

DEVELOPMENT  
OF A  
BIAXIAL TEST FIXTURE

January 1980

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**AEROSPACE STRUCTURES  
INFORMATION AND ANALYSIS CENTER**

**OPERATED FOR THE AIRFORCE FLIGHT DYNAMICS LABORATORY  
BY ANAMET LABORATORIES, INC.**

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OF A  
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This report describes the development, fabrication and testing of fixturing designed to determine the biaxial properties of materials. The fixturing was designed to be particularly compatible with composite materials, although it is not limited to use with those materials. As part of the work, a second fixture was built which applies only internal pressure to thin ring specimens.

The work was done by the Aerospace Structures Information and Analysis Center, which is operated for the Air Force Flight Dynamics Laboratory, by Anamet Laboratories, Inc., under Contract No. F33615-77-C-3046. The work was performed under ASIAC Problem No. 112.

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I. INTRODUCTION

The Aerospace Structures Information and Analysis Center has designed and fabricated a specimen load system for conducting biaxial material characterizations of composite materials. In particular, the system is useful for determining a major portion of the biaxial failure envelopes for composite materials. Portions of the triaxial failure surface where at least two of the principal stresses are negative may also be explored with the system. In addition, with proper control, the system may be used to evaluate the multiaxial fatigue properties of composites. Materials with high Poisson's ratios, which cannot usually be evaluated with ring burst tests, may be easily tested in the ASIAC system. Theoretical aspects of the system have been described in Anamet Laboratories, Inc. Report No. 277.502, "Technical Proposal for Test System for Conducting Biaxial Tests of Composite Laminates." Design of the test system is such that it is best used with any standard compression or universal testing machine with a minimum capacity of 100,000 lbs.

The test system, which is useful for examining quadrants II, III and IV of the biaxial stress plane, utilizes short cylindrical specimens. The specimens may be loaded with combinations of axial compression, internal pressure and external pressure. A unique feature of the test system is that end restraints are minimized by applying all loads through hydrostatic pressures. Hoop stresses are produced by applying internal or external pressures through the use of pressurized oil. Radial stresses may be produced by simultaneously applying internal and external pressures. Axial stress is induced through specimen interaction with a high pressure lubricant trapped between the specimen ends and parallel platens.

Because of the mechanism of loading, restraint to end dilation and twisting is governed by the viscous or plastic

shear strength of the lubricant. Lead foil, indium foil, polyethylene film and combination stacks of films and foils have been evaluated for use as the solid high pressure lubricant. The solid lubricant serves other functions in addition to minimizing restraint. For example, the foil compensates for slight irregularities and mismatch between platens and specimens. It also assists in the attainment of an oil-tight seal between the specimen ends and platens. Such a seal is necessary for the application of surface oil pressures.

This report describes the development of the system to date and some of the problems encountered. It also presents the results of biaxial testing of specially made and strain gaged composite specimens. The test results are quite encouraging, and they show that further refinement and use of the system is warranted.

## II. DESCRIPTION OF TEST SYSTEM

Principal components of the platen and pressure system are shown in Figure 1. A dimensioned drawing of the system is given in Figure 2. The small hollow cylinder acts as the lower platen. A step in the solid cylinder serves as the upper platen bearing surface. The upper platen is stepped to reduce the area perpendicular to the specimen axis. This reduces the axial load required to overcome the axial resultant of the oil pressure and allows a smaller testing machine to be used. The platens are made from through-hardened 4340 steel to minimize specimen damage to the platen surfaces. If damage or wear should occur, the through-hardening allows the platens to be reground without the necessity for repeating case hardening or heat treating.

Specimens compatible with the biaxial fixture are approximately 4 inch in diameter and less than 3 inches in length. Typical test specimens and foil gaskets are shown in Figure 3. The specimens are sandwiched between gaskets which bear against the two platens. Gasket performance was evaluated by crushing a series of Fiberglass epoxy specimens using various gasket combinations. During those tests, specimen hourglassing, or barreling, was monitored using dial gages. It was found that a laminate gasket consisting of 0.003 inch polyethylene sandwiched between 0.002 inch soft lead foil generally produced the least amount of hourglassing or barreling.

A photograph of the fixturing installed in an MTS Model 810, 110 kip, servohydraulic testing machine is given in Figure 4. In this figure, the specimen is about to be tested under axial compression. A self-aligning platen is secured to the load cell to eliminate eccentricity of the load axis. When internal pressure is applied, a splash guard and catch pan are incorporated in the system. For the application of external oil pressures, the heavy pressure collet is placed about the specimen,

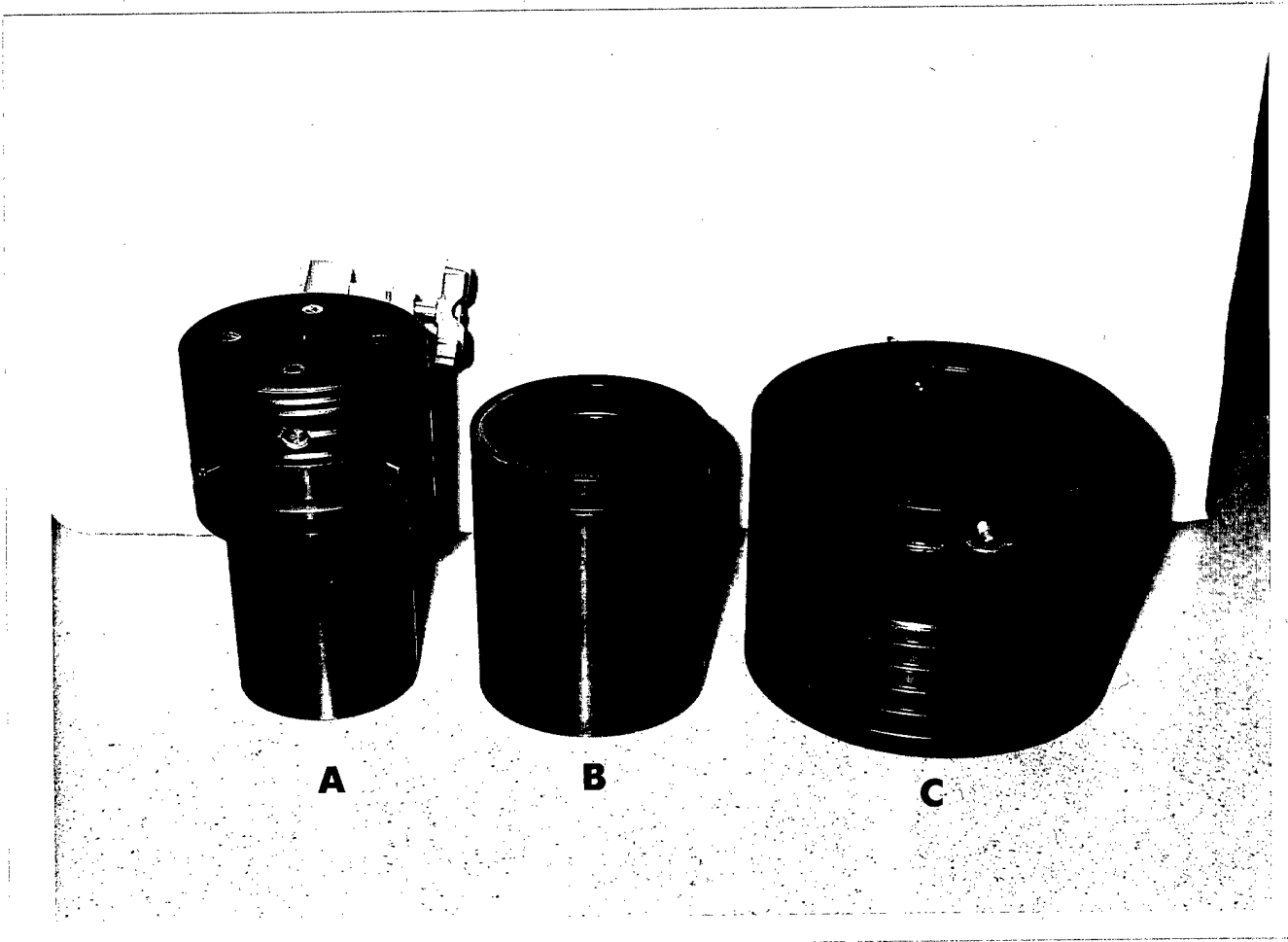


Figure 1 Principal Components of the Platen and Pressure System

- A - Upper Platen
- B - Lower Platen
- C - External Pressure Collet



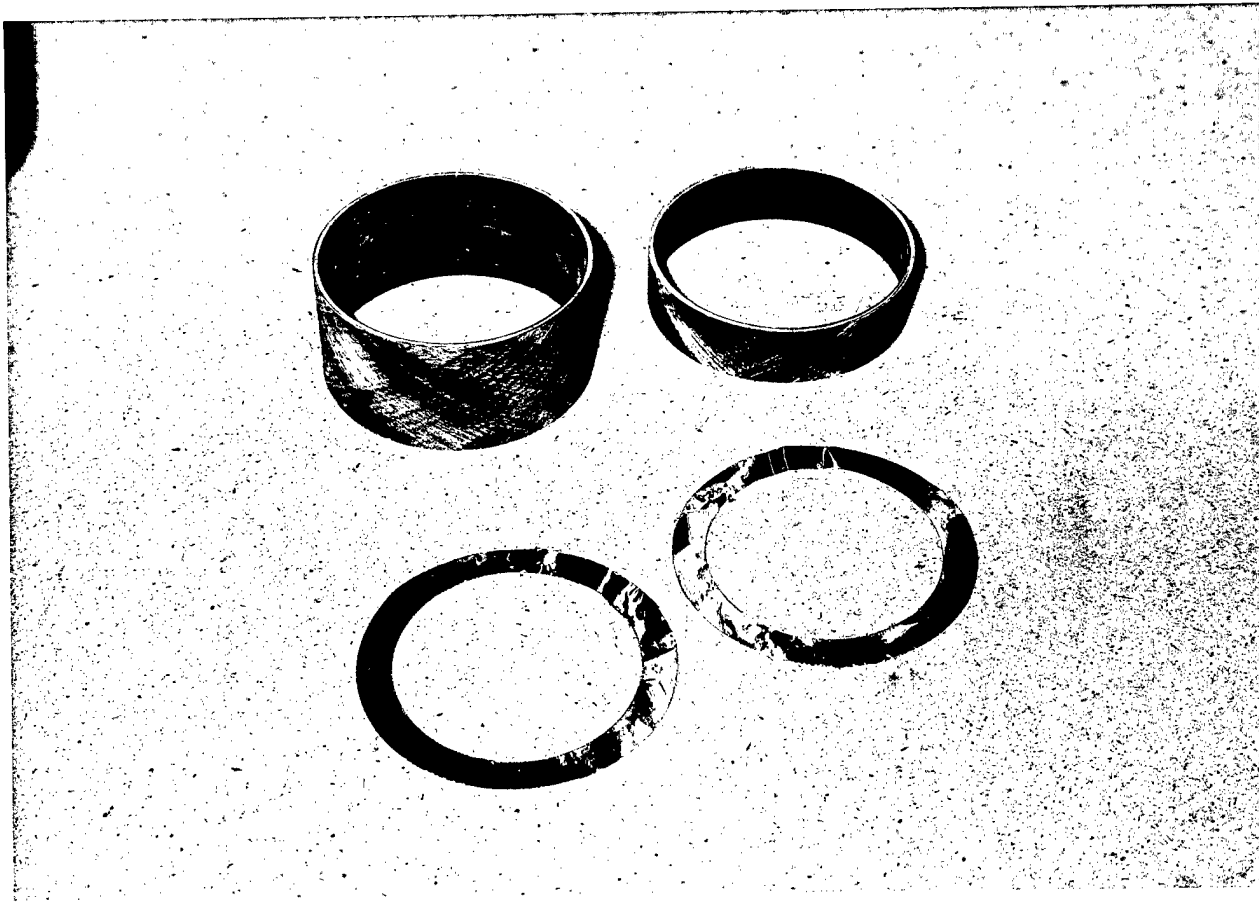


Figure 3 Typical Test Specimens and Foil Gaskets

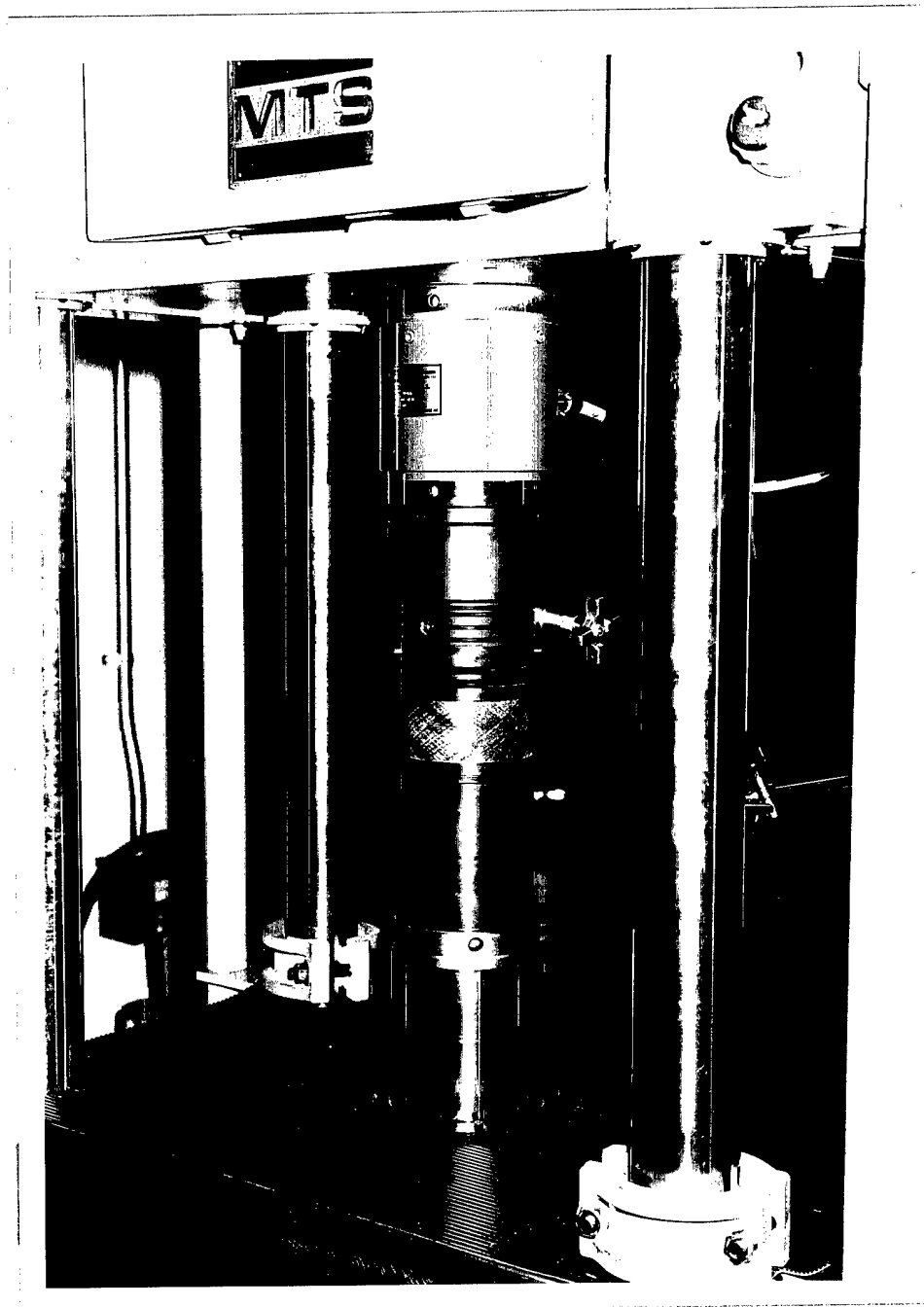


Figure 4    Fixture Installed in Testing Machine  
Prior to Axial Compression Test

as shown in Figure 5. The collet has been designed to withstand working pressures of 10,000 psi. In a few tests, an Enerpac 10,000 psi hydraulic power supply has been used to furnish the pressurized oil; however, hydraulic pressure for most of the tests was provided by an HIP, Inc. Model 87-6-5 manual pressure generator. Internal and external oil pressures were monitored with a standard pressure gage and a Datronic Model 502-3000G pressure transducer.

Many of the composite specimens tested in the fixture have been instrumented with resistive foil strain gages. Strain gage readings, as well as readings from the pressure transducer and MTS load cell, were taken using a Sun Systems ADACUS Data Processing and Readout System. This system contains an AD-I-SCE-10/32 Data Monitor with analog to digital converter, a DCP-10/P2/ADC-1 Display/Control Printer and two IM32/16 input multiplexers. Bridge completion, balancing and calibration are all internal to the Sun System. Internal calibrations are always checked with external shunt resistors. In the print mode, the ADACUS System scans at a rate of  $2\frac{1}{2}$  channels per second. As composite materials may be viscoelastic, the strain gage data should be taken as rapidly as possible. To speed up the system scan rate, the ADACUS System was modified to bypass the printer and send the data directly to the memory of an IMSAI 8080 microprocessor. This allowed the scan rate to be increased to  $12\frac{1}{2}$  channels per second. After completion of a test, the stored data was read into an ASR33 TTY, where punch tape and hardcopy records were made. Later, the punch tapes were read through the ASR33 and a file created in a PDP11/34. Loads corresponding to strain values were found through linear interpolation with time. A specially written program in the PDP11/34 allowed plots to be made of strains vs. stresses (see Appendix A). The plots were made on a TEKTRONIX Model 4631 hardcopy unit.

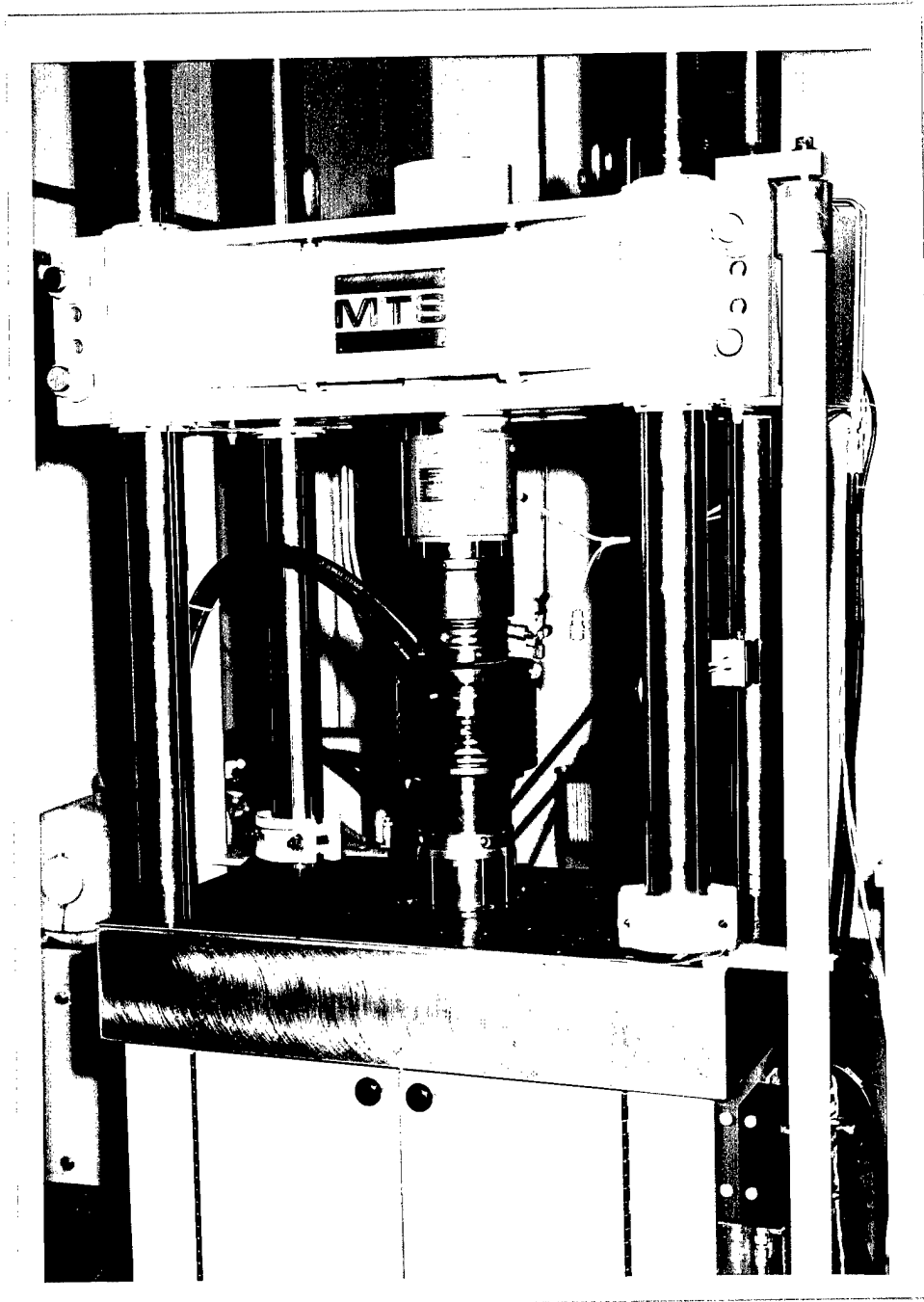


Figure 5 Fixture Installed in Testing Machine Prior to External Pressure and Axial Compression Test

It was discovered early in the program that the foil gaskets by themselves could not adequately contain the pressurized oil. To overcome this problem, and to prevent the oil from contacting the specimens, rubber gaskets were designed and incorporated into the system. The gaskets were molded from butyl rubber with a Shore A hardness of 60. They were precision molded tubes with wall thicknesses of 0.125 inches and heights 0.025 inches higher than the composite specimens. The rubber gasket diameters were such that some gaskets could be slipped inside the specimens and others could be slipped outside the specimens. Small openings were cut in the rubber gaskets to allow penetration of strain gage leads. After the leads were passed through the openings, RTV rubber was applied as a sealant. Small connector plugs were epoxy potted inside the pressure collet and in a groove machined in the center plug. Strain gage leads were terminated with plugs mating with the potted plugs. With this arrangement, hydraulic oil pressures could be applied to the specimens, and at the same time, strain gage readings taken.

### III. DESCRIPTION OF SPECIMENS

In the initial development of the system, numerous specimens were tested to evaluate various gasket combinations and seal systems. Those tests were largely qualitative, and data was not recorded. Due to availability and attractive cost, the preliminary test specimens were made from Bondstrand 2000 Fiberglas-reinforced epoxy resin pipe. Details of the ply layup were unknown; however, it appeared to be a wound  $\pm 45^\circ$  structure. The Fiberglas epoxy specimens had an outside diameter of 4.375 in., a wall thickness of typically 0.100 in. and heights of either 1.000 in. or 2.000 in.

After seal and gasket problems were solved, a number of uninstrumented graphite-epoxy specimens were tested under internal pressure and axial load. Those specimens had outside diameters of 4.000 in., wall thicknesses of 0.043 in. and heights of either 1.000 in. or 2.000 in. Localized buckling problems with the first two of these specimens suggested the specimen ends were either not flat or not parallel. Careful measurements of the remaining specimens disclosed variations in height of as much as  $\pm 0.003$  inches. The specimen ends were then ground flat and parallel to within 0.0005 in. With this change, the localized buckling problems ceased. The purpose of the preliminary graphite-epoxy tests was to use dial gages to semi-quantitatively evaluate system performance with relatively thin walled high strength materials.

As the preliminary graphite-epoxy tests yielded promising results, a series of tests were performed on carefully made strain gaged specimens. The specimens were graphite-epoxy, and measured 4.000 inches O.D., were 1.000 inches high and had a wall thickness of 0.043 inches. The ends were ground flat and parallel to within 0.0005 inches. Four specimens had a  $[0^\circ/\pm 45^\circ/90^\circ]_S$  ply layup. All specimens were strain gaged, as shown in Figure 6. The instrumented specimens were provided by AFFDL.

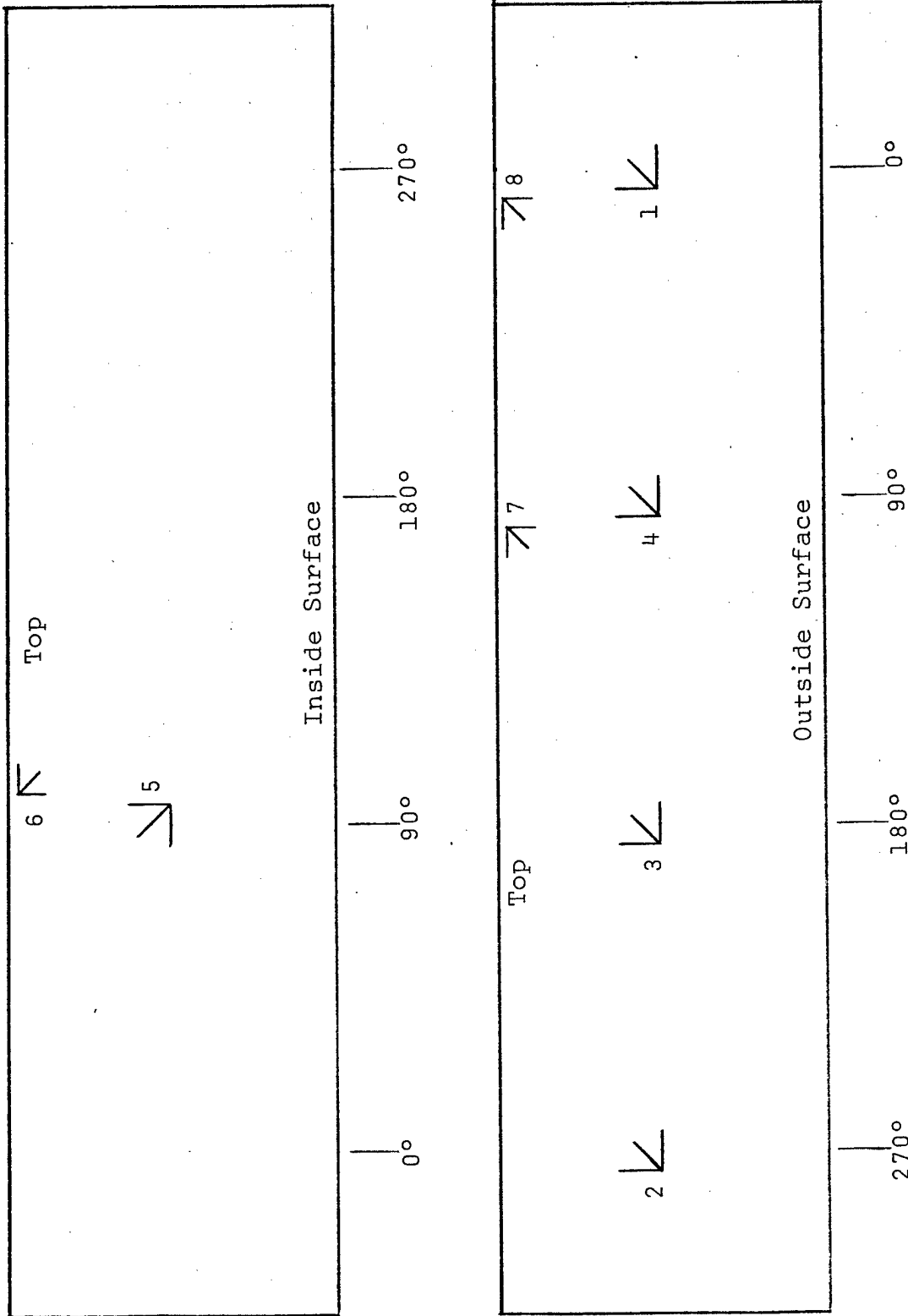


Figure 6 Unrolled view of specimen showing relative rosette locations and identifications. Rosettes 6, 7 & 8 are stacked rosettes with 0.062" gage lengths. The remaining rosettes are standard rosettes with 0.125" gage lengths.

IV. TEST RESULTS

Tests performed on the seven strain gaged specimens are summarized in Table 1.

TABLE 1  
SUMMARY OF TESTS

<u>Test No.</u>	<u>Specimen Type</u>	<u>Loading</u>	<u>Notes</u>
1	$\pm 45^\circ$	Axial only	
2	$0^\circ/\pm 45^\circ/90^\circ$	Internal pressure	200 lb. axial pre-load
3	$\pm 45^\circ$	Internal pressure	Constant 100 lb. axial load
4-A	$\pm 45^\circ$	Axial only	Same specimen, partial compressions
4-B	$\pm 45^\circ$	Axial only	Same specimen, partial compressions
4-C	$\pm 45^\circ$	Axial only	Same specimen, partial compressions
5	$\pm 45^\circ$	External pressure	Same specimen as used in 4-A,B,C
6	$0^\circ/\pm 45^\circ/90^\circ$	Internal pressure and axial load	Internal pressure equals axial load, pure shear condition
7	$0^\circ/\pm 45^\circ/90^\circ$	External pressure and axial load	Hoop stress equal to axial stress
8	$0^\circ/\pm 45^\circ/90^\circ$	External pressure	Edge damaged - not tested

For each of the tests performed, stress-strain plots were created from strain gage, load cell and pressure transducer outputs. The stress-strain plots for each test are summarized in Table 2.

TABLE 2  
 SUMMARY OF PLOTS

<u>Test No.</u>	<u>Description</u>	<u>Rosette Nos.</u>	<u>Figure No.</u>
1	Axial strain vs. axial stress	1,2,3,4	7
	Axial strain vs. axial stress	4,5	8
	Axial strain vs. axial stress	7,8	9
	Hoop strain vs. axial stress	2,3,4	11
	Hoop strain vs. axial stress	4,5	12
	Hoop strain vs. axial stress	6,7,8	13
	Max. shear strain vs. axial stress	2,3,4	14
	Max. shear strain vs. axial stress	4,5	15
	Max. shear strain vs. axial stress	6,7,8	16
	2	Axial strain vs. hoop stress	1,2,3,4
Axial strain vs. hoop stress		4,5	20
Axial strain vs. hoop stress		6,7,8	23
Hoop strain vs. hoop stress		1,2,3,4	18
Hoop strain vs. hoop stress		4,5	21
Hoop strain vs. hoop stress		6,7,8	24
Max. shear strain vs. hoop stress		1,2,3,4	19
Max. shear strain vs. hoop stress		4,5	22
Max. shear strain vs. hoop stress		7,8	25
3		Axial strain vs. hoop stress	1,2,3,4
	Axial strain vs. hoop stress	4,5	30
	Axial strain vs. hoop stress	6,7,8	33
	Hoop strain vs. axial stress	1,2,3,4	28
	Hoop strain vs. axial stress	4,5	31
	Hoop strain vs. axial stress	6,7,8	34
	Max. shear strain vs. hoop stress	1,2,3,4	29
	Max. shear strain vs. hoop stress	4,5	32
	Max. shear strain vs. hoop stress	6,7,8	35
	4-A	Axial strain vs. axial stress	1,2,3,4
Axial strain vs. axial stress		4,5	40
Axial strain vs. axial stress		6,7,8	43
Hoop strain vs. axial stress		1,2,3,4	38
Hoop strain vs. axial stress		4,5	41
Hoop strain vs. axial stress		6,7,8	44
Max. shear strain vs. axial stress		1,2,3,4	39
Max. shear strain vs. axial stress		4,5	42
Max. shear strain vs. axial stress		6,7,8	45

TABLE 2  
(Continued)

<u>Test No.</u>	<u>Description</u>	<u>Rosette Nos.</u>	<u>Figure No.</u>
4-B	Axial strain vs. axial stress	1,2,3,4	46
	Axial strain vs. axial stress	4,5	49
	Axial strain vs. axial stress	6,7,8	52
	Hoop strain vs. axial stress	1,4	47
	Hoop strain vs. axial stress	4,5	50
	Hoop strain vs. axial stress	6,7,8	53
	Max. shear strain vs. axial stress	1,4	48
	Max. shear strain vs. axial stress	4,5	51
	Max. shear strain vs. axial stress	6,7,8	54
4-C	Axial strain vs. axial stress	1,2,3,4	55
	Axial strain vs. axial stress	4,5	58
	Axial strain vs. axial stress	6,7,8	61
	Hoop strain vs. axial stress	1,2,3,4	56
	Hoop strain vs. axial stress	4,5	59
	Hoop strain vs. axial stress	6,7,8	62
	Max. shear strain vs. axial stress	1,2,3,4	57
	Max. shear strain vs. axial stress	4,5	60
	Max. shear strain vs. axial stress	6,7,8	63
5	Axial strain vs. hoop stress	5,6	68
	Hoop strain vs. hoop stress	5,6	69
	Max. shear strain vs. hoop stress	5,6	70
6	Axial strain vs. axial stress	1,2,3	73
	Axial strain vs. axial stress	6,7,8	74
	Hoop strain vs. hoop stress	1,2,3,4	75
	Hoop strain vs. hoop stress	4,5	76
	Hoop strain vs. hoop stress	7,8	77
7	Axial strain vs. axial stress	1,2,4	80
	Axial strain vs. axial stress	4,5	82
	Axial strain vs. axial stress	7,8	83
	Hoop strain vs. hoop stress	1,2,3,4	85
	Hoop strain vs. hoop stress	7,8	86
	Max. shear strain vs. axial stress	1,2	81
	Max. shear strain vs. axial stress	7,8	84

Only axial load was applied to the specimen in Test 1. The specimen layup was  $\pm 45^\circ$ . Figure 7 is a comparison of the axial strains vs. axial stress for the four gages located at the center of the specimen on the outside surface. The axial strain gage elements were not in close agreement, indicating either non-uniformity of load or local variations in specimen compliance. The specimen began to buckle when a compressive axial stress of approximately 19,000 psi was reached. This is shown by the curving back of the axial stress in this plot. Figure 8 is a comparison of the axial strains vs. axial stress for the two gages located at the center of the specimen but on opposite surfaces. The output from these gages show that no bending, and thus no buckling, was occurring at this position. Figure 9 is a comparison plot of axial strains vs. axial stress for the two gages located at the top of the specimen but on opposite surfaces. These figures show that the output from the gages at Points 1, 4, 5, 6, 7 and 8 compare fairly well, but do not compare with the output from gages at Points 2 and 3. Figure 10 is a photograph of this specimen after testing. This figure shows that the buckles occurred on the end opposite from gages at Points 6, 7 and 8. Figure 11 is a comparison plot of hoop strains vs. axial stress for three gages located at the center of the specimen on the outside surface. The hoop strain component for the strain rosette at Point 1 did not produce a signal. The shape of these curves matched the corresponding curves shown in Figure 7. Figures 12 and 13 are the comparison plots of hoop strains vs. axial stress for the gage locations corresponding to those of Figures 8 and 9, respectively. Again, the shapes of the curves are in agreement with the corresponding axial strain curves. Figures 14, 15 and 16 are comparison plots of the maximum shear strain vs. axial load for the gage locations presented in Figures 7, 8 and 9, respectively.

