs.	RTD	81	136	3,000	-	-	Tab Failure
W1106A-19	6 - 0.031	0°	260°F / 500 Cyc.	RTD	83	120	-	2.5 x 10 ⁶	181.2	Tab Failure
W1106A-20	6 - 0.031	0°	260°F / 500 Cyc.	RTD	89.5	130	-	-	-	Immediate Failure
W1106B-1	6 - 0.031	0°	260°F / 500 Cyc.	RTD	96.5	140	2,000	-	-	Tab Failure
W1106B-2	6 - 0.031	0°	260°F / 500 Cyc.	RTD	93	135	-	-	-	Immediate Tab Failure
W1106B-3	6 - 0.031	0°	260°F / 500 Cyc.	RTD	86.5	125	3,000	-	-	Tab Failure
W1106B-4	6 - 0.031	0°	260°F / 1000 Cyc.	RTD	63.5	105	-	5.253 x 10 ⁶	194.0	Tab Failure
W1106B-5	6 - 0.031	0°	260°F / 1000 Cyc.	RTD	85	140	2,000	-	-	Tab Failure
W1106B-6	6 - 0.031	0°	260°F / 1000 Cyc.	RTD	70	115	-	7.607 x 10 ⁶	168.3	Tab Failure
W1106B-7	6 - 0.031	0°	260°F / 1000 Cyc.	RTD	79	130	3,000	-	-	Tab Failure
W1106B-8	6 - 0.031	0°	260°F / 1000 Cyc.	RTD	76	125	-	2.436 x 10 ⁶	174.9	Tab Failure
W1106B-9	6 - 0.031	0°	350°F / 500 Cyc.	RTD	69.5	110	6,000	-	-	Tab Failure
W1106B-10	6 - 0.031	0°	350°F / 500 Cyc.	RTD	63.5	100	-	2.653 x 10 ⁶	177	Tab Failure
W1106B-11	6 - 0.031	0°	350°F / 500 Cyc.	RTD	76	120	95,000	-	-	Tab Failure
W1106B-12	6 - 0.031	0°	350°F / 500 Cyc.	RTD	79	125	-	2.061 x 10 ⁶	177	Immediate Tab Failure
W1106B-13	6 - 0.031	0°	350°F / 500 Cyc.	RTD	85.5	135	-	-	-	Tab Failure
W1106B-14	6 - 0.031	0°	350°F / 1000 Cyc.	RTD	75	115	-	2.93 x 10 ⁶	172.6	Tab Failure
W1106B-15	6 - 0.031	0°	350°F / 1000 Cyc.	RTD	81	125	4,000	-	-	Tab Failure
W1106B-16	6 - 0.031	0°	350°F / 1000 Cyc.	RTD	78	120	2,000	-	-	Tab Failure
W1106B-17	6 - 0.031	0°	350°F / 1000 Cyc.	RTD	76.5	118	8,000	-	-	Tab Failure
W1106B-18	6 - 0.031	0°	350°F / 1000 Cyc.	RTD	75.5	116	1,000	-	-	Tab Failure

TABLE XVI FATIGUE PROPERTIES SUMMARY -
CARBON FIBER REINFORCED EPOXY COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M111A-5	6 - 0.032	0°	260°F / 500 Hrs.		260°F	73.3	1,000			Tab Failure
M111A-6	6 - 0.033	0°	260°F / 500 Hrs.		260°F	68.5	3,000			Tab Failure
M111A-7	6 - 0.033	0°	260°F / 500 Hrs.		260°F	64.5	2,000	2.46 x 10 ⁶	152.4	Tab Failure
M111A-8	6 - 0.032	0°	260°F / 500 Hrs.		260°F	55	-			Tab Failure
M111A-9	6 - 0.031	0°	260°F / 500 Hrs.		260°F	61.5	2,000			Tab Failure
M111A-10	6 - 0.032	0°	260°F / 500 Cyc.		260°F	75	-	2.381 x 10 ⁶	155.8	Tab Failure
M111A-11	6 - 0.033	0°	260°F / 500 Cyc.		260°F	62	-	2.4 x 10 ⁶	-	Tab Failure
M111A-12	6 - 0.033	0°	260°F / 500 Cyc.		260°F	88.5	18,000			Tab Failure
M111A-13	6 - 0.033	0°	260°F / 500 Cyc.		260°F	85	-	2.343 x 10 ⁶	158.9	Tab Failure
M111A-14	6 - 0.032	0°	260°F / 500 Cyc.		260°F	91.5	4,000			Tab Failure
M111A-15	6 - 0.031	0°	260°F / 1000 Cyc.		260°F	70.5	-	5.046 x 10 ⁶	163.2	Tab Failure
M111A-16	6 - 0.034	0°	260°F / 1000 Cyc.		260°F	80	-	2.865 x 10 ⁶	164.5	Tab Failure
M111A-17	6 - 0.033	0°	260°F / 1000 Cyc.		260°F	90	1,000			Tab Failure
M111A-18	6 - 0.033	0°	260°F / 1000 Cyc.		260°F	86.5	2,000			Tab Failure
M111A-19	6 - 0.033	0°	260°F / 1000 Cyc.		260°F	83.5	132,000			Tab Failure
M111B-1	6 - 0.031	0°	350°F / 500 Hrs.		350°F	47	-	2.4 x 10 ⁶	156	Tab Failure
M111B-2	6 - 0.032	0°	350°F / 500 Hrs.		350°F	69.5	1,000	2.385 x 10 ⁶	187.1	Tab Failure
M111B-3	6 - 0.032	0°	350°F / 500 Hrs.		350°F	63	66,000			Tab Failure
M111B-4	6 - 0.031	0°	350°F / 500 Hrs.		350°F	66	8,000			Tab Failure
M111B-5	6 - 0.032	0°	350°F / 500 Hrs.		350°F	67.5	-			Tab Failure
M111B-6	6 - 0.031	0°	350°F / 500 Cyc.		350°F	82.5	130	2.013 x 10 ⁶	166.2	Immediate Tab Failure
M111B-7	6 - 0.032	0°	350°F / 500 Cyc.		350°F	92	2,000			Tab Failure
M111B-8	6 - 0.032	0°	350°F / 500 Cyc.		350°F	88.5	-			Tab Failure
M111B-9	6 - 0.033	0°	350°F / 500 Cyc.		350°F	85.5	15,000			Tab Failure
M111B-10	6 - 0.032	0°	350°F / 500 Cyc.		350°F	84	7,000			Tab Failure
M111B-11	6 - 0.033	0°	350°F / 1000 Cyc.		350°F	82.5	3,000			Tab Failure
M111B-12	6 - 0.031	0°	350°F / 1000 Cyc.		350°F	79.5	209,000			Immediate Tab Failure
M111B-13	6 - 0.033	0°	350°F / 1000 Cyc.		350°F	81	-			Tab Failure
M111B-14	6 - 0.032	0°	350°F / 1000 Cyc.		350°F	81	1,000			Tab Failure
M111B-15	6 - 0.033	0°	350°F / 1000 Cyc.		350°F	78.5	59,000			Tab Failure

TABLE XVI
FATIGUE PROPERTIES SUMMARY -
VARNOL 5206/NOBONOR 11 CARBONITE COMPOSITES

Specimen Number	Thickness (In.)	Orientation	PULSE CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (psi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M1130B-1	9 - 0.047	[0/45/135/0/90]°	260°F / 500 Hrs.		RTD	87.5	1,000			
M1130B-2	9 - 0.049	"	260°F / 500 Hrs.		RTD	76	-	2,006 x 10 ⁶	92.0	
M1130B-3	9 - 0.048	"	260°F / 500 Hrs.		RTD	81.5	-	2.15 x 10 ⁶	81.1	Immediate Tab Failure
M1130B-4	9 - 0.046	"	260°F / 500 Hrs.		RTD	85	-			Tab Failure
M1130B-5	9 - 0.048	"	260°F / 500 Hrs.		RTD	87.5	2,000			Immediate Failure
M1130B-6	9 - 0.048	"	350°F / 500 Hrs.		RTD	128	-			
M1130B-7	9 - 0.048	"	350°F / 500 Hrs.		RTD	114	1,000			
M1130B-8	9 - 0.049	"	350°F / 500 Hrs.		RTD	92.5	-	2.17 x 10 ⁶	90.0	
M1130B-9	9 - 0.047	"	350°F / 500 Hrs.		RTD	107	3,000			
M1130B-10	9 - 0.049	"	350°F / 500 Hrs.		RTD	99.5	-	2.613 x 10 ⁶	87.4	
M1131A-1	9 - 0.048	"	250°F / 500 Cyc.		RTD	81.5	9,000			
M1131A-2	9 - 0.048	"	250°F / 500 Cyc.		RTD	75.5	65,000			Tab Failure
M1131A-3	9 - 0.047	"	250°F / 500 Cyc.		RTD	66.5	117,000			
M1131A-4	9 - 0.048	"	250°F / 500 Cyc.		RTD	73.5	-	2.495 x 10 ⁶	80.5	Tab Failure
M1131A-5	9 - 0.048	"	250°F / 500 Cyc.		RTD	74.5	-	2.626 x 10 ⁶	86.2	
M1131A-6	9 - 0.048	"	250°F / 1000 Cyc.		RTD	87.5	21,000			Tab Failure
M1131A-7	9 - 0.047	"	250°F / 1000 Cyc.		RTD	81	2,282 x 10 ⁶			Tab Failure
M1131A-8	9 - 0.049	"	250°F / 1000 Cyc.		RTD	85	18,000			Tab Failure
M1131A-9	9 - 0.048	"	250°F / 1000 Cyc.		RTD	82.5	1,000			Tab Failure
M1131A-10	9 - 0.049	"	250°F / 1000 Cyc.		RTD	83.5	5,000			Tab Failure
M1130A-8	9 - 0.049	"	330°F / 500 Cyc.		RTD	116	-			Immediate Failure
M1130A-9	9 - 0.048	"	350°F / 500 Cyc.		RTD	77.5	-	7.58 x 10 ⁶	87.4	
M1130A-10	9 - 0.049	"	350°F / 500 Cyc.		RTD	97	164,000			
M1131B-1	9 - 0.048	"	330°F / 500 Cyc.		RTD	103	1,000			
M1131B-2	9 - 0.049	"	350°F / 500 Cyc.		RTD	101	27,000			
M1131B-3	9 - 0.048	"	350°F / 1000 Cyc.		RTD	76.5	-	2.076 x 10 ⁶	81.8	
M1131B-4	9 - 0.049	"	350°F / 1000 Cyc.		RTD	89	20,000			
M1131B-5	9 - 0.048	"	350°F / 1000 Cyc.		RTD	83	-	2.412 x 10 ⁶	85	Tab Failure
M1131B-6	9 - 0.048	"	350°F / 1000 Cyc.		RTD	93	3,000			
M1131B-7	9 - 0.048	"	350°F / 1000 Cyc.		RTD	87	239,000			

TABLE XVI
TENSILE PROPERTIES OF SANDWICH COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PULSE CONDITIONING		Test Temp. (°F)	Stress Level (Z _{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
M11-0A-1	3 - 0.047	[0/45/135/0/90] _s	260°F / 500 Hrs.		260°F	86	4,000	2.231 x 10 ⁶	83.8	Tab Failure
M11-0A-2	3 - 0.049	"	260°F / 500 Hrs.		260°F	79	-	-	-	-
M11-0A-3	3 - 0.049	"	260°F / 500 Hrs.		260°F	83.5	7,000	-	-	-
M11-0A-4	3 - 0.049	"	260°F / 500 Hrs.		260°F	81	1,000	-	-	-
M11-0A-5	3 - 0.047	"	260°F / 500 Hrs.		260°F	81	7,000	-	-	-
M11-0A-6	3 - 0.048	"	260°F / 500 Cye.		260°F	82.5	1,000	-	-	-
M11-0A-7	3 - 0.049	"	260°F / 500 Cye.		260°F	77	4,000	-	-	-
M11-0A-8	3 - 0.048	"	260°F / 500 Cye.		260°F	71	-	2.5x10 ⁶	68.2	Tab Failure
M11-0A-9	3 - 0.048	"	260°F / 500 Cye.		260°F	74.5	-	2.6x10 ⁶	81.3	Tab Failure
M11-0A-10	3 - 0.048	"	260°F / 500 Cye.		260°F	70	42,000	-	-	-
M11-0B-1	3 - 0.049	"	260°F / 1000 Cye.		260°F	72	1,021,000	-	-	-
M11-0B-2	3 - 0.048	"	260°F / 1000 Cye.		260°F	87	1,000	-	-	-
M11-0B-3	3 - 0.047	"	260°F / 1000 Cye.		260°F	80.5	16,000	-	-	-
M11-0B-4	3 - 0.048	"	260°F / 1000 Cye.		260°F	78	29,000	-	-	-
M11-0B-5	3 - 0.049	"	260°F / 1000 Cye.		260°F	75.5	-	2.015 x 10 ⁶	74.5	Tab Failure
M11-0B-6	3 - 0.048	"	350°F / 500 Hrs.		350°F	81	6,000	-	-	-
M11-0B-7	3 - 0.048	"	350°F / 500 Hrs.		350°F	83.5	1,000	-	-	-
M11-0B-8	3 - 0.049	"	350°F / 500 Hrs.		350°F	77	41,000	-	-	-
M11-0B-9	3 - 0.048	"	350°F / 500 Hrs.		350°F	74.5	10,000	-	-	-
M11-0B-10	3 - 0.048	"	350°F / 500 Hrs.		350°F	70.5	1,286,000	-	-	-
M11-1A-1	3 - 0.048	"	350°F / 500 Cye.		350°F	78	-	4.427 x 10 ⁶	94.7	Immediate Tab Failure
M11-1A-2	3 - 0.047	"	350°F / 500 Cye.		350°F	90	2,000	-	-	-
M11-1A-3	3 - 0.046	"	350°F / 500 Cye.		350°F	84	-	-	-	-
M11-1A-4	3 - 0.048	"	350°F / 500 Cye.		350°F	81.5	2,000	-	-	-
M11-1A-5	3 - 0.048	"	350°F / 500 Cye.		350°F	79	392,000	-	-	-
M11-1A-6	3 - 0.048	"	350°F / 1000 Cye.		350°F	88	1,000	-	-	-
M11-1A-7	3 - 0.047	"	350°F / 1000 Cye.		350°F	81.5	-	2.337 x 10 ⁶	85.5	Tab Failure
M11-1A-8	3 - 0.047	"	350°F / 1000 Cye.		350°F	85.5	2,000	-	-	-
M11-1A-9	3 - 0.048	"	350°F / 1000 Cye.		350°F	84	10,000	-	-	-
M11-1A-10	3 - 0.048	[0/45/135/0/90] _s	350°F / 1000 Cye.		350°F	83	-	-	-	Immediate Tab Failure

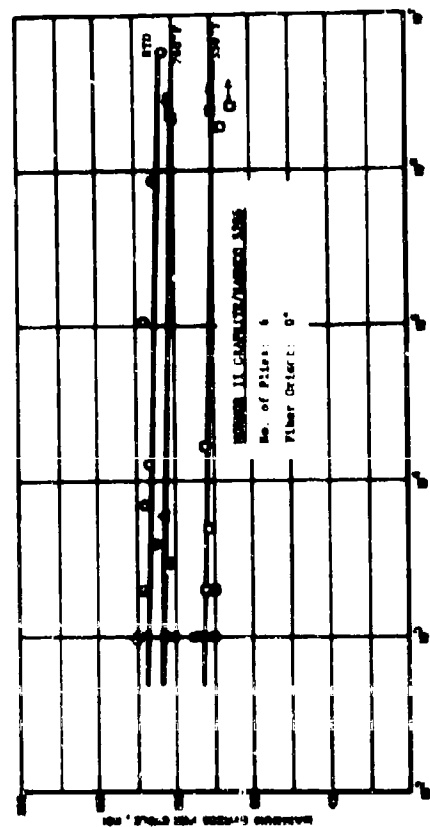


Fig. 134 FATIGUE S-N DIAGRAM FOR 5' HERRIN II CHARLITE/MAKRO 5100 COMPOSITE, TESTED AT VARIOUS TEMPERATURES ($\bar{t} = 0.1$, $\square = 1.00$ CFS)

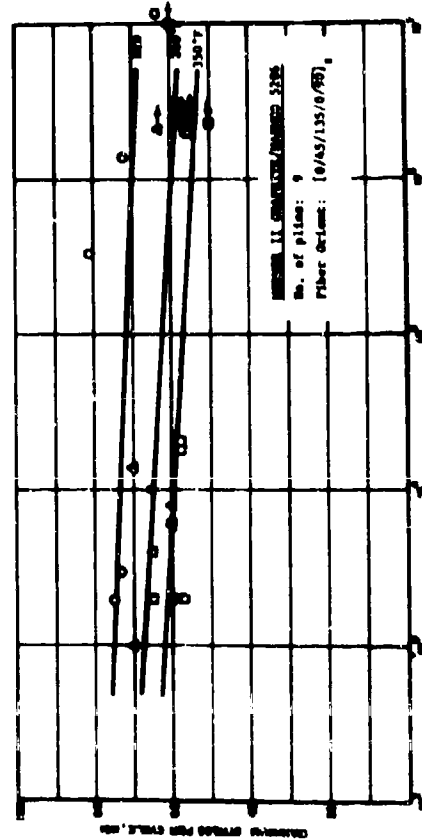


Fig. 135 FATIGUE S-N DIAGRAM FOR 5' HERRIN II CHARLITE/MAKRO 5200 COMPOSITE, TESTED AT VARIOUS TEMPERATURES ($\bar{t} = 0.1$, $\square = 1.00$ CFS)

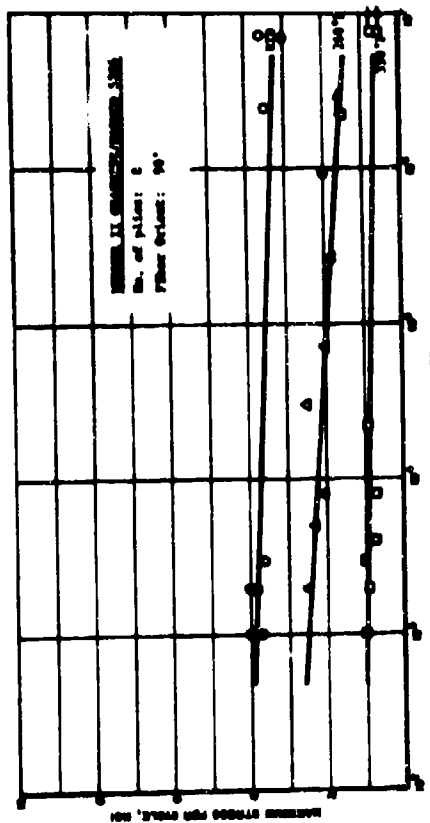


Fig. 137 FATIGUE S-N DIAGRAM FOR 5' HERRIN II CHARLITE/MAKRO 5300 COMPOSITE, TESTED AT VARIOUS TEMPERATURES ($\bar{t} = 0.1$, $\square = 1.00$ CFS)

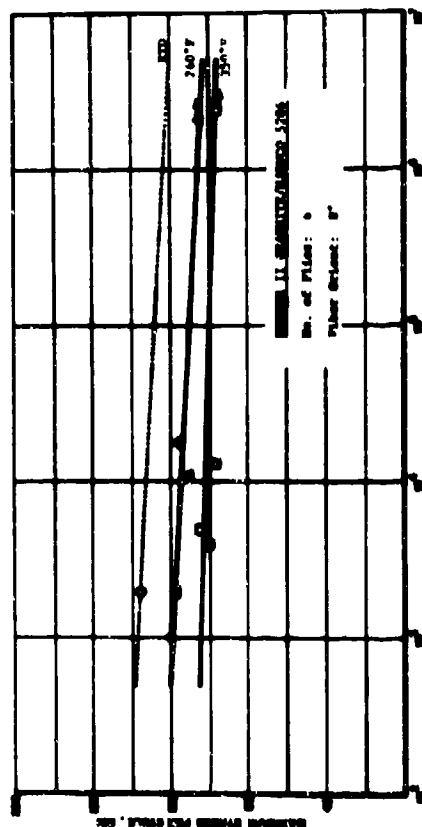


Fig. 139 FATIGUE S-N DIAGRAM FOR 5' HERRIN II CHARLITE/MAKRO 5400 COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 90% R.H. ($\bar{t} = 0.1$, $\square = 1.00$ CFS)

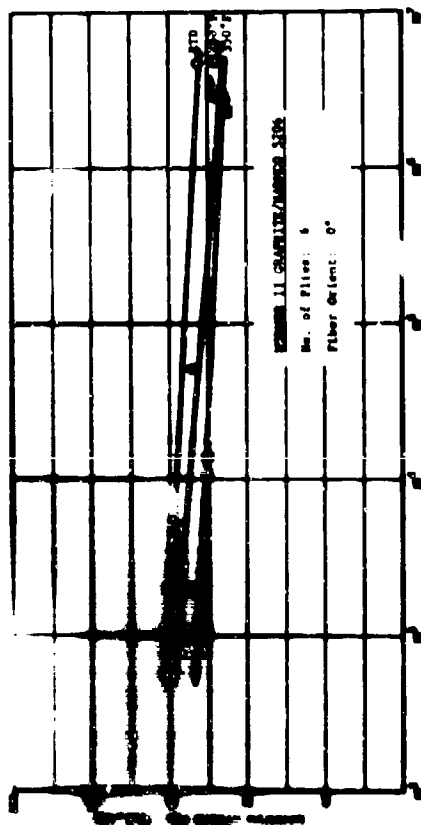


Fig. 140 FATIGUE S-N DIAGRAM FOR 1" MEMBER II GRAPHITE/EPOXY 570° COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO WET D.B. (R = 0.1, σ = 1000 CPM)

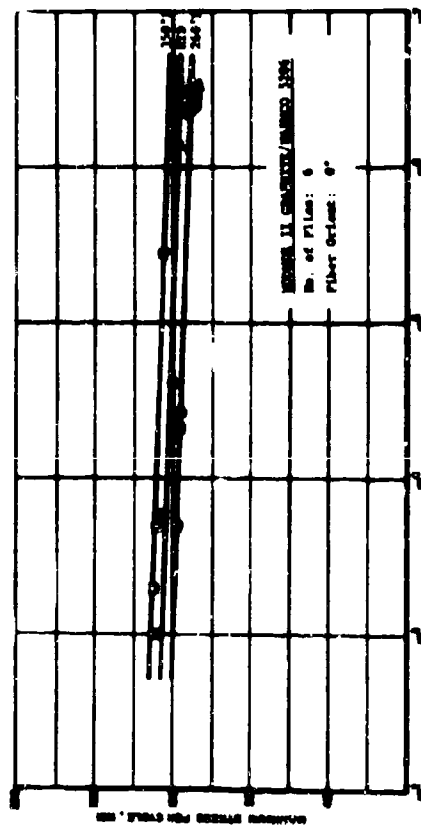


Fig. 142 FATIGUE S-N DIAGRAM FOR 1" MEMBER II GRAPHITE/EPOXY 570° COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering) (R = 0.1, σ = 1000 CPM)

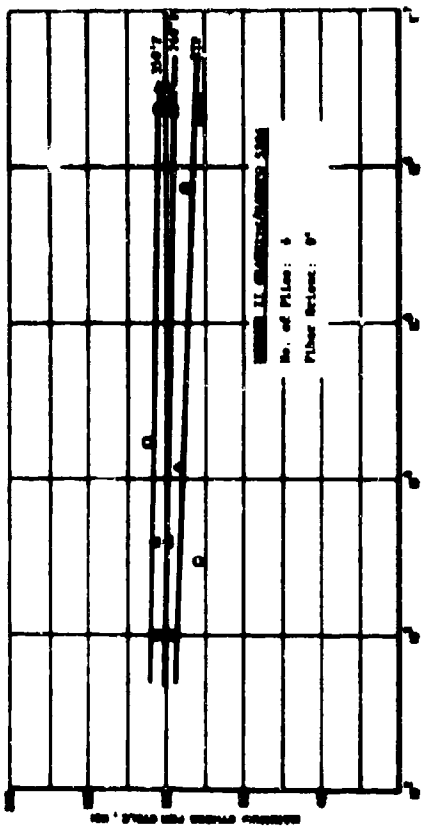


Fig. 141 FATIGUE S-N DIAGRAM FOR 0" MEMBER II GRAPHITE/EPOXY 570° COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle) (R = 0.1, σ = 1000 CPM)

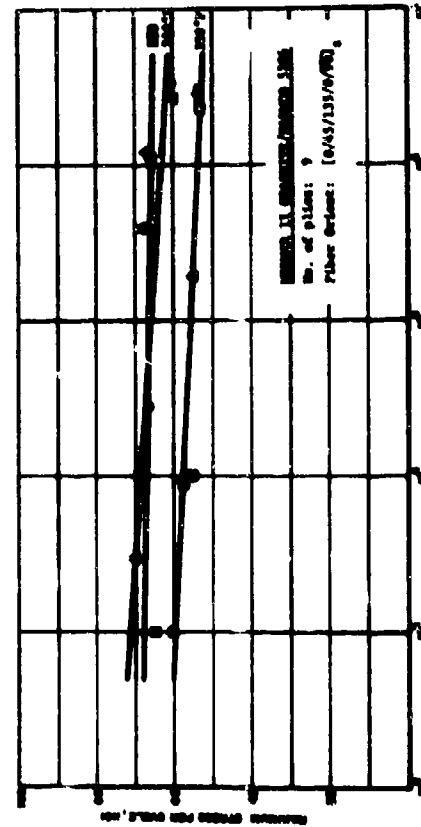


Fig. 143 FATIGUE S-N DIAGRAM FOR 0" MEMBER II GRAPHITE/EPOXY 570° COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO WET D.B. (R = 0.1, σ = 1000 CPM)

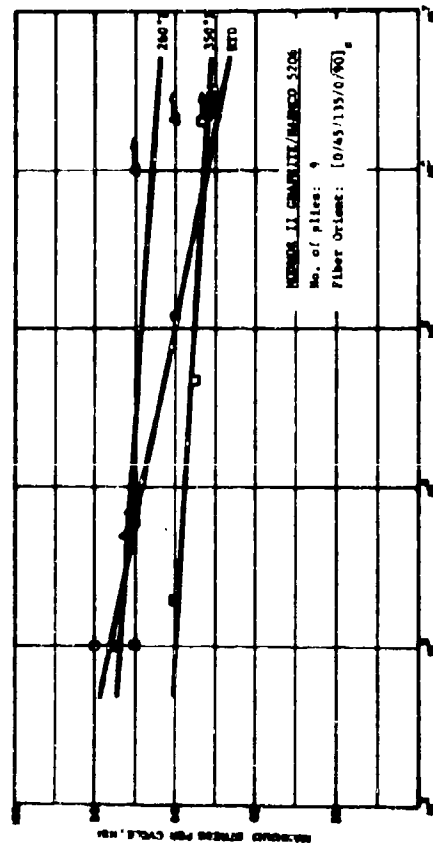


FIG. 144 FATIGUE S-N DIAGRAM FOR MINER II GRAPHITE/NUMBER 5206 (0/AS/135/0/90). LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H. ($R = 0.1$, $\sigma = 1800$ cpm)

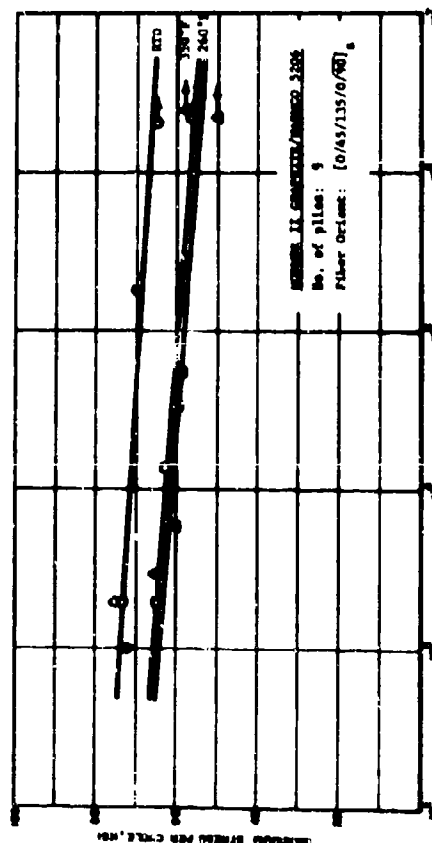


FIG. 145 FATIGUE S-N DIAGRAM FOR MINER II GRAPHITE/NUMBER 5206 (0/AS/135/0/90). LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE No. 2 (Accelerated Weathering) ($R = 0.1$, $\sigma = 1800$ cpm)

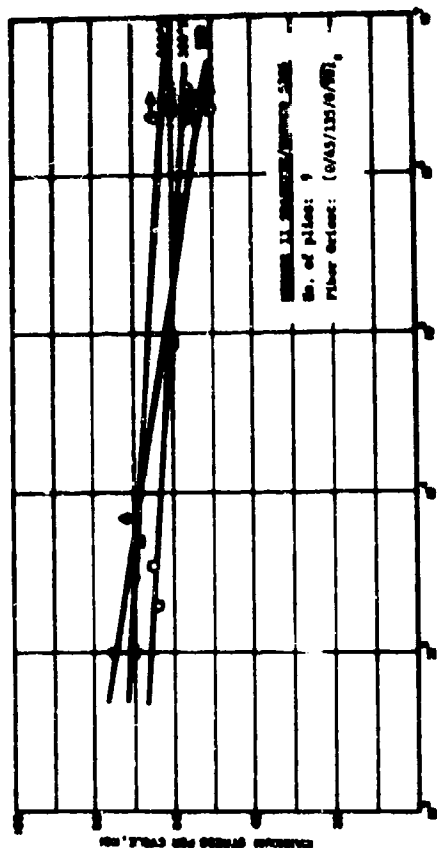


FIG. 146 FATIGUE S-N DIAGRAM FOR MINER II GRAPHITE/NUMBER 5206 (0/AS/135/0/90). LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE No. 1 (Thermal-Humidity Cycle) ($R = 0.1$, $\sigma = 1800$ cpm)

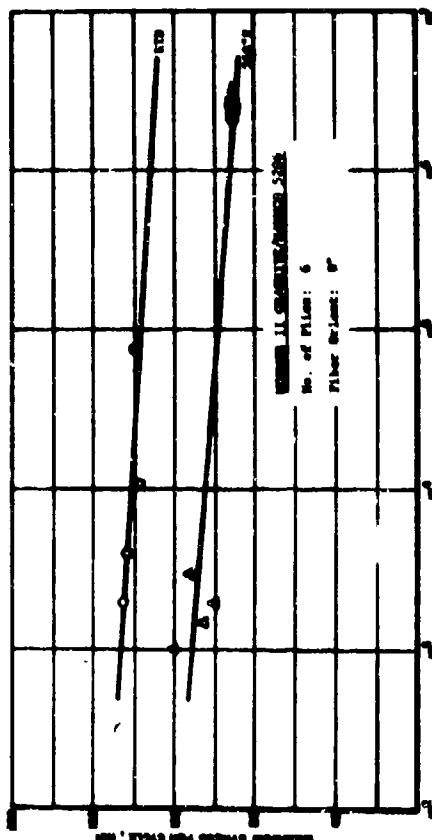


FIG. 147 FATIGUE S-N DIAGRAM FOR MINER II GRAPHITE/NUMBER 5206 (0/AS/135/0/90). LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 900 HOURS EXPOSURE TO 90% R.H. ($R = 0.1$, $\sigma = 1800$ cpm)

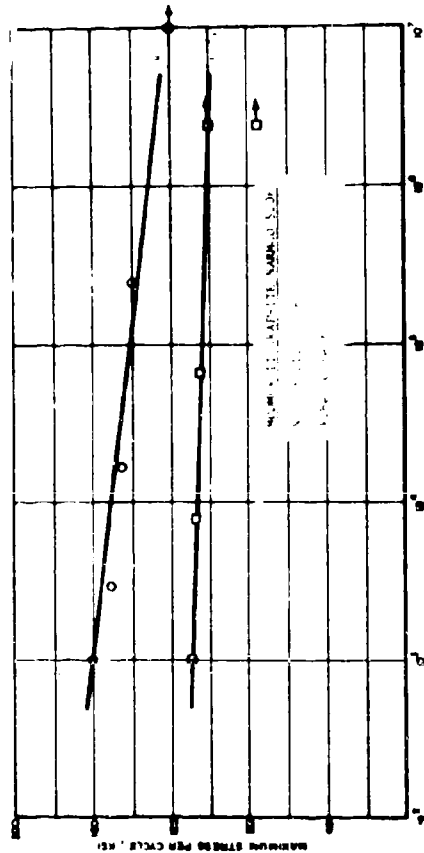


Fig. 32: Fatigue S-N Diagram for II: Number II (Graphite/Manisco 5206 Composite, Tested at Room Temperature After 500 Cycles Exposure to 260°F (R = 0.1, $\sigma = 1800$ CPM)

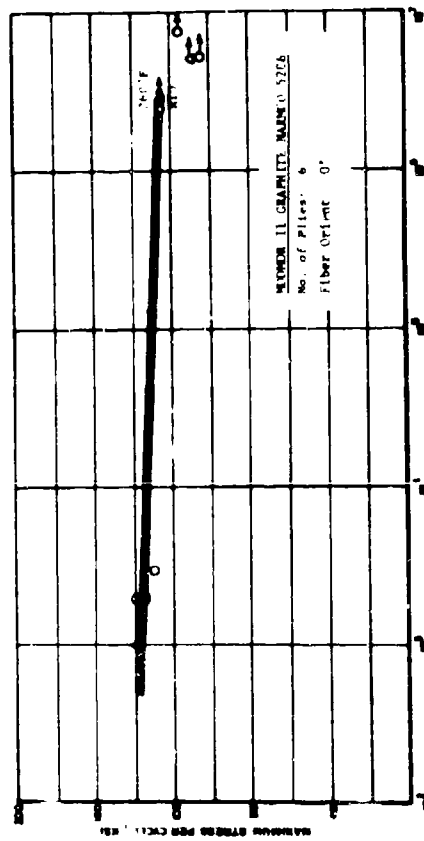


Fig. 33: Fatigue S-N Diagram for II: Number II (Graphite/Manisco 5206 Composite, Tested at Room Temperature After 500 Cycles Exposure to 350°F (R = 0.1, $\sigma = 1800$ CPM)

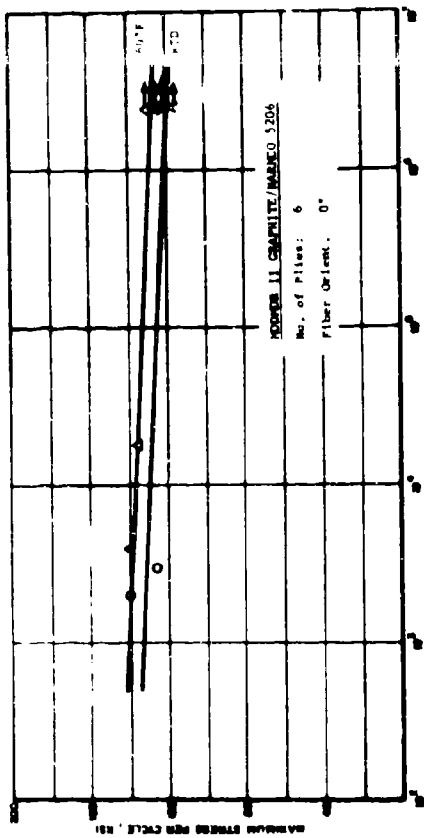


Fig. 34: Fatigue S-N Diagram for II: Number II (Graphite/Manisco 5206 Composite, Tested at Room Temperature After 500 Cycles Exposure to 260°F (R = 0.1, $\sigma = 1800$ CPM)

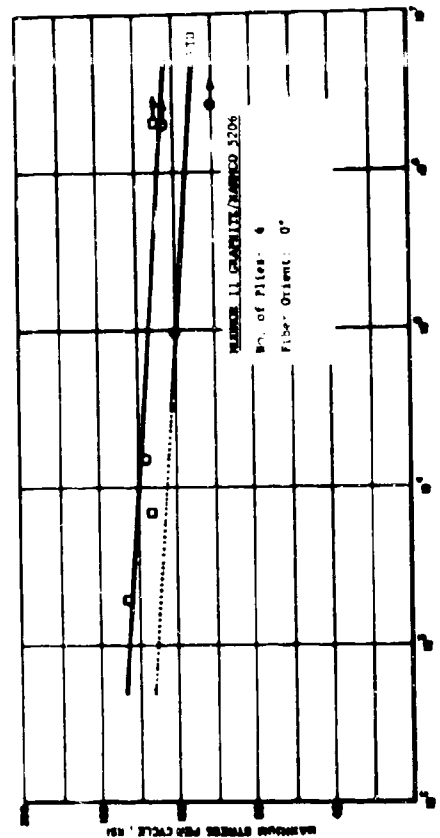
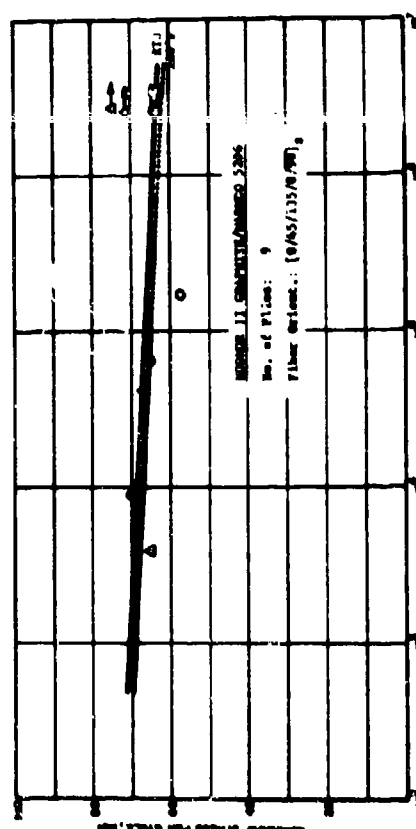
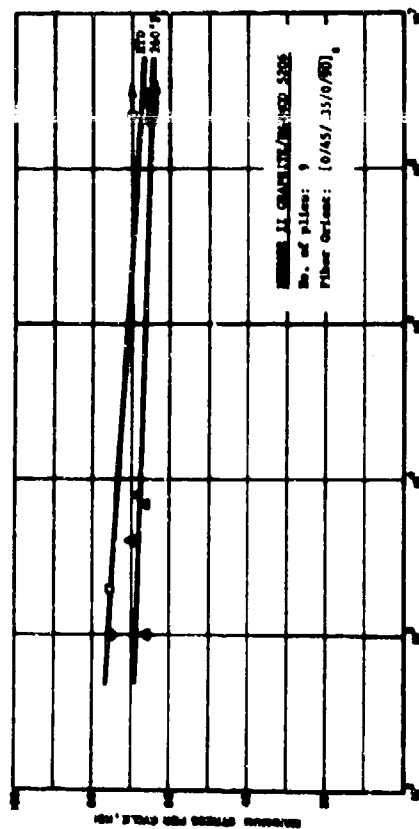
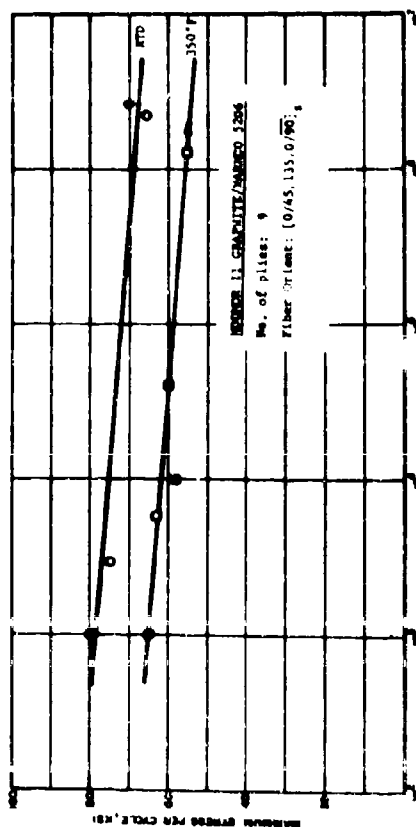
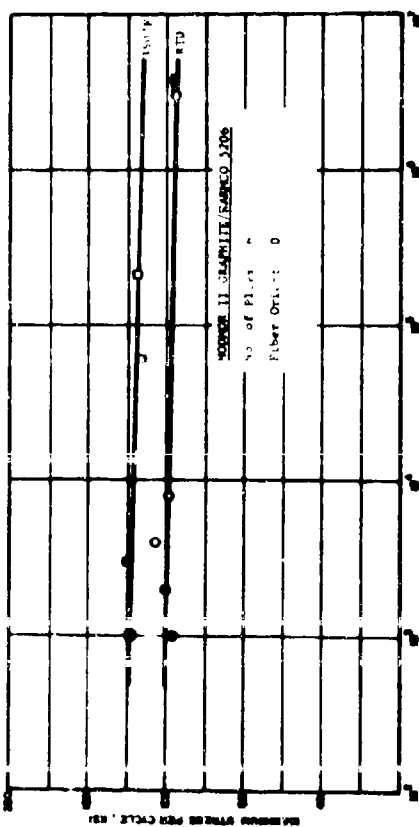


Fig. 35: Fatigue S-N Diagram for II: Number II (Graphite/Manisco 5206 Composite, Tested at Room Temperature After 500 Cycles Exposure to 350°F (R = 0.1, $\sigma = 1800$ CPM)



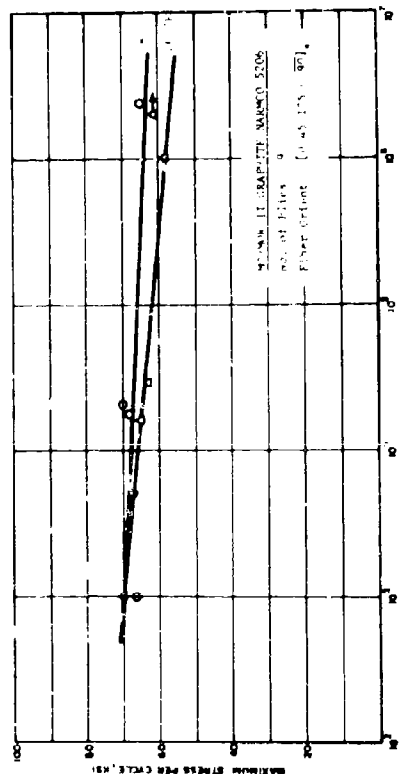


FIG. 152 FATIGUE S-N DIAGRAM FOR MODKIN II GRAPHITE/MARMO S206 [0/45/15/-90]₂ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 350°F (R = 0.1, f = 1800 CPM)

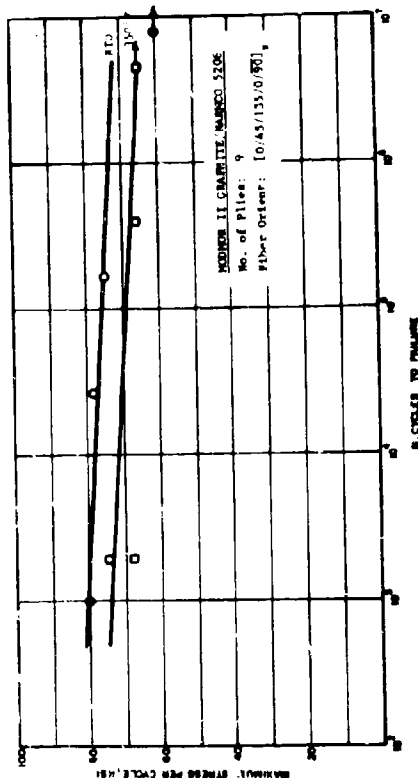


FIG. 153 FATIGUE S-N DIAGRAM FOR MODKIN II GRAPHITE/MARMO S206 [0/45/15/0/90]₂ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 350°F (R = 0.1, f = 1800 CPM)

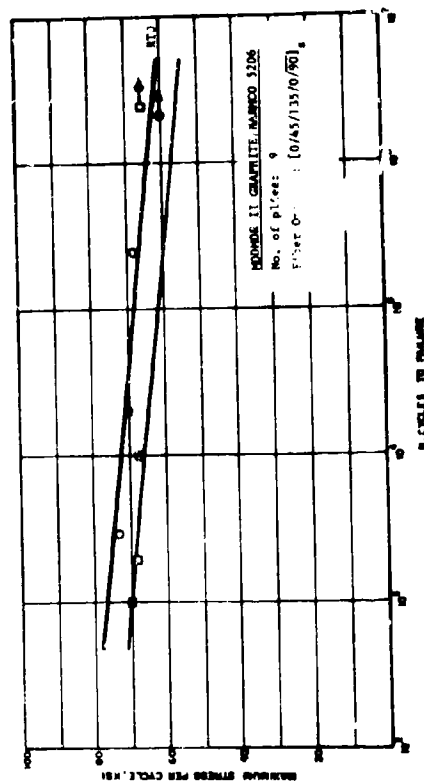


FIG. 154 FATIGUE S-N DIAGRAM FOR MODKIN II GRAPHITE/MARMO S206 [0/45/15/0/90]₂ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F (R = 0.1, f = 1800 CPM)

TABLE XVII CREEP AND STRESS RUPTURE PROPERTIES
SUMMARY - NARSCO 5206/REX-40R II
GRAPHITE COMPOSITES

Specimen Number	Thickness (plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress level (ksi) (σ _{ult})	Time to Failure (Hours)	Time Applied without Failure (Hours)		Comment
			Type	Duration						
M1107B-11	6	0°	None	-	260°F	80	-	1010	-	
M1107B-12	6	0°	None	-	260°F	85	-	1001	-	
M1107B-13	6	0°	None	-	260°F	75	-	1002	-	
M1107B-14	6	0°	None	-	260°F	80	-	1012	-	
M1107B-15	6	0°	None	-	260°F	90	-	1007	-	
M1107B-16	6	0°	None	-	260°F	90	-	1004	-	
M1107B-17	6	0°	None	-	260°F	90	-	1003	-	
M1107B-18	6	0°	None	-	260°F	95	-	1003	-	
M1107B-19	6	0°	None	-	260°F	90	-	1011	-	
M1107B-20	6	0°	None	-	260°F	90	21.4	-	-	
M1148-21	6	0°	None	-	260°F	98	-	-	-	Broke during loading
M1148-22	6	0°	None	-	260°F	85	-	-	-	Tab Failure, broke during loading
M1148-23	6	0°	None	-	260°F	92	-	-	-	Broke during loading
M1148-24	6	0°	None	-	260°F	80	-	-	-	Broke during loading
M1148-25	6	0°	None	-	260°F	78	.033	-	-	Broke at tabs
M1148-29	6	0°	None	-	260°F	95	-	-	-	Broke during loading
M1148-30	6	0°	None	-	260°F	90	-	-	-	Broke during loading
M1148-31	6	0°	None	-	260°F	90	-	-	-	Broke during loading
M1148-32	6	0°	None	-	260°F	92	-	-	-	Broke during loading
M1148-34	6	0°	None	-	260°F	94	-	-	-	Broke during loading
M1148-35	6	0°	None	-	260°F	95	-	-	-	Broke during loading
M1148-33	6	0°	None	-	260°F	96	0.17	-	-	Broke during loading

TABLE VIII
CREEP AND STRESS RUPTURE PROPERTIES
SUMMARY - WAREDO 5206/NOVOR II
CARBIDE COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	FILM COMPOSITION		Test Temp. (°F)	Stress Level (% of σ_{ult}) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
W1101A-1	6	0°	None	-	350°F	80	120	-	
W1101A-2	6	0°	None	-	350°F	70	105	693	
W1101A-3	6	0°	None	-	350°F	80	120	692	
W1101A-4	6	0°	None	-	350°F	90	135	.07	
W1101A-5	6	0°	None	-	350°F	80	120	-	1006
W1101A-6	6	0°	None	-	350°F	90	141	356	
W1101A-7	6	0°	None	-	350°F	92	138	-	Broke during loading
W1101A-8	6	0°	None	-	350°F	90	135	-	Broke during loading
W1101A-9	6	0°	None	-	350°F	100	150	.0167	Broke during loading
W1101A-10	6	0°	None	-	350°F	70	105	8.28	
W1101A-22	6	0°	None	-	350°F	85	127	-	Broke during loading
W1101A-24	6	0°	None	-	350°F	80	120	-	Broke during loading
W1101A-25	6	0°	None	-	350°F	78	127	0.02	
W1101A-26	6	0°	None	-	350°F	75	110	-	Broke during loading
W1101A-27	6	0°	None	-	350°F	83	124	0.25	
W1101A-28	6	0°	None	-	350°F	90	149	-	Broke at Load
W1101A-29	6	0°	None	-	350°F	92	146	-	Broke at Load
W1101A-30	6	0°	None	-	350°F	96	152	-	Broke at Load
W1101A-31	6	0°	None	-	350°F	95	151	-	Broke at Load
W1101A-40	6	0°	None	-	350°F	98	156	0.01	

TABLE VIII CREEP AND STRESS RELAXATION PROPERTIES
OF CARBON FIBER REINFORCED EPOXY COMPOSITES
GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIORITY CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (7 ult)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
M1117-13	8	0.043	90°	-	260°F	70	2.14	-	1010
M1117-14	8	0.044	90°	-	260°F	80	2.40	.067	Broke in Handling
M1117-15	8	0.044	90°	-	260°F	-	-	-	Broke in Handling
M1117-16	8	0.044	90°	-	260°F	-	-	-	-
M1117-17	8	0.044	90°	-	260°F	75	2.29	440	-
M1117-18	8	0.044	90°	-	260°F	80	2.40	776	-
M1118-1	8	0.044	90°	-	260°F	-	-	-	Broke in Handling
M1118-2	8	0.043	90°	-	260°F	85	2.60	130.0	Broke during loading
M1118-3	8	0.044	90°	-	260°F	80	2.40	-	-
M1118-4	8	0.044	90°	-	260°F	90	2.75	43.1	-
M1118-5	8	0.044	90°	-	350°F	80	2.43	.25	Strain gauge failed
M1118-6	8	0.043	90°	-	350°F	77	2.34	-	Failed in loading
M1118-7	8	0.043	90°	-	350°F	73	2.21	-	Failed in loading
M1118-8	8	0.043	90°	-	350°F	70	2.12	.167	-
M1118-9	8	0.043	90°	-	350°F	89	2.09	-	Failed in loading
M1118-10	8	0.044	90°	-	350°F	40	1.22	-	Failed in loading
M1118-11	8	0.043	90°	-	350°F	62	1.88	.1	-
M1118-12	9	0.043	90°	-	350°F	89	2.71	-	Failed in loading
M1118-13	9	0.043	90°	-	350°F	58	1.76	-	Failed in loading
M1118-14	9	0.044	90°	-	350°F	56	1.69	6.05	-
M1134B-1	9	0.050	[0/45/135/0/90] _s	-	260°F	70	61.3	-	1010
M1134B-2	9	0.051	"	-	260°F	70	61.3	-	1011
M1134B-3	9	0.050	"	-	260°F	80	70	-	1009
M1134B-4	9	0.050	"	-	260°F	80	70	30	-
M1134B-5	9	0.051	[0/45/135/0/90] _s	-	260°F	90	78.8	16	-
M1134B-6	9	0.050	[0/45/135/0/90] _s	-	260°F	90	78.8	-	Immediate failure
M1134B-7	9	0.050	"	-	260°F	85	74.4	674	-
M1134B-8	9	0.050	"	-	260°F	85	74.4	994	-
M1134B-9	9	0.050	"	-	260°F	75	65.5	725	-
M1134B-10	9	0.050	[0/45/135/0/90] _s	-	260°F	92	-	-	Broke during loading

TABLE XVII CREEP AND STRESS RELAXATION PROPERTIES
SUMMARY - MARCO 300 MODAR II
GRAPHITE COMPOSITE

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
M1149-24	9	0.050	[0/45/135/0/90] _s	-	260°F	85	74	-	Broke during loading
M1149-25	9	0.050	"	-	260°F	90	78.2	-	Broke during loading
M1149-31	9	0.048	"	-	260°F	90	77.3	-	Broke during loading
M1149-33	9	0.049	"	-	260°F	86	73.8	0.05	Broke during loading
M1149-32	9	0.049	"	-	260°F	88	75.5	-	Broke during loading
M1149-22	9	0.050	"	-	260°F	88	74.5	111.4	Broke during loading
M1149-25	9	0.049	"	-	260°F	92	77.9	0.05	-
M1149-23	9	0.047	"	-	260°F	89	75.3	-	Broke during loading
M1149-21	9	0.049	"	-	260°F	90	76.2	-	Broke immediately
M1149-24	9	0.049	"	-	260°F	91	77	-	Broke during loading
M1149-34	9	0.049	"	-	260°F	83	71.2	0.005	-
M1149-35	9	0.047	[0/45/135/0/90] _s	-	260°F	80	68.7	0.41	-
M1149-28	9	0.050	[0/45/135/0/90] _s	-	350°F	90	71.2	-	Broke during loading
M1149-29	9	0.050	"	-	350°F	85	67.3	-	Broke during loading
M1149-30	9	0.050	"	-	350°F	80	63.3	-	Broke during loading
M1149-36	9	0.050	"	-	350°F	70	55.7	-	Broke during loading
M1149-19	9	0.050	"	-	350°F	88	69.6	-	Broke during loading
M1149-37	9	0.050	"	-	350°F	92	76.8	-	Broke during loading
M1149-39	9	0.049	"	-	350°F	95	79.3	-	Broke during loading
M1149-40	9	0.051	"	-	350°F	97	80.9	-	Broke during loading
M1149-38	9	0.049	[0/45/135/0/90] _s	-	350°F	93	77.6	2.01	Broke during loading
M1135A-1	9	0.049	[0/45/135/0/90] _s	-	350°F	70	55.4	309.4	-
M1135A-2	9	0.049	"	-	350°F	75	59.4	214.1	-
M1135A-3	9	0.049	"	-	350°F	80	63.3	694	-
M1135A-4	9	0.049	"	-	350°F	80	63.3	657	-
M1135A-5	9	0.049	"	-	350°F	85	67.3	.008	-
M1135A-6	9	0.049	"	-	350°F	83.5	66	.3	-
M1135A-7	9	0.049	"	-	350°F	70	55.4	125	-
M1135A-8	9	0.049	"	-	350°F	81.6	65.6	-	Immediate failure
M1135A-9	9	0.049	"	-	350°F	70	55.4	.5	-
M1135A-10	9	0.049	[0/45/135/0/90] _s	-	350°F	75	59.4	562	-

TABLE VIII TENSILE AND STRESS RUPTURE PROPERTIES
STANDARD - NARCO 520/MOD-11
GLASS/EPIC COMPOSITES

Sample Number	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (σ _{ult})	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
M148-1	6	0°	98% RH	500 Hrs.	260°F				
M148-2	6	0°	98% RH	500 Hrs.	260°F				
M148-3	6	0°	98% RH	500 Hrs.	260°F				
M148-4	6	0°	98% RH	500 Hrs.	260°F				
M148-5	6	0°	98% RH	500 Hrs.	260°F				
M148-6	6	0°	98% RH	500 Hrs.	350°F	65			Broke during loading
M148-7	6	0°	98% RH	500 Hrs.	350°F	75			Broke during loading
M148-8	6	0°	98% RH	500 Hrs.	350°F	80			Broke during loading
M148-9	6	0°	98% RH	500 Hrs.	350°F	85			Broke during loading
M148-10	6	0°	98% RH	500 Hrs.	350°F	90			Broke during loading
M1098-15	6	0°	98% RH	1000 Hrs.	260°F	89		1000	
M1098-16	6	0°	98% RH	1000 Hrs.	260°F	87		1000	Strain gage failed after 485 hrs.
M1098-17	6	0°	98% RH	1000 Hrs.	260°F	85	12.4		
M1098-18	6	0°	98% RH	1000 Hrs.	260°F	83	44.8		
M1098-19	6	0°	98% RH	1000 Hrs.	260°F	81		1000	
M110A-5	6	0°	98% RH	1000 Hrs.	350°F	88	50.7		
M110A-6	6	0°	98% RH	1000 Hrs.	350°F	86		1000	Lost strain gage at .067 hrs.
M110A-7	6	0°	98% RH	1000 Hrs.	350°F	84		1000	Strain gage failed after 568 hrs.
M110A-8	6	0°	98% RH	1000 Hrs.	350°F	82		1000	
M110A-9	6	0°	98% RH	1000 Hrs.	350°F	80		1000	Strain gage failed
M148-11	6	0°	Thermo-Humidity Cycle		260°F	80	.033		
M148-12	6	0°	Thermo-Humidity Cycle		260°F	78			Broke during loading
M148-13	6	0°	Thermo-Humidity Cycle		260°F	90			Tab failure, broke during loading
M148-14	6	0°	Thermo-Humidity Cycle		260°F	88			Tab failure, broke during loading
M148-15	6	0°	Thermo-Humidity Cycle		260°F	85			Tab failure, broke during loading
M148-21	6	0°	Thermo-Humidity Cycle		260°F	94			Broke during loading
M148-23	6	0°	Thermo-Humidity Cycle		260°F	92			Broke during loading
M148-28	6	0°	Thermo-Humidity Cycle		260°F	88			Broke during loading

TABLE A-1 CREEP AND STRESS RELAXATION PROPERTIES
SUMMARY - NAME: 5206/ANOMR II
GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% _{ult}) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
M1148-16	6	0°	Thermo-Humidity Cycle		350°F	88	132.6	1000	
M1148-17	6	0°	Thermo-Humidity Cycle		350°F	91	137.4	0.25	Broke during loading
M1148-18	6	0°	Thermo-Humidity Cycle		350°F	93	140.4	-	Broke during loading
M1148-19	6	0°	Thermo-Humidity Cycle		350°F	95	143.4	-	Broke during loading
M1148-20	6	0°	Thermo-Humidity Cycle		350°F	94	141.9	-	Broke during loading
M11098-20	6	0°	Acc. Wthrg.		260°F	84	150	.033	Strain gage failed
M1110A-1	6	0°	Acc. Wthrg.		260°F	90	161	.05	
M1110A-2	6	0°	Acc. Wthrg.		260°F	88	157	1.0	
M1110A-3	6	0°	Acc. Wthrg.		260°F	86	154	6.2	
M1110A-4	6	0°	Acc. Wthrg.		260°F	85	152	29.7	
M1110A-10	6	0°	Acc. Wthrg.		350°F	91	133	.66	Strain gage failed
M1110A-11	6	0°	Acc. Wthrg.		350°F	89	130	-	Failed in loading
M1110A-12	6	0°	Acc. Wthrg.		350°F	87	127	926	Strain gage failed
M1110A-13	6	0°	Acc. Wthrg.		350°F	85	124	-	Strain gage failed
M1110A-14	6	0°	Acc. Wthrg.		350°F	83	121	-	Strain gage failed
M1149-1	9	[0/45/135/0/90] _s	90% RH / 500 Hrs.		260°F	95	76.6	-	Broke during loading
M1149-4	9	"	90% RH / 500 Hrs.		260°F	81	65.3	0.02	Broke during loading
M1149-3	9	"	90% RH / 500 Hrs.		260°F	82	66.1	0.01	Broke during loading
M1149-2	9	"	90% RH / 500 Hrs.		260°F	80	64.5	2.5	Broke during loading
M1149-5	9	"	90% RH / 500 Hrs.		260°F	90	72.6	-	Broke during loading
M1149-6	9	"	90% RH / 500 Hrs.		350°F	98	62.5	-	Broke during loading
M1149-7	9	"	90% RH / 500 Hrs.		350°F	96	61.2	-	Broke during loading
M1149-8	9	"	90% RH / 500 Hrs.		350°F	93	59.3	-	Broke during loading
M1149-9	9	"	90% RH / 500 Hrs.		350°F	90	57.4	-	Broke during loading
M1149-10	9	[0/45/135/0/90] _s	90% RH / 500 Hrs.		350°F	89	56.1	-	Broke during loading

Specimen Number	Thickness (Plies. (In.))	Orientation	Prior Conditioning Type	Duration	Test Temp. (°F)	Stress Level (ksi)	Time to Failure (Hours)	Time Applied Without Failure (Hours)	Comment
M137B-1	9	0.050	0° RH	100 Hrs.	260°F	90	-	1000	
M137B-2	9	0.049	90° RH	100 Hrs.	260°F	90	-	1000	
M137B-3	9	0.049	0° RH	100 Hrs.	260°F	90	-	1000	
M137B-4	9	0.049	0° RH	100 Hrs.	260°F	90	-	1000	
M137B-5	9	0.050	0° RH	100 Hrs.	260°F	90	-	1000	
M138A-1	9	0.049	0° RH	100 Hrs.	260°F	90	-	1000	
M138A-2	9	0.049	0° RH	100 Hrs.	260°F	90	-	1000	
M138A-3	9	0.050	0° RH	100 Hrs.	260°F	90	-	1000	
M138A-4	9	0.048	0° RH	100 Hrs.	260°F	90	-	1000	
M138A-5	9	0.049	0° RH	100 Hrs.	260°F	90	-	1000	
M149-11	9	0.049	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Broke during loading
M149-12	9	0.049	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Broke during loading
M149-13	9	0.048	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Tab failure, broke during load
M149-14	9	0.049	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Tab failure, broke during load
M149-15	9	0.049	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Tab failure, broke during load
M148-2	9	0.048	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Overload
M148-16	9	0.049	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Broke on Loading
M148-17	9	0.050	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	Broke on Loading
M148-18	9	0.049	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	
M148-19	9	0.050	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	
M148-20	9	0.049	Therm. Humidity Cycle	100 Hrs.	260°F	90	-	1000	
M137B-6	9	0.045	Acc. Withng.	100 Hrs.	260°F	90	-	1000	Immediate failure
M137B-7	9	0.050	Acc. Withng.	100 Hrs.	260°F	90	-	1000	Over overheated
M137B-8	9	0.048	Acc. Withng.	100 Hrs.	260°F	90	-	1000	
M137B-9	9	0.049	Acc. Withng.	100 Hrs.	260°F	90	-	1000	No strain readings
M137B-10	9	0.049	Acc. Withng.	100 Hrs.	260°F	90	-	1000	
M138A-6	9	0.045	Acc. Withng.	100 Hrs.	350°F	90	-	1000	Broke during loading
M138A-7	9	0.050	Acc. Withng.	100 Hrs.	350°F	90	-	1000	
M138A-8	9	0.049	Acc. Withng.	100 Hrs.	350°F	90	-	1000	
M138A-9	9	0.049	Acc. Withng.	100 Hrs.	350°F	90	-	1000	
M138A-10	9	0.050	Acc. Withng.	100 Hrs.	350°F	90	-	1000	

TABLE XI.1: TENSILE AND COMPRESSION CAPTURE PROPERTIES
SUMMARY - MARNO 500C TYPE II
GRAPHITE COMPOSITES

Specimen Number	Th. class (Plis) (in.)	Orientation	PRIME CONDITIONING		Test Temp. (°F)	Stress Level (σ _{ult}) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
M111B-16	6	0.032	0°	260°F / 500 Hrs.	260°F	70	114	-	1055
M111B-17	6	0.032	0°	260°F / 500 Hrs.	260°F	75	122	-	1061
M111B-18	6	0.032	0°	260°F / 500 Hrs.	260°F	130	130	-	1061
M111B-19	6	0.032	0°	260°F / 500 Hrs.	260°F	70	114	479	-
M111B-20	6	0.032	0°	260°F / 500 Hrs.	260°F	70	111	-	1038
M112A-1	6	0.032	0°	260°F / 500 Hrs.	350°F	80	127	222	-
M112A-2	6	0.032	0°	260°F / 500 Hrs.	350°F	75	119	-	1015
M112A-3	6	0.032	0°	260°F / 500 Hrs.	350°F	70	111	653	-
M112A-4	6	0.032	0°	260°F / 500 Hrs.	350°F	65	103	-	1004
M112A-5	6	0.032	0°	260°F / 500 Hrs.	350°F	85	130	-	1006
M112A-16	6	0.033	0°	350°F / 500 Hrs.	260°F	70	107	-	1007
M112A-17	6	0.033	0°	350°F / 500 Hrs.	260°F	75	115	-	1005
M112A-18	6	0.033	0°	350°F / 500 Hrs.	260°F	80	122	-	998
M112A-19	6	0.033	0°	350°F / 500 Hrs.	260°F	90	138	-	1006
M112A-20	6	0.032	0°	350°F / 500 Hrs.	260°F	90	141	97.7	-
M112B-1	6	0.033	0°	350°F / 500 Hrs.	350°F	80	127	685	-
M112B-2	6	0.031	0°	350°F / 500 Hrs.	350°F	70	121	918	-
M112B-3	6	0.032	0°	350°F / 500 Hrs.	350°F	75	119	950	-
M112B-4	6	0.033	0°	350°F / 500 Hrs.	350°F	80	127	184	-
M112B-5	6	0.033	0°	350°F / 500 Hrs.	350°F	70	57.1	-	1016
M14B-1	9	0.048	[0/45/135/0/90] _B	260°F / 500 Hrs.	260°F	70	57.1	-	1012
M14B-2	9	0.048	"	260°F / 500 Hrs.	260°F	75	61.2	-	1153
M14B-3	9	0.048	"	260°F / 500 Hrs.	260°F	75	61.2	-	1012
M14B-4	9	0.048	"	260°F / 500 Hrs.	260°F	80	65.2	-	-
M14B-5	9	0.049	"	260°F / 500 Hrs.	260°F	65	53	50.3	-
M14B-6	9	0.049	[0/45/135/0/90] _B	260°F / 500 Hrs.	350°F	70	57.2	-	1008
M14B-7	9	0.048	"	260°F / 500 Hrs.	350°F	75	61.2	405	-
M14B-8	9	0.048	"	260°F / 500 Hrs.	350°F	85	69.4	761.6	-
M14B-9	9	0.050	"	260°F / 500 Hrs.	350°F	60	49	666	-
M14B-10	9	0.048	[0/45/135/0/90] _B	260°F / 500 Hrs.	350°F	60	49	666	-

Strain gage failed after .5 hrs.

Strain gage failed after .5 hrs.