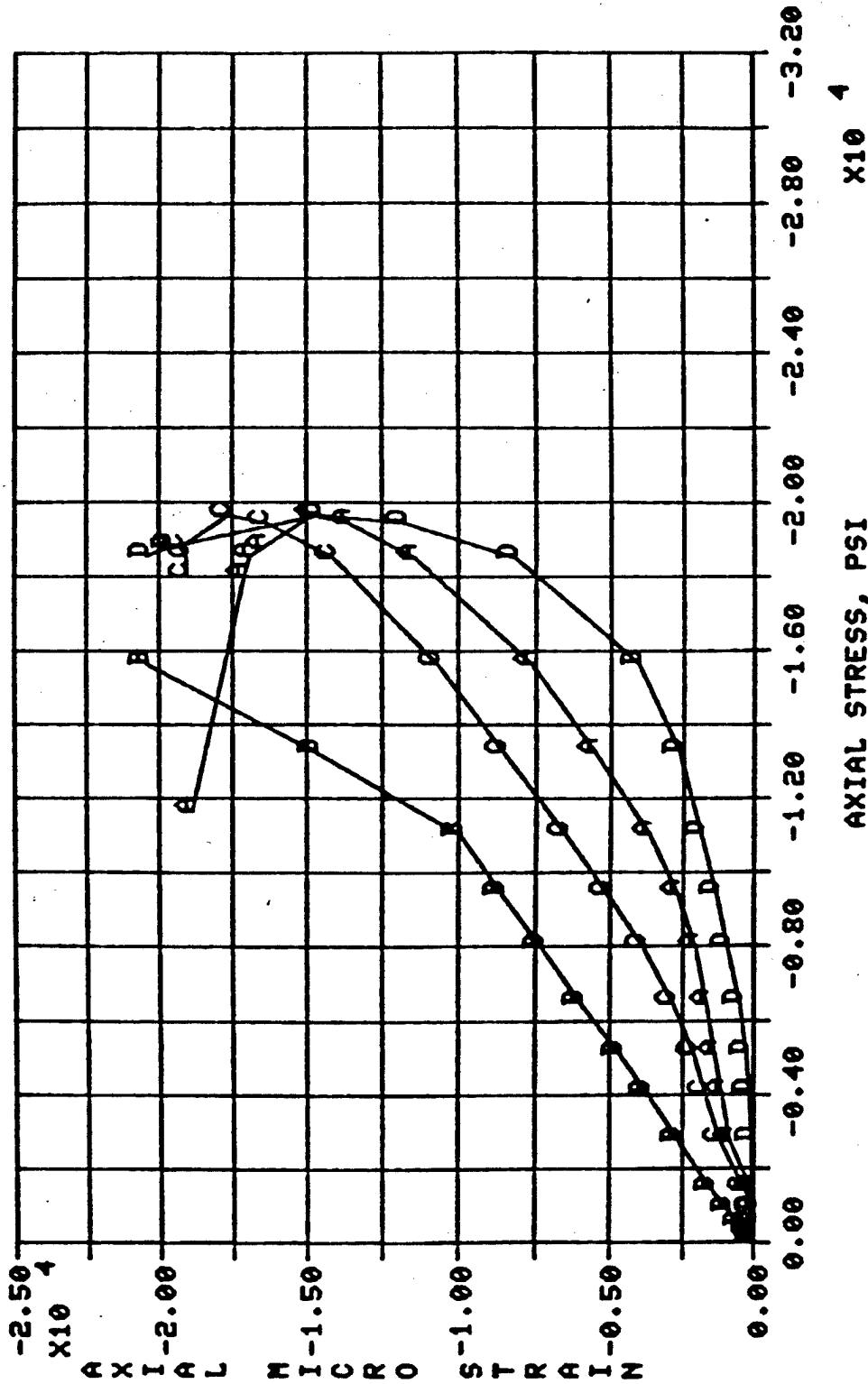


Figure 7 Test 1. Layout +45° Axial Load Only  
 Axial Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

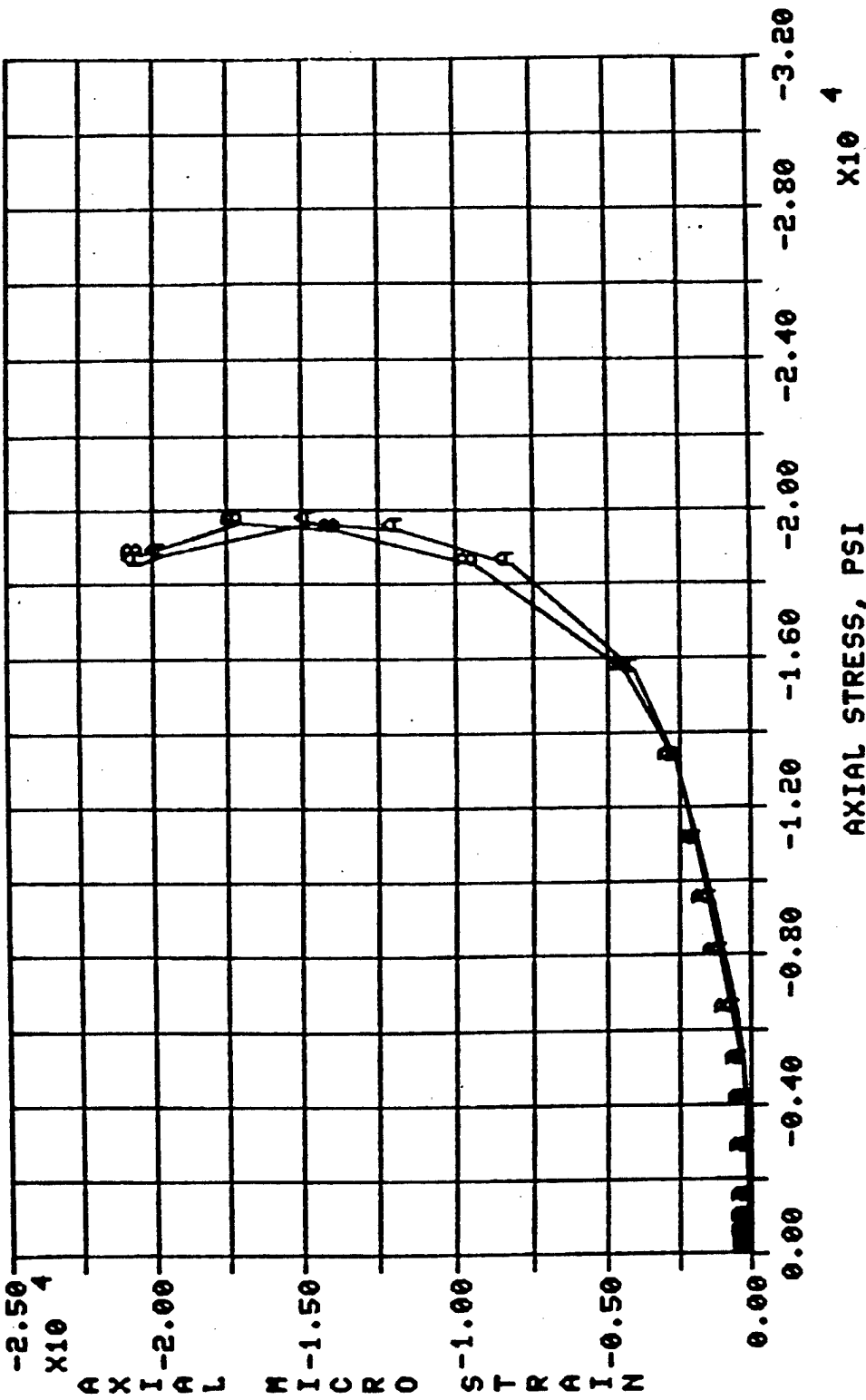


Figure 8 Test 1. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

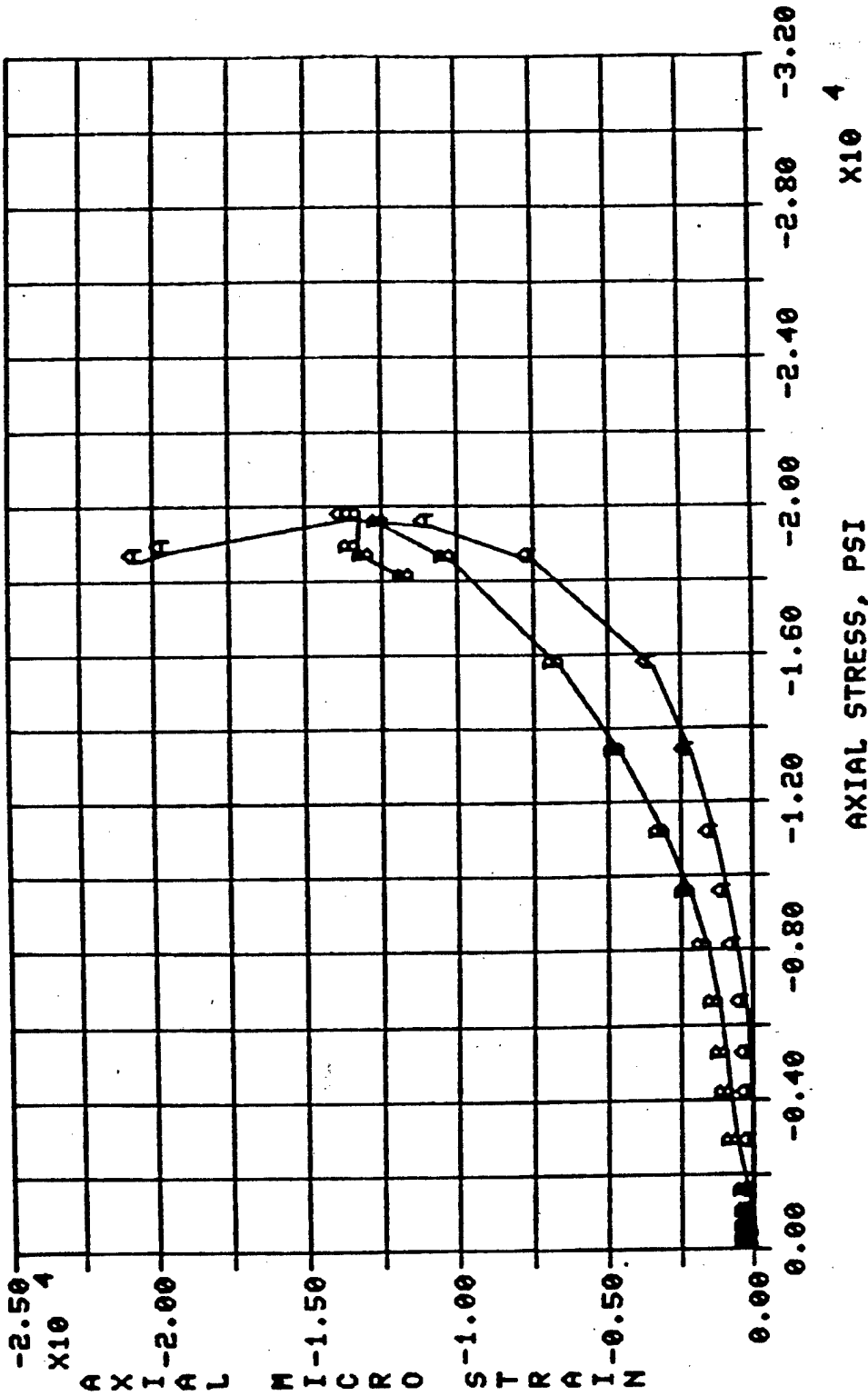


Figure 9 Test 1. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Edge Rosettes  
 A - Rosette No. 7  
 B - Rosette No. 8

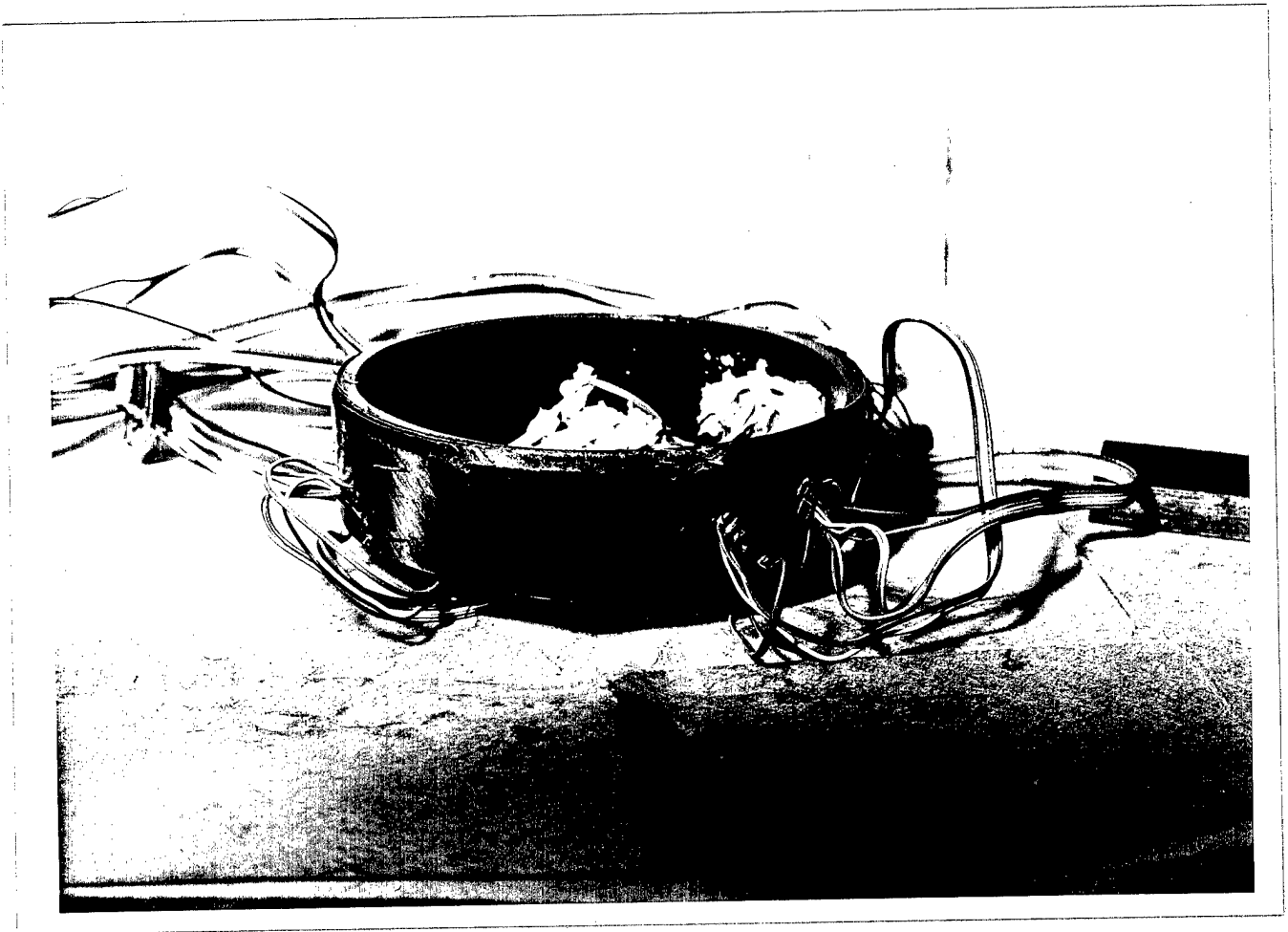


Figure 10 Test Specimen No. 1 After  
Crushing by Axial Load. Ply  
Layup is  $\pm 45^\circ$ .

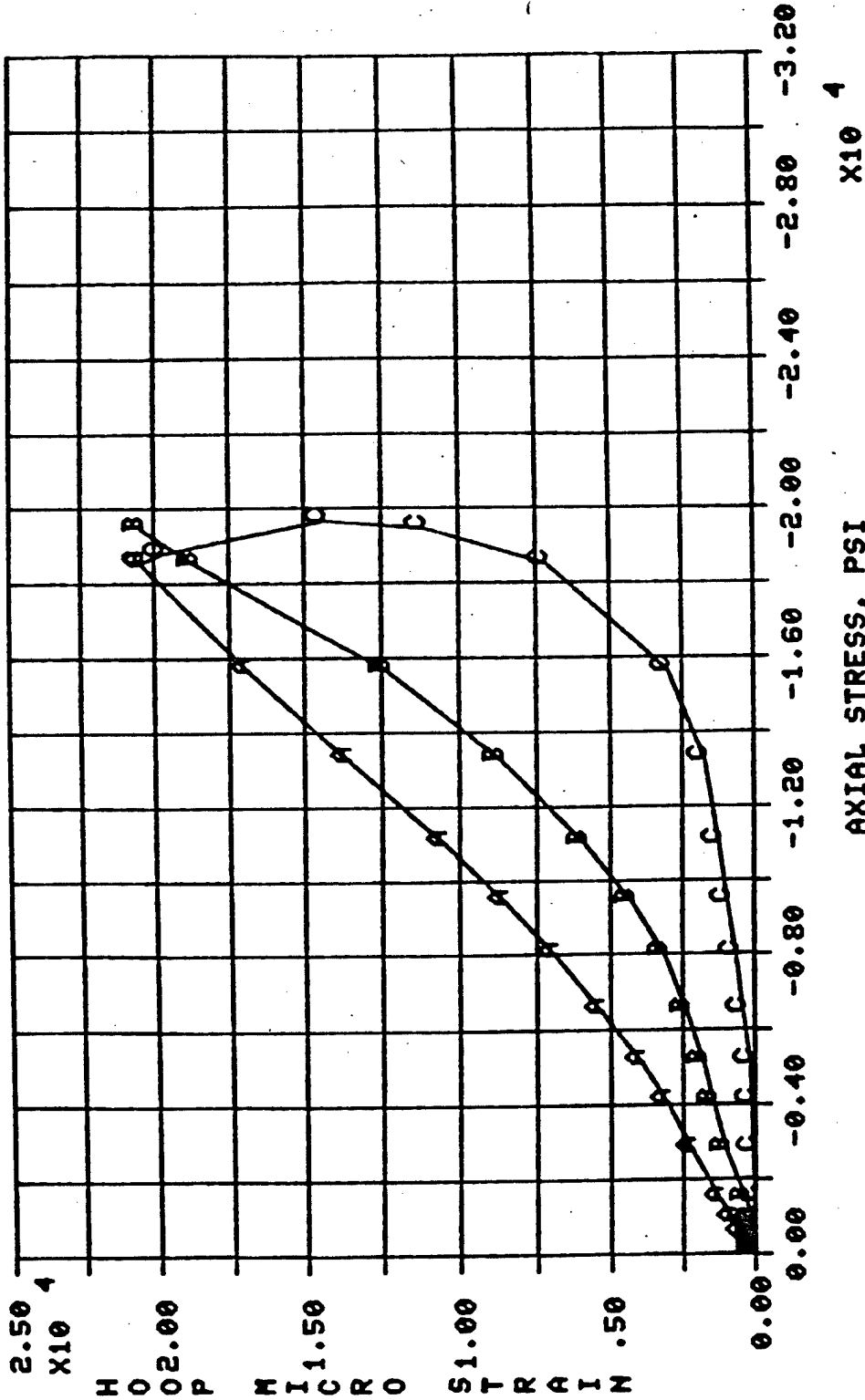


Figure 11 Test 1. Layout  $\pm 45^\circ$ , Axial Load Only  
 Hoop Response, Outside Rosettes

- A - Rosette No. 2
- B - Rosette No. 3
- C - Rosette No. 4

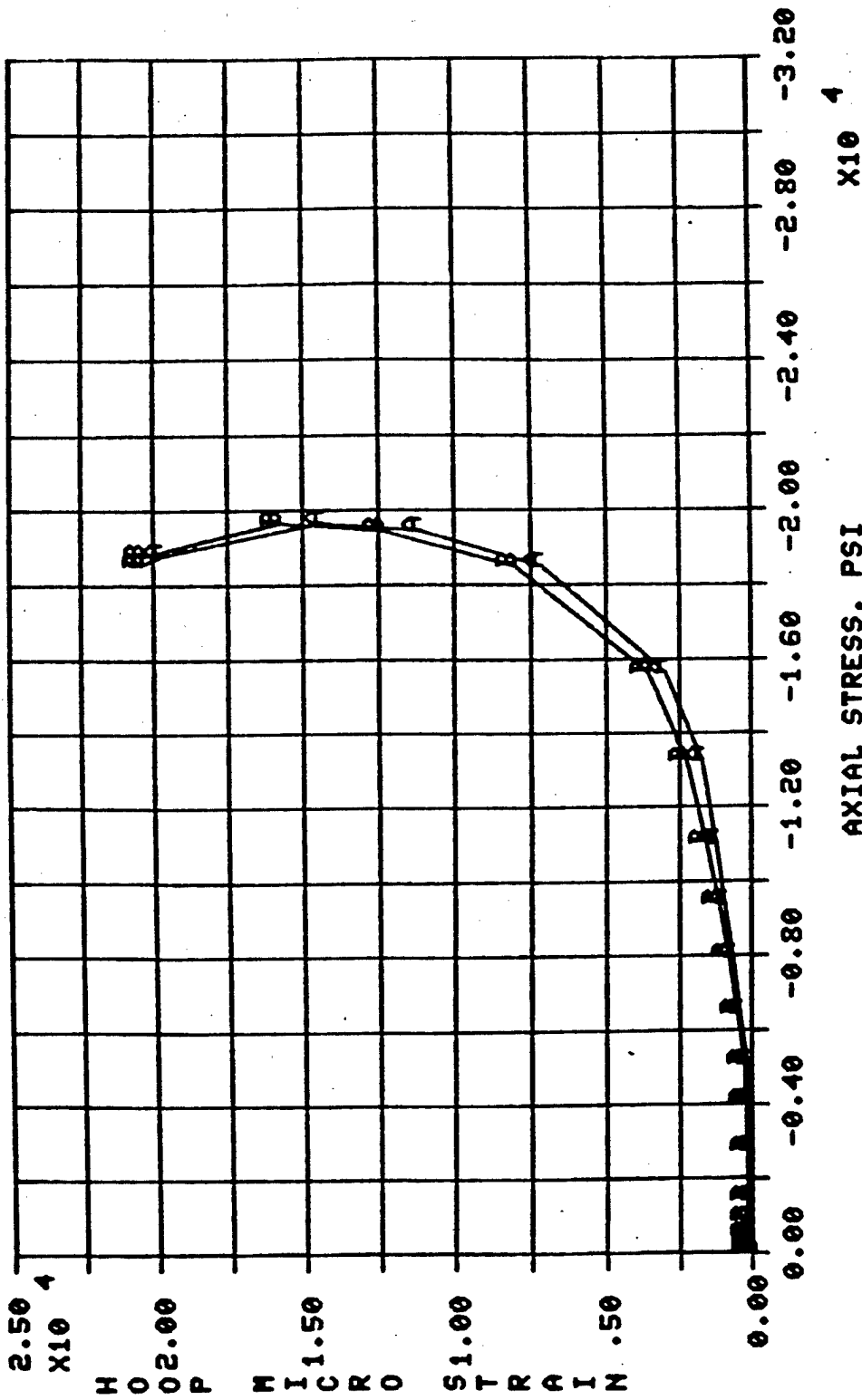


Figure 12 Test 1. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

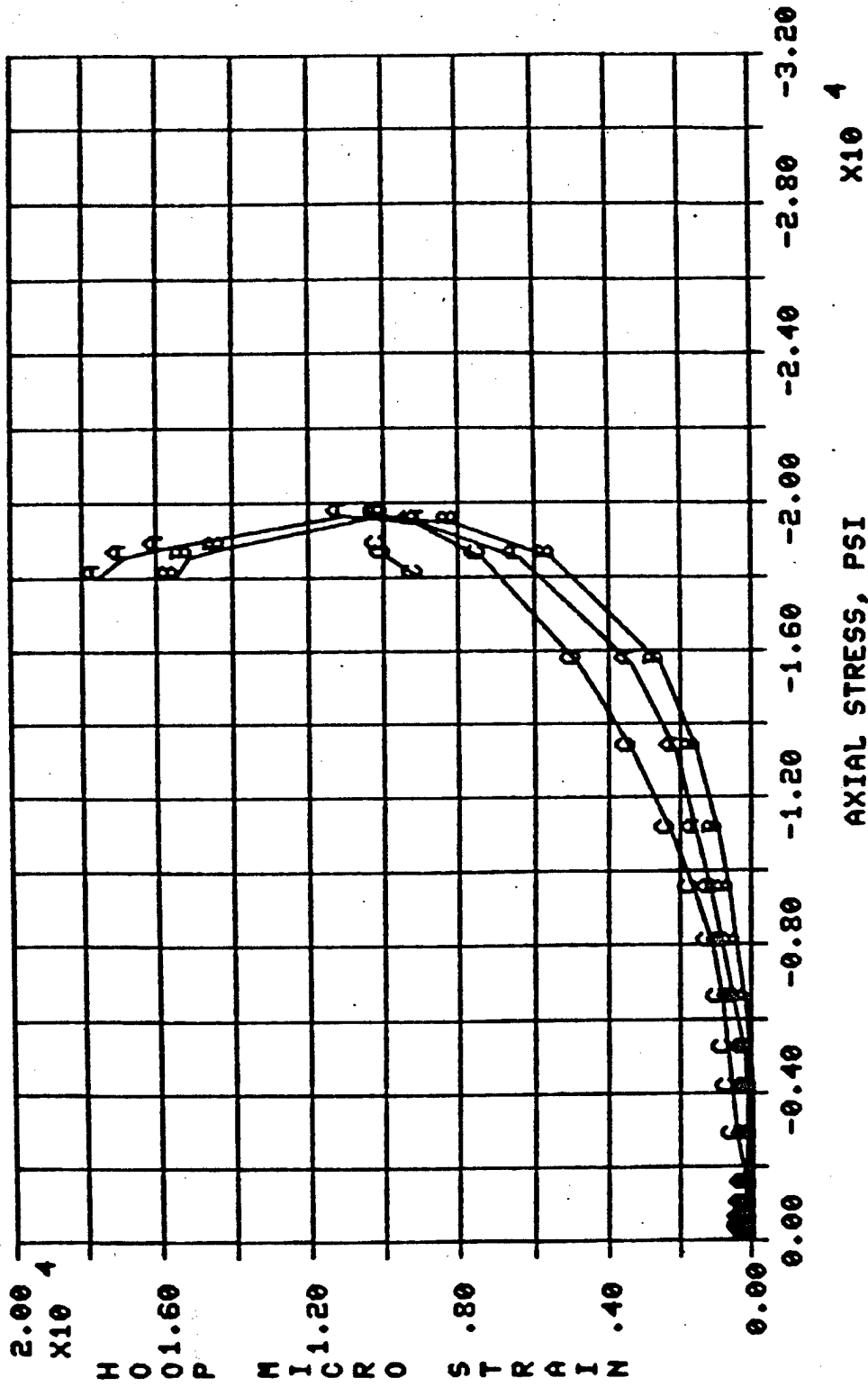


Figure 13 Test 1. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Edge Rosettes

- A - Rosette No. 6
- B - Rosette No. 7
- C - Rosette No. 8

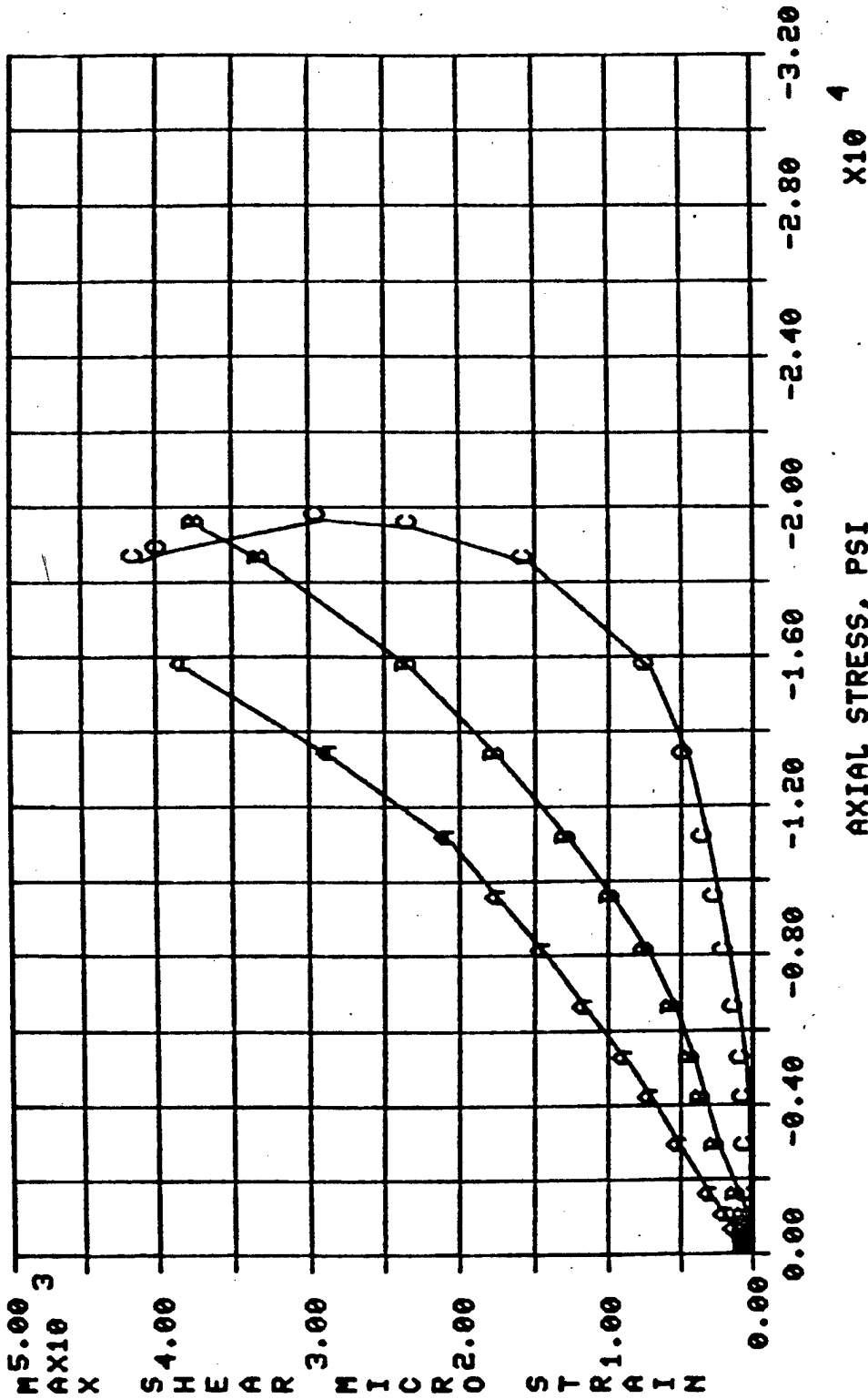


Figure 14 Test 1. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Outside Rosettes

- A - Rosette No. 2
- B - Rosette No. 3
- C - Rosette No. 4

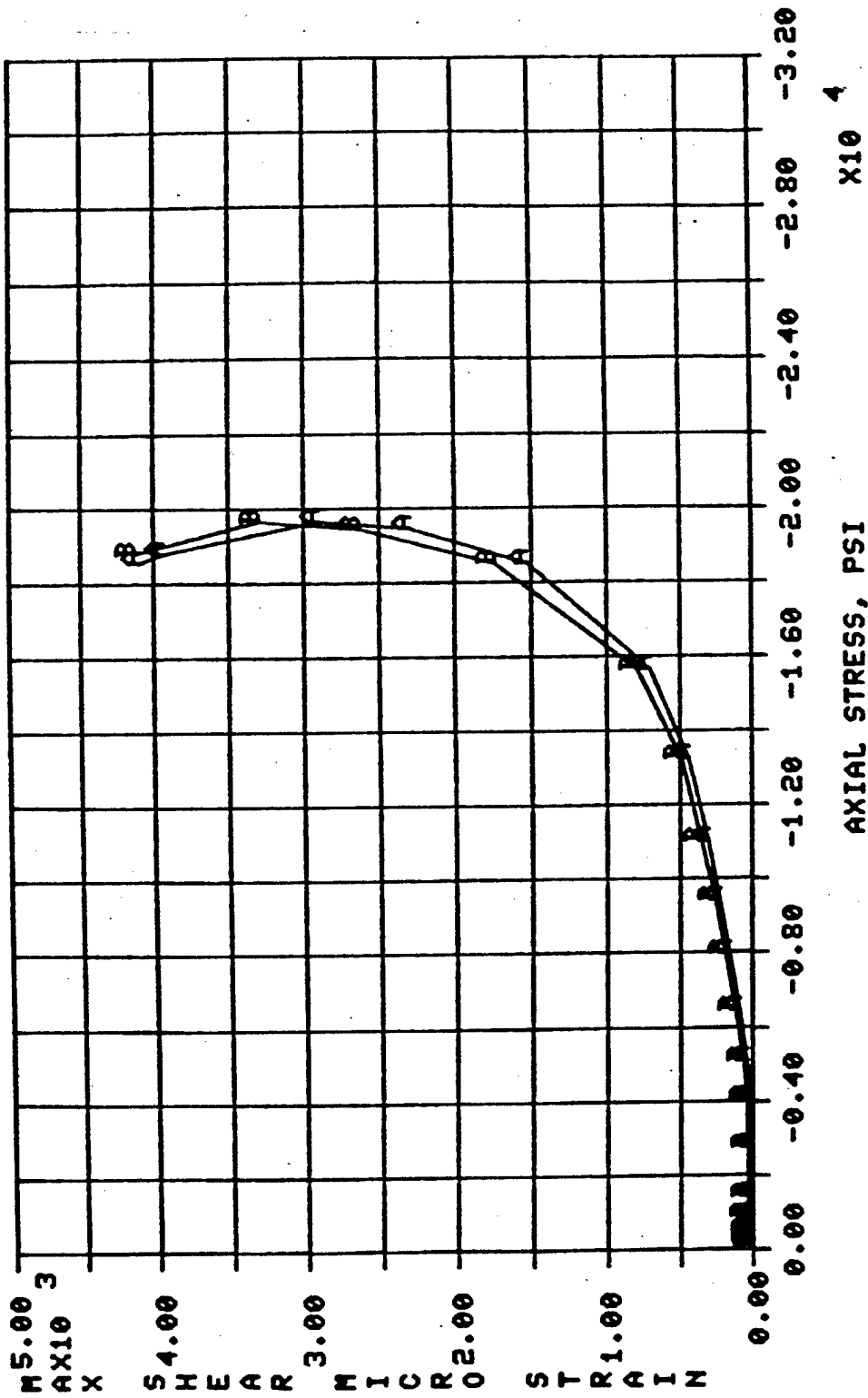


Figure 15 Test 1. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5

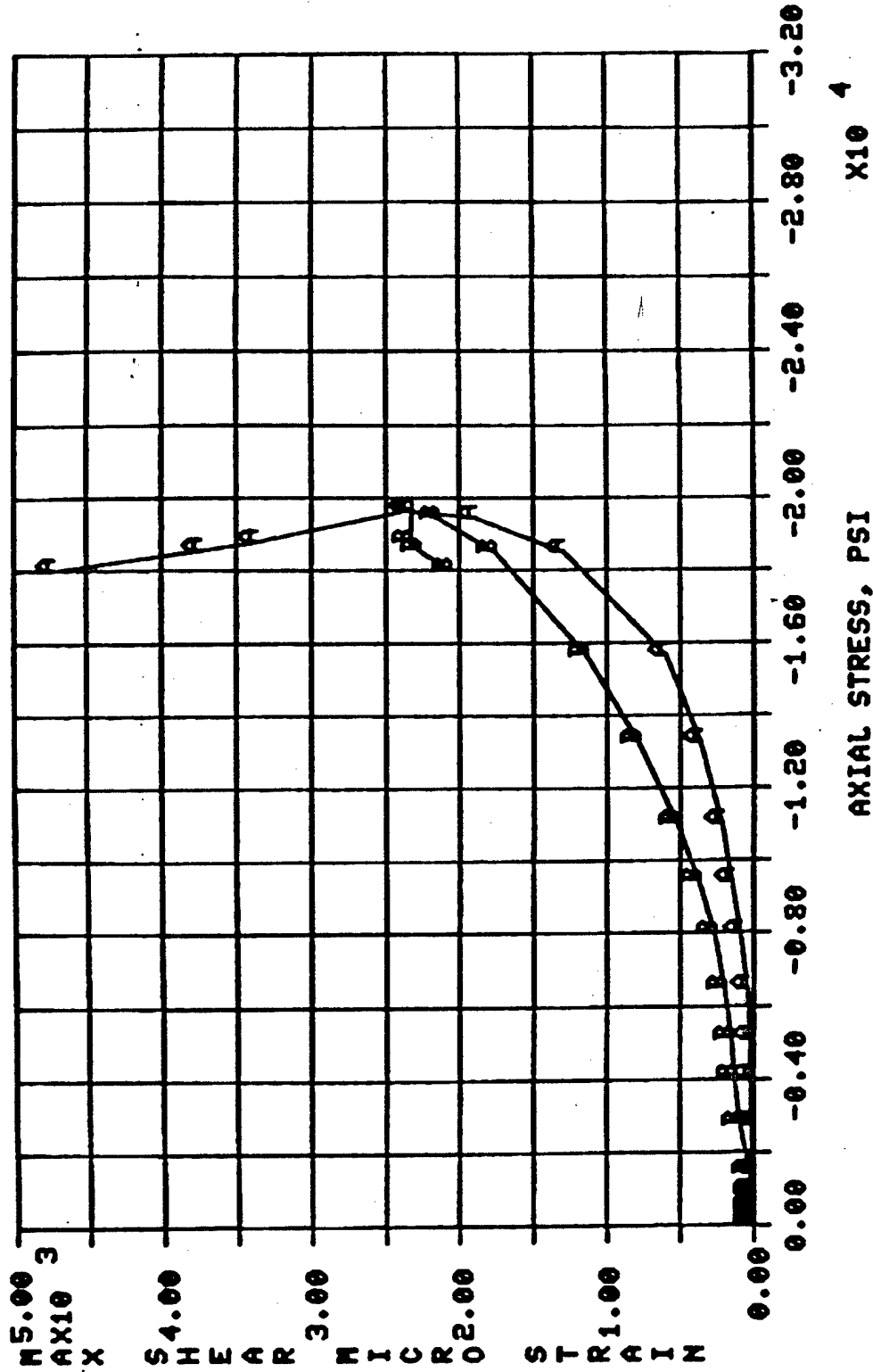


Figure 16 Test 1. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear Response, Edge Rosettes  
 A - Rosette No. 7  
 B - Rosette No. 8

Test 2 was performed on a specimen with a ply layup of  $0^\circ/\pm 45^\circ/90^\circ$  under internal pressure. Figures 17, 18 and 19 are comparison plots of axial strain, hoop strain and maximum shear strain, respectively, versus hoop stress for the four gages located at the center of the specimen on the outside surface. These strains show good agreement. Strains were not recorded for this specimen until the hoop stress level reached approximately 16,000 psi. This was presumably due to the data acquisition system operating in the automatic balance mode during the first few data scans. Figures 20, 21 and 22 are comparison plots of axial, hoop and maximum shear strains, respectively, versus hoop stress for the two gages located at the center of the specimen but on opposite surfaces. Figures 23, 24 and 25 present comparison plots of axial, hoop and maximum shear strains, respectively, versus hoop stress for the three gages along the top of the specimen. Two of these gages are at the same location, but on opposite surfaces. Very good agreement was found between the inside and outside gages and the maximum shear strains at all rosette locations were almost identical. Hoop stresses greater than 120,000 psi were produced by the internal pressure and final fracture was catastrophic. The specimen after failure is shown in Figure 26.

Test 3 was using a  $\pm 45^\circ$  ply layup specimen under internal pressure. A 100 pound axial load was applied to the specimen prior to the internal pressure. This axial load was kept constant throughout the testing. Data was recorded at only one scan during this test. Figures 27, 28 and 29 present comparisons for axial, hoop and maximum shear strains, respectively, versus hoop stress for the outside center gages. Figures 30, 31 and 32 are comparison plots for axial, hoop and maximum shear strains, respectively, versus hoop stress for the gage locations at the center of the specimen, but on opposite surfaces. Figures 33, 34 and 35 present the comparison plots for

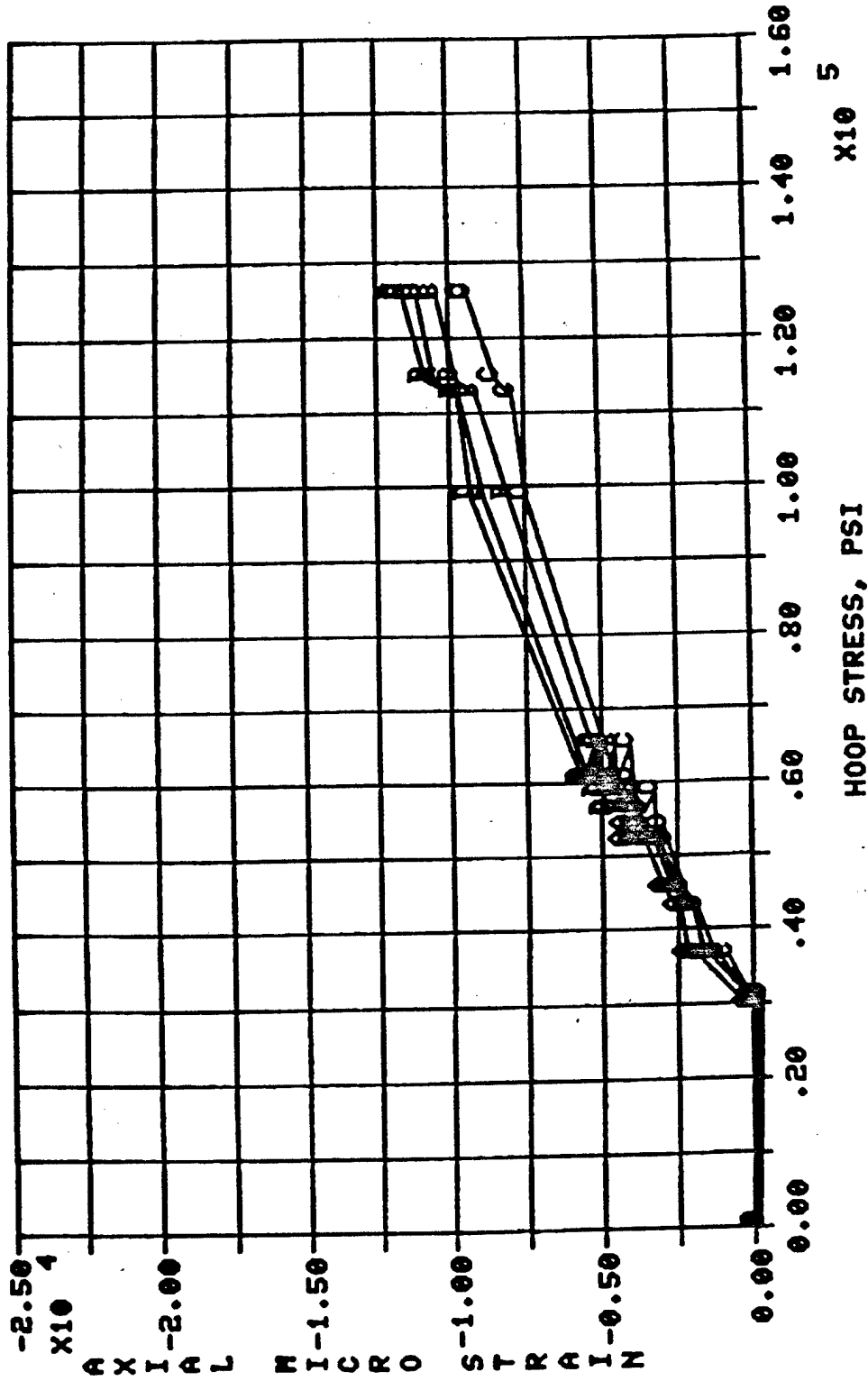


Figure 17 Test 2. Layout 0°/+45°/90° Int.  
 Pressure Axial Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

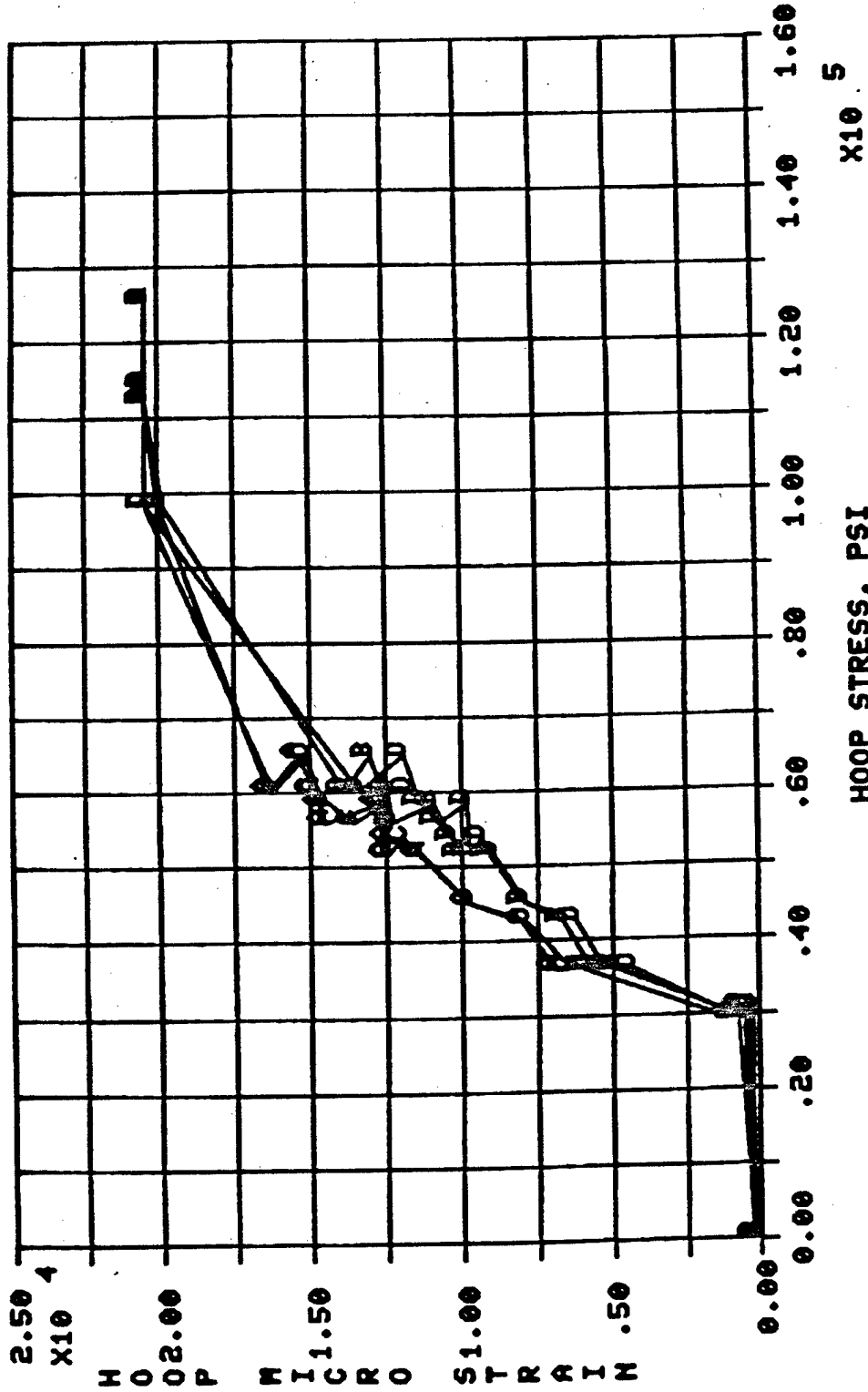


Figure 18 Test 2. Layout  $0^\circ/\pm 45^\circ/90^\circ$  Int. Pressure Hoop Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

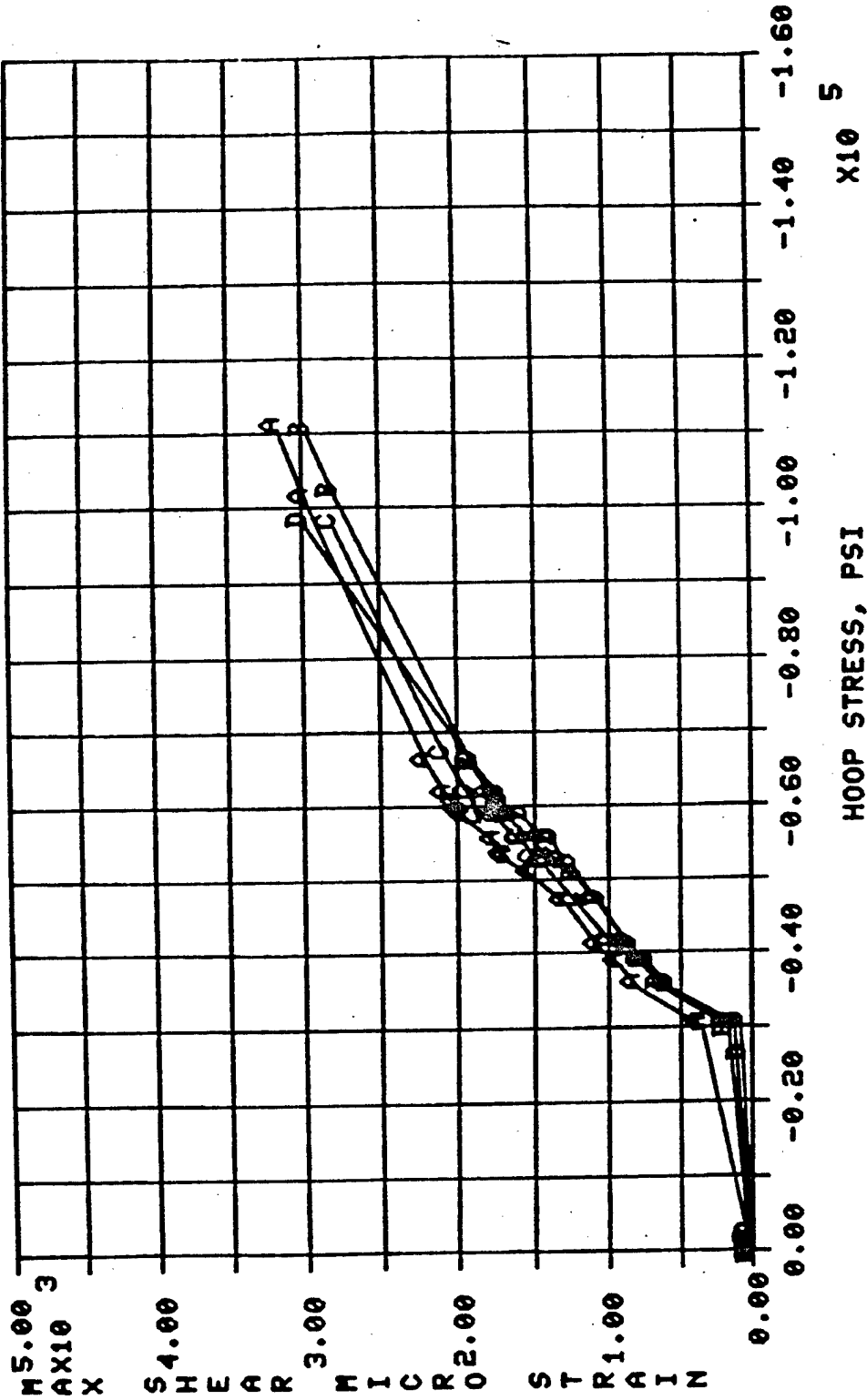


Figure 19 Test 2. Layout 0°/±45°/90° Int. Pressure  
 Max. Shear, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

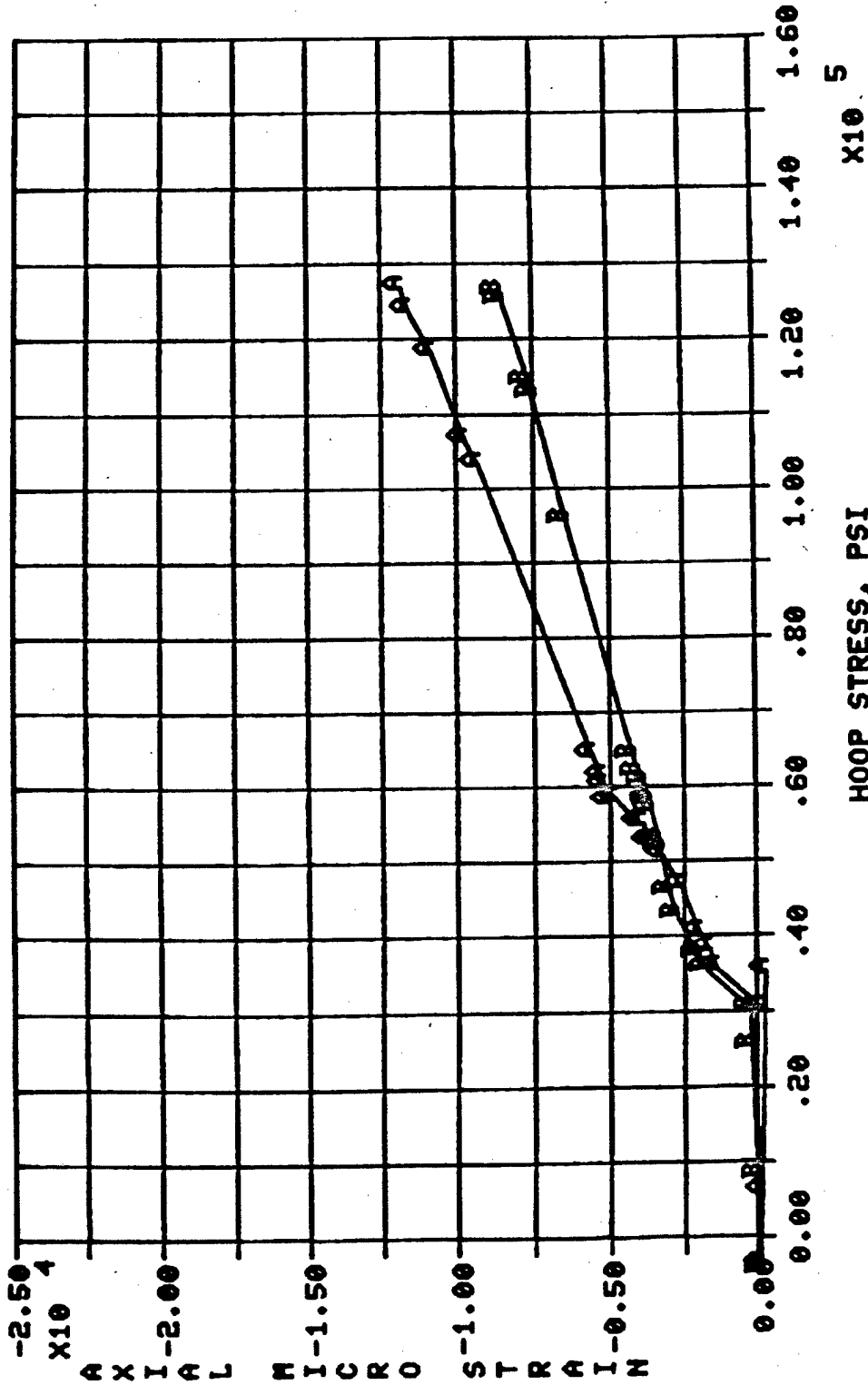


Figure 20 Test 2. Layup 0°/±45°/90° Int. Pressure  
 Axial Response, Inside/Outside Rosettes  
 Least Squares Fit  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

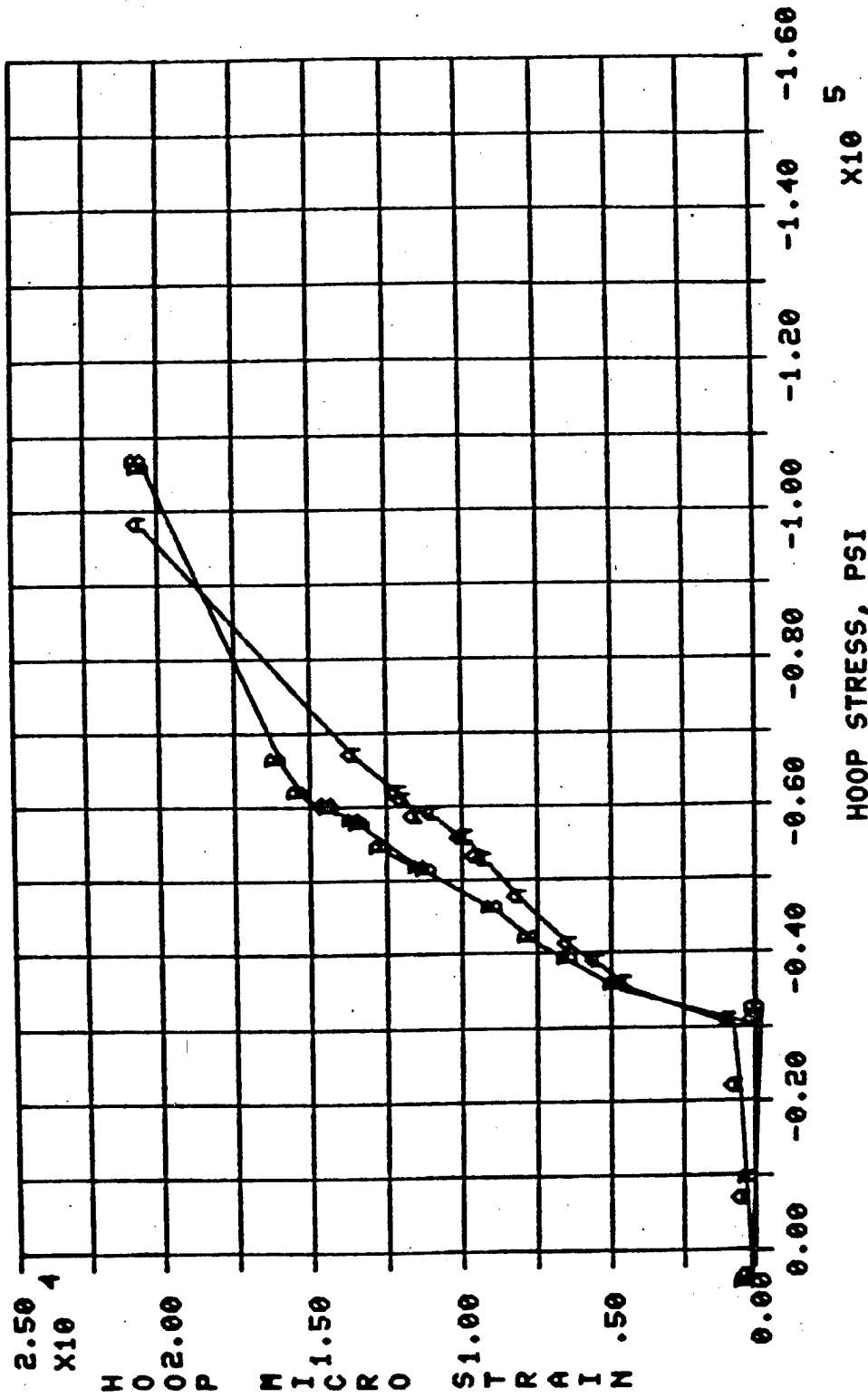


Figure 21 Test 2. Layup 0°/±45°/90° Int. Pressure  
 Hoop Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

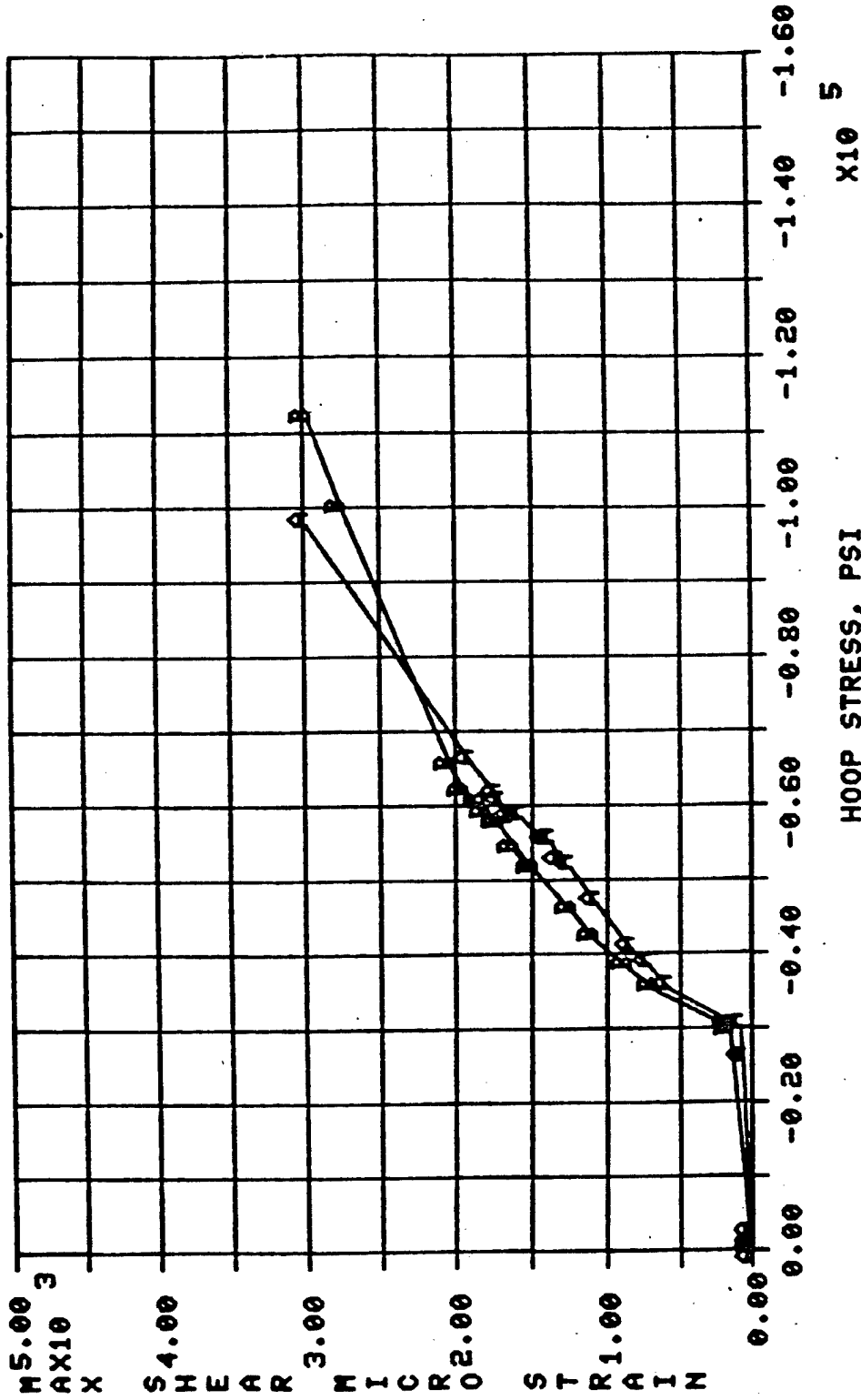


Figure 22 Test 2. Layup 0°/±45°/90° Int. Pressure  
 Max. Shear, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