Heater malfunctioned, temp too high

TABLE 1. CREEP AND STRESS RELAXATION TESTS
SUNBA - NARCO 3200 AND 3200-1
GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	Prior Conditioning		Test Temp. (°F)	Stress Level (% Yult) (Ksi)	Time to Failure (Hours)	Time Applied Without Failure (Hours)	Comment
			Type	Duration					
M112B-1	9	0.031	0° 45° 135° 0° 90°	350°F 500 hrs.	260°F	80	60.5	1000	-
M112B-2	9	0.031	"	350°F 500 hrs.	260°F	91	65.2	-	-
M112B-3	9	0.049	"	350°F 500 hrs.	260°F	77.5	58.5	1000	-
M112B-4	9	0.049	"	350°F 500 hrs.	260°F	70	54.5	1000	-
M112B-5	9	0.049	"	350°F 500 hrs.	260°F	85.5	64.5	-	-
M112B-6	9	0.048	"	350°F 500 hrs.	250°F	65	50.5	1110	-
M112B-7	9	0.048	"	350°F 500 hrs.	350°F	70	54.5	1111	-
M112B-8	9	0.048	"	350°F 500 hrs.	350°F	75	58.3	309	-
M112B-9	9	0.048	"	350°F 500 hrs.	350°F	60	47.7	1008	-
M112B-10	9	0.049	0° 45° 135° 0° 90°	350°F 500 hrs.	350°F	80	64.5	30.1	Broke
M112A-6	6	0.033	0°	260°F 1000 cye.	260°F	70	104	739	-
M112A-7	6	0.033	0°	260°F 1000 cye.	260°F	75	117	50	Oven overheated
M112A-8	6	0.033	0°	260°F 1000 cye.	260°F	80	125	1000	-
M112A-9	6	0.033	0°	260°F 1000 cye.	260°F	85	133	1000	-
M112A-10	6	0.033	0°	260°F 1000 cye.	260°F	90	140	508	-
M112A-11	6	0.033	0°	260°F 1000 cye.	350°F	80	118	-	-
M112A-12	6	0.033	0°	260°F 1000 cye.	350°F	75	110	-	-
M112A-13	6	0.033	0°	260°F 1000 cye.	350°F	70	104	-	-
M112A-14	6	0.033	0°	260°F 1000 cye.	350°F	65	106	-	-
M112A-15	6	0.033	0°	260°F 1000 cye.	350°F	90	133	188	-
M112B-6	6	0.032	0°	350°F 1000 cye.	260°F	83	83	9.8	Strain gage failed
M112B-7	6	0.032	0°	350°F 1000 cye.	260°F	79	130	2.4	Strain gage failed
M112B-8	6	0.032	0°	350°F 1000 cye.	260°F	84	138	.167	-
M112B-9	6	0.032	0°	350°F 1000 cye.	260°F	79	130	168	-
M112B-10	6	0.032	0°	350°F 1000 cye.	260°F	73	121	918	-
M112B-11	6	0.033	0°	350°F 1000 cye.	350°F	70	119	-	-
M112B-12	6	0.033	0°	350°F 1000 cye.	350°F	75	128	-	-
M112B-13	6	0.033	0°	350°F 1000 cye.	350°F	80	136	861	-
M112B-14	6	0.033	0°	350°F 1000 cye.	350°F	85	144	1.9	-
M112B-15	6	0.033	0°	350°F 1000 cye.	350°F	90	153	0.167	-

TABLE XVII CRFP AND STRESS RUPTURE PROPERTIES
SUMMARY - NARCO 576/1000R II
GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
M1142A-1	0.050	[0/45/135/0/90] _s	260°F / 1000 cyc.	260°F / 1000 cyc.	260°F	90	72.5	1000	-
M1142A-2	0.050	"	260°F / 1000 cyc.	260°F / 1000 cyc.	260°F	88	70.9	-	Tab failure, broke during loading
M1142A-3	0.049	"	260°F / 1000 cyc.	260°F / 1000 cyc.	260°F	93	74.9	-	Broke during loading
M1142A-4	0.049	"	260°F / 1000 cyc.	260°F / 1000 cyc.	260°F	92	74.1	1000	-
M1142A-5	0.048	"	260°F / 1000 cyc.	260°F / 1000 cyc.	260°F	95	76.6	-	Oven overheated
M1142A-6	0.050	"	260°F / 1000 cyc.	260°F / 1000 cyc.	350°F	88	71.2	-	-
M1142A-7	0.049	"	260°F / 1000 cyc.	260°F / 1000 cyc.	350°F	84	68	.016	-
M1142A-8	0.050	"	260°F / 1000 cyc.	260°F / 1000 cyc.	350°F	80	64.8	65.5	-
M1142A-9	0.049	"	260°F / 1000 cyc.	260°F / 1000 cyc.	350°F	86	69.6	.039	-
M1142A-10	0.051	"	260°F / 1000 cyc.	260°F / 1000 cyc.	350°F	82	66.4	312.9	Tab failure
M1142C-1	9	[0/45/135/0/90] _s	350°F / 1000 cyc.	350°F / 1000 cyc.	260°F	70	55.8	.75	-
M1142C-2	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	260°F	75	59.7	-	1007
M1142C-3	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	260°F	80	63.7	-	1006
M1142C-4	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	260°F	70	55.8	-	1018
M1142C-5	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	260°F	80	63.7	-	1005
M1142C-6	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	350°F	70	54.5	-	1000
M1142C-7	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	350°F	75	58.0	-	1000
M1142C-8	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	350°F	80	62.3	-	1000
M1142C-9	9	"	350°F / 1000 cyc.	350°F / 1000 cyc.	350°F	85	66.2	745	-
M1142C-10	9	[0/45/135/0/90] _s	350°F / 1000 cyc.	350°F / 1000 cyc.	350°F	90	70.1	-	Broke in loading

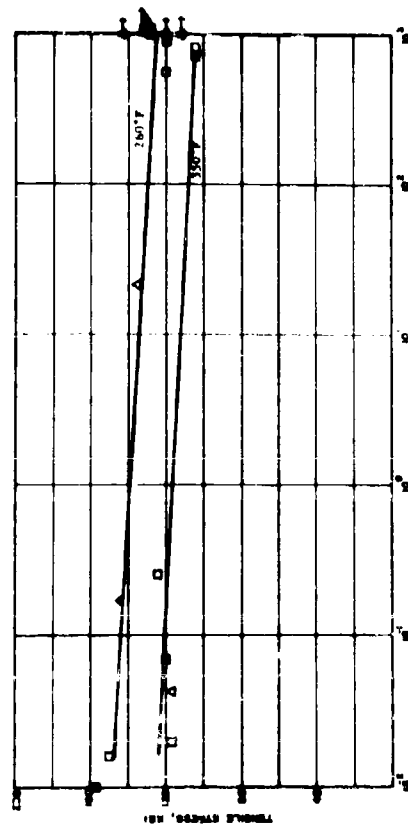


FIG. 359 STRESS RUPTURE DIAGRAM FOR 0° MONOR II CARBITE/MARCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES

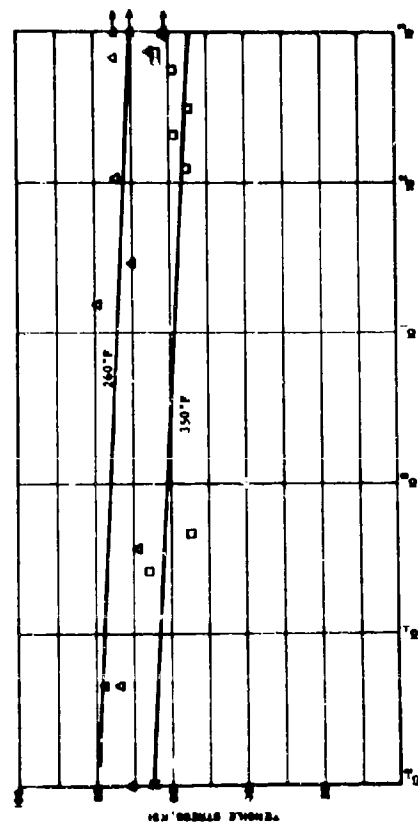


FIG. 361 STRESS RUPTURE DIAGRAM FOR 0.45/1.5/0.90 MONOR II CARBITE/MARCO 5206 LAMINATE TESTED AT VARIOUS TEMPERATURES

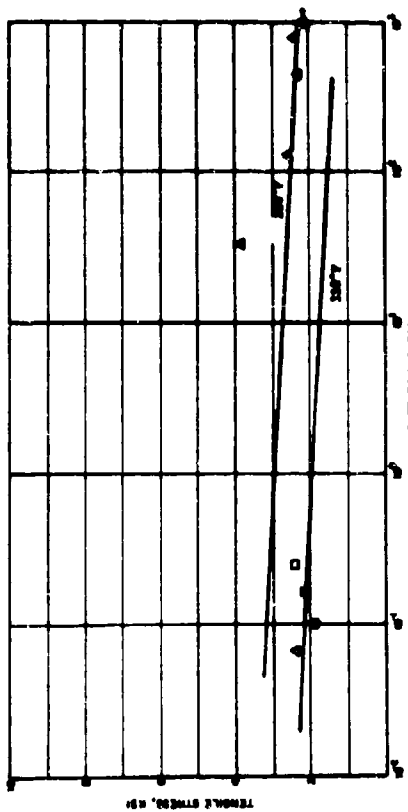


FIG. 360 STRESS RUPTURE DIAGRAM FOR 90° MONOR II CARBITE/MARCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES

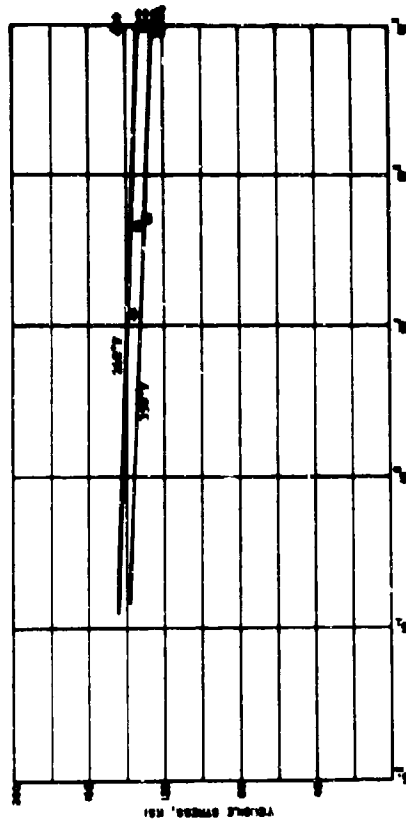
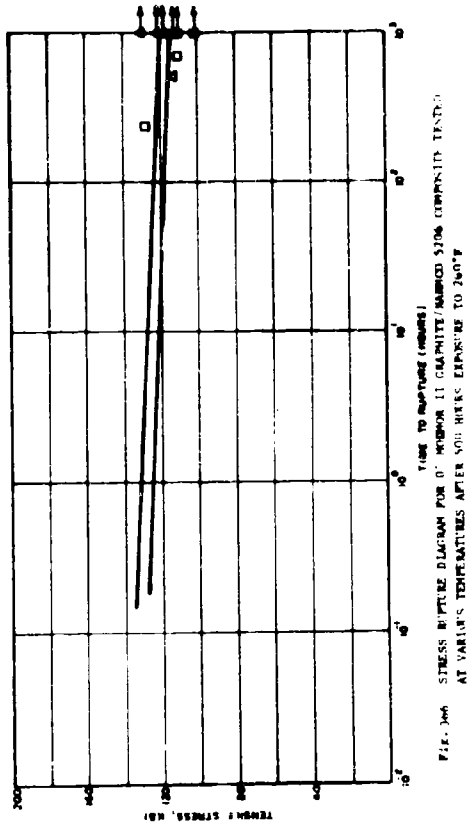
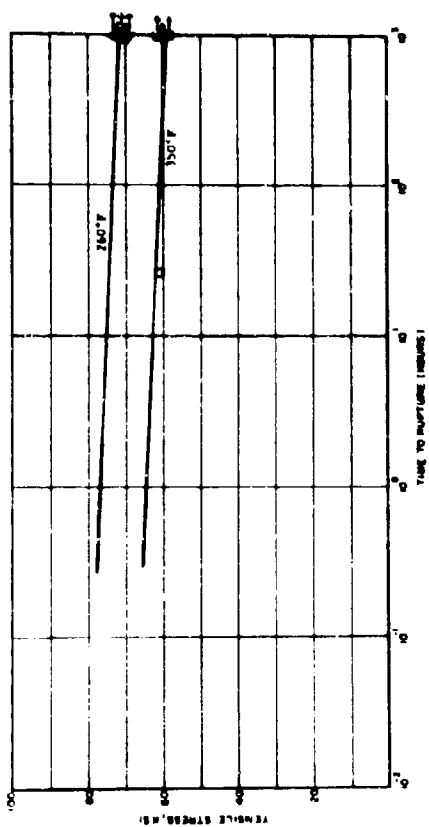
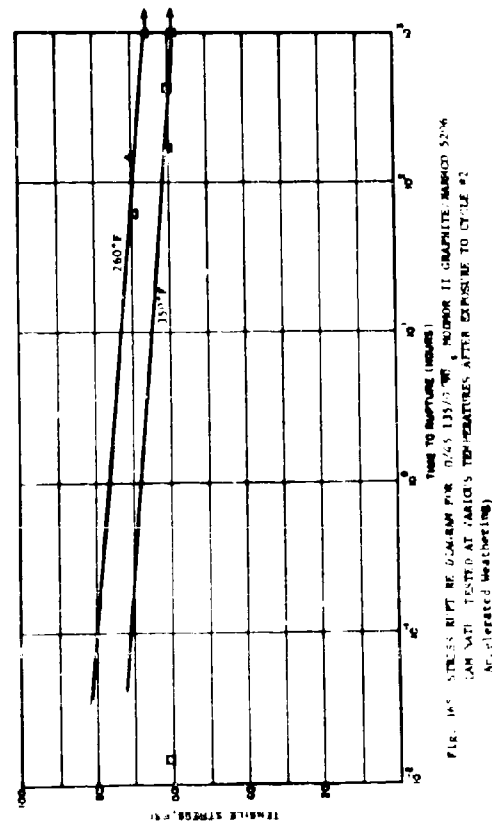
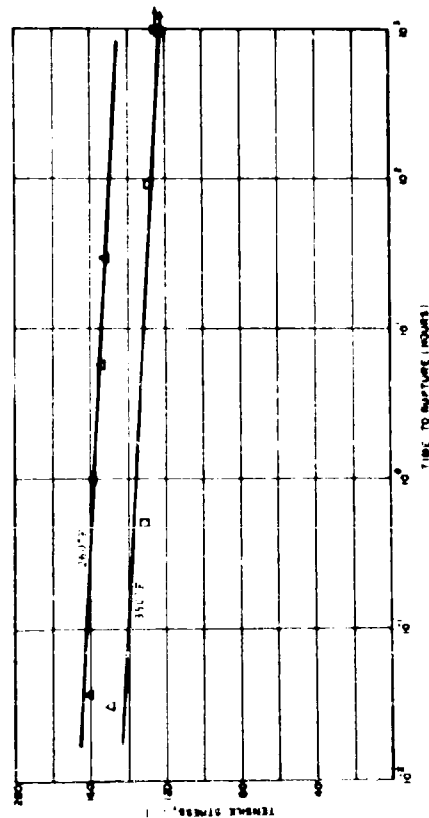


FIG. 362 STRESS RUPTURE DIAGRAM FOR 0° MONOR II CARBITE/MARCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90°C



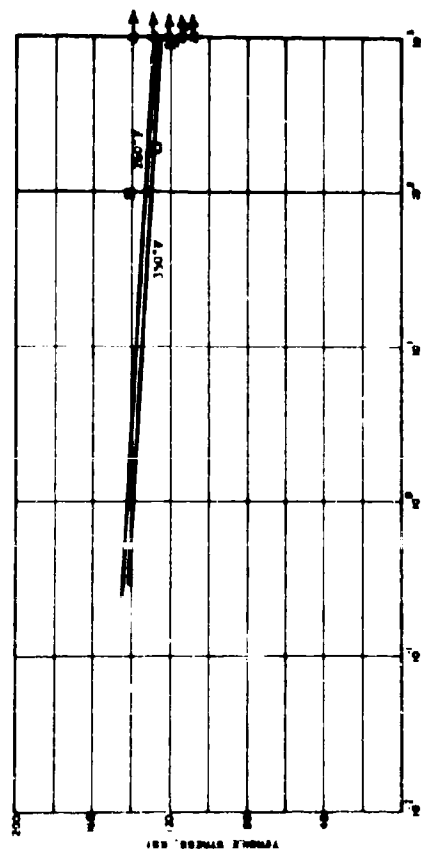


FIG. 16. STRESS RUPTURE DIAGRAM FOR 0° FIBER II CHARPY/BARCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

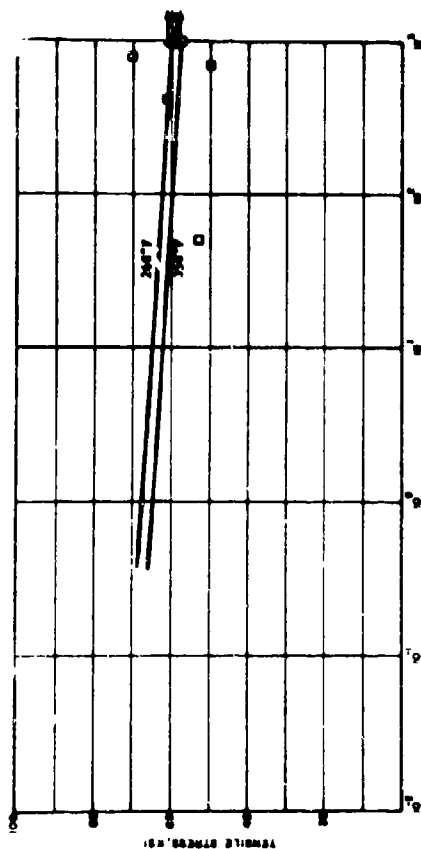


FIG. 168. STRESS RUPTURE DIAGRAM FOR 0° FIBER II CHARPY/BARCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 360°F

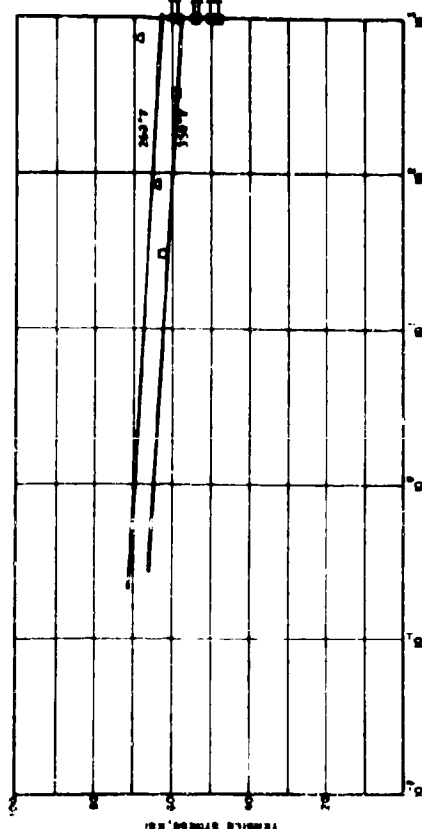


FIG. 169. STRESS RUPTURE DIAGRAM FOR 0° FIBER II CHARPY/BARCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F

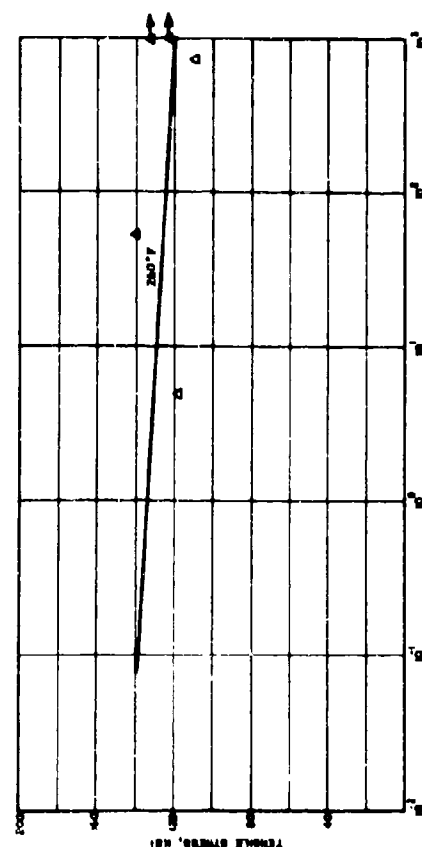
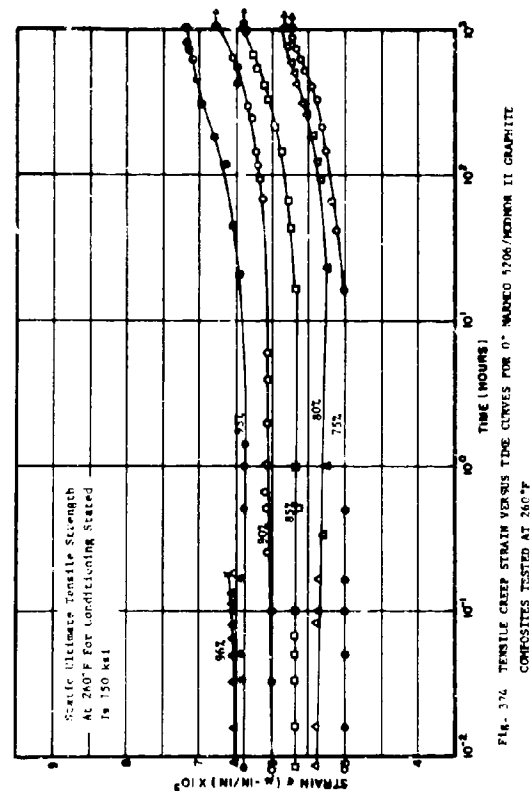
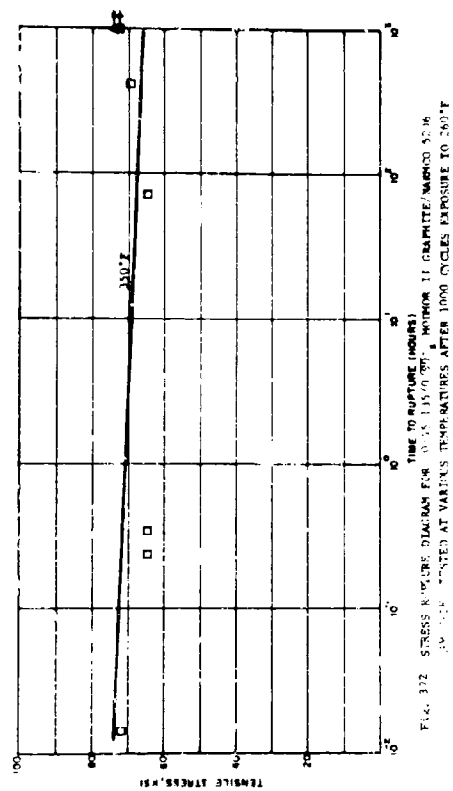
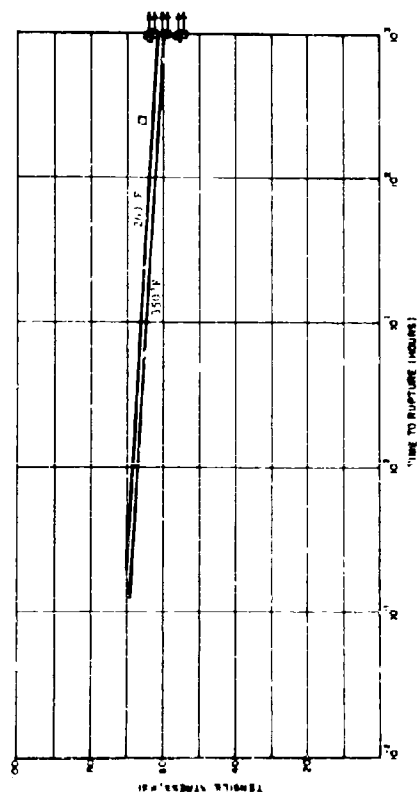
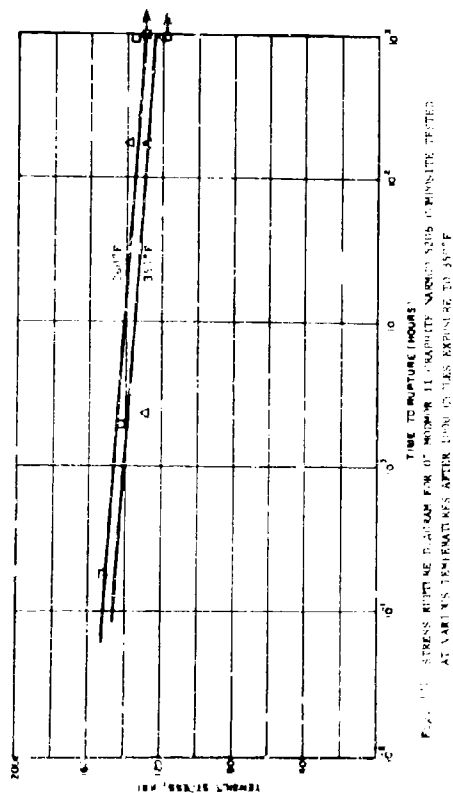


FIG. 170. STRESS RUPTURE DIAGRAM FOR 0° FIBER II CHARPY/BARCO 5206 COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 360°F



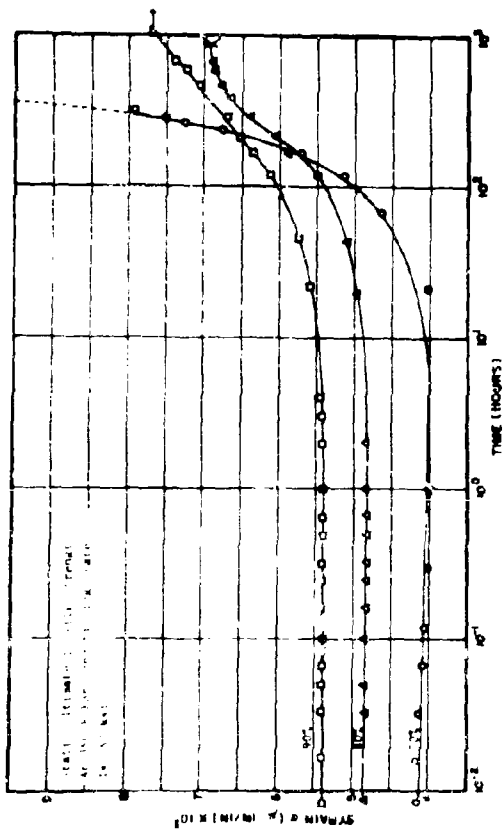


FIG. 17- TIME-TEMPERATURE STRAIN VERSUS TIME CURVES FOR 0° MARQU 5206/MENHER II GRAPHITE COMPOSITES TESTED AT 150°F

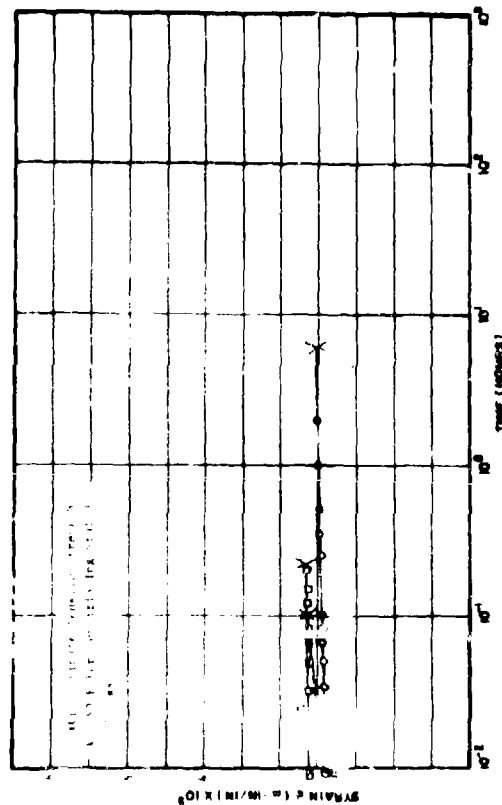


FIG. 18- TIME-TEMPERATURE STRAIN VERSUS TIME CURVES FOR 90° MARQU 5206/MENHER II GRAPHITE COMPOSITES TESTED AT 150°F

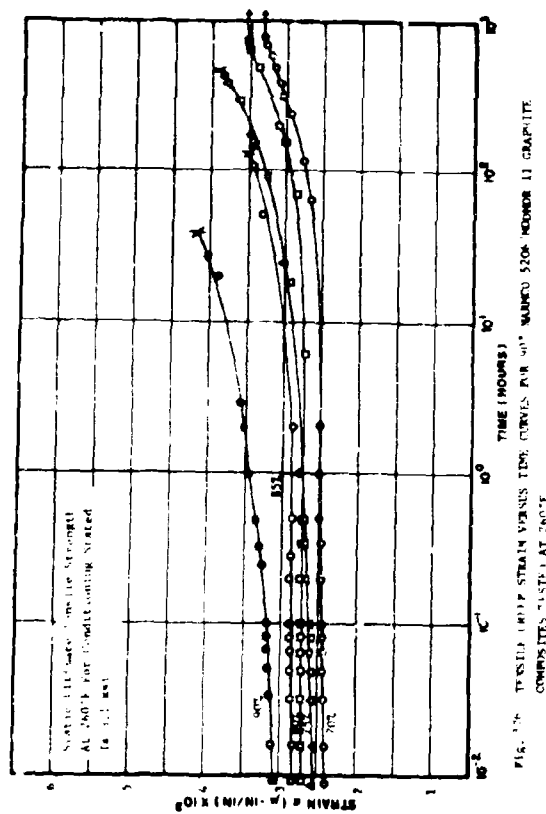


FIG. 19- TIME-TEMPERATURE STRAIN VERSUS TIME CURVES FOR 0° MARQU 5206/MENHER II GRAPHITE COMPOSITES TESTED AT 260°F

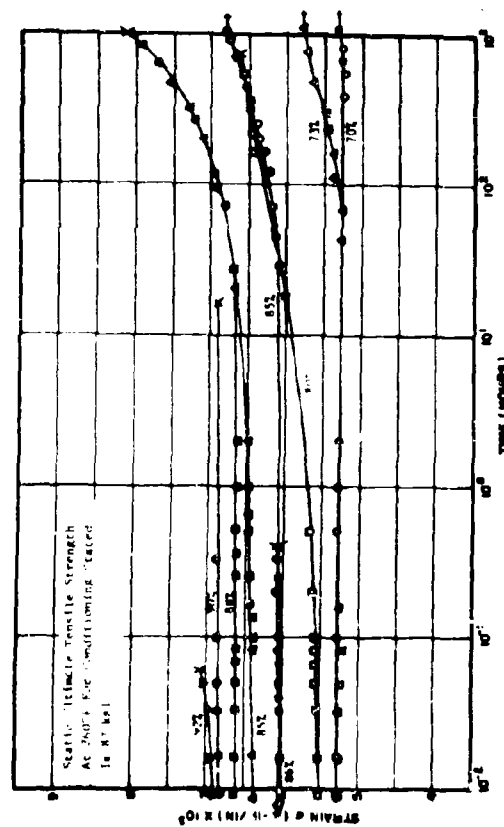


FIG. 20- TIME-TEMPERATURE STRAIN VERSUS TIME CURVES FOR 90° MARQU 5206/MENHER II GRAPHITE LAMINATES TESTED AT 260°F

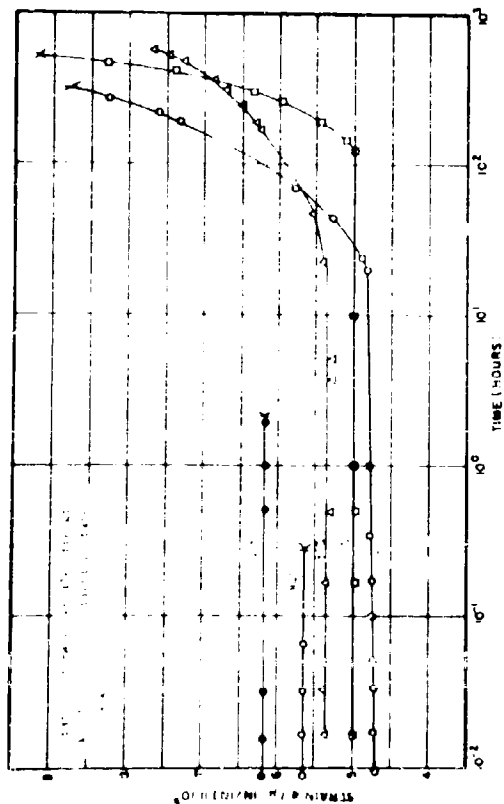


FIG. 11. STRAIN VERSUS TIME FOR SAMPLE 11 (ACCELERATED)

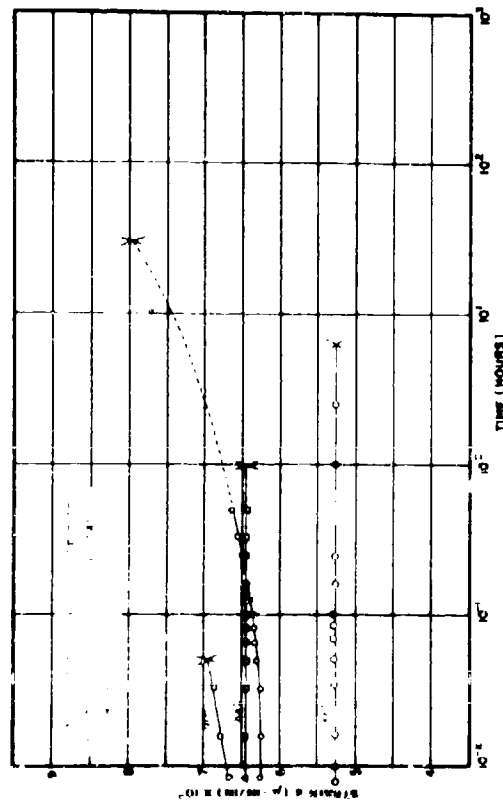


FIG. 12. STRAIN VERSUS TIME FOR SAMPLE 12 (ACCELERATED)

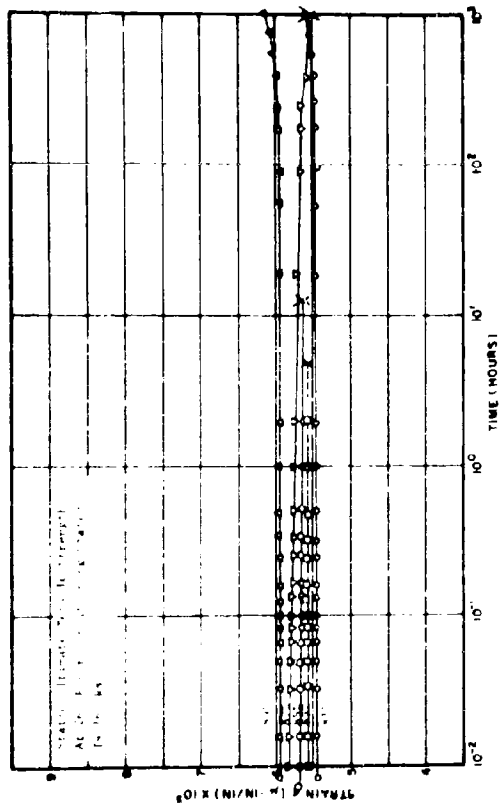


FIG. 13. STRAIN VERSUS TIME FOR SAMPLE 13 (ACCELERATED)

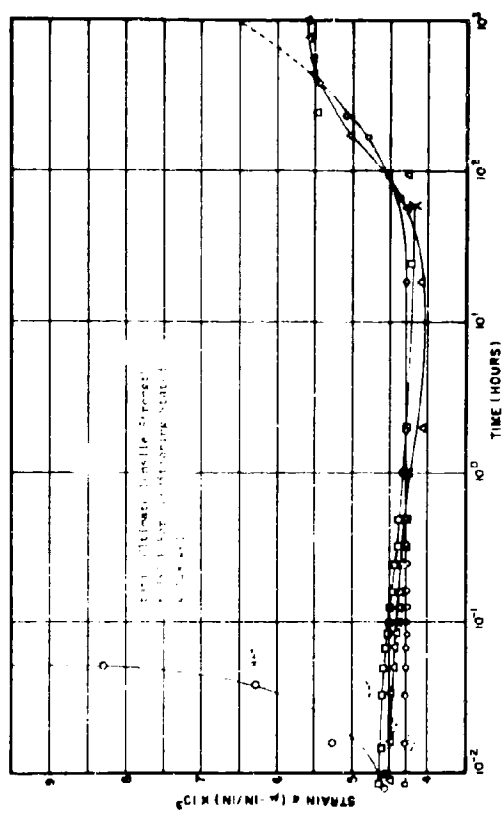


FIG. 14. STRAIN VERSUS TIME FOR SAMPLE 14 (ACCELERATED)

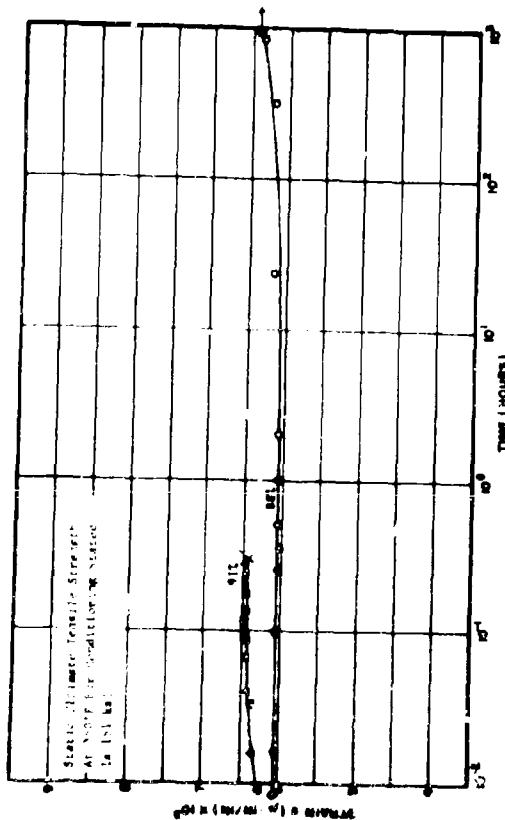


FIG. 181 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° MARKED 3206 KENOR II GRAPHITE COMPOSITES TESTED AT 130°F AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (THAT-HUMIDITY CYCLE)

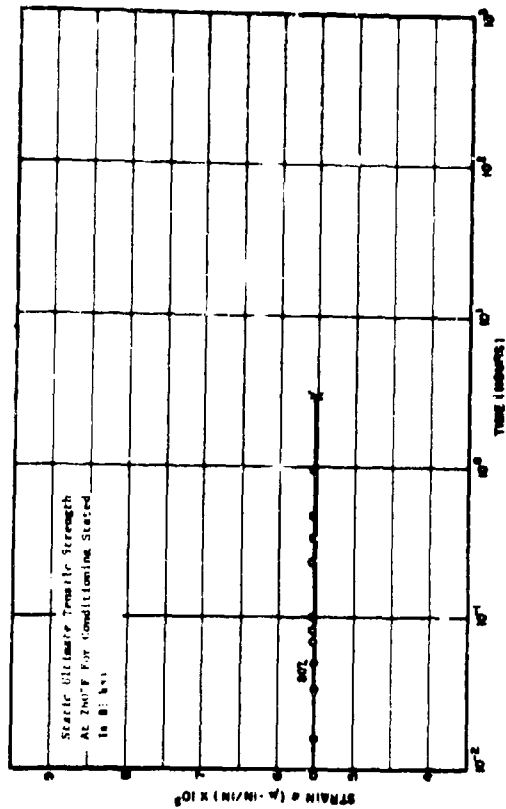


FIG. 182 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0°/45°/135°/0°/90° MARKED 3206 KENOR II GRAPHITE LAMINATES TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 98% RH

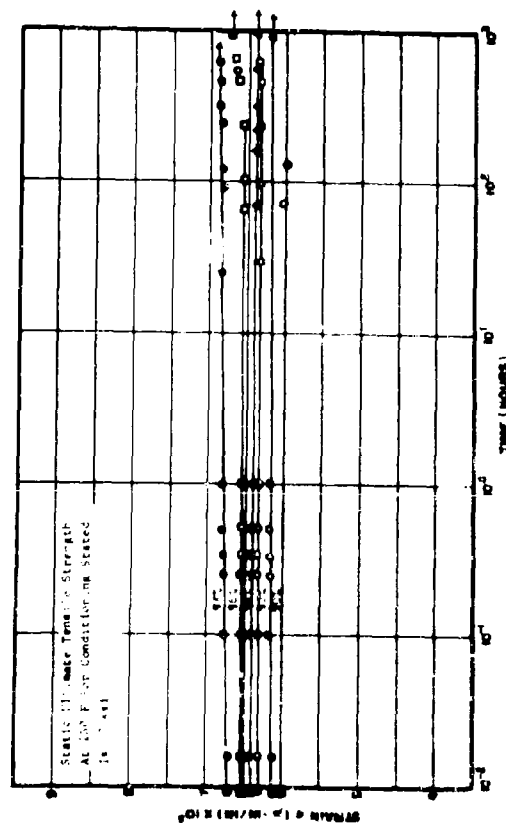


FIG. 183 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0°/45°/135°/0°/90° MARKED 3206 KENOR II GRAPHITE LAMINATES TESTED AT 260°F AFTER 1000 HOURS EXPOSURE TO 98% RH

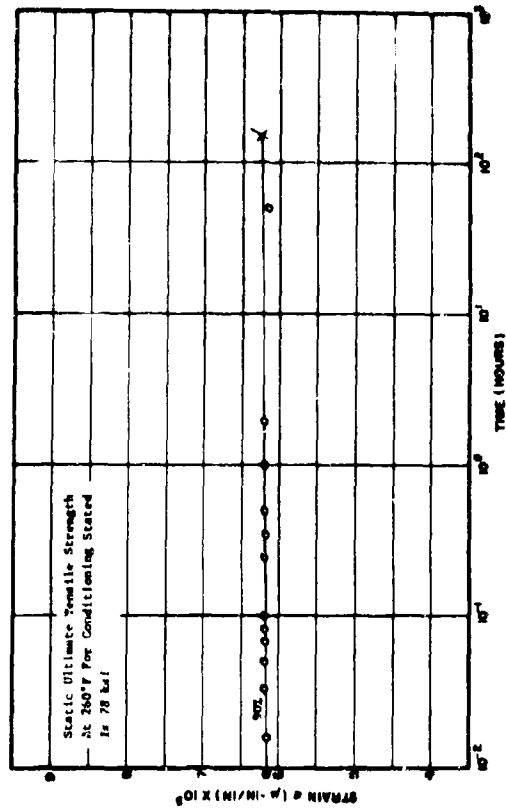


FIG. 184 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0°/45°/135°/0°/90° MARKED 3206 KENOR II GRAPHITE LAMINATES TESTED AT 260°F AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

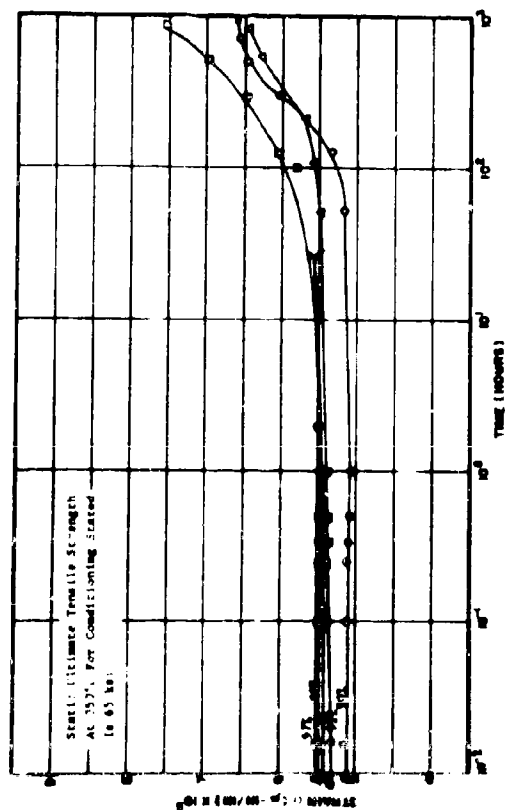


FIG. 147 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR (0/AS/135/0/10)₂ MARKED 5206/NUMBER II GRAPHITE LAMINATES TESTED AT 350°F AFTER 1000 HOURS EXPOSURE TO 94% RH

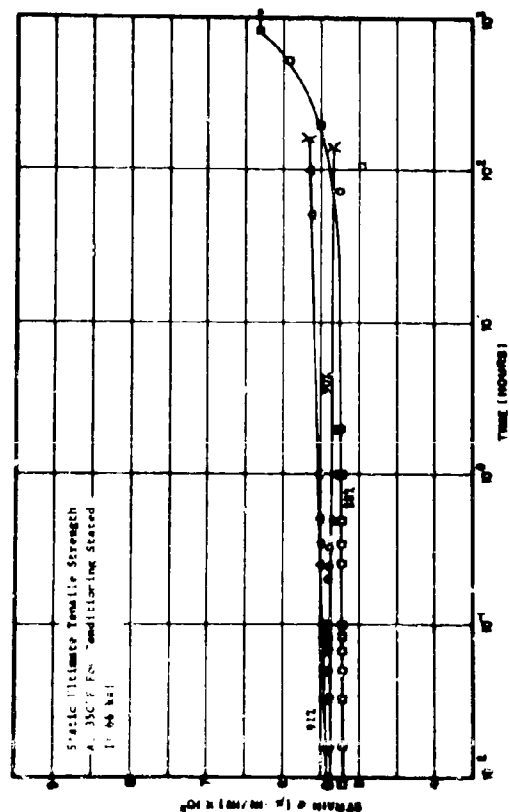


FIG. 148 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR (0/AS/135/0/10)₂ MARKED 5206/NUMBER II GRAPHITE LAMINATES TESTED AT 350°F AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering)

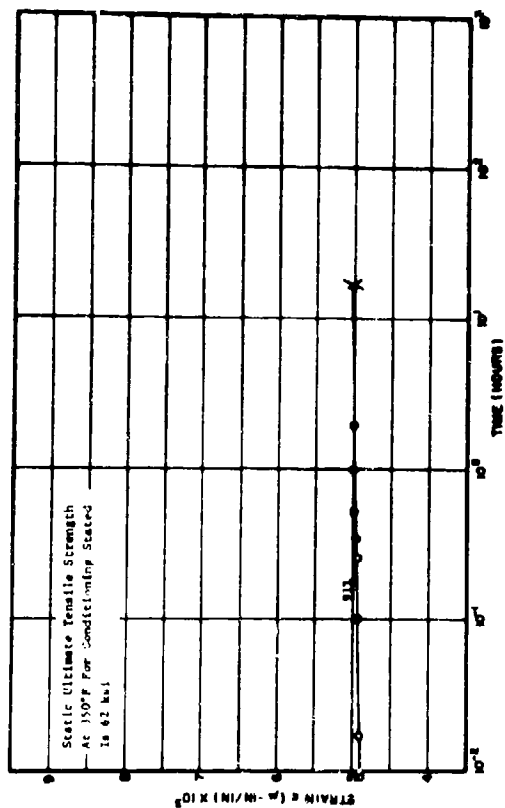


FIG. 149 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR (0/AS/135/0/10)₂ MARKED 5206/NUMBER II GRAPHITE LAMINATES TESTED AT 350°F AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (Thermo-Humidity Cycle)

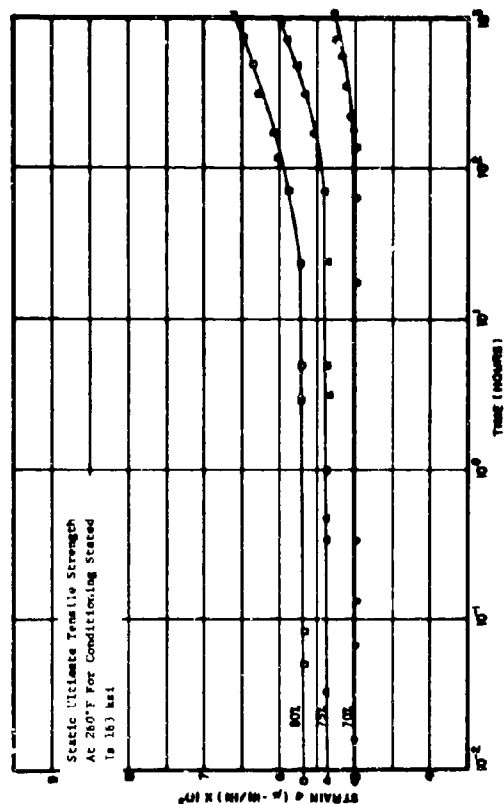


FIG. 150 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR (0/AS/135/0/10)₂ MARKED 5206/NUMBER II GRAPHITE COMPOSITES TESTED AT 350°F AFTER 500 HOURS EXPOSURE TO 94% RH

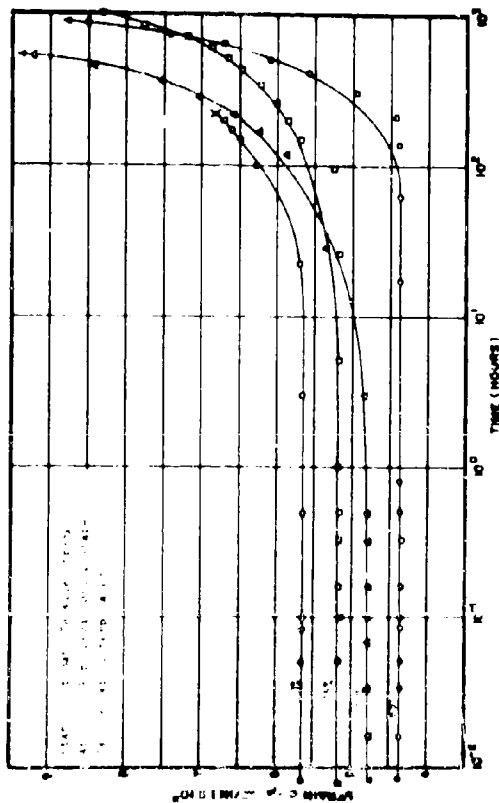


FIG. 31. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° MARKED 3506/Modex II GRAPHITE COMPOSITES TESTED AT 150°F AFTER 500 HOURS EXPOSURE TO 260°F

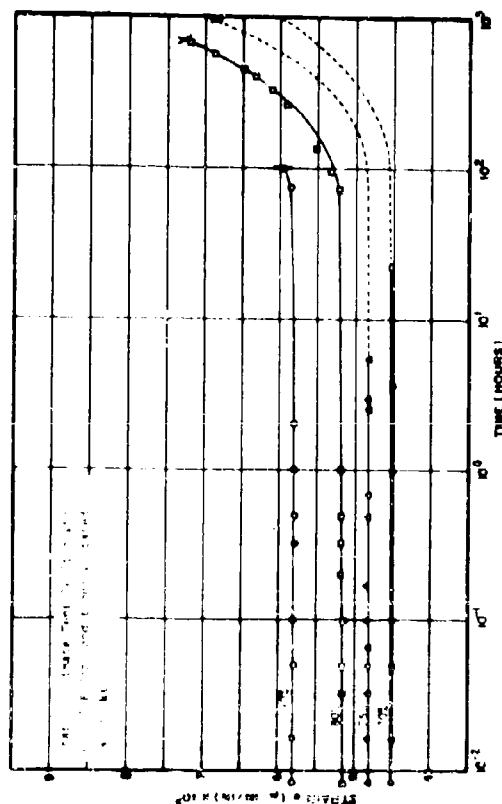


FIG. 32. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° MARKED 3506/Modex II GRAPHITE COMPOSITES TESTED AT 150°F AFTER 500 HOURS EXPOSURE TO 260°F

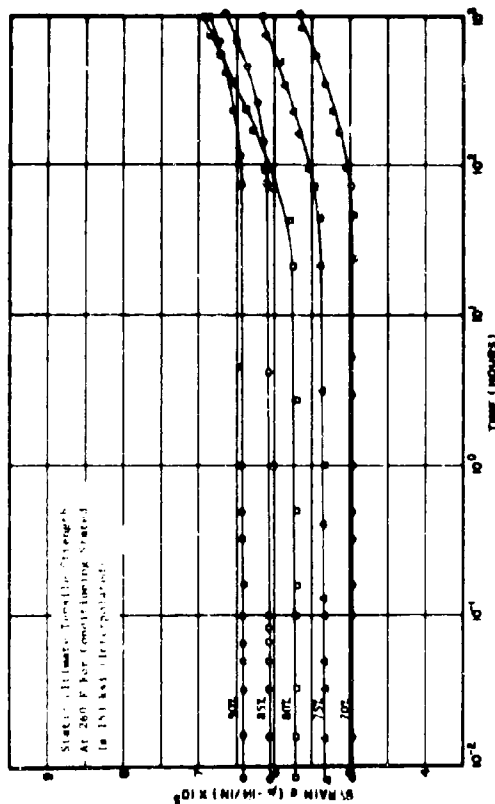


FIG. 33. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° MARKED 3506/Modex II GRAPHITE COMPOSITES TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 350°F

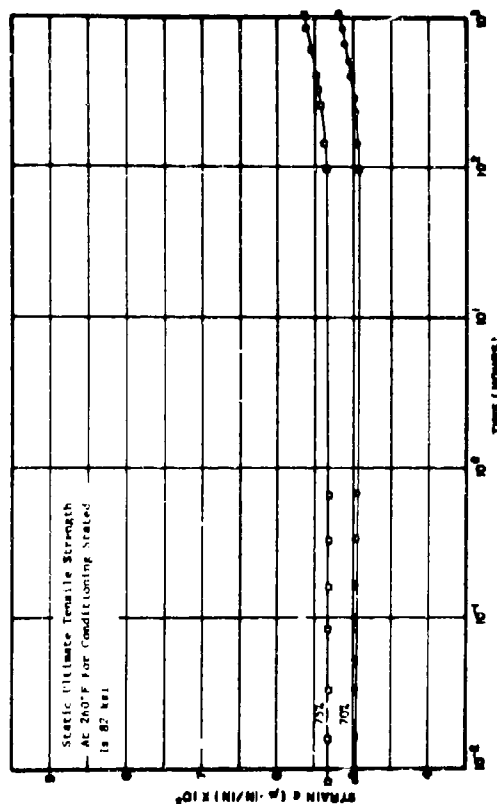


FIG. 34. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° MARKED 3506/Modex II GRAPHITE COMPOSITES TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 260°F

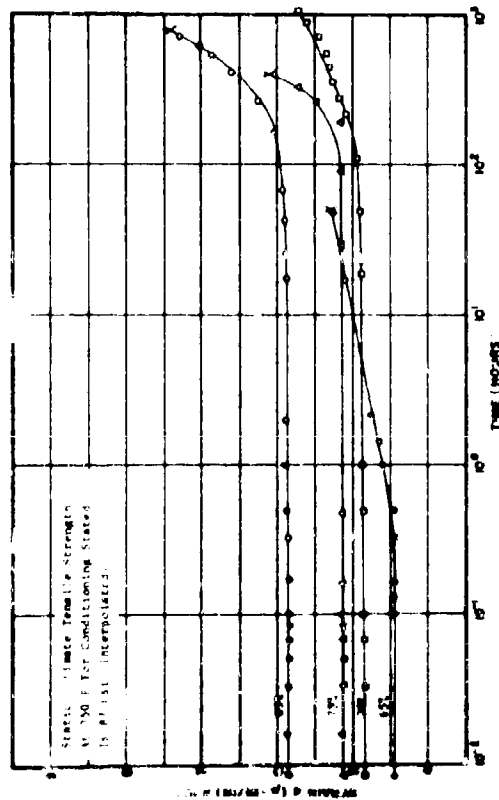


FIG. 139 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 9° MARCO 5206 NUMBER II
GRAPHITE LAMINATES TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 350°F

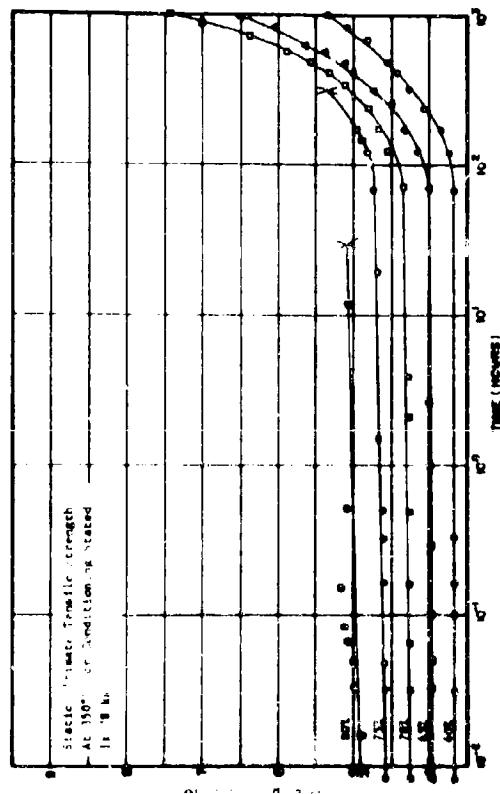


FIG. 140 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 9° MARCO 5206 NUMBER II
GRAPHITE LAMINATES TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 350°F

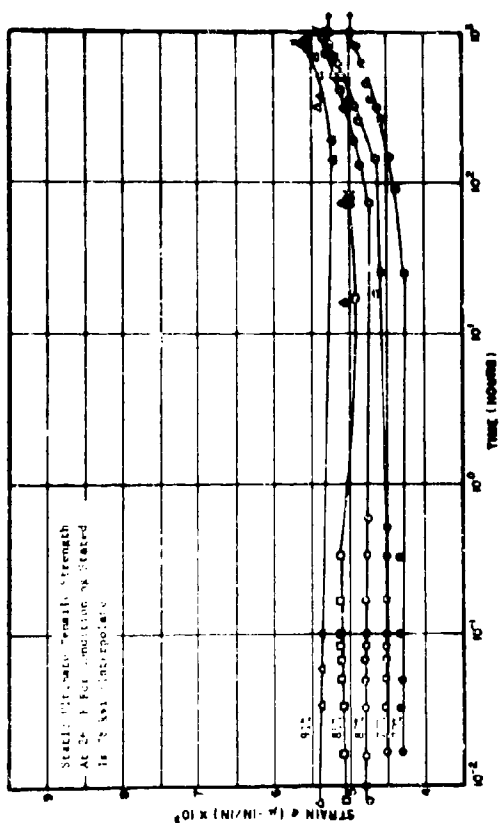


FIG. 141 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 9° MARCO 5206 NUMBER II
GRAPHITE LAMINATES TESTED AT 260°F AFTER 500 HOURS EXPOSURE TO 350°F

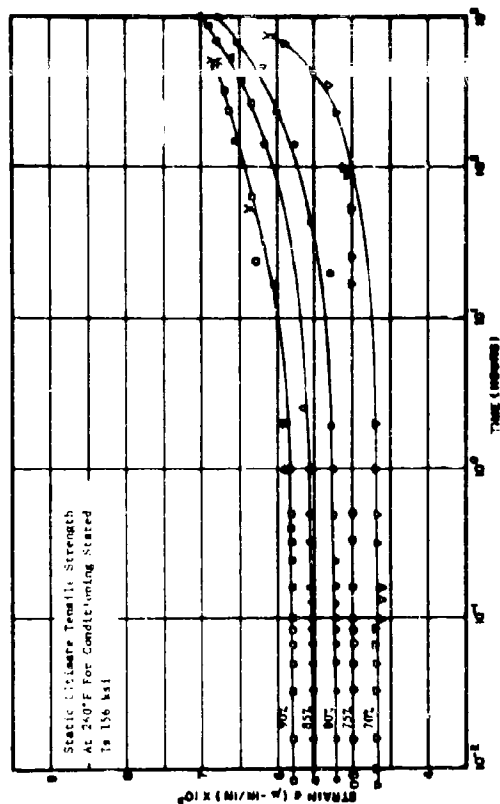


FIG. 142 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 9° MARCO 5206 NUMBER II GRAPHITE LAMINATES TESTED AT 260°F AFTER 1000 CYCLES EXPOSURE TO 350°F

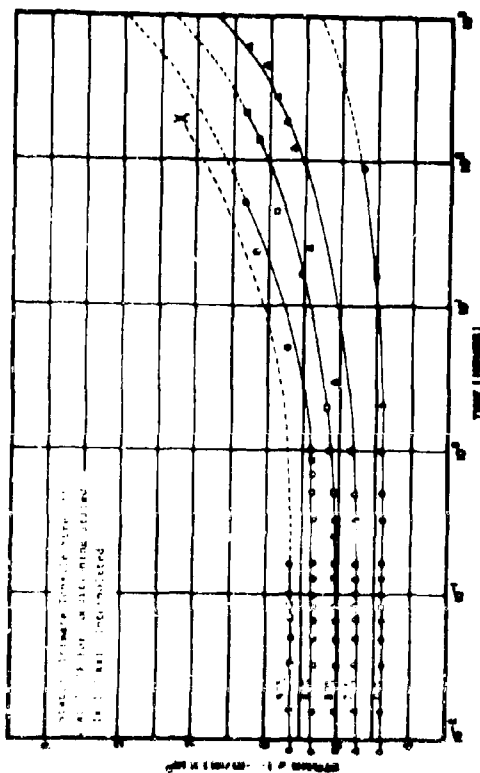


FIG. 402 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BANDED 5206/NEOSUR II GRAPHITE COMPOSITES TESTED AT 150°F AFTER 1000 CYCLES EXPOSURE TO 260°F

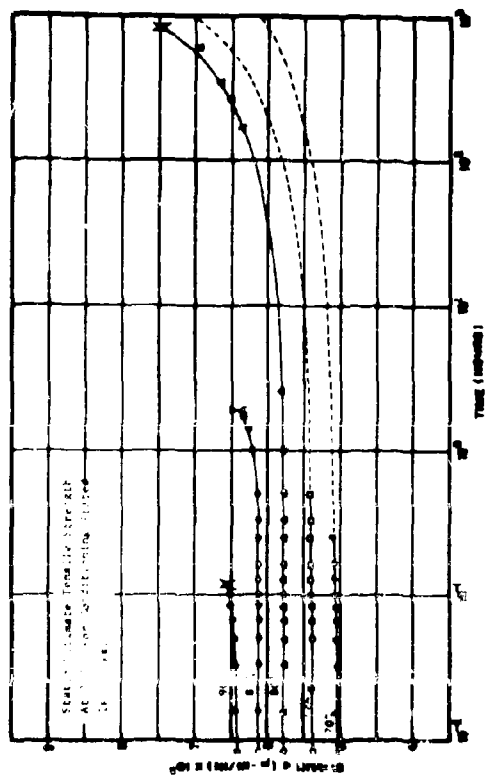


FIG. 403 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BANDED 5206/NEOSUR II GRAPHITE COMPOSITES TESTED AT 150°F AFTER 1000 CYCLES EXPOSURE TO 260°F

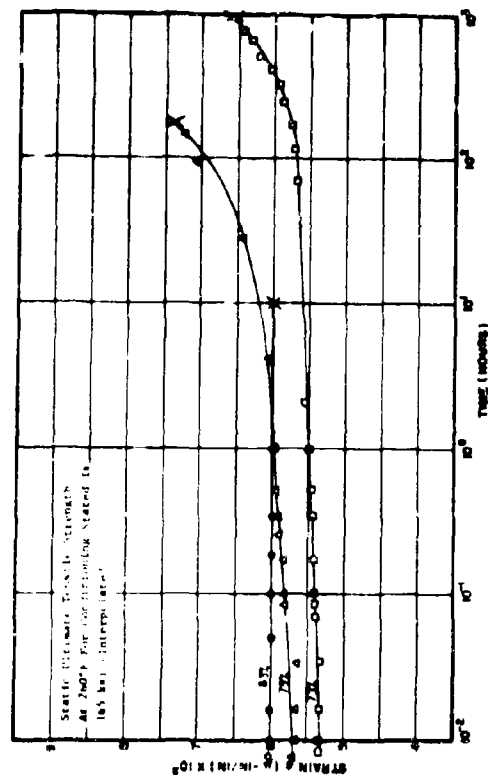


FIG. 404 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BANDED 5206/NEOSUR II GRAPHITE COMPOSITES TESTED AT 260°F AFTER 1000 CYCLES EXPOSURE TO 350°F

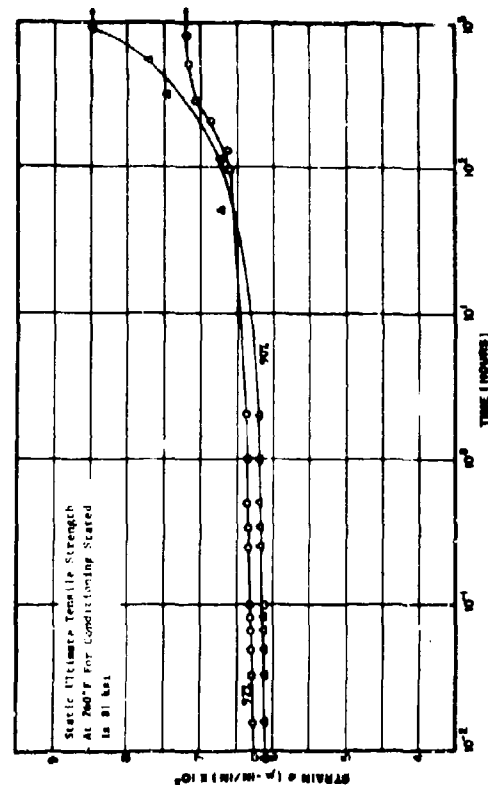


FIG. 405 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BANDED 5206/NEOSUR II GRAPHITE COMPOSITES TESTED AT 260°F AFTER 1000 CYCLES EXPOSURE TO 350°F

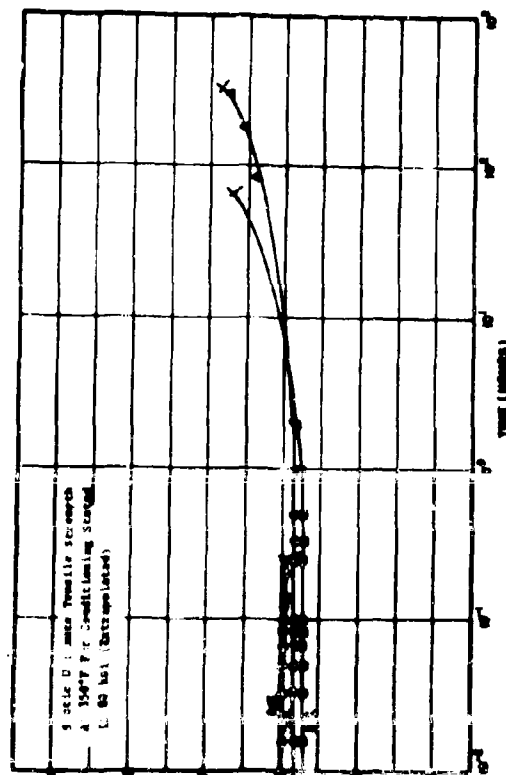


FIG. 401 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR (0/45/135/0/90), BAKED 3506/HOLDER II GRAPHITE LAMINATES TESTED AT 350°F AFTER 1000 CYCLES EXPOSURE TO 350°F.