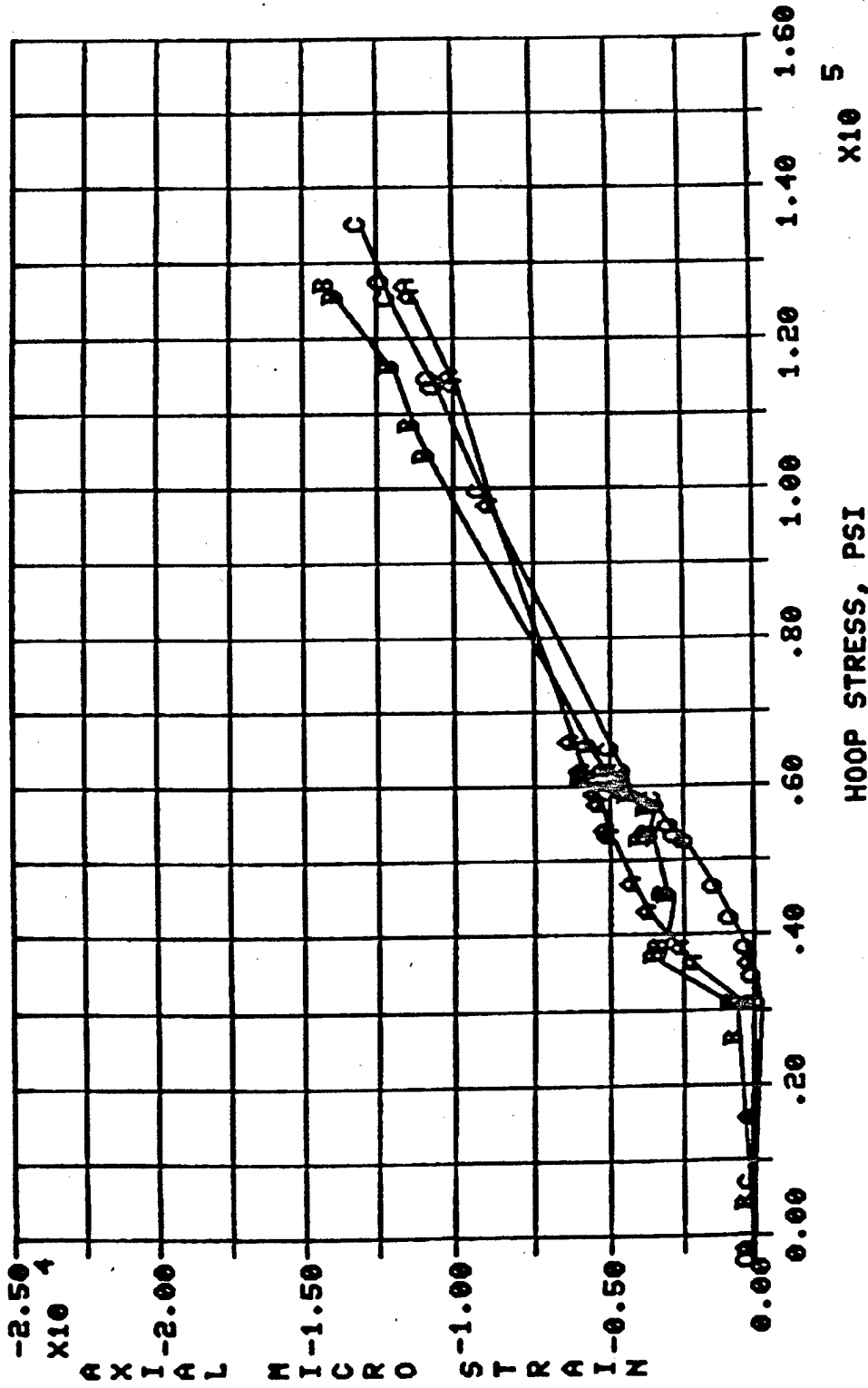


Figure 23 Test 2. Layout 0°/±45°/90° Int. Pressure  
 Axial Response, Edge Rosettes  
 Least Squares Fit  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

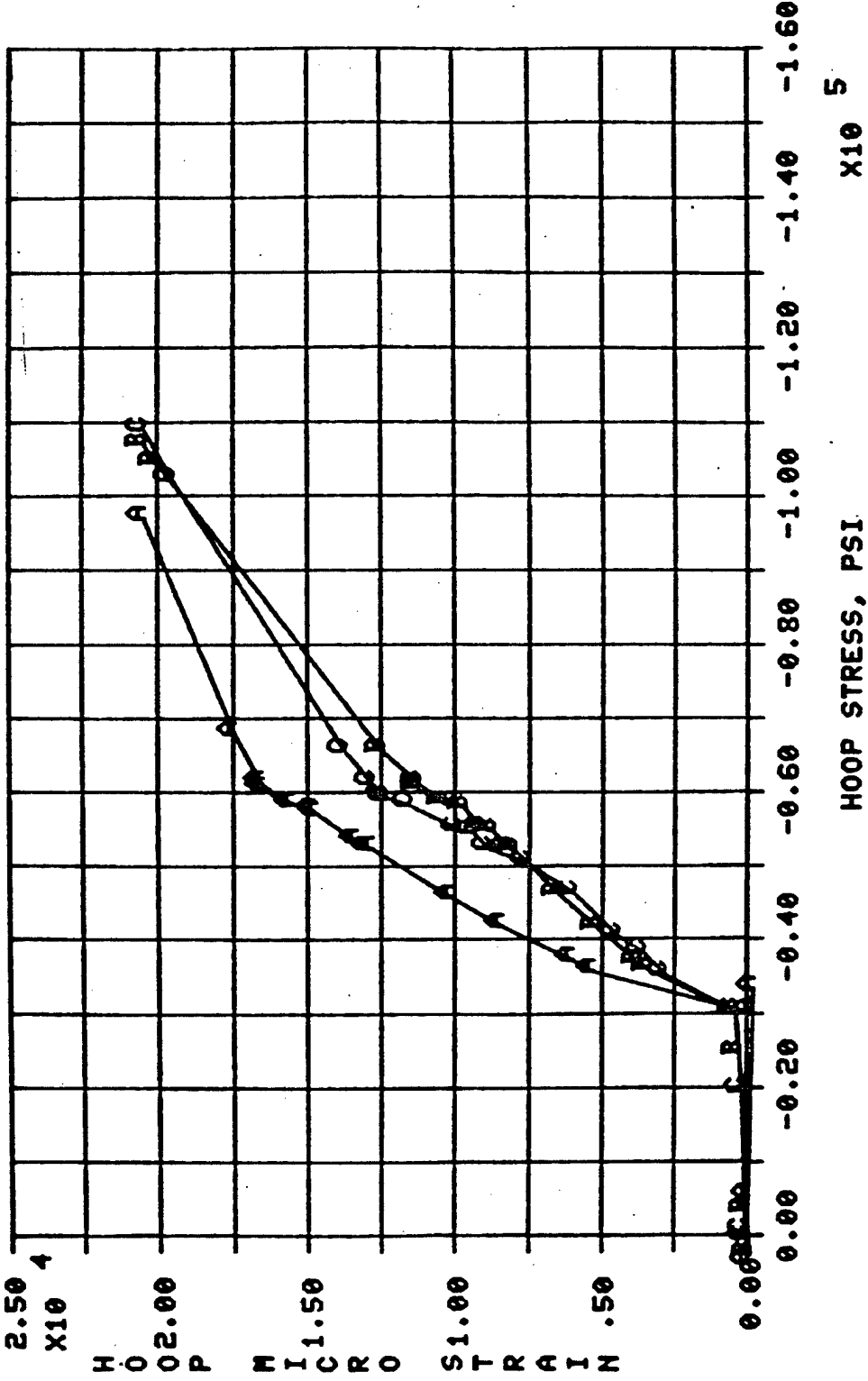


Figure 24 Test 2. Layout 0°/±45°/90° Int. Pressure  
 Hoop Response, Edge Rosettes  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

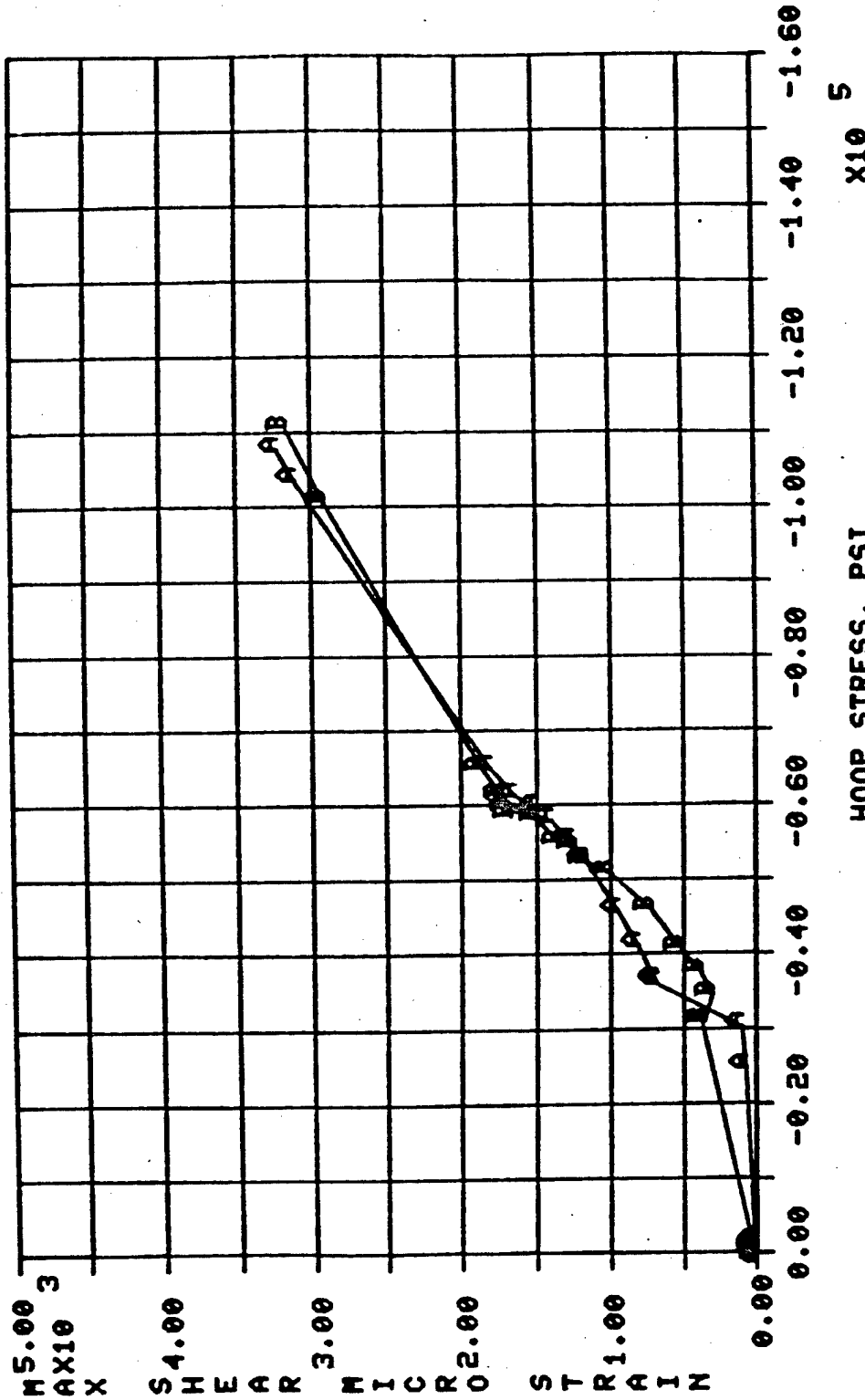


Figure 25 Test 2. Layout 0°/±45°/90° Int. Pressure  
 Max. Shear, Edge Rosettes  
 A - Rosette No. 7  
 B - Rosette No. 8



Figure 26 Test Specimen No. 2 After Rupture by Internal Pressure. Ply layup is  $0^{\circ}/\pm 45^{\circ}/90^{\circ}$ .

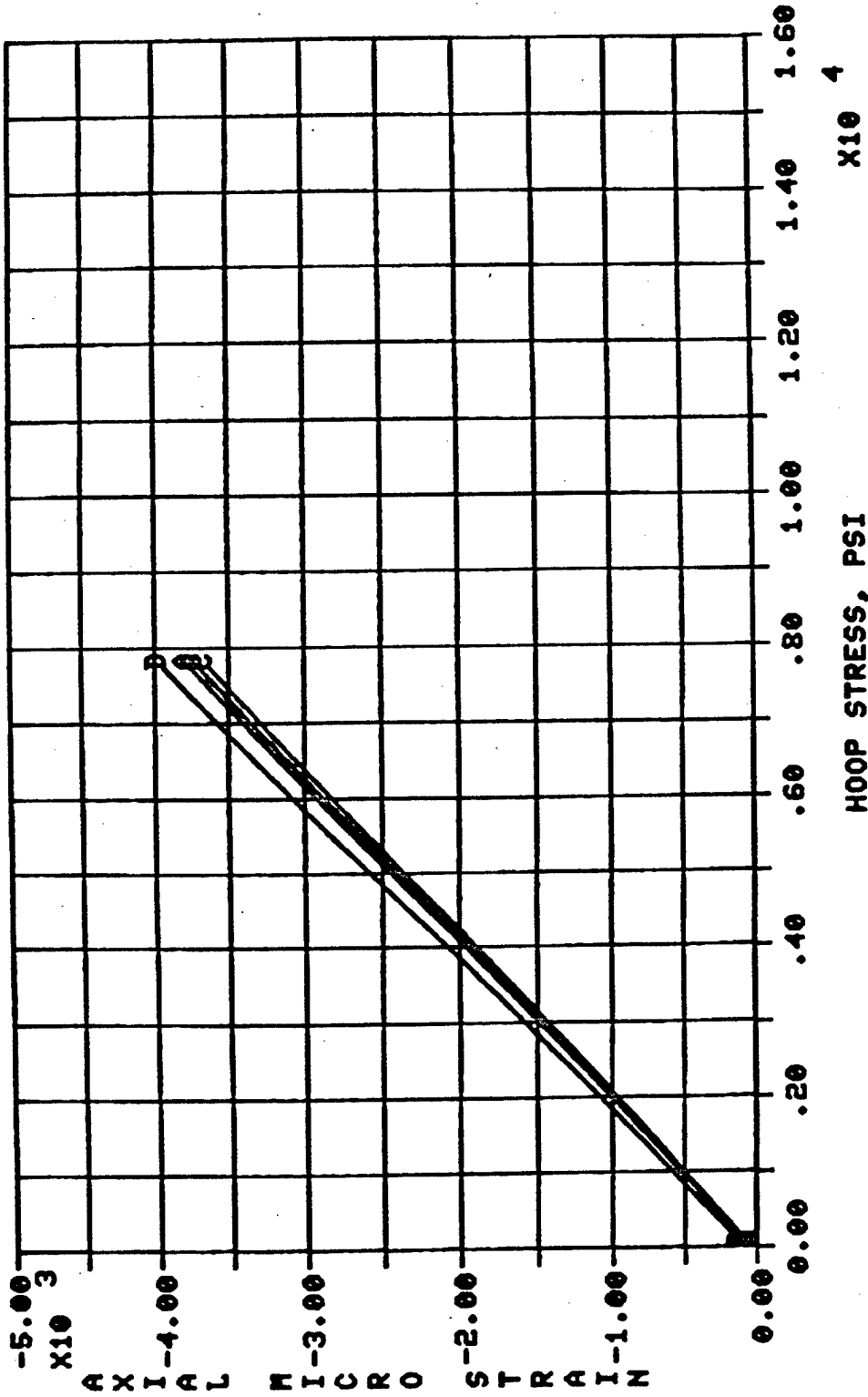


Figure 27 Test 3.  $\pm 45^\circ$  Int. Pressure  
Axial Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

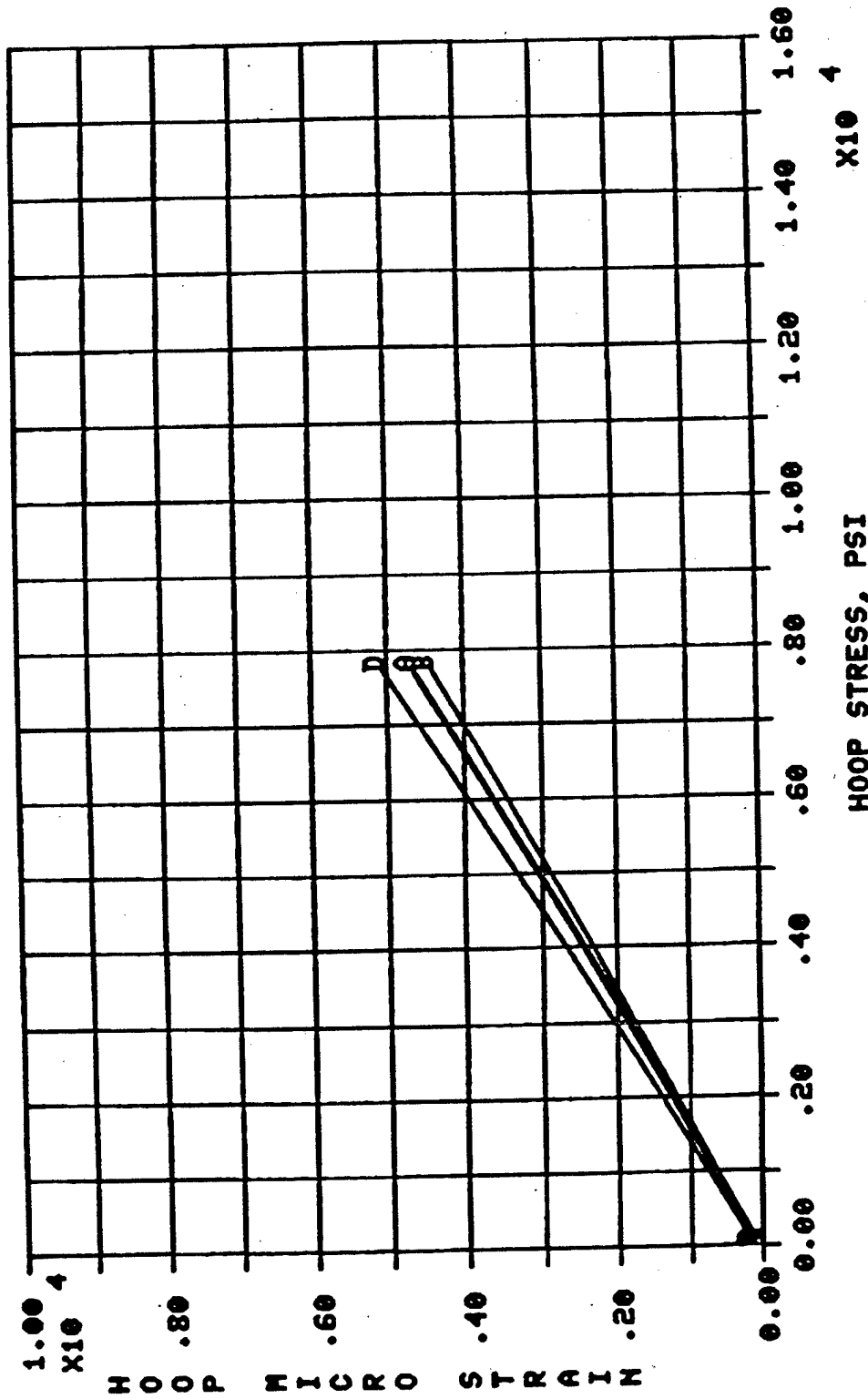


Figure 28 Test 3.  $\pm 45^\circ$  Int. Pressure  
Hoop Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

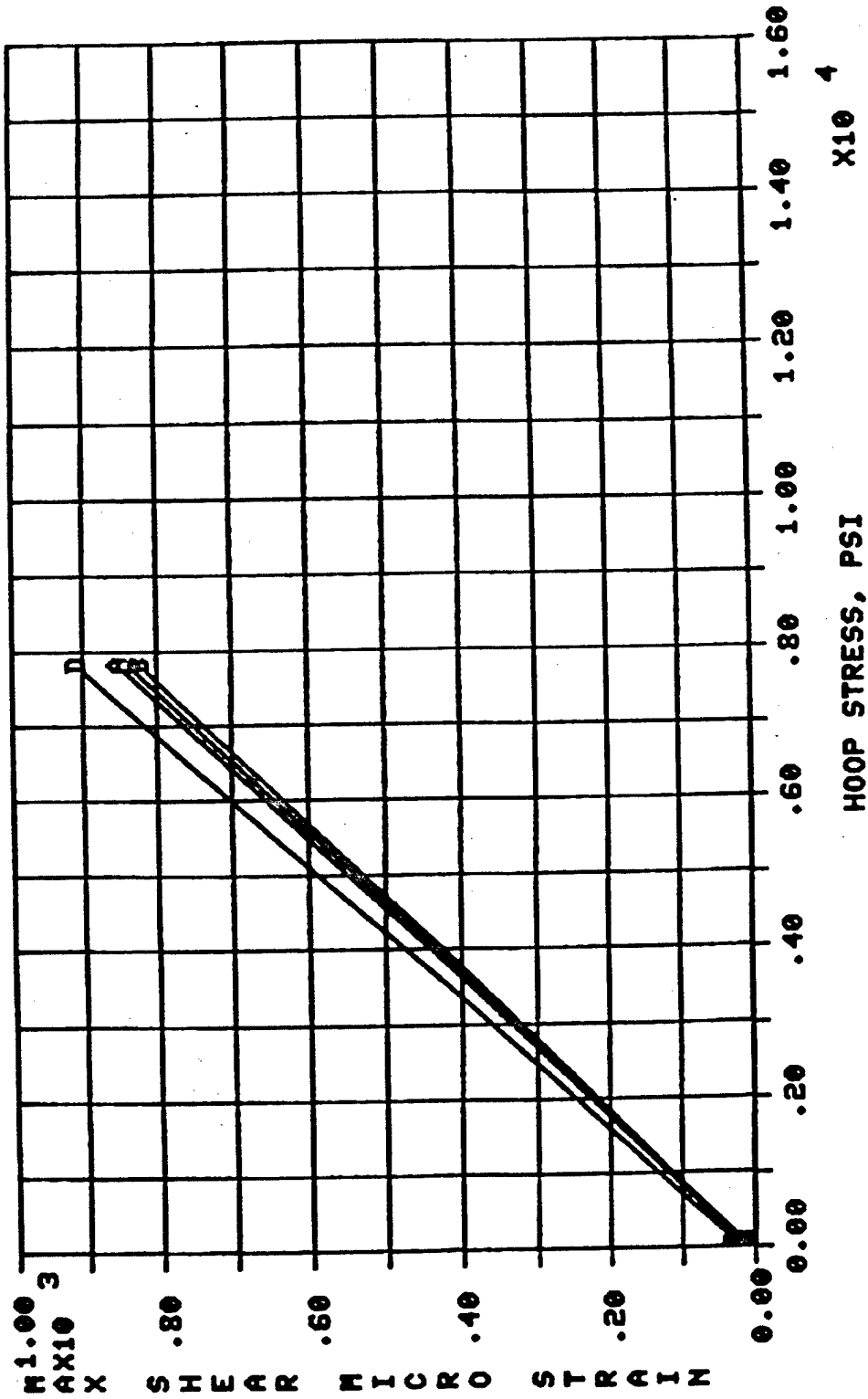


Figure 29 Test 3. ±45° Int. Pressure  
 Max. Shear, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

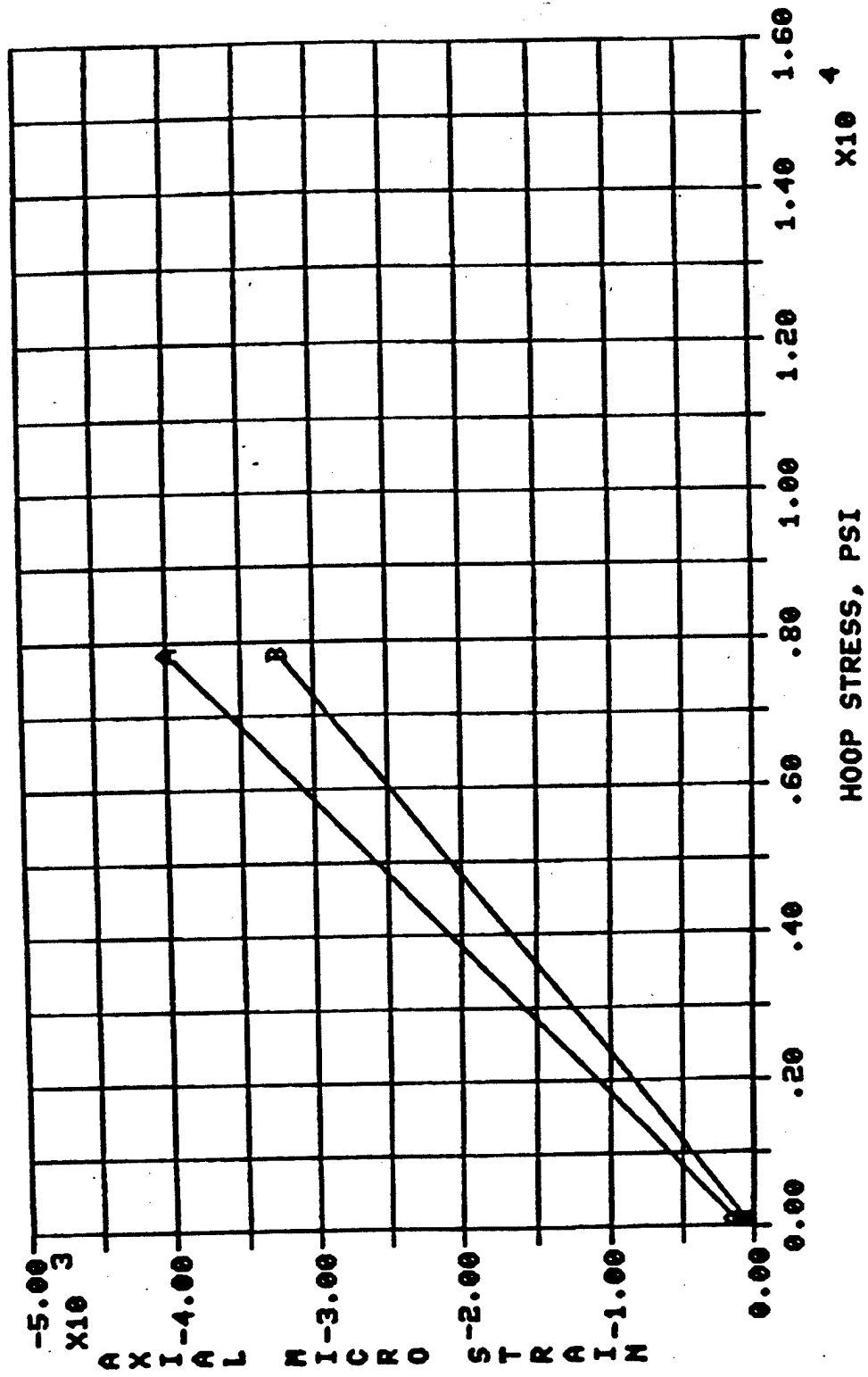


Figure 30 Test 3. ±45° Int. Pressure Axial Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

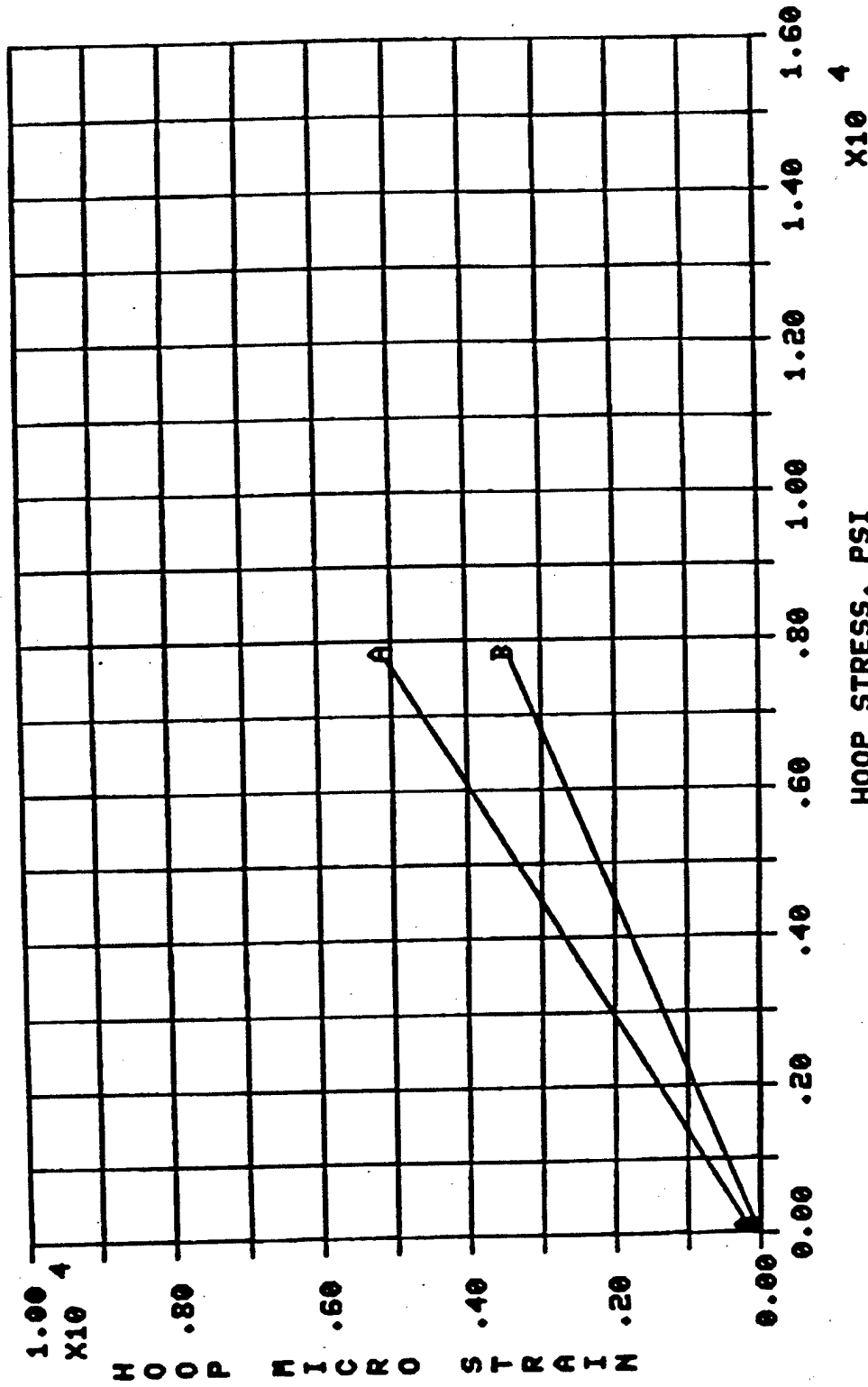


Figure 31 Test 3. ±45° Int. Pressure Hoop Response, Inside/Outside Rosettes  
A - Rosette No. 4 (outside)  
B - Rosette No. 5 (inside)

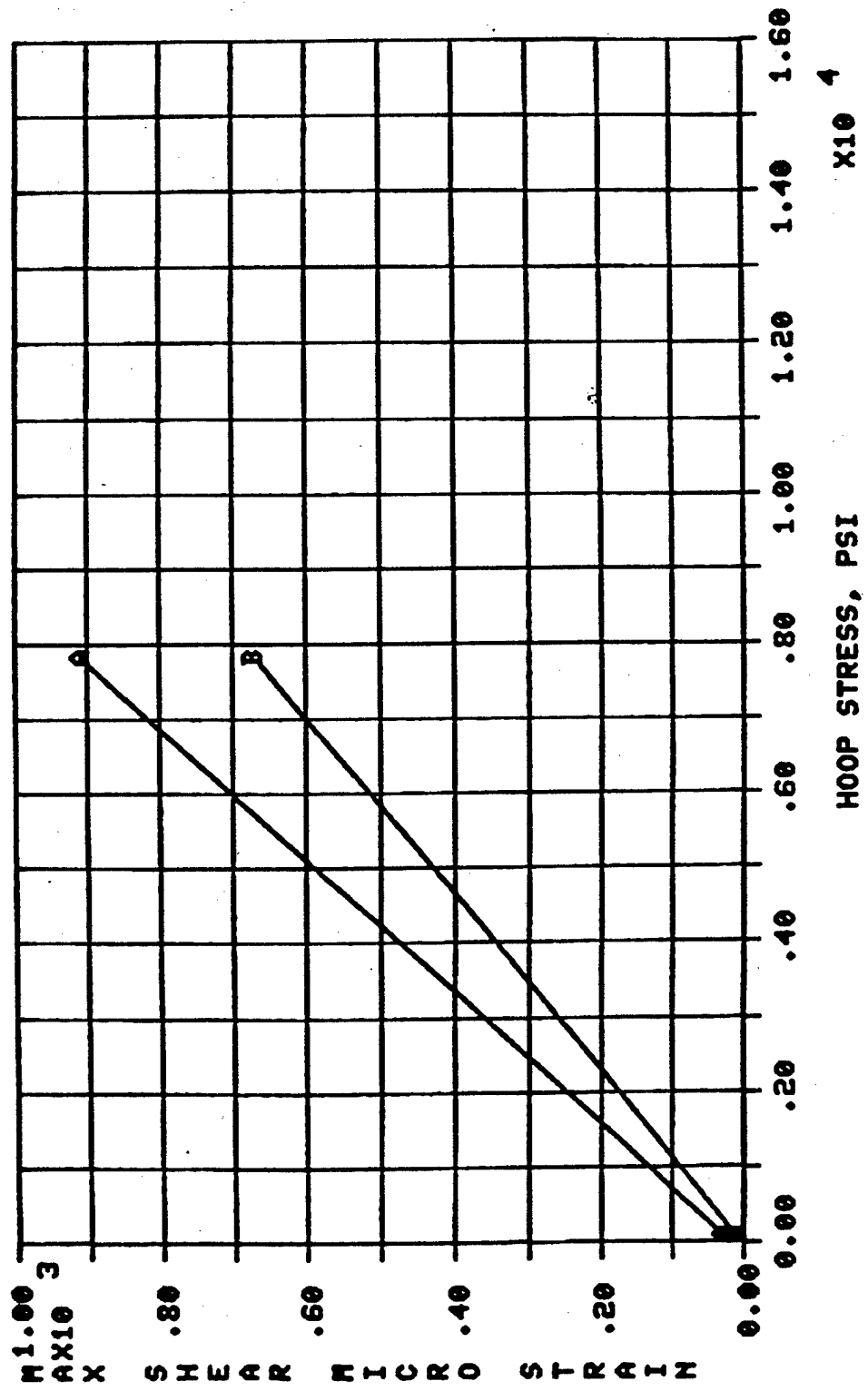


Figure 32 Test 3.  $\pm 45^\circ$  Int. Pressure Max.  
 Shear, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

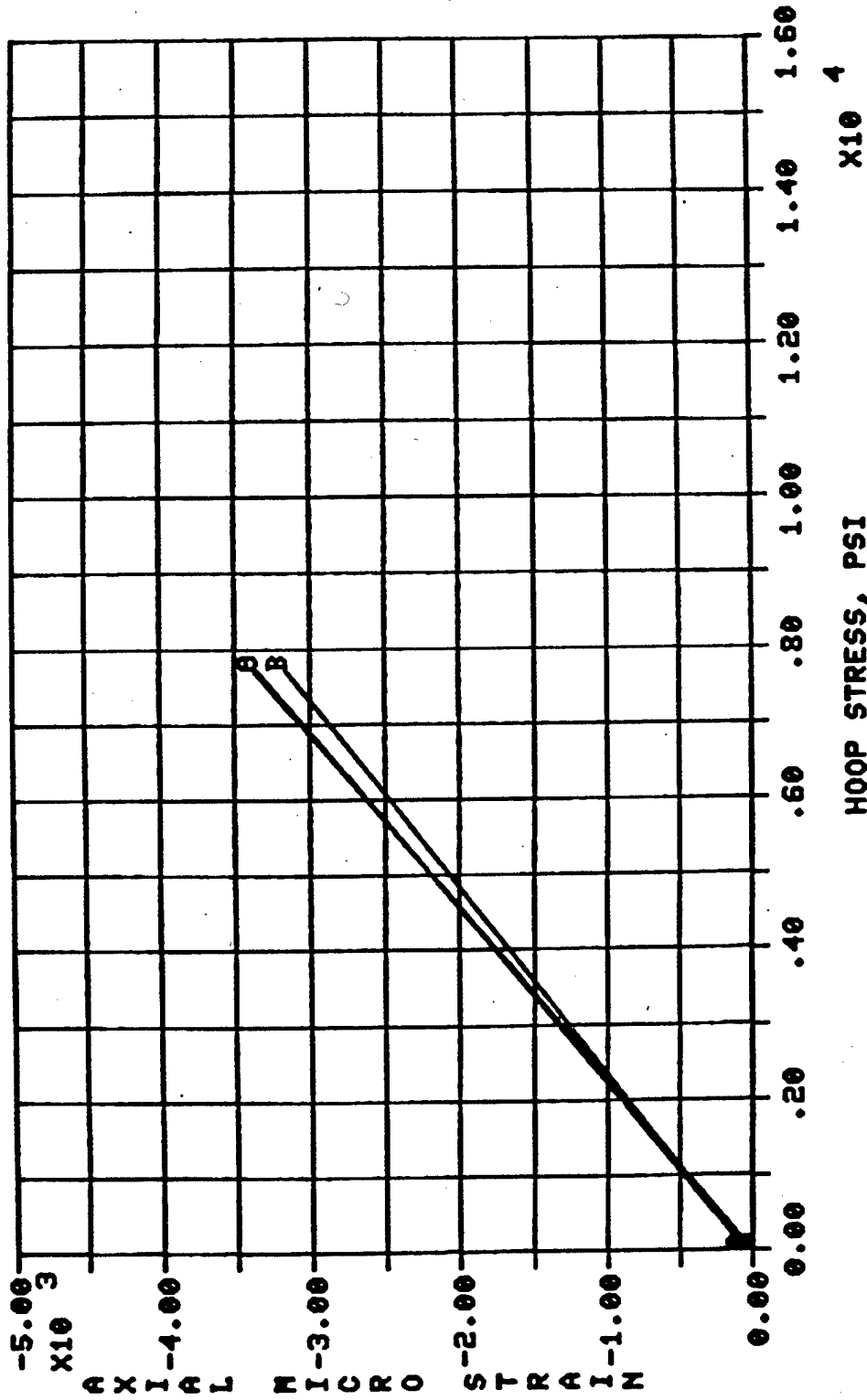


Figure 33 Test 3.  $\pm 45^\circ$  Int. Pressure  
Axial Response, Edge Rosettes  
A - Rosette No. 6  
B - Rosette No. 7  
C - Rosette No. 8

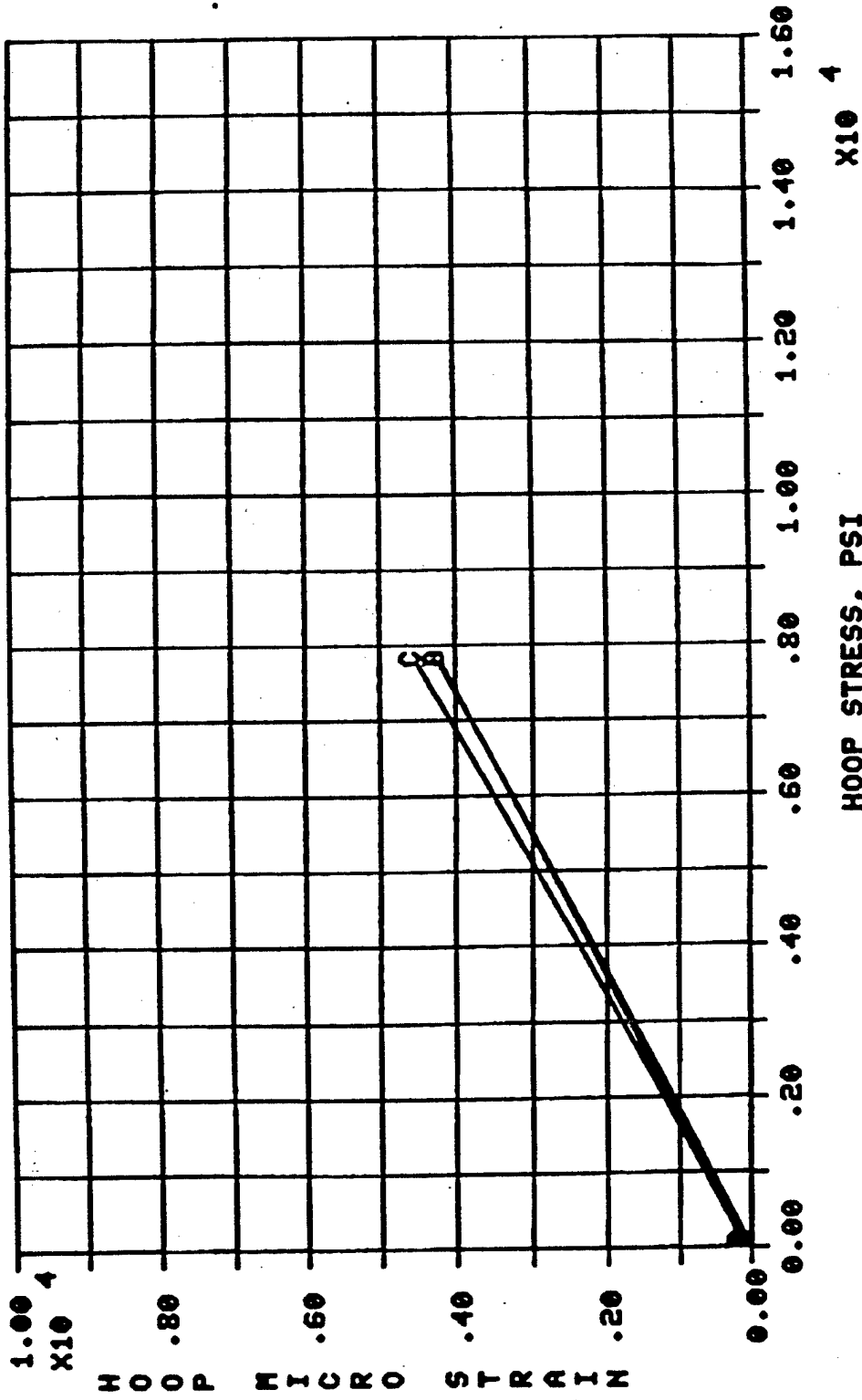


Figure 34 Test 3. ±45° Int. Pressure  
Hoop Response, Edge Rosettes  
A - Rosette No. 6  
B - Rosette No. 7  
C - Rosette No. 8

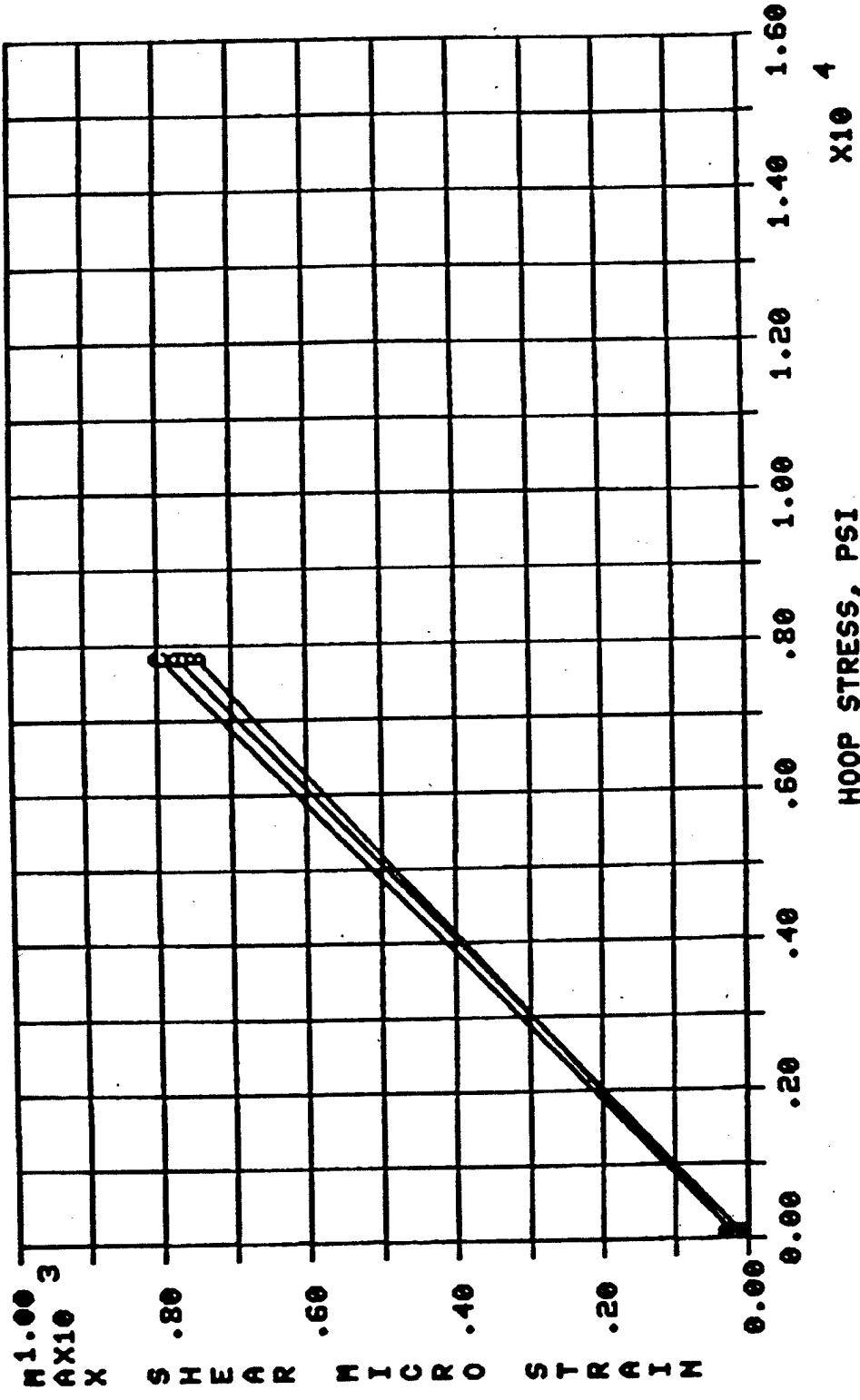


Figure 35 Test 3. ±45° Int. Pressure  
 Max. Shear, Edge Rosettes  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

axial, hoop and maximum shear strains, respectively, versus hoop stress for the gage locations along the edge of the specimen. These plots show excellent agreement for axial and hoop strains for all gages located on the outside surface. Figures 30, 31 and 32 show that some bending was occurring. Maximum shear strains at all rosette locations were in very good agreement. Figure 36 shows the specimen after rupture by the internal pressure.

Test 4 consisted of applying three different partial compressions to the same specimen. The specimen layup was  $\pm 45^\circ$ . For the first partial compression, which was designated as Test 4-A, the axial stress was taken to approximately 5,300 psi. The resulting strain versus axial stress curves are given in Figures 37 through 45. During Test 4-B, the axial stress reached 10,800 psi, twice the value of Test 4-A. Figures 46, 47 and 48 present the comparison plots for axial, hoop and maximum shear strains, respectively, for the locations along the outside center of the specimen. Figures 49, 50 and 51 present the corresponding information for the two gages located at the same location but on the inside and outside surfaces. Figures 52, 53 and 54 are comparison plots for the edge locations. Comparing the figures for Test 4-B (Figures 46 through 54) with those of Test 4-A (Figures 37 through 45) shows excellent agreement between the two tests. This indicates the tests were repeatable for this specimen up to at least 5,300 psi axial stress. These two tests show considerable scatter between the four gages located on the outside surface along the center of the specimen. Scatter of data is also seen between the edge gage locations. The comparison between inside and outside gage results (see Figures 49, 50 and 51) shows little bending is occurring at this location. Figures 55, 56 and 57 are comparison plots of axial, hoop and maximum shear strains, respectively, versus axial stress for the locations along the outside

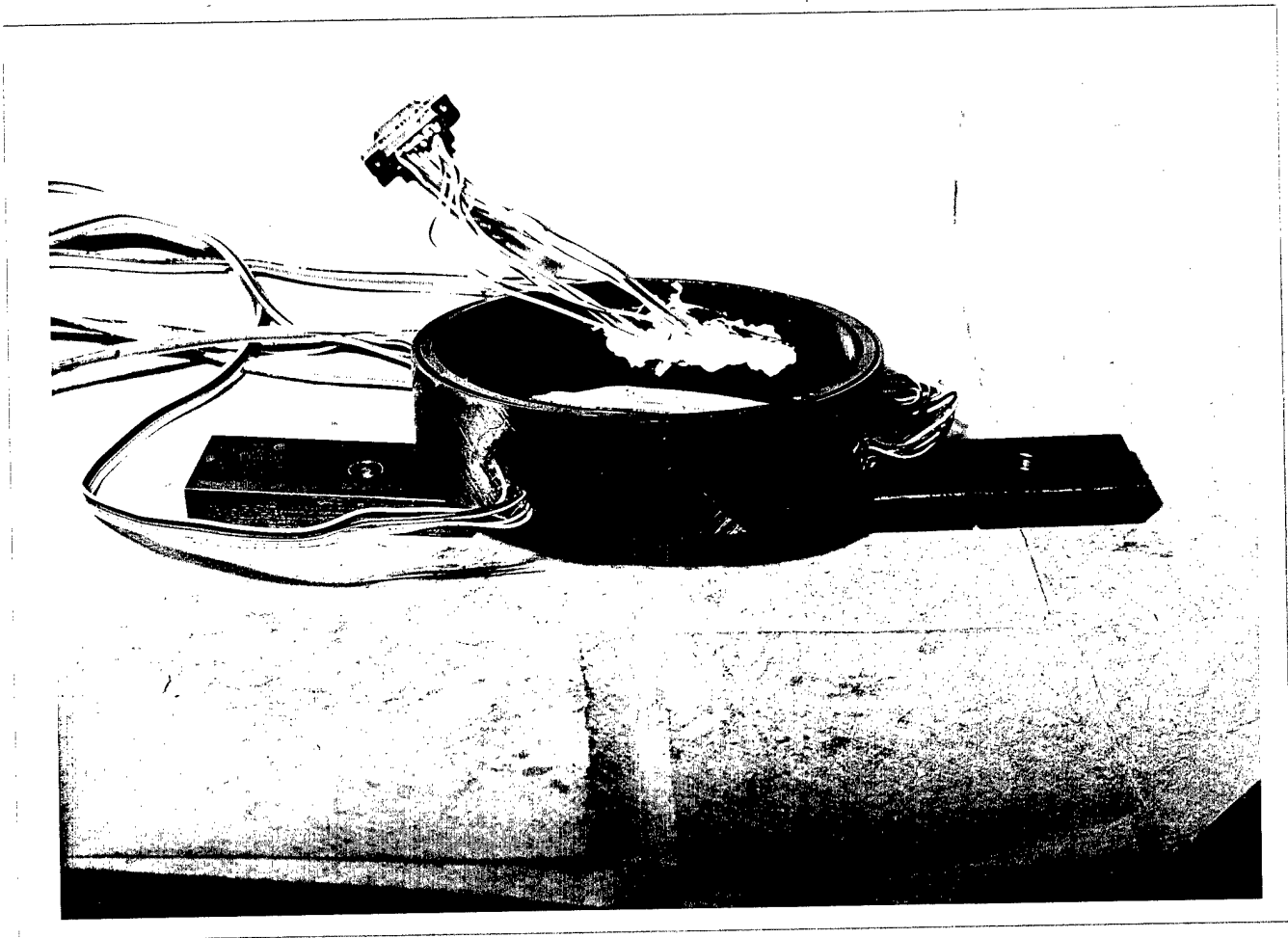


Figure 36 Test Specimen No. 3 After Rupture by  
Internal Pressure. Ply Layup is  $\pm 45^\circ$ .

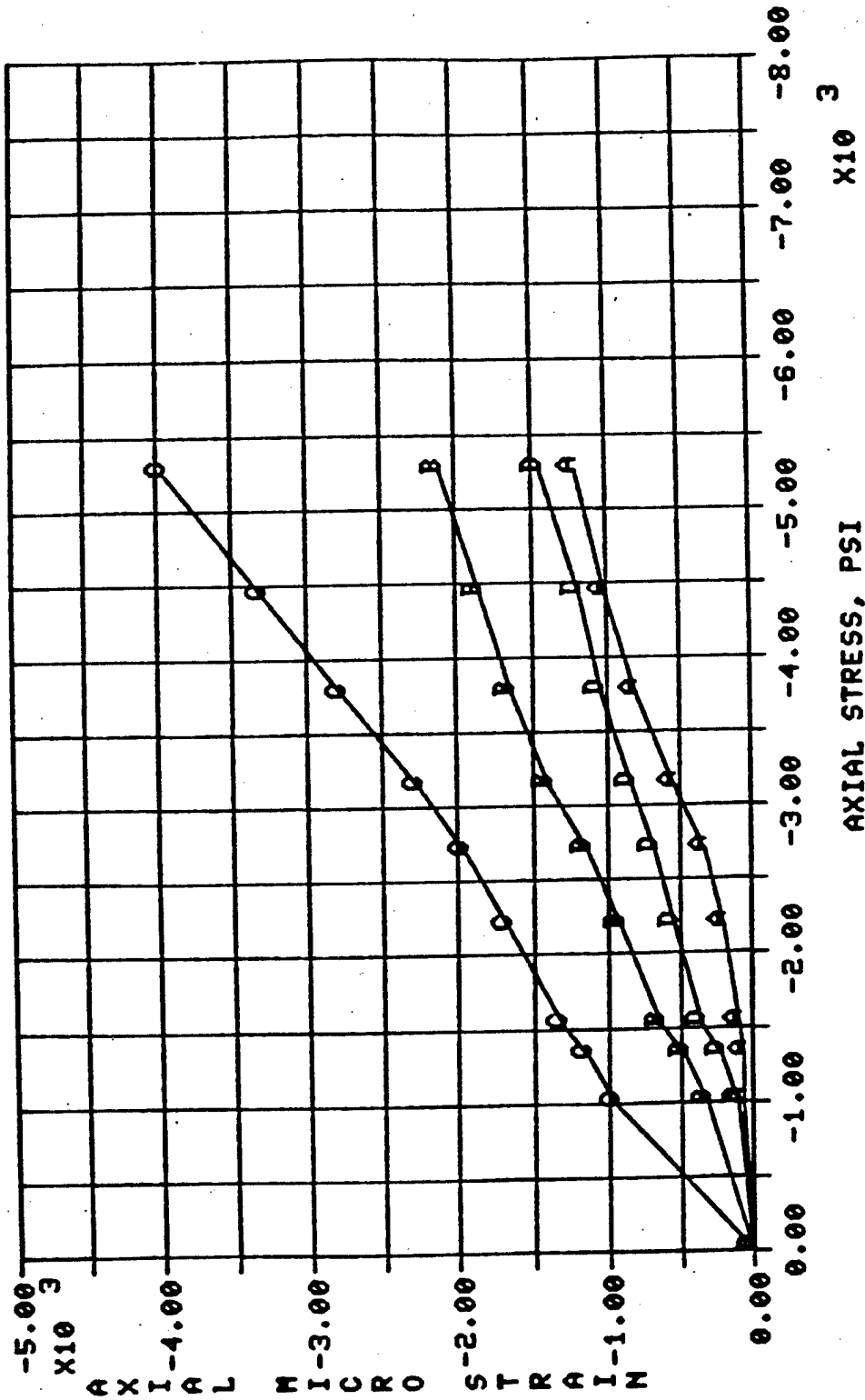


Figure 37 Test 4-A. Layout +45° Axial Load Only  
 Axial Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