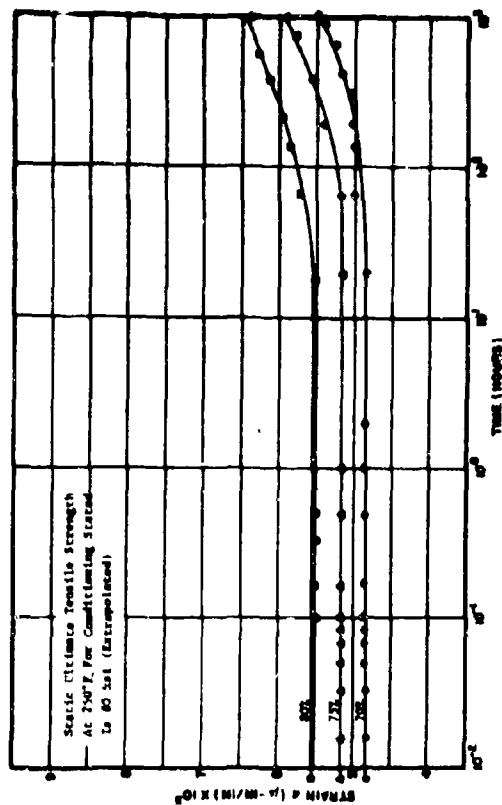


FIG. 404 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR (0/45/135/0/90), BAKED 3506/HOLDER II GRAPHITE LAMINATES TESTED AT 350°F AFTER 1000 CYCLES EXPOSURE TO 350°F.

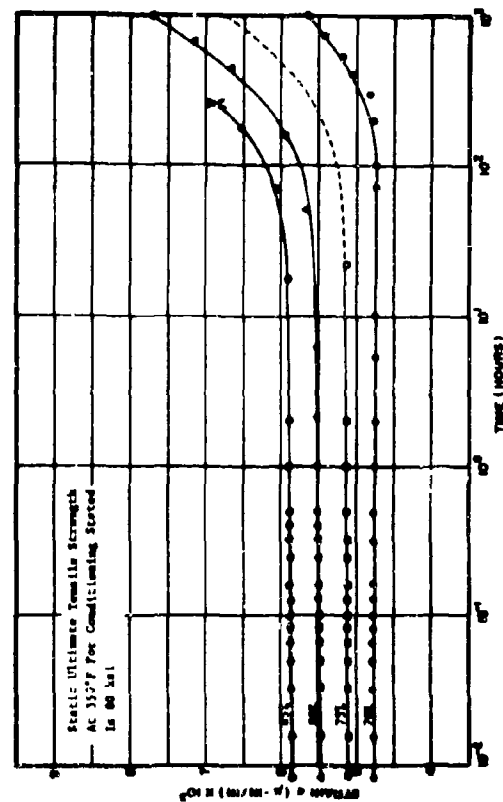


FIG. 405 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR (0/45/135/0/90), BAKED 3506/HOLDER II GRAPHITE LAMINATES TESTED AT 350°F AFTER 1000 CYCLES EXPOSURE TO 350°F.

APPENDIX III

DATA SUMMARY FOR HERCULES 3002M/COURTAULDS HMS GRAPHITE COMPOSITES

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TABLE XVIII
TENSILE PROPERTIES SUMMARY -
ELECTROLYTICALLY TREATED
ALUMINUM ALLOY

Orientation	Type Load	Pre-Test Conditioning	Test Temp. (°F)	E ($\times 10^3$)	σ_{ult} (ksi)	ϵ_{ult} (in./in.)
0°	Tension	None	RTD	26.9	98	3,360
0°	Tension	None	260°F	28.3	119	4,100
0°	Tension	None	350°F	29.8	115	3,850
90°	Tension	None	RTD	0.98	2.3	2,260
90°	Tension	None	260°F	0.95	4.7	5,000
90°	Tension	None	350°F	0.89	4.1	4,570
[0/45/135/0/90]°	Tension	None	RTD	13.9	48	3,500
[0/45/135/0/90]°	Tension	None	260°F	17.2	56	3,530
[0/45/135/0/90]°	Tension	None	350°F	16.2	57	3,580
0°	Compression	None	RTD	24.6	100	4,300
0°	Compression	None	RTD	22.5	97	4,110
0°	Compression	None	260°F	25.8	98	3,870
0°	Compression	None	350°F	24.6	83	3,580
0°	Compression	None	350°F	24.9	92	3,420
90°	Compression	None	RTD	1.25	21.4	19,670
90°	Compression	None	RTD	1.21	32.9	29,000
90°	Compression	None	260°F	1.11	29.7	> 30,000
90°	Compression	None	350°F	1.36	18.7	20,530
90°	Compression	None	350°F	1.10	27.2	> 30,000

of Sandvik - Brant Data

Orientation	Mode of Failure	Strain at Failure (%)	Modulus of Elasticity (ksi)	Yield or Tensile (ksi)	Elongation at Break (%)
[0/45/135/0/90] _s	Compression	None	13.4	6.57	60
[0/45/135/0/90] _s	Compression	None	11.6	0.73	59
[0/45/135/0/90] _s	Compression	None	9.7	0.45	54
[0/45/135/0/90] _s	Compression	None	12.5	0.42	55
[0/45/135/0/90] _s	Compression	None	9.7	0.44	53
0°	In-Plane Shear	None	0.85	-	10.4
0°	In-Plane Shear	None	0.54	-	8.9
0°	In-Plane Shear	None	0.51	-	6.3
0°	Int. Shear	None	-	-	13.7
0°	Int. Shear	None	-	-	9.7
0°	Int. Shear	None	-	-	7.5
[0/45/135/0/90] _s	Int. Shear	None	-	-	10.2
[0/45/135/0/90] _s	Int. Shear	None	-	-	7.4
[0/45/135/0/90] _s	Int. Shear	None	-	-	5.2
0°	Flexural	None	-	-	138
0°	Flexural	None	-	-	110
0°	Flexural	None	-	-	107
40°	Flexural	None	-	-	10.5
50°	Flexural	None	-	-	8.1
50°	Flexural	None	-	-	7.1

Manufacture Data

STATIC PROPERTIES OF
BUTYL RUBBER
KATH

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	psi x 10 ³	in/in	ult (ksi)	ult (ksi) (n.)
0°	Tension	98% RH/500 Hrs	RTD	28.9	0.24	117	3,910
0°	Tension	98% RH/500 Hrs	60°F	-	-	109	-
0°	Tension	98% RH/500 Hrs	350°F	-	-	109	-
0°	Tension	98% RH/1000 Hrs	RTD	26.6	0.20	109	3,930
0°	Tension	98% RH/1000 Hrs	260°F	28.1	0.44	124	4,280
0°	Tension	98% RH/1000 Hrs	350°F	25.6	0.68	101	3,830
0°	Tension	Thermo-Humidity Cycle	RTD	27.1	0.29	105	3,790
0°	Tension	Thermo-Humidity Cycle	260°F	-	-	126	-
0°	Tension	Thermo-Humidity Cycle	350°F	-	-	115	-
0°	Tension	Acc. Wehring.	RTD	26.9	0.29	101	3,681
0°	Tension	Acc. Wehring.	260°F	28.3	0.39	133	4,630
0°	Tension	Acc. Wehring.	350°F	27.5	0.45	114	4,140
90°	Tension	98% RH/500 Hrs	RTD	0.95	0.00	1.7	1,810
90°	Tension	98% RH/500 Hrs	260°F	-	-	2.4	-
90°	Tension	98% RH/500 Hrs	350°F	-	-	3.5	-
90°	Tension	98% RH/1000 Hrs	RTD	1.07	0.00	1.5	1,360
90°	Tension	98% RH/1000 Hrs	260°F	1.13	0.00	1.7	1,620
90°	Tension	98% RH/1000 Hrs	350°F	0.89	0.01	4.0	4,780
90°	Tension	Thermo-Humidity Cycle	RTD	1.08	0.00	1.7	1,660
90°	Tension	Thermo-Humidity Cycle	260°F	-	-	1.1	-
90°	Tension	Thermo-Humidity Cycle	350°F	-	-	0.9	-

TABLE XVIII STATIC PROPERTIES SUMMARY -
OF FILMS JOINTLY COMING
FROM RAPIDITY EXPERIMENTS

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	L (psi × 10 ⁶)	ν (in/in)	σ _{ult} (ksi)	ε _{ult} (μ-in./in.)
90°	Tension	Acc. Wthrg.	RTD	1.22	0.01	5.5	4,660
90°	Tension	Acc. Wthrg.	260°F	0.87	0.0	2.0	4,240
90°	Tension	Acc. Wthrg.	350°F	0.27	0.0	1.1	7,940
[0/45/135/0/90]	Tension	98% RH/500 Hrs	RTD	14.4	0.49	53	3,600
[0/45/135/0/90]	Tension	98% RH/500 Hrs	260°F	-	-	57	-
[0/45/135/0/90]	Tension	98% RH/500 Hrs	350°F	-	-	51	-
[0/45/135/0/90]	Tension	98% RH/1000 Hrs	RTD	14.0	0.43	58	3,990
[0/45/135/0/90]	Tension	98% RH/1000 Hrs	260°F	13.5	0.43	55	4,020
[0/45/135/0/90]	Tension	98% RH/1000 Hrs	350°F	12.6	0.59	43	3,470
[0/45/135/0/90]	Tension	Thermo-Humidity Cycle	RTD	14.7	0.45	52	3,500
[0/45/135/0/90]	Tension	Thermo-Humidity Cycle	260°F	-	-	58	-
[0/45/135/0/90]	Tension	Thermo-Humidity Cycle	350°F	-	-	50	-
[0/45/135/0/90]	Tens	Acc. Wthrg.	RTD	15.6	0.46	55	3,590
[0/45/135/0/90]	Tension	Acc. Wthrg.	260°F	14.2	0.42	58	4,040
[0/45/135/0/90]	Tension	Acc. Wthrg.	350°F	14.1	0.40	51	4,100

(A) AIR-SEA-ICE TESTS SUMMARY -
 (B) AIR-SEA-ICE TESTS SUMMARY -
 (C) AIR-SEA-ICE TESTS SUMMARY -
 (D) AIR-SEA-ICE TESTS SUMMARY -

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	P (psi x 10 ⁶)	V (in ³ /in)	ult (ksi)	ult (ksi-in./in.)
0°	Compression	98% RH/500 Hrs	RTD	21.6	0.22	90	4,370
0°	Compression	98% RH/500 Hrs	260°F	-	-	108	-
0°	Compression	98% RH/500 Hrs	350°F	-	-	97	-
0°	Compression	98% RH/1000 Hrs	RTD	23.1	0.26	96	4,290
0°	Compression	98% RH/1000 Hrs	260°F	20.9	0.22	84	3,900
0°	Compression	98% RH/1000 Hrs	350°F	23.5	0.30	82	3,640
0°	Compression	Thermo-Humidity Cycle	RTD	24.3	0.38	100	4,800
0°	Compression	Thermo-Humidity Cycle	260°F	-	-	105	-
0°	Compression	Thermo-Humidity Cycle	350°F	-	-	108	-
0°	Compression	Acc. Withng.	RTD	22.6	0.45	91	3,670
0°	Compression	Acc. Withng.	260°F	21.0	0.26	78	3,510
0°	Compression	Acc. Withng.	350°F	23.2	0.24	65	3,070
90°	Compression	98% RH/500 Hrs	RTD	1.09	0.0	30.0	>30,000
90°	Compression	98% RH/500 Hrs	260°F	-	-	18.2	-
90°	Compression	98% RH/500 Hrs	350°F	-	-	12.1	-
90°	Compression	98% RH/1000 Hrs	RTD	1.23	0.01	27.3	>30,000
90°	Compression	98% RH/1000 Hrs	260°F	0.78	0.0	15.4	>30,000
90°	Compression	98% RH/1000 Hrs	350°F	0.45	0.0	9.1	>30,000
90°	Compression	Thermo-Humidity Cycle	RTD	1.19	0.00	25.7	20,600
90°	Compression	Thermo-Humidity Cycle	260°F	-	-	17.6	-
90°	Compression	Thermo-Humidity Cycle	350°F	-	-	12.3	-

Table 1. Mechanical Properties of
 100% Magnesium

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in/in)
90°	Compression	Acc. Wetting.	RTD	1.19	0.00	29.0	> 30,000
90°	Compression	Acc. Wetting.	260°F	0.59	0.00	15.9	> 30,000
90°	Compression	Acc. Wetting.	350°F	0.17	0.00	9.5	> 30,000
0/45/135/0/90] s	Compression	98% RH/500 Hrs	RTD	10.6	0.32	52	5,180
0/45/135/0/90] s	Compression	98% RH/500 Hrs	260	-	-	53	-
0/45/135/0/90] s	Compression	98% RH/500 Hrs	350	-	-	53	-
0/45/135/0/90] s	Compression	98% RH/1000 Hrs	RTD	6.3	0.11	55	6,010
0/45/135/0/90] s	Compression	98% RH/1000 Hrs	260	9.4	0.37	50	5,430
0/45/135/0/90] s	Compression	98% RH/1000 Hrs	350	10.5	0.54	49	4,420
0/45/135/0/90] s	Compression	Thermo-Humidity Cycle	RTD	11.5	-	53	3,810
0/45/135/0/90] s	Compression	Thermo-Humidity Cycle	260	-	-	51	-
0/45/135/0/90] s	Compression	Thermo-Humidity Cycle	350	-	-	53	-
0/45/135/0/90] s	Compression	Acc. Wetting.	RTD	9.5	0.46	54	5,170
0/45/135/0/90] s	Compression	Acc. Wetting.	260	10.1	0.44	555	5,050
0/45/135/0/90] s	Compression	Acc. Wetting.	350	8.2	0.27	50	5,700
0°	In Plane Shr	98% RH/500 Hrs	RTD	0.84	-	11.7	> 30,000
0°	In Plane Shr	98% RH/500 Hrs	260	-	-	5.5	-
0°	In Plane Shr	98% RH/500 Hrs	350	0.90	-	-	> 30,000
0°	In Plane Shr	98% RH/1000 Hrs	RTD	0.90	-	11.1	> 30,000
0°	In Plane Shr	98% RH/1000 Hrs	260	0.71	-	8.0	> 30,000
0°	In Plane Shr	98% RH/1000 Hrs	350	0.10	-	5.3	> 30,000

TABLE 1. STATIC ELECTRICAL STRESS
ON THE ROOM CONDUCTORS
IN THE ROOM CONDUCTORS

Orientation	Type Load	Prior Conditioning	Temp. (F)	V (in/in)	σ_{ult} (ksi)	σ_{ult} (in/in)
2°	In Plane Shr	Thermo-Humidity Cycle	RTD	0.12	10.4	> 30,000
3°	In Plane Shr	Thermo-Humidity Cycle	260	-	5.4	-
3°	In Plane Shr	Thermo-Humidity Cycle	350	-	5.3	-
3°	In Plane Shr	Acc. Withrg.	RTD	0.88	11.3	29,000
3°	In Plane Shr	Acc. Withrg.	260	0.79	6.1	> 30,000
3°	In Plane Shr	Acc. Withrg.	350	0.12	5.2	> 30,000
3°	Interl ar Shr	98% RH/500 Hrs	RTD	-	12.5	-
3°	Interl ar Shr	98% RH/500 Hrs	260	-	10.2	-
3°	Interl ar Shr	98% RH/500 Hrs	350	-	7.3	-
3°	Interl ar Shr	98% RH/1000 Hrs	RTD	-	9.6	-
3°	Interl ar Shr	98% RH/1000 Hrs	260	-	7.4	-
3°	Interl ar Shr	98% RH/1000 Hrs	350	-	5.4	-
3°	Interl ar Shr	Thermo-Humidity Cycle	RTD	-	10.4	-
3°	Interl ar Shr	Thermo-Humidity Cycle	260	-	7.2	-
3°	Interl ar Shr	Thermo-Humidity Cycle	350	-	4.9	-
3°	Interl ar Shr	Acc. Withrg.	RTD	-	11.1	-
3°	Interl ar Shr	Acc. Withrg.	260	-	9.6	-
3°	Interl ar Shr	Acc. Withrg.	350	-	7.1	-

TABLE XVII - STATIC PROPERTIES - POLYMER
SPECIMENS 3002 M/GMRT-12
ON GRAPHITE COMPOSITION

Orientation	Test Load	Prime Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	Δ (in/in)	Stress (ksi)	Elongation (in/in)
0°	Tension	260°F/100 Hrs	RTD	-	-	140	-
0°	Tension	260°F/100 Hrs	260	-	-	135	-
0°	Tension	260°F/500 Hrs	RTD	28.8	0.27	97	3,310
0°	Tension	260°F/500 Hrs	260	28.9	0.30	129	4,460
0°	Tension	350°F/100 Hrs	RTD	-	-	111	-
0°	Tension	350°F/100 Hrs	260	-	-	130	-
0°	Tension	350°F/100 Hrs	350	-	-	128	-
0°	Tension	350°F/500 Hrs	RTD	27.1	0.25	107	1,860
0°	Tension	350°F/500 Hrs	350	30.7	0.36	124	1,900
90°	Tension	260°F/100 Hrs	RTD	-	-	7.0	-
90°	Tension	260°F/100 Hrs	260	-	-	1.8	-
90°	Tension	260°F/500 Hrs	RTD	1.00	0.01	2.2	2,180
90°	Tension	260°F/500 Hrs	260	-	-	-	-
90°	Tension	350°F/100 Hrs	RTD	**	-	1.3	-
90°	Tension	350°F/100 Hrs	260	-	-	2.0	-
90°	Tension	350°F/100 Hrs	350	-	-	1.3	-

** Specimens Broke During Conditioning Cycle

TABLE VIII
TENSILE PROPERTIES OF POLY-
BIPHENYLENE VINYLENE
FILMS

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	ϵ (cm^2/mol)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in/in)
90°	Tension	350°F/500 Hrs	RTD	0.56	0.0	0.7	1.190
90°	Tension	350°F/500 Hrs	350	0.87	0.0	0.7	1.040
[0/45/135/0/90]s	Tension	260°F/100 Hrs	RTD	-	-	45	-
[0/45/135/0/90]s	Tension	260°F/100 Hrs	260	-	-	60	-
[0/45/135/0/90]s	Tension	260°F/500 Hrs	RTD	13.9	0.39	47	3.280
[0/45/135/0/90]s	Tension	260°F/500 Hrs	260	15.6	0.40	65	1.960
[0/45/135/0/90]s	Tension	350°F/100 Hrs	RTD	-	-	43	-
[0/45/135/0/90]s	Tension	350°F/100 Hrs	260	-	-	63	-
[0/45/135/0/90]s	Tension	350°F/100 Hrs	350	-	-	68	-
[0/45/135/0/90]s	Tension	350°F/500 Hrs	RTD	14.4	0.43	51	3.430
[0/45/135/0/90]s	Tension	350°F/500 Hrs	350	15.5	0.44	53	3.390
0°	Compression	260°F/100 Hrs	RTD	-	-	97	-
0°	Compression	260°F/100 Hrs	260	-	-	103	-
0°	Compression	260°F/500 Hrs	RTD	21.6	0.24	94	5.190
0°	Compression	260°F/500 Hrs	260	17.5	0.31	81	4.620
0°	Compression	350°F/100 Hrs	RTD	20.5	0.29	87	4.010
0°	Compression	350°F/100 Hrs	350	-	-	102	-
0°	Compression	350°F/500 Hrs	RTD	22.8	0.20	95	4.110
0°	Compression	350°F/500 Hrs	350	23.0	0.30	90	4.500

TABLE XVIII
HEAVY DUTY
100 GRIP

Relocation	Type Load	Prior Conditioning	Test Temp. (°F)	F (in./in.)	N (in./in.)	Yield (ksi)	Yield (in./in.)
90°	Compression	260°F/100 Hrs	RTD	-	-	34.3	-
90°	Compression	260°F/100 Hrs	260	-	-	29.6	-
90°	Compression	260°F/500 Hrs	RTD	1.10	0.00	30.7	> 30,000
90°	Compression	260°F/500 Hrs	260	1.17	0.00	30.9	> 30,000
90°	Compression	350°F/100 Hrs	RTD	-	-	34.6	-
90°	Compression	350°F/100 Hrs	350	-	-	21.5	-
90°	Compression	350°F/500 Hrs	RTD	0.32	0.00	27.6	> 40,000
90°	Compression	350°F/500 Hrs	350	0.34	0.01	22.6	28,000
[0°/45°/135°/0°/90°] _s	Compression	260°F/100 Hrs	RTD	-	-	57	-
[0°/45°/135°/0°/90°] _s	Compression	260°F/100 Hrs	260	-	-	60	-
[0°/45°/135°/0°/90°] _s	Compression	260°F/500 Hrs	RTD	8.31	0.34	54	6,580
[0°/45°/135°/0°/90°] _s	Compression	260°F/500 Hrs	260	8.45	0.28	50	5,350
[0°/45°/135°/0°/90°] _s	Compression	350°F/100 Hrs	RTD	-	-	60	-
[0°/45°/135°/0°/90°] _s	Compression	350°F/100 Hrs	350	-	-	55	-
[0°/45°/135°/0°/90°] _s	Compression	350°F/500 Hrs	RTD	10.50	0.33	64	7,470
[0°/45°/135°/0°/90°] _s	Compression	350°F/500 Hrs	350	10.02	0.32	52	6,470

TABLE XVII

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	γ (in./in.)	σ_{ult} (ksi)	ϵ_{ult} (in.-in./in.)
0°	In Plane Shr	260°F/100 Hrs	RTD	-	-	9.6	-
0°	In Plane Shr	260°F/100 Hrs	260	-	-	8.7	-
0°	In Plane Shr	260°F/500 Hrs	RTD	0.74	-	10.0	17,100
0°	In Plane Shr	260°F/500 Hrs	260	0.69	-	9.4	>30,000
0°	In Plane Shr	350°F/100 Hrs	RTD	-	-	10.6	-
0°	In Plane Shr	350°F/100 Hrs	260	-	-	8.0	-
0°	In Plane Shr	350°F/500 Hrs	RTD	0.78	-	9.9	19,300
0°	In Plane Shr	350°F/500 Hrs	350	0.46	-	6.7	>30,000
0°	Int Shear	260°F/100 Hrs	RTD	-	-	13.5	-
0°	Int Shear	260°F/100 Hrs	260	-	-	9.5	-
0°	Int Shear	260°F/500 Hrs	RTD	-	-	13.4	-
0°	Int Shear	260°F/500 Hrs	260	-	-	9.9	-
0°	Int Shear	350°F/100 Hrs	RTD	-	-	14.1	-
0°	Int Shear	350°F/100 Hrs	260	-	-	10.0	-
0°	Int Shear	350°F/500 Hrs	RTD	-	-	13.6	-
0°	Int Shear	350°F/500 Hrs	350	-	-	5.2	-

Orientation	Type and	Temp. Conditioning	Time	Weight (g)	Weight (g)
0°	Tension	260°F/500 cycles	RTD	-	110
0°	Tension	260°F/500 cycles	260	-	124
0°	Tension	260°F/1000 cycles	RTD	0.35	113
0°	Tension	260°F/1000 cycles	260	0.29	116
0°	Tension	350°F/500 cycles	RTD	-	104
0°	Tension	350°F/500 cycles	260	-	118
0°	Tension	350°F/500 cycles	350	-	124
0°	Tension	350°F/1000 cycles	RTD	0.31	116
0°	Tension	350°F/1000 cycles	350	0.28	129
90°	Tension	260°F/500 cycles	RTD	-	1.6
90°	Tension	260°F/500 cycles	260	-	1.6
90°	Tension	260°F/1000 cycles	RTD	0.00	2.7
90°	Tension	260°F/1000 cycles	260	0.00	1.7
90°	Tension	350°F/500 cycles	RTD	-	2.3
90°	Tension	350°F/500 cycles	260	-	1.6
90°	Tension	350°F/500 cycles	350	-	1.2
90°	Tension	350°F/1000 cycles	RTD	**	-
90°	Tension	350°F/1000 cycles	350	0.03	0.9

** Broken During Conditioning

400/100
KIRKLAND

Orientation	Type Load	Conditioning	Test Temp. (°F)	P (psi $\times 10^6$)	ν (in/in)	E_{int} (ksi)	E_{ext} (in./in.)
[0/45/135/0/90] _s	Tension	260 °F/500 cycles	RTD	-	-	47	-
[0/45/135/0/90] _s	Tension	260 °F/500 cycles	260	-	-	60	-
[0/45/135/0/90] _s	Tension	260 °F/1000 cycles	RTD	13.7	0.43	52	3,530
[0/45/135/0/90] _s	Tension	260 °F/1000 cycles	260	15.1	0.49	59	3,880
[0/45/135/0/90] _s	Tension	350 °F/500 cycles	RTD	-	-	44	-
[0/45/135/0/90] _s	Tension	350 °F/500 cycles	260	-	-	56	-
[0/45/135/0/90] _s	Tension	350 °F/500 cycles	350	-	-	60	-
[0/45/135/0/90] _s	Tension	350 °F/1000 cycles	RTD	15.0	0.36	41	2,780
[0/45/135/0/90] _s	Tension	350 °F/1000 cycles	350	15.3	0.49	58	3,760
0°	Compression	260 °F/500 cycles	RTD	-	-	108	-
0°	Compression	260 °F/500 cycles	260	-	-	109	-
0°	Compression	260 °F/1000 cycles	RTD	19.2	0.28	96	4,960
0°	Compression	260 °F/1000 cycles	260	24.0	0.23	102	4,560
0°	Compression	350 °F/500 cycles	RTD	-	-	107	-
0°	Compression	350 °F/500 cycles	350	-	-	100	-
0°	Compression	350 °F/1000 cycles	RTD	20.8	0.19	108	5,270
0°	Compression	350 °F/1000 cycles	350	20.6	0.23	99	4,900

Orientation	Type Load	Cond. Cycling	Life (hr)	Ult. WSD	Cost (\$)
90°	Compression	260°F/500 cycles	-	30.8	-
90°	Compression	260°F/100 cycles	-	28.6	-
90°	Compression	260°F/1000 cycles	1.5	32.8	> \$1,000
90°	Compression	260°F/1000 cycles	1.0	29.8	> \$1,000
90°	Compression	350°F/500 cycles	-	29.5	-
90°	Compression	350°F/500 cycles	-	22.7	-
90°	Compression	350°F/1000 cycles	1.5	32.4	> \$1,000
90°	Compression	350°F/1000 cycles	1.0	22.6	> \$1,000
[0/45/135/0/90]s	Compression	260°F/500 cycles	-	59	-
[0/45/135/0/90]s	Compression	260°F/100 cycles	-	58	-
[0/45/135/0/90]s	Compression	260°F/1000 cycles	10.0	62	0.100
[0/45/135/0/90]s	Compression	260°F/1000 cycles	10.0	59	0.260
[0/45/135/0/90]s	Compression	350°F/500 cycles	-	59	-
[0/45/135/0/90]s	Compression	350°F/500 cycles	-	55	-
[0/45/135/0/90]s	Compression	350°F/1000 cycles	9.5	59	0.410
[0/45/135/0/90]s	Compression	350°F/1000 cycles	9.8	54	0.560

TABLE XVIII STATIC PROPERTIES -
HERCULES 5002M/COURTESY
DES GRAPHITIS SOCIÉTÉS

Orientation	Type Load	Test Temp. (°F)	ϵ (in/in)	γ (in/in)	σ_{ult} (ksi)	ϵ_{ult} ($\epsilon_{ult} - \epsilon_{in}$)/ ϵ_{in}
0°	In Plane Shr	RTD	-	-	10.8	-
0°	In Plane Shr	260	-	-	7.0	-
0°	In Plane Shr	RTD	0.79	-	10.7	23,500
0°	In Plane Shr	260	0.65	-	7.4	25,000
0°	In Plane Shr	RTD	-	-	9.4	-
0°	In Plane Shr	260	-	-	-	-
0°	In Plane Shr	RTD	0.76	-	8.6	17,100
0°	In Plane Shr	350	0.46	-	6.0	>30,000
0°	Int Shear	RTD	-	-	12.7	-
0°	Int Shear	260	-	-	9.5	-
0°	Int Shear	RTD	-	-	14.2	-
0°	Int Shear	260	-	-	11.6	-
0°	Int Shear	RTD	-	-	12.9	-
0°	Int Shear	260	-	-	10.7	-
0°	Int Shear	RTD	-	-	13.0	-
0°	Int Shear	350	-	-	6.4	-

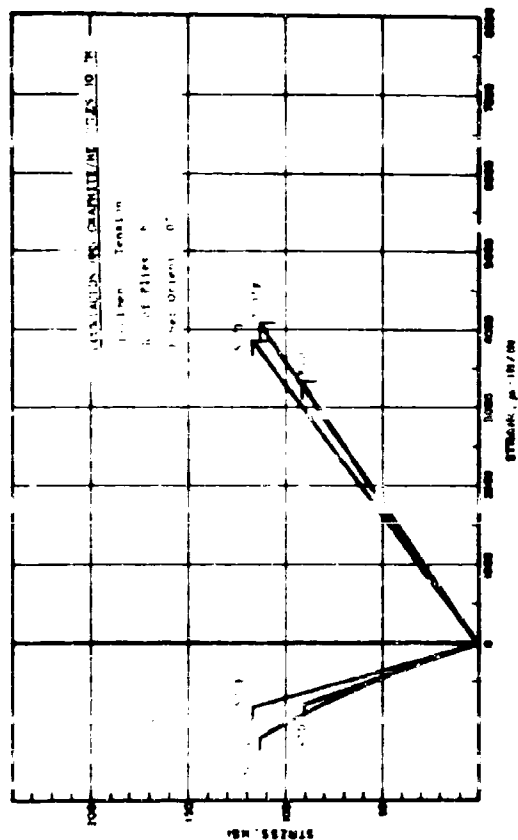


FIG. 403 STRESS-STRAIN DIAGRAM FOR 100% COMPOSITE OF GRAPHITE/RESIN AT VARIOUS TEMPERATURES

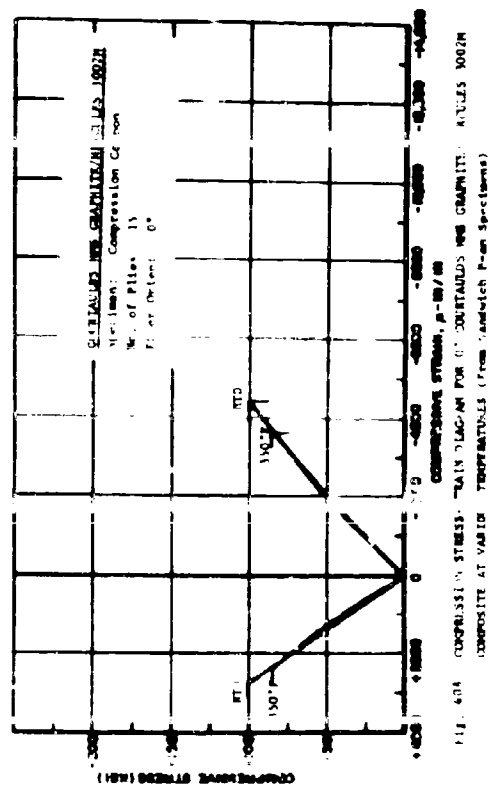


FIG. 404 COMPRESSION STRESS-STRAIN DIAGRAM FOR 100% COMPOSITE OF GRAPHITE/RESIN AT VARIOUS TEMPERATURES (From Sandwich Panel Specimens)

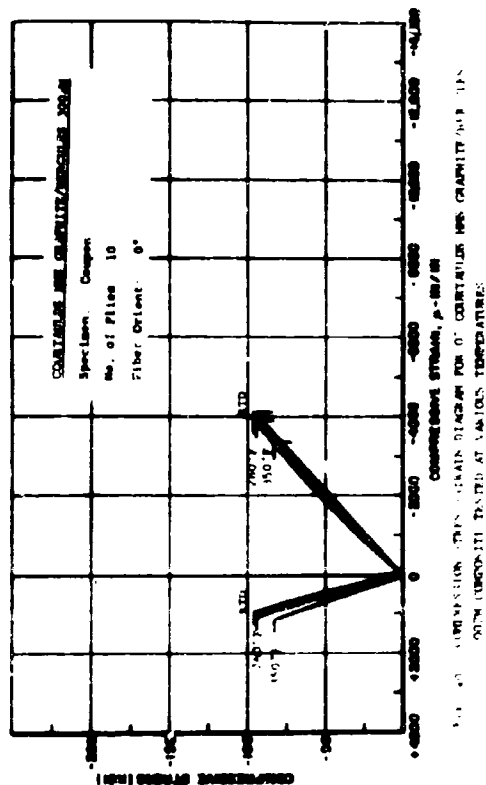


FIG. 405 STRESS-STRAIN DIAGRAM FOR 100% COMPOSITE OF GRAPHITE/RESIN AT VARIOUS TEMPERATURES

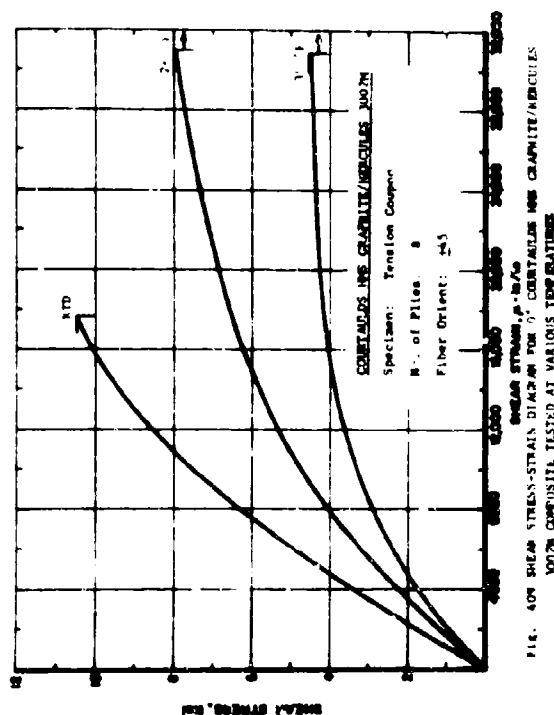


FIG. 406 SHEAR STRESS-STRAIN DIAGRAM FOR 100% COMPOSITE OF GRAPHITE/RESIN AT VARIOUS TEMPERATURES

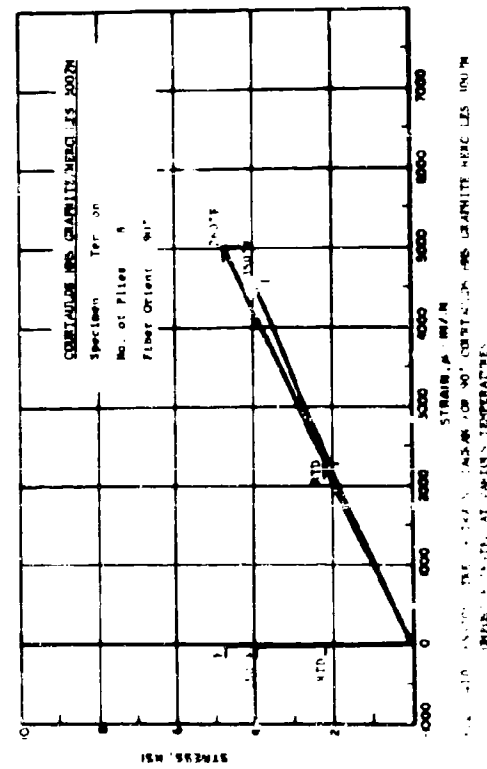


FIG. 416 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° COMPOSITE OF 90° GRAPHTITE/HERCULES 100% AT VARIOUS TEMPERATURES

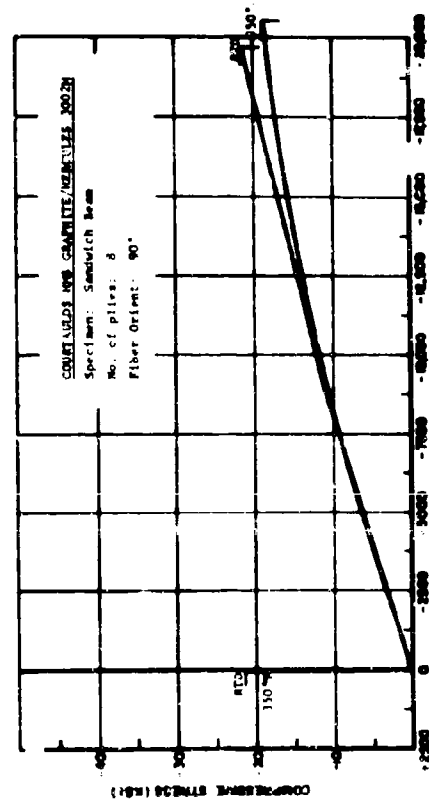


FIG. 417 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° COMPOSITE OF 90° GRAPHTITE/HERCULES 100% AT VARIOUS TEMPERATURES (From Sandwich Beam Specimens)

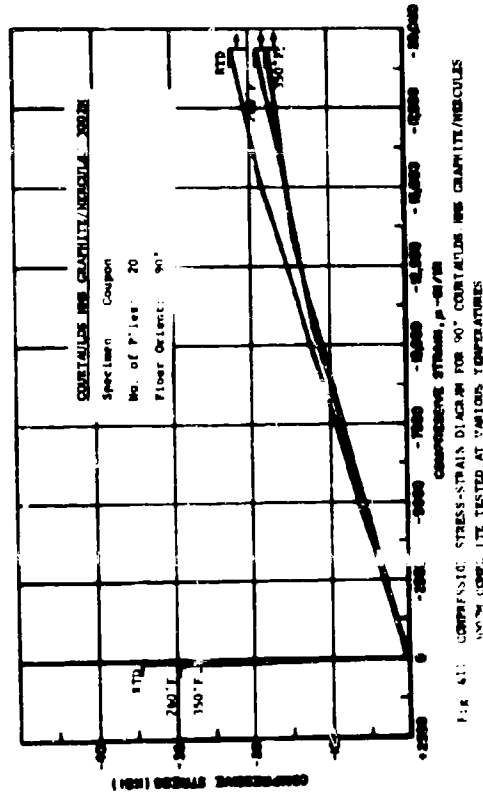


FIG. 418 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° COMPOSITE OF 90° GRAPHTITE/HERCULES 100% AT VARIOUS TEMPERATURES

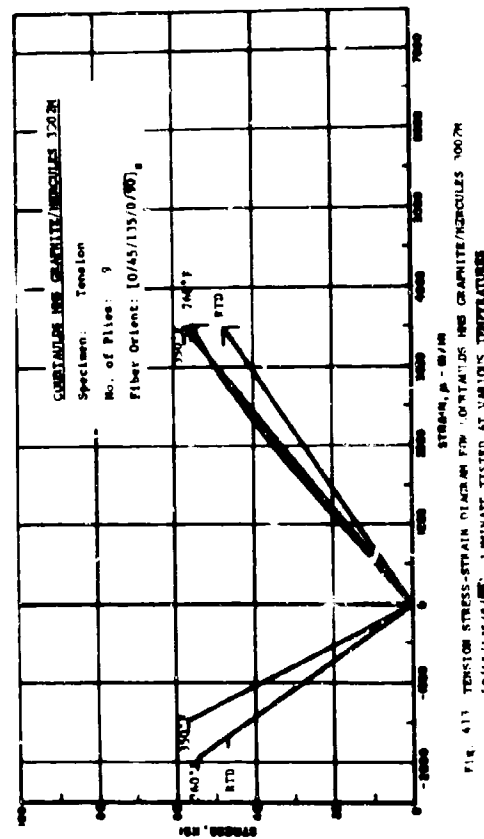


FIG. 419 TENSION STRESS-STRAIN DIAGRAM FOR 90° COMPOSITE OF 90° GRAPHTITE/HERCULES 100% AT VARIOUS TEMPERATURES

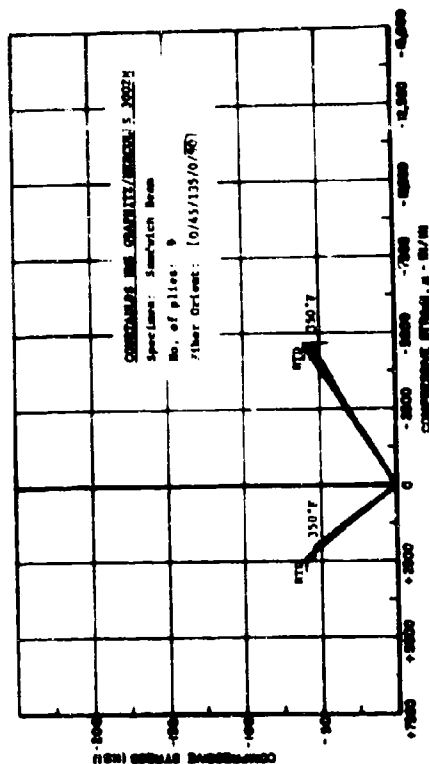


Fig. 415 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3007M LAMINATE AT VARIOUS TEMPERATURES (From Sandwich Beam Specimen)

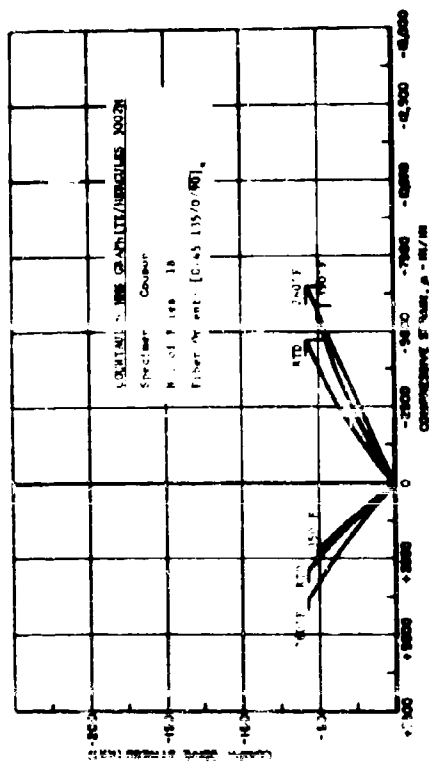


Fig. 414 TENSION STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3007M LAMINATE TESTED AT VARIOUS TEMPERATURES

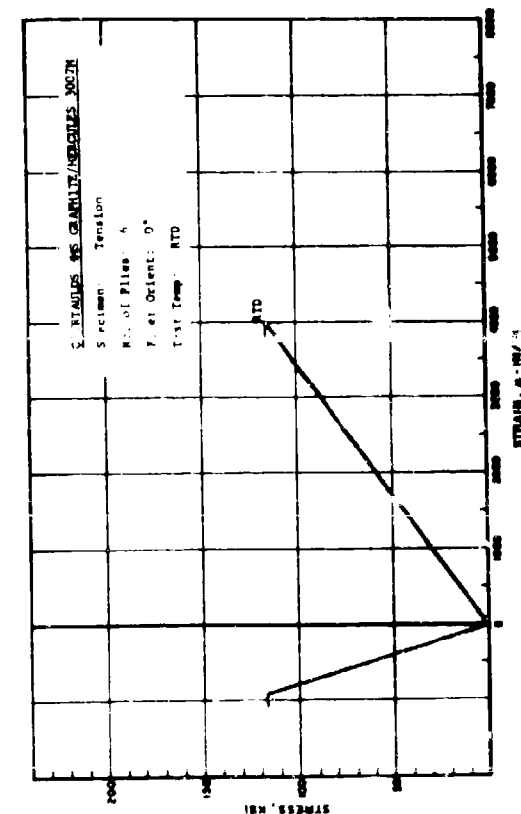


Fig. 416 TENSION STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3007M COMPOSITE TESTED AT ROOM TEMPERATURE AFTER 50 HOURS EXPOSURE TO 90% R.H.

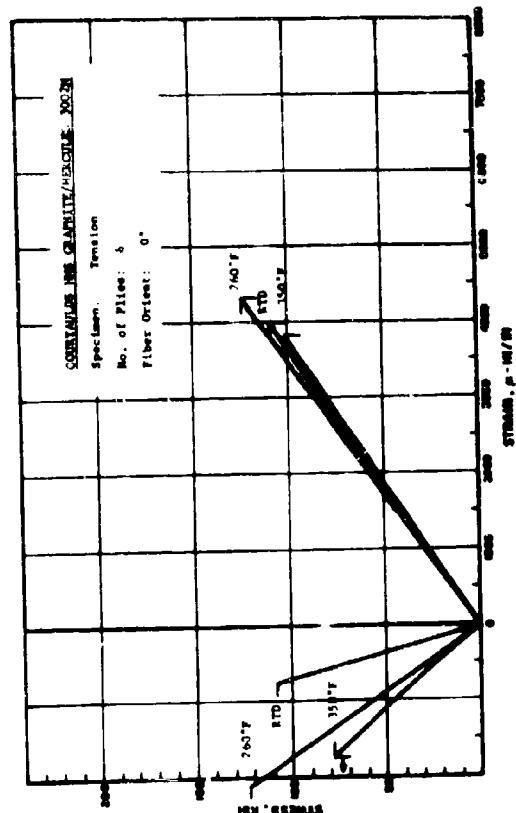
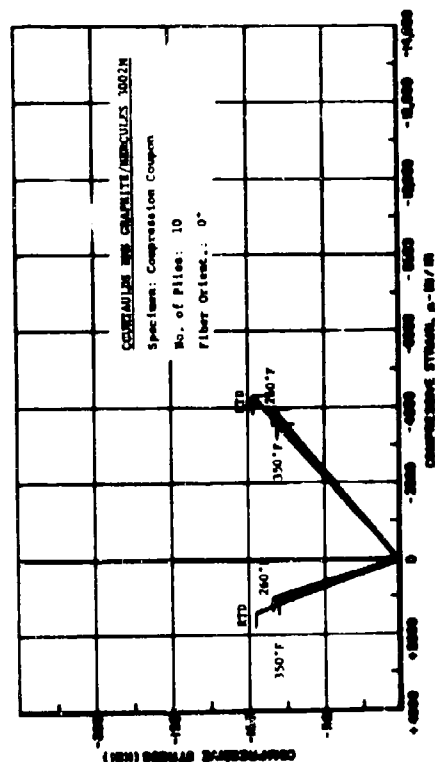
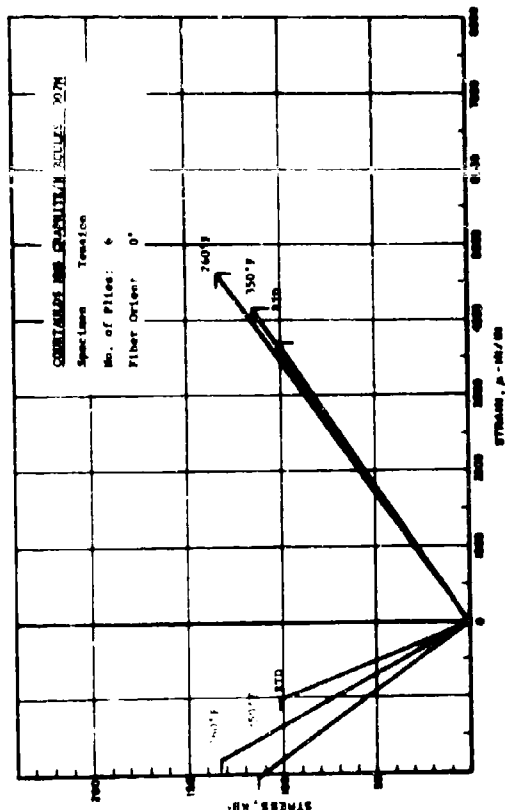
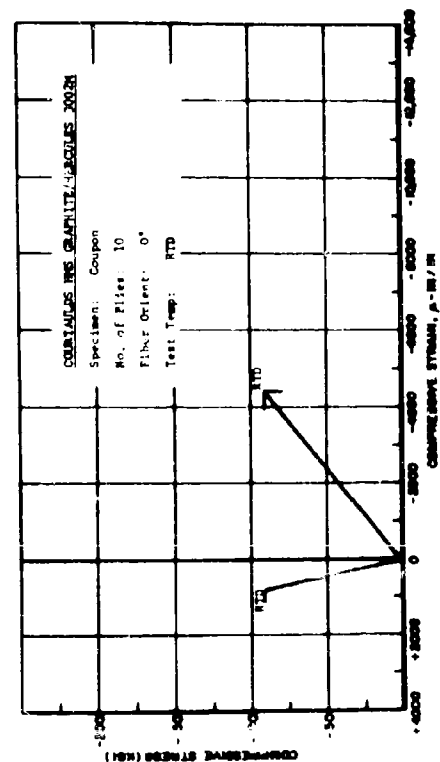
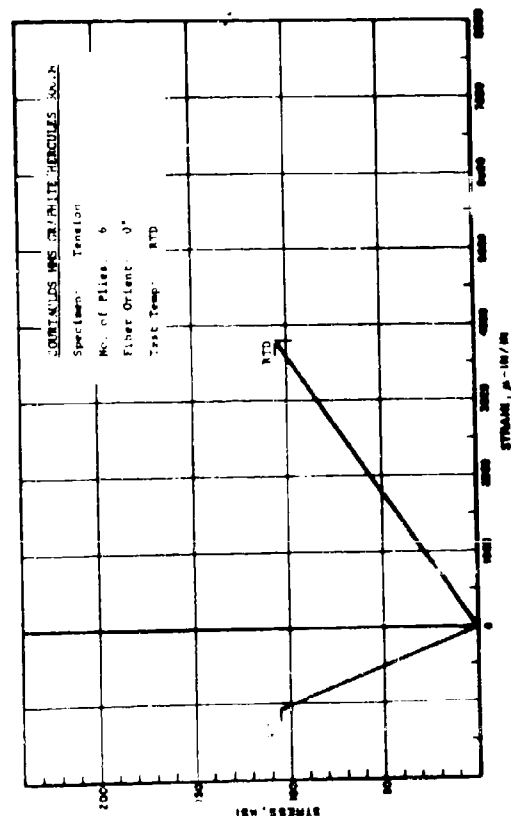


Fig. 417 TENSION STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3007M COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.



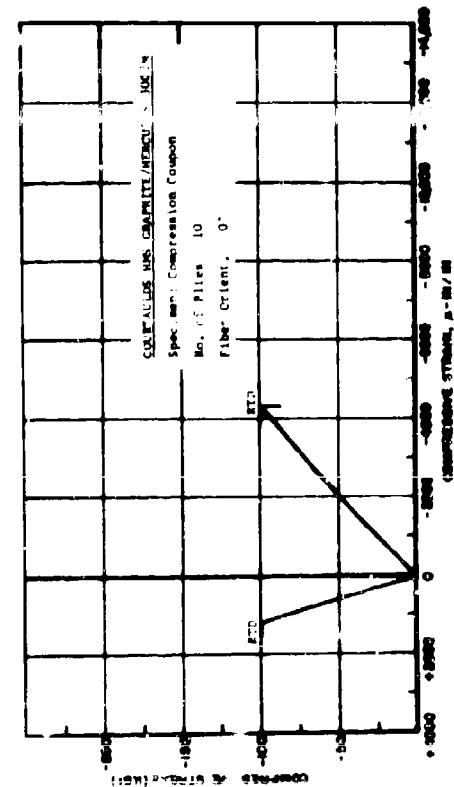


FIG. 422 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° CARBON/GRAPHITE/MERCURY COMPOSITE, TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY

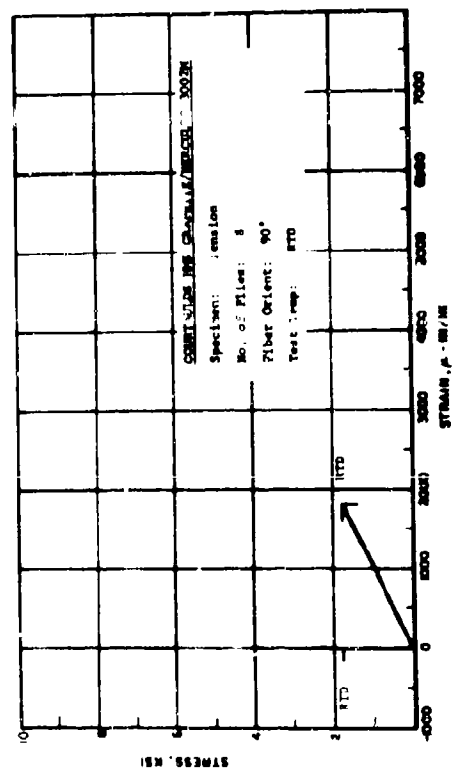


FIG. 424 TENSION STRESS-STRAIN DIAGRAM FOR 90° CARBON/GRAPHITE/MERCURY COMPOSITE TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 90% R.H.

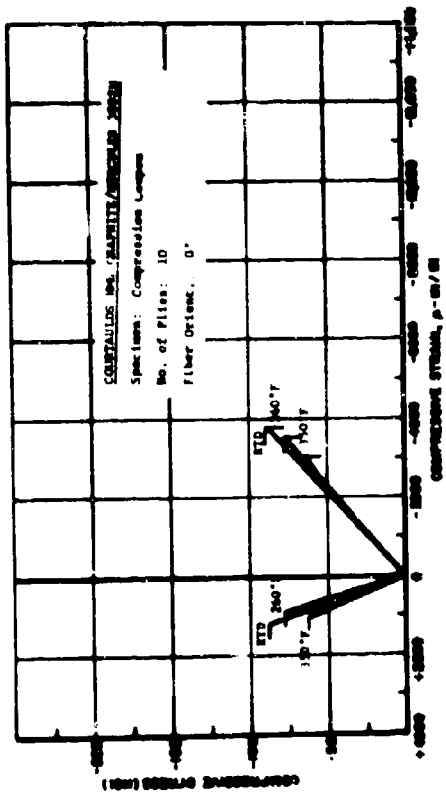


FIG. 423 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° CARBON/GRAPHITE/MERCURY COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY

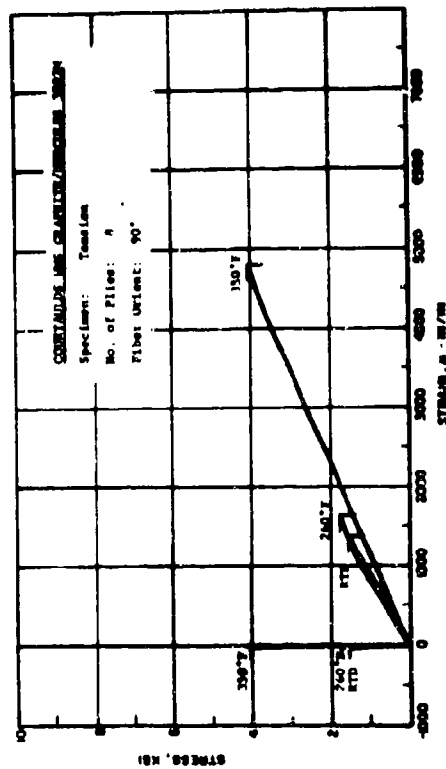


FIG. 425 TENSION STRESS-STRAIN DIAGRAM FOR 90° CARBON/GRAPHITE/MERCURY COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

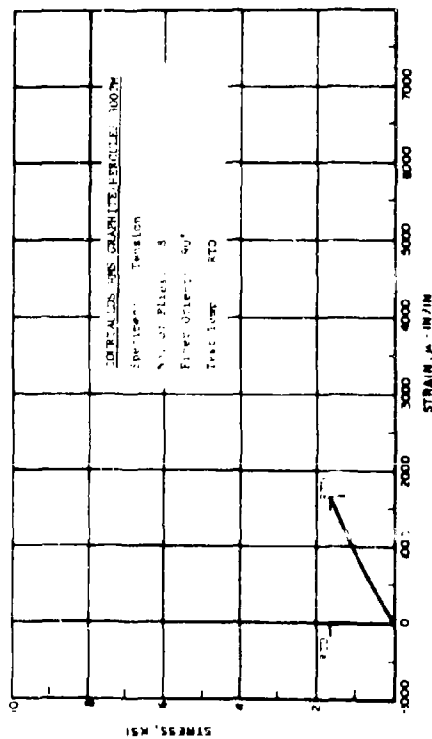


Fig. 42b: Tension stress-strain diagram for 90° carbon/graphite fibers at room temperature after 500 humidity cycles. The graph shows stress (ksi) vs. strain (in/in) for three specimens. Specimen 1 (RTD) shows a linear increase in stress up to approximately 1.5 ksi at 0.001 in/in strain. Specimens 2 and 3 show a similar linear increase up to approximately 1.5 ksi at 0.001 in/in strain. The y-axis is labeled 'STRESS, KSI' and ranges from 0 to 2. The x-axis is labeled 'STRAIN, IN/IN' and ranges from 0 to 0.001.

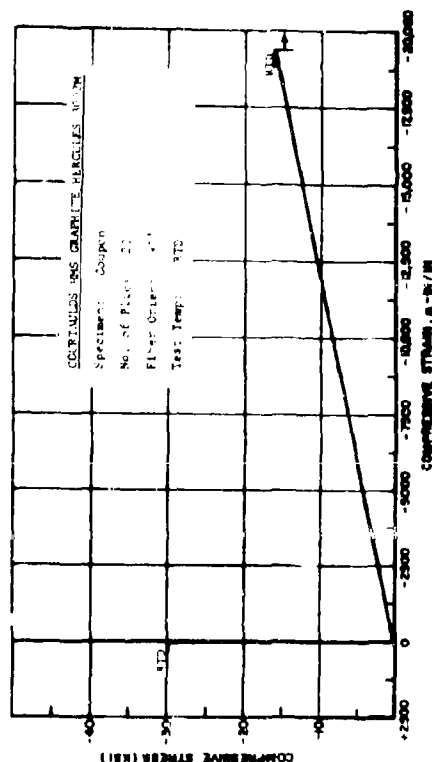


Fig. 42c: Compression stress-strain diagram for 90° carbon/graphite fibers at room temperature after 500 humidity cycles. The graph shows compressive stress (ksi) vs. compressive strain (in/in) for three specimens. Specimen 1 (RTD) shows a linear increase in compressive stress up to approximately 1.5 ksi at 0.001 in/in strain. Specimens 2 and 3 show a similar linear increase up to approximately 1.5 ksi at 0.001 in/in strain. The y-axis is labeled 'COMPRESSIVE STRESS, KSI' and ranges from 0 to 2. The x-axis is labeled 'COMPRESSIVE STRAIN, IN/IN' and ranges from 0 to 0.001.

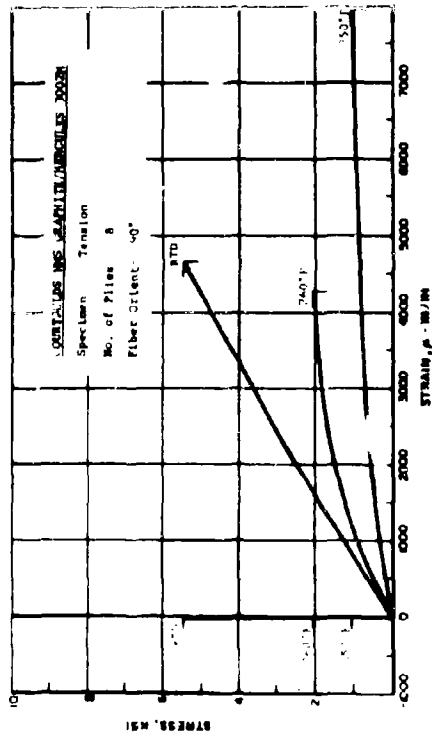


Fig. 42d: Tension stress-strain diagram for 90° carbon/graphite fibers at room temperature after 1000 humidity cycles. The graph shows stress (ksi) vs. strain (in/in) for three specimens. Specimen 1 (RTD) shows a linear increase in stress up to approximately 1.5 ksi at 0.001 in/in strain. Specimens 2 and 3 show a similar linear increase up to approximately 1.5 ksi at 0.001 in/in strain. The y-axis is labeled 'STRESS, KSI' and ranges from 0 to 2. The x-axis is labeled 'STRAIN, IN/IN' and ranges from 0 to 0.001.

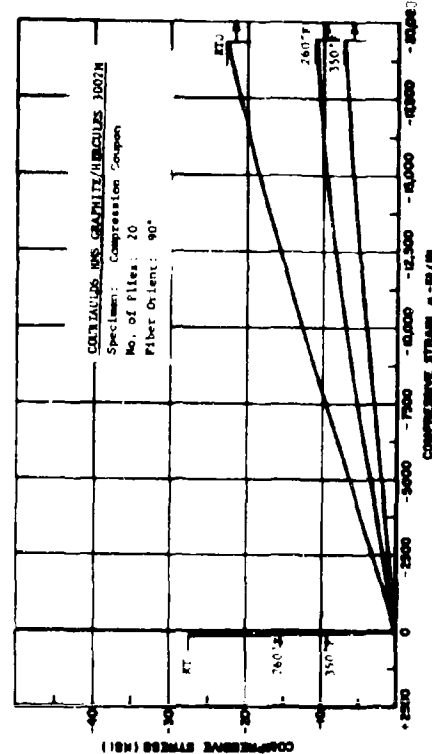


Fig. 42e: Compression stress-strain diagram for 90° carbon/graphite fibers at room temperature after 1000 humidity cycles. The graph shows compressive stress (ksi) vs. compressive strain (in/in) for three specimens. Specimen 1 (RTD) shows a linear increase in compressive stress up to approximately 1.5 ksi at 0.001 in/in strain. Specimens 2 and 3 show a similar linear increase up to approximately 1.5 ksi at 0.001 in/in strain. The y-axis is labeled 'COMPRESSIVE STRESS, KSI' and ranges from 0 to 2. The x-axis is labeled 'COMPRESSIVE STRAIN, IN/IN' and ranges from 0 to 0.001.

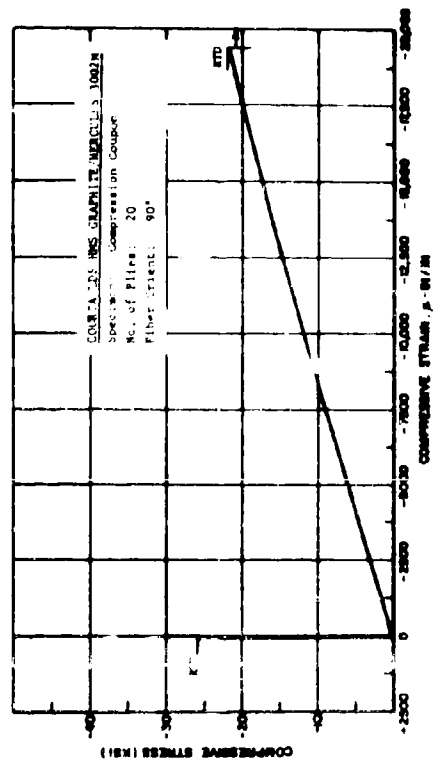


FIG. 1 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° ORIENTED HMS GRAPHITE FIBERS
100% COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY
100% (RTD) Accelerated Weathering

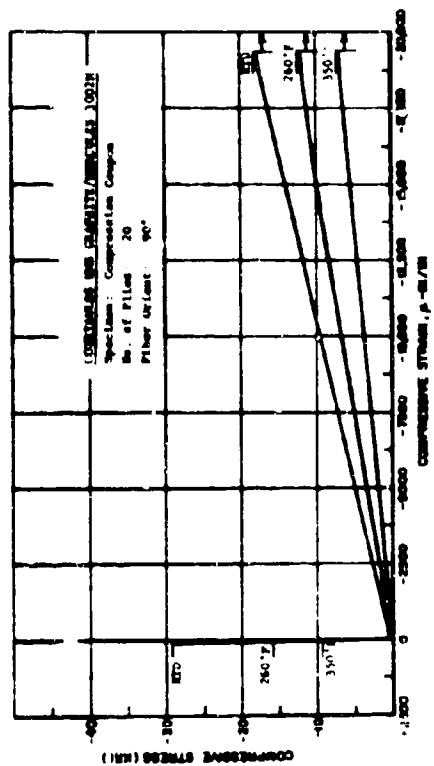


FIG. 2 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° ORIENTED HMS GRAPHITE FIBERS
100% COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY
100% (RTD) Accelerated Weathering

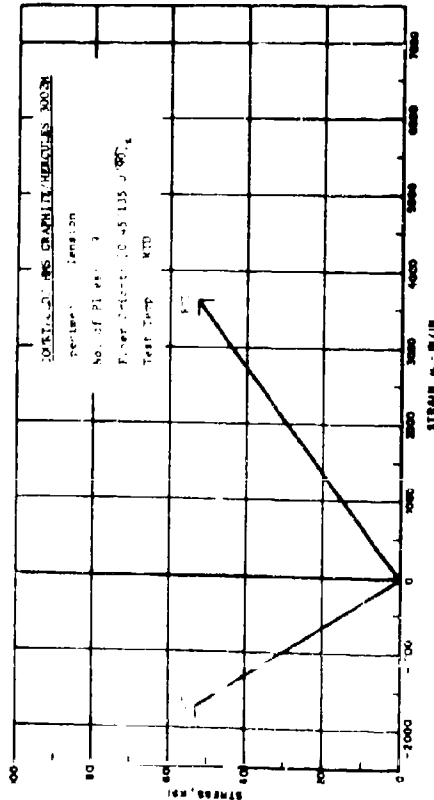


FIG. 3 TENSION STRESS-STRAIN DIAGRAM FOR 0° ORIENTED HMS GRAPHITE FIBERS
100% COMPOSITE TESTED AT ROOM TEMPERATURE AFTER 100 HOURS EXPOSURE
100% (RTD)

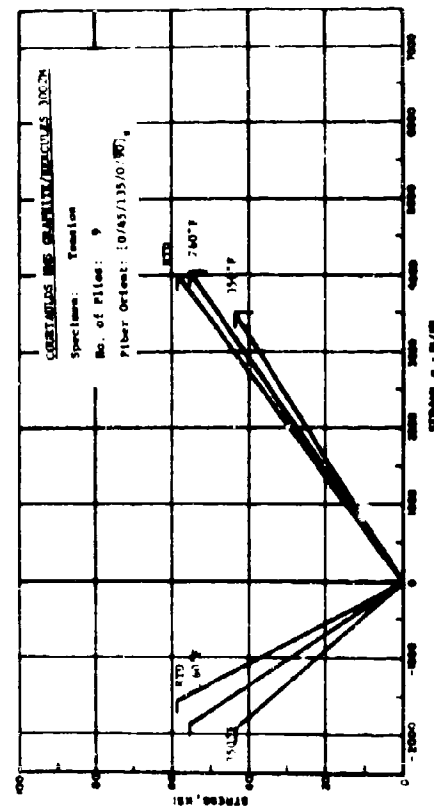


FIG. 4 TENSION STRESS-STRAIN DIAGRAM FOR 0° ORIENTED HMS GRAPHITE FIBERS
100% COMPOSITE TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO HUMIDITY

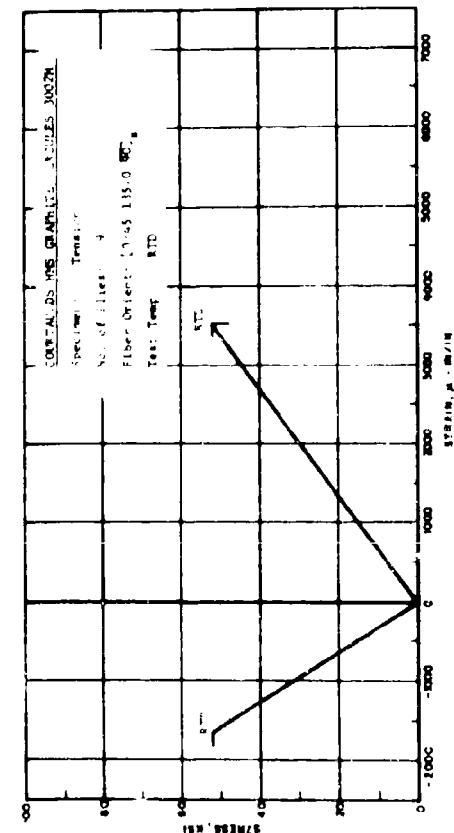


FIG. 4.5 TENSION STRESS-STRAIN DIAGRAM FOR CONTAINERS INS. GRAPHITE/HERCULES 1002N
0.45/135/0 90° LAMINATE TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO
100% HUMIDITY FOR 100 HOURS

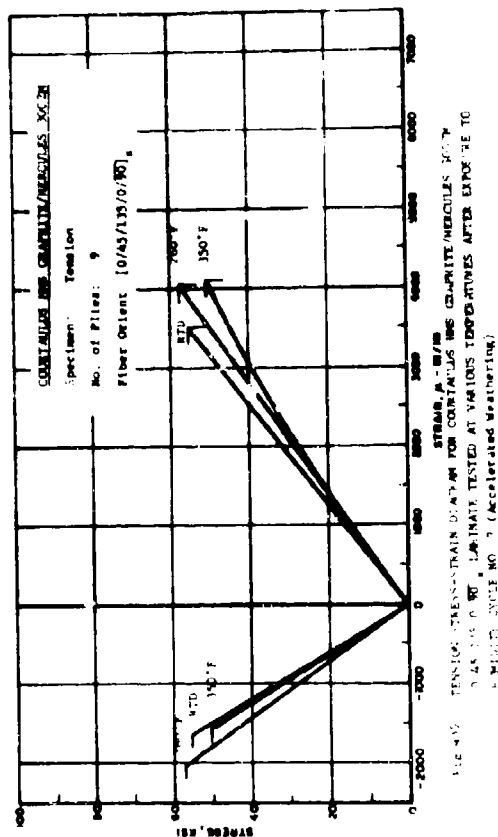


FIG. 4.6 TENSION STRESS-STRAIN DIAGRAM FOR CONTAINERS INS. GRAPHITE/HERCULES 1002N
0.45/135/0 90° LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO
100% HUMIDITY FOR 100 HOURS

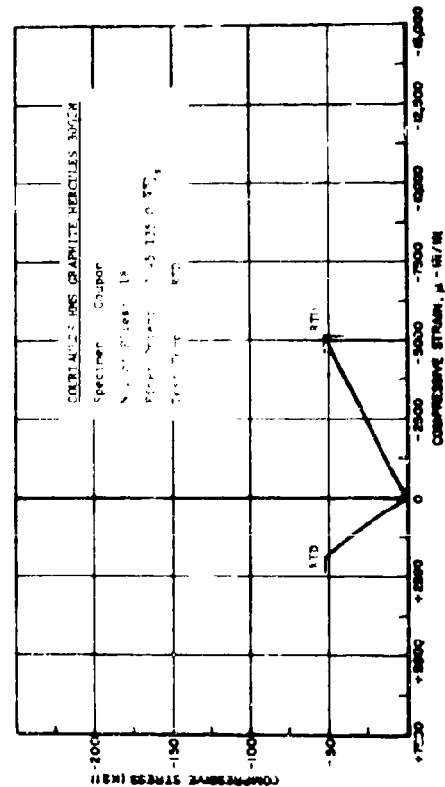


FIG. 4.7 COMPRESSION STRESS-STRAIN DIAGRAM FOR CONTAINERS INS. GRAPHITE/HERCULES
1002N 0/45/135/0 90° LAMINATE TESTED AT ROOM TEMPERATURE AFTER 500
HOURS EXPOSURE TO 90% R.H.

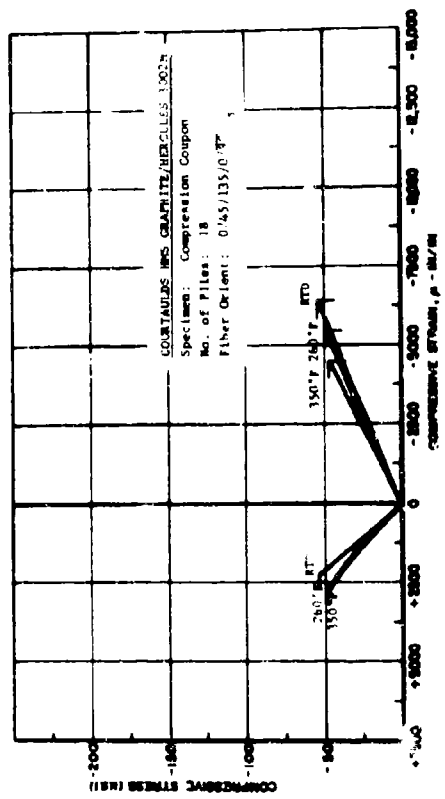


FIG. 4.8 COMPRESSION STRESS-STRAIN DIAGRAM FOR CONTAINERS INS. GRAPHITE/HERCULES 1002N
0.45/135/0 90° LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS
EXPOSURE TO 90% R.H.

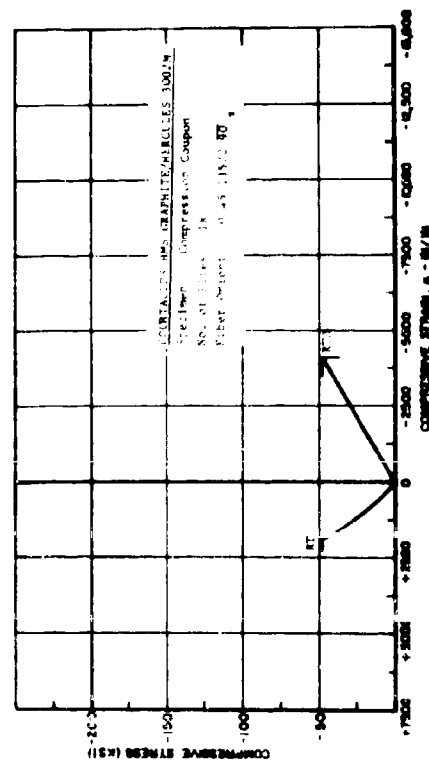


FIG. 43: STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3002N LAMINATE TESTED AT ROOM TEMPERATURE AFTER EXPOSURE TO HUMIDITY (90% R.H.). (Thermohumidity Cycle)

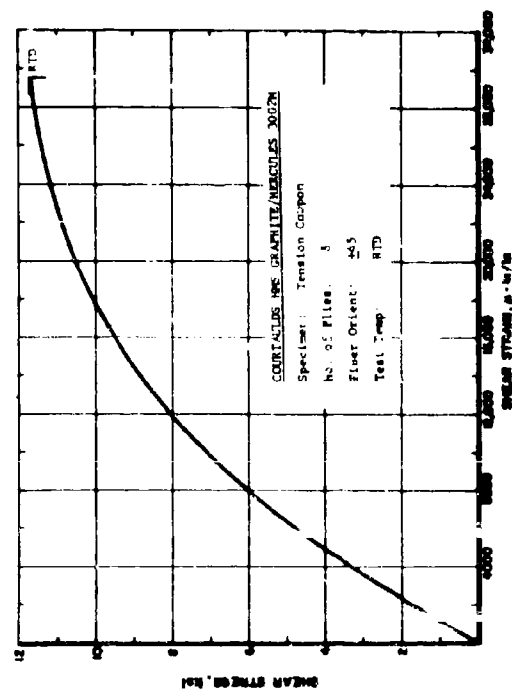


FIG. 44: SHEAR STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3002N LAMINATE TESTED AT ROOM TEMPERATURE AFTER 500 HOURS EXPOSURE TO 90% R.H.

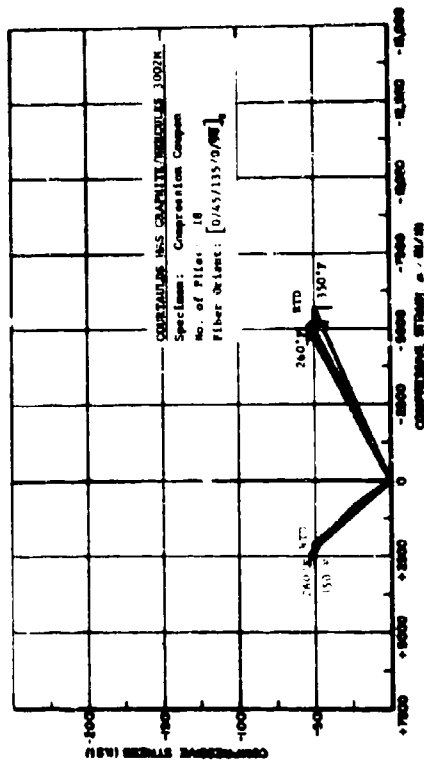


FIG. 45: COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3002N LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY (90% R.H.). (Accelerated Weathering)

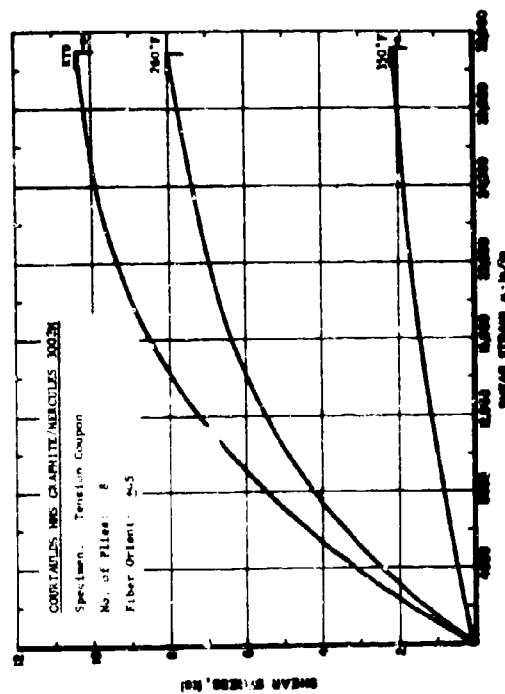


FIG. 46: SHEAR STRESS-STRAIN DIAGRAM FOR 0° COURTAULD HMS GRAPHITE/HERCULES 3002N LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.

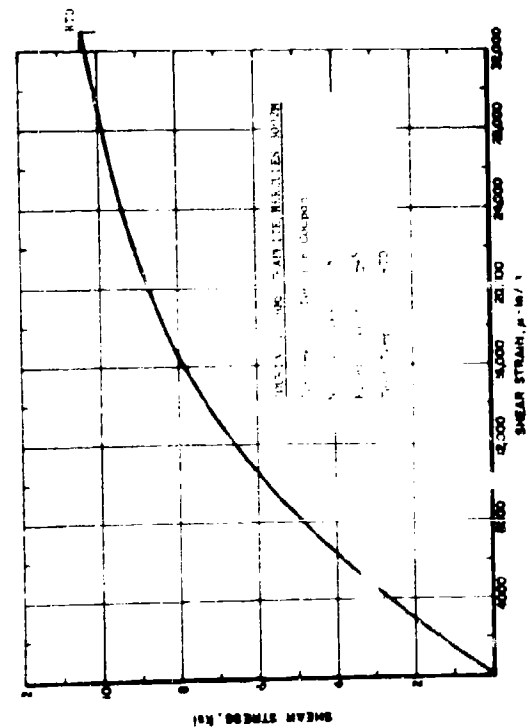


FIG. 10. SHEAR STRESS-STRAIN DIAGRAM FOR COUNTAS HNS GRAPHITE HERCULES 30078. SPECIMEN TESTED AT 100% TENSION AFTER 500 HOURS EXPOSURE TO 70°F.

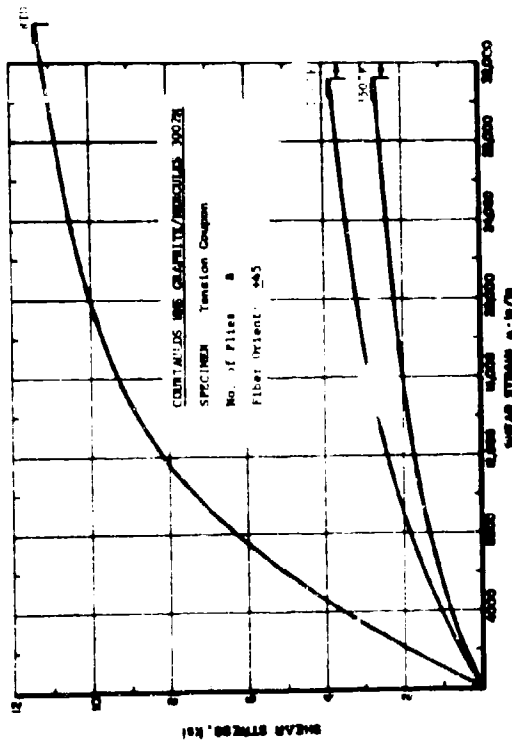


FIG. 11. SHEAR STRESS-STRAIN DIAGRAM FOR COUNTAS HNS GRAPHITE HERCULES 30078. SPECIMEN TESTED AT 100% TENSION AFTER 500 HOURS EXPOSURE TO 70°F.

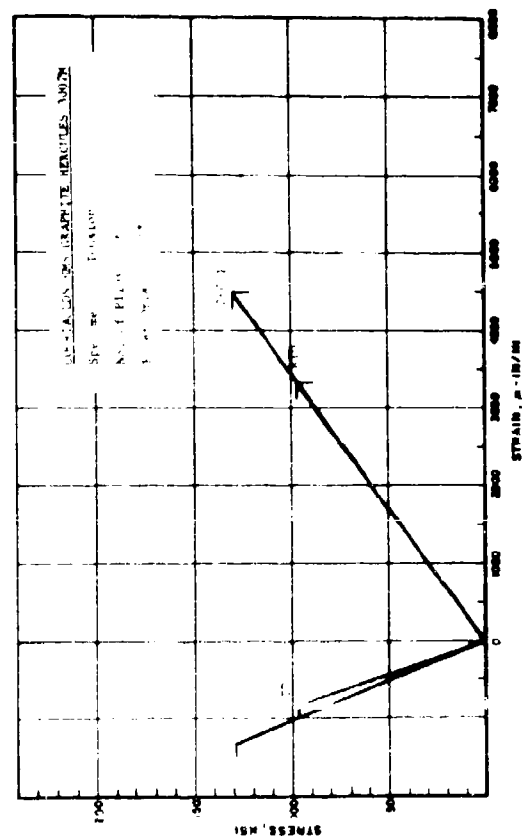


FIG. 12. STRESS-STRAIN DIAGRAM FOR COUNTAS HNS GRAPHITE HERCULES 30078. SPECIMEN TESTED AT 100% TENSION AFTER 500 HOURS EXPOSURE TO 70°F.

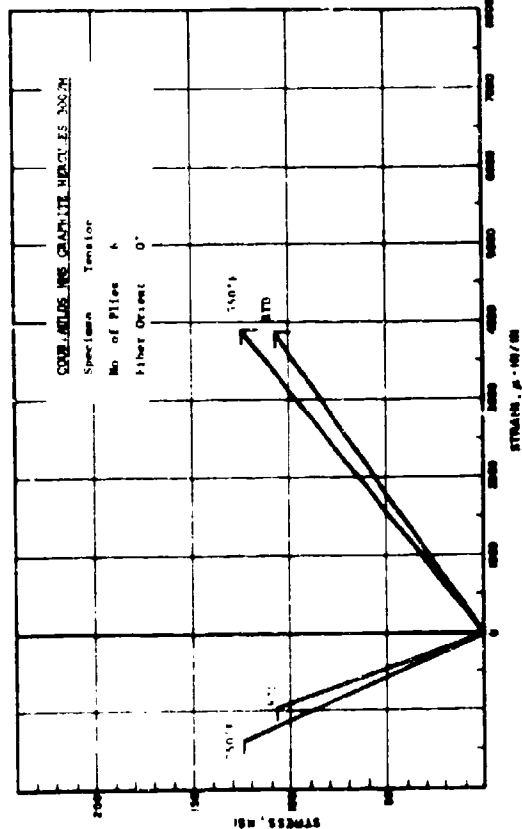


FIG. 13. STRESS-STRAIN DIAGRAM FOR COUNTAS HNS GRAPHITE HERCULES 30078. SPECIMEN TESTED AT 100% TENSION AFTER 500 HOURS EXPOSURE TO 70°F.

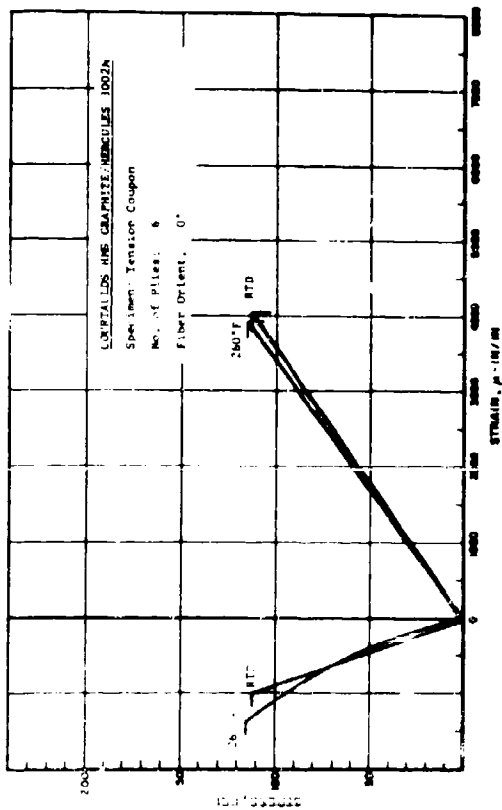


FIG. 47 TENSION STRESS-STRAIN DIAGRAM FOR 0° GRAPHITE/HERCULES 1002M COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

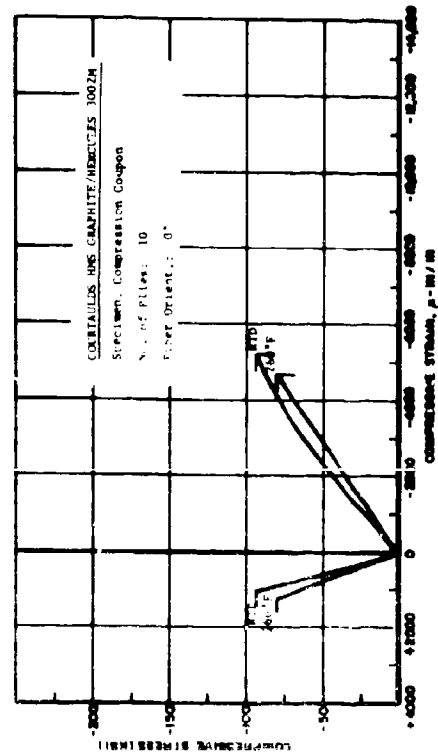


FIG. 48 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° GRAPHITE/HERCULES 1002M COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO 260°F

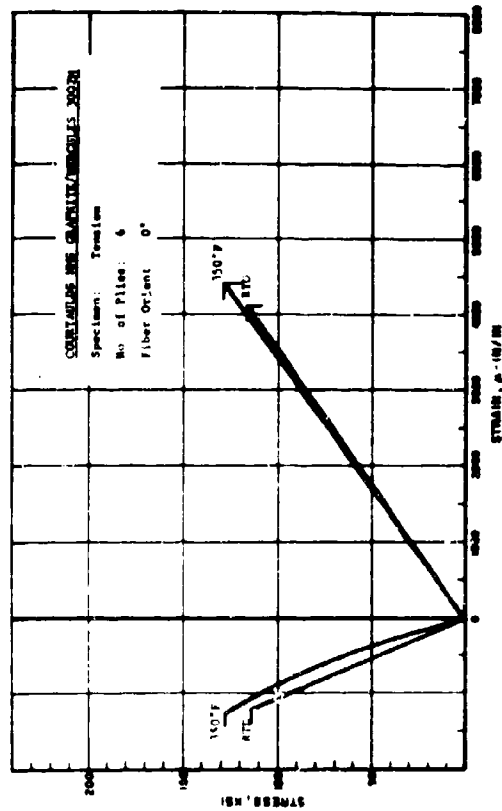


FIG. 49 TENSION STRESS-STRAIN DIAGRAM FOR 0° GRAPHITE/HERCULES 1002M COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 150°F

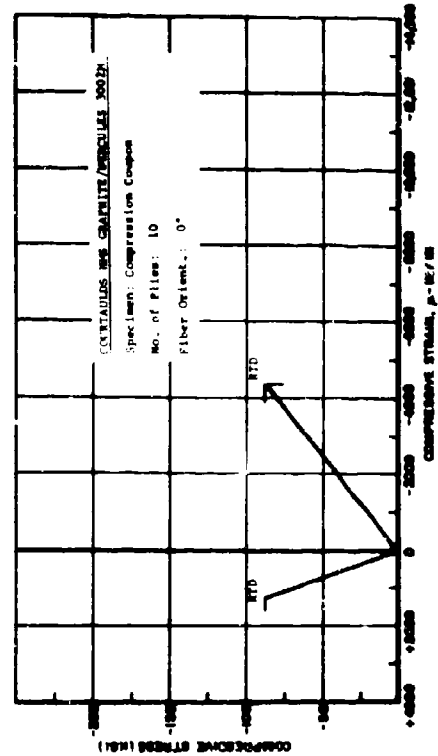


FIG. 49 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° GRAPHITE/HERCULES 1002M COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO 150°F

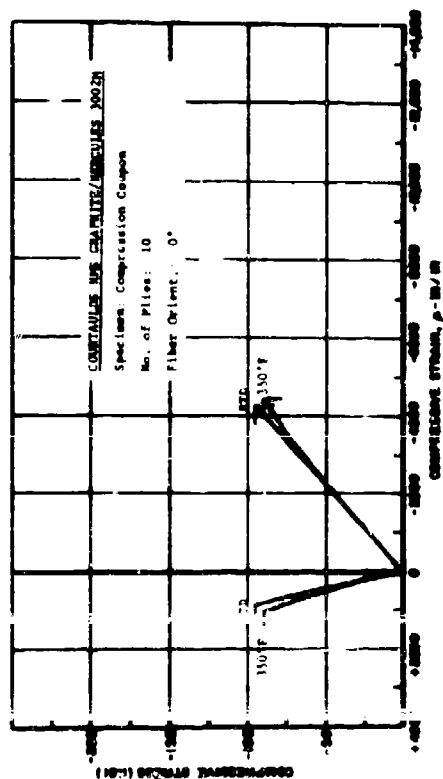


FIG. 450 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° CARBON/GRAPHITE/MERCURIC 3002H COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 260°F

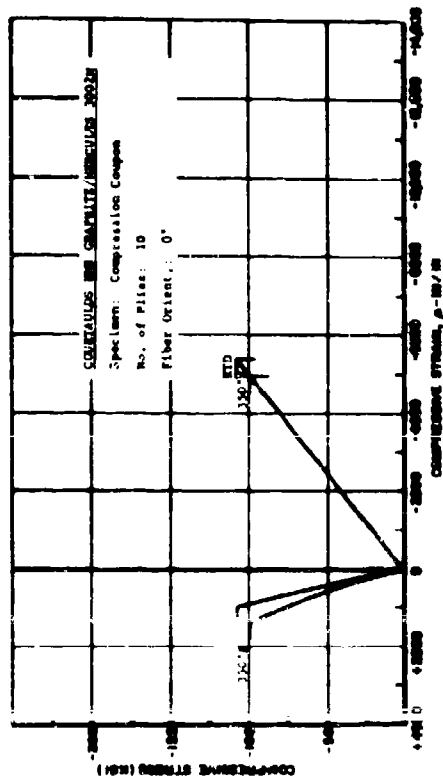


FIG. 452 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° CARBON/GRAPHITE/MERCURIC 3002H COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

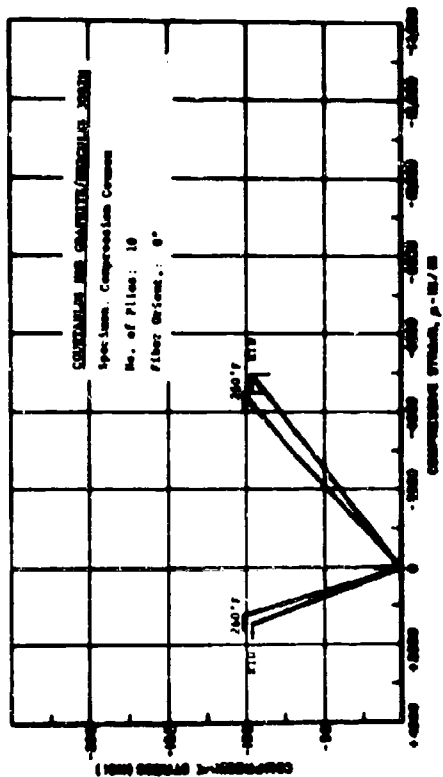


FIG. 451 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° CARBON/GRAPHITE/MERCURIC 3002H COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

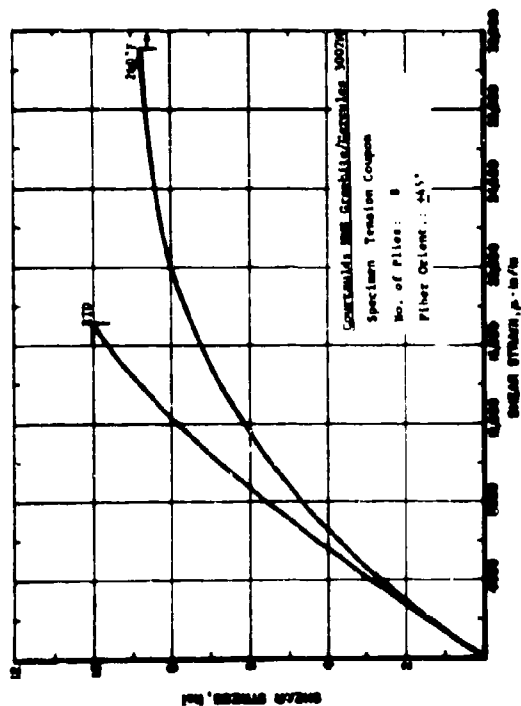


FIG. 453 SHEAR STRESS-STRAIN DIAGRAM FOR 0° CARBON/GRAPHITE/MERCURIC 3002H COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 260°F

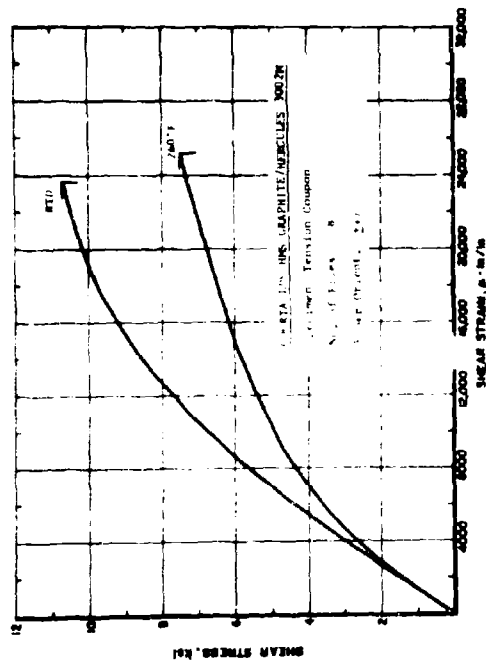


Fig. 1. Shear stress-strain diagram for 100% graphite/mercules 300Z at various temperatures after 100% cycles.

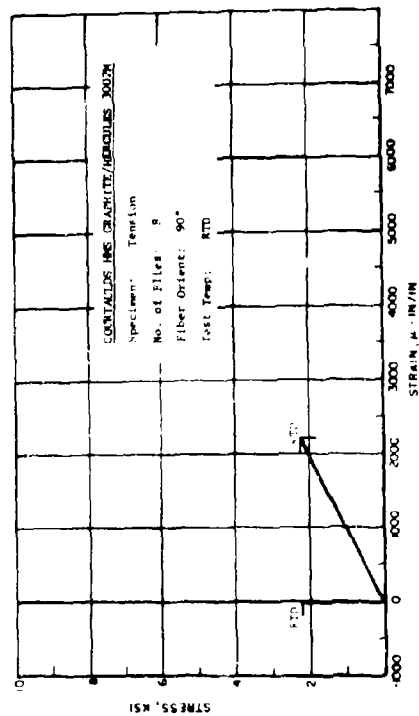


Fig. 2. Stress-strain diagram for 100% graphite/mercules 300Z at various temperatures after 100% cycles.

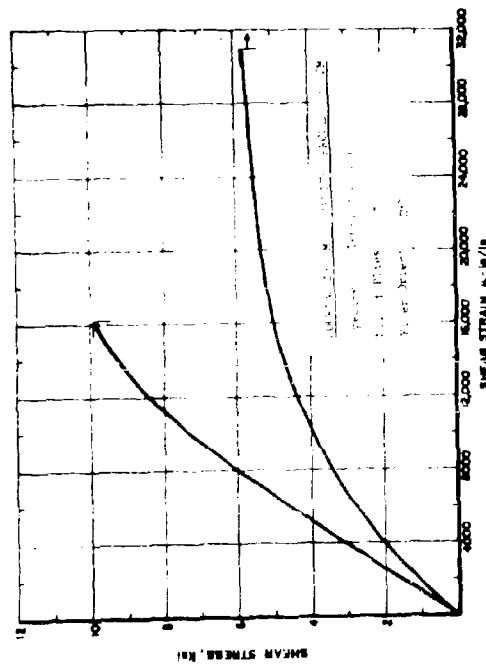


Fig. 3. Shear stress-strain diagram for 100% graphite/mercules 300Z at various temperatures after 100% cycles.

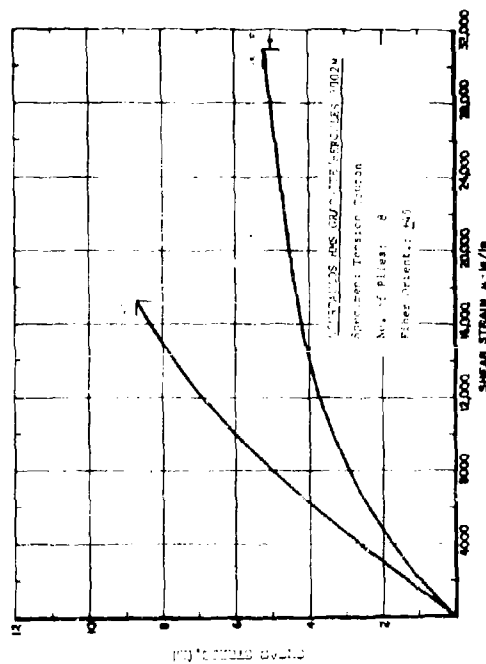


Fig. 4. Shear stress-strain diagram for 100% graphite/mercules 300Z at various temperatures after 100% cycles.

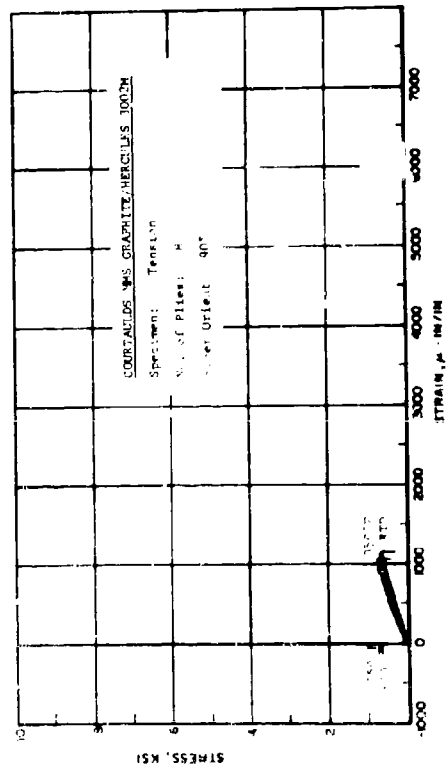


FIG. 4-1 TENSION STRESS-STRAIN DIAGRAM FOR 90° COURTAULD'S HMS GRAPHITE/HERCULES 3002H COMPOSITE TESTED AT 150°F TEMPERATURE AFTER 1000 CYCLES EXPOSURE TO 150°F

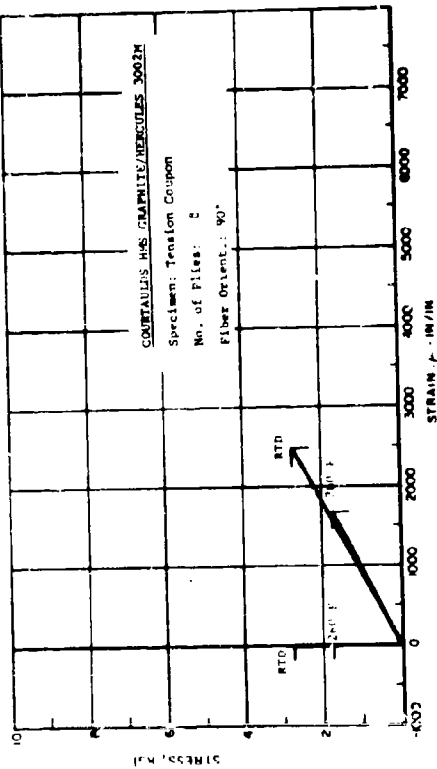


FIG. 4-2 TENSION STRESS-STRAIN DIAGRAM FOR 90° COURTAULD'S HMS GRAPHITE/HERCULES 3002H COMPOSITE TESTED AT 260°F TEMPERATURE AFTER 1000 CYCLES EXPOSURE TO 260°F

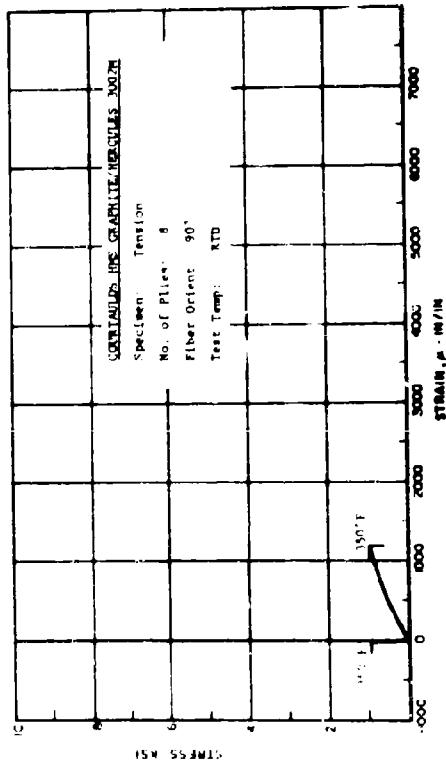


FIG. 4-3 TENSION STRESS-STRAIN DIAGRAM FOR 90° COURTAULD'S HMS GRAPHITE/HERCULES 3002H COMPOSITE TESTED AT 150°F TEMPERATURE AFTER 1000 CYCLES EXPOSURE TO 150°F

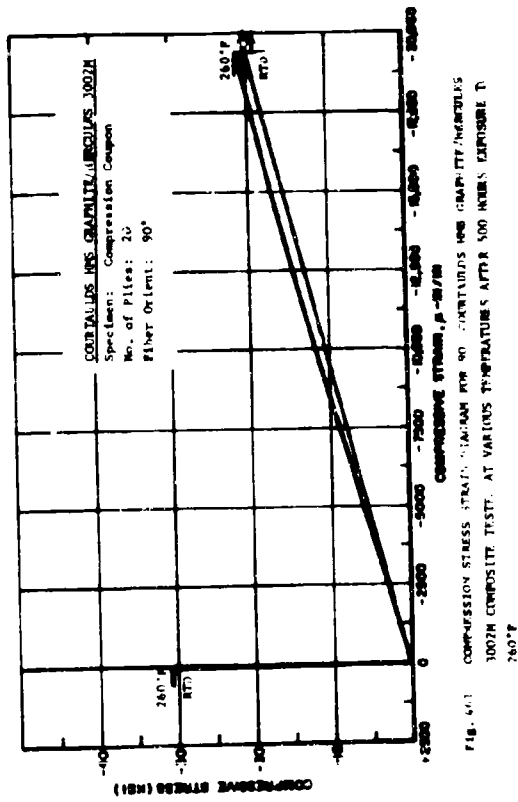


FIG. 4-4 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° COURTAULD'S HMS GRAPHITE/HERCULES 3002H COMPOSITE TESTED AT 260°F TEMPERATURE AFTER 1000 CYCLES EXPOSURE TO 260°F

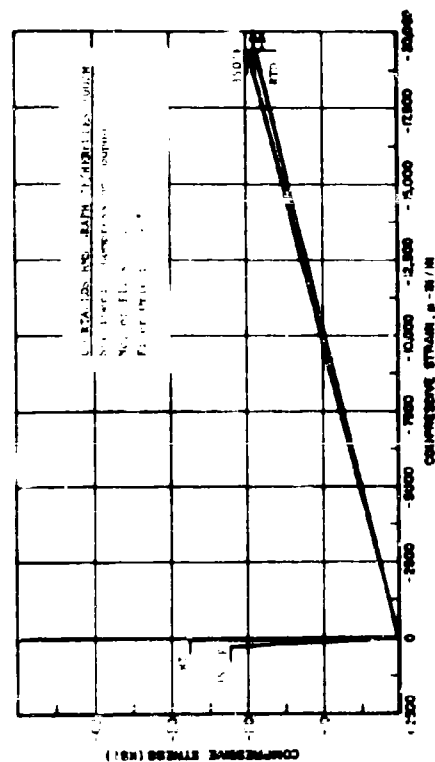


Fig. 1. Compression stress-strain diagram for 90° carbon fiber reinforced epoxy at 100°C and 150°C. Specimen: Compression Coupon, No. of Piles: 20, Fiber Orient: 90°.

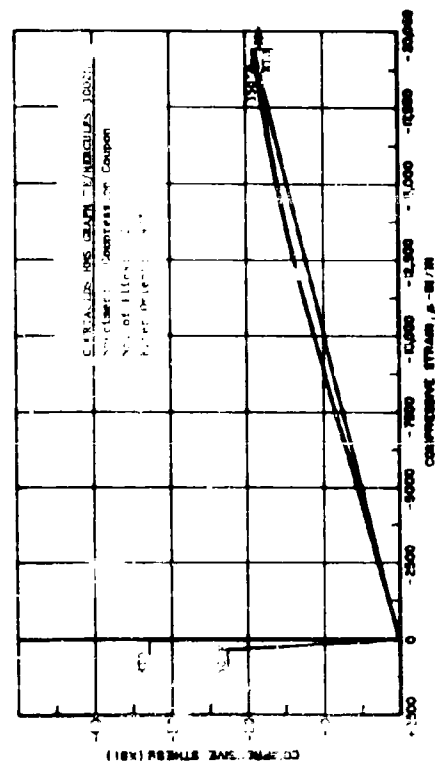


Fig. 2. Compression stress-strain diagram for 90° carbon fiber reinforced epoxy at 100°C and 150°C. Specimen: Compression Coupon, No. of Piles: 20, Fiber Orient: 90°.

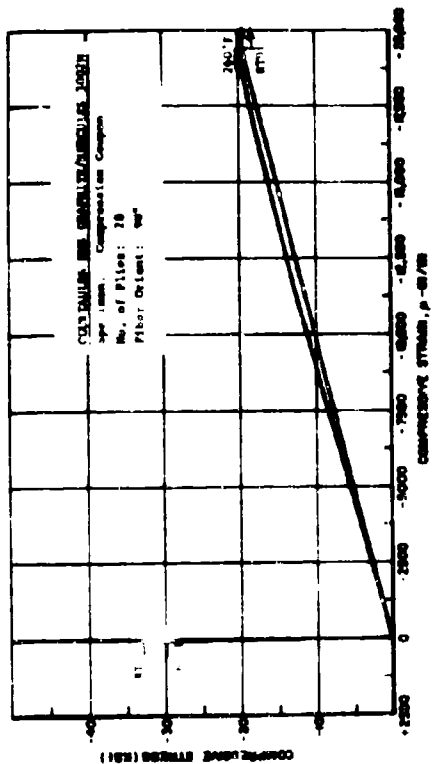


Fig. 3. Compression stress-strain diagram for 90° carbon fiber reinforced epoxy at 100°C and 150°C. Specimen: Compression Coupon, No. of Piles: 20, Fiber Orient: 90°.

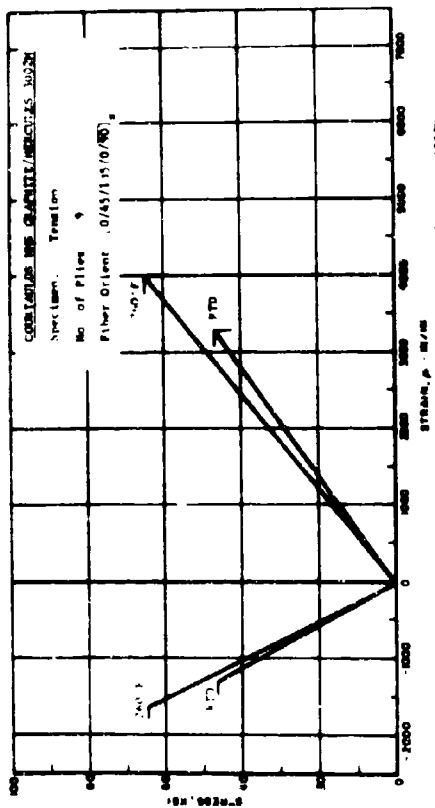


Fig. 4. Compression stress-strain diagram for 90° carbon fiber reinforced epoxy at 100°C and 150°C. Specimen: Compression Coupon, No. of Piles: 20, Fiber Orient: 90°/15°/0°/90°.

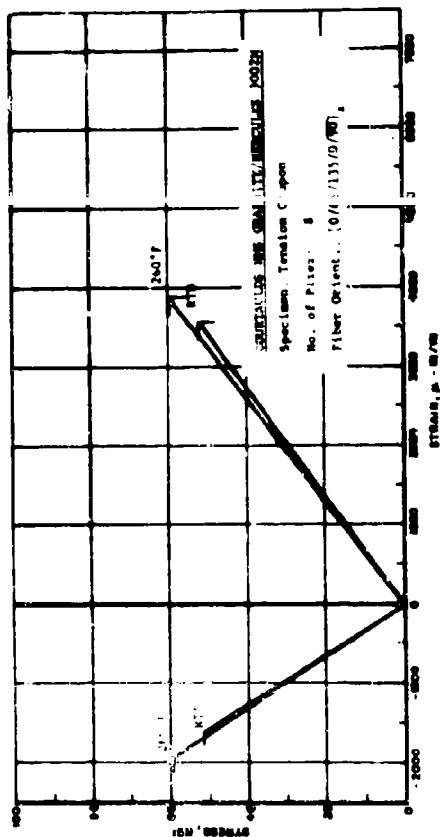


FIG. 3-1 TENSION STRESS-STRAIN DIAGRAM FOR CORTAULUS PPS GRAPHITE/HERCULES 3002H, 0.45/135/0/90, CARBONATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

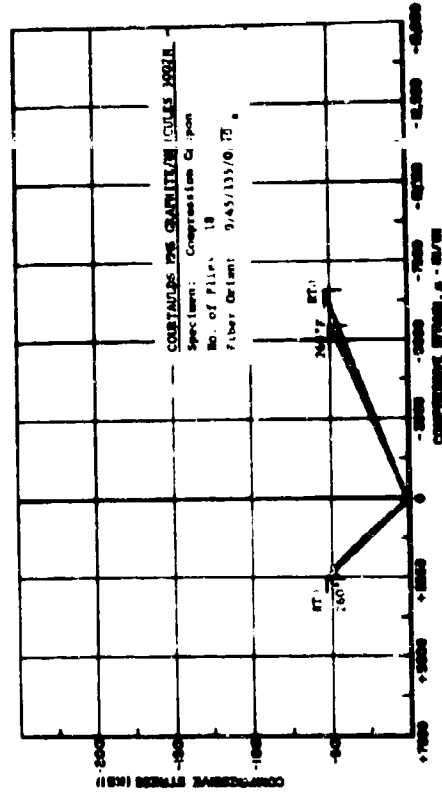


FIG. 3-2 COMPRESSION STRESS-STRAIN DIAGRAM FOR CORTAULUS PPS GRAPHITE/HERCULES 3002H, 0.45/135/0/90, CARBONATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 260°F

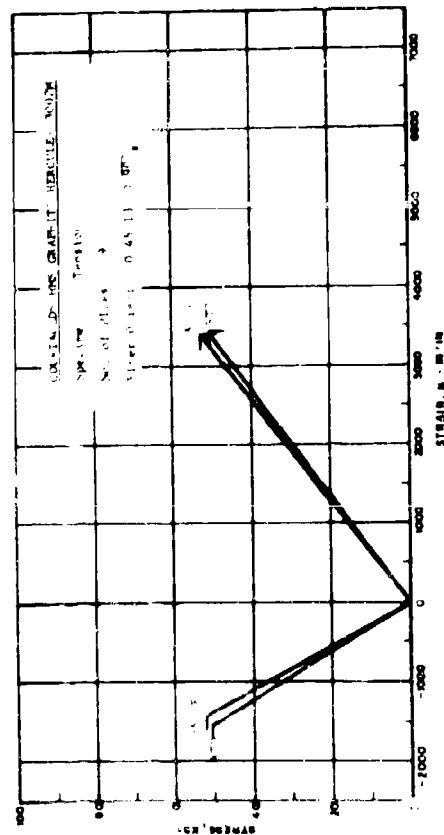


FIG. 3-3 TENSION STRESS-STRAIN DIAGRAM FOR CORTAULUS PPS GRAPHITE/HERCULES 3002H, 0.45/135/0/90, CARBONATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 150°F

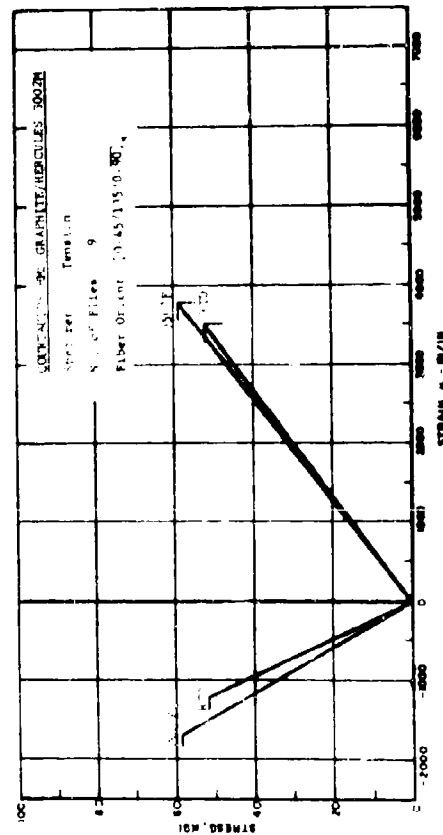


FIG. 3-4 COMPRESSION STRESS-STRAIN DIAGRAM FOR CORTAULUS PPS GRAPHITE/HERCULES 3002H, 0.45/135/0/90, CARBONATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 150°F

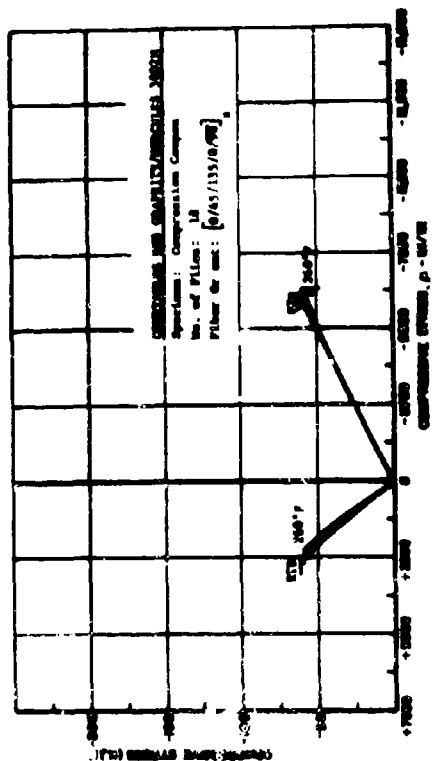


FIG. 471 COMPRESSION STRESS-STRAIN FOR COURTAULD'S HMS GRAPHITE/MINERALS 3002H [0/45/135/0/90], LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 760°F

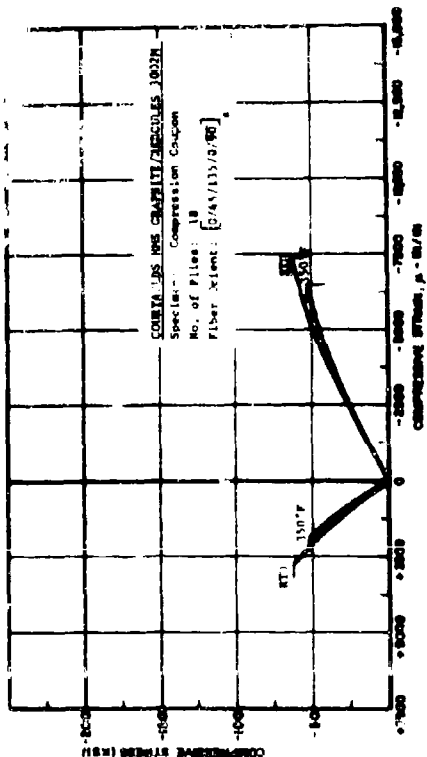


FIG. 472 COMPRESSION STRESS-STRAIN FOR COURTAULD'S HMS GRAPHITE/MINERALS 3002H [0/45/135/0/90], LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 500 MINUTES EXPOSURE TO 310°F

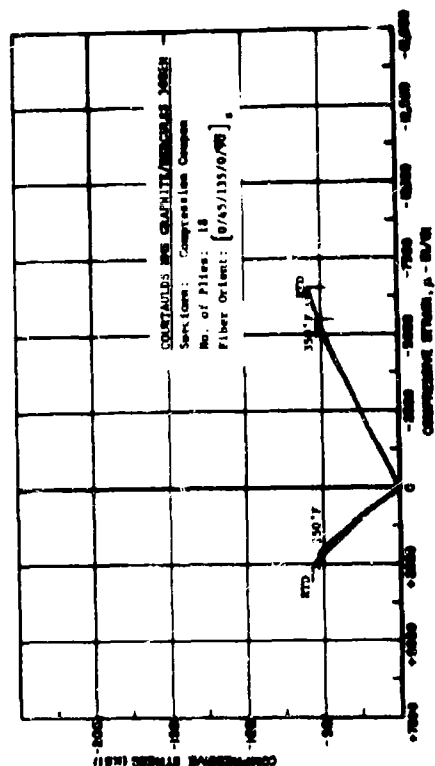


FIG. 473 COMPRESSION STRESS-STRAIN FOR COURTAULD'S HMS GRAPHITE/MINERALS 3002H [0/45/135/0/90], LAMINATE TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

TABLE A-1X FAILURE PROPERTIES OF TABS
TENSILE STRENGTH AND FATIGUE
LIFE OF TABS

Specimen Number	Thickness (Plies) (In.)	Orientation	PRION CONDITIONING		Test Temp. (°F)	Stress (ksi) (2' ult)	Cycles to failure (cycles)	Applied without failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
C1205A-6	6 - 0.062		None	-	RTD	100	140	-	-	Failed under static load at tab
C1205A-7	6 - 0.062		None	-	RTD	10	100	-	-	Immediate Tab Failure
C1205A-8	6 - 0.062		None	-	RTD	71.0	70	5.192 x 10 ⁶	111.1	Immediate Tab Failure
C1205A-9	6 - 0.062		None	-	RTD	27	85	-	-	Immediate Tab Failure
C1205A-10	6 - 0.062		None	-	RTD	81.5	80	-	-	Tab Failure under static load
C1205A-11	6 - 0.062		None	-	RTD	9.5	74	-	-	Immediate Tab Failure
C1205A-12	6 - 0.062		None	-	RTD	76.5	75	-	-	Immediate Tab Failure
C1205A-13	6 - 0.062		None	-	RTD	81.5	80	-	-	Immediate Tab Failure
C1205A-14	6 - 0.062		None	-	RTD	74.5	73	10 ⁷	112.6	Immediate Tab Failure
C1205A-15	6 - 0.062		None	-	RTD	76.5	75	963,000	-	Tab Failure
C1205A-16	6 - 0.057	40°	None	-	RTD	5	6	2,000	-	Immediate Tab Failure
C1205A-17	6 - 0.057	40°	None	-	RTD	36	4	595,000	-	Immediate Tab Failure
C1205A-18	6 - 0.057	40°	None	-	RTD	45	5	6,000	-	Immediate Tab Failure
C1205A-19	6 - 0.057	40°	None	-	RTD	45	4.5	-	-	Immediate Tab Failure
C1205A-20	6 - 0.057	90°	None	-	RTD	11	4.5	1,000	-	Immediate Tab Failure
C1205A-21	6 - 0.057	90°	None	-	RTD	36	4.0	-	-	Immediate Tab Failure
C1205A-22	6 - 0.057	90°	None	-	RTD	52	3.5	3,000	-	Immediate Tab Failure
C1205A-23	6 - 0.055	90°	None	-	RTD	15	3.5	3,000	-	Immediate Tab Failure
C1205A-24	6 - 0.057	90°	None	-	RTD	47.5	5	445,000	-	Immediate Tab Failure
C127A-6	9 - 0.062	0/45/135/0/90°	None	-	RTD	125	60	-	-	Immediate Tab Failure
C127A-7	9 - 0.063	0/45/135/0/90°	None	-	RTD	105	50	1,000	-	Tab Failure
C127A-8	9 - 0.061	0/45/135/0/90°	None	-	RTD	84	40	-	10 ⁷	59.1
C127A-9	9 - 0.058	0/45/135/0/90°	None	-	RTD	105	50	-	-	Immediate Tab Failure
C127A-10	9 - 0.062	0/45/135/0/90°	None	-	RTD	94	45	-	10 ⁷	66.2
C127A-11	9 - 0.060	0/45/135/0/90°	None	-	RTD	98.5	47	3,000	-	Immediate Tab Failure
C127A-12	9 - 0.061	0/45/135/0/90°	None	-	RTD	100	48	1,000	-	Immediate Tab Failure
C127A-13	9 - 0.062	0/45/135/0/90°	None	-	RTD	96.5	46	-	3.09 x 10 ⁶	3.7
C127A-14	9 - 0.061	0/45/135/0/90°	None	-	RTD	100	48	-	-	Immediate Tab Failure
C127A-15	9 - 0.062	0/45/135/0/90°	None	-	RTD	98.5	47	-	-	Immediate Tab Failure

TABLE A14. CABLES NORTH IRE STRONG
CABLES 30000 LB. STRENGTH
CABLES 30000 LB. STRENGTH

Specimen Number	Thickness (Plies) (in.)	Orientation	[PRIOR CONDITIONING]		Test Temp. (°F)	Stress Level (% ultimate)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
C1207A-11	6 - 0.063	0	None	-	260°F	81	-	3.168x10 ⁶	101.1	Tab Failure
C1207A-12	6 - 0.063	0	None	-	260°F	81	-	2.550x10 ⁶	106.2	Tab Failure
C1207A-13	6 - 0.063	0	None	-	260°F	81	-	-	-	Tab Failed under
C1207A-14	6 - 0.063	0	None	-	260°F	81	-	-	-	Tab Failure
C1207A-15	6 - 0.063	0	None	-	260°F	81	-	-	-	Immediate Tab Failure
C1207A-16	6 - 0.063	0	None	-	260°F	81	-	-	-	Immediate Tab Failure
C1207A-17	6 - 0.063	0	None	-	260°F	81	-	-	-	Immediate Tab Failure
C1207A-18	6 - 0.063	0	None	-	260°F	81	-	-	-	Immediate Tab Failure
C1207A-19	6 - 0.063	0	None	-	260°F	81	-	-	-	Tab Failure
C1207A-20	6 - 0.063	0	None	-	260°F	81	-	2.117x10 ⁶	115.0	Tab Failure
C1213A-11	8 - 0.063	0	None	-	260°F	81	-	7.131x10 ⁶	-	Failed under Static Load
C1213A-12	8 - 0.063	0	None	-	260°F	81	-	-	-	Tab Area Failure
C1213A-13	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1213A-14	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1213A-15	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1213A-16	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1213A-17	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1213A-18	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1213A-19	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1213A-20	8 - 0.063	0	None	-	260°F	81	-	-	-	-
C1233B-2	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	Failed under Static Load
C1233B-3	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	Tab Area Failure
C1233B-4	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	Failed under Static Load
C1233B-5	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	Failed under Static Load
C1233B-6	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	Immediate Tab Failure
C1233B-7	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	-
C1233B-8	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	-
C1233B-9	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	-
C1233B-10	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	-
C1233B-11	9 - 0.063	0/45/135/0/90	None	-	260°F	81	-	-	-	-

Specimen Number	Thickness (plies) (in.)	Orientation	PULSE CONDITIONING		Test Temp. (°F)	Stress Level (°ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
C1207B-1	6 - 0.043	0°	None	-	350°F	27	10 ⁶	2.142 x 10 ⁶	86.4	Tab Failure
C1207B-2	6 - 0.042	0°	None	-	350°F	64.3	-	-	-	Tab Failure
C1207B-3	6 - 0.044	0°	None	-	320°F	45.5	2,000	-	-	Tab Failure
C1207B-4	6 - 0.044	0°	None	-	350°F	45.5	1,000	-	-	Tab Failure
C1207B-5	6 - 0.043	0°	None	-	350°F	91.5	-	-	-	Immediate Tab Failure
C1207B-6	6 - 0.042	0°	None	-	350°F	90.5	-	2.474 x 10 ⁶	114.5	Tab Failure
C1207B-7	6 - 0.043	0°	None	-	350°F	41.5	25,000	-	-	Tab Failure
C1207B-8	6 - 2.043	0°	None	-	350°F	43	29,000	-	-	Tab Failure
C1207B-9	6 - 0.044	0°	None	-	350°F	92	-	-	-	Immediate Tab Failure
C1207B-10	6 - 0.044	0°	None	-	350°F	89.4	-	5.071 x 10 ⁶	106.2	Tab Failure
C1214-3	8 - 0.043	90°	None	-	350°F	37	-	-	-	(Failed Under Static Load while coming up to Temperature)
C1214-4	8 - 0.044	90°	None	-	350°F	24.5	-	-	-	Immediate Failure
C1214-5	8 - 0.043	90°	None	-	350°F	19.5	-	-	-	Failed Under Static
C1214-6	8 - 0.043	90°	None	-	350°F	17	10,000	-	-	Immediate Failure
C1214-7	8 - 0.043	90°	None	-	350°F	17	-	-	-	Failed Under Static
C1214-8	8 - 0.043	90°	None	-	350°F	15	1,000	-	-	Immediate Failure
C1214-9	8 - 0.043	90°	None	-	350°F	15	-	-	-	Failed Under Static
C1214-10	8 - 0.044	90°	None	-	350°F	10	25,000	-	-	Immediate Failure
C1214-11	8 - 0.044	90°	None	-	350°F	7.5	27,000	-	-	Failed Under Static
C1214-12	8 - 0.044	90°	None	-	350°F	6	7,000	-	-	Immediate Failure
C1234A-1	9 - 0.051	0/45/135/0/90	None	-	350°F	83	-	2.504 x 10 ⁶	-	Tab Failure
C1234A-2	9 - 0.053	0/45/135/0/90	None	-	350°F	99.5	1,000	-	-	Immediate Failure
C1234A-3	9 - 0.053	0/45/135/0/90	None	-	350°F	88	132,000	-	-	Tab Failure
C1234A-4	9 - 0.052	0/45/135/0/90	None	-	350°F	88	-	-	-	Immediate Failure
C1234A-5	9 - 0.050	0/45/135/0/90	None	-	350°F	90	-	2.068 x 10 ⁶	52.5	Tab Failure
C1234A-6	9 - 0.054	0/45/135/0/90	None	-	350°F	93	11,000	-	-	Tab Failure
C1234A-7	9 - 0.054	0/45/135/0/90	None	-	350°F	93	12,000	-	-	Tab Failure
C1234A-8	9 - 0.053	0/45/135/0/90	None	-	350°F	99.5	22,000	-	-	Immediate Tab Failure
C1234A-9	9 - 0.054	0/45/135/0/90	None	-	350°F	91.5	-	-	-	Immediate Tab Failure
C1234A-10	9 - 0.054	0/45/135/0/90	None	-	350°F	91.5	-	-	-	Immediate Tab Failure

TABLE XIX FAILURE PROPERTIES SUMMARY -
HERCULES 3000/5000 RESIN/3000 RESIN
GRAPHITE COMPOSITES

Specimen Number	Thickness (plies) (in.)	Orientation	Prior Conditioning		Test Temp. (°F)	Stress Level (% ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
C1205B-7	6 - 0.043	0°	98% RH	500 Hrs.	RTD	85.5	100	1,000		Tab Failure
C1205B-8	6 - 0.044	0°	98% RH	500 Hrs.	RTD	84	98	5,000		Tab Failure
C1205B-9	6 - 0.045	0°	98% RH	500 Hrs.	RTD	79.5	93		110.8	Tab Area Failure (Two Specimens broke during fabrication)
C1205B-10	6 -	0°	98% RH	500 Hrs.	RTD					
C1205B-11	6 -	0°	98% RH	500 Hrs.	RTD					
C1205B-12	6 - 0.043	0°	98% RH	500 Hrs.	260°F	64	70			
C1205B-13	6 - 0.044	0°	98% RH	500 Hrs.	260°F	50.5	55		71.9	Failed while coming up to temperature
C1205B-14	6 - 0.044	0°	98% RH	500 Hrs.	260°F	59.5	65			
C1205B-15	6 - 0.044	0°	98% RH	500 Hrs.	260°F	55	60		91.3	Immediate Failure
C1205B-16	6 - 0.044	0°	98% RH	500 Hrs.	260°F	59.5	65			Failed coming up to temp. Immediate Tab Failure
C1205B-17	6 - 0.042	0°	98% RH	500 Hrs.	350°F	64	70			Tab Failure
C1205B-18	6 - 0.043	0°	98% RH	500 Hrs.	350°F	46	50		79.1	Tab Failure
C1205B-19	6 - 0.043	0°	98% RH	500 Hrs.	350°F	41.5	45			Failed under static load
C1205B-20	6 - 0.043	0°	98% RH	500 Hrs.	350°F	44	48		89.2	Tab Failure
C1205B-21	6 - 0.043	0°	98% RH	1000 Hrs.	RTD	82.5	90	1,000		Tab Failure
C1205B-22	6 - 0.042	0°	98% RH	1000 Hrs.	RTD	73.5	80	33,000		Tab Failure
C1205B-23	6 - 0.042	0°	98% RH	1000 Hrs.	RTD	78	85		125.6	Tab Failure
C1205B-24	6 - 0.040	0°	98% RH	1000 Hrs.	RTD	82.5	90	21,000		Tab Failure
C1205B-25	6 - 0.044	0°	98% RH	1000 Hrs.	RTD	87	95	1,000		Failed under static load
C1205B-26	6 - 0.043	0°	98% RH	1000 Hrs.	RTD	52.5	65			Tab Failure
C1205B-27	6 - 0.043	0°	98% RH	1000 Hrs.	260°F	40.5	50		80.0	Tab Failure
C1205B-28	6 - 0.046	0°	98% RH	1000 Hrs.	260°F	48.5	60	1,000		Tab Failure
C1205B-29	6 - 0.045	0°	98% RH	1000 Hrs.	260°F	44.5	55		62.6	Tab Failure
C1205B-30	6 - 0.044	0°	98% RH	1000 Hrs.	260°F	47	58	106,000		Failed under static load coming to temperature
C1205B-31	6 - 0.043	0°	98% RH	1000 Hrs.	260°F	54.5	55		100.2	Tab Failure
C1205B-32	6 - 0.042	0°	98% RH	1000 Hrs.	350°F	69	70	2,000		Tab Failure under static load coming to temp.
C1205B-33	6 - 0.043	0°	98% RH	1000 Hrs.	350°F	64.5	65		126.3	
C1205B-34	6 - 0.043	0°	98% RH	1000 Hrs.	350°F	54.5	55			
C1205B-35	6 - 0.042	0°	98% RH	1000 Hrs.	350°F	69.5	70			

TABLE XIX
FATIGUE PROPERTIES SUMMARY
ENGLIS 3002-10 STAINLESS STEEL
CRAP-III COMPOSITION

Specimen	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
CI205B-17	6 - 0.041	0	Thermo-Humidity Cycle		RTD	76	-	-	-	Immediate Tab Failure
CI205B-18	6 - 0.043	0	Thermo-Humidity Cycle		RTD	66.5	-	-	-	Immediate Tab Failure
CI205B-19	6 - 0.043	0	Thermo-Humidity Cycle		RTD	57	-	-	-	Tab Failure
CI205B-20	6 - 0.042	0	Thermo-Humidity Cycle		RTD	62	847,000	2.45×10^6	84.4	Tab Failure
CI205B-21	6 - 0.043	0	Thermo-Humidity Cycle		RTD	65	77,000	-	-	Tab Failure
CI209A-5	6 - 0.042	0	Thermo-Humidity Cycle		260°F	63.2	-	-	-	Tab Failure
CI209A-6	6 - 0.042	0	Thermo-Humidity Cycle		260°F	55.5	-	2.087×10^6	101.5	Tab Failure
CI209A-7	6 - 0.042	0	Thermo-Humidity Cycle		260°F	79.5	-	2.194×10^6	108.0	Tab Failure
CI209A-8	6 - 0.041	0	Thermo-Humidity Cycle		260°F	71.5	84,000	-	-	Immediate Tab Failure
CI209A-9	6 - 0.042	0	Thermo-Humidity Cycle		260°F	75.5	884,000	-	-	Tab Failure
CI209B-5	6 - 0.043	0	Thermo-Humidity Cycle		350°F	65	-	-	-	Failed coming to temp.
CI209B-6	6 - 0.043	0	Thermo-Humidity Cycle		350°F	56.5	-	2.472×10^6	91.6	Tab Failure
CI209B-7	6 - 0.042	0	Thermo-Humidity Cycle		350°F	61	-	2.345×10^6	96.0	Failed coming to temp.
CI209B-8	6 - 0.043	0	Thermo-Humidity Cycle		350°F	65	-	-	-	Tab Failure
CI209B-9	6 - 0.044	0	Thermo-Humidity Cycle		350°F	63.5	67,000	-	-	Failed coming to temp.
CI205C-1	6 - 0.044	0	Acc. Wehring.		RTD	87	-	-	-	Immediate Tab Failure
CI205C-2	6 - 0.043	0	Acc. Wehring.		RTD	80	165,000	-	-	Tab Failure
CI205C-3	6 - 0.043	0	Acc. Wehring.		RTD	85	-	-	-	Immediate Tab Failure
CI205C-4	6 - 0.043	0	Acc. Wehring.		RTD	78	-	-	-	Immediate Tab Failure
CI205C-5	6 - 0.043	0	Acc. Wehring.		RTD	75	-	-	-	Immediate Tab Failure
CI209A-10	6 - 0.043	0	Acc. Wehring.		260°F	57	-	2.434×10^6	105.0	Tab Failure
CI209A-11	6 - 0.043	0	Acc. Wehring.		260°F	64	-	7.685×10^6	95.4	Tab Failure
CI209A-12	6 - 0.045	0	Acc. Wehring.		260°F	75	-	-	-	Tab Failure
CI209A-13	6 - 0.043	0	Acc. Wehring.		260°F	67.5	1,040,000	-	-	Tab Failure
CI209A-14	6 - 0.043	0	Acc. Wehring.		260°F	71.5	4,000	-	-	Tab Failure
CI209B-10	6 - 0.044	0	Acc. Wehring.		350°F	66	-	2.085×10^6	98.6	Tab Failed under Static
CI209B-11	6 - 0.044	0	Acc. Wehring.		350°F	74.5	-	-	-	Tab Failed under Static
CI209B-12	6 - 0.044	0	Acc. Wehring.		350°F	70	-	-	-	Tab Failed under Static
CI209B-13	6 - 0.043	0	Acc. Wehring.		350°F	67.5	-	2.458×10^6	101.9	Tab Failed under Static Load
CI209B-14	6 - 0.043	0	Acc. Wehring.		350°F	60.5	-	-	-	Tab Failed under Static Load