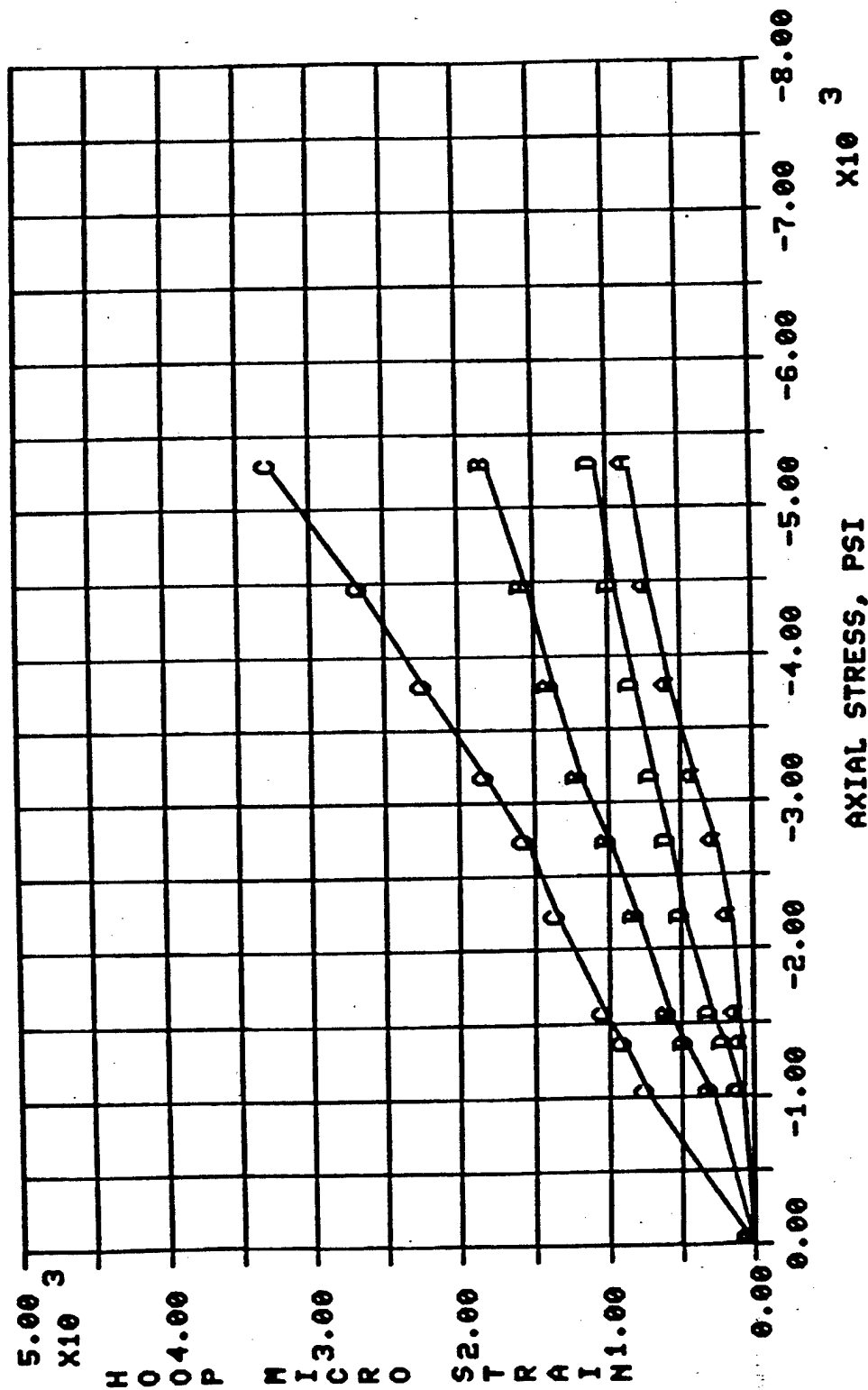


Figure 38 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

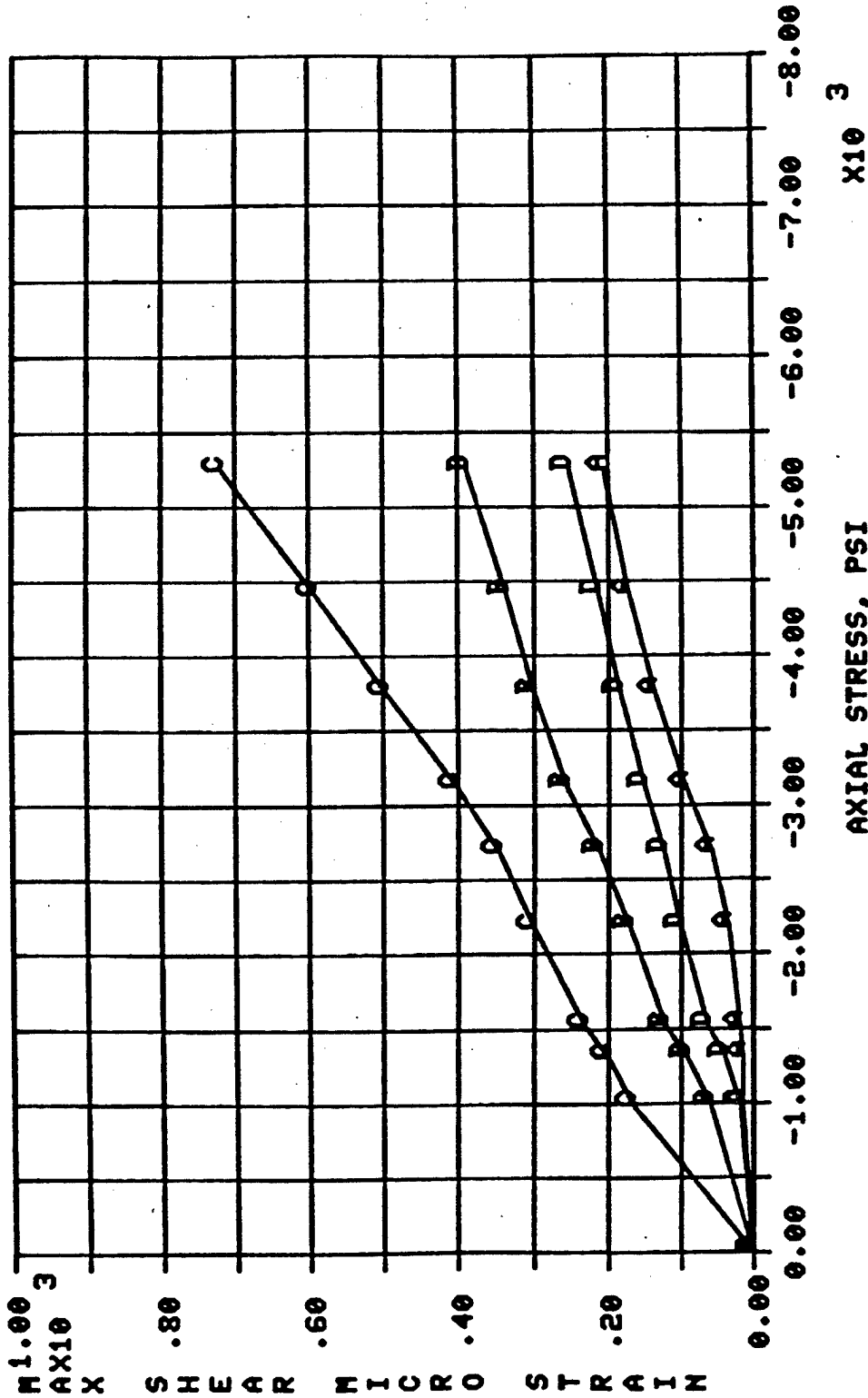


Figure 39 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

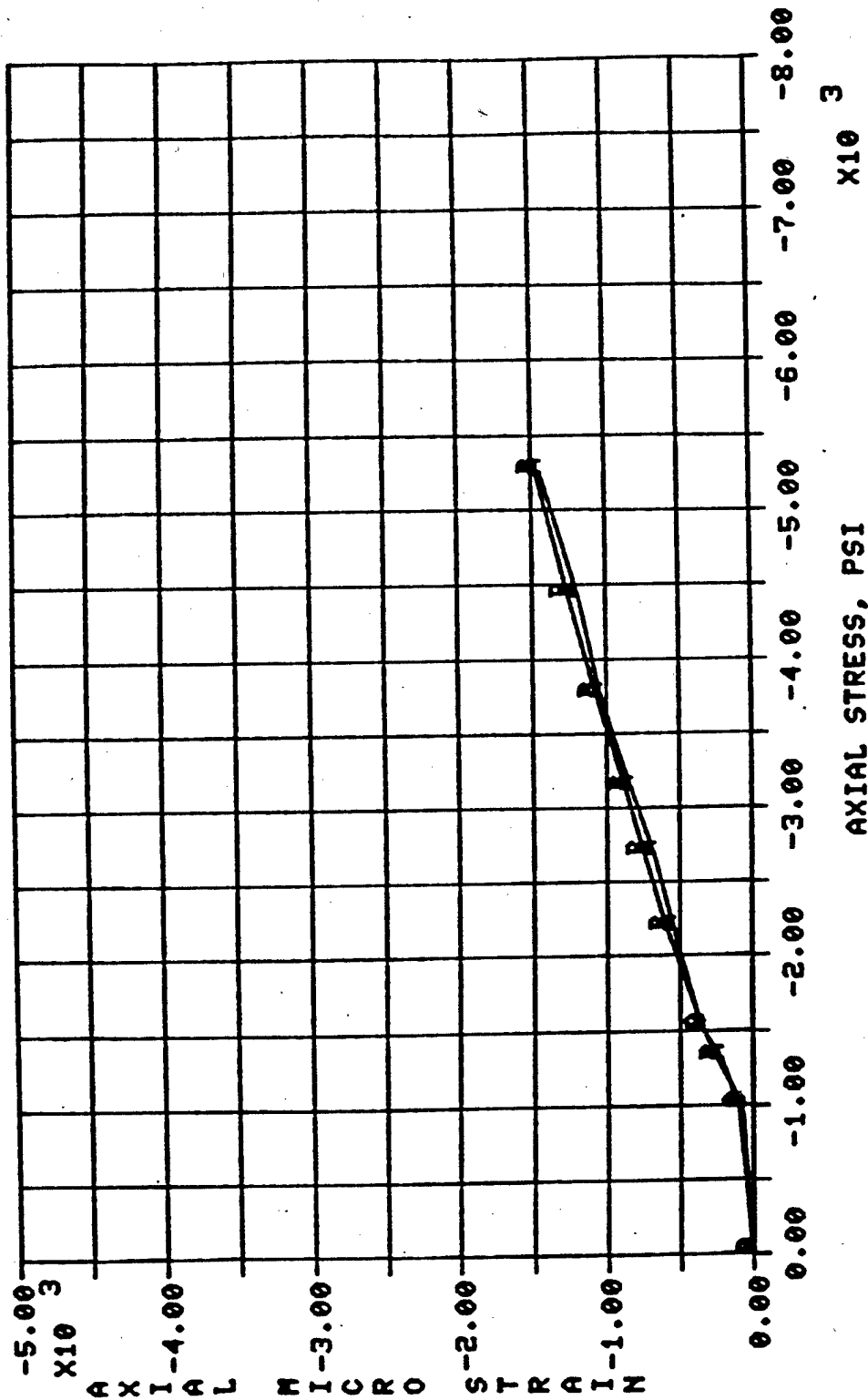


Figure 40 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

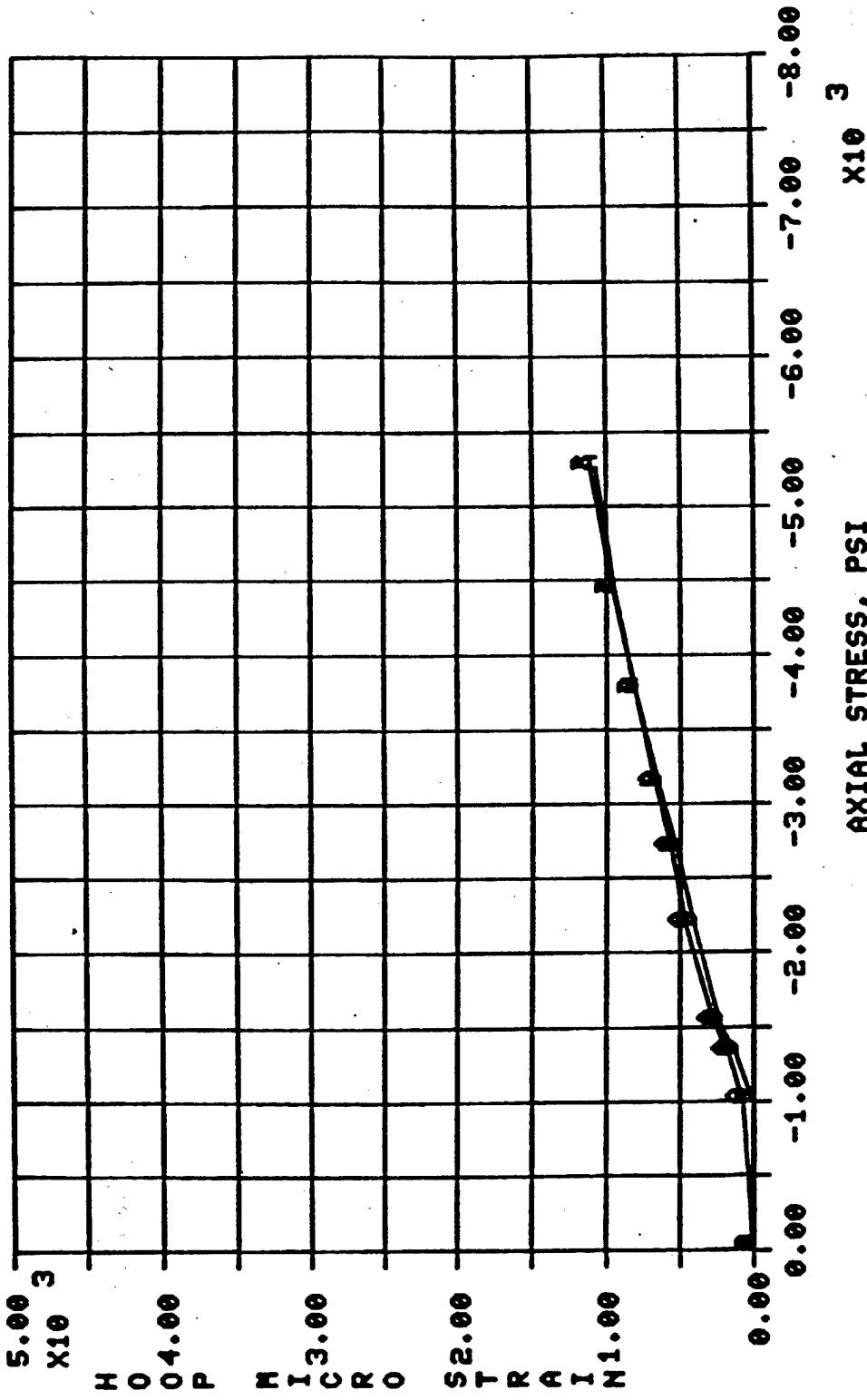


Figure 41 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

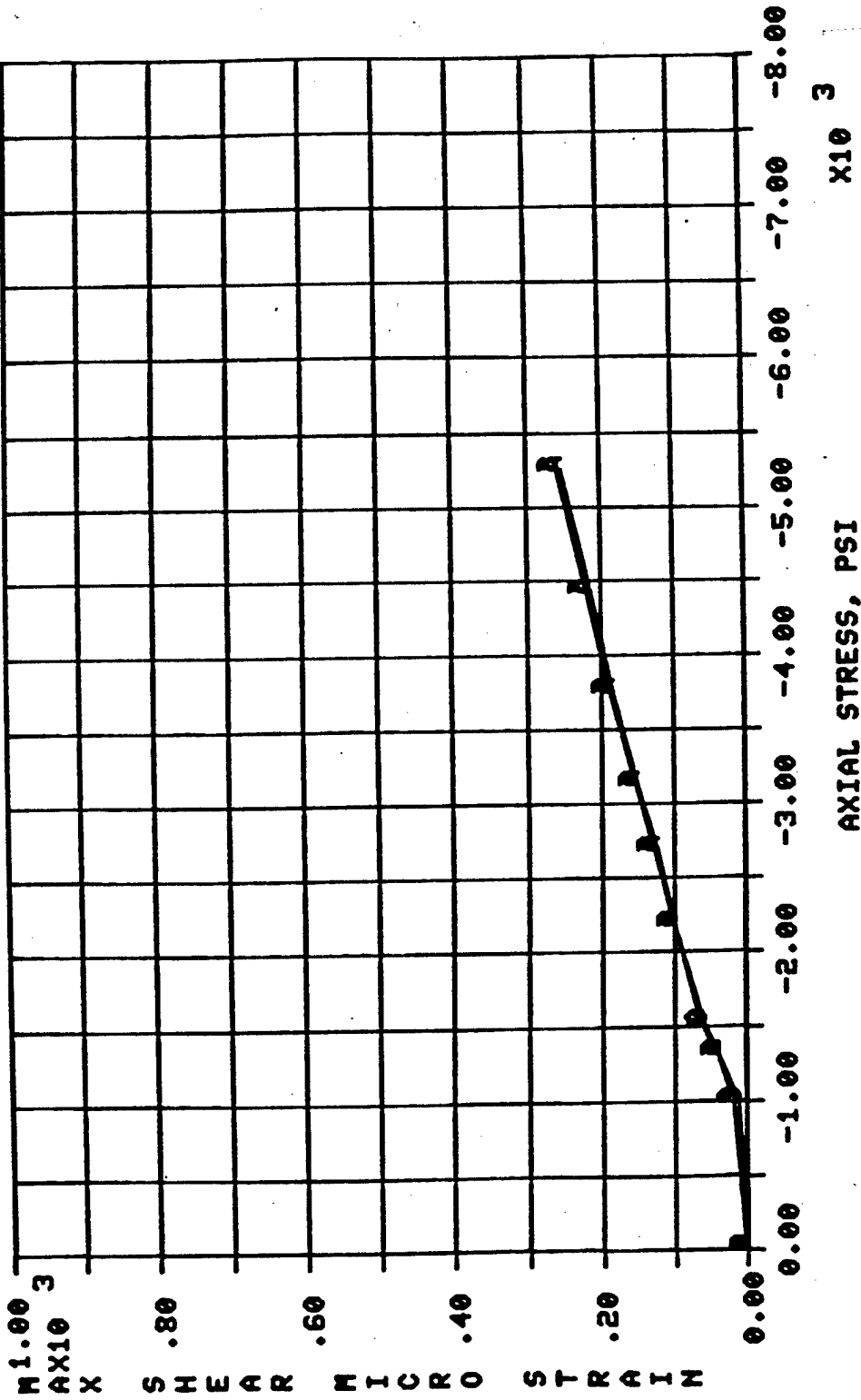


Figure 42 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

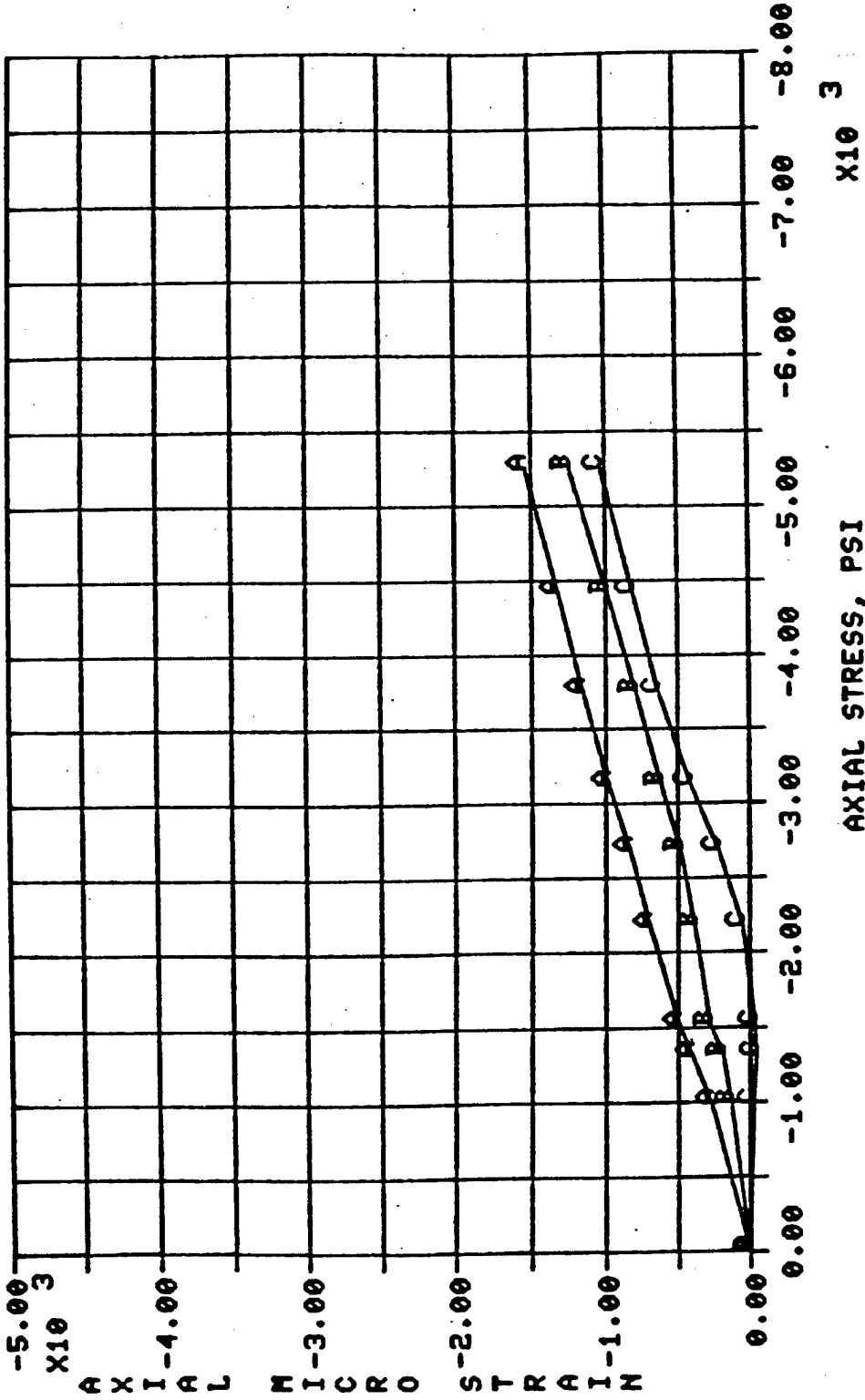


Figure 43 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Edge Rosettes  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

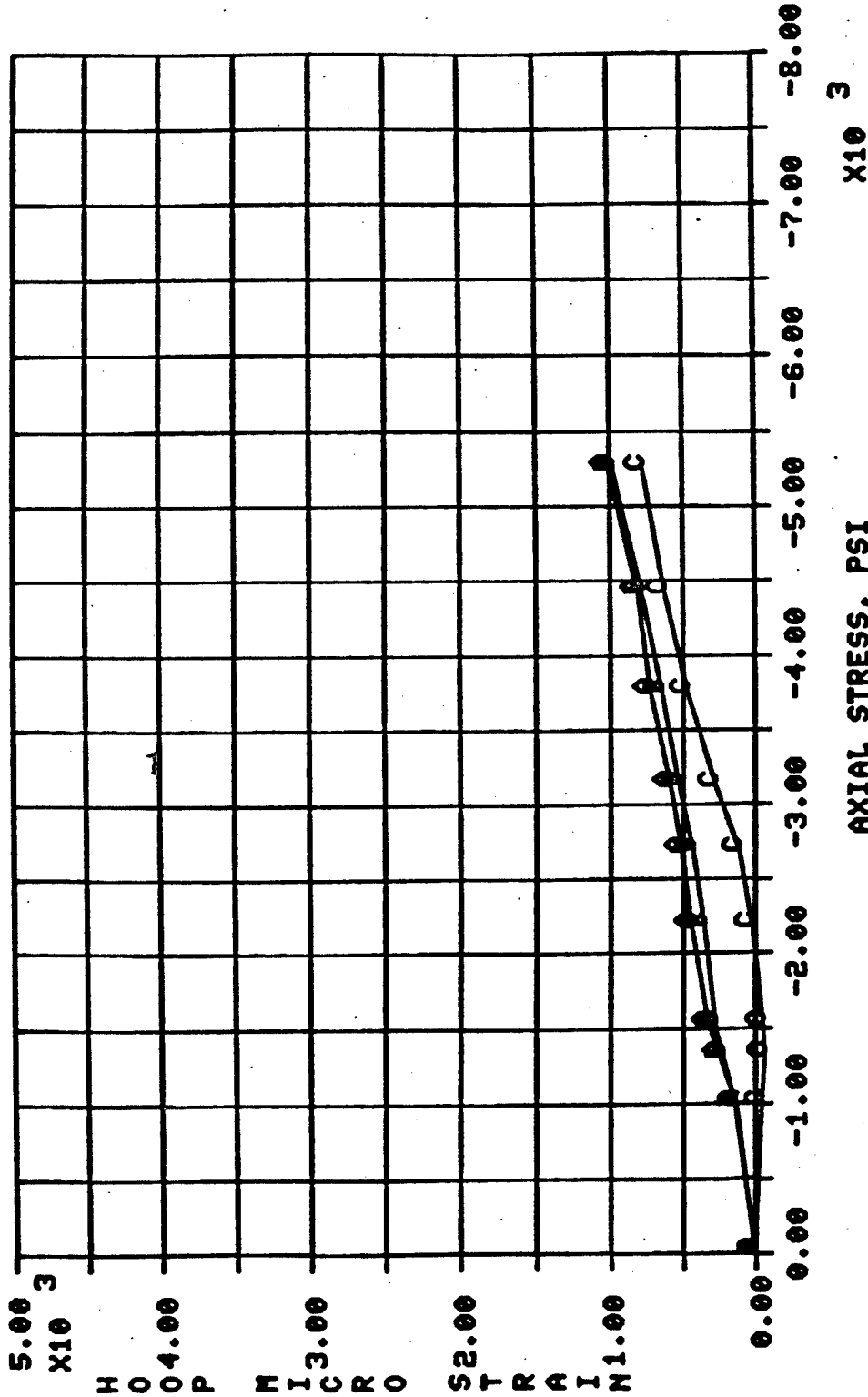


Figure 44 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Edge Rosettes

- A - Rosette No. 6
- B - Rosette No. 7
- C - Rosette No. 8

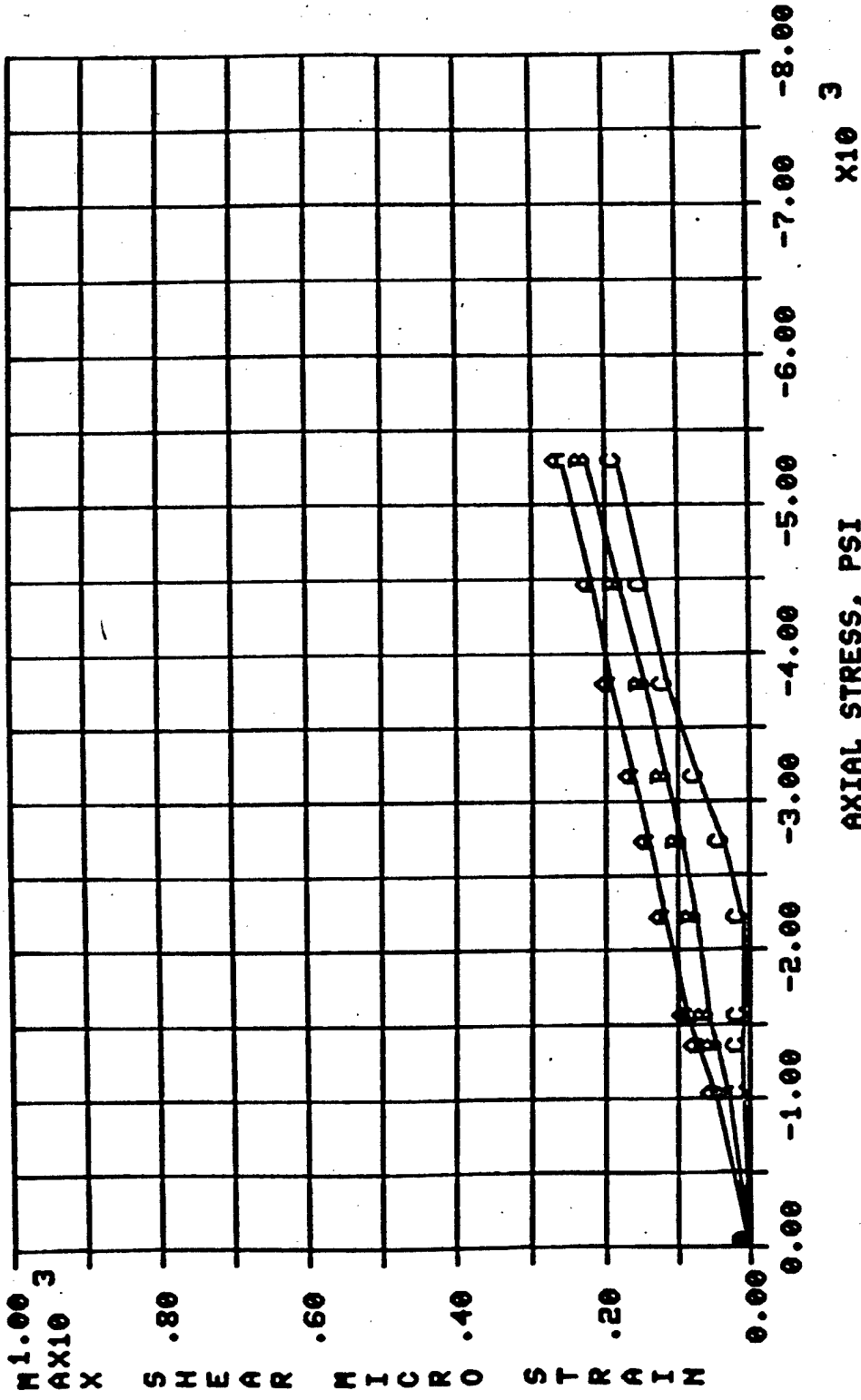


Figure 45 Test 4-A. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Edge Rosettes  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

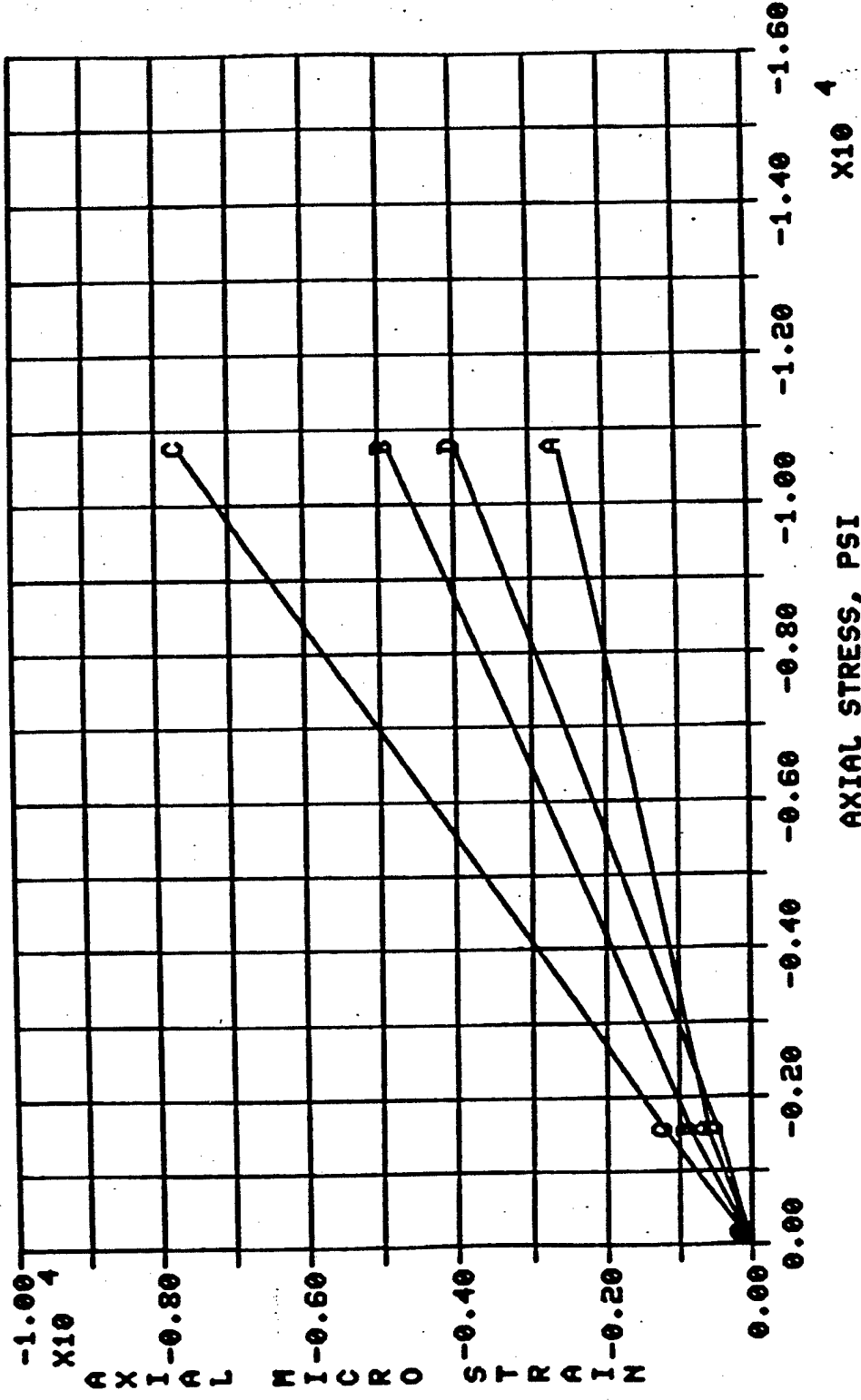


Figure 46 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

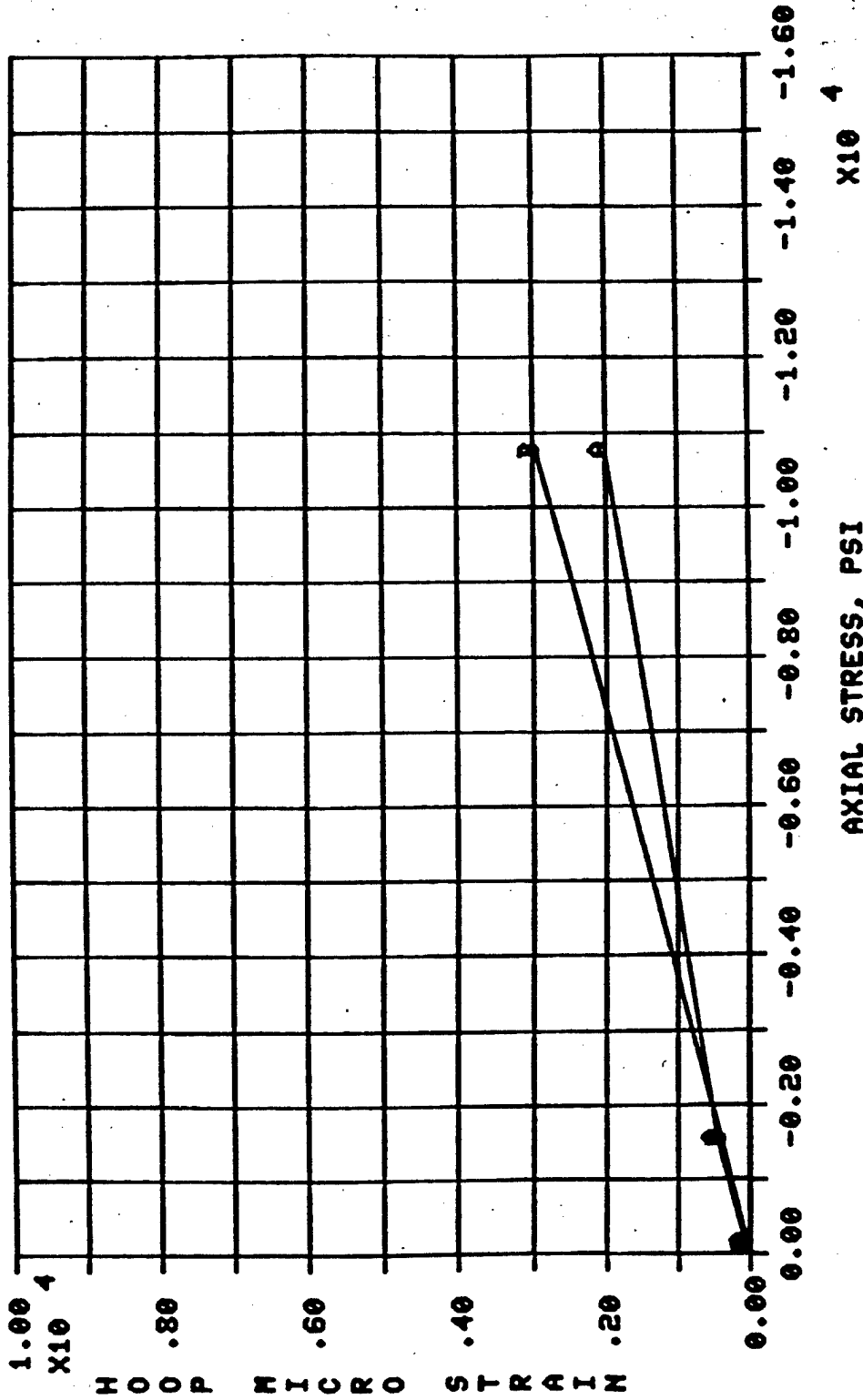


Figure 47. Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
Hoop Response, Outside Rosettes

A - Rosette No. 1  
B - Rosette No. 4

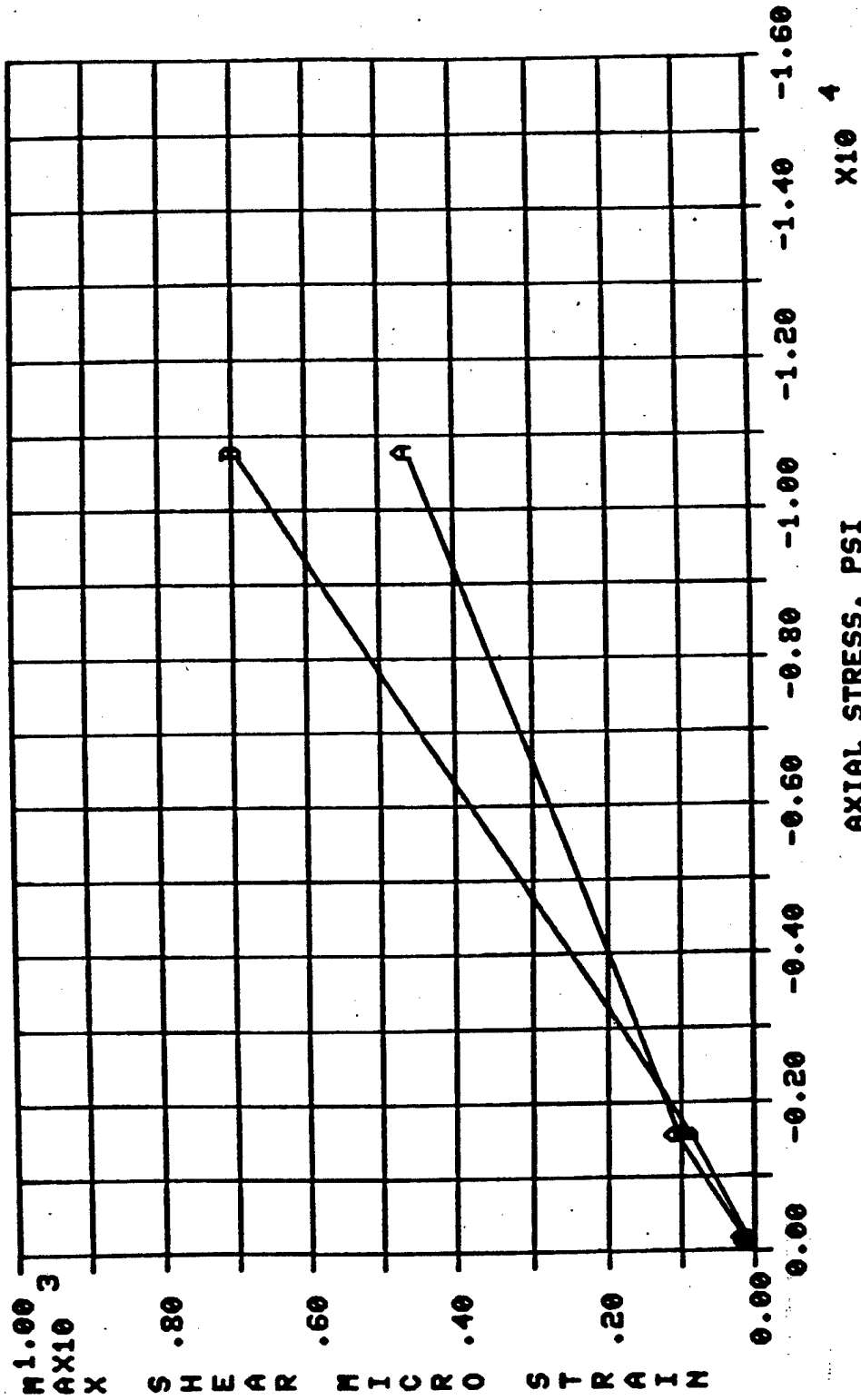


Figure 48 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
Max. Shear, Outside Rosettes  
A - Rosette No. 1  
B - Rosette No. 4

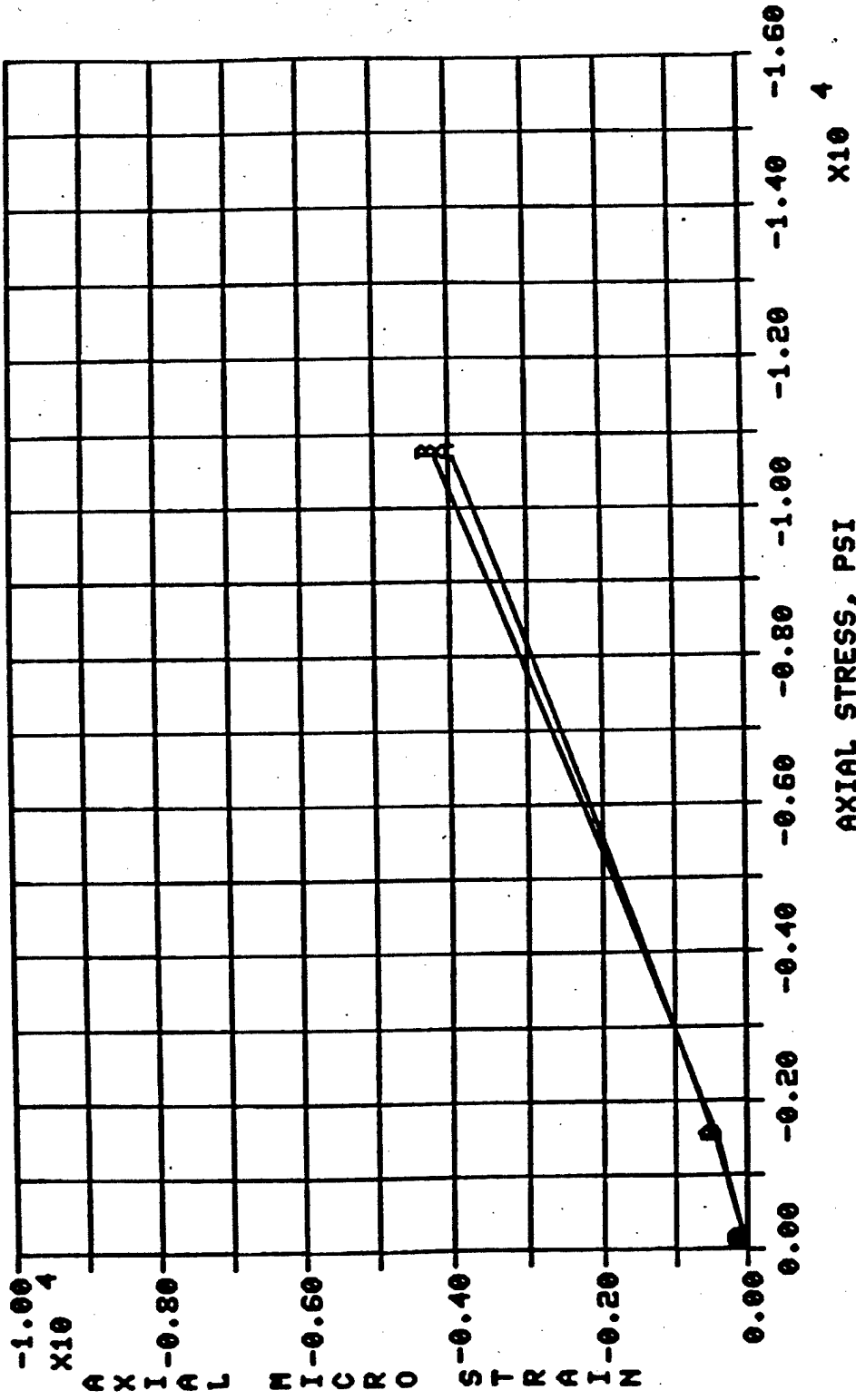


Figure 49 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

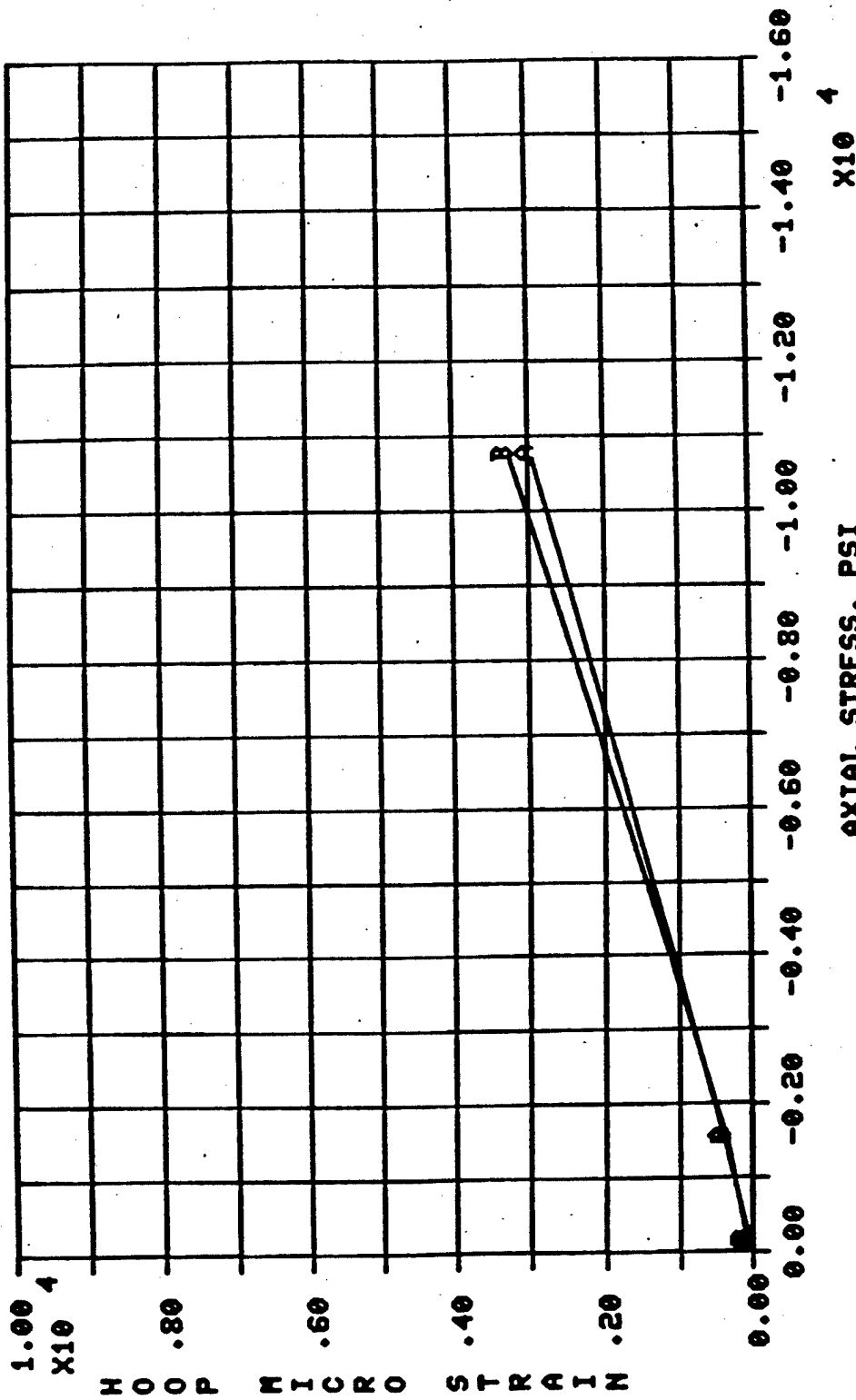


Figure 50 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
Hoop Response, Inside/Outside Rosettes  
A - Rosette No. 4 (outside)  
B - Rosette No. 5 (inside)