FACTURE PROOF
SUSTAIN 1002M
QUALITY CONTROL

Specimen Number	Thickness (Plier) (In.)	Orientation	Prior Conditioning Type	Duration	Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
C1228A-6	9 - 0.066	0/45/135/90	98° RH	500 Hrs.	RTD	114	-	-	-	Immediate Tab Failure
C1228A-7	9 - 0.066	"	98° RH	500 Hrs.	RTD	95	-	-	-	Immediate Tab Failure
C1228A-8	9 - 0.064	"	98° RH	500 Hrs.	RTD	76	-	2.121 x 10 ⁶	50	Tab Area Failure
C1228A-9	9 - 0.066	"	98° RH	500 Hrs.	RTD	85.5	-	-	-	-
C1228A-10	9 - 0.066	"	98° RH	500 Hrs.	RTD	81.5	-	2.755 x 10 ⁶	53.6	Tab Area Failure
C1235B-1	9 - 0.065	"	98° RH	500 Hrs.	260°F	96	-	-	-	Immediate Tab Failure
C1235B-2	9 - 0.064	"	98° RH	500 Hrs.	260°F	70	-	2.475 x 10 ⁶	48.9	Tab Area Failure
C1235B-3	9 - 0.064	"	98° RH	500 Hrs.	260°F	78.5	-	-	-	Failed coming to temp.
C1235B-4	9 - 0.065	"	98° RH	500 Hrs.	260°F	71.5	-	-	-	Immediate Tab Failure
C1235B-5	9 - 0.066	"	98° RH	500 Hrs.	260°F	75	-	-	-	Immediate Tab Failure
C1235B-6	9 - 0.064	"	98° RH	500 Hrs.	350°F	108	-	-	-	Tab Failure to Temp.
C1235B-7	9 - 0.065	"	98° RH	500 Hrs.	350°F	118	-	-	-	Immediate Tab Failure
C1235B-8	9 - 0.063	"	98° RH	500 Hrs.	350°F	98.5	-	-	-	Immediate Tab Failure
C1235B-9	9 - 0.064	"	98° RH	500 Hrs.	350°F	98.5	-	-	-	Tab Failed under static load coming to temp.
C1235B-10	9 - 0.062	"	98° RH	500 Hrs.	350°F	88.5	-	2.0 x 10 ⁶	51.6	Immediate Tab Failure
C1228A-11	9 - 0.065	"	98° RH	1000 Hrs.	RTD	146	-	-	-	Immediate Tab Failure
C1228A-12	9 - 0.065	"	98° RH	1000 Hrs.	RTD	103	-	-	-	Immediate Tab Failure
C1228A-13	9 - 0.065	"	98° RH	1000 Hrs.	RTD	86	-	-	-	Failed under static load
C1228A-14	9 - 0.065	"	98° RH	1000 Hrs.	RTD	60.5	-	-	-	Immediate Tab Failure
C1228A-15	9 - 0.065	"	98° RH	1000 Hrs.	RTD	51.5	-	2 x 10 ⁶	41.3	Tab Failure
C1235B-6	9 - 0.063	"	98° RH	1000 Hrs.	260°F	90	-	-	-	Immediate Failure
C1235B-7	9 - 0.063	"	98° RH	1000 Hrs.	260°F	63	-	2.08 x 10 ⁶	50.4	Tab Failure
C1235B-8	9 - 0.062	"	98° RH	1000 Hrs.	260°F	72.5	-	2.323 x 10 ⁶	-	Tab Failure
C1235B-9	9 - 0.063	"	98° RH	1000 Hrs.	260°F	81.5	-	-	-	Failed under static load
C1235B-10	9 - 0.063	"	98° RH	1000 Hrs.	260°F	81.5	-	-	-	Immediate Tab Failure
C1235B-6	9 - 0.064	"	98° RH	1000 Hrs.	350°F	108	-	-	-	Immediate Failure
C1235B-7	9 - 0.064	"	98° RH	1000 Hrs.	350°F	92	-	2.377 x 10 ⁶	44.0	Tab Failure
C1235B-8	9 - 0.065	"	98° RH	1000 Hrs.	350°F	103.5	-	4.6 x 10 ⁶	55.7	Tab Failure
C1235B-9	9 - 0.062	"	98° RH	1000 Hrs.	350°F	115	-	2.666 x 10 ⁶	50.7	Tab Failure
C1235B-10	9 - 0.063	0/45/135/90/90/90	98° RH	1000 Hrs.	350°F	126	-	-	-	Immediate Failure

TABLE XIX
THERMAL STRESS ANALYSIS
RESULTS FOR THERMAL
GRAPHITE CONDUITS

Specimen Number	Thickness (Pile) (in.)	Orientation	Prior Conditioning Type	Prior Conditioning Duration	Test Temp. (°F)	Stress Level (T _{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
C1228-5	9 - 0.065	[0/45/135/0/90]	Thermo-Humidity Cycle		RTD	96.5	1,000			Tab Failure
C1228-6	9 - 0.063	"	Thermo-Humidity Cycle		RTD	67.5		2.23 x 10 ⁶	50.1	Tab Failure
C1228-7	9 - 0.064	"	Thermo-Humidity Cycle		RTD	77				Immediate Failure
C1228-8	9 - 0.066	"	Thermo-Humidity Cycle		RTD	73.5		2.267 x 10 ⁶	50.3	Tab Failure
C1228-9	9 - 0.066	"	Thermo-Humidity Cycle		RTD	81	1,000			Tab Failure
C1236A-1	9 - 0.062	"	Thermo-Humidity Cycle		260°F	78		2.037 x 10 ⁶	48.8	Tab Failure
C1236A-2	9 - 0.063	"	Thermo-Humidity Cycle		260°F	95.5		2.603 x 10 ⁶		Tab Failure
C1236A-3	9 - 0.063	"	Thermo-Humidity Cycle		260°F	86.5		2.469 x 10 ⁶	57.8	Tab Failure
C1236A-4	9 - 0.062	"	Thermo-Humidity Cycle		260°F	111	1,000			Tab Failure
C1236A-5	9 - 0.063	"	Thermo-Humidity Cycle		260°F	104	9,000			Tab Failure
C1237A-1	9 - 0.061	"	Thermo-Humidity Cycle		350°F	110				Immediate Tab Failure
C1237A-2	9 - 0.061	"	Thermo-Humidity Cycle		350°F	80				(Tab failed under static load coming to temp.)
C1237A-3	9 - 0.061	"	Thermo-Humidity Cycle		350°F	80				Tab Failure
C1237A-4	9 - 0.060	"	Thermo-Humidity Cycle		350°F	70		2.25 x 10 ⁶	56.3	Tab Failure
C1237A-5	9 - 0.061	"	Thermo-Humidity Cycle		350°F	76		2.02 x 10 ⁶	48.5	Tab Failure
C1228-10	9 - 0.064	"	Acc. Withring		RTD	82	160,000			Tab Failure
C1228-11	9 - 0.065	"	Acc. Withring		RTD	91	1,000			Tab Failure
C1229A-1	9 - 0.064	"	Acc. Withring		RTD	72.5		2.01 x 10 ⁶	51.8	Tab Failure
C1229A-2	9 - 0.065	"	Acc. Withring		RTD	78	2,000			Tab Failure
C1229A-3	9 - 0.065	"	Acc. Withring		RTD	91				Immediate Tab Failure
C1236A-6	9 -	"	Acc. Withring		260°F	50	3,000			
C1236A-7	9 -	"	Acc. Withring		260°F	45	7,000			
C1236A-8	9 -	"	Acc. Withring		260°F	40				Immediate Tab Failure
C1236A-9	9 -	"	Acc. Withring		260°F	38	1,010,000			
C1236A-10	9 -	"	Acc. Withring		260°F	40	21,000			
C1237A-6	9 - 0.061	"	Acc. Withring		350°F	98	145,000			Tab Failure
C1237A-7	9 - 0.061	"	Acc. Withring		350°F	100	3,000			Failed under Static Ld.
C1237A-8	9 - 0.061	"	Acc. Withring		350°F	108				Tab Failed under Static Load While Coming up to Temperature
C1237A-9	9 - 0.061	"	Acc. Withring		350°F	86.5		2.163 x 10 ⁶	55.4	
C1237A-10	9 - 0.062	"	Acc. Withring		350°F	102				

Specimen No.	Thickness (Plies in.)	Orientation	Exposure Conditions		Test Temp. (°F)	Stress Level (% ultimate)	Rate (cycles)	Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
C1-168-9	6	0°	260°F	1,000 Cycles	RTD	72.5	1,330,000	2.411 × 10 ⁶	105.6	Tab Failure
C1-168-10	6	0°	260°F	1,000 Cycles	RTD	80.5	-	-	-	-
C1-168-11	6	0°	260°F	1,000 Cycles	RTD	93	33,000	-	-	-
C1-168-12	6	0°	260°F	1,000 Cycles	RTD	93	1,000	-	-	-
C1-168-13	6	0°	260°F	1,000 Cycles	RTD	90	2,000	-	-	-
C1-168-14	6	0°	260°F	1,000 Cycles	RTD	80	-	-	-	-
C1-168-15	6	0°	260°F	1,000 Cycles	RTD	75	-	13.0 × 10 ⁶	116.6	Immediate Tab Failure
C1-168-16	6	0°	260°F	1,000 Cycles	RTD	74.5	307,000	-	-	-
C1-168-17	6	0°	260°F	1,000 Cycles	RTD	80	1,000	-	-	-
C1-168-18	6	0°	260°F	1,000 Cycles	RTD	80.5	-	2.056 × 10 ⁶	99.4	Tab Failure
C1-168-19	6	0°	260°F	1,000 Cycles	RTD	74	-	-	-	-
C1-168-20	6	0°	260°F	1,000 Cycles	RTD	63.5	1,000	-	-	-
C1-168-21	6	0°	260°F	1,000 Cycles	RTD	50.5	328,000	-	-	-
C1-168-22	6	0°	260°F	1,000 Cycles	RTD	50	-	-	-	-
C1-168-23	6	0°	260°F	1,000 Cycles	RTD	40	1,000	-	-	-
C1-168-24	6	0°	260°F	1,000 Cycles	RTD	88.5	100	-	-	-
C1-168-25	6	0°	260°F	1,000 Cycles	RTD	70.5	-	-	-	-
C1-168-26	6	0°	260°F	1,000 Cycles	RTD	71	-	-	-	-
C1-168-27	6	0°	260°F	1,000 Cycles	RTD	60	-	-	-	-
C1-168-28	6	0°	260°F	1,000 Cycles	RTD	53	-	-	-	-
C1-168-29	6	0°	260°F	1,000 Cycles	RTD	86.5	2,000	-	-	-
C1-168-30	6	0°	260°F	1,000 Cycles	RTD	77	-	2.34 × 10 ⁶	103.6	Tab Failure
C1-168-31	6	0°	260°F	1,000 Cycles	RTD	91.5	-	-	-	-
C1-168-32	6	0°	260°F	1,000 Cycles	RTD	81.5	301,000	-	-	-
C1-168-33	6	0°	260°F	1,000 Cycles	RTD	86.5	-	-	-	-
C1-168-34	6	0°	260°F	1,000 Cycles	RTD	60.5	-	-	-	-
C1-168-35	6	0°	260°F	1,000 Cycles	RTD	69	910,000	-	-	-
C1-168-36	6	0°	260°F	1,000 Cycles	RTD	64.5	1,000	-	-	-
C1-168-37	6	0°	260°F	1,000 Cycles	RTD	75	767,000	-	-	-
C1-168-38	6	0°	260°F	1,000 Cycles	RTD	67	1,000	-	-	-
C1-168-39	6	0°	260°F	1,000 Cycles	RTD	78	-	2.411 × 10 ⁶	96.1	Tab Failure
C1-168-40	6	0°	260°F	1,000 Cycles	RTD	66.5	-	-	-	-

TABLE XII FATIGUE PROPERTIES SUMMARY -
SPECIMENS 3032P/COMTALIDS 105
GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	PAUSE CONDITIONING	Test Temp. (°F)	Stress Level (ksi)	Cycle to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
C1211A-5	6 - 0.042	0	260°F / 500 Hrs.	260°F	70	-	2.26 x 10 ⁶	86.5	Failed under Static Ld. Tab Failure
C1211A-6	6 - 0.045	0	260°F / 500 Hrs.	260°F	80	-	-	-	Failed under Static Ld. Tab Failure
C1211A-7	6 - 0.043	0	260°F / 500 Hrs.	260°F	75	53,000	-	-	Tab Failure
C1211A-8	6 - 0.044	0	260°F / 500 Hrs.	260°F	78	-	-	-	Immediate Tab Failure
C1211A-9	6 - 0.04	0	260°F / 500 Hrs.	260°F	95	2,000	-	-	Tab Failure
C1211A-10	6 - 0.044	0	260°F / 500 Cyc.	260°F	85	-	2.04 x 10 ⁶	96.9	Tab Failure
C1211A-11	6 - 0.043	0	260°F / 500 Cyc.	260°F	90	-	2.363 x 10 ⁶	73.4	Tab Failure
C1211A-12	6 - 0.041	0	260°F / 500 Cyc.	260°F	100	1,000	-	-	Tab Failure
C1211A-13	6 - 0.045	0	260°F / 500 Cyc.	260°F	95	-	2.48 x 10 ⁶	105.6	Tab Failure
C1211A-14	6 - 0.044	0	260°F / 500 Cyc.	260°F	85	-	-	-	Immediate Tab Failure
C1211A-15	6 - 0.045	0	260°F / 1000 Cyc.	260°F	85	-	-	-	Immediate Tab Failure
C1211A-16	6 - 0.045	0	260°F / 1000 Cyc.	260°F	70	264,000	-	-	Tab Failure
C1211A-17	6 - 0.044	0	260°F / 1000 Cyc.	260°F	65	-	2.053 x 10 ⁶	86.4	Tab Failure
C1211A-18	6 - 0.043	0	260°F / 1000 Cyc.	260°F	75	-	2.543 x 10 ⁶	90.5	Tab Failure
C1211A-19	6 - 0.044	0	260°F / 1000 Cyc.	260°F	70	-	2.04 x 10 ⁶	108.1	Tab Failure
C1211B-1	6 - 0.042	0	350°F / 500 Hrs.	350°F	80	581,000	-	-	Immediate Tab Failure
C1211B-2	6 - 0.044	0	350°F / 500 Hrs.	350°F	85	-	-	-	Failed under Static Ld.
C1211B-3	6 - 0.043	0	350°F / 500 Hrs.	350°F	83	-	-	-	Tab Failure
C1211B-4	6 - 0.042	0	350°F / 500 Hrs.	350°F	82	-	2.392 x 10 ⁶	98.3	Tab Failure
C1211B-5	6 - 0.044	0	350°F / 500 Hrs.	350°F	80	-	7.482 x 10 ⁶	96.7	Tab Failure
C1211B-6	6 - 0.045	0	350°F / 500 Cyc.	350°F	90	848,000	-	-	Tab Failure
C1211B-7	6 - 0.044	0	350°F / 500 Cyc.	350°F	100	69,000	-	-	Immediate Tab Failure
C1211B-8	6 - 0.040	0	350°F / 500 Cyc.	350°F	95	-	-	-	Failed under Static Ld.
C1211B-9	6 - 0.045	0	350°F / 500 Cyc.	350°F	93	-	-	-	Immediate Tab Failure
C1211B-10	6 - 0.045	0	350°F / 1000 Cyc.	350°F	85	-	-	-	Tab Failure
C1211B-11	6 - 0.044	0	350°F / 1000 Cyc.	350°F	80	149,000	-	-	Tab Failure
C1211B-12	6 - 0.046	0	350°F / 1000 Cyc.	350°F	90	1,000	-	-	Tab Failure
C1211B-13	6 - 0.043	0	350°F / 1000 Cyc.	350°F	85	2,000	-	-	Tab Failure
C1211B-14	6 - 0.044	0	350°F / 1000 Cyc.	350°F	59	-	2.126 x 10 ⁶	94.2	Tab Failure
C1211B-15	6 - 0.046	0	350°F / 1000 Cyc.	350°F	76	-	-	-	Tab Failure

TABLE 1. PROPERTIES OF KAPAL
KAPAL FOR COUPLING HNS
KAPAL COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIME CONDITIONING		Test Temp. (°F)	Stress level (psi) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
			Type	Duration						
CL130-1	9 - 0.051	0°	260°F / 500 Hrs.	260°F / 500 Hrs.	RT	145	70	-	-	Immediate Tab Failure
CL130E-1	9 - 0.051	0°	260°F / 500 Hrs.	260°F / 500 Hrs.	RT	126	61	-	-	Immediate Tab Failure
CL130E-3	9 - 0.050	0°	260°F / 500 Hrs.	260°F / 500 Hrs.	RT	107	50	-	-	Immediate Tab Failure
CL130E-4	9 - 0.051	0°	260°F / 500 Hrs.	260°F / 500 Hrs.	RT	73.3	49	-	-	Immediate Tab Failure
CL130E-5	9 - 0.051	0°	260°F / 500 Hrs.	260°F / 500 Hrs.	RT	64	30	-	43.0	Tab Failure
CL130E-6	9 - 0.051	0°	250°F / 500 Hrs.	250°F / 500 Hrs.	RT	92	30	-	-	Immediate failure
CL130E-7	9 - 0.051	0°	350°F / 500 Hrs.	350°F / 500 Hrs.	RT	78.5	40	2,000	-	Possible Tab Failure
CL130E-8	9 - 0.051	0°	350°F / 500 Hrs.	350°F / 500 Hrs.	RT	64	35	-	47.1	Tab Failure
CL130E-9	9 - 0.051	0°	350°F / 500 Hrs.	350°F / 500 Hrs.	RT	75	38	119,000	-	Tab Failure
CL130E-10	9 - 0.051	0°	350°F / 500 Hrs.	350°F / 500 Hrs.	RT	86.5	40	-	-	Immediate Tab Failure
CL131A-1	9 - 0.051	0°	260°F / 500 Cycles	260°F / 500 Cycles	RT	95.7	45	-	-	Immediate Tab Failure
CL131A-2	9 - 0.051	0°	260°F / 500 Cycles	260°F / 500 Cycles	RT	82	46	-	-	Immediate Tab Failure
CL131A-3	9 - 0.051	0°	260°F / 500 Cycles	260°F / 500 Cycles	RT	63.1	30	-	48.2	Tab Failure
CL131A-4	9 - 0.051	0°	260°F / 500 Cycles	260°F / 500 Cycles	RT	72	35	335,000	-	Tab Failure
CL131A-5	9 - 0.051	0°	260°F / 500 Cycles	260°F / 500 Cycles	RT	81.3	38	26,000	-	Tab Failure
CL131A-6	9 - 0.051	0°	260°F / 1000 Cycles	260°F / 1000 Cycles	RTD	135	64	-	-	Tab Failure Under
CL131A-7	9 - 0.051	0°	260°F / 1000 Cycles	260°F / 1000 Cycles	RTD	96	59	-	-	Immediate Tab Failure
CL131A-8	9 - 0.051	0°	260°F / 1000 Cycles	260°F / 1000 Cycles	RTD	86.5	45	-	-	Immediate Tab Failure
CL131A-9	9 - 0.051	0°	260°F / 1000 Cycles	260°F / 1000 Cycles	RTD	57.5	30	-	47.0	Tab Failure
CL131A-10	9 - 0.051	0°	260°F / 1000 Cycles	260°F / 1000 Cycles	RTD	77	40	-	-	Immediate Tab Failure
CL131A-11	9 - 0.051	0°	350°F / 500 Cycles	350°F / 500 Cycles	RTD	114	50	-	-	Immediate Tab Failure
CL131A-12	9 - 0.051	0°	350°F / 500 Cycles	350°F / 500 Cycles	RTD	103	45	1,000	-	Tab Failure
CL131A-13	9 - 0.049	0°	350°F / 500 Cycles	350°F / 500 Cycles	RTD	91.5	40	-	-	Immediate Tab Failure
CL131A-14	9 - 0.048	0°	350°F / 500 Cycles	350°F / 500 Cycles	RTD	80	35	49,000	-	Tab Failure
CL131B-1	9 - 0.051	0°	350°F / 500 Cycles	350°F / 500 Cycles	RTD	68.5	30	-	46.4	Tab Failure
CL131B-2	9 - 0.051	0°	350°F / 1000 Cycles	350°F / 1000 Cycles	RTD	110	45	2,000	-	Immediate Tab Failure
CL131B-3	9 - 0.051	0°	350°F / 1000 Cycles	350°F / 1000 Cycles	RTD	97.5	40	-	52.4	Tab Failure
CL131B-4	9 - 0.049	0°	350°F / 1000 Cycles	350°F / 1000 Cycles	RTD	105	43	-	-	Immediate Tab Failure
CL131B-5	9 - 0.050	0°	350°F / 1000 Cycles	350°F / 1000 Cycles	RTD	102	42	22,000	-	Tab Failure
CL131B-6	9 - 0.049	0°	350°F / 1000 Cycles	350°F / 1000 Cycles	RTD	100	41	1,000	-	Tab Failure
CL131B-7	9 - 0.049	0°	350°F / 1000 Cycles	350°F / 1000 Cycles	RTD	100	41	-	-	Tab Failure

TABLE XIX FATIGUE PROPERTIES SUMMARY -
HPLCULES 3700N/COURTAULUS HNS
CARBONITE COMPOSITES

Specimen Number	Thickness (Piles) (In.)	Orientation	Prior Conditioning Type	Duration	Test Temp. (°F)	Stress Level (% ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
C1240A-1	9 - 0.053	[0/45/135/0/90]s	260°F / 500 Hrs.	260°F / 500 Hrs.	260°F	77	-	-	-	Immediate Tab Failure
C1240A-2	9 - 0.054	"	260°F / 500 Hrs.	260°F / 500 Hrs.	260°F	61.5	-	2.173x10 ⁶	50.3	Tab Failure
C1240A-3	9 - 0.054	"	260°F / 500 Hrs.	260°F / 500 Hrs.	260°F	49.5	1,167,000	-	-	Tab Failure
C1240A-4	9 - 0.054	"	260°F / 500 Hrs.	260°F / 500 Hrs.	260°F	30	2,000	-	-	Tab Failure
C1240A-5	9 - -	"	260°F / 500 Hrs.	260°F / 500 Hrs.	260°F	30	Specimen Broke During Fabrication	-	-	Immediate Tab Failure
C1240A-6	9 - 0.051	"	260°F / 500 Cyc.	260°F / 500 Cyc.	260°F	100	-	-	-	Tab Failure
C1240A-7	9 - 0.054	"	260°F / 500 Cyc.	260°F / 500 Cyc.	260°F	75	-	7.662 x 10 ⁶	48.1	Tab Failure
C1240A-8	9 - 0.053	"	260°F / 500 Cyc.	260°F / 500 Cyc.	260°F	83.5	2,000	-	-	Tab Failure
C1240A-9	9 - 0.054	"	260°F / 500 Cyc.	260°F / 500 Cyc.	260°F	80	115,000	-	-	Tab Failure
C1240A-10	9 - 0.053	"	260°F / 500 Cyc.	260°F / 500 Cyc.	260°F	61.5	1,000	-	-	Tab Failure
C1240B-1	9 - 0.053	"	260°F / 1000 Cyc.	260°F / 1000 Cyc.	260°F	84	1,000	-	-	Tab Failure
C1240B-2	9 - 0.053	"	260°F / 1000 Cyc.	260°F / 1000 Cyc.	260°F	76	-	2.793 x 10 ⁶	52.8	Tab Failure
C1240B-3	9 - 0.054	"	260°F / 1000 Cyc.	260°F / 1000 Cyc.	260°F	84	-	2.396 x 10 ⁶	53.7	Tab Failure
C1240B-4	9 - 0.054	"	260°F / 1000 Cyc.	260°F / 1000 Cyc.	260°F	92.5	1,000	-	-	Tab Failure
C1240B-5	9 - 0.053	"	260°F / 1000 Cyc.	260°F / 1000 Cyc.	260°F	89	-	-	-	Immediate Tab Failure
C1240B-6	9 - 0.054	"	350°F / 500 Hrs.	350°F / 500 Hrs.	350°F	94.5	-	-	-	Immediate Tab Failure
C1240B-7	9 - 0.053	"	350°F / 500 Hrs.	350°F / 500 Hrs.	350°F	85	-	-	-	Tab Failed under Static Load coming to Temp.
C1240B-8	9 - 0.054	"	350°F / 500 Hrs.	350°F / 500 Hrs.	350°F	75.5	-	2.234 x 10 ⁶	50.7	Tab Failure
C1240B-9	9 - 0.054	"	350°F / 500 Hrs.	350°F / 500 Hrs.	350°F	81	-	2.345 x 10 ⁶	47.4	Tab Failure
C1240B-10	9 - -	"	350°F / 500 Hrs.	350°F / 500 Hrs.	350°F	Specimen Broke During Fabrication	-	-	-	Failed under Static Load
C1241A-1	9 - 0.053	"	350°F / 500 Cyc.	350°F / 500 Cyc.	350°F	108.5	-	-	-	Failed under Static Load
C1241A-2	9 - 0.054	"	350°F / 500 Cyc.	350°F / 500 Cyc.	350°F	92	2,000	-	-	Immediate Tab Failure
C1241A-3	9 - 0.056	"	350°F / 500 Cyc.	350°F / 500 Cyc.	350°F	83.5	-	-	-	Immediate Tab Failure
C1241A-4	9 - 0.054	"	350°F / 500 Cyc.	350°F / 500 Cyc.	350°F	80.5	-	-	-	Immediate Tab Failure
C1241A-5	9 - 0.053	"	350°F / 500 Cyc.	350°F / 500 Cyc.	350°F	75	-	-	-	Immediate Tab Failure
C1241A-6	9 - 0.054	"	350°F / 1000 Cyc.	350°F / 1000 Cyc.	350°F	103	-	-	-	Immediate Tab Failure
C1241A-7	9 - 0.056	"	350°F / 1000 Cyc.	350°F / 1000 Cyc.	350°F	86	-	-	-	Immediate Tab Failure
C1241A-8	9 - 0.057	"	350°F / 1000 Cyc.	350°F / 1000 Cyc.	350°F	77.5	-	-	-	Immediate Tab Failure
C1241A-9	9 - 0.054	"	350°F / 1000 Cyc.	350°F / 1000 Cyc.	350°F	60	-	2.459 x 10 ⁶	47.2	Tab Failure
C1241A-10	9 - 0.054	[0/45/135/0/90]s	350°F / 1000 Cyc.	350°F / 1000 Cyc.	350°F	69	-	-	-	Immediate Tab Failure

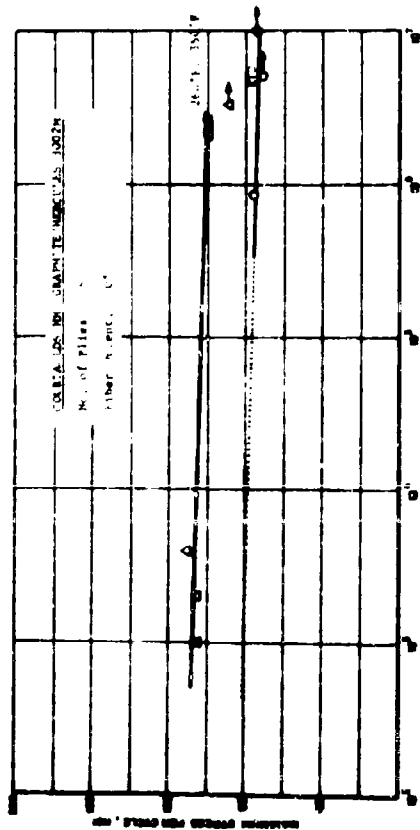


FIG. 42 FATIGUE S-N DIAGRAM FOR GRAPHITE HERCULES 3007N COMPOSITE AT VARIOUS TEMPERATURES

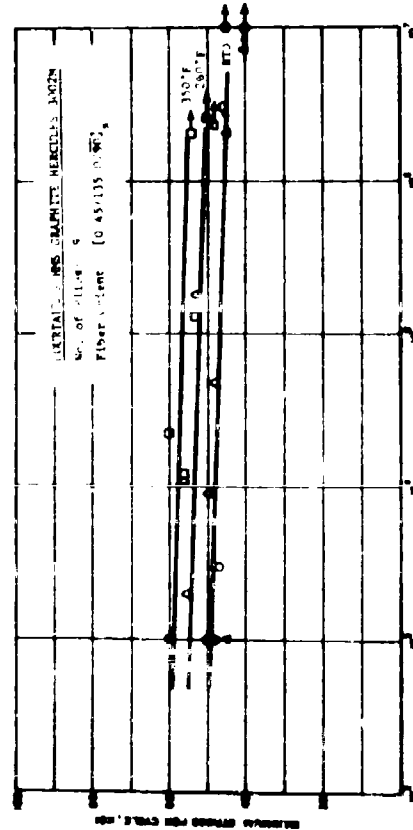


FIG. 43 FATIGUE S-N DIAGRAM FOR GRAPHITE HERCULES 3007N COMPOSITE AT VARIOUS TEMPERATURES

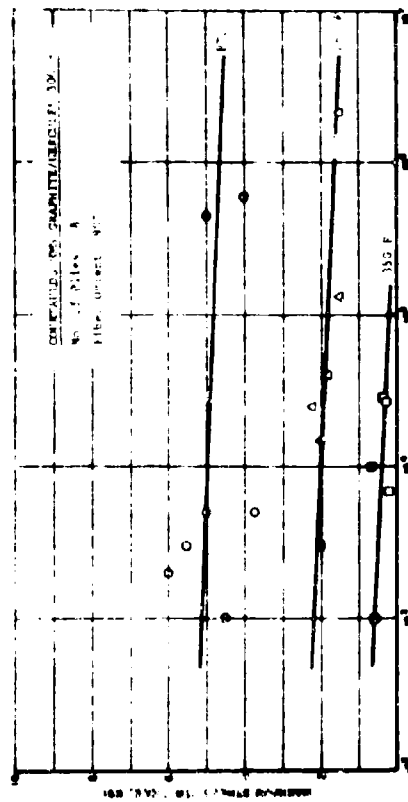


FIG. 44 FATIGUE S-N DIAGRAM FOR GRAPHITE HERCULES 3007N COMPOSITE AT VARIOUS TEMPERATURES

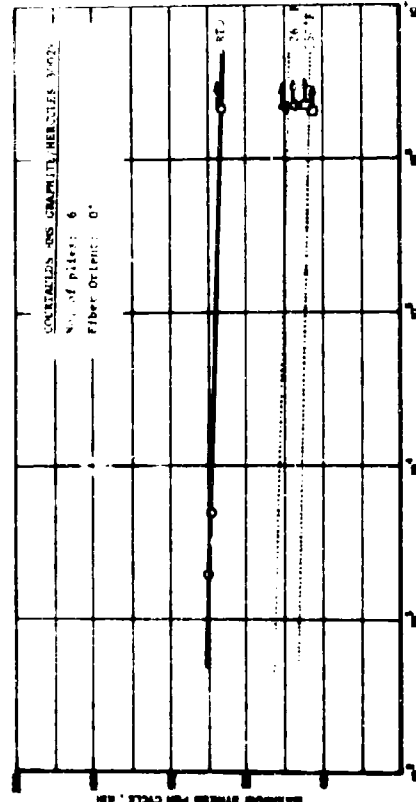


FIG. 45 FATIGUE S-N DIAGRAM FOR GRAPHITE HERCULES 3007N COMPOSITE AT VARIOUS TEMPERATURES

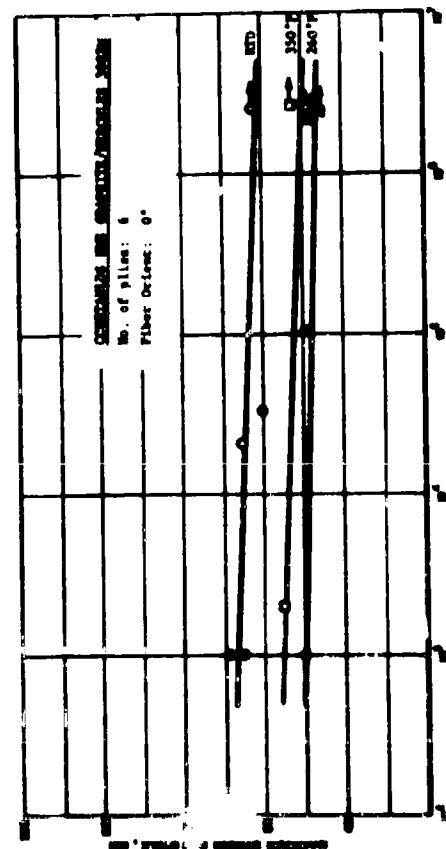


FIG. 477 FAILURE S-N DIAGRAM FOR 0° CARBON/GRAPHITE/MERCERIZED RAYON COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 90% R.H.
 (A = 0.1, $\delta = 1200$ cps)

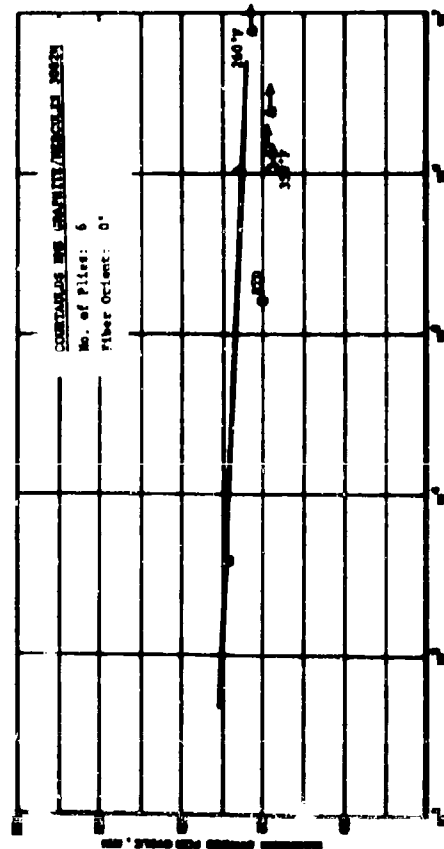


FIG. 476 FAILURE S-N DIAGRAM FOR 0° CARBON/GRAPHITE/MERCERIZED RAYON COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (ACCELERATED WEATHERING)
 (A = 0.1, $\delta = 1200$ cps)

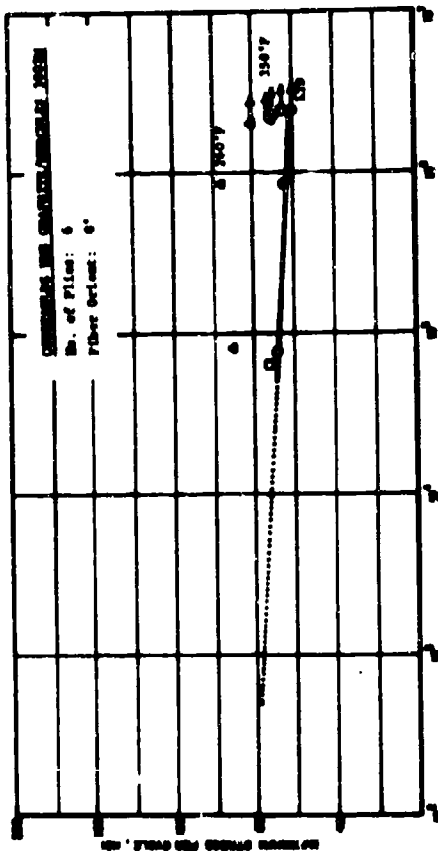


FIG. 478 FAILURE S-N DIAGRAM FOR 0° CARBON/GRAPHITE/MERCERIZED RAYON COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 1 (THERMAL-HUMIDITY CYCLE)
 (A = 0.1, $\delta = 1200$ cps)

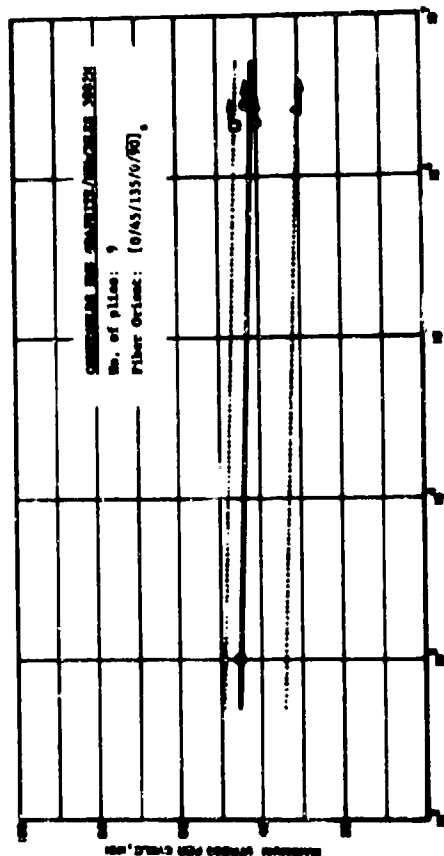


FIG. 480 FAILURE S-N DIAGRAM FOR CARBON/GRAPHITE/MERCERIZED RAYON LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 90% R.H.
 (A = 0.1, $\delta = 1200$ cps)

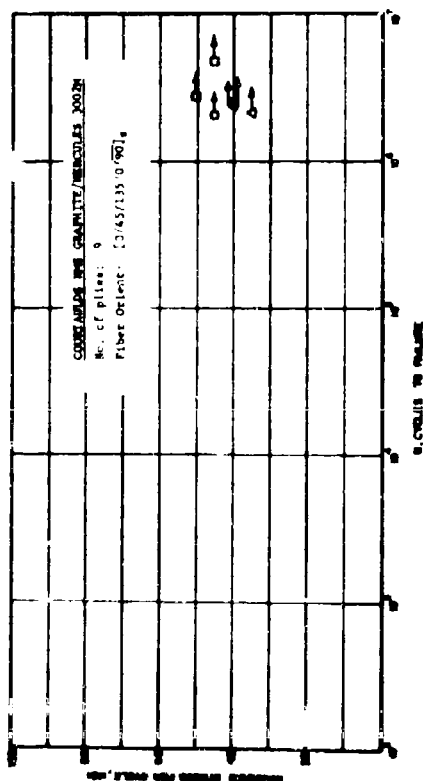


FIG. 461 FATIGUE S-N DIAGRAM FOR COMPOSITES KHS GRAPHITE/HERCULES 3002M (0/45/135/0/90)₉ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 50% RH.
(R = 0.1, $\dot{\epsilon}$ = 1800 cpm)

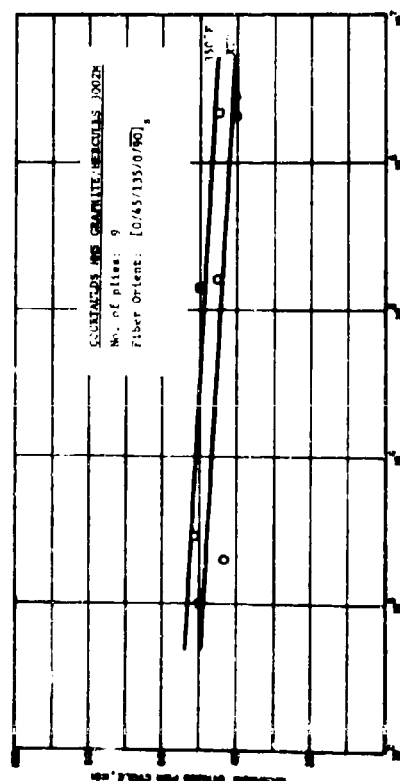


FIG. 462 FATIGUE S-N DIAGRAM FOR COMPOSITES KHS GRAPHITE/HERCULES 3002M (0/45/135/0/90)₉ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 2 (Accelerated Weathering) (R = 0.1, $\dot{\epsilon}$ = 1800 cpm)

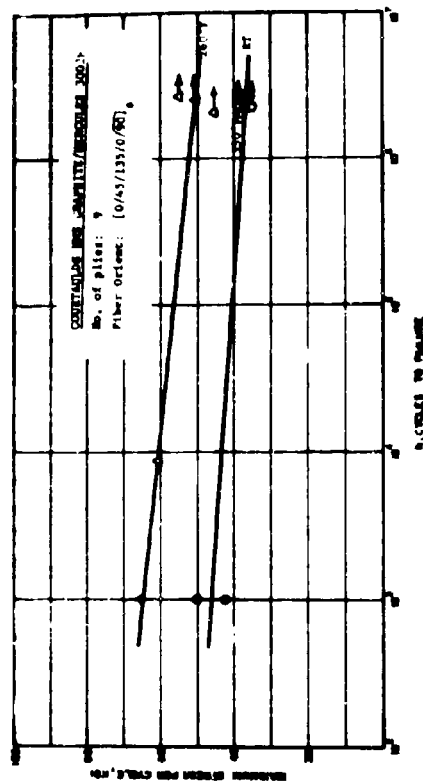


FIG. 463 FATIGUE S-N DIAGRAM FOR COMPOSITES KHS GRAPHITE/HERCULES 3002M (0/45/135/0/90)₉ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER EXPOSURE TO HUMIDITY CYCLE NO. 3 (Accelerated Weathering) (R = 0.1, $\dot{\epsilon}$ = 1800 cpm)

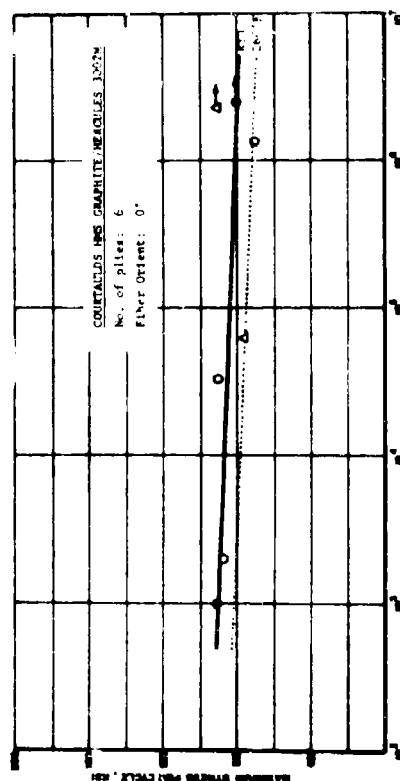


FIG. 464 FATIGUE S-N DIAGRAM FOR COMPOSITES KHS GRAPHITE/HERCULES 3002M COMPOSITE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 26°C (R = 0.1, $\dot{\epsilon}$ = 1800 cpm)

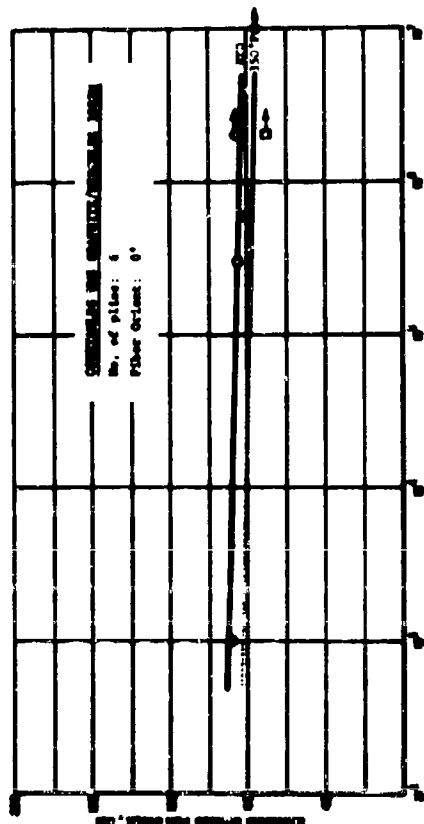


FIG. 445 PLOT OF S-N DIAGRAM FOR CORBION/RESIN 3020 COMPOSITE, TESTED AT 150°F. (R = 0.1, $\sigma = 1000$ cps)

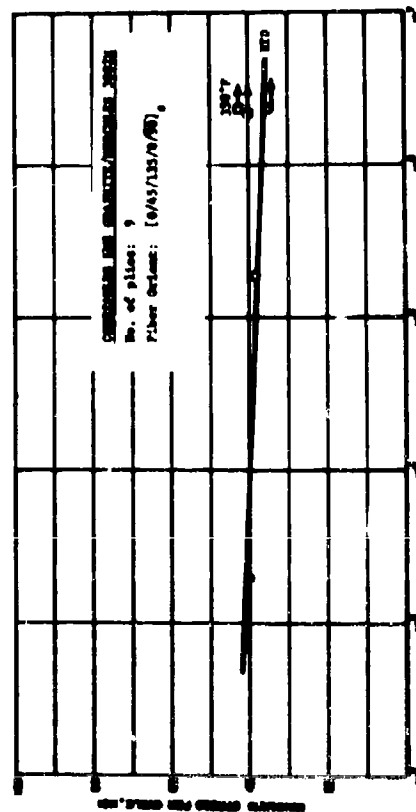


FIG. 447 PLOT OF S-N DIAGRAM FOR CORBION/RESIN 3020 COMPOSITE, TESTED AT 150°F. (R = 0.1, $\sigma = 1000$ cps)

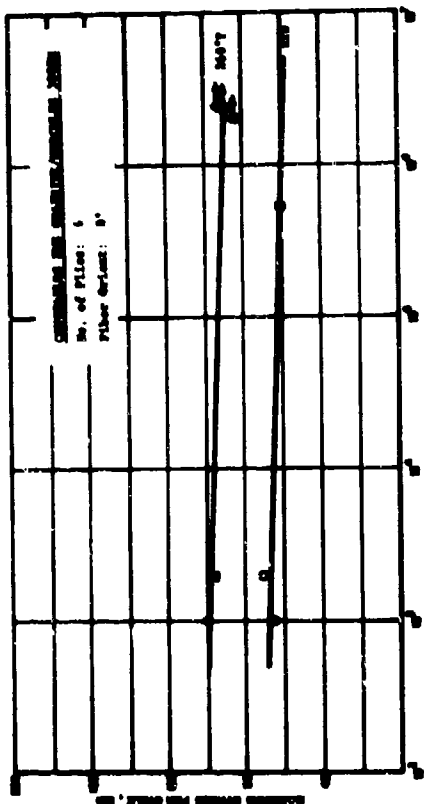


FIG. 446 PLOT OF S-N DIAGRAM FOR CORBION/RESIN 3020 COMPOSITE, TESTED AT 260°F. (R = 0.1, $\sigma = 1000$ cps)

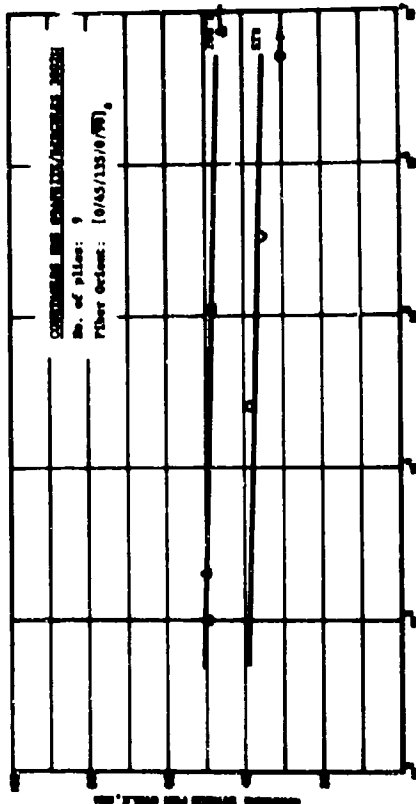


FIG. 448 PLOT OF S-N DIAGRAM FOR CORBION/RESIN 3020 COMPOSITE, TESTED AT 260°F. (R = 0.1, $\sigma = 1000$ cps)

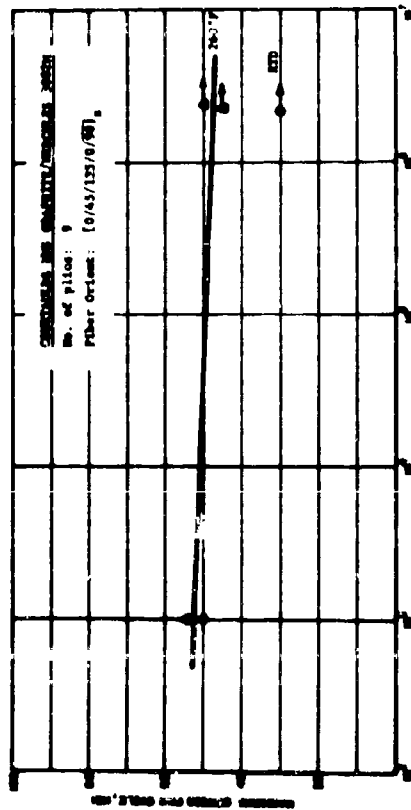


FIG. 430 S-N DIAGRAM FOR 0° CARBON/GRAPHITE/KEVLAR 300N [0.43/135/0/93]
 LAYERS, TESTED AT VARIOUS TEMPERATURES AFTER 1500 CYCLES EXPOSURE TO 340°F
 ($\sigma = 0.1$, $\phi = 1800$ cps)

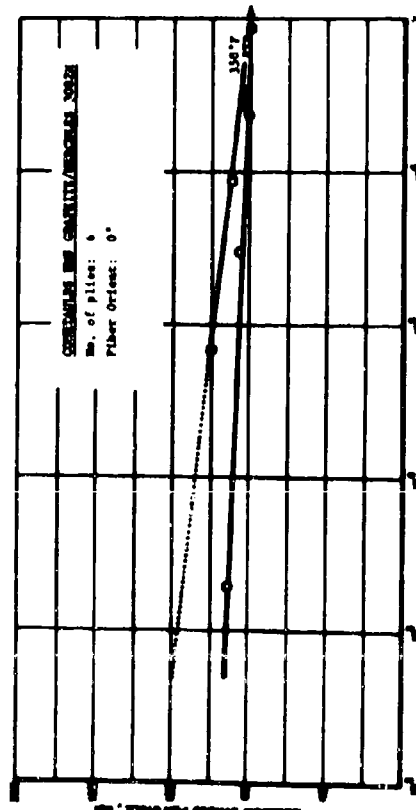


FIG. 431 S-N DIAGRAM FOR 0° CARBON/GRAPHITE/KEVLAR 300N COMPOSITE,
 TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 350°F

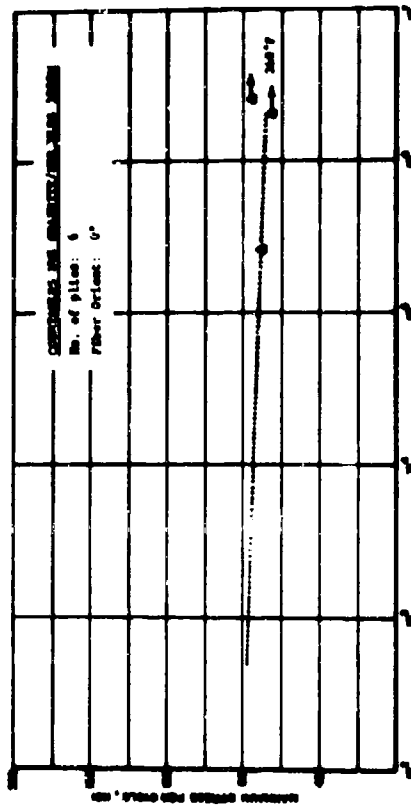


FIG. 432 S-N DIAGRAM FOR 0° CARBON/GRAPHITE/KEVLAR 300N COMPOSITE, TESTED
 AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 340°F

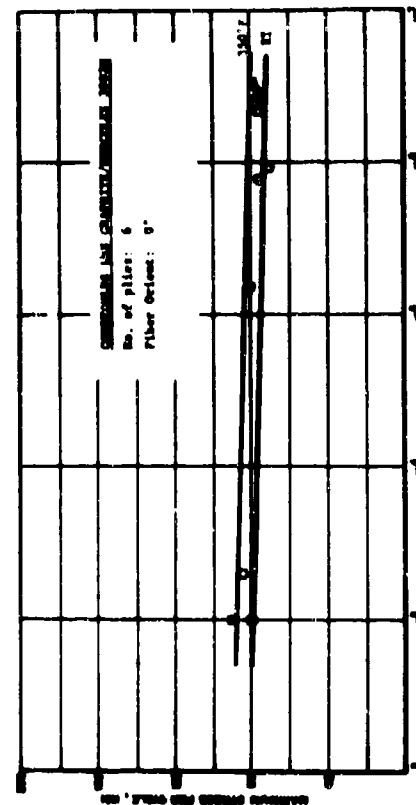


FIG. 433 S-N DIAGRAM FOR 0° CARBON/GRAPHITE/KEVLAR 300N COMPOSITE, TESTED
 AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F
 ($\sigma = 0.1$, $\phi = 1800$ cps)

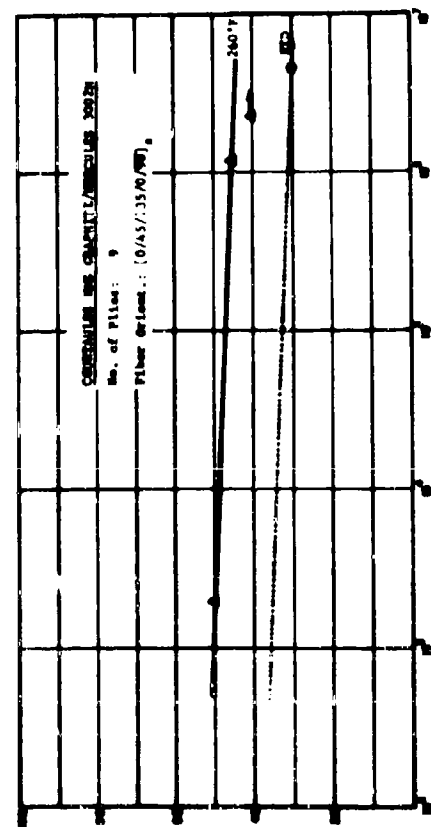


Fig. 493 S-N DIAGRAM FOR CONTINUOUS AND GRANITIC/HERCULES 3007H [0/45/-35/0/90]₂ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 350°F (R = 0.1, $\sigma = 1000$ cps)

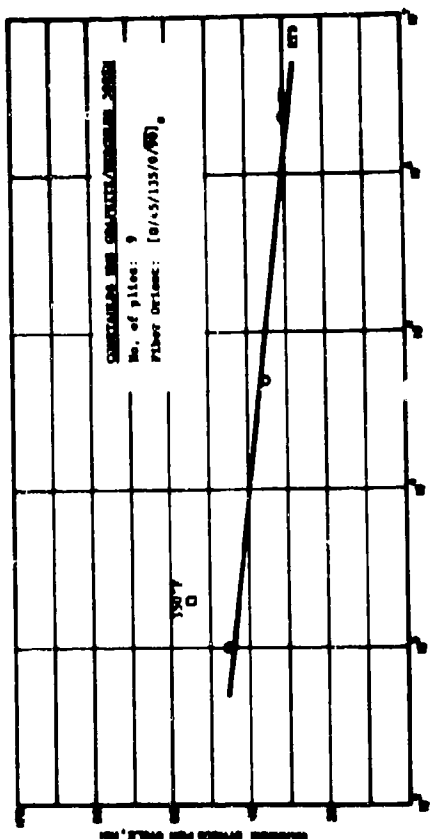


Fig. 494 S-N DIAGRAM FOR CONTINUOUS AND GRANITIC/HERCULES 3007H [0/45/135/0/90]₂ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 350°F (R = 0.1, $\sigma = 1000$ cps)

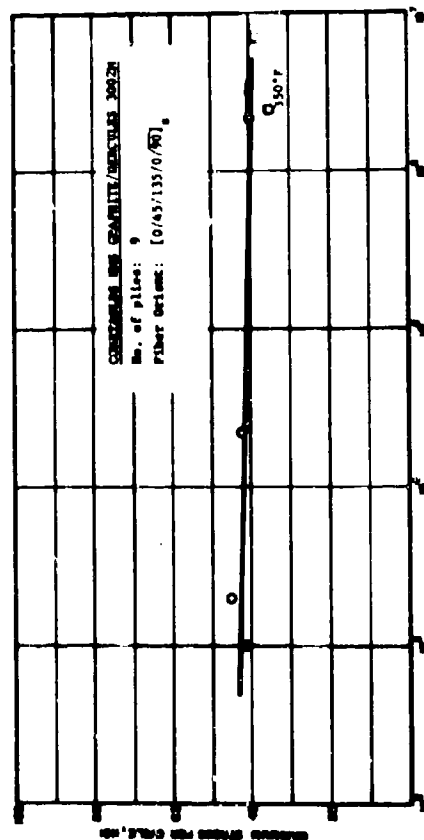


Fig. 495 S-N DIAGRAM FOR CONTINUOUS AND GRANITIC/HERCULES 3007H [0/45/135/0/90]₂ LAMINATE, TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F (R = 0.1, $\sigma = 1000$ cps)

TABLE XX CRIMP AND STRESS FAILURE PROPERTIES
SUMMARY - HERCULES 30/20 COUNTERS
HVS - GRAPHITE COMPOSITE

Specimen No. Ser	Thickness (Plies) (in.)	Orientation	PULSE CONDITIONING		Test Temp. (°F)	Stress Level (% ult) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
C12.7B-11	6	0°	None		260°F	98	.008	-	Failed at tab
C12.7B-12	6	0°	None		260°F	98	.016	-	
C12.7B-13	6	0°	None		260°F	96	.01	-	failed at tab
C12.7B-14	6	0°	None		260°F	96	.008	-	failed at tab
C12.7B-15	6	0°	None		260°F	94	.016	-	
C12.7B-16	6	0°	None		260°F	94	.008	-	failed at tab
C12.7B-17	6	0°	None		260°F	92	.5	-	failed at tab
C12.7B-18	6	0°	None		260°F	84	.008	-	failed at tab
C12.7B-19	6	0°	None		260°F	82	.033	-	Tab Area Failure
C12.7B-20	6	0°	None		260°F	80	.008	-	Tab Area Failure
C12.8A-1	6	0°	None		350°F	94	.05	-	
C12.8A-2	6	0°	None		350°F	96	1.3	-	
C12.8A-3	6	0°	None		350°F	98	6.5	-	
C12.8A-4	6	0°	None		350°F	92	.82	-	
C12.8A-5	6	0°	None		350°F	90	.32	-	
C12.8A-6	6	0°	None		350°F	88	38.7	-	
C12.8A-7	6	0°	None		350°F	86	926	-	Strain Gage Failed
C12.8A-8	6	0°	None		350°F	84	96.6	-	Strain gage failed after 1 broke
C12.8A-9	6	0°	None		350°F	82	94.3	-	Strain gage Failed
C12.8A-10	6	0°	None		350°F	80	165	-	
C12.7-13	8	90°	None		260°F	35	1.65	-	
C12.7-14	8	90°	None		260°F	50	.008	-	
C12.7-15	8	90°	None		260°F	45	2.13	-	Strain gage failed
C12.7-16	8	90°	None		260°F	90	4.26	-	Failed during loading
C12.7-17	8	90°	None		260°F	53	2.50	-	
C12.7-18	8	90°	None		260°F	43	2.2.03	-	
C12.3-1	8	90°	None		260°F	47	2.22	-	Immediate failure
C12.3-2	8	90°	None		260°F	58	2.74	-	Failed during loading
C12.3-3	8	90°	None		260°F	40	.89	-	
C12.3-4	8	90°	None		260°F	55	2.60	-	

Specimen Number	Thickness (Plating) (In.)
1	0.000
2	0.000
3	0.000
4	0.000
5	0.000
6	0.000
7	0.000
8	0.000
9	0.000
10	0.000
11	0.000
12	0.000
13	0.000
14	0.000
15	0.000
16	0.000
17	0.000
18	0.000
19	0.000
20	0.000
21	0.000
22	0.000
23	0.000
24	0.000
25	0.000
26	0.000
27	0.000
28	0.000
29	0.000
30	0.000
31	0.000
32	0.000
33	0.000
34	0.000
35	0.000
36	0.000
37	0.000
38	0.000
39	0.000
40	0.000
41	0.000
42	0.000
43	0.000
44	0.000
45	0.000
46	0.000
47	0.000
48	0.000
49	0.000
50	0.000
51	0.000
52	0.000
53	0.000
54	0.000
55	0.000
56	0.000
57	0.000
58	0.000
59	0.000
60	0.000
61	0.000
62	0.000
63	0.000
64	0.000
65	0.000
66	0.000
67	0.000
68	0.000
69	0.000
70	0.000
71	0.000
72	0.000
73	0.000
74	0.000
75	0.000
76	0.000
77	0.000
78	0.000
79	0.000
80	0.000
81	0.000
82	0.000
83	0.000
84	0.000
85	0.000
86	0.000
87	0.000
88	0.000
89	0.000
90	0.000
91	0.000
92	0.000
93	0.000
94	0.000
95	0.000
96	0.000
97	0.000
98	0.000
99	0.000
100	0.000

Specimen Number	Thickness (Pls) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (ult)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
C1235A-5	8	0	None		350°F	85	4.52	-	Strain gage failed during loading
C1235A-6	8	0	None		350°F	62	3.29	-	Failed during loading
C1235A-7	8	0	None		350°F	46	4.52	-	Failed during loading
C1235A-8	8	0	None		350°F	71	4.52	-	Failed during loading
C1235A-9	8	0	None		350°F	97	4.52	-	Failed during loading
C1235A-10	8	0	None		350°F	85	4.52	-	Failed during loading
C1235A-11	8	0	None		350°F	84	4.52	-	Failed during loading
C1235A-12	8	0	None		350°F	84	4.52	-	Immediate failure
C1235A-13	8	0	None		350°F	97	4.52	-	Failed during loading
C1235A-14	8	0	None		350°F	65	3.45	-	Strain gage failed
C1235A-15	8	0	None		260°F	94	54.3	-	Oven overheated after 666 hrs.
C1235A-16	8	0	None		260°F	94	53.2	-	Strain gage failed
C1235A-17	8	0	None		260°F	94	52.1	-	
C1235A-18	8	0	None		260°F	90	49.9	-	
C1235A-19	8	0	None		260°F	90	49.9	-	
C1235A-20	8	0	None		260°F	92	51	-	
C1235A-21	8	0	None		260°F	96	54.2	-	
C1235A-22	8	0	None		260°F	94	52.1	-	
C1235A-23	8	0	None		260°F	96	53.2	-	
C1235A-24	8	0	None		260°F	98	54.3	-	
C1235A-25	8	0	None		350°F	98	58.7	-	
C1235A-26	8	0	None		350°F	96	57.7	-	
C1235A-27	8	0	None		350°F	92	53.3	-	
C1235A-28	8	0	None		350°F	90	54.1	-	
C1235A-29	8	0	None		350°F	94	56.5	-	
C1235A-30	8	0	None		350°F	88	52.9	-	
C1235A-31	8	0	None		350°F	86	51.7	-	
C1235A-32	8	0	None		350°F	84	50.2	-	
C1235A-33	8	0	None		350°F	96	57.7	-	
C1235A-34	8	0	None		350°F	98	58.7	-	

TABLE XX CREEP AND STRESS RUPTURE PROPERTIES
SUMMARY - HERCULES 3007H CARBONFIBER
HNS - GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% ult) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
C1248-1	6	0°	98° RH	500 Hrs.	260°F	90	98.1	1030	Tab failure
C1248-2	6	0°	98° RH	500 Hrs.	260°F	94	102	-	Tab failure - broke during loading
C1248-3	6	0°	98° RH	500 Hrs.	260°F	92	100	-	Tab failure - broke during loading
C1248-4	6	0°	98° RH	500 Hrs.	260°F	96	105	-	Tab failure - broke during loading
C1248-5	6	0°	98° RH	500 Hrs.	260°F	98	107	-	Tab failure - broke during loading
C1248-6	6	0°	98° RH	500 Hrs.	350°F	88	95.9	-	Tab failure - broke during loading
C1248-7	6	0°	98° RH	500 Hrs.	350°F	86	93.7	-	Tab failure - broke during loading
C1248-8	6	0°	98° RH	500 Hrs.	350°F	85	92.6	-	Tab failure - broke during loading
C1248-9	6	0°	98° RH	500 Hrs.	350°F	83	90.4	-	Tab failure - broke during loading
C1248-10	6	0°	98° RH	500 Hrs.	350°F	81	88.3	-	Tab failure - broke during loading
C12098-15	6	0°	98° RH	1000 Hrs.	260°F	-	-	-	Broken during Conditioning
C12098-16	6	0°	98° RH	1000 Hrs.	260°F	-	-	-	Broken during Conditioning
C12098-17	6	0°	98° RH	1000 Hrs.	260°F	-	-	-	Broken during Conditioning
C12098-18	6	0°	98° RH	1000 Hrs.	260°F	-	-	-	Broken during Conditioning
C12098-19	6	0°	98° RH	1000 Hrs.	260°F	-	-	-	Broken during Conditioning
C1210A-5	6	0°	98° RH	1000 Hrs.	350°F	-	-	-	Broken during Conditioning
C1210A-6	6	0°	98° RH	1000 Hrs.	350°F	-	-	-	Broken during Conditioning
C1210A-7	6	0°	98° RH	1000 Hrs.	350°F	-	-	-	Broken during Conditioning
C1210A-8	6	0°	98° RH	1000 Hrs.	350°F	-	-	-	Broken during Conditioning
C1210A-9	6	0°	98° RH	1000 Hrs.	350°F	-	-	-	Broken during Conditioning
C1248-11	6	0°	Thermo-Humidity Cycle		260°F	-	-	-	Broken in Conditioning
C1248-12	6	0°	Thermo-Humidity Cycle		260°F	-	-	-	Broken in Conditioning
C1248-13	6	0°	Thermo-Humidity Cycle		260°F	-	-	-	Broken in Conditioning
C1248-14	6	0°	Thermo-Humidity Cycle		260°F	-	-	-	Broken in Conditioning
C1248-15	6	0°	Thermo-Humidity Cycle		260°F	-	-	-	Broken in Conditioning
C1248-16	6	0°	Thermo-Humidity Cycle		350°F	-	-	-	Broken in Conditioning
C1248-17	6	0°	Thermo-Humidity Cycle		350°F	-	-	-	Broken in Conditioning
C1248-18	6	0°	Thermo-Humidity Cycle		350°F	-	-	-	Broken in Conditioning
C1248-19	6	0°	Thermo-Humidity Cycle		350°F	-	-	-	Broken in Conditioning
C1248-20	6	0°	Thermo-Humidity Cycle		350°F	-	-	-	Broken in Conditioning

TABLE XA CREEP AND STRESS RUPTURE PROPERTIES
SUMMARY - HERCULES 3002M C0 HTAULDS
HNS - GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (% ult) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
CI2098-20	6	0	Acc. Wthrg.		260°F	88	117	-	Oven overheated
CI210A-1	6	0	Acc. Wthrg.		260°F	86	114	2.8	
CI210A-2	6	0	Acc. Wthrg.		260°F	80	106	1000	
CI210A-3	6	0	Acc. Wthrg.		260°F	92	109	1001	
CI210A-4	6	0	Acc. Wthrg.		260°F	84	111.5	-	
CI210A-10	6	0	Acc. Wthrg.		350°F	-	-	-	Broken during Conditioning
CI210A-11	6	0	Acc. Wthrg.		350°F	-	-	-	Broken during Conditioning
CI210A-12	6	0	Acc. Wthrg.		350°F	-	-	-	Broken during Conditioning
CI210A-13	6	0	Acc. Wthrg.		350°F	-	-	-	Broken during Conditioning
CI210A-14	6	0	Acc. Wthrg.		350°F	-	-	-	Broken during Conditioning
CI249-1	9	0/45/135/0/90°	98% RH	500 Hrs.	260°F	-	-	-	Broken during Conditioning
CI249-2	9	"	98% RH	500 Hrs.	260°F	-	-	-	Broken during Conditioning
CI249-3	9	"	98% RH	500 Hrs.	260°F	-	-	-	Broken during Conditioning
CI249-4	9	"	98% RH	500 Hrs.	260°F	-	-	-	Broken during Conditioning
CI249-5	9	"	98% RH	500 Hrs.	260°F	-	-	-	Broken during Conditioning
CI249-6	9	"	98% RH	500 Hrs.	350°F	-	-	-	Broken during Conditioning
CI249-7	9	"	98% RH	500 Hrs.	350°F	-	-	-	Broken during Conditioning
CI249-8	9	"	98% RH	500 Hrs.	350°F	-	-	-	Broken during Conditioning
CI249-9	9	"	98% RH	500 Hrs.	350°F	-	-	-	Broken during Conditioning
CI249-10	9	0/45/135/0/90°	98% RH	500 Hrs.	350°F	-	-	-	Broken during Conditioning
CI237B-1	9	0/45/135/0/90°	98% RH	1000 Hrs.	260°F	96	53.1	1000	
CI237B-2	9	"	98% RH	1000 Hrs.	260°F	90	49.8	1000	
CI237B-3	9	"	98% RH	1000 Hrs.	260°F	98	54.2	-	
CI237B-4	9	"	98% RH	1000 Hrs.	260°F	97	53.7	1000	
CI237B-5	9	"	98% RH	1000 Hrs.	260°F	99	54.8	1000	
CI238A-1	9	"	98% RH	1000 Hrs.	350°F	90	39.0	1000	
CI238A-2	9	"	98% RH	1000 Hrs.	350°F	93	40.3	1000	
CI238A-3	9	"	98% RH	1000 Hrs.	350°F	98	42.5	1000	
CI238A-4	9	"	98% RH	1000 Hrs.	350°F	96	41.6	1000	
CI238A-5	9	0/45/135/0/90°	98% RH	1000 Hrs.	350°F	95	41.2	1000	

Tab failure - broke during loading

TABLE XX CREEP AND STRESS RUPTURE PROPERTIES
SUMMARY - HERCULES 3002M CONTRAULDS
HMS - GRAPHITE COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientat on	PRIOR CONDITIONING		Test Temp. (°F)	Stress Level (ksi) (ult)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
			Type	Duration					
C1249-11	0.068	0°/45°/135/0° 90°	Thermo-Humidity Cycle		260°F	-	-	-	Broke during conditioning
C1249-12	0.066	"	Thermo-Humidity Cycle		260°F	-	-	-	Broke during conditioning
C1249-13	0.067	"	Thermo-Humidity Cycle		260°F	-	-	-	Broke during conditioning
C1249-14	0.067	"	Thermo-Humidity Cycle		260°F	-	-	-	Broke during conditioning
C1249-15	0.067	"	Thermo-Humidity Cycle		260°F	-	-	-	Broke during conditioning
C1249-16	0.066	"	Thermo-Humidity Cycle		350°F	-	-	-	Broke during conditioning
C1249-17	0.066	"	Thermo-Humidity Cycle		350°F	-	-	-	Broke during conditioning
C1249-18	0.067	"	Thermo-Humidity Cycle		350°F	-	-	-	Broke during conditioning
C1249-19	0.066	"	Thermo-Humidity Cycle		350°F	-	-	-	Broke during conditioning
C1249-20	0.066	0°/45°/135° 90°	Thermo-Humidity Cycle		350°F	-	-	-	Broke during conditioning
C1237B-6	0.063	0°/45°/135° 90°	Acc. Wthrg.		260°F	96	55.3	-	Tab failure - broke during loading
C1237B-7	0.066	"	Acc. Wthrg.		260°F	90	51.9	259.7	Tab failure
C1237B-8	0.065	"	Acc. Wthrg.		260°F	95	52.9	-	1000
C1237B-9	0.066	"	Acc. Wthrg.		260°F	94	54.2	-	1000
C1237B-10	0.066	"	Acc. Wthrg.		260°F	97	55.9	-	Tab failure
C123BA-6	0.064	"	Acc. Wthrg.		350°F	96	48.0	-	-
C123BA-7	0.066	"	Acc. Wthrg.		350°F	98	49.0	1000	-
C123BA-8	0.066	"	Acc. Wthrg.		350°F	93	46.5	1000	-
C123BA-9	0.065	"	Acc. Wthrg.		350°F	90	45.1	1000	-
C123BA-10	0.065	0°/45°/135° 90°	Acc. Wthrg.		350°F	100	50.1	-	-
C1211B-16	0.045	0°	260°F/500 Hrs.		260°F	98	126.4	-	Broke during loading and split
C1211B-17	0.045	0°	260°F/500 Hrs.		260°F	96	123.8	-	Broke during loading and split
C1211B-18	0.044	0°	260°F/500 Hrs.		260°F	94	121.2	-	Broke during loading and split
C1211B-19	0.047	0°	260°F/500 Hrs.		260°F	92	118.6	-	Broke during loading and split
C1211B-20	0.045	0°	260°F/500 Hrs.		260°F	90	116.1	-	Broke during loading 1/4" from tab
C1212A-1	0.048	0°	260°F/500 Hrs.		330°F	85	101.1	-	Broke during loading and split
C1212A-2	0.048	0°	260°F/500 Hrs.		330°F	78	92.3	1000	-
C1212A-3	0.046	0°	260°F/500 Hrs.		330°F	80	95.2	-	Tab failure - broke during loading
C1212A-4	0.046	0°	260°F/500 Hrs.		330°F	79	94.0	-	Tab failure - broke during loading
C1212A-5	0.046	0°	260°F/500 Hrs.		330°F	80	95.2	-	Tab failure - broke during loading

TABLE IX CREEP AND STRESS RUPTURE PROPERTIES
S. - AF - 6, 400°C, 300,000 PSI, 100,000 HRS
S. - RADIATION CROSSED

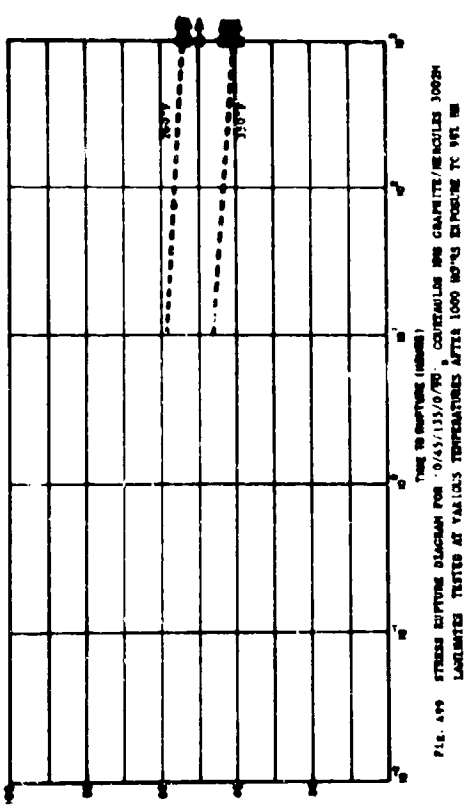
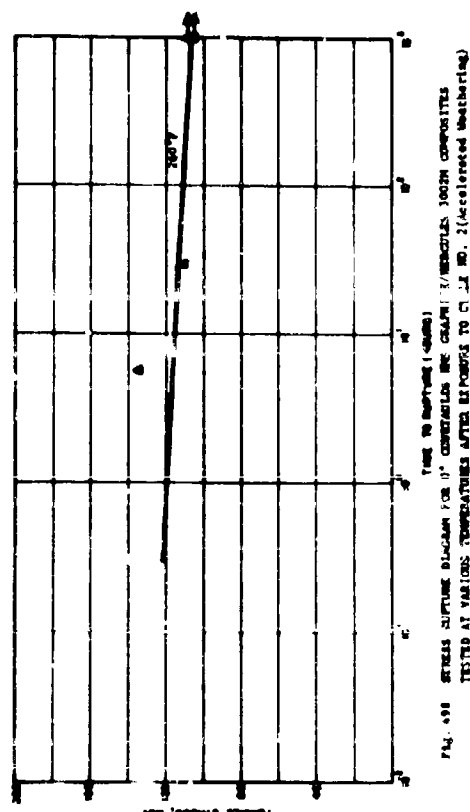
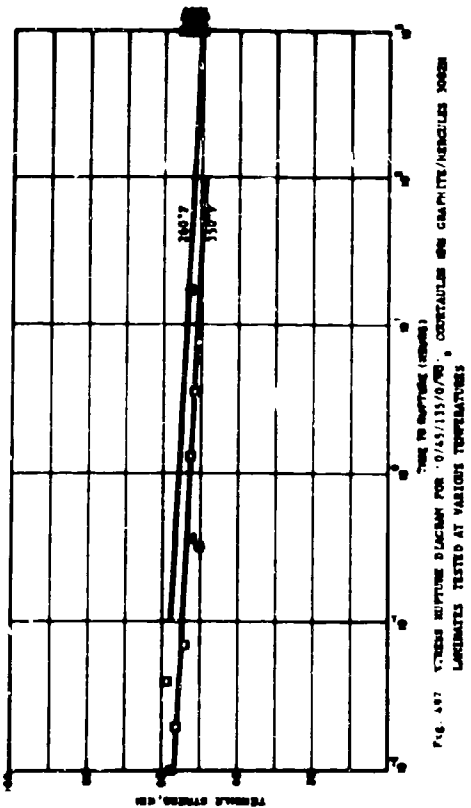
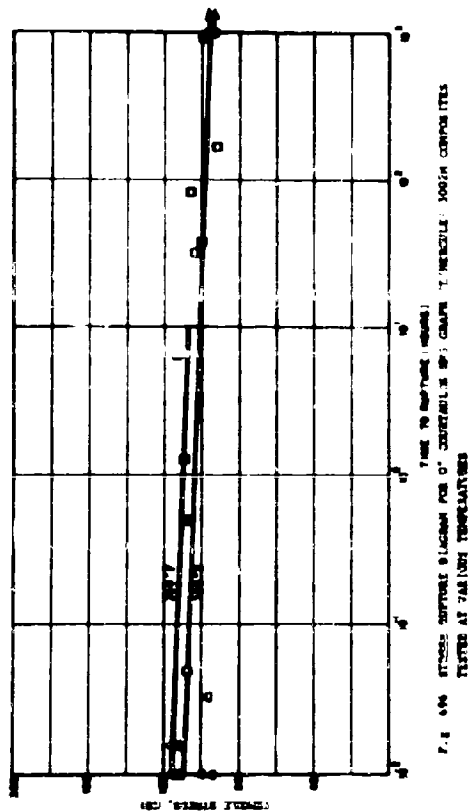
Specimen Number	Thickness (in.)	Deflection	Type	Duration	Test Temp. (°F)	Stress Level (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
C1212A-6	6	0.046	0°	260°F/1000 cye.	260°F	90	104.6	-	Tab failure - broke during loading
C1212A-7	6	0.047	0°	260°F/1000 cye.	260°F	85	98.6	-	Broke - double tab failure
C1212A-8	6	0.046	0°	260°F/1000 cye.	260°F	86	99.8	-	Broke during loading 1/4" from tab
C1212A-9	6	0.046	0°	260°F/1000 cye.	260°F	85	98.6	-	Broke - double tab failure
C1212A-10	6	0.047	0°	260°F/1000 cye.	260°F	83	96.3	1000	-
C1212A-11	6	0.048	0°	260°F/1000 cye.	350°F	85	100.1	1000	Broke during loading - double fail.
C1212A-12	6	0.048	0°	260°F/1000 cye.	350°F	86	101.2	1000	-
C1212A-13	6	0.050	0°	260°F/1000 cye.	350°F	85	100.1	1000	-
C1212A-14	6	0.047	0°	260°F/1000 cye.	350°F	86	101.1	16.4	Tab failure
C1212A-15	6	0.049	0°	260°F/1000 cye.	350°F	85	100.1	-	Tab failure - broke during loading
C1212B-6	6	0.046	0°	350°F/1000 cye.	260°F	83	93.8	-	Tab failure - broke during loading
C1212B-7	6	0.046	0°	350°F/1000 cye.	260°F	84	94.9	-	Broke during loading - double fail.
C1212B-8	6	0.044	0°	350°F/1000 cye.	260°F	86	97.2	-	Broke during loading - double fail.
C1212B-9	6	0.045	0°	350°F/1000 cye.	260°F	88	99.4	1000	-
C1212B-10	6	0.047	0°	350°F/1000 cye.	260°F	90	101.7	-	Tab failure - broke during loading
C1212B-11	6	0.047	0°	350°F/1000 cye.	350°F	85	109.6	.05	Tab failure
C1212B-12	6	0.046	0°	350°F/1000 cye.	350°F	90	116	-	Tab failure - broke during loading
C1212B-13	6	0.042	0°	350°F/1000 cye.	350°F	84	104	1.7	Tab area failure
C1212B-14	6	0.041	0°	350°F/1000 cye.	350°F	80	103	-	Tab failure - broke during loading
C1212B-15	6	0.043	0°	350°F/1000 cye.	350°F	78	100.6	1000	-

TABLE XX CREEP AND STRESS RUPTURE PROPERTIES
SIMPART - MERCURY 300/400 KTAU
100 - CHARPIT COMPRESSES

Specimen Number	Thickness (Plies) (In.)	Orientation	PRICE LOADING INC Type	Test Temp. (°F)	Stress Level (Cult) (Ksi.)	Time to failure (hours)	Time Applied without failure (hours)	Comment
1212A-16	6	0°	350°F/500 Hrs.	260°F	-	-	-	Delaminated in Conditioning
1212A-17	6	0°	350°F/500 Hrs.	260°F	-	-	-	Delaminated in Conditioning
1212A-18	6	0°	350°F/500 Hrs.	260°F	-	-	-	Delaminated in Conditioning
1212A-19	6	0°	350°F/500 Hrs.	260°F	-	-	-	Delaminated in Conditioning
1212A-20	6	0°	350°F/500 Hrs.	260°F	-	-	-	Delaminated in Conditioning
1212B-1	6	0°	350°F/500 Hrs.	300°F	44.1	325	-	Strain gage failed after 1 hour
1212B-2	6	0°	350°F/500 Hrs.	300°F	72.1	105	-	
1212B-3	6	0°	350°F/500 Hrs.	300°F	76.1	438	1000	
1212B-4	6	0°	350°F/500 Hrs.	300°F	81.1	438	-	
1212B-5	6	0°	350°F/500 Hrs.	300°F	81.1	1016	-	
1241B-1	9	0°	260°F/500 Hrs.	260°F	40	64.7	-	Tab Failure
1241B-2	9	0°	260°F/500 Hrs.	260°F	42	106	-	Tab Failure
1241B-3	9	0°	260°F/500 Hrs.	260°F	44	237	-	Tab Failure
1241B-4	9	0°	260°F/500 Hrs.	260°F	46	131	-	Tab Failure - broke during loading
1241B-5	9	0°	260°F/500 Hrs.	260°F	46	45.1	-	
1241B-6	9	0°	260°F/500 Hrs.	350°F	90	42.5	-	Broke during loading
1241B-7	9	0°	260°F/500 Hrs.	350°F	92	140.4	-	Broke in middle
1241B-8	9	0°	260°F/500 Hrs.	350°F	88	289	-	Strain Gage Failed
1241B-9	9	0°	260°F/500 Hrs.	350°F	92	133	-	Tab failure
1241B-10	9	0°	260°F/500 Hrs.	350°F	97	45.8	1000	
1242B-1	9	0°	350°F/500 Hrs.	260°F	-	-	-	
1242B-2	9	0°	350°F/500 Hrs.	260°F	-	-	-	
1242B-3	9	0°	350°F/500 Hrs.	260°F	-	-	-	Broke during conditioning
1242B-4	9	0°	350°F/500 Hrs.	260°F	-	-	-	Broke during conditioning
1242B-5	9	0°	350°F/500 Hrs.	260°F	-	-	-	Broke during conditioning
1242B-6	9	0°	350°F/500 Hrs.	350°F	90	44.6	1000	
1242B-7	9	0°	350°F/500 Hrs.	350°F	93	49.2	1000	
1242B-8	9	0°	350°F/500 Hrs.	350°F	97	51.3	202.4	Broke in middle
1242B-9	9	0°	350°F/500 Hrs.	350°F	95	50.2	1000	
1242B-10	9	0°	350°F/500 Hrs.	350°F	99	52.3	1000	

TAB. F XX CREEP AND STRESS RUPTURE PROPERTIES
SUMMARY - MERCURY 300M COMPAUNDS
HMS - (GRAPHITE COMPOSITES)

Specimen Number	Thickness (in.)	Orientation	Prior Conditioning Type	Duration	Test Temp. (°F)	Stress Level (ksi) (alt)	Time to Failure (Hours)	Time Applied Without Failure (Hours)	Comment
C1242A-1	9	0/45/135/0/90	260°F/1000 cyc.		260°F	90	4.2	-	Broke in middle
C1242A-2	9	"	260°F/1000 cyc.		260°F	91	-	-	Tab failure - broke during loading
C1242A-3	9	"	260°F/1000 cyc.		260°F	89	-	-	Tab failure - broke during loading
C1242A-4	9	"	260°F/1000 cyc.		260°F	87	246	1000	-
C1242A-5	9	"	260°F/1000 cyc.		260°F	86	-	-	-
C1242A-6	9	"	260°F/1000 cyc.		350°F	90	-	-	Broke during loading
C1242A-7	9	"	260°F/1000 cyc.		350°F	85	-	1000	-
C1242A-8	9	"	260°F/1000 cyc.		350°F	86	-	-	-
C1242A-9	9	"	260°F/1000 cyc.		350°F	87	18.5	-	-
C1242A-10	9	0/45/135/0/90	260°F/1000 cyc.		350°F	89	236	-	-
C1242C-1	9	0/45/135/0/90	350°F/1000 cyc.		260°F	92	336	-	-
C1242C-2	9	"	350°F/1000 cyc.		260°F	85	445.3	-	-
C1242C-3	9	"	350°F/1000 cyc.		260°F	94	-	-	Tab failure - broke during loading
C1242C-4	9	"	350°F/1000 cyc.		260°F	90	-	-	Oven overheated
C1242C-5	9	"	350°F/1000 cyc.		260°F	94	-	1000	-
C1242C-6	9	"	350°F/1000 cyc.		350°F	85	25	-	Tab failure
C1242C-7	9	"	350°F/1000 cyc.		350°F	87	50.1	-	-
C1242C-8	9	"	350°F/1000 cyc.		350°F	84	-	-	Tab failure - broke during loading
C1242C-9	9	"	350°F/1000 cyc.		350°F	83	-	-	Tab failure - broke during loading
C1242C-10	9	0/45/135/0/90	350°F/1000 cyc.		350°F	82	-	-	Tab failure - broke during loading



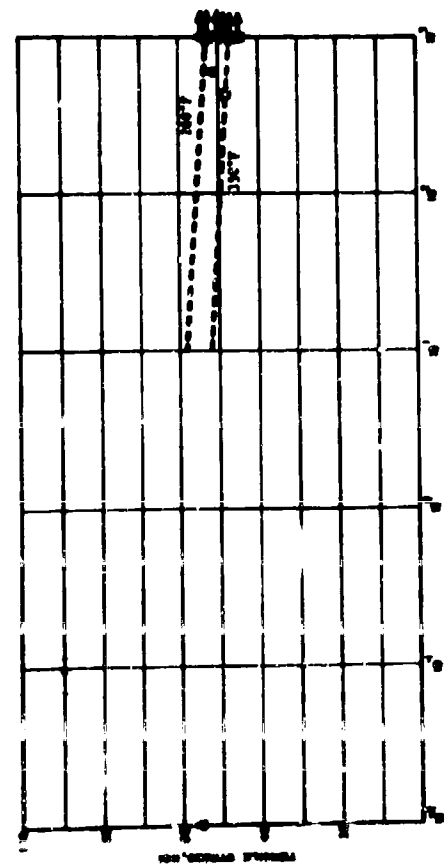


FIG. 301 STRESS vs. TIME TO RUPTURE FOR 301 STAINLESS STEEL AT 1000°C. (OAS/135) 70. CONCENTRATIONS AND QUALITIES/REMARKS: 3000H LACIMENTS TESTED 1. VARIATION SUBMITTED AFTER EXPOSURE TO CYCLE NO. 7. Accelerated No-chilling

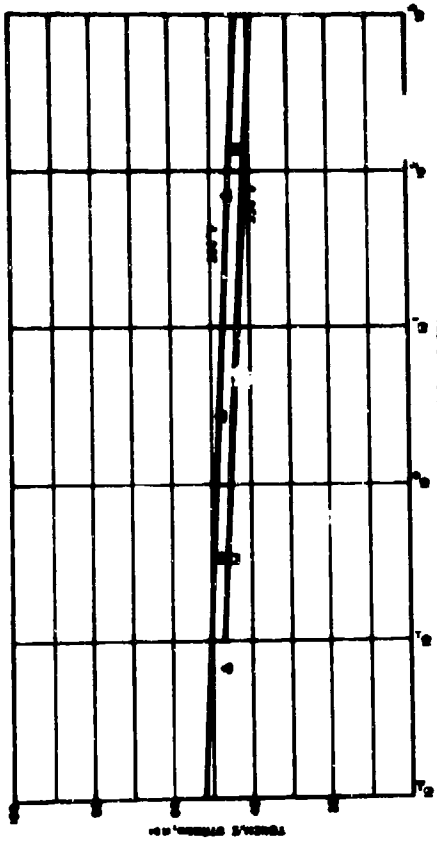


FIG. 301 STRESS vs. TIME TO RUPTURE FOR 301 STAINLESS STEEL AT 1000°C. (OAS/135) 70. CONCENTRATIONS AND QUALITIES/REMARKS: 3000H LACIMENTS TESTED 1. VARIATION SUBMITTED AFTER EXPOSURE TO CYCLE NO. 7. Accelerated No-chilling

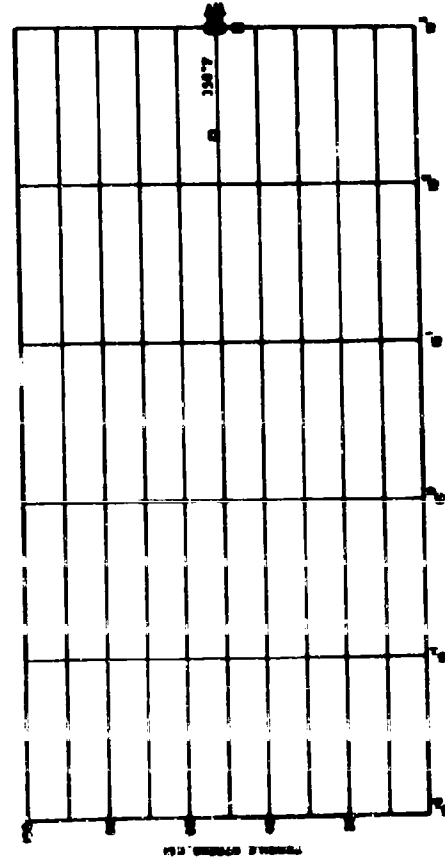


FIG. 301 STRESS vs. TIME TO RUPTURE FOR 301 STAINLESS STEEL AT 1000°C. (OAS/135) 70. CONCENTRATIONS AND QUALITIES/REMARKS: 3000H LACIMENTS TESTED 1. VARIATION SUBMITTED AFTER EXPOSURE TO CYCLE NO. 7. Accelerated No-chilling

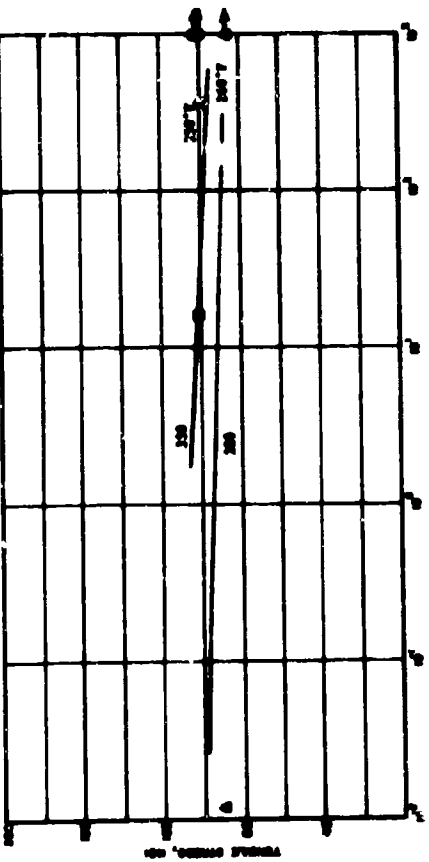


FIG. 301 STRESS vs. TIME TO RUPTURE FOR 301 STAINLESS STEEL AT 1000°C. (OAS/135) 70. CONCENTRATIONS AND QUALITIES/REMARKS: 3000H LACIMENTS TESTED 1. VARIATION SUBMITTED AFTER EXPOSURE TO CYCLE NO. 7. Accelerated No-chilling

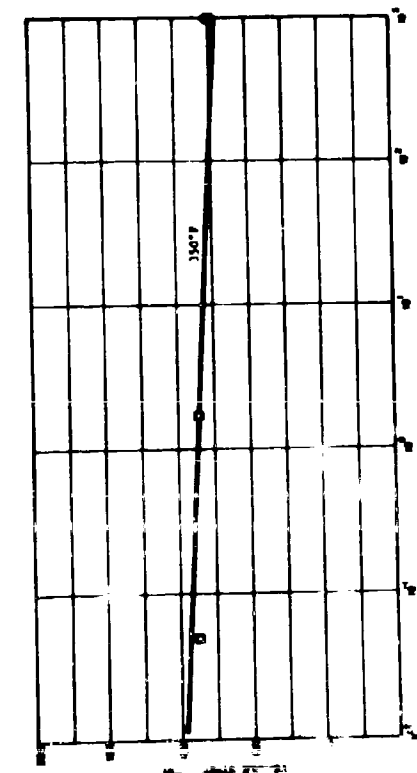


FIG. 504 STRESS RUPTURE DIAGRAM FOR 0° GRAPHITE/KEVLAR 300N COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

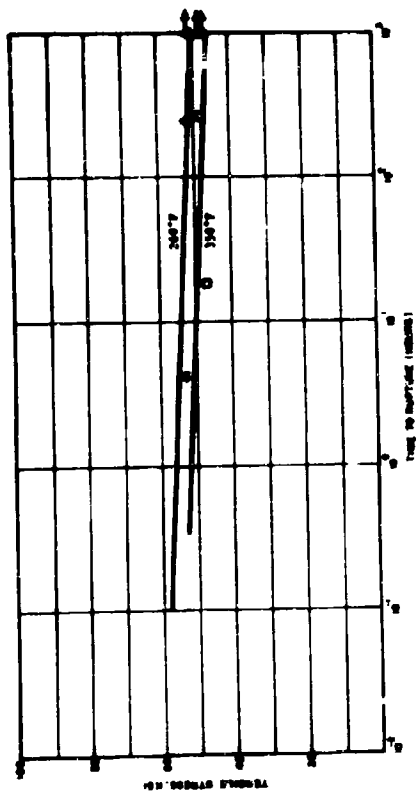


FIG. 505 STRESS RUPTURE DIAGRAM FOR 0° GRAPHITE/KEVLAR 300N COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

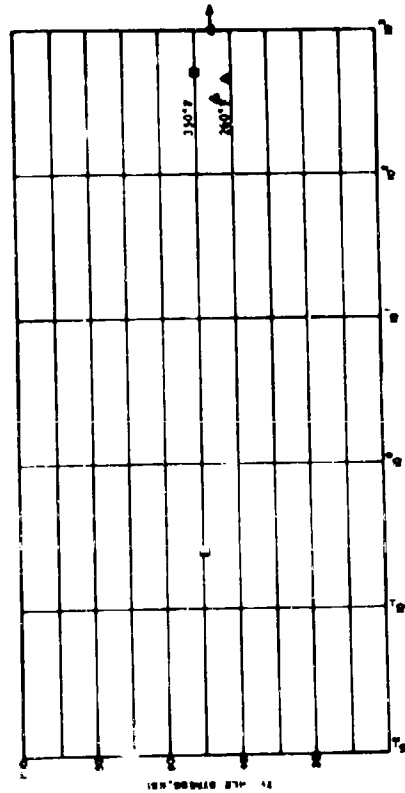


FIG. 506 STRESS RUPTURE DIAGRAM FOR 0° GRAPHITE/KEVLAR 300N COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 350°F

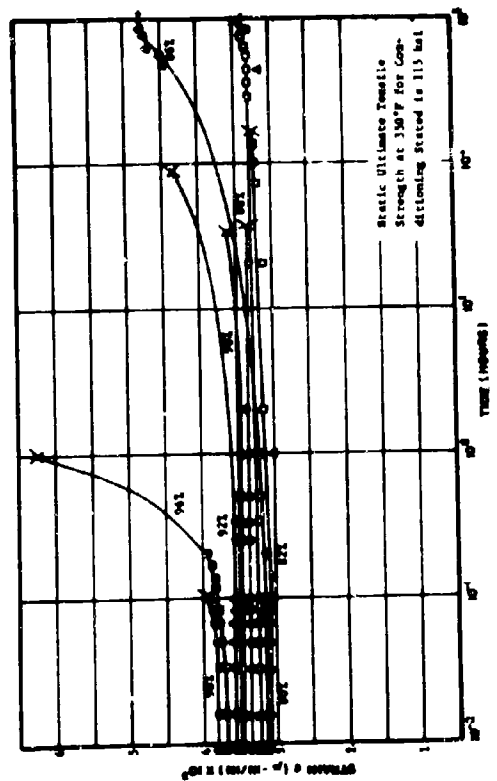


FIG. 507 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° KEVLAR 300N/COMPOSITE 800 GRAPHITE COMPOSITE TESTED AT 350°F

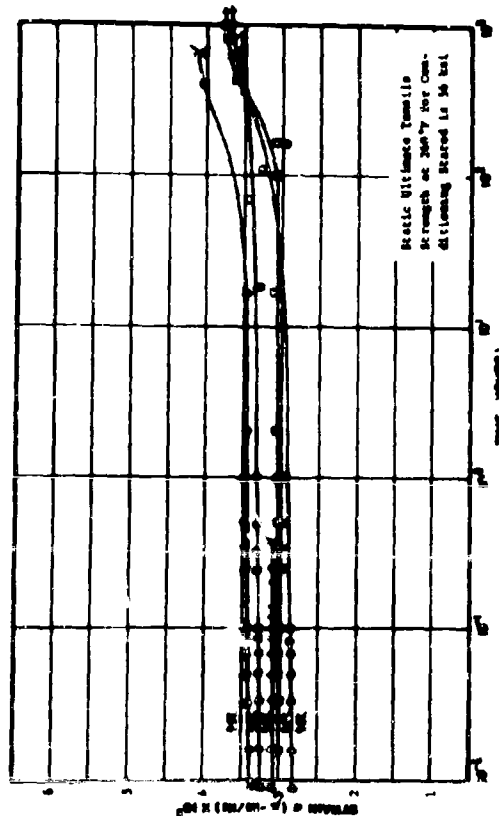


FIG. 509 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.1 INCHES 3030/COMPOSITE SPECIMEN TESTED AT 350°F

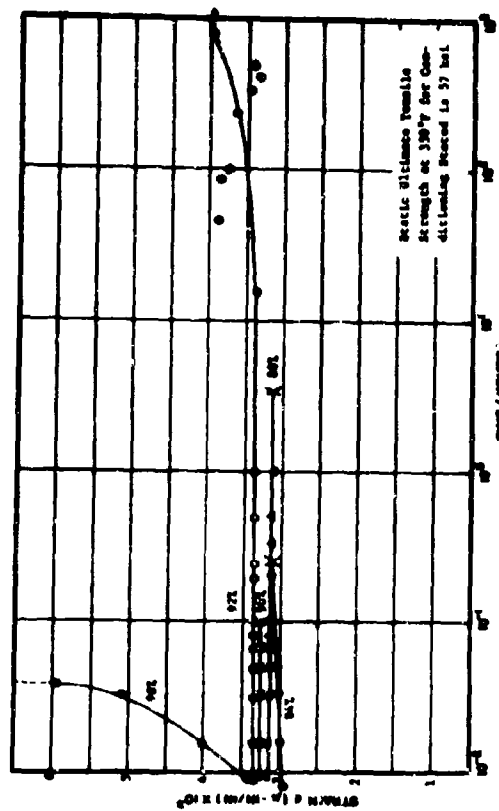


FIG. 510 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.1 INCHES 3030/COMPOSITE SPECIMEN TESTED AT 350°F

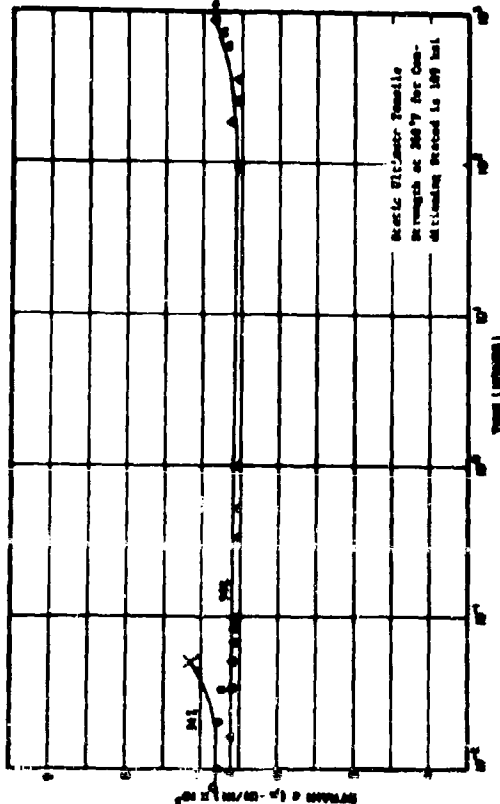


FIG. 511 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.1 INCHES 3030/COMPOSITE SPECIMEN TESTED AT 350°F

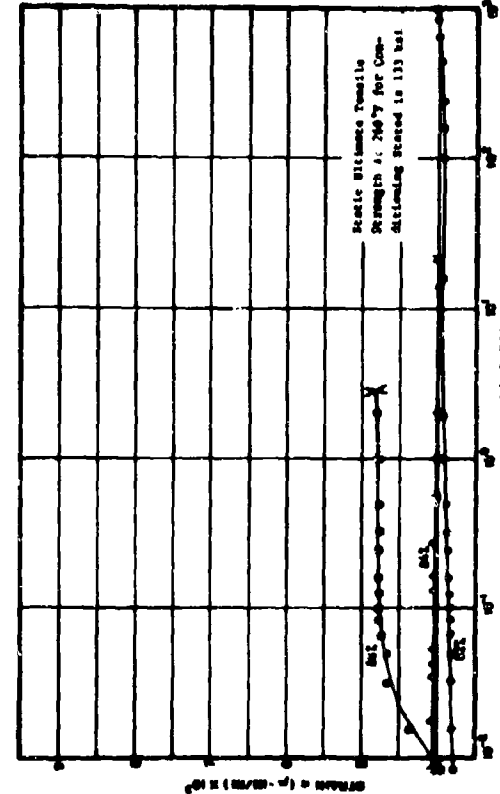


FIG. 512 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0.1 INCHES 3030/COMPOSITE SPECIMEN TESTED AT 350°F

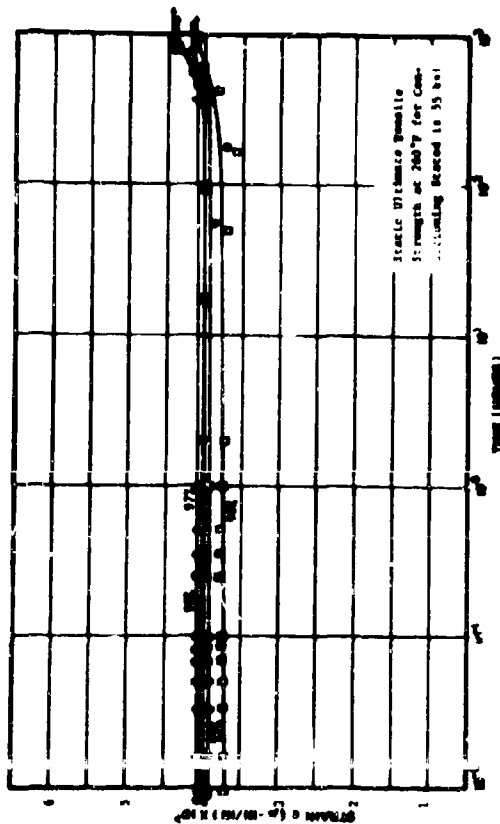


Fig. 512. Graphite laminate tested at 260°F after 1000 hours exposure to wet air.

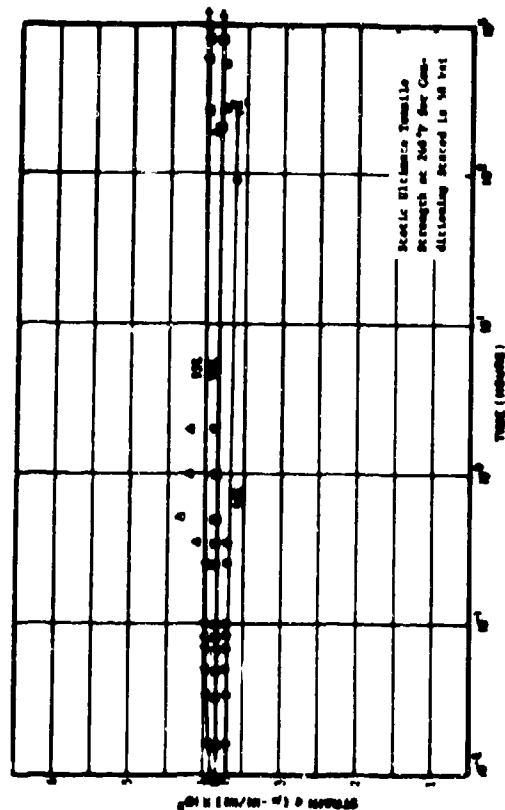


Fig. 513. Graphite laminate tested at 260°F after exposure to humidity cycle no. 2.

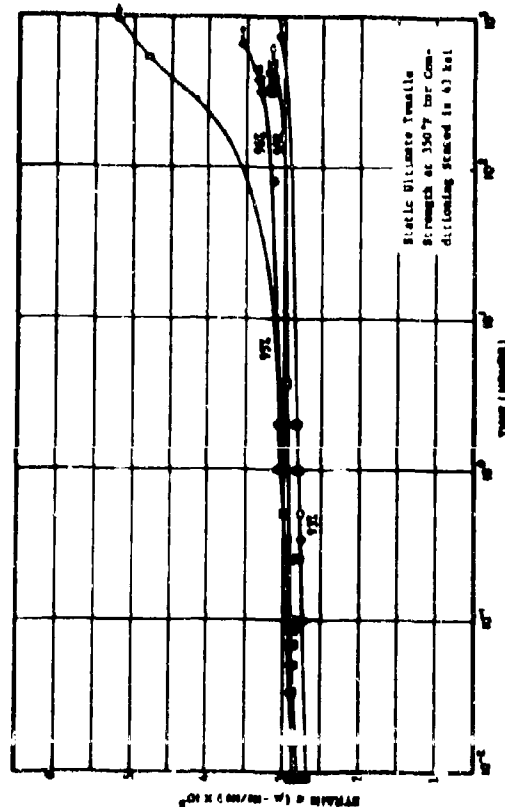


Fig. 514. Graphite laminate tested at 350°F after 1000 hours exposure to wet air.

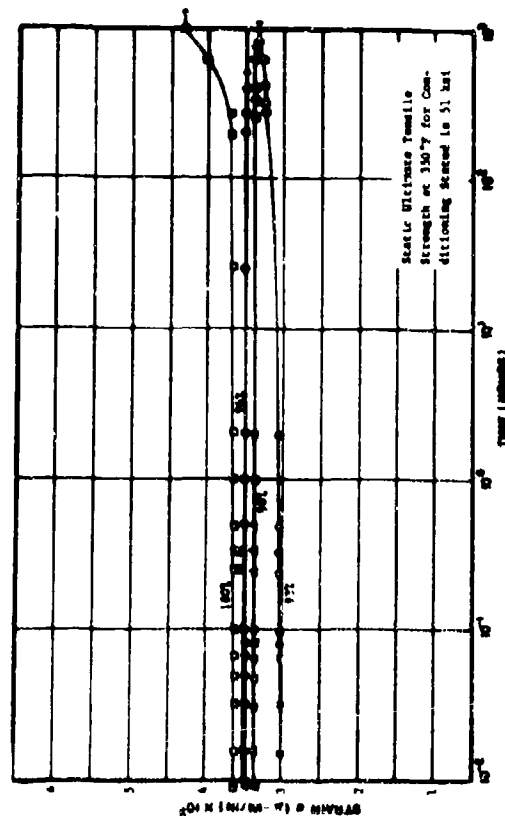


Fig. 515. Graphite laminate tested at 350°F after exposure to humidity cycle no. 2.

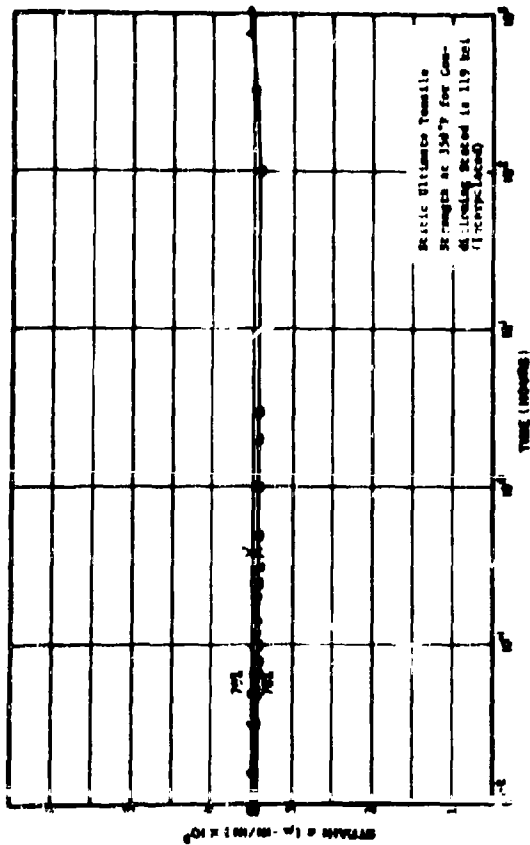


FIG. 516 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BEAMS 3622N/3622N/3622N
COMPOSITE LAMINATES TESTED AT 350°F AFTER 500 HOURS EXPOSURE TO 350°F

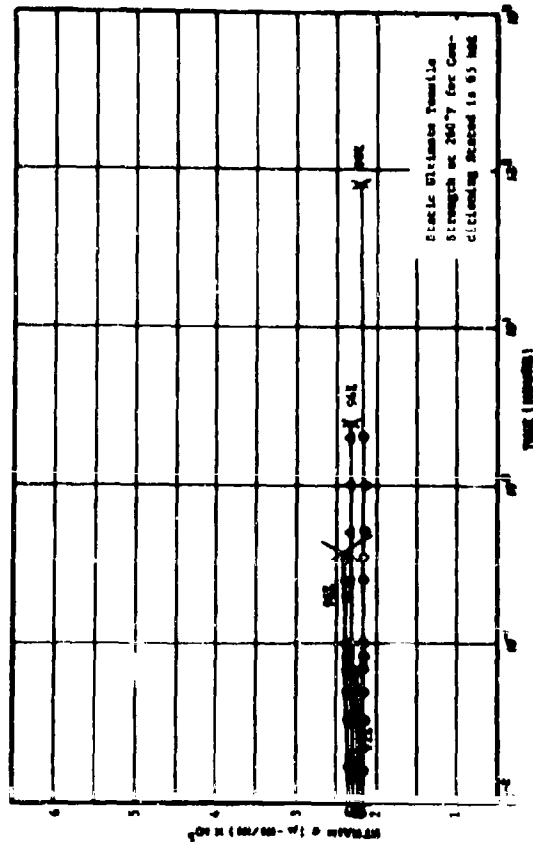


FIG. 518 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BEAMS 3622N/3622N/3622N
COMPOSITE LAMINATES TESTED AT 350°F AFTER 500 HOURS EXPOSURE TO 350°F

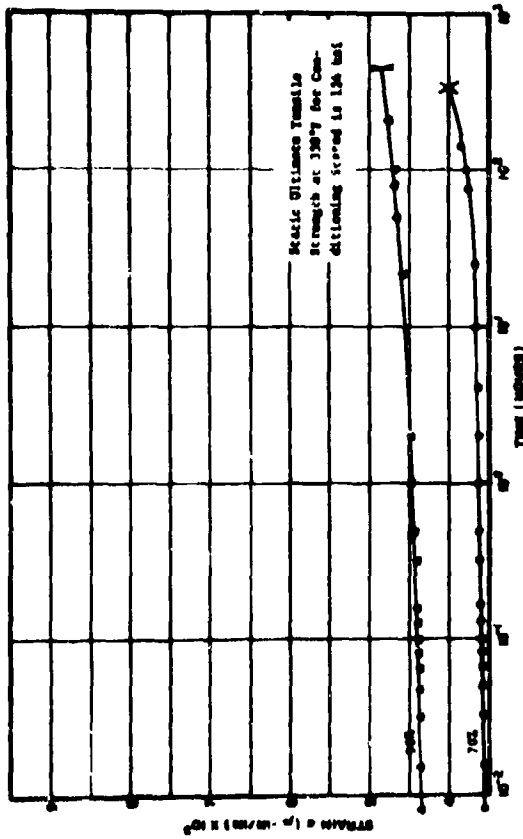


FIG. 517 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BEAMS 3622N/3622N/3622N
COMPOSITE LAMINATES TESTED AT 350°F AFTER 500 HOURS EXPOSURE TO 350°F

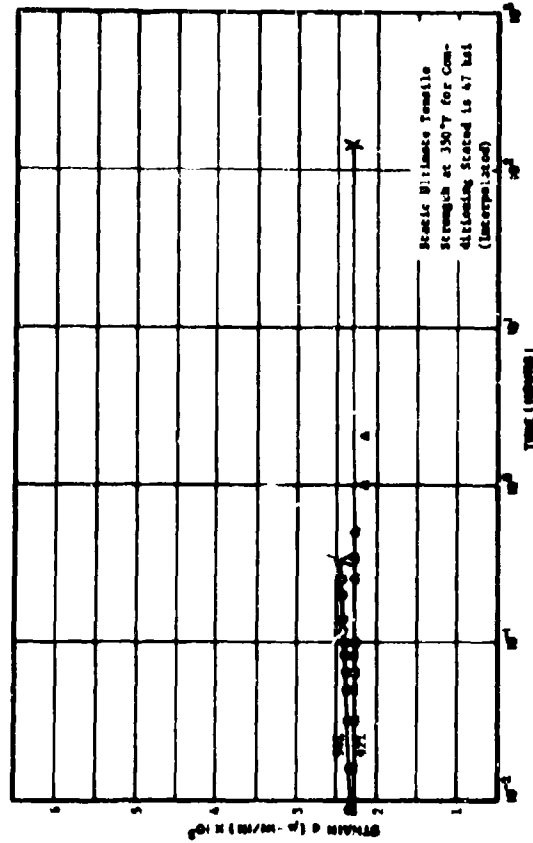


FIG. 519 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° BEAMS 3622N/3622N/3622N
COMPOSITE LAMINATES TESTED AT 350°F AFTER 500 HOURS EXPOSURE TO 350°F

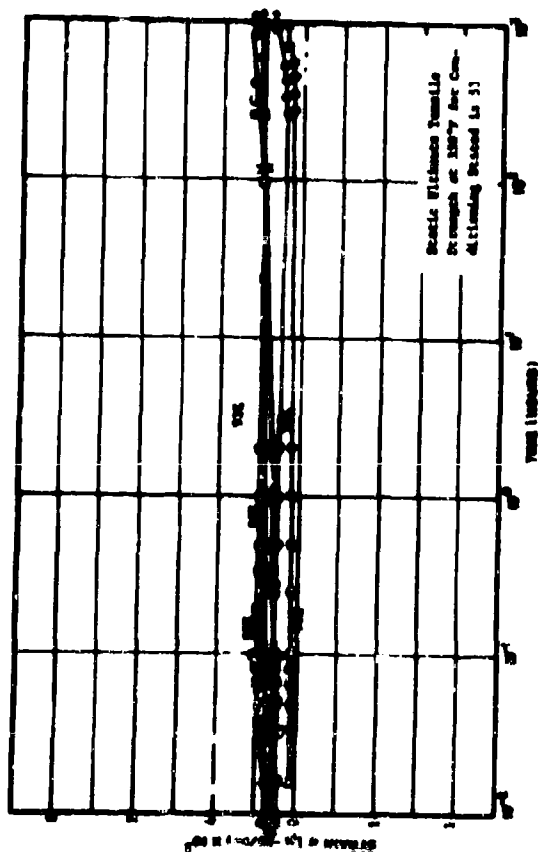


FIG. 5-10 TIME TO CRACK BEAMS TESTED AT 100°F (133°F/50°F), 6" x 6" CONCRETE BEAMS/CONCRETE BEAMS
AND CRACKS LAID OUT TESTED AT 100°F AFTER 100 HOURS EXPOSURE TO 100°F

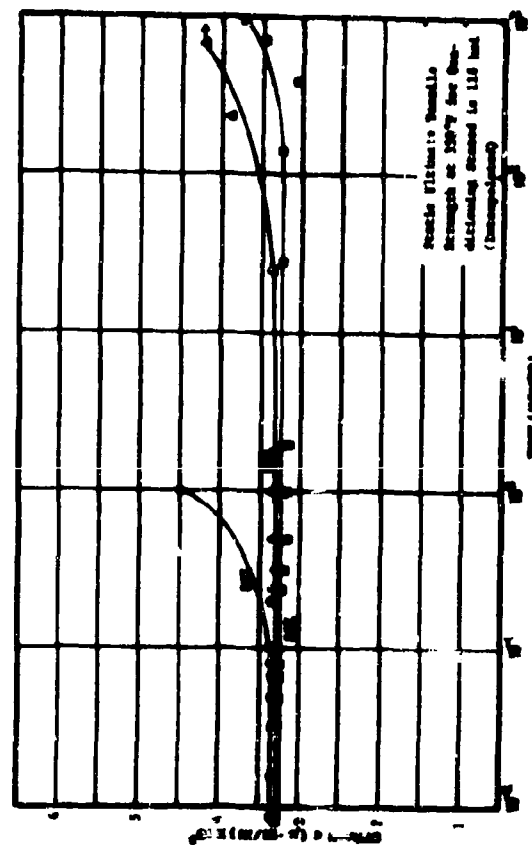


FIG. 5-11 TIME TO CRACK BEAMS TESTED AT 100°F (133°F/50°F), 6" x 6" CONCRETE BEAMS/CONCRETE BEAMS
AND CRACKS LAID OUT TESTED AT 100°F AFTER 100 HOURS EXPOSURE TO 100°F

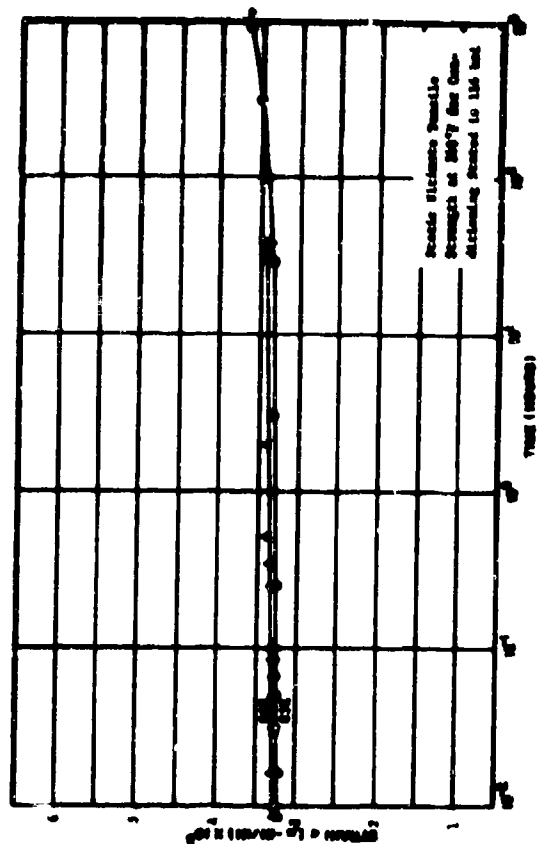


FIG. 5-12 TIME TO CRACK BEAMS TESTED AT 100°F (133°F/50°F), 6" x 6" CONCRETE BEAMS/CONCRETE BEAMS
AND CRACKS LAID OUT TESTED AT 100°F AFTER 100 HOURS EXPOSURE TO 100°F

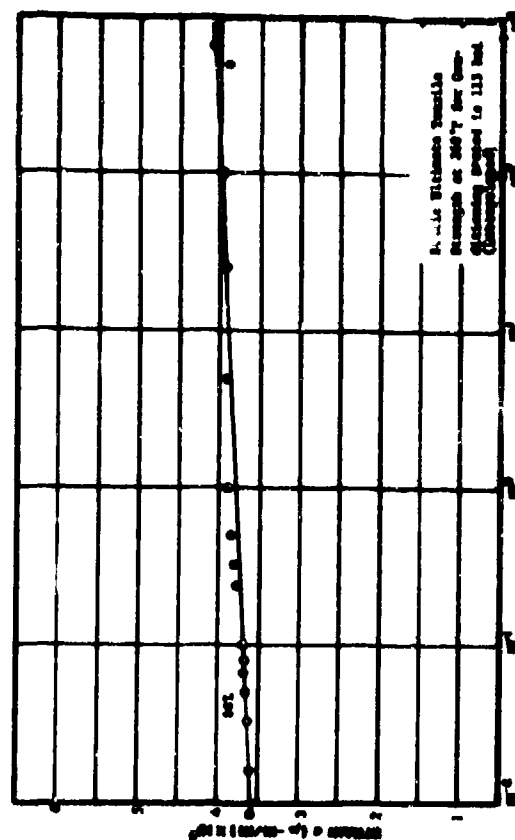


FIG. 5-13 TIME TO CRACK BEAMS TESTED AT 100°F (133°F/50°F), 6" x 6" CONCRETE BEAMS/CONCRETE BEAMS
AND CRACKS LAID OUT TESTED AT 100°F AFTER 100 HOURS EXPOSURE TO 100°F

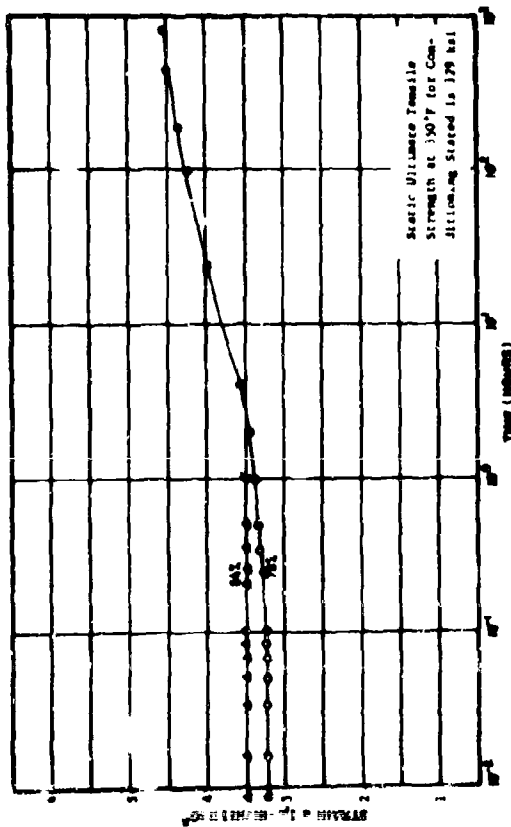


FIG. 52. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90]_s REINFORCED 3002H/CONTRIMOLDS 1000 CYCLES EXPOSURE TO 350°F

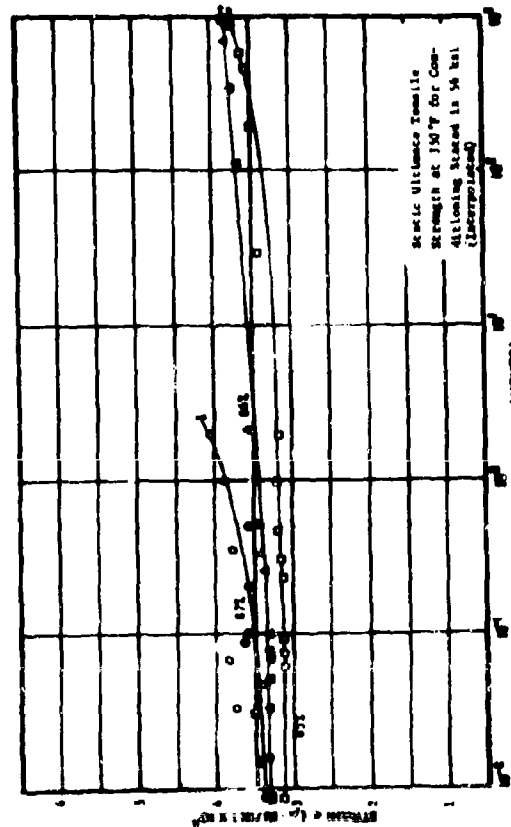


FIG. 53. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90]_s REINFORCED 3002H/CONTRIMOLDS 1000 CYCLES EXPOSURE TO 350°F

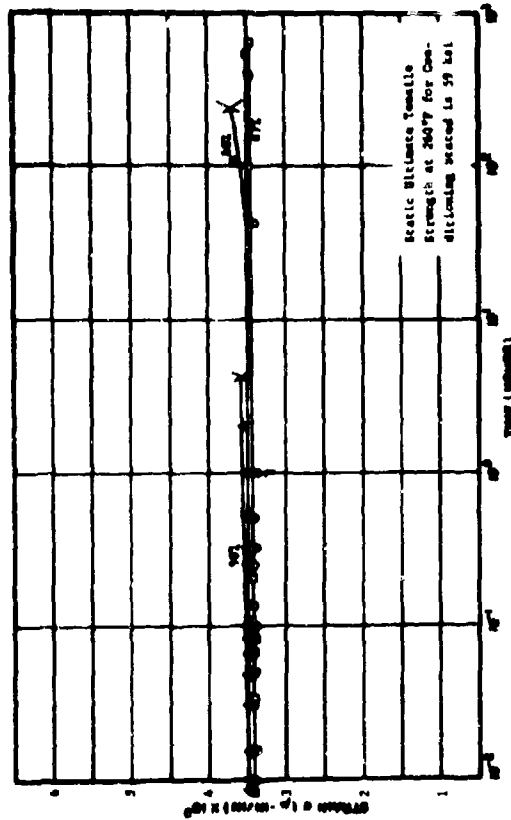


FIG. 54. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90]_s REINFORCED 3002H/CONTRIMOLDS 1000 CYCLES EXPOSURE TO 240°F

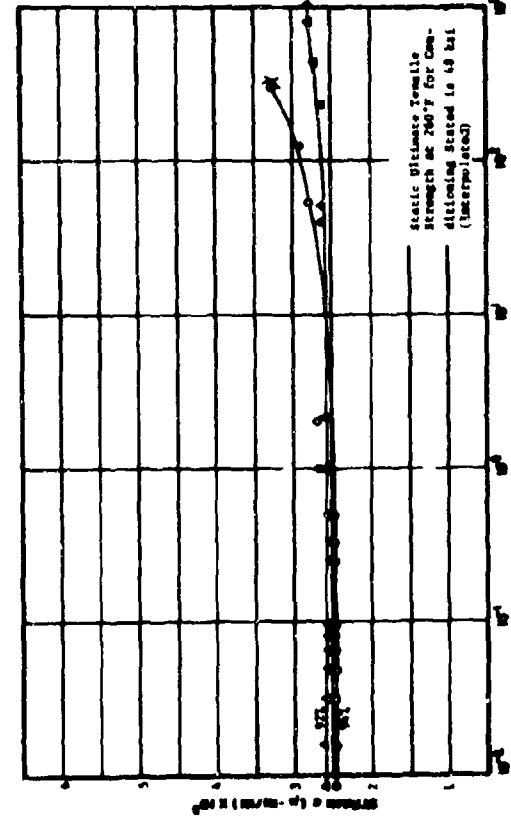


FIG. 55. TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90]_s REINFORCED 3002H/CONTRIMOLDS 1000 CYCLES EXPOSURE TO 240°F

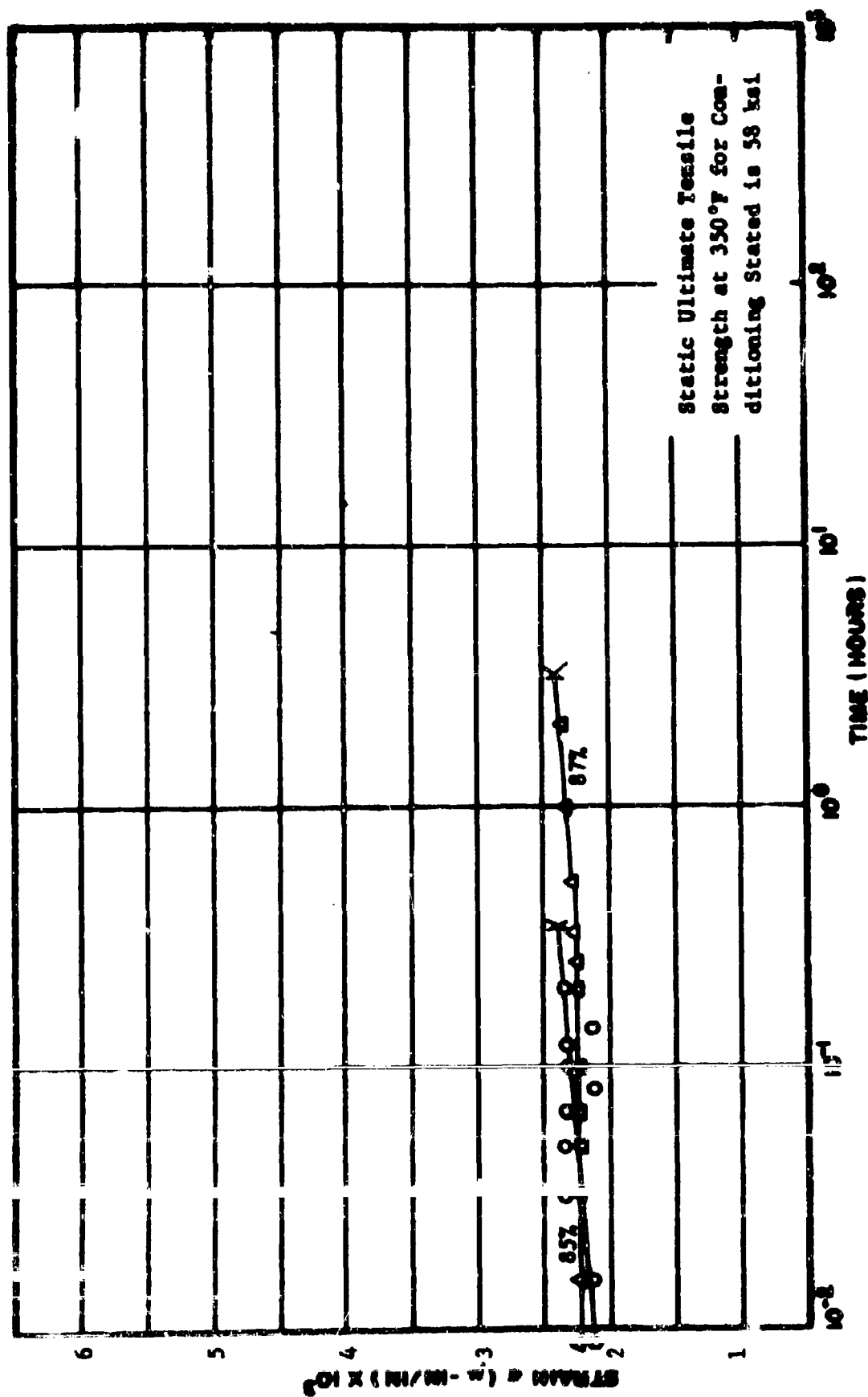


FIG. 52 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR [0/45/135/0/90], HERCULES 3002M/COUNTAUIDS HNS GRAPHITE LAMINATES TESTED AT 350°F AFTER 1000 CYCLES EXPOSURE TO 350°F

APPENDIX IV

DATA SUMMARY FOR 6061 ALUMINUM/BORON COMPOSITES

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APPENDIX IV

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TABLE XX. STATIC PROPERTIES SUMMARY -
6061 ALUMINUM-BORON COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
0°	Tension	None	RT	29.0	0.27	205	7,150
			160	30.0	0.29	194	6,920
			400	33.8	0.21	180	6,920
			600	29.7	0.21	169	6,580
90°			RT	19.9	0.12	23.5	3,780
			160	16.6	0.15	23.9	4,000
			400	13.2	0.14	24.2	4,650
			600	14.9	-	20.9	2,370
0	Compression		RT	33.7	0.26	367	11,550
			160	31.5	0.20	359	11,900
			400	30.6	0.14	324	10,950
			600	32.5	0.28	286	9,810
90			RT	17.9	0.06	42.4	11,450
			160	18.2	0.00	43.7	12,510
			400	15.0	0.00	67.6	14,690
			600	12.8	0.00	31.1	4,650
0°	Flexural		RT	-	-	249	-
			160	-	-	246	-
			400	-	-	243	-
			600	-	-	238	-