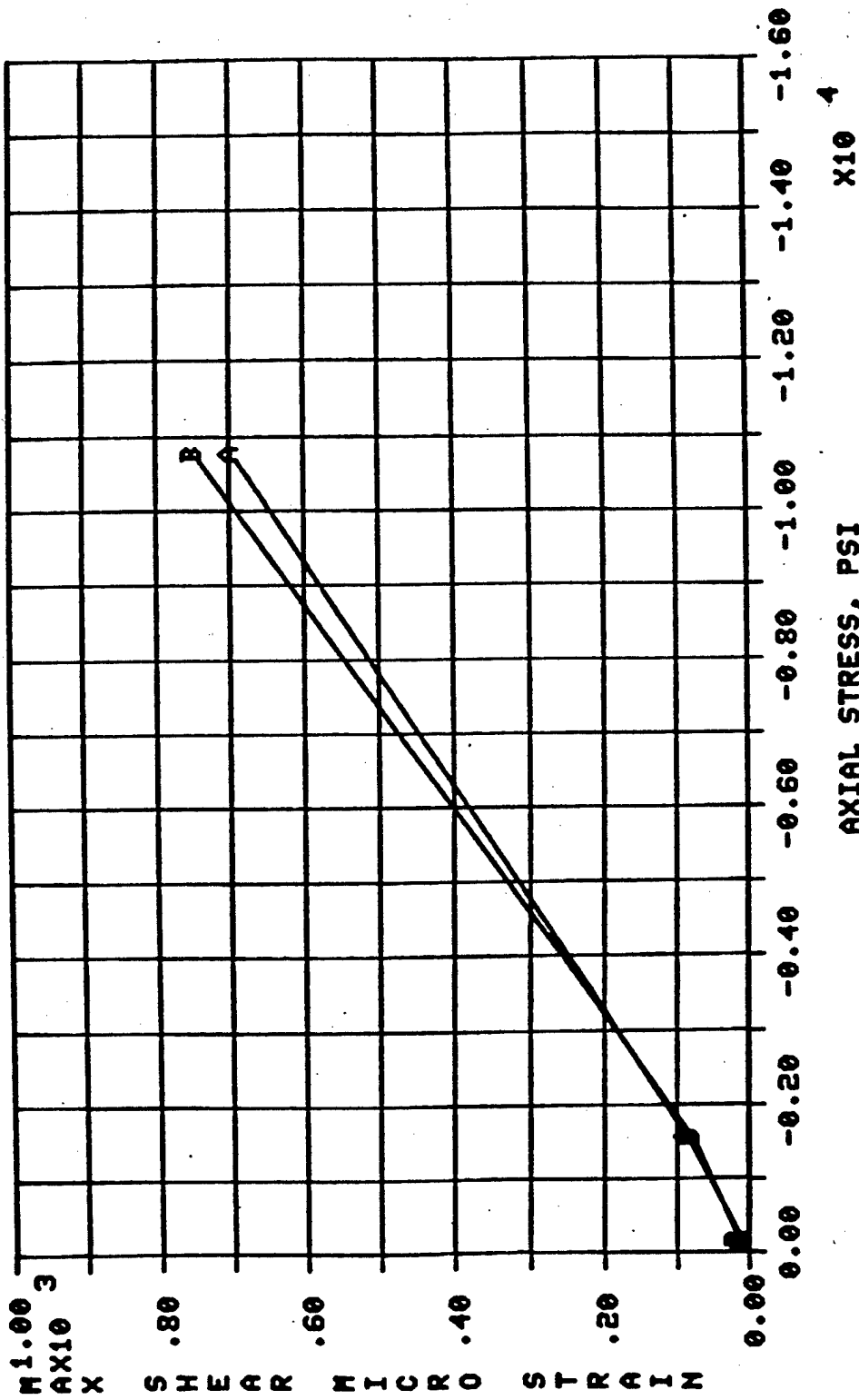


Figure 51 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Inside/Outside Rosettes  
 A - Rosette No. 4  
 B - Rosette No. 5 (inside)

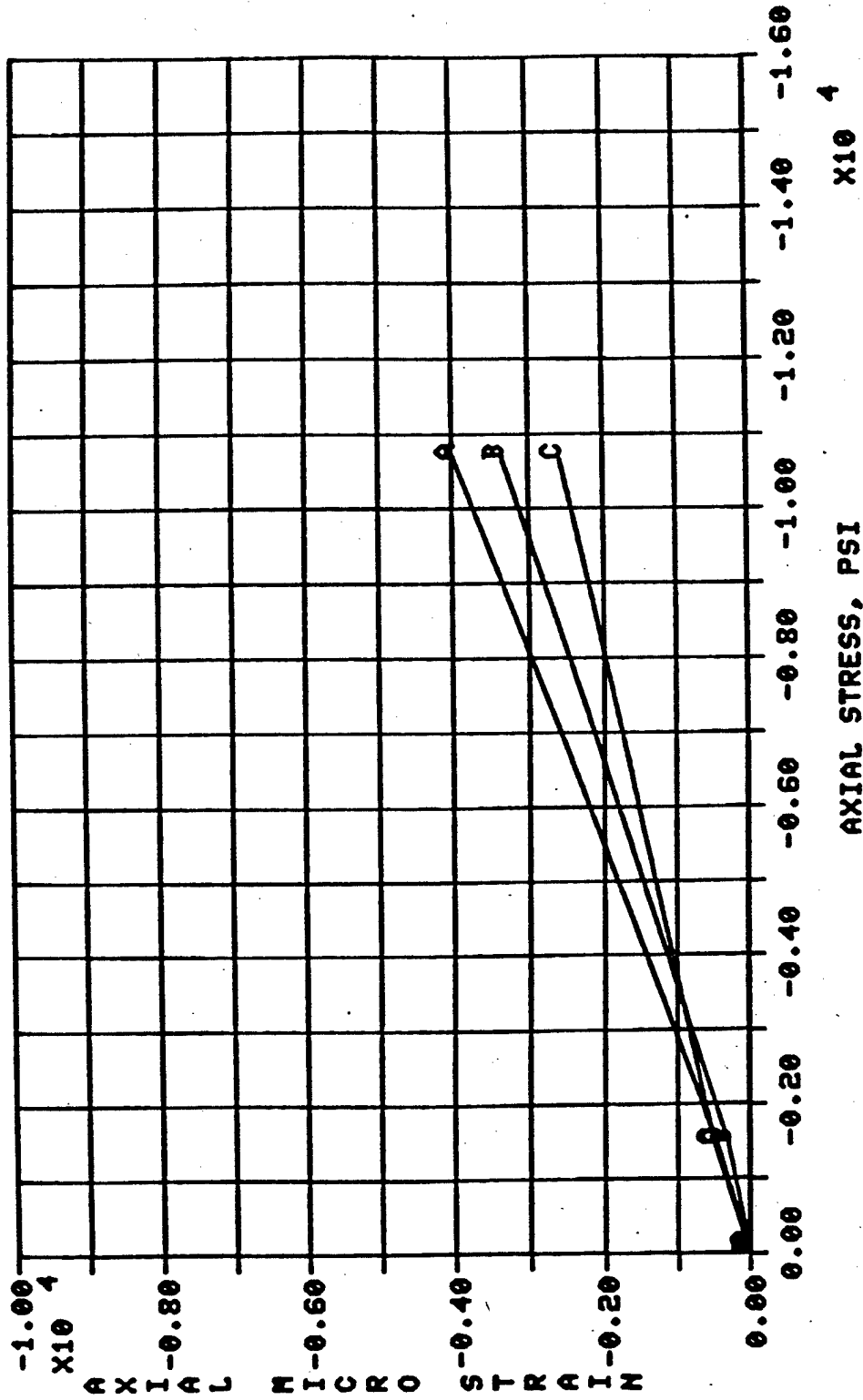


Figure 52 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Edge Rosettes  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

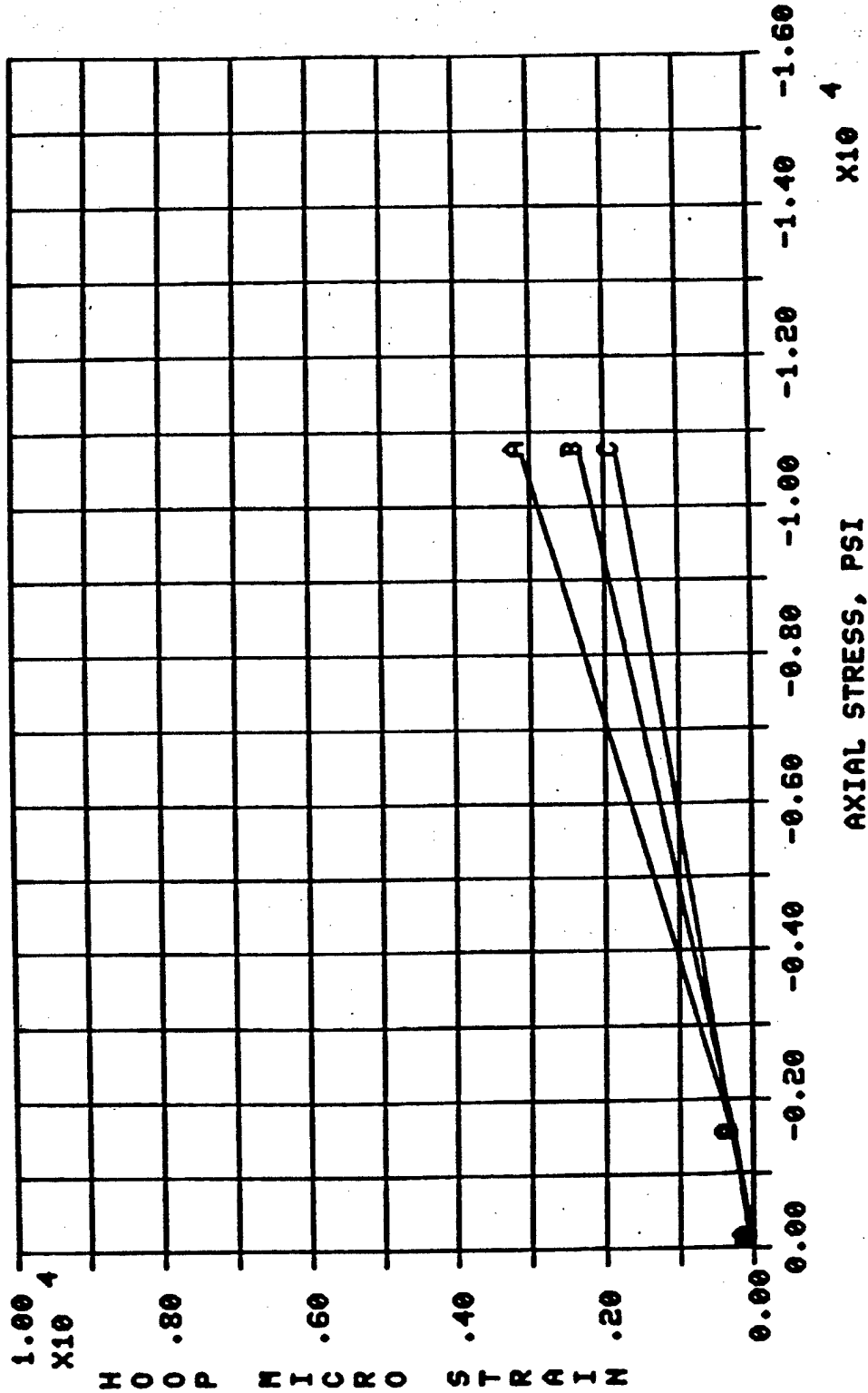


Figure 53 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
Hoop Response, Edge Rosettes

- A - Rosette No. 6
- B - Rosette No. 7
- C - Rosette No. 8

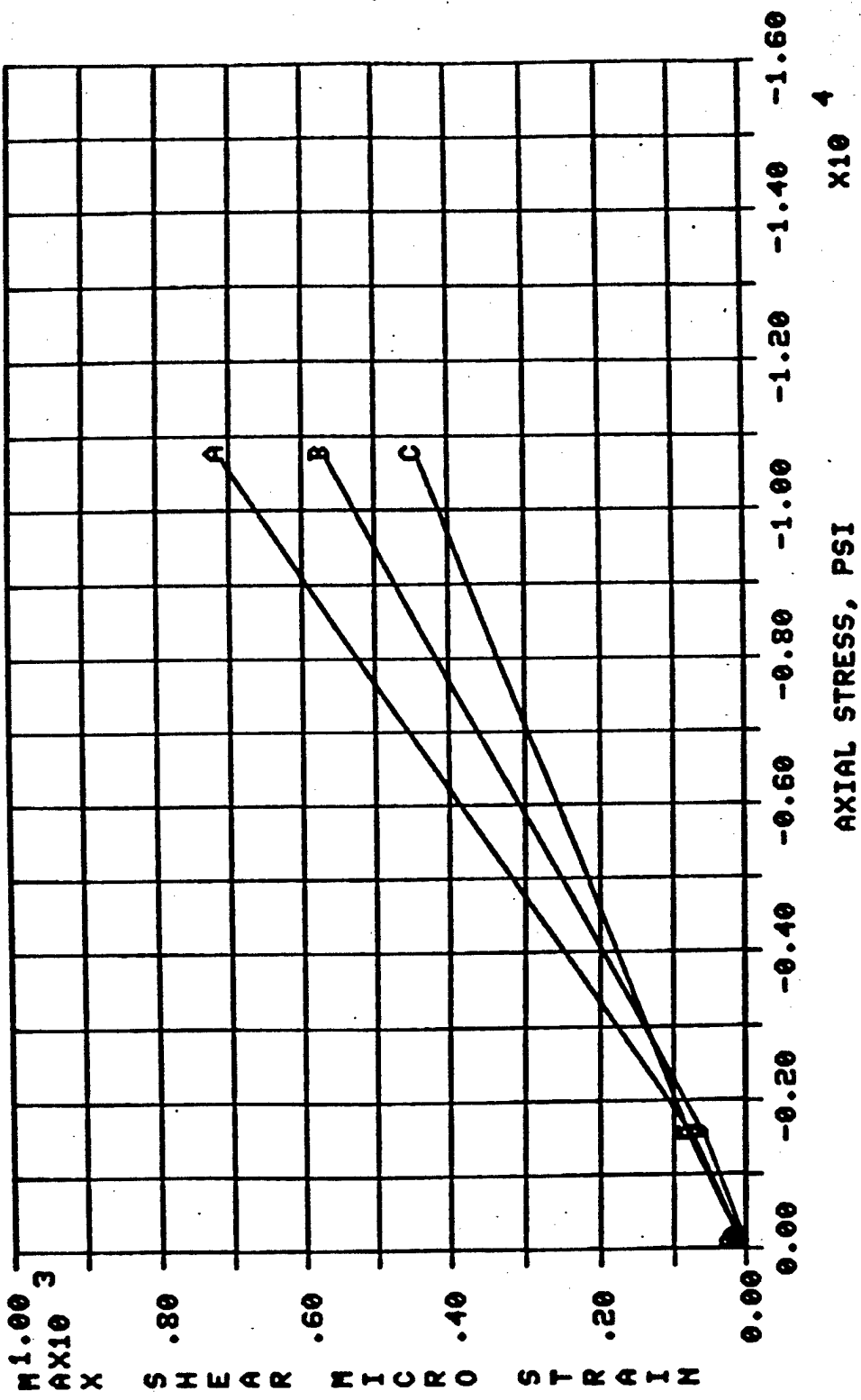


Figure 54 Test 4-B. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Edge Rosettes  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

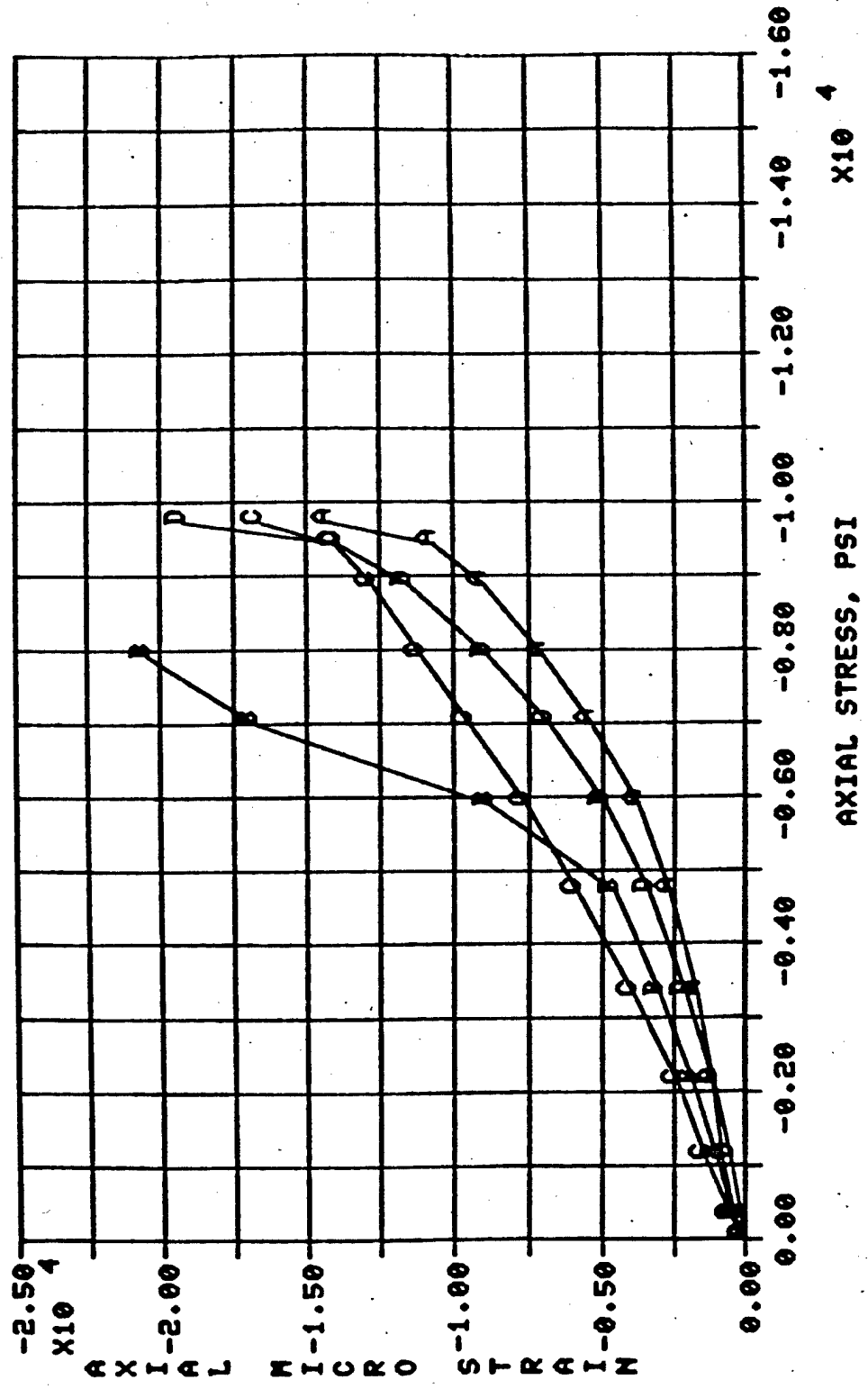


Figure 55 Test 4-C. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

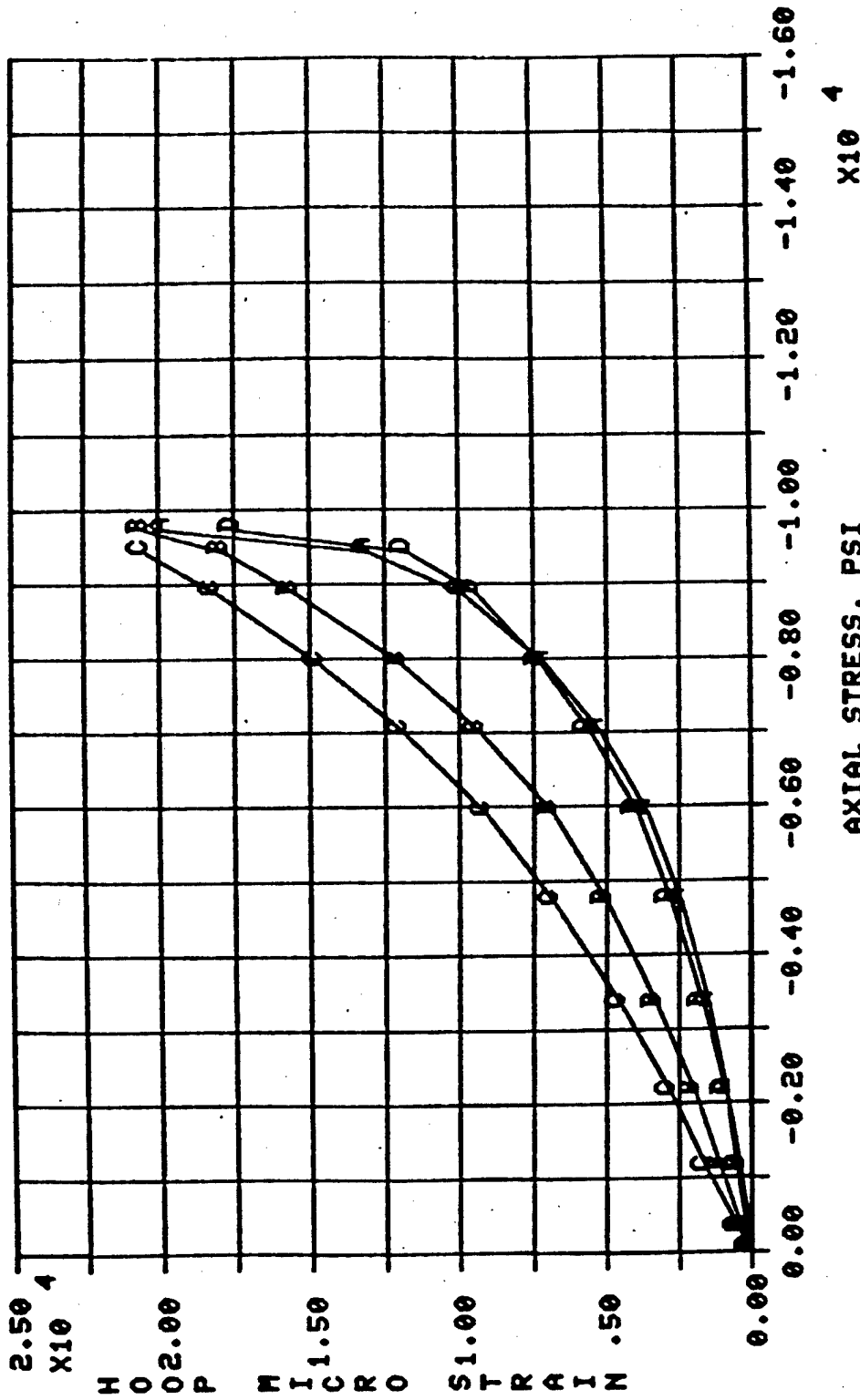


Figure 56 Test 4-C. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

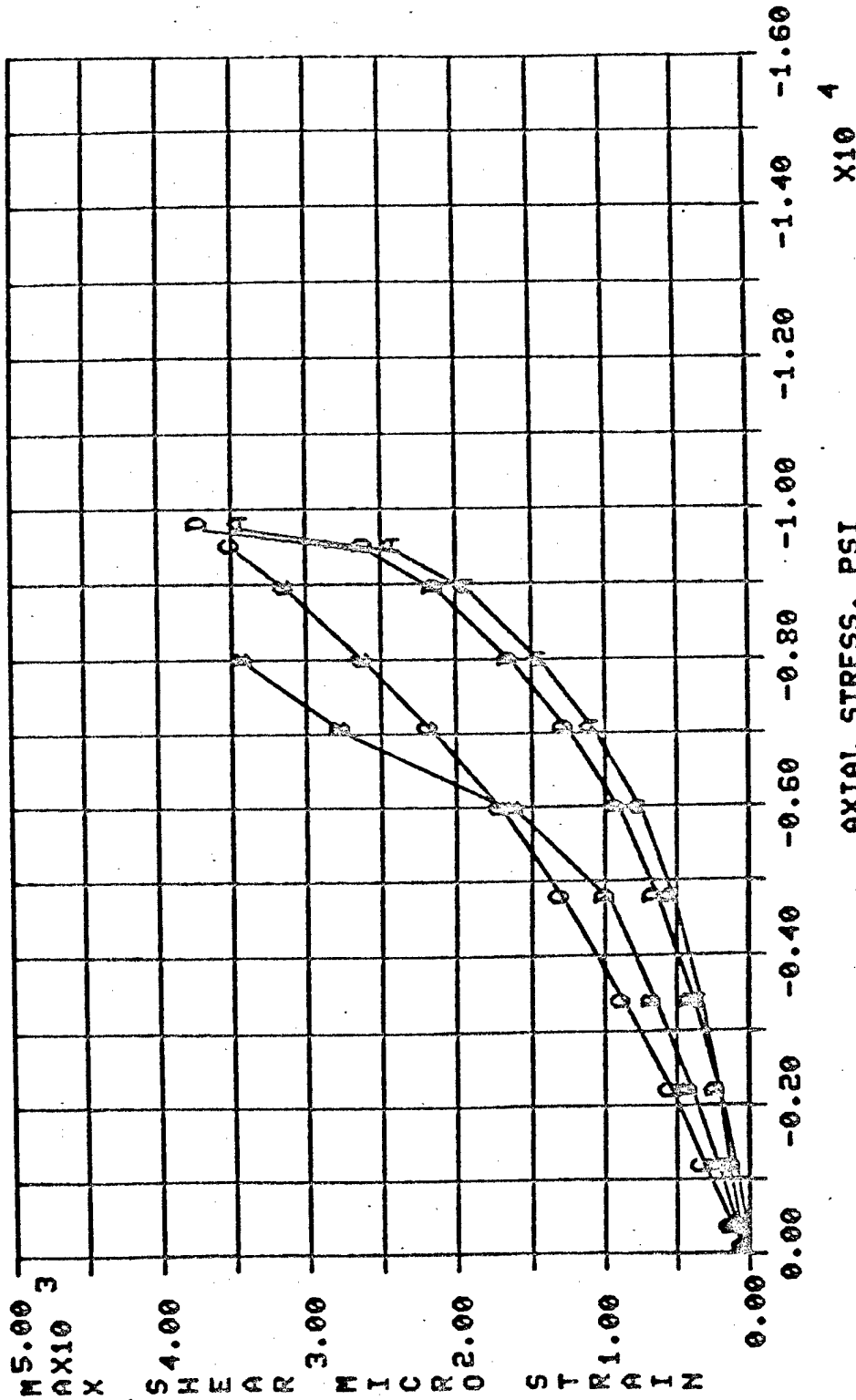


Figure 57 Test 4-C. Layout #45 Axial Load Only  
 Max. Shear Response, Outside Rosettes  
 A - Rosette No. 1  
 B - Rosette No. 2  
 C - Rosette No. 3  
 D - Rosette No. 4

surface of the specimen for Test 4-C. Strains at Locations 1 and 4 are in good agreement. Figures 58, 59 and 60 are comparison plots of axial, hoop and maximum shear strains, respectively, versus axial stress for the inside/outside comparison gages. Here good agreement is shown, indicating very little bending is occurring. Figures 61, 62 and 63 are comparison plots of axial, hoop and maximum shear strains, respectively, versus axial stress for the edge rosettes. Fairly good agreement is shown, much better than the gages located at the center of the specimen showed.

If the results of Tests 4-A, 4-B and 4-C are plotted together, such as in Figures 64 through 67, an interesting point comes to light. From these figures, one sees that Test 4-A and Test 4-B give almost identical results, while Test 4-C produced much higher strains. Also, note that the axial stress of Test 4-B is higher than that of Test 4-C. It is thought that Test 4-B damaged the specimen (internal breakage of fibers), and this could account for the behavior of Test 4-C.

For Test 5, external pressure was applied to the same specimen as used in Tests 4-A, 4-B and 4-C. Figures 68, 69 and 70 present the axial, hoop and maximum shear strains, respectively, for two rosettes located on the inside surface, one at the center and one at the edge. Both rosettes are located at the same angular location. The results are in very poor agreement. This could be because the specimen was damaged in Test 4, as discussed above, or because buckling was taking place. Fracture of the specimen, shown in Figure 71, was from ply delamination and hoop direction blooming.