TABLE XXI STATIC PROPERTIES SUMMARY -
6061 AL/MIN BOREN COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
90°	Flexural	None	RT	-	-	52.5	-
			160	-	-	51.3	-
			400	-	-	44.7	-
			600	-	-	36.9	-
0°	Int'l'mbr Sh'r		RT	-	-	20.1	-
			160	-	-	19.9	-
			400	-	-	17.2	-
			600	-	-	14.2	-
90°			RT	-	-	7.5	-
			160	-	-	7.2	-
			400	-	-	5.1	-
			600	-	-	3.2	-

ALUMINA STATIC PROPERTIES SUMMARY -
6061 ALUMINUM BORON COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
0°	Tension	700°F/100 hrs	RT	27.1	0.27	177	6,800
			160	28.2	0.19	179	7,740
			400	28.2	0.21	159	6,190
			600	31.7	0.18	173	7,360
		700°F/500 hrs	RT	28.5	0.26	183	6,370
			160	27.6	0.19	165	6,780
			400	31.2	0.18	153	5,140
			600	31.7	0.24	163	5,990
		600°F/1000 hrs	RT	27.8	0.28	162	6,070
			160	24.6	0.27	169	6,780
			400	29.7	0.20	170	6,520
			600	28.7	0.20	166	5,720
90°	Tension	600°F/100 hrs	RT	15.8	0.03	16.7	5,020
			160	10.6	0.19	14.2	8,170
			400	14.4	0.14	15.8	4,510
			600	12.8	0.00	10.9	6,890
		600°F/500 hrs	RT	18.1	0.00	17.3	7,750
			160	17.7	0.00	16.6	7,130
			400	12.9	0.00	14.9	5,200
			600	13.7	0.00	12.5	5,810

TABLE XXI STATIC PROPERTIES SUMMARY -
6061 ALUMINUM BORON COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
90°	Tension	600°F/1000 hrs	RT	17.6	0.00	17.6	4,920
			160	19.5	0.00	17.1	5,100
			400	12.6	0.00	15.2	5,640
			600	10.9	0.00	12.6	3,530
0°	Compression	600°F/100 hrs	RT	29.7	0.29	311	10,160
			160	29.5	0.27	299	9,910
			400	29.0	0.25	288	9,940
			600	27.5	0.25	246	9,230
		600°F/500 hrs	RT	30.1	0.29	275	8,890
			160	31.2	0.23	285	9,240
			400	30.1	0.28	279	10,100
			600	30.7	0.26	244	8,300
90°	Tension	600°F/100 hrs	RT	11.9	0.00	29.7	13,700
			160	11.8	0.00	30.8	14,900
			400	9.7	0.00	29.8	13,600
			600	7.2	0.00	27.8	20,600

TABLE XXI STATIC PROPERTIES SUMMARY -
6061 ALUMINUM BORON COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	v (in/in)	E _{ult} (ksi)	E _{ult} (n-in./in.)
90°	Compression	600°F/500 hrs	RT	11.8	0.00	30.9	> 30,000
			160	9.0	0.00	30.5	> 30,000
			400	9.1	0.00	27.6	> 30,000
			600	9.0	0.00	28.1	> 30,000
0°	Tension	600°F/100 cycles	RT	27.6	0.27	205	7,400
			160	28.2	0.29	196	7,220
			400	29.1	0.22	179	6,040
			600	28.9	0.19	187	7,500
		600°F/500 cycles	RT	26.9	0.28	178	7,020
			160	25.5	0.26	169	6,740
			400	27.9	0.20	134	6,010
			600	28.3	0.19	166	6,850
		600°F/1000 cycles	RT	24.1	0.28	161	6,720
			160	24.6	0.25	151	6,500
			400	28.0	-	147	5,980
			600	26.6	0.22	144	5,970
90°	Compression	600°F/100 cycles	RT	17.7	0.00	18.9	5,860
			160	16.1	0.00	17.6	5,720
			400	11.9	0.00	15.2	3,960
			600	11.0	0.00	12.9	3,050

TABLE XVI STATIC PROPERTIES SUMMARY
6061 ALUMINUM BORON COMPOSITE

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
0°	Tension	600°F/500 cycles	RT	17.2	0.00	15.9	6,540
			160	17.4	0.00	15.5	5,640
			400	10.5	0.00	13.2	6,580
			600	9.2	0.00	10.1	5,640
		600°F/1000 cycles	RT	16.5	0.00	14.9	4,610
			160	16.4	0.00	15.2	6,690
	Compression	600°F/500 cycles	400	11.1	0.00	12.8	6,090
			600	9.5	0.00	9.1	8,820
			RT	29.0	0.23	299	10,370
			160	29.1	0.23	286	9,730
50°	Tension	600°F/500 cycles	400	28.0	0.27	262	10,150
			600	28.9	0.26	242	9,050
		600°F/500 cycles	RT	8.9	0.00	29.6	30,000
			160	9.0	0.00	31.4	30,000
	Compression	600°F/500 cycles	400	9.0	0.00	30.1	30,000
			600	8.0	0.00	27.7	30,000

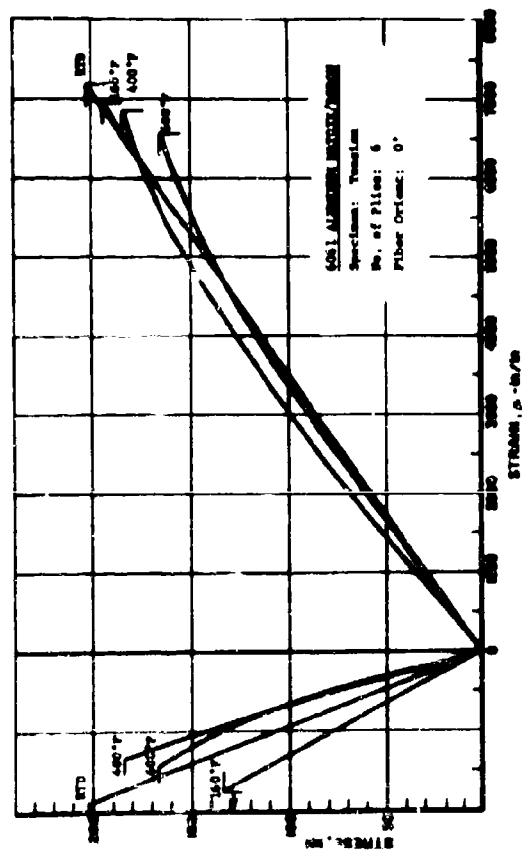


Fig. 519 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6061 ALUMINUM MATRIX/COMPOSITE (3.6 ml) COMPOSITES TESTED AT VARIOUS TEMPERATURES

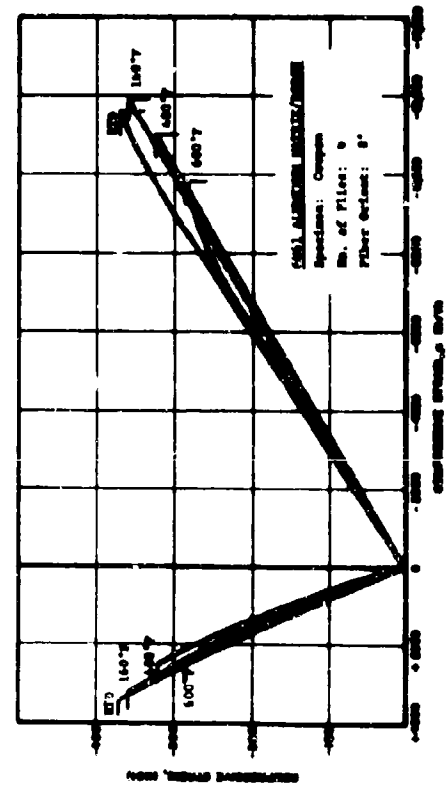


Fig. 531 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° 6061 ALUMINUM MATRIX/COMPOSITE (3.6 ml) COMPOSITES TESTED AT VARIOUS TEMPERATURES

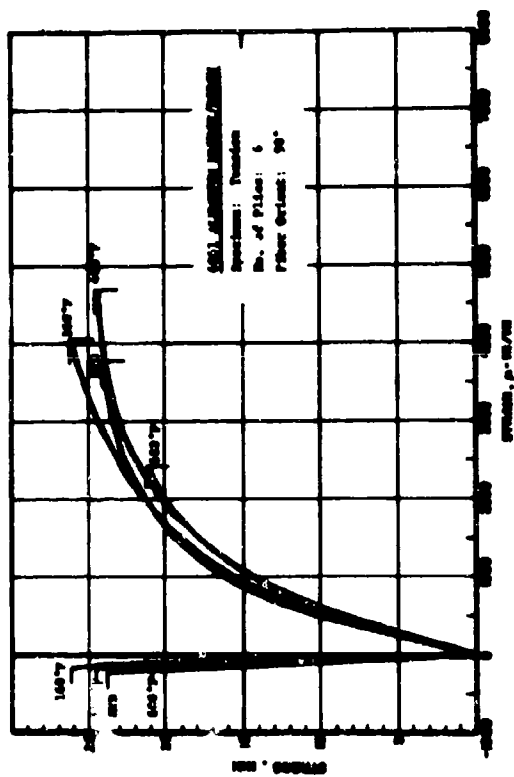


Fig. 530 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/COMPOSITE (3.6 ml) COMPOSITES TESTED AT VARIOUS TEMPERATURES

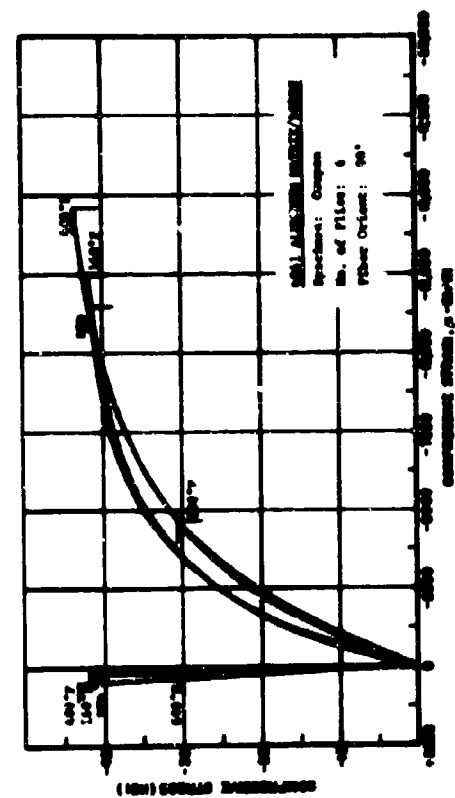
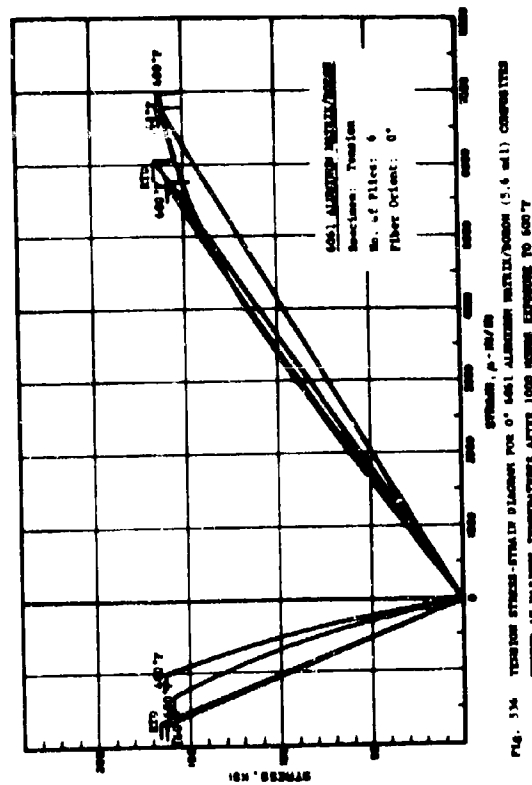
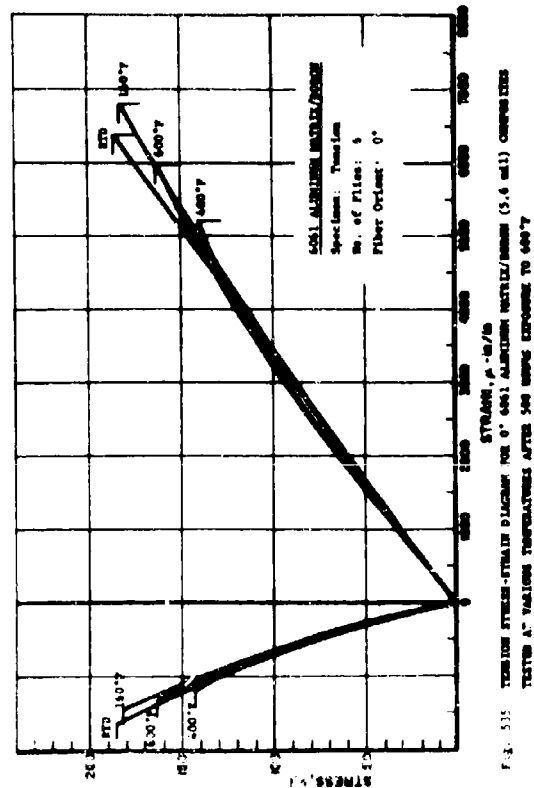
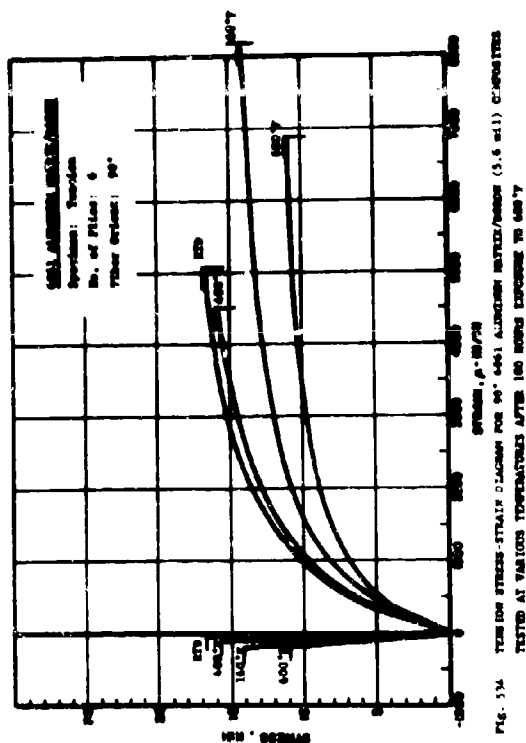
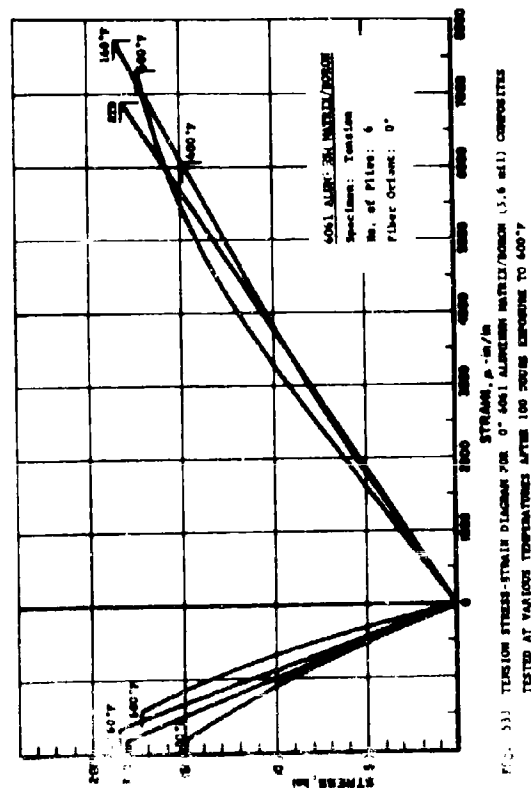


Fig. 532 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/COMPOSITE (3.6 ml) COMPOSITES TESTED AT VARIOUS TEMPERATURES



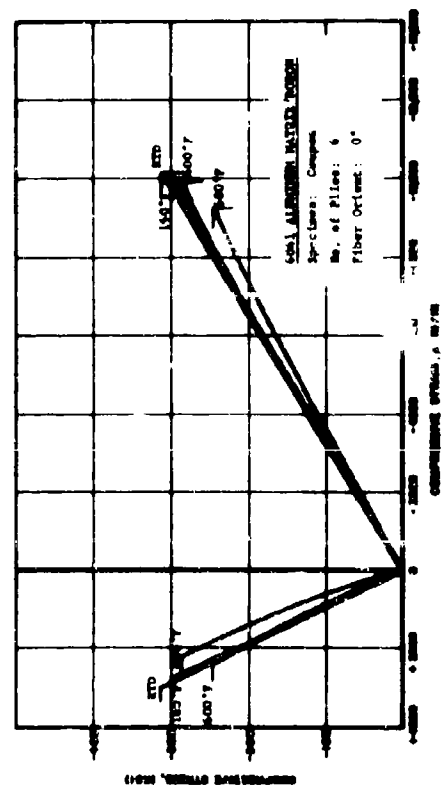


FIG. 51. COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° 6061 ALUMINUM MATRIX/CARBON (5.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO 600°F

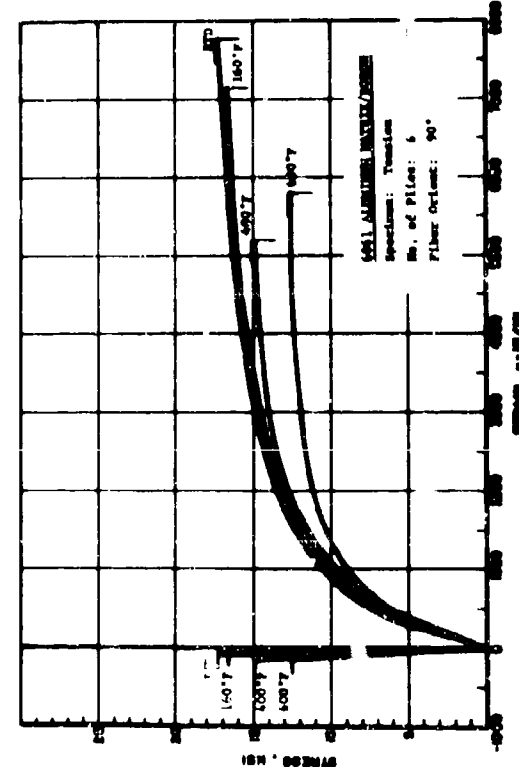


FIG. 53. TENSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/CARBON (5.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 600°F

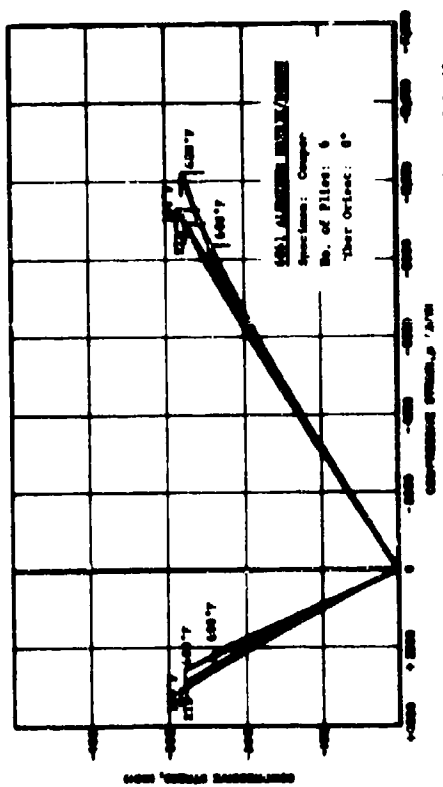


FIG. 53. COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° 6061 ALUMINUM MATRIX/CARBON (5.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 600°F

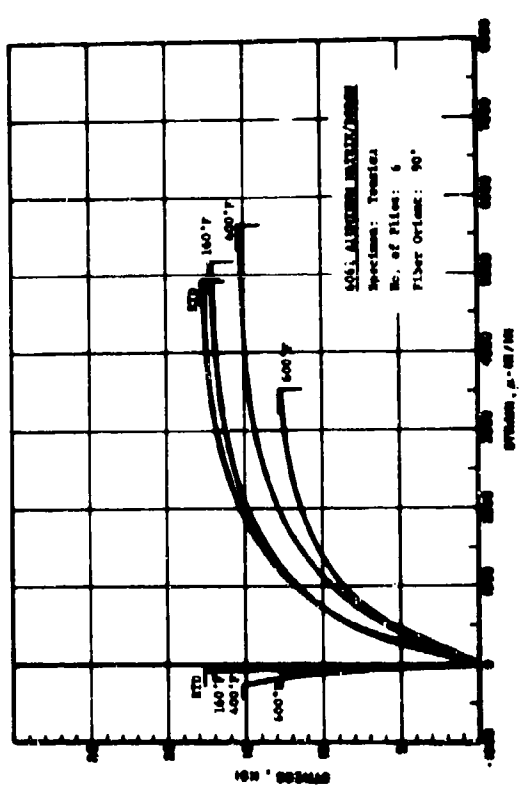


FIG. 54. TENSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/CARBON (5.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 600°F

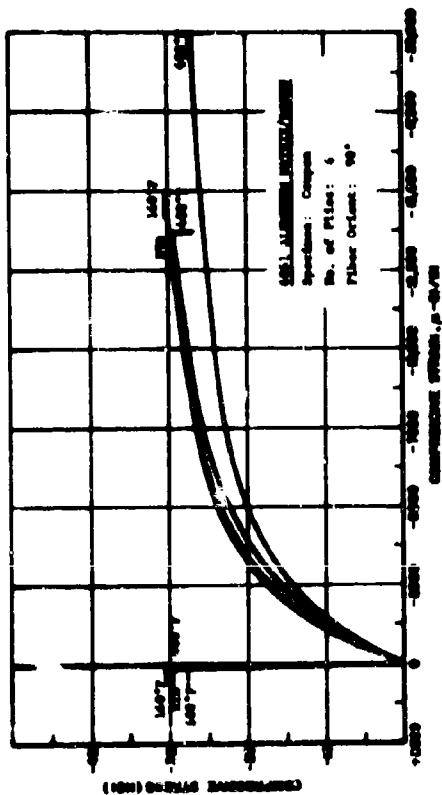


FIG. 541 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/POSS (3.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 600°F

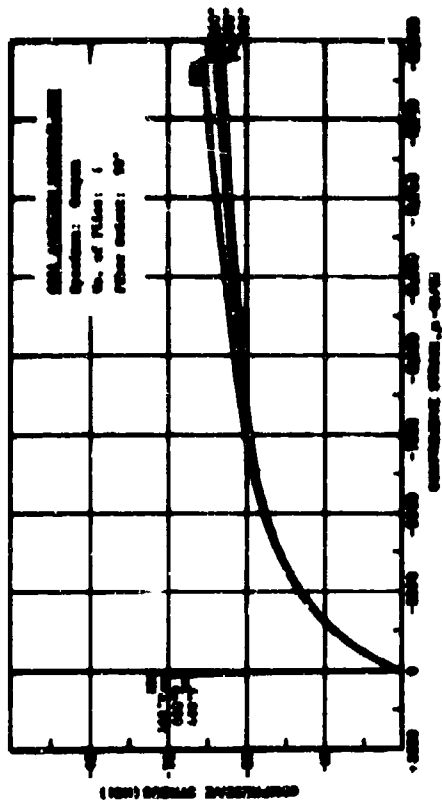


FIG. 542 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/POSS (3.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 600°F

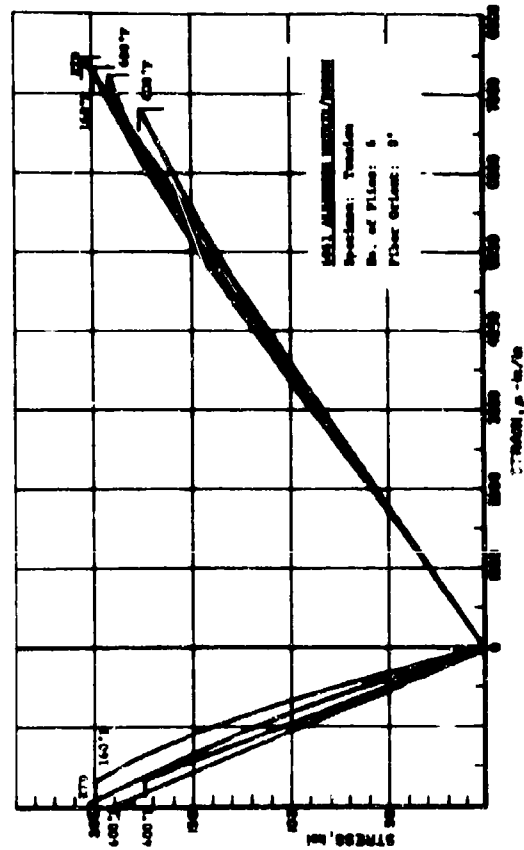


FIG. 543 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6061 ALUMINUM MATRIX/POSS (3.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 600°F

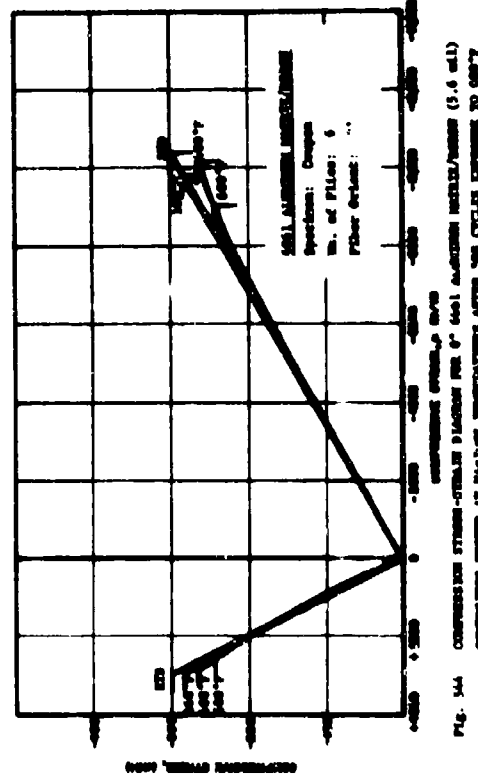


FIG. 544 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° 6061 ALUMINUM MATRIX/POSS (3.6 wt%) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 600°F

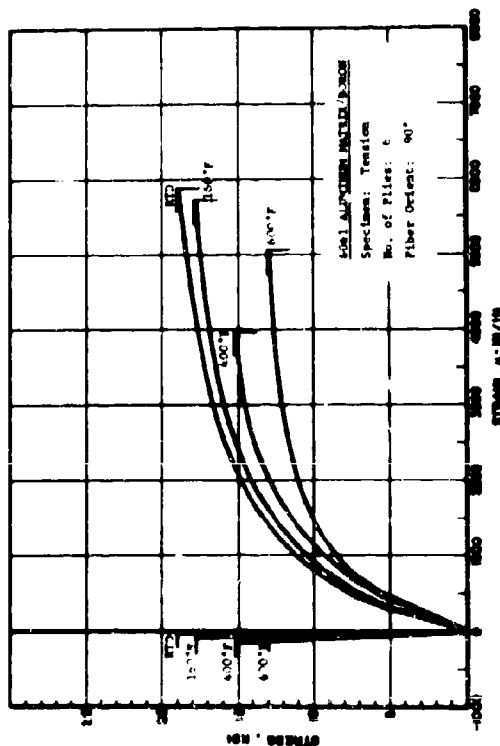


Fig. 53. TENSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/BORON (5.6 ml/l) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 600°F

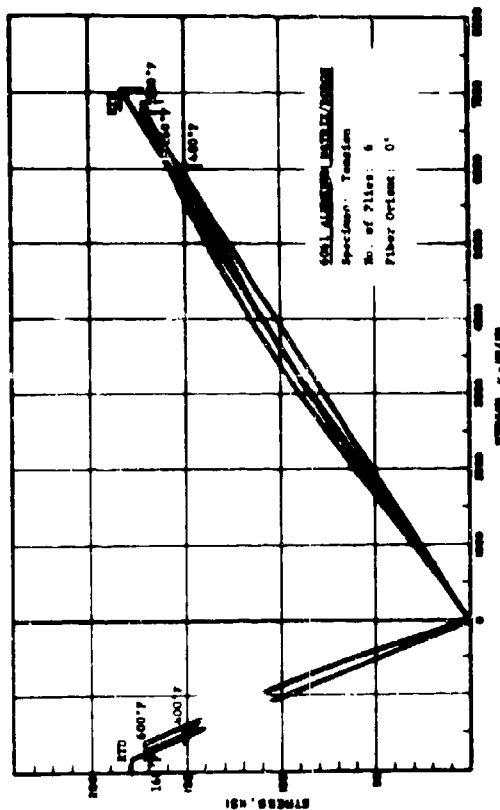


Fig. 54. TENSION STRESS-STRAIN DIAGRAM FOR 0° 6061 ALUMINUM MATRIX/BORON (5.6 ml/l) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 600°F

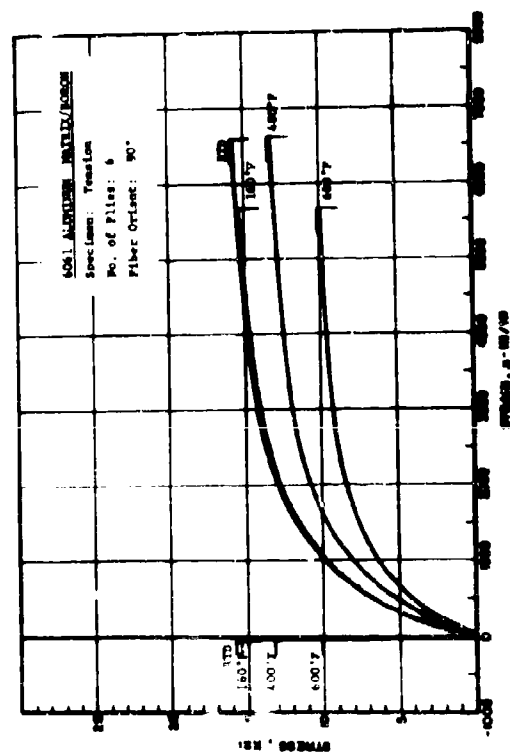


Fig. 55. TENSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/BORON (5.6 ml/l) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 600°F

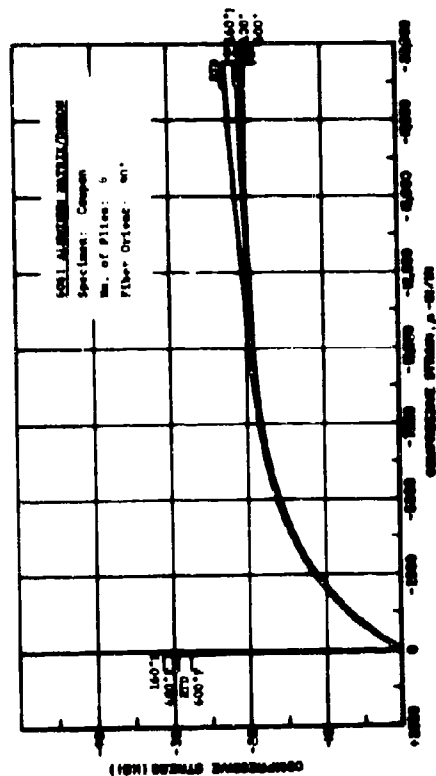


Fig. 56. COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6061 ALUMINUM MATRIX/BORON (5.6 ml/l) COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 600°F

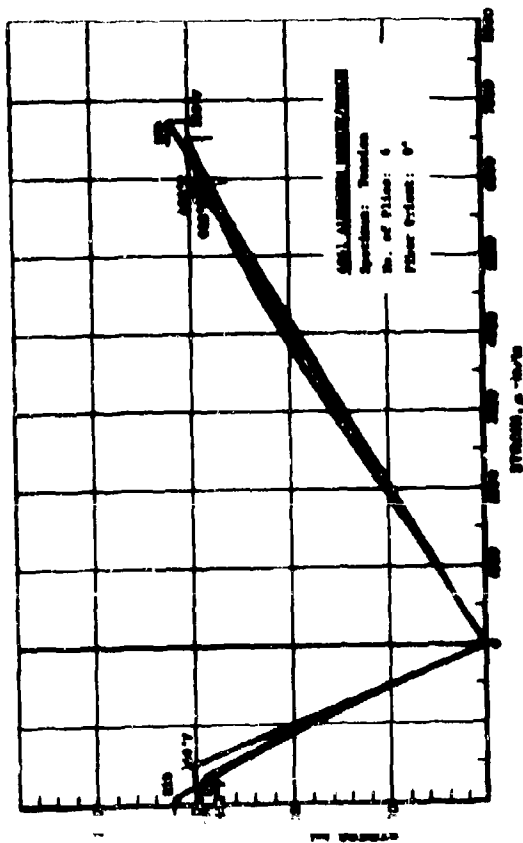


FIG. 541 TENSILE STRESS-TIME BEHAVIOR FOR 40% ALUMINUM NITRATE/PYRENE (3.6 ml) CURED 1200 HOURS AT 600°C. TEMPERATURES AFTER 1000 CYCLES EXPOSED TO 600°C

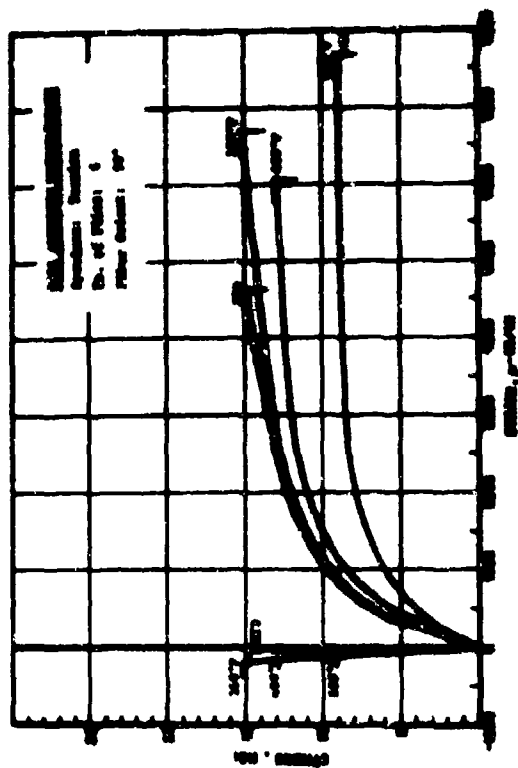


FIG. 542 TENSILE STRESS-TIME BEHAVIOR FOR 40% ALUMINUM NITRATE/PYRENE (3.6 ml) CURED 1200 HOURS AT 600°C. TEMPERATURES AFTER 1000 CYCLES EXPOSED TO 600°C

TABLE XXII TENSILE PROPERTIES SUMMARY -
60% ALUMINUM MATRIX (EPOXY)
FIBER: Kevlar 49

Specimen Number	Thickness (In.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
1929P-86	6 0.043	0°	0.1	RTD	73	28,000	-	-	Immediate Failure
1929P-87	5 0.042	0°	0.1	RTD	71	-	-	-	-
1929P-88	6 0.042	0°	0.1	RTD	68.5	4,500	-	-	-
1929P-89	6 0.043	0°	0.1	RTD	66	28,000	-	-	-
1929P-90	6 0.043	0°	0.1	RTD	63.5	102,000	-	-	-
1929P-91	6 0.042	0°	0.1	160°F	77.5	1,000	-	-	Immediate Failure
1929P-92	6 0.043	0°	0.1	160°F	72	-	-	-	-
1929P-93	6 0.043	0°	0.1	160°F	67	161,000	-	-	Immediate Failure
1929P-94	6 0.043	0°	0.1	160°F	69.5	-	-	-	Immediate Failure
1929P-95	6 0.043	0°	0.1	160°F	64.5	-	-	-	Immediate Failure
1929P-96	6 0.044	0°	0.1	400°F	69.5	364,000	-	-	-
1929P-97	6 0.042	0°	0.1	400°F	64	314,000	-	-	-
1929P-98	6 0.044	0°	0.1	400°F	75	192,000	-	-	-
1929P-99	6 0.043	0°	0.1	400°F	80.5	184,000	-	-	-
1929P-100	6 0.043	0°	0.1	400°F	89	1,000	-	-	-
1929P-101	6 0.043	0°	0.1	600°F	83	42,000	-	-	-
1929P-102	6 0.042	0°	0.1	600°F	94.5	1,000	-	-	-
1929P-103	6 0.043	0°	0.1	600°F	86	2,000	-	-	-
1929P-104	6 0.043	0°	0.1	600°F	77	137,000	-	-	-
1929P-105	6 0.042	0°	0.1	600°F	71	334,000	-	-	-
1928-1	6 0.045	0°	-1	RTD	44*	2,492,000	-	-	-
1928-2	6 0.044	0°	-1	RTD	54*	77,000	-	-	-
1928-3	6 0.045	0°	-1	RTD	63.5*	6,000	-	-	-
1928-4	6 0.045	0°	-1	RTD	58.5*	16,000	-	-	-
1928-5	6 0.046	0°	-1	RTD	49*	89,000	-	-	-

* From Tensile Ultimate Stress

1A-11 CXTT FATIGUE PROPERTIES SUMMARY -
5051 ALUMINUM MATRIX 2025
5.4 mil (0.0001375)

Specimen Number	Thickness (Plies) (In.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (T _{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
1928-6	6	0°	-1	160°F	62 ± 120	3,000	-	-	
1928-7	6	0°	-1	160°F	56.5 ± 110	14,000	-	-	
1928-8	6	0°	-1	160°F	48 ± 95	73,000	-	-	
1928-9	6	0°	-1	160°F	38.5 ± 75	-	2.0 × 10 ⁶	-	
1928-10	6	0°	-1	160°F	44 ± 85	2,956,000	-	-	
1928-11	6	0°	-1	400°F	55.5 ± 100	89,000	-	-	
1928-12	6	0°	-1	400°F	48.5 ± 120	2,000	-	-	
1928-13	6	0°	-1	400°F	61 ± 110	29,000	-	-	
1928-14	6	0°	-1	400°F	52.5 ± 95	116,000	-	-	
1928-15	6	0°	-1	400°F	64 ± 115	8,000	-	-	
1928-16	6	0°	-1	600°F	56 ± 95	3,000	-	-	
1928-17	6	0°	-1	600°F	50.5 ± 85	496,000	-	-	
1928-18	6	0°	-1	600°F	59 ± 100	7,000	-	-	
1928-19	6	0°	-1	600°F	53.5 ± 90	36,000	-	-	
1928-20	6	0°	-1	600°F	51.5 ± 87	-	-	-	Immediate Failure
1928-21	6	0°	10	RTD	39.5 -145	-	-	-	Immediate Failure
1928-22	6	0°	10	RTD	38 -140	1,000	-	-	
1928-23	6	0°	10	RTD	35.5 -130	9,000	-	-	
1928-24	6	0°	10	RTD	33 -120	-	2.013 × 10 ⁶	145	
1928-25	6	0°	10	RTD	34 -125	-	2.4 × 10 ⁶	144	
1928-26	6	0°	10	160°F	33.5 -128	-	2.315 × 10 ⁶	138	
1928-27	6	0°	10	160°F	36 -130	-	2.433 × 10 ⁶	141	
1928-28	6	0°	10	160°F	40.5 -165	4,000	-	-	
1928-29	6	0°	10	160°F	39 -160	1,700,000	-	-	
1928-30	6	0°	10	160°F	40 -163	-	-	-	Immediate Failure

* From Tensile Elongate Stress

TABLE XVII
ALUMINUM MATRIX/FIBER
COMPOSITE

Specimen Number	Thickness (Plies) (in.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (% Yule) (ksi)	Cycles to Failure (cycles)	Applied without Failure (cycles)	Residual Strength (ksi)	Comment
19285-31	6	0°	10	400°F	28 -80	656,000	-	-	
19285-32	6	0°	10	400°F	41.5 -135	1,000	-	-	
19285-33	6	0°	10	400°F	37 -120	13,000	-	-	
19285-34	6	0°	10	400°F	34 -110	15,000	-	-	
19285-35	6	0°	10	400°F	35.5 -115	31,000	-	-	
19285-36	6	0°	10	600°F	30 -85	1,000	-	-	
19285-37	6	0°	10	600°F	33 -95	15,000	-	-	
19285-38	6	0°	10	600°F	35 -100	3,000	-	-	
19285-39	6	0°	10	600°F	31.5 -90	18,000	-	-	
19285-40	6	0°	10	600°F	28 -80	21,000	-	-	
19308-76	6	40°	0.1	RTD	51 12	159,000	-	-	
19308-77	6	90°	0.1	RTD	59.5 14	60,000	-	-	
19308-78	6	0°	0.1	RTD	68 16	31,000	-	-	
19308-79	6	0°	0.1	RTD	76.5 18	12,000	-	-	
19308-80	6	40°	0.1	RTD	42.5 10	756,000	-	-	
19308-81	6	90°	0.1	160°F	54 14	87,000	-	-	
19308-82	6	90°	0.1	160°F	68 21	4,000	-	-	
19308-83	6	90°	0.1	160°F	46.5 12	358,000	-	-	
19308-84	6	90°	0.1	160°F	69.5 18	21,000	-	-	
19308-85	6	90°	0.1	160°F	42.5 11	568,000	-	-	
19308-86	6	90°	0.1	400°F	41.5 10	212,000	-	-	
19308-87	6	90°	0.1	400°F	54 14	31,000	-	-	
19308-88	6	90°	0.1	400°F	74.5 18	6,800	-	-	
19308-89	6	90°	0.1	400°F	49.5 12	100,000	-	-	
19308-90	6	90°	0.1	400°F	33 8	2,026,000	-	-	

-80° F. 1-1/2" PROPERLY
6061 ALUMINUM
(50,000 PSI) (0.001 IN.)

Specimen Number	Thickness (Plies) In.	Orientation	R-Ratio	Test Temp. (°F)	Stress (ksi)	Cycles to Failure (cycles)	Cycles Applied Without Failure (cycles)	Residual Strength (ksi)	Comment
1930C-91	6	90°	0.1	600°F	32	12	1,000	-	
1930C-92	6	90°	0.1	600°F	48	12	1,000	-	
1930C-93	6	90°	0.1	600°F	24	175,000	-	-	
1930C-94	6	90°	0.1	600°F	33.5	7	14,000	-	
1930C-95	6	90°	0.1	600°F	29	6	-	-	
1928C-41	6	90°	-1	RTD	42.5*	14,000	-	-	Failed Under Static LD.
1928C-42	6	90°	-1	RTD	25.5*	1,153,000	-	-	
1928C-43	6	90°	-1	RTD	34*	144,000	-	-	
1928C-44	6	90°	-1	RTD	38*	56,000	-	-	
1928C-45	6	90°	-1	RTD	30*	100,000	-	-	
1928C-46	6	90°	-1	160°F	38.5*	25,000	-	-	
1928C-47	6	90°	-1	160°F	46.5*	4,000	-	-	
1928C-48	6	90°	-1	160°F	31*	72,000	-	-	
1928C-49	6	90°	-1	160°F	27*	481,000	-	-	
1928C-50	6	90°	-1	160°F	23*	302,000	-	-	
1928D-51	6	90°	-1	400°F	33*	376,000	-	-	
1928D-52	6	90°	-1	400°F	41.5*	2,000	-	-	
1928D-53	6	90°	-1	400°F	37*	55,000	-	-	
1928D-54	6	90°	-1	400°F	39*	4,000	-	-	
1928E-55	6	90°	-1	400°F	30*	152,000	-	-	
1928E-56	6	90°	-1	600°F	48*	5,000	-	-	
1928E-57	6	90°	-1	600°F	43*	30,000	-	-	
1928E-58	6	90°	-1	600°F	38*	37,000	-	-	
1928E-59	6	90°	-1	600°F	33.5*	164,000	-	-	
1928E-60	6	90°	-1	600°F	29*	457,000	-	-	

TABLE 3.1

Specimen Number	Thickness (in.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (% ult) (ksi)	Cycles to Failure (cycles)	Applied Stresses (ksi)	Residual Strength (ksi)	Comments
928E-61	0.043	90°	10	RTD	70.5	-	-	-	Immediate Failure
928E-62	0.043	90°	10	RTD	-2.5	-18	-	33.4	-
1928E-63	0.043	90°	10	RTD	34	-25	-	33.3	-
1928E-64	0.043	90°	10	RTD	70.5	-30	1,000	-	-
1928E-65	0.043	90°	10	RTD	63.5	-2	1,511,000	-	-
1928E-66	0.043	90°	10	160°F	66.5	-29	1,000	-	-
1928E-67	0.043	90°	10	160°F	62	-27	147,000	-	-
1928E-68	0.043	90°	10	160°F	68.5	-30	1,000	-	-
1928E-69	0.043	90°	10	160°F	64	-28	1,000	-	-
1928E-70	0.043	90°	10	160°F	57	-25	-	25.7	Specimen was stressed
1928E-71	0.043	90°	10	400°F	52.5	-25	-	-	Immediate Failure
1928E-72	0.043	90°	10	400°F	38	-18	20,000	-	-
1928E-73	0.043	90°	10	400°F	31.5	-15	226,000	-	-
1928E-74	0.043	90°	10	400°F	42	-20	9,000	-	-
1928E-75	0.043	90°	10	400°F	25	-12	-	20.8	-
1928E-76	0.043	90°	10	400°F	48.5	-15	107,000	-	-
1928E-77	0.043	90°	10	600°F	64.5	-20	5,000	-	-
1928E-78	0.043	90°	10	600°F	32	-10	-	-	-
1928E-79	0.043	90°	10	600°F	42	-13	127,000	-	-
1928E-80	0.043	90°	10	600°F	29	-9	763,000	-	-

* From compressive ultimate stress



Fig. 552 FATIGUE S-N DIAGRAM FOR 0° 4061 AL/ALN/BORON COMPOSITES, TESTED AT VARIOUS TEMPERATURES (R = 0.1, $\dot{\epsilon}$ = 1000 cpm)



Fig. 553 FATIGUE S-N DIAGRAM FOR 0° 4061 AL/ALN/BORON COMPOSITES, TESTED AT VARIOUS TEMPERATURES (R = -1, $\dot{\epsilon}$ = 1000 cpm)

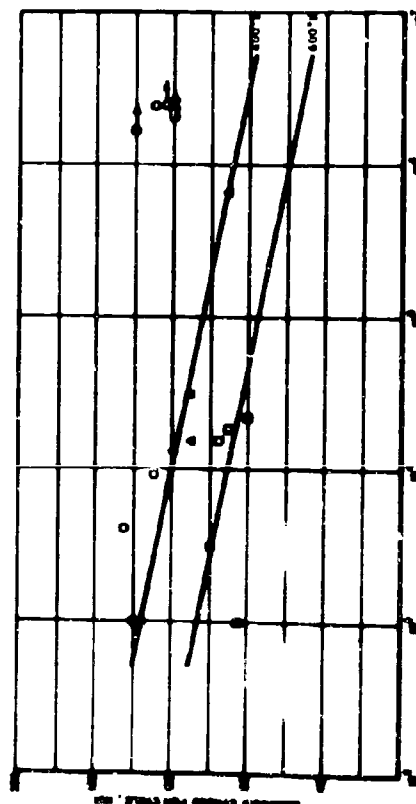


Fig. 551 FATIGUE S-N DIAGRAM FOR 0° 4061 AL/ALN/BORON COMPOSITES, TESTED AT VARIOUS TEMPERATURES (R = 10, $\dot{\epsilon}$ = 1000 cpm)



Fig. 554 FATIGUE S-N DIAGRAM FOR 90° 4061 AL/ALN/BORON COMPOSITES, TESTED AT VARIOUS TEMPERATURES (R = 0.1, $\dot{\epsilon}$ = 1000 cpm)



Fig. 553 NUMBER 5-1 STRESS PER 10⁶ CYCLES/STRESS CORRELATION, STRESS AT FAILURE
STRESS (S = 1, S = 1000 psi)

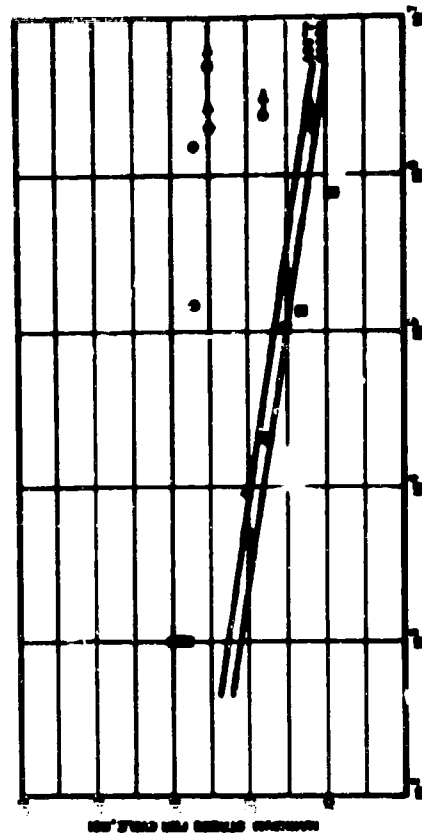


Fig. 556 NUMBER 5-2 STRESS PER 10⁶ CYCLES/STRESS CORRELATION, STRESS AT FAILURE
STRESS (S = 10, S = 1000 psi)

Specimen Number	Thickness (P in.) (In.)	Orientation	Test Temp. (°F)	Stress Level (psi) (ksi)	Time to Failure (Hours)	Time Applied without Failure (Hours)	Comment
1929P-107	0.042	0°	RT	92	-	-	Broke during loading
1929P-108	0.043	0°	RT	92	-	-	Broke during loading
1929P-109	0.04	0°	RT	91	.34	-	Broke during loading
1929P-110	0.04	0°	RT	90	-	-	Broke during loading
1929P-111	0.04	0°	RT	90	-	1000	Lost gauge during loading
1929P-112	0.042	0°	160°F	90	.25	-	Broke during loading
1929P-113	0.04	0°	160°F	90	-	1000	Broke during loading
1929P-114	0.04	0°	160°F	95	-	-	Broke during loading
1929P-115	0.042	0°	160°F	93	-	1000	Broke during loading
1929P-116	0.04	0°	200°F	82	-	1000	Broke during loading
1929P-117	0.04	0°	400°F	88	.75	-	Broke during loading
1929P-118	0.043	0°	400°F	80	-	1000	Broke during loading
1929P-119	0.045	0°	400°F	84	-	-	Broke during loading
1929P-120	0.044	0°	400°F	86	-	-	Broke during loading
1929P-121	0.045	0°	600°F	90	-	1000	Broke during loading
1929P-122	0.044	0°	600°F	92	-	1000	Broke during loading
1929P-123	0.045	0°	600°F	98	-	-	Broke during loading
1929P-124	0.045	0°	600°F	96	-	-	Broke during loading
1929P-125	0.044	0°	600°F	94	-	1000	Lost gauge during loading

TABLE
TENSILE AND STRESS-RUPURE
PROPERTY SUMMARY
6061 ALUMINUM
(5-MILL) COMPOSITES

Specimen Number	Thickness (Plies) (in.)	Orientation	Test Temp. (°F)	Stress Level (% T _{ult}) (ksi)	Time to Failure (Hours)	Time Applied Without Failure (Hours)	Comment
1930-90	6 0.041	0	RT	71	16.5	1000	
1930-97	6 0.041	90°	RT	71	17.6	1000	
1930-98	6 0.041	90°	RT	87	18.5	1011	
1930-99	6 0.052	90°	RT	75	20.0	1002	
1930-100	6 0.051	90°	RT	90	21.1	1008	
1930-101	6 0.050	90°	160°F	75	18.4	451.7	
1930-102	6 0.050	90°	160°F	90	23.3	45.7	
1930-103	6 0.051	90°	160°F	93	24.1	.05	
1930-104	6 0.052	90°	160°F	88	21.7	116.2	
1930-105	6 0.051	90°	160°F	85	22.0	426.3	
1930-106	6 0.046	90°	400°F	93	22.5	25	Broke during Loading
1930-107	6 0.046	90°	400°F	94	22.7	-	
1930-108	6 0.047	90°	400°F	90	21.8	258	Broke during Loading
1930-109	6 0.047	90°	400°F	96	23.2	-	
1930-110	6 0.047	90°	400°F	92	22.2	1000	
1930-111	6 0.046	90°	600°F	90	18.8	14.8	Broke during Loading
1930-112	6 0.049	90°	600°F	92	19.2	-	Broke during Loading
1930-113	6 0.052	90°	600°F	92	19.2	-	
1930-114	6 0.046	90°	600°F	94	19.6	4.4	
1930-115	6 0.051	90°	600°F	92	19.2	1000	

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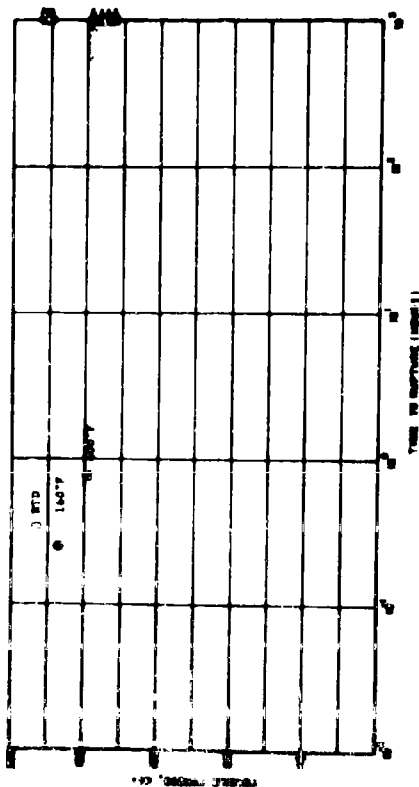


FIG. 53 STRESS RUPTURE DIAGRAMS FOR 6061 ALUMINUM/BORON COMPOSITES TESTED AT VARIOUS TEMPERATURES

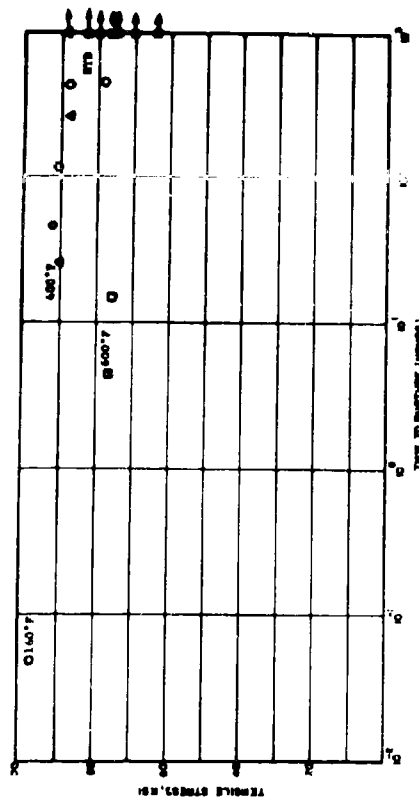


FIG. 54 STRESS RUPTURE DIAGRAMS FOR 6061 ALUMINUM/BORON COMPOSITES TESTED AT VARIOUS TEMPERATURES

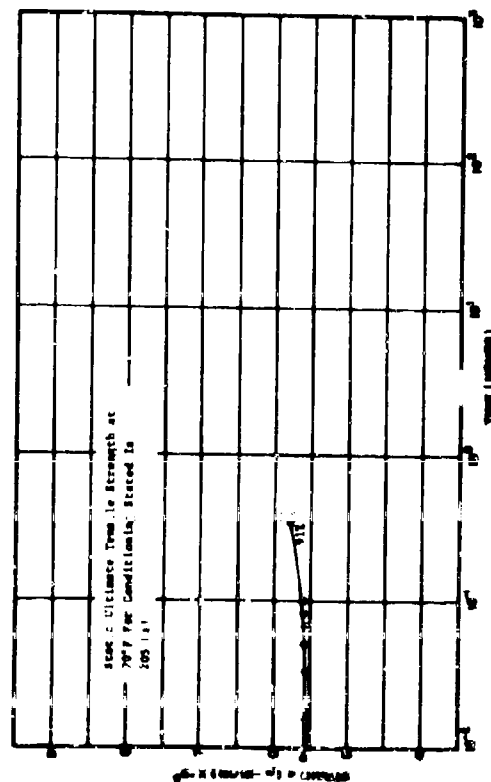


FIG. 55 TIME TO CREEP AT 100 KSI VERSUS TIME CURVES FOR 6061 ALUMINUM/BORON COMPOSITES TESTED AT ROOM TEMPERATURE

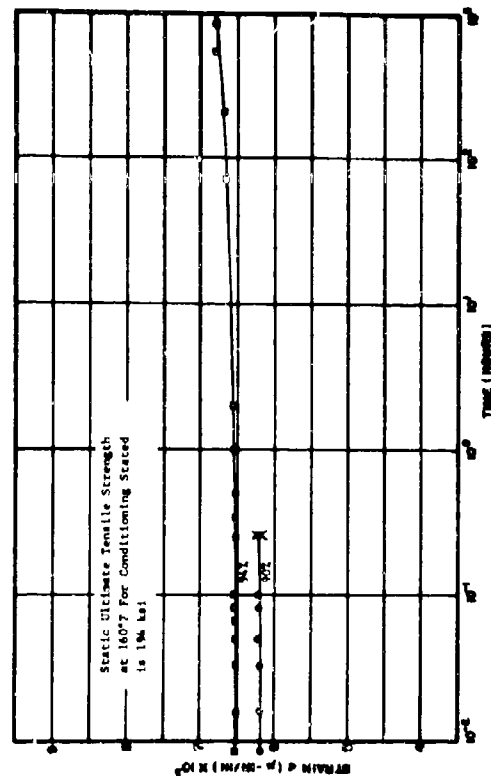


FIG. 56 TIME TO CREEP AT 100 KSI VERSUS TIME CURVES FOR 6061 ALUMINUM/BORON COMPOSITES TESTED AT 160°F

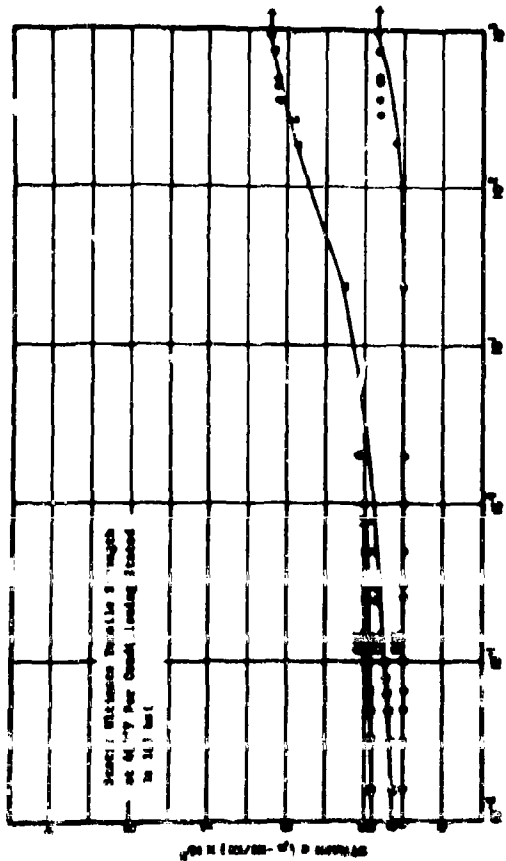


FIG. 541 TENSILE COMP STRENGTH VERSUS TIME CURVES FOR 6061 ALUMINUM BRON COMPOSITES TESTED AT 400°F

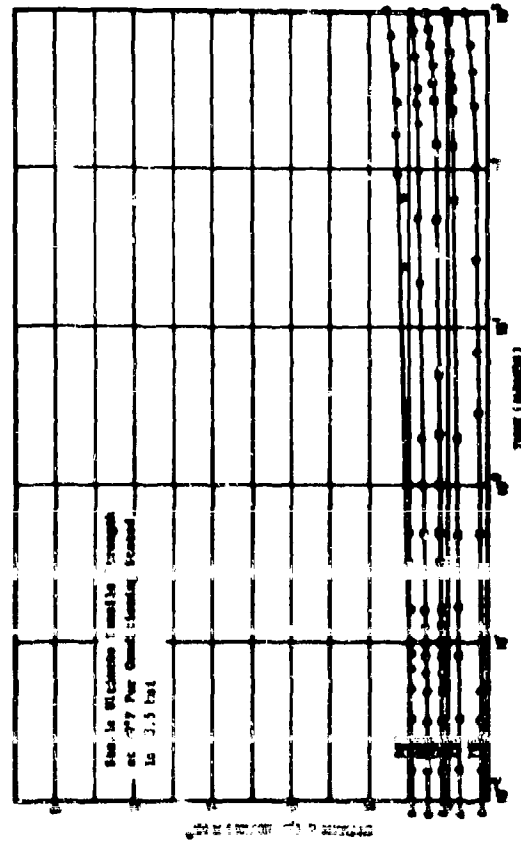


FIG. 543 TENSILE COMP STRENGTH VERSUS TIME CURVES FOR 6061 ALUMINUM BRON COMPOSITES TESTED AT 400°F

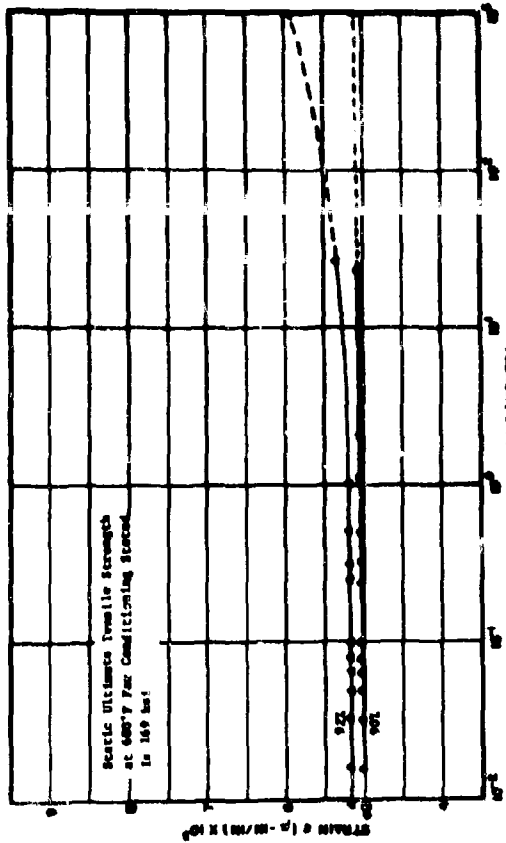


FIG. 542 TENSILE COMP STRENGTH VERSUS TIME CURVES FOR 6061 ALUM BRON COMPOSITES TESTED AT 600°F

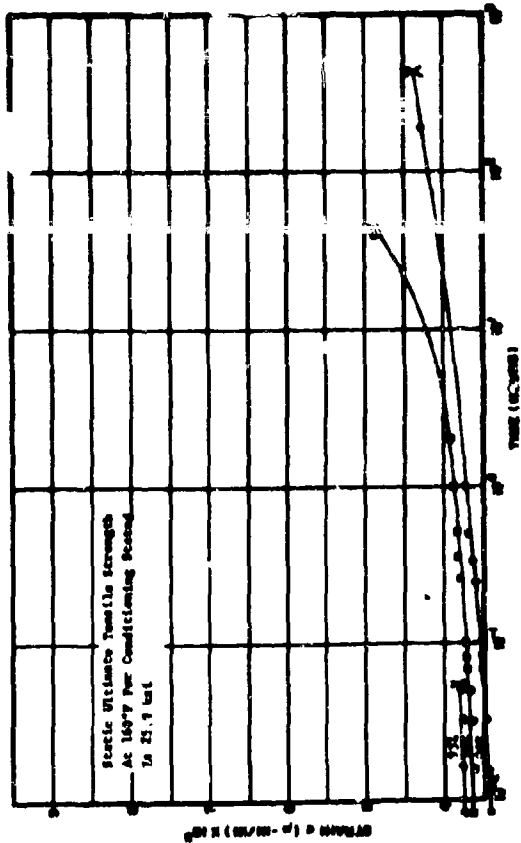


FIG. 544 TENSILE COMP STRENGTH VERSUS TIME CURVES FOR 6061 ALUM BRON COMPOSITES TESTED AT 600°F

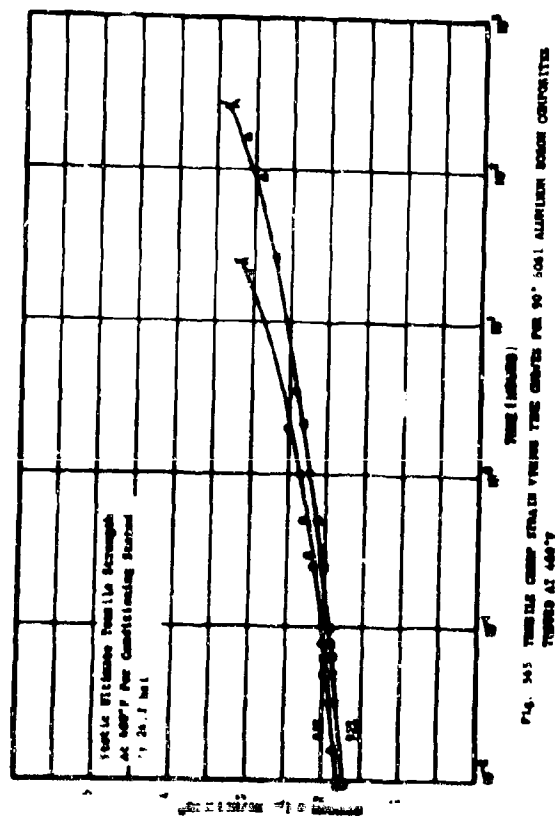


FIG. 545 TENSILE COMP STRENGTH VERSUS TIME CURVES FOR 90° 50:1 ALUMINUM BRONZE COMPOSITES TESTED AT 400°F

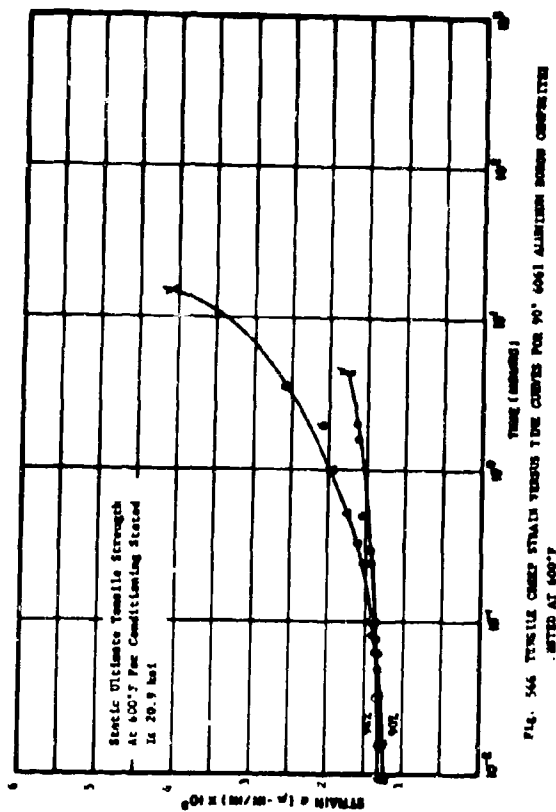


FIG. 546 TENSILE COMP STRENGTH VERSUS TIME CURVES FOR 90° 60:1 ALUMINUM BRONZE COMPOSITES TESTED AT 400°F

APPENDIX V

DATA SUMMARY FOR 6Al-4V-TITANIUM/BORSIC COMPOSITES

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TABLE XI IV STATIC PROPERTIES SUMMARY
6Al-4V-TITANIUM/BORSIC COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	v (in/in)	σ _{ult} (ksi)	E _{ult} (μ-in./in.)
0°	Tension	None	RT	38.8	0.20	171	4,260
0°	Tension	None	400	37.7	0.22	170	4,450
0°	Tension	None	600	37.3	0.23	145	3,960
0°	Tension	None	800	37.9		138	4,440
90°	Tension	None	RT	28.2	0.18	85.1	8,310
90°	Tension	None	400	23.1	0.15	53.9	5,050
90°	Tension	None	600	22.4	0.17	47.0	3,630
90°	Tension	None	800	24.2	-	47.8	4,610
0°	Compression	None	RT	36.8	0.25	690	19,500
0°	Compression	None	400	35.8	0.23	661	19,170
0°	Compression	None	600	35.1	0.23	629	18,360
0°	Compression	None	800	34.4	0.23	577	20,080
90°	Compression	None	RT	29.6	0.17	209	11,480
90°	Compression	None	400	29.7	0.17	201	11,700
90°	Compression	None	600	28.7	0.16	188	13,060
90°	Compression	None	800	27.8	0.13	195	14,030
0°	Flexural	None	RT	-	-	218	-
0°	Flexural	None	400	-	-	211	-
0°	Flexural	None	600	-	-	192	-
0°	Flexural	None	800	-	-	179	-

TABLE XXIV STATIC PROPERTIES SUMMARY
601-VOLITAN GFR-EPIC COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ν (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
0°	Tension	800°F/1000 Hrs	RT	28.4	0.22	160	4,290
0°	Tension	800°F/1000 Hrs	400	36.7	0.24	158	4,350
0°	Tension	800°F/1000 Hrs	600	35.3	0.23	136	3,780
0°	Tension	800°F/1000 Hrs	800	35.7	-	113	3,280
30°	Tension	800°F/100 Hrs	RT	27.3	0.18	66.2	3,740
30°	Tension	800°F/100 Hrs	400	25.7	0.21	60.9	4,310
30°	Tension	800°F/100 Hrs	600	22.9	0.24	46.4	4,410
30°	Tension	800°F/100 Hrs	800	27.2	-	42.8	2,660
40°	Tension	800°F/500 Hrs	RT	23.6	0.19	59.3	5,090
40°	Tension	800°F/500 Hrs	400	23.4	0.21	60.8	3,860
40°	Tension	800°F/500 Hrs	600	21.4	0.23	54.2	3,710
40°	Tension	800°F/500 Hrs	800	13.7	-	39.8	4,250
40°	Tension	800°F/1000 Hrs	RT	25.5	0.29	51.0	2,140
40°	Tension	800°F/1000 Hrs	400	25.5	0.29	50.0	2,630
40°	Tension	800°F/1000 Hrs	600	23.3	0.20	30.4	1,940
40°	Tension	800°F/1000 Hrs	800	15.9	-	25.8	3,160
0°	Compression	800°F/100 Hrs	RT	37.7	0.22	653	20,750
0°	Compression	800°F/100 Hrs	400	35.7	0.23	582	18,680
0°	Compression	800°F/100 Hrs	600	31.3	0.20	556	24,590
0°	Compression	800°F/100 Hrs	800	31.9	0.22	535	16,790

STRENGTH PROPERTIES OF COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	σ (psi x 10 ⁶)	ϵ (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
90	Flexural	None	RT	-	-	90	-
90	Flexural	-	400	-	-	78	-
45	Flexure	None	500	-	-	62	-
90	Flexural	None	800	-	-	*	-
0	Int. Shear	None	RT	-	-	37	-
0	Int. Shear	None	400	-	-	35	-
0	Int. Shear	None	600	-	-	31	-
0	Int. Shear	None	800	-	-	-	-
45	Int. Shear	None	RT	-	-	11.7	-
90	Int. Shear	None	400	-	-	9.1	-
90	Int. Shear	None	600	-	-	7.3	-
90	Int. Shear	None	800	-	-	4.5	-
0	Tension	800°F/100 Hrs	RT	37.8	0.21	178	4,760
0	Tension	800°F/100 Hrs	400	38.2	0.24	196	5,470
0	Tension	800°F/100 Hrs	600	35.4	0.23	150	4,020
0	Tension	800°F/100 Hrs	800	33.0	-	130	3,570
0	Tension	800°F/500 Hrs	RT	38.3	0.23	185	4,980
0	Tension	800°F/500 Hrs	400	37.8	0.23	173	4,670
0	Tension	800°F/500 Hrs	600	37.5	0.26	160	4,320
0	Tension	800°F/500 Hrs	800	36.0	-	139	4,140

* No Material Left

STRENGTH AND THERMAL PROPERTIES OF EPOXY-BLENDED CARBON FIBER COMPOSITES

Orientation	Imp. Load	Pre-Load Conditioning	Test Temp (°F)	$\sigma_{ult} \times 10^6$	ϵ_{ult} (in/in)	σ_{ult} (ksi)	ϵ_{ult} (μ -in./in.)
0°	Compression	800°F/500 Hrs	RT	36.6	0.23	630	18,070
0°	Compression	800°F/500 Hrs	400	34.5	0.23	565	17,810
0°	Compression	800°F/500 Hrs	600	33.6	0.20	527	16,910
0°	Compression	800°F/500 Hrs	800	32.9	0.21	500	16,080
0°	Compression	800°F/100 Hrs	RT	28.4	0.16	205	10,320
0°	Compression	800°F/100 Hrs	400	27.5	0.18	204	10,000
0°	Compression	800°F/100 Hrs	600	27.5	0.19	185	8,600
0°	Compression	800°F/100 Hrs	800	27.4	0.19	190	9,360
0°	Compression	800°F/500 Hrs	RT	24.6	0.19	212	10,390
0°	Compression	800°F/500 Hrs	400	28.1	0.16	198	11,230
0°	Compression	800°F/500 Hrs	600	26.2	0.19	190	10,270
0°	Compression	800°F/500 Hrs	800	25.1	0.18	189	10,930
0°	Tension	800°F/100 Cy.	RT	38.2	0.22	160	4,290
0°	Tension	800°F/100 Cy.	400	35.7	0.18	149	3,970
0°	Tension	800°F/100 Cy.	600	36.4	0.19	125	3,690
0°	Tension	800°F/100 Cy.	800	39.6	-	128	3,280
0°	Tension	800°F/500 Cy.	RT	38.0	0.22	174	4,790
0°	Tension	800°F/500 Cy.	400	40.2	0.20	148	4,120
0°	Tension	800°F/500 Cy.	600	41.1	0.24	139	3,860
0°	Tension	800°F/500 Cy.	800	39.1	-	146	3,950

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TABLE XXV. TENSILE PROPERTIES OF EPOXY COMPOSITES

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	E (psi x 10 ⁶)	ϵ (in/in)	σ_{ult} (ksf)	ϵ_{ult} (in.-in./in.)
0°	Tension	800°F/1000 Cy.	RT	19.1	0.31	148	4,040
0°	Tension	800°F/1000 Cy.	400	38.5	0.21	141	3,910
0°	Tension	800°F/1000 Cy.	600	40.4	0.33	123	3,410
0°	Tension	800°F/1000 Cy.	800	32.2	-	96.8	4,330
90°	Tension	800°F/100 Cy.	RT	27.7	0.19	48.6	3,260
90°	Tension	800°F/100 Cy.	400	26.2	0.22	35.0	2,620
90°	Tension	800°F/100 Cy.	600	24.7	0.25	26.6	1,470
90°	Tension	800°F/100 Cy.	800	19.6	-	29.1	3,880
90°	Tension	800°F/500 Cy.	RT	26.7	0.24	50.4	2,530
90°	Tension	800°F/500 Cy.	400	21.6	0.16	38.6	5,300
90°	Tension	800°F/500 Cy.	600	20.1	0.16	30.4	2,370
90°	Tension	800°F/500 Cy.	800	20.2	-	26.5	3,090
45°	Tension	800°F/1000 Cy.	RT	22.9	0.21	40.6	2,940
90°	Tension	800°F/1000 Cy.	400	21.7	0.20	36.1	3,880
90°	Tension	800°F/1000 Cy.	600	22.5	0.22	30.4	2,350
90°	Tension	800°F/1000 Cy.	800	21.7	-	27.0	3,380
0°	Compression	800°F/500 Cy.	RT				
0°	Compression	800°F/500 Cy.	400				
0°	Compression	800°F/500 Cy.	600				
0°	Compression	800°F/500 Cy.	800				

TABLE XXIV STATIC PROPERTIES SUMMARY
9Al-4V-TITANIUM-10% Ni-10% Cu-1% Fe

Orientation	Type Load	Prior Conditioning	Test Temp. (°F)	$\sigma_{ult} \times 10^7$	ϵ_{ult} (in/in)	σ_{ult} (ksi)	ϵ_{ult} (in-in./in.)
90°	Compression	800°F/500 Cy.	RT	28.0	0.19	203	11,450
90°	Compression	800°F/500 Cy.	400	27.9	0.15	197	14,470
90°	Compression	800°F/500 Cy.	600	28.0	0.20	182	10,790
90°	Compression	800°F/500 Cy.	800	27.7	0.19	182	11,030

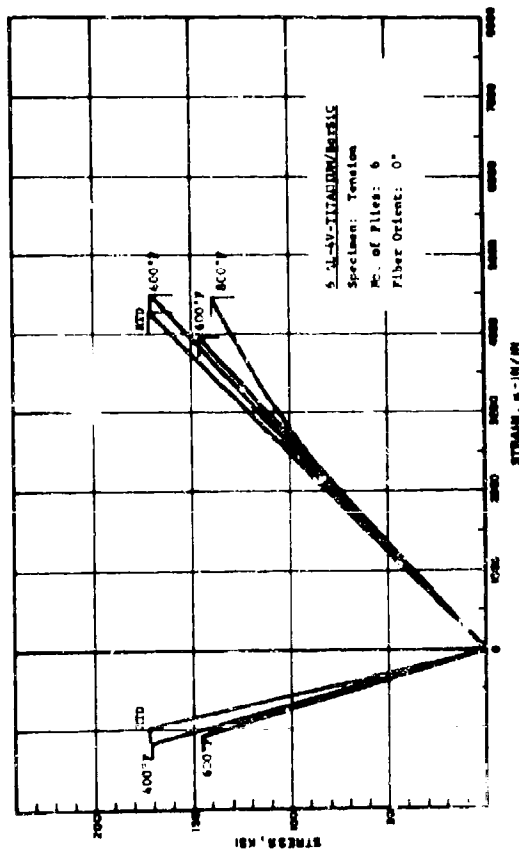


Fig. 567 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES

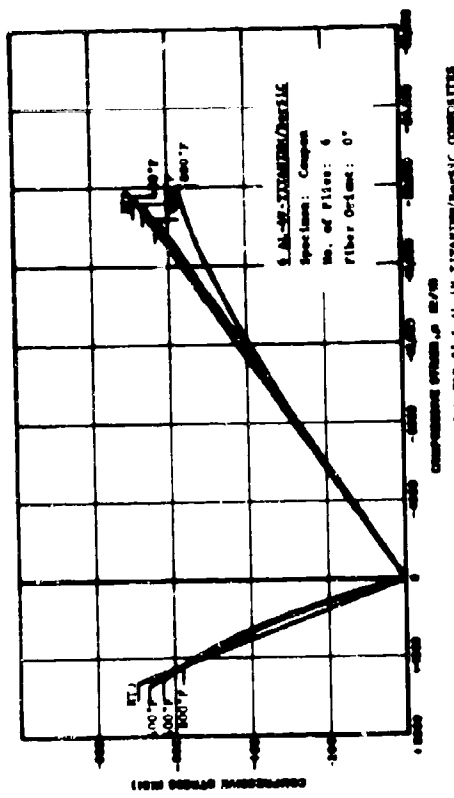


Fig. 568 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES

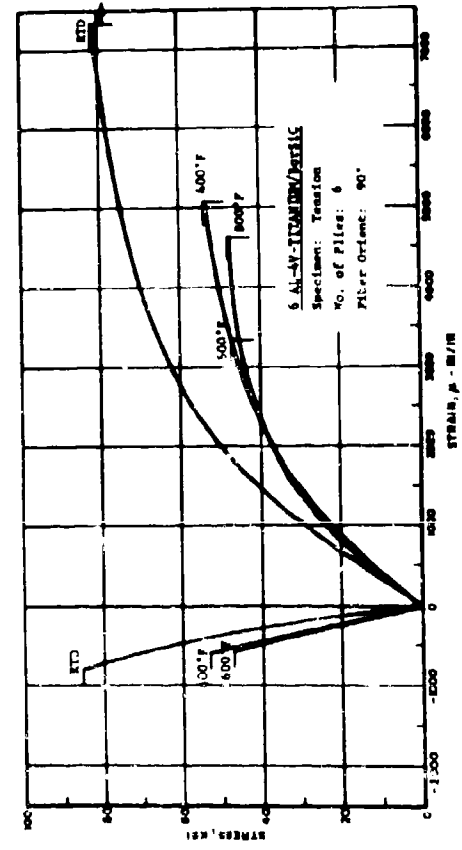


Fig. 569 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES

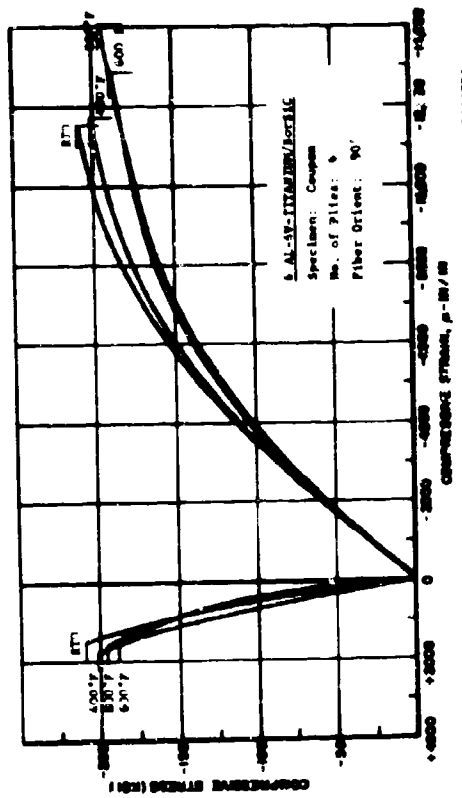


Fig. 570 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES

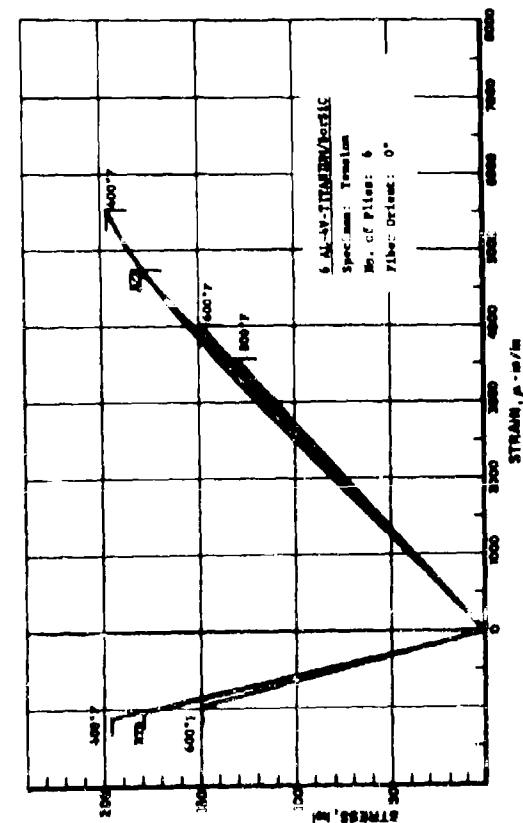


Fig. 571 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/KEVLAR COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO 800°F

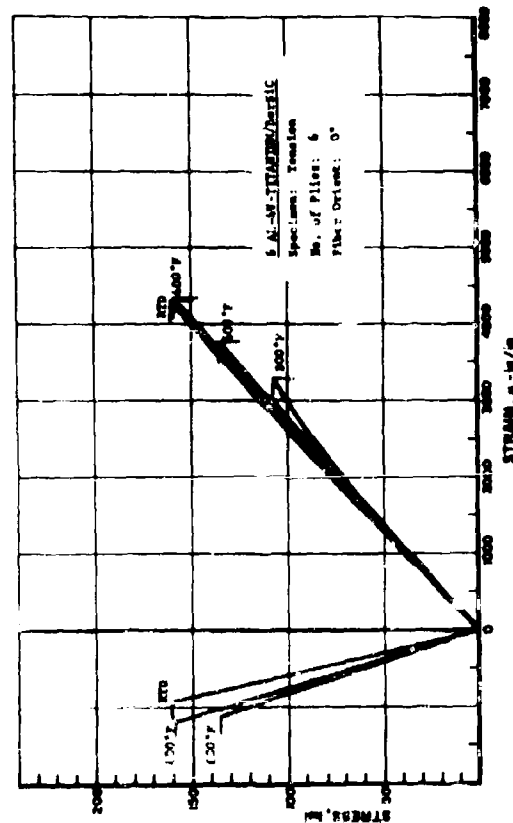


Fig. 573 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/KEVLAR COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 800°F

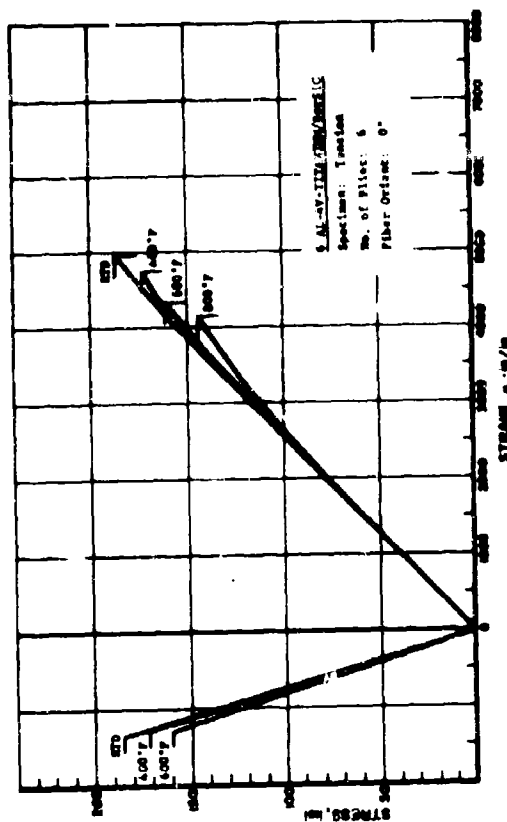


Fig. 572 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/KEVLAR COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 800°F

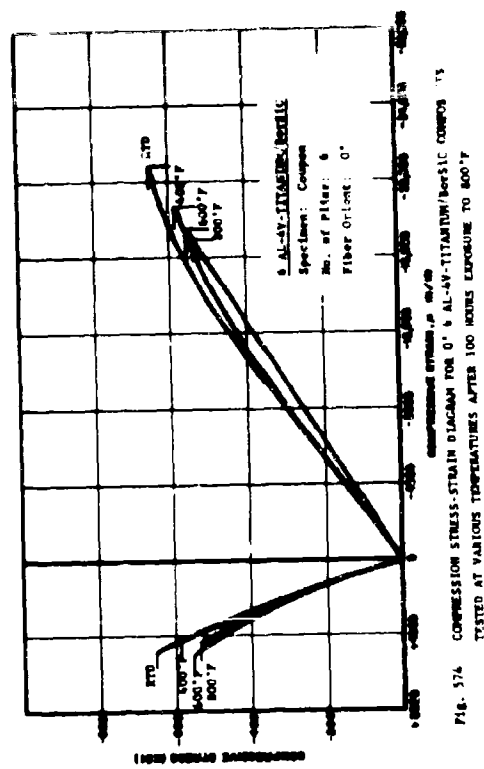


Fig. 574 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/KEVLAR COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO 800°F

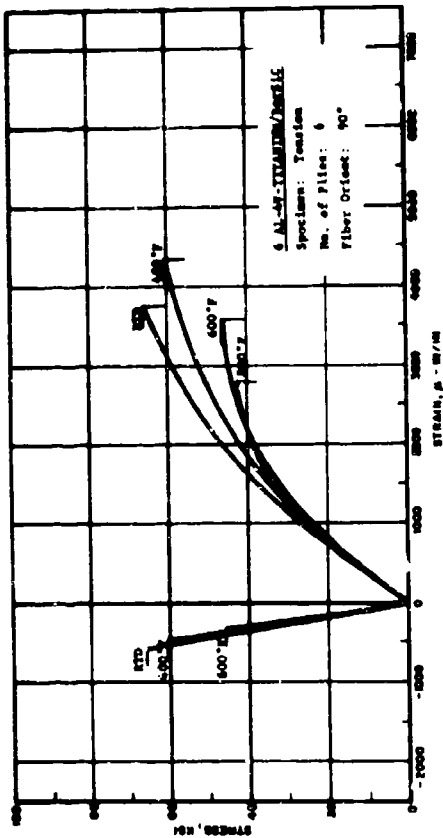


Fig. 576 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO 800°F

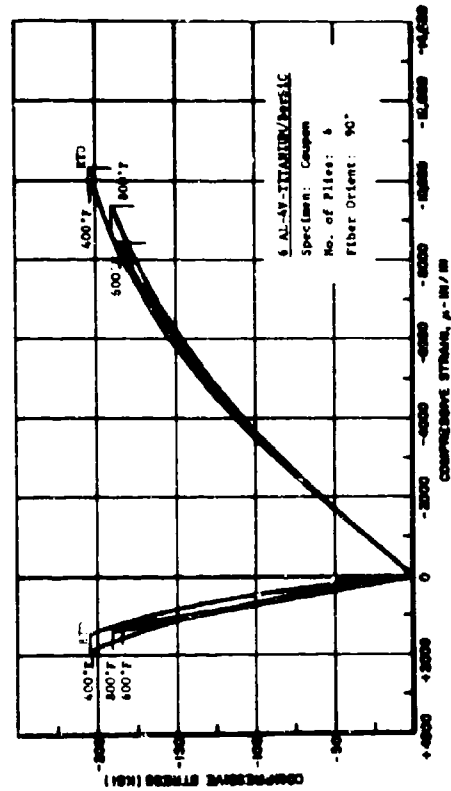


Fig. 578 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 HOURS EXPOSURE TO 800°F

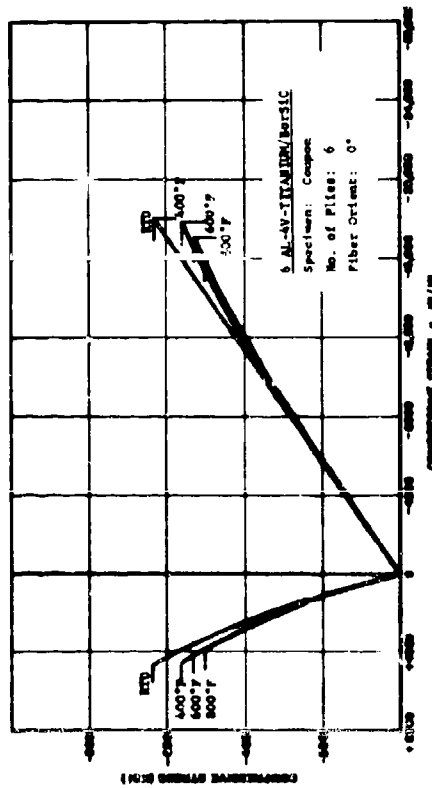


Fig. 575 COMPRESSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 800°F

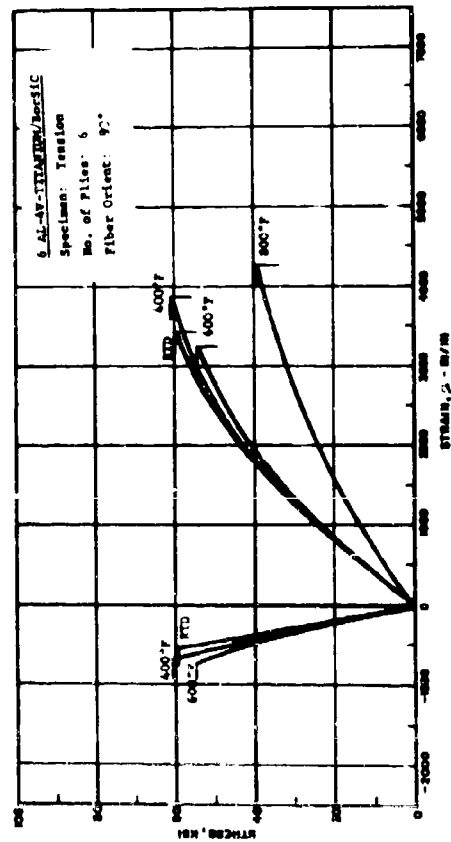


Fig. 577 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 800°F

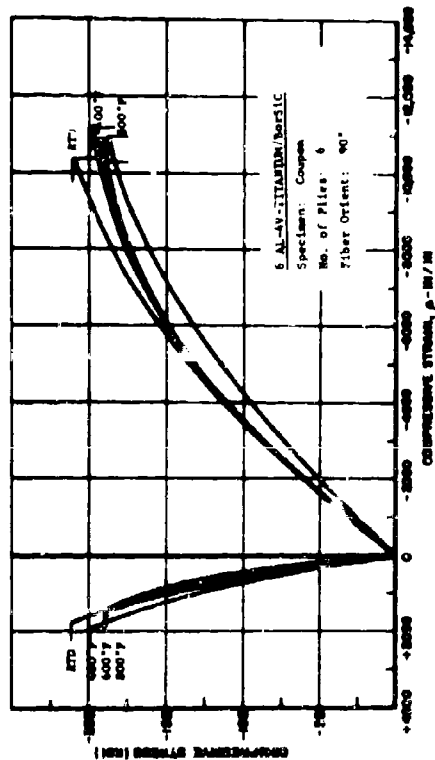


FIG. 579 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 HOURS EXPOSURE TO 800°F

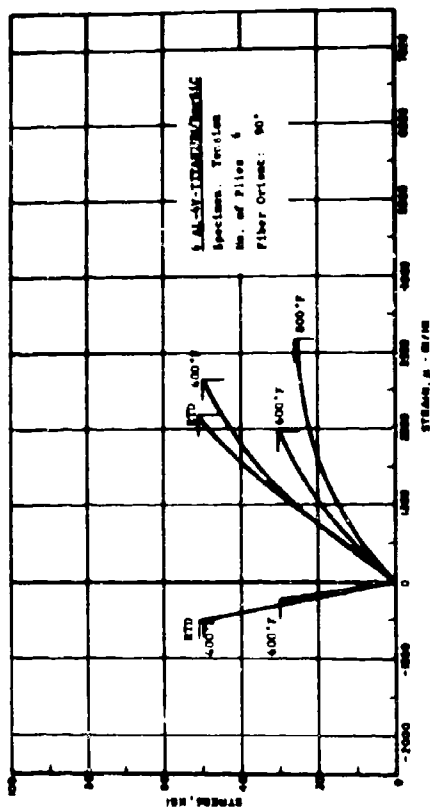


FIG. 580 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 1000 HOURS EXPOSURE TO 800°F

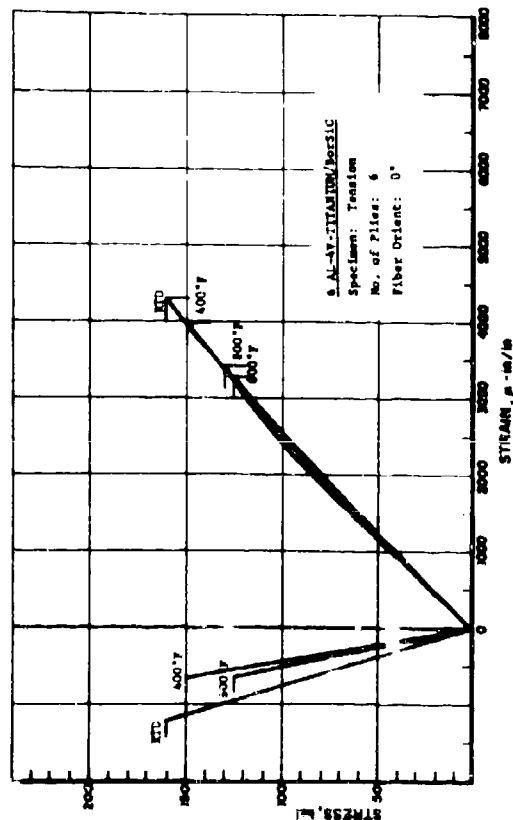


FIG. 581 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 800°F

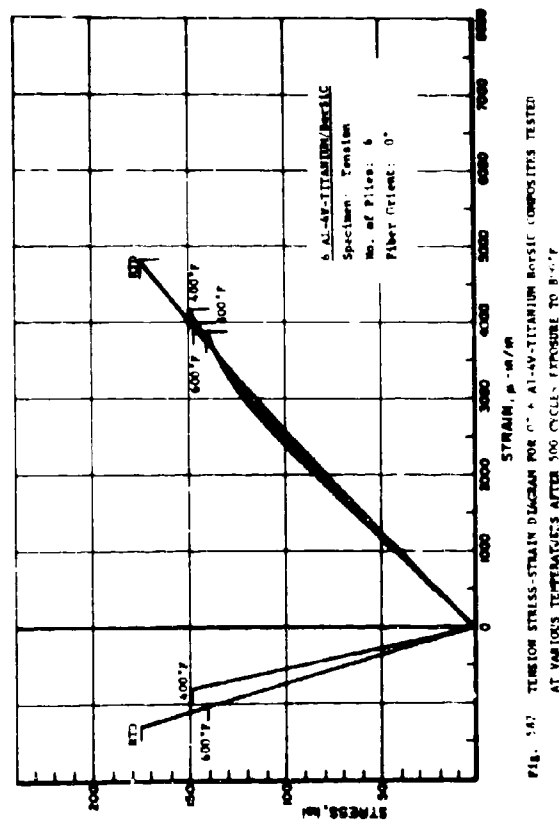


FIG. 582 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/BORSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 800°F

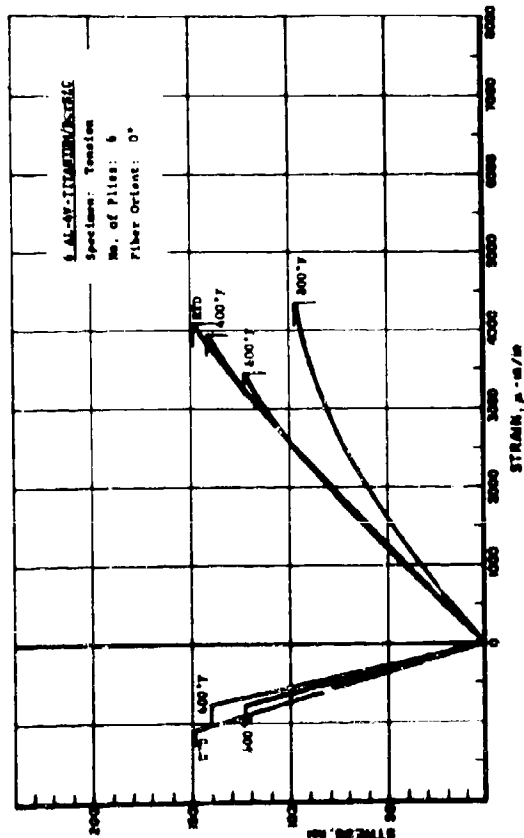


Fig. 543 TENSION STRESS-STRAIN DIAGRAM FOR 0° 6 AL-4V-TITANIUM/BOHSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 1000 CYCLES EXPOSURE TO 800°F

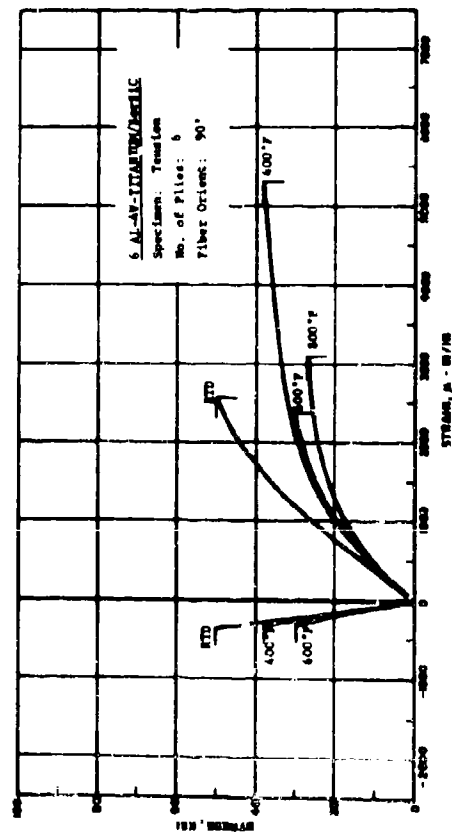


Fig. 545 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BOHSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 800°F

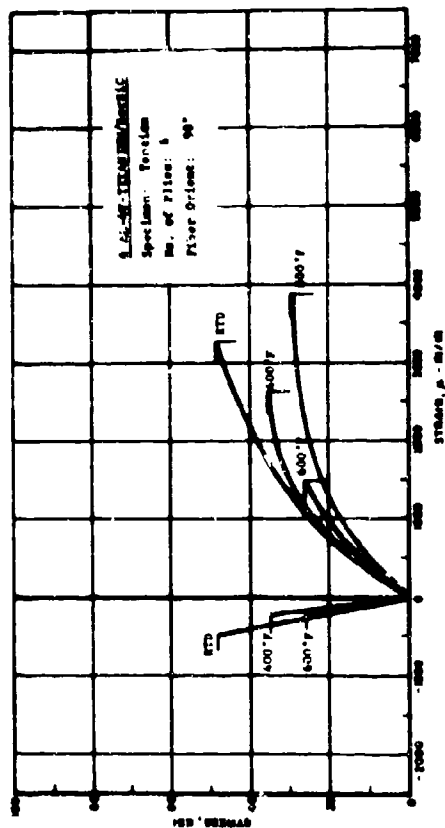


Fig. 546 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BOHSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 800°F

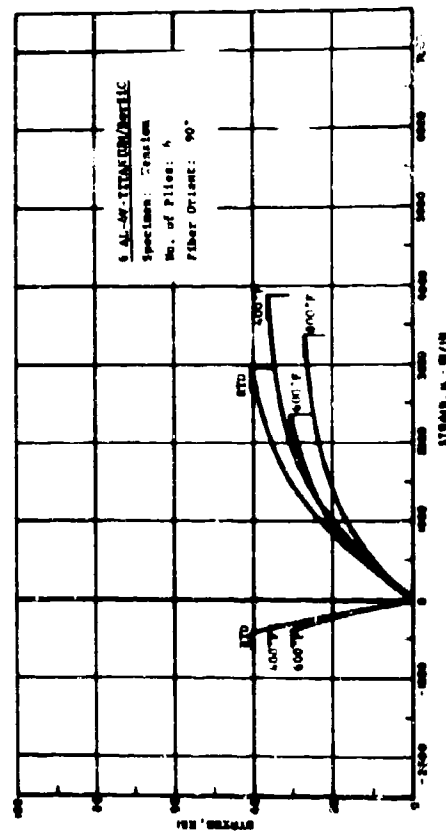


Fig. 546 TENSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/BOHSIC COMPOSITES TESTED AT VARIOUS TEMPERATURES AFTER 100 CYCLES EXPOSURE TO 800°F

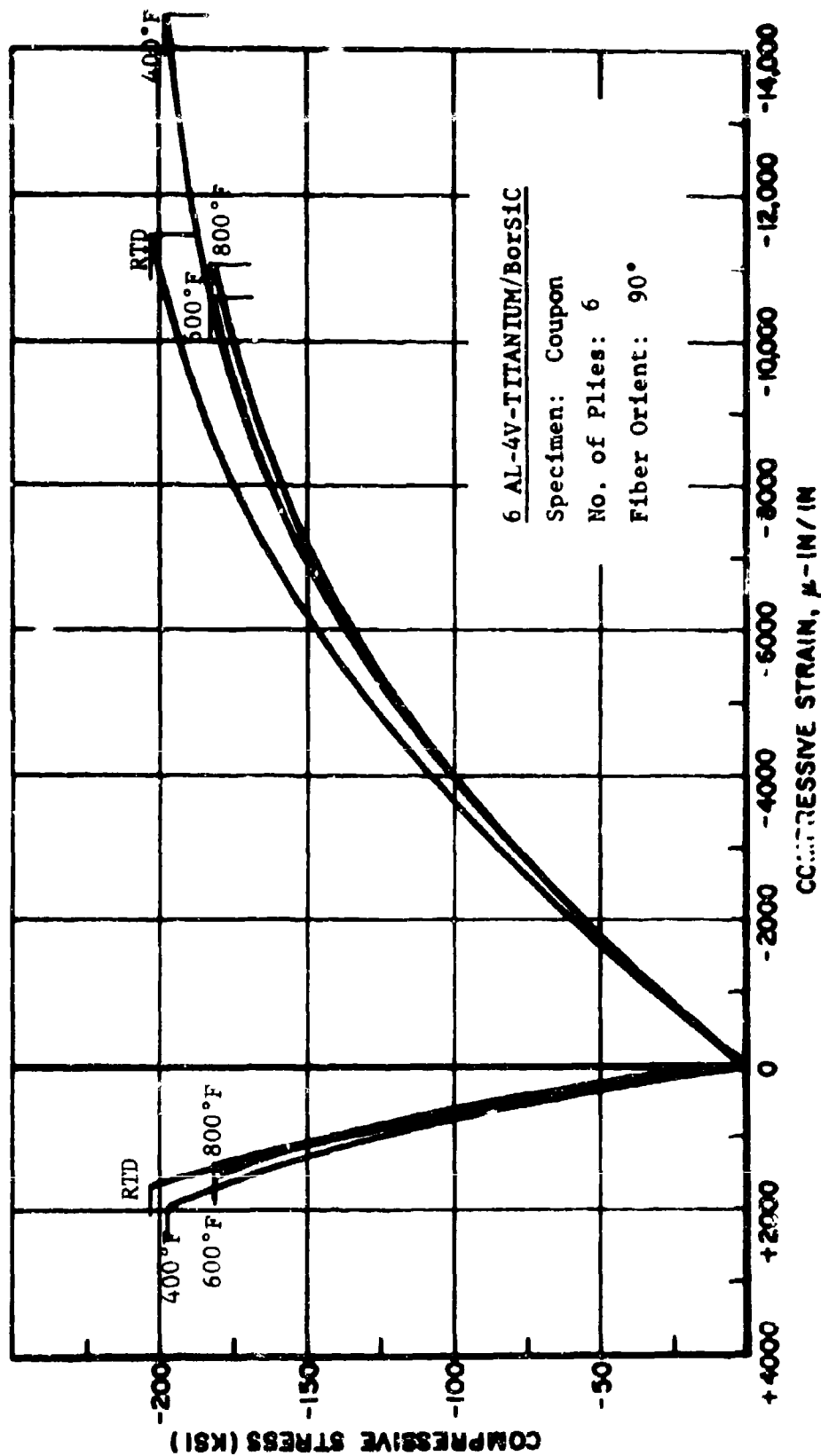


Fig. 587 COMPRESSION STRESS-STRAIN DIAGRAM FOR 90° 6 AL-4V-TITANIUM/Borsic COMPOSITES
TESTED AT VARIOUS TEMPERATURES AFTER 500 CYCLES EXPOSURE TO 800°F

TEST DATA
 TENSILE STRENGTH
 TENSILE ELONGATION
 TENSILE MODULUS
 TENSILE YIELD STRENGTH
 TENSILE REDUCTION OF AREA

Specimen Number	Thickness (Plies) (in.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (% of σ_{ult}) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
SN26-1B-1	6	0°	0.1	RTD	73	24,000	-	-	
SN26-1B-4	6	0°	0.1	RTD	76	29,000	-	-	
SN26-1B-7	6	0°	0.1	RTD	82	12,000	-	-	
SN26-1C-2	6	0°	0.1	RTD	70.5	15,000	-	-	
SN26-1C-5	6	0°	0.1	RTD	67.5	26,000	-	-	
SN26-1C-8	6	0°	0.1	400°F	73.5	14,000	-	-	
SN26-1D-3	6	0°	0.1	400°F	76.5	7,000	-	-	
SN26-1D-6	6	0°	0.1	400°F	70.5	17,000	-	-	
SN26-1D-9	6	0°	0.1	400°F	68	19,000	-	-	
SN26-2B-1	6	0°	0.1	400°F	59	30,000	-	-	
SN26-2B-4	6	0°	0.1	400°F	65.5	8,000	-	-	
SN26-2B-7	6	0°	0.1	400°F	72.5	29,000	-	-	
SN26-2C-2	6	0°	0.1	600°F	83	31,000	-	-	
SN26-2C-5	6	0°	0.1	600°F	89.5	1,000	-	-	
SN26-2C-8	6	0°	0.1	600°F	58.5	76,000	-	-	
SN26-2D-3	6	0°	0.1	800°F	69	14,000	-	-	
SN26-2D-6	6	0°	0.1	800°F	61.5	41,000	-	-	
SN26-2D-9	6	0°	0.1	800°F	54.5	81,000	-	-	
SN26-3B-1	6	0°	0.1	800°F	43.5	211,000	-	-	
SN26-3B-4	6	0°	0.1	800°F	36	-	7.33 x 10 ⁶	180	
SN26-5B-1	6	0°	-1	RTD	47*	32,000	-	-	
SN26-5B-2	6	0°	-1	RTD	55.5*	17,000	-	-	
SN26-5B-3	6	0°	-1	RTD	41*	16,000	-	-	
SN26-5B-4	6	0°	-1	RTD	35*	27,000	-	-	
SN26-5C-1	6	0°	-1	RTD	29*	114,000	-	-	

* From Tensile Ultimate Stress

TABLE XXV FATIGUE PROPERTIES SUMMARY
601-4V TITANIUM/BUSIIC
(5. mil) COMPOSITES -
BASELINE DATA

Specimen Number	Thickness (In.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (ksi) (Full)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
SN26-5C-2	6	0°	-1	-100°F	+80	51,700	-	-	
SN26-5C-3	6	0°	-1	-100°F	+90	24,000	-	-	
SN26-5C-4	6	0°	-1	-100°F	+10	1,200	-	-	
SN26-5D-1	6	0°	-1	-100°F	+60	141,000	-	-	
SN26-5D-2	6	0°	-1	-100°F	+100	24,000	-	-	
SN26-5D-3	6	0°	-1	-100°F	+80	1,000	-	-	
SN27-6B-1	6	0°	-1	-100°F	+100	3,000	-	-	
SN27-6B-2	6	0°	-1	-100°F	+100	18,000	-	-	
SN27-6B-3	6	0°	-1	-100°F	+100	21,000	-	-	
SN27-6C-1	6	0°	-1	-100°F	+100	60,000	-	-	
SN27-6C-2	6	0°	-1	-100°F	- Tests were not run	-	-	-	
SN27-6C-3	6	0°	-1	-100°F	- Tests were not run	-	-	-	
SN27-6D-1	6	0°	-1	-100°F	- Tests were not run	-	-	-	
SN27-6D-2	6	0°	-1	-100°F	- Tests were not run	-	-	-	
SN27-6D-3	6	0°	-1	-100°F	- Tests were not run	-	-	-	
SN25-5B-1	6	0°	10	RTD	-95	-	2.51 x 10 ⁶	197	
SN25-5B-2	6	0°	10	RTD	-150	1,016,000	-	-	
SN25-5B-3	6	0°	10	RTD	-165	-	2.23 x 10 ⁶	206	
SN25-5C-1	6	0°	10	RTD	-175	1,364,000	-	-	
SN25-5C-2	6	0°	10	RTD	-185	1,672,000	-	-	
SN25-5C-3	6	0°	10	400°F	-185	496,000	-	-	
SN25-5D-1	6	0°	10	400°F	-200	69,000	-	-	
SN25-5D-2	6	0°	10	400°F	-220	2,000	-	-	
SN25-5D-3	6	0°	10	400°F	-210	-	-	-	Immediate Failure.

One Spec. Short

Specimen Number	Thickness (Plies) (in.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comments
SN27-3A-1	6	0°	10	600°F	31	1,000	-	-	
SN27-3A-2	6	0°	10	600°F	28	2,000	-	-	
SN27-3A-3	6	0°	10	600°F	24	759,000	-	-	
SN27-3A-4	6	0°	10	600°F	26	-	-	-	
SN27-3A-5	6	0°	10	600°F	25	32,000	-	-	Immediate Failure
SN27-3A-6	6	0°	10	800°F	-	-	-	-	
SN27-3A-7	6	0°	10	800°F	-	-	-	-	
SN27-3A-8	6	0°	10	800°F	-	-	-	-	
SN27-3A-9	6	0°	10	800°F	-	-	-	-	
SN27-3A-10	6	0°	10	800°F	-	-	-	-	
SN26-2A-22	6	90°	0.1	RTD	70.5	60	-	-	Immediate Failure
SN26-3A-22	6	90°	0.1	RTD	53	45	1,000	-	
SN26-3A-22	6	90°	0.1	RTD	35	30	8,000	-	
SN26-4A-21	6	90°	0.1	RTD	23.5	20	34,000	-	
SN26-4A-22	6	90°	0.1	RTD	12	10	-	2.15 x 10 ⁶	
SN27-2A-1	6	90°	0.1	400°F	93	50	3,000	-	
SN27-2A-2	6	90°	0.1	400°F	74	40	5,000	-	
SN27-2A-3	6	90°	0.1	400°F	56	30	27,000	-	
SN27-2A-4	6	90°	0.1	400°F	46.5	25	206,000	-	
SN27-2A-5	6	90°	0.1	400°F	37	20	34,000	-	
SN27-2A-6	6	90°	0.1	600°F	96	45	-	-	Immediate Failure
SN27-2A-7	6	90°	0.1	600°F	42.5	20	23,000	-	
SN27-2A-8	6	90°	0.1	600°F	64	30	4,000	-	
SN27-2A-9	6	90°	0.1	600°F	32	15	67,000	-	
SN27-2A-10	6	90°	0.1	600°F	21	10	134,000	-	

TABLE XXV FATIGUE PROPERTIES SUMMARY
6Al-4V TITANIUM ROCKET
(5.7-11) COMBUSTION -
BASELINE DATA

Specimen Number	Thickness (Piles) (In.)	Orientation	R-Ratio	Test Temp. (°F)	Stress Level (Ult) (ksi)	Cycles to Failure (Cycles)	Cycles Applied Without Failure (Cycles)	Residual Strength (ksi)	Comment
SN27-2A-11	6	0.048	0.1	400°F	94	40	13,000	-	
SN27-2A-12	6	0.042	0.1	400°F	96	53	2,000	-	
SN27-2A-13	6	0.045	0.1	800°F	95	35	2,000	-	
SN27-2A-14	6	0.044	0.1	800°F	90	30	-	-	Failed under Stat Load
SN27-2A-15	6	0.048	0.1	800°F	92	27	15,000	-	
SN26-5A-21	6	0.042	-1	RTD	35	30	-	-	Immediate Failure
SN26-5A-2	6	0.042	-1	RTD	17.5	5	-	-	Immediate Failure
SN26-5A-3	6	0.041	-1	RTD	6	5	2,000	-	
SN26-5A-4	6	0.043	-1	RTD	2.5	4	-	-	Failed in Bending
SN26-5A-5	6	0.044	-1	RTD	4	3.5	-	-	Immediate Failure
SN26-5A-6	6	0.044	-1	400°F	74 *	40	-	-	Immediate Failure
SN26-5A-7	6	0.044	-1	400°F	42.5*	23	21,000	-	
SN26-5A-8	6	0.044	-1	400°F	55.5*	30	1,000	-	
SN26-5A-9	6	0.043	-1	400°F	46.5*	25	5,000	-	
SN26-5A-10	6	0.043	-1	400°F	37 *	20	2,675 x 10 ⁶	-112	
SN26-5A-11	6	0.043	-1	600°F	64 *	30	1,000	-	
SN26-5A-12	6	0.042	-1	600°F	53.5*	25	3,000	-	
SN26-5A-13	6	0.042	-1	600°F	42.5*	20	356,000	-	
SN26-5A-14	6	0.043	-1	600°F	32 *	15	4,000	-	
SN26-5A-15	6	0.043	-1	600°F	21 *	10	53,000	-	
SN26-5A-16	6	0.043	-1	800°F	-	Tests were not run	-	-	
SN26-5A-17	6	0.043	-1	800°F	-	Tests were not run	-	-	
SN26-5A-18	6	0.044	-1	800°F	-	Tests were not run	-	-	
SN26-5A-19	6	0.043	-1	800°F	-	Tests were not run	-	-	
SN26-5A-20	6	0.043	-1	800°F	-	Tests were not run	-	-	

* From tensile ultimate stress

TESTING OF PROPERTIES - STRESS
FATIGUE - FUNDAMENTAL
OF THE PROPERTIES -
STRESS - FATIGUE

Specimen Number	Thickness (Plies) (In.)	Orientation	R-Ratio	Test Temp (°F)	Stress Level (% ult) (ksi)	Cycles to Failure (cycles)	Cycles Applied without Failure (cycles)	Residual Strength (ksi)	Comment
SN27-6A-21	6	0°	10	RTD	48	137,000	-	-	
SN27-6A-22	6	90°	10	RTD	9.5	-	10.3 x 10 ⁶	131	
SN27-6A-23	6	90°	10	RTD	55	106,000	-	-	
SN27-6A-24	6	90°	10	RTD	62	1,000	-	-	
SN27-6A-25	6	90°	10	RTD	45.5	789,000	-	-	
SN27-6A-26	6	90°	10	400°F	49.5	-	3.016 x 10 ⁶	130	
SN27-6A-27	6	90°	10	400°F	60	2,000	-	-	
SN27-6A-28	6	90°	10	400°F	55	4,000	-	-	
SN27-6A-29	6	90°	10	400°F	52.5	110,000	-	-	
SN27-6A-30	6	90°	10	400°F	57.5	215,000	-	-	
SN27-6A-31	6	90°	10	600°F	53	45,000	-	-	
SN27-6A-32	6	90°	10	600°F	61.5	2,000	-	-	
SN27-6A-33	6	90°	10	600°F	56	-	-	-	
SN27-6A-34	6	90°	10	600°F	58.5	-	-	-	
SN27-6A-35	6	90°	10	600°F	- 90	557,000	-	-	
SN27-6A-36	6	90°	10	800°F	- Tests were not run	-	-	-	
SN27-6A-37	6	90°	10	800°F	- Tests were not run	-	-	-	
SN27-6A-38	6	90°	10	800°F	- Tests were not run	-	-	-	
SN27-6A-39	6	90°	10	800°F	- Tests were not run	-	-	-	
SN27-6A-40	6	90°	10	800°F	- Tests were not run	-	-	-	

Immediate Failure
Immediate Failure

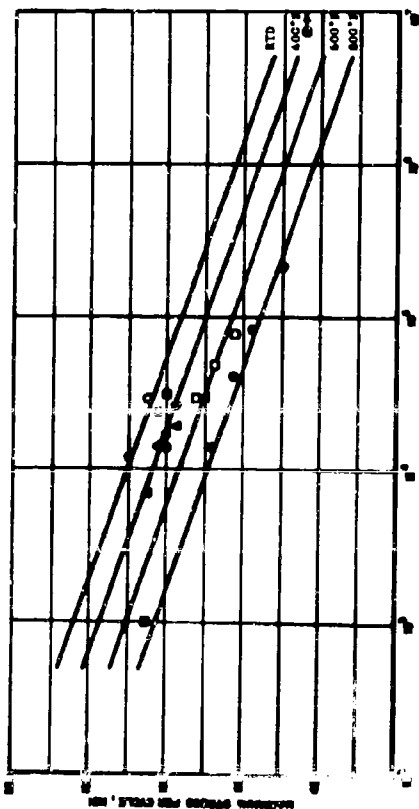


Fig. 588 FATIGUE S-N DIAGRAM FOR 0° 6Al-4V-TITANIUM/BORIC COMPOSITES TESTED AT VARIOUS TEMPERATURES ($R = 0.1$, $d = 1800$ cm)

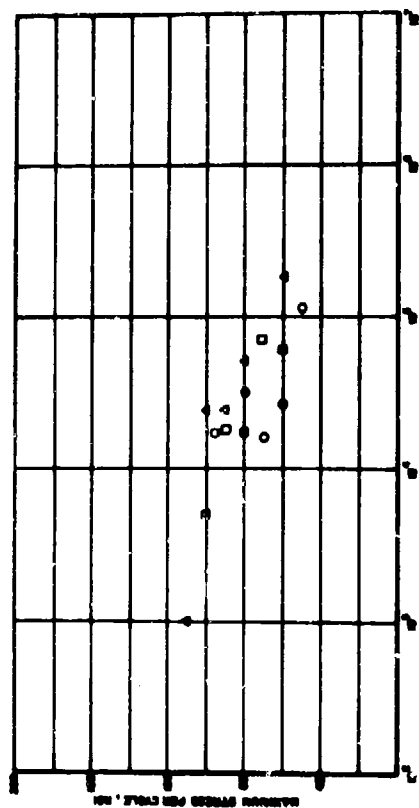


Fig. 589 FATIGUE S-N DIAGRAM FOR 0° 6Al-4V-TITANIUM/BORIC COMPOSITES TESTED AT VARIOUS TEMPERATURES ($R = -1$, $d = 1800$ cm)

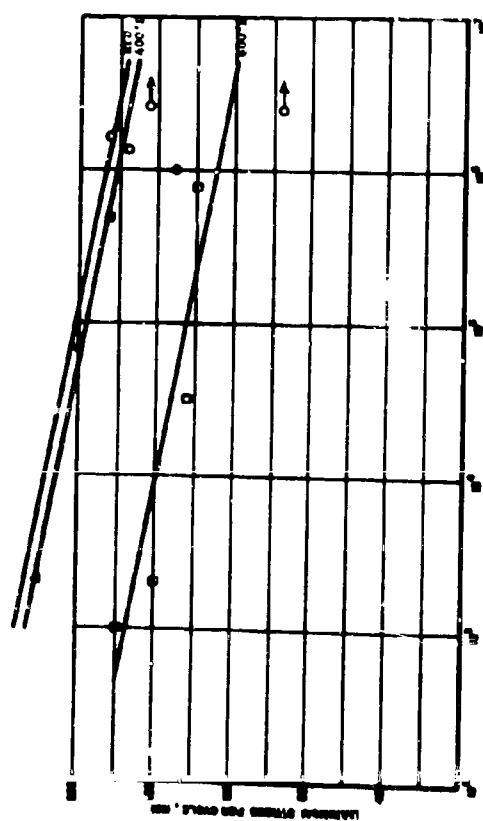


Fig. 590 FATIGUE S-N DIAGRAM FOR 0° 6Al-4V-TITANIUM/BORIC COMPOSITES TESTED AT VARIOUS TEMPERATURES ($R = 10$, $d = 1800$ cm)

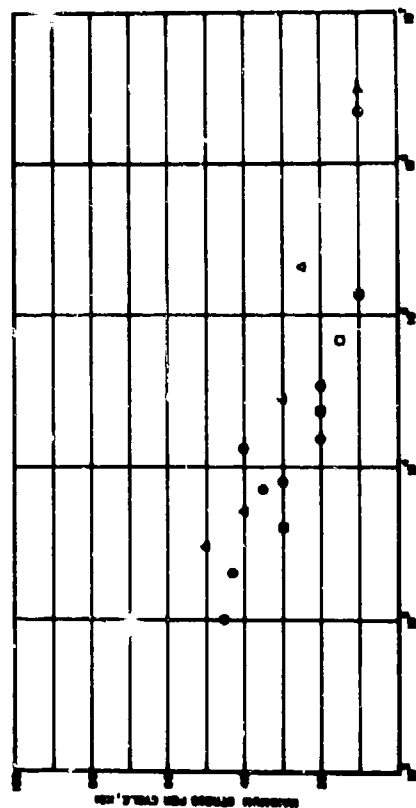


Fig. 591 FATIGUE S-N DIAGRAM FOR 90° 6Al-4V-TITANIUM/BORIC COMPOSITES TESTED AT VARIOUS TEMPERATURES ($R = 0.1$, $d = 1800$ cm)

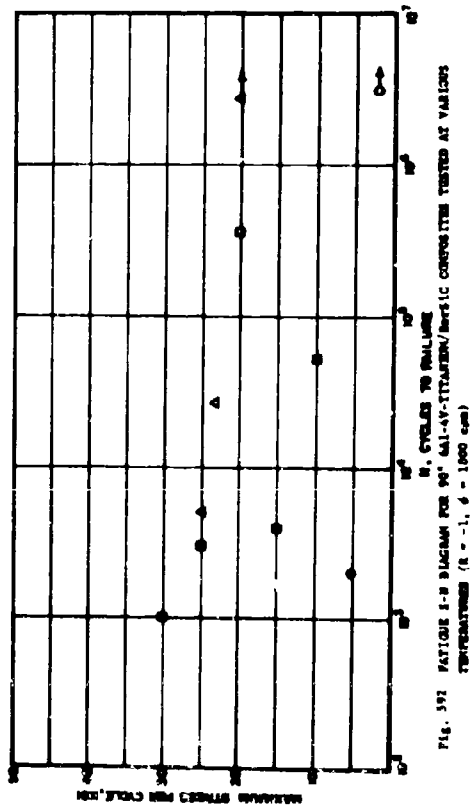


Fig. 592 FATIGUE S-N DIAGRAM FOR 90° AL-4V-TITANIUM/RESIN COMPOSITE TESTED AT VARIOUS TEMPERATURES ($R = -1$, $f = 1000$ cps)

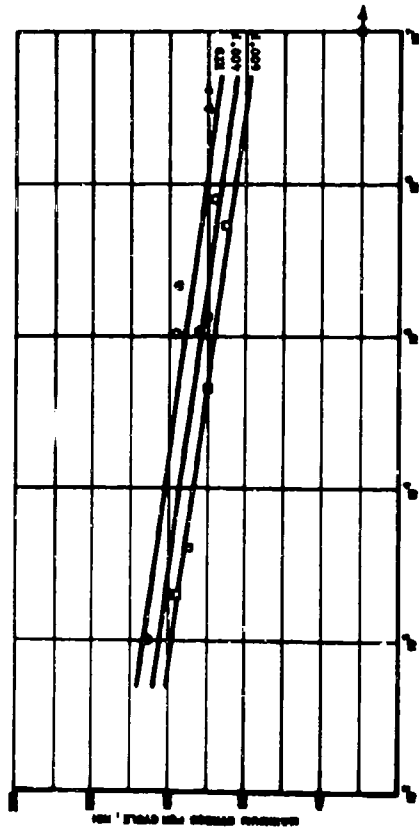


Fig. 593 FATIGUE S-N DIAGRAM FOR 90° AL-4V-TITANIUM/RESIN COMPOSITE TESTED AT VARIOUS TEMPERATURES ($R = 10$, $f = 1000$ cps)

TABLE XXVI
CREEP AND STRESS RUPTURE PROPERTIES
6A1-4V TITANIUM BORSIC (5.7:1)
COMPOSITES

Specimen Number	Thickness (Plies) (In.)	Orientation	Test Temp. (°F)	Stress Level (% σ_{ult}) (ksi)	Time to Failure (hours)	Time Applied without Failure (hours)	Comment
SN26-3B-7	6	0°	RTD	94	147.5	-	Broke during loading
SN26-3C-2	6	0°	RTD	90	141.3	-	Lost gage @ 3 min.
SN26-3C-5	6	0°	RTD	93	146.0	-	broke during fabrication
SN26-3C-8	6	0°	RTD	92	144.4	-	
SN26-3D-3	6	0°	RTD	92	144.4	-	
SN26-3D-6	6	0°	400°F	85	144.5	-	Broke during loading
SN26-3D-9	6	0°	400°F	79	134.3	-	Broke during loading
SN26-4B-1	6	0°	400°F	90	153.0	11.3	Broke in Middle
SN26-4B-4	3	0°	400°F	88	149.6	.016	Broke in Middle
SN26-4B-7	6	0°	400°F	82	139.0	-	Broke during loading
SN26-4C-2	6	0°	600°F	85	121.8	-	Broke during loading
SN26-4C-5	6	0°	600°F	86	122.9	.050	
SN26-4C-8	6	0°	600°F	83	118.6	-	Broke after 2 hours
SN26-4D-3	6	0°	600°F	90	128.7	-	Broke during loading
SN26-4D-6	6	0°	600°F	90	128.7	-	Broke during loading
SN26-4D-9	6	0°	800°F	80	108.8	-	Broke during loading
SN28-4A-3	6	0°	800°F	96	130.5	-	Broke during loading
SN28-4A-4	6	0°	800°F	90	122.4	-	Broke during loading
SN28-4A-5	6	0°	800°F	94	127.8	-	Broke during loading
SN28-4A-6	6	0°	800°F	85	115.6	.167	

TABLE XXVI (REPEAT SERIES) TENSILE PROPERTIES SUMMARY
FALCON 1000

Specimen Number	Thickness (plies) (in.)	Orientation	Test Temp. (°F)	Stress Level (σ _{ult}) (ksi)	Time to Failure (hours)	Time Applied without Failure (hours)	Comment
SN25-SA-1	6	0.047	90°	80	58	-	Broke during loading
SN25-SA-2	6	0.048	90°	88	63.8	-	Broke during loading
SN25-SA-3	6	0.047	90°	84	60.9	-	Broke during loading
SN25-SA-4	6	0.047	90°	41	29.7	1000	
SN25-SA-5	6	0.048	90°	50	36.2	1000	
SN25-SA-6	6	0.048	90°	85	45.8	-	Broke during loading
SN25-SA-7	6	0.047	90°	76	40.9	-	Broke during loading
SN25-SA-8	6	0.049	90°	78	42.0	-	Broke during lubrication
SN25-SA-9	6	0.046	90°	80	43.1	-	Broke during loading
SN25-SA-10	6	0.046	90°	80	43.1	.033	Broke
SN25-SA-11	6	0.041	90°	90	42.3	-	Broke during loading
SN25-SA-12	6	0.041	90°	85	39.9	-	Broke during loading
SN25-SA-13	6	0.041	90°	80	37.6	1.0	
SN25-SA-14	6	0.042	90°	83	39.0	-	Broke during loading
SN25-SA-15	6	0.042	90°	78	36.6	.033	
SN25-SA-16	6	0.050	90°	88	42.0	-	Broke during loading
SN25-SA-17	6	0.050	90°	80	38.2	-	Broke during loading
SN25-SA-18	6	0.050	90°	78	37.2	-	Broke during loading
SN25-SA-19	6	.051	90°	75	36.0	-	Broke during loading
SN25-SA-20	6	0.052	90°	84	40.1	-	(Ran 1.8 hours)

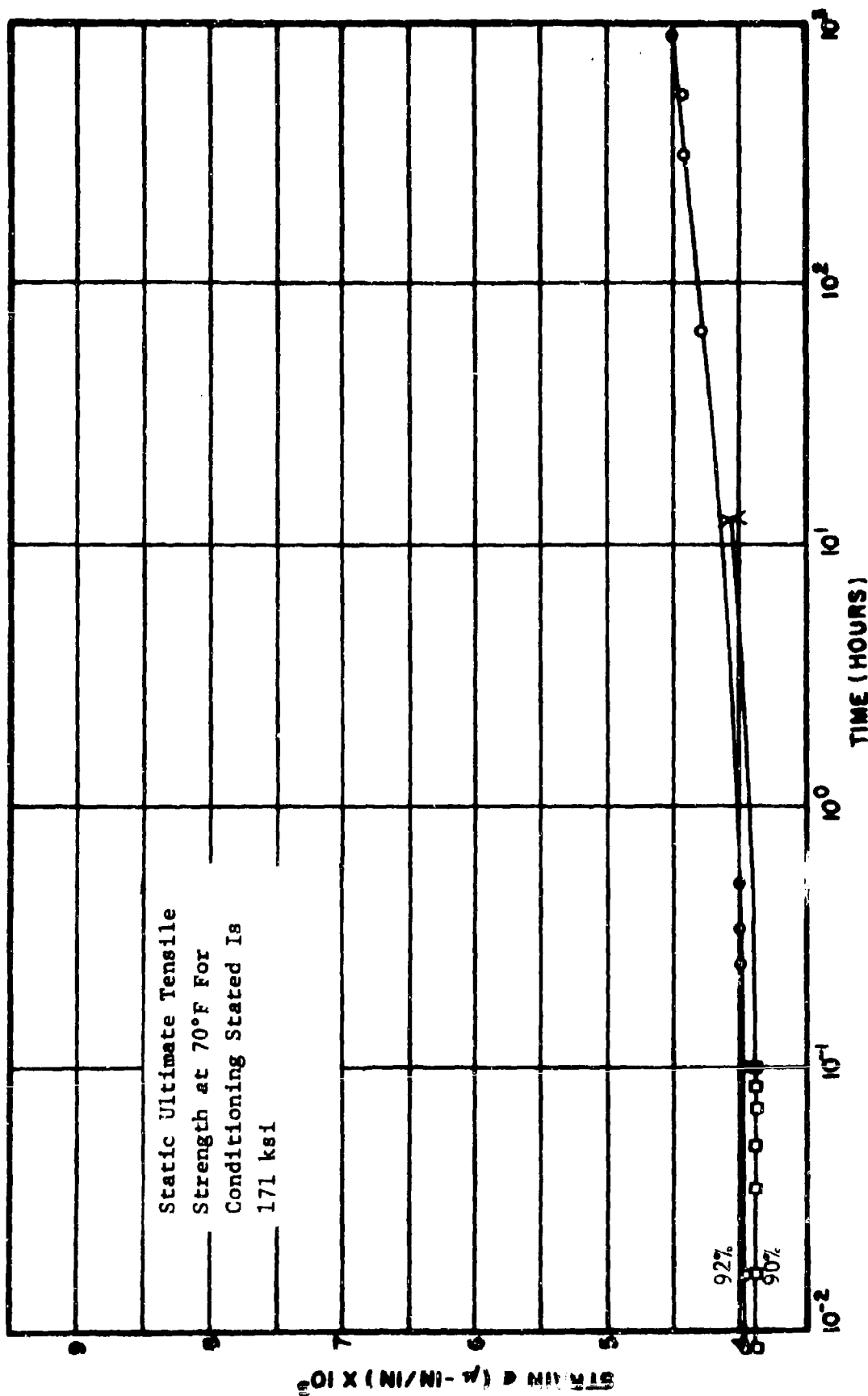


Fig. 594 TENSILE CREEP STRAIN VERSUS TIME CURVES FOR 0° 6Al-4V-TITANIUM BORSIC COMPOSITES TESTED AT ROOM TEMPERATURE