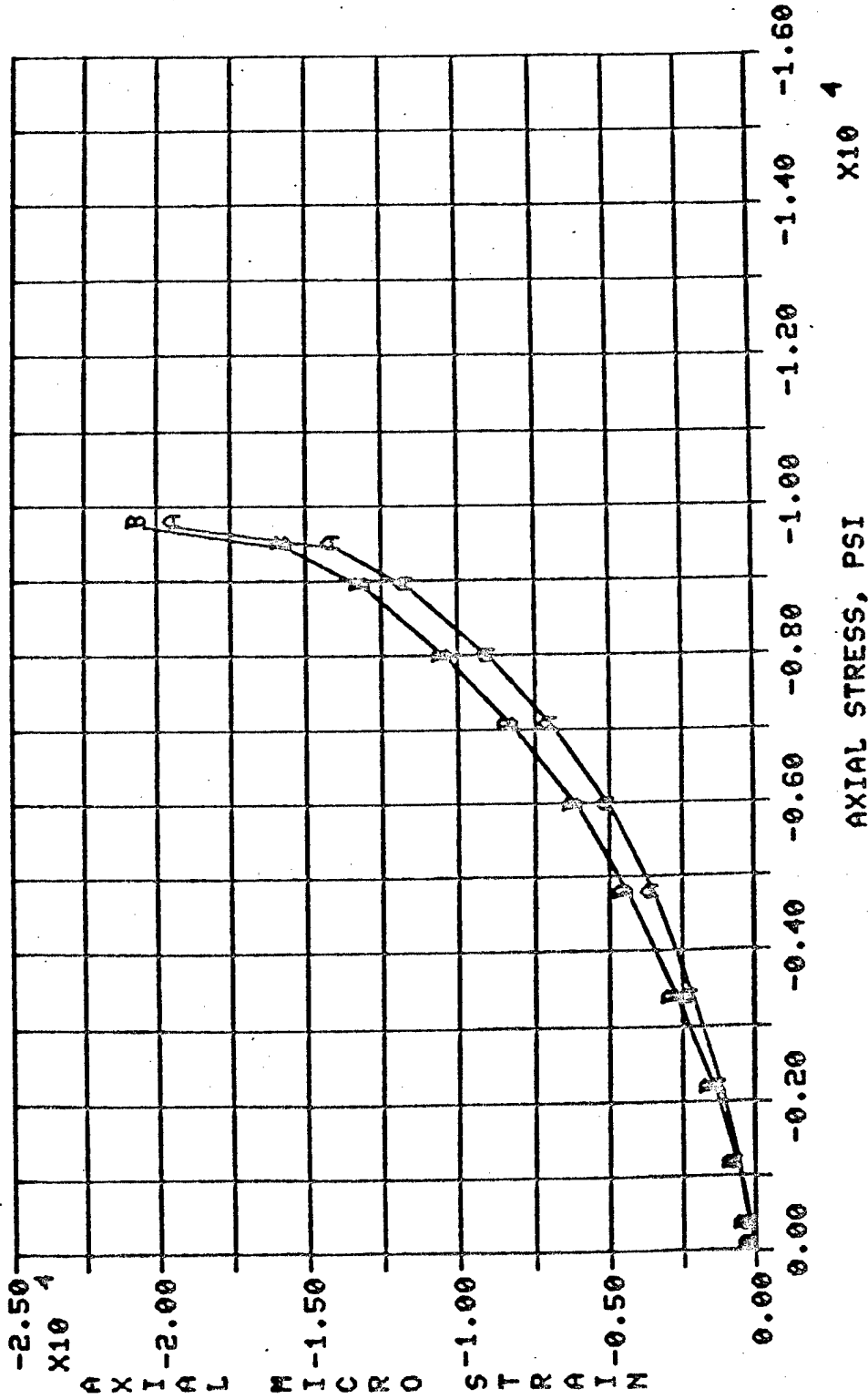


Figure 58 Test 4-C Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

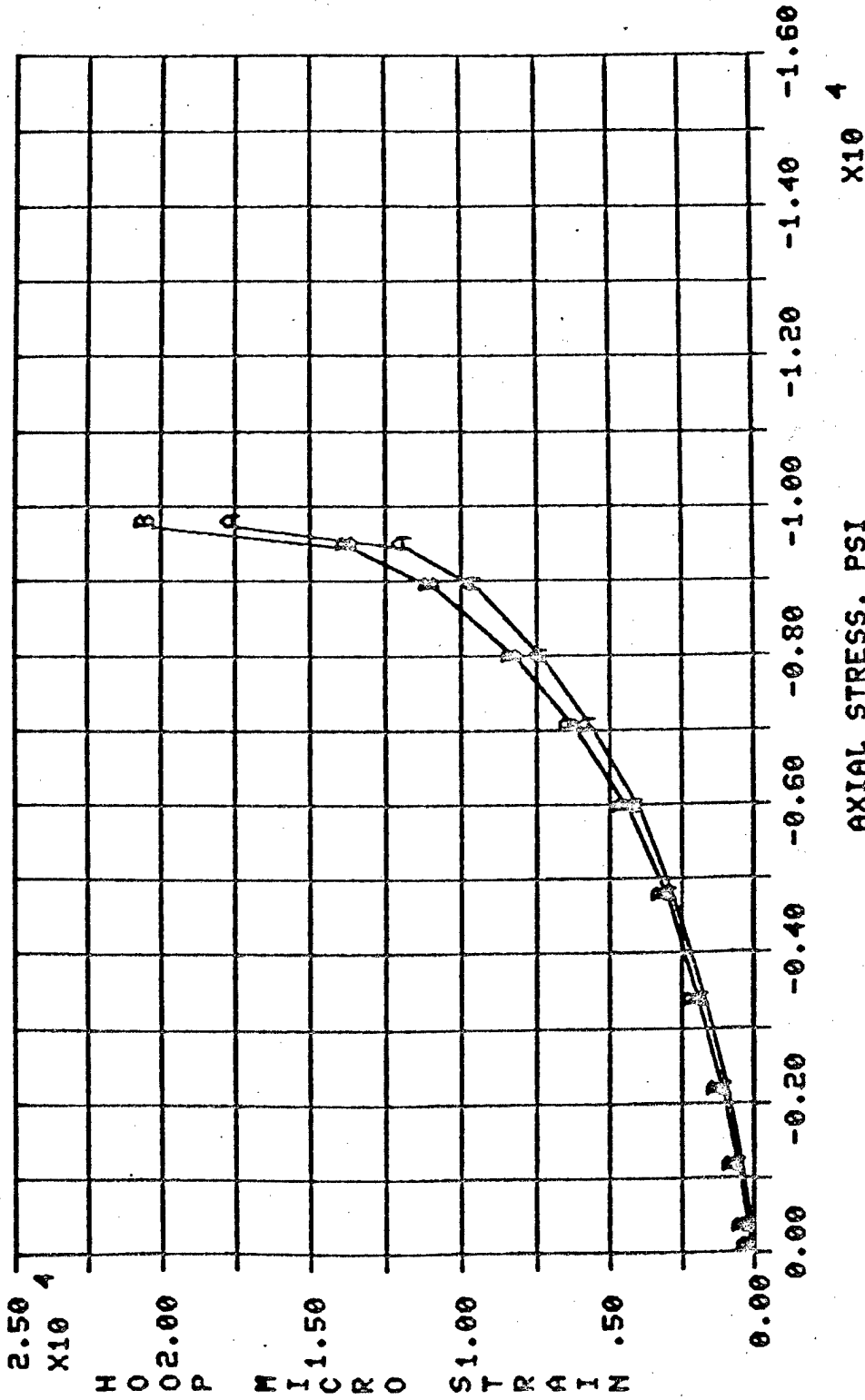


Figure 59 Test 4-C. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

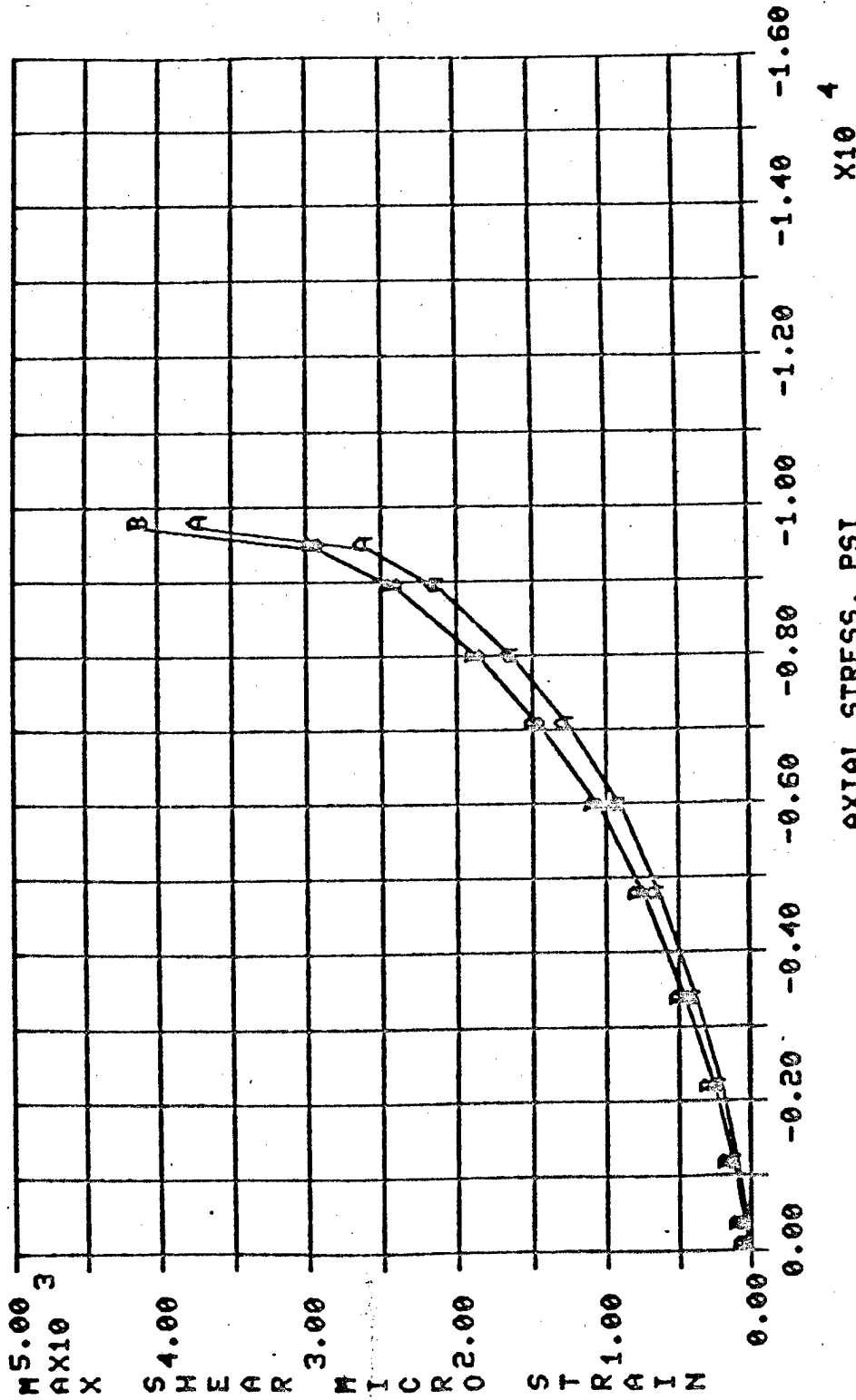


Figure 60 Test 4-C. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

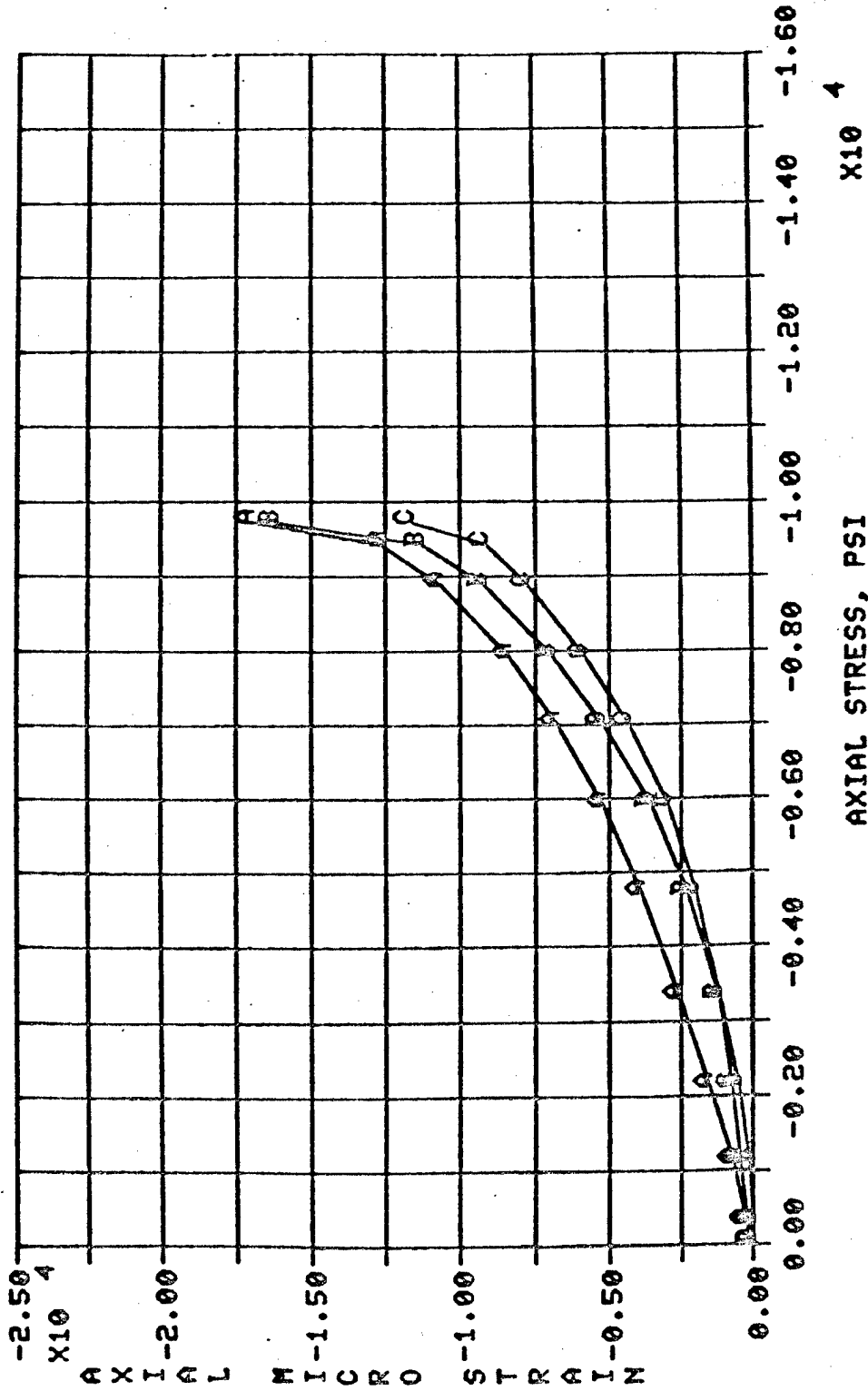


Figure 61 Test 4-C. Layout  $\pm 45^\circ$  Axial Load Only  
 Axial Response, Edge Rosettes  
 A - Rosette No. 6  
 B - Rosette No. 7  
 C - Rosette No. 8

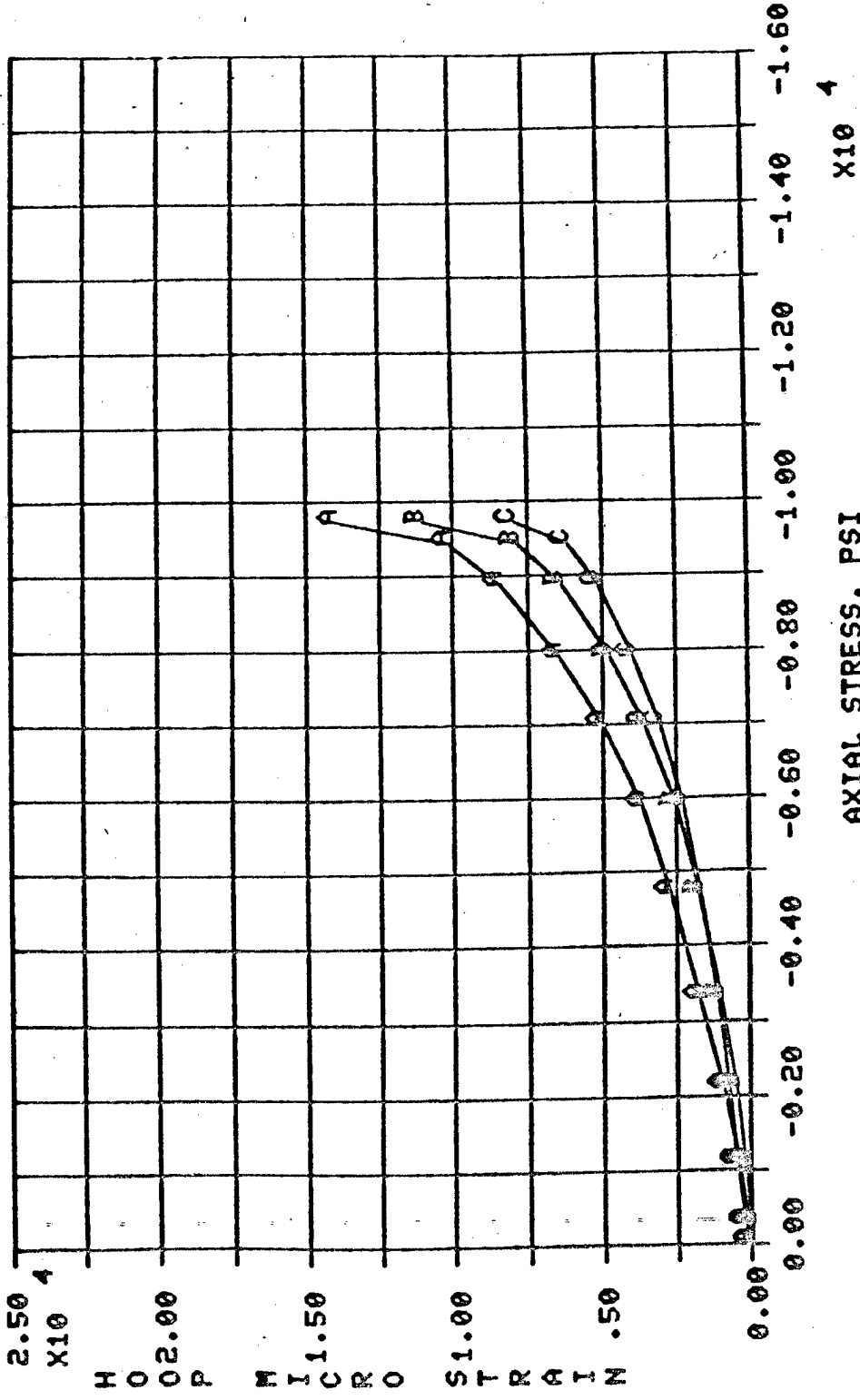


Figure 62 Test 4-C. Layout  $\pm 45^\circ$  Axial Load Only  
 Hoop Response, Edge Rosettes

- A - Rosette No. 6
- B - Rosette No. 7
- C - Rosette No. 8

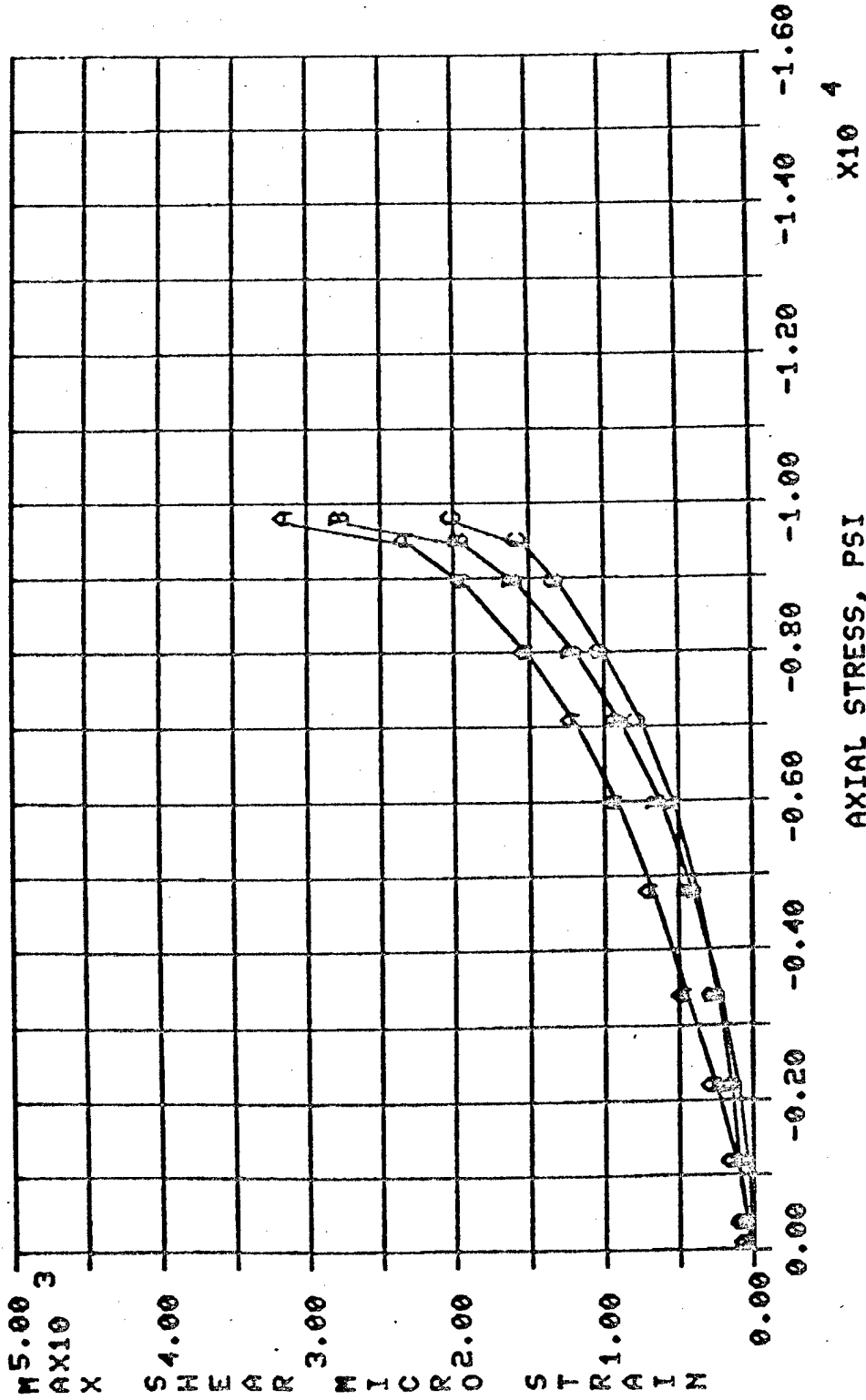


Figure 63 Test 4-C. Layout  $\pm 45^\circ$  Axial Load Only  
 Max. Shear, Edge Rosettes

- A - Rosette No. 6
- B - Rosette No. 7
- C - Rosette No. 8

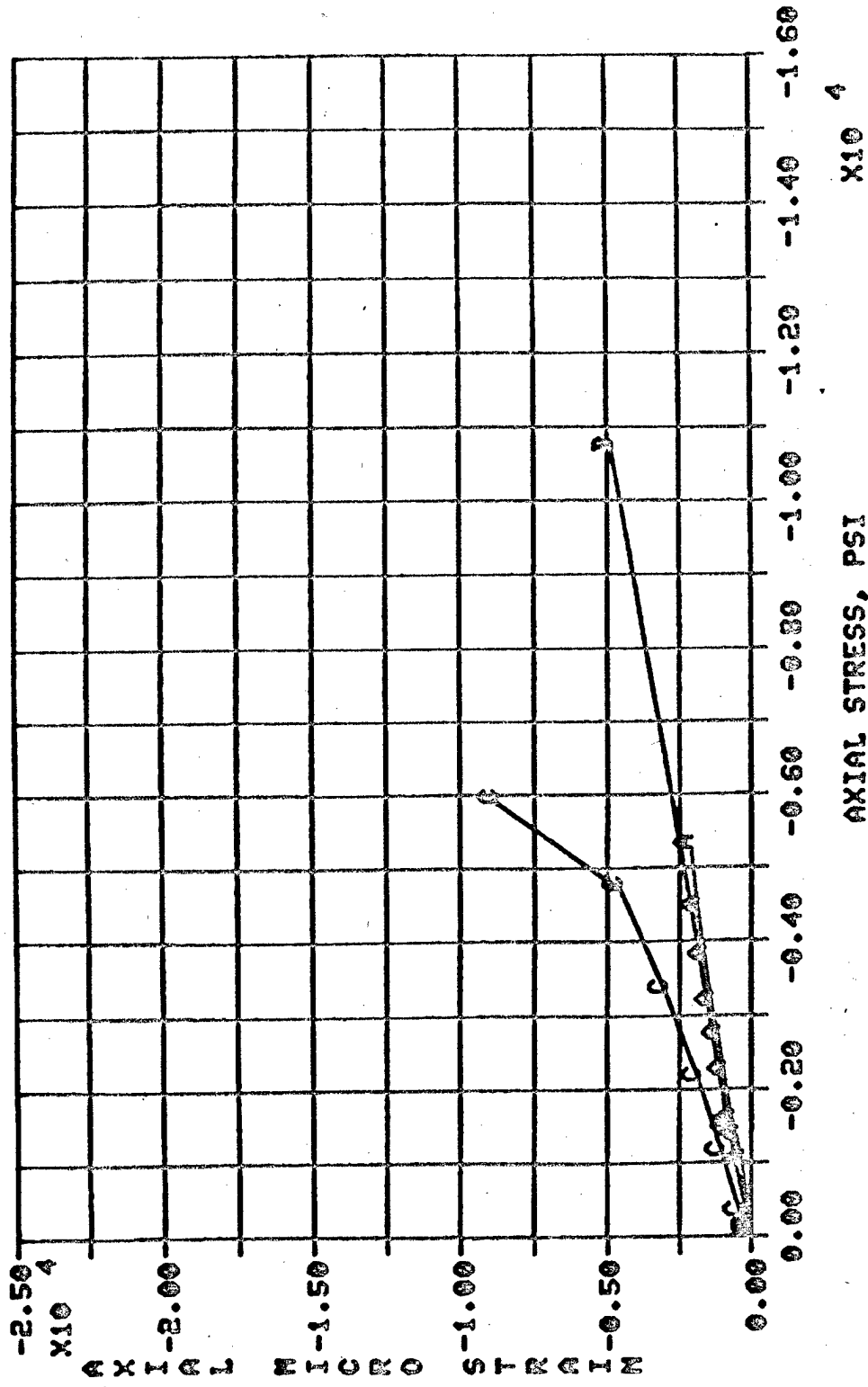


Figure 64 Tests 4-A, B, C. Layout  $\pm 45^\circ$  Axial Only  
 Axial Response, Rosette No. 2  
 A - Test 4-A  
 B - Test 4-B  
 C - Test 4-C

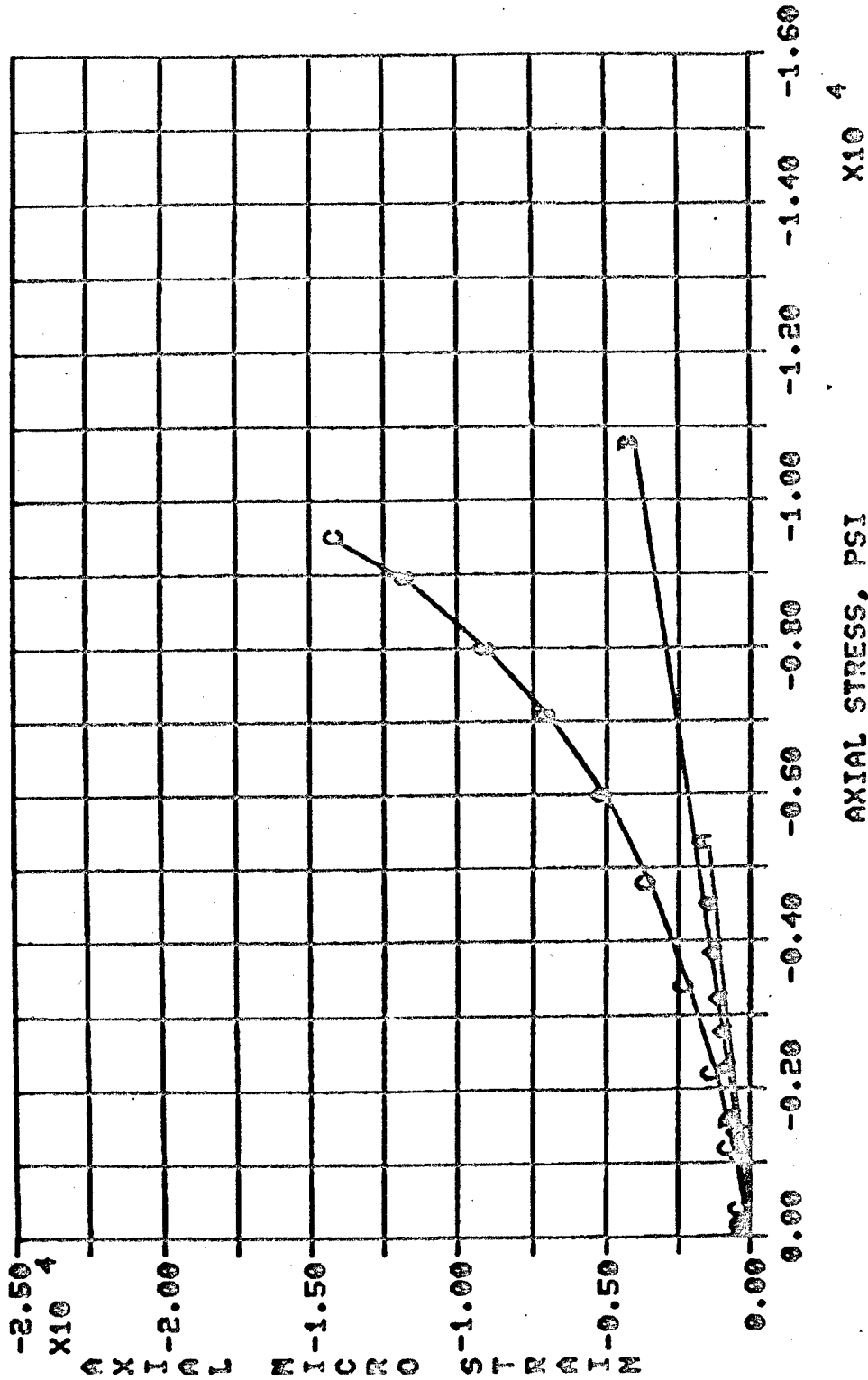


Figure 65 Tests 4-A, B, C. Layout #45° Axial Only  
 Axial Response, Rosette No. 4  
 A - Test 4-A  
 B - Test 4-B  
 C - Test 4-C

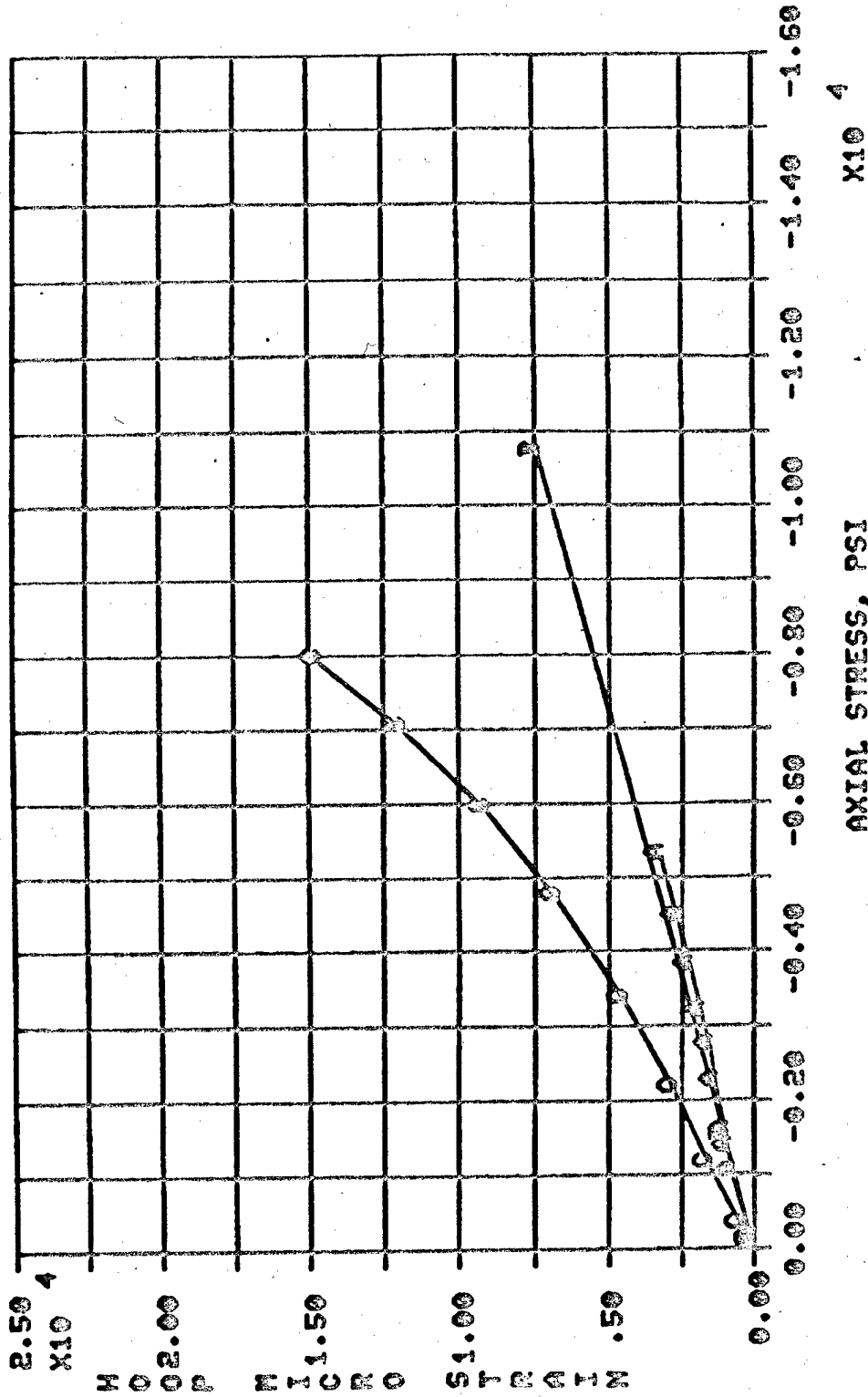


Figure 66 Tests 4-A, B, C. Layout  $\pm 45^\circ$  Axial Only  
 Hoop Response, Rosette No. 3  
 A - Test 4-A  
 B - Test 4-B  
 C - Test 4-C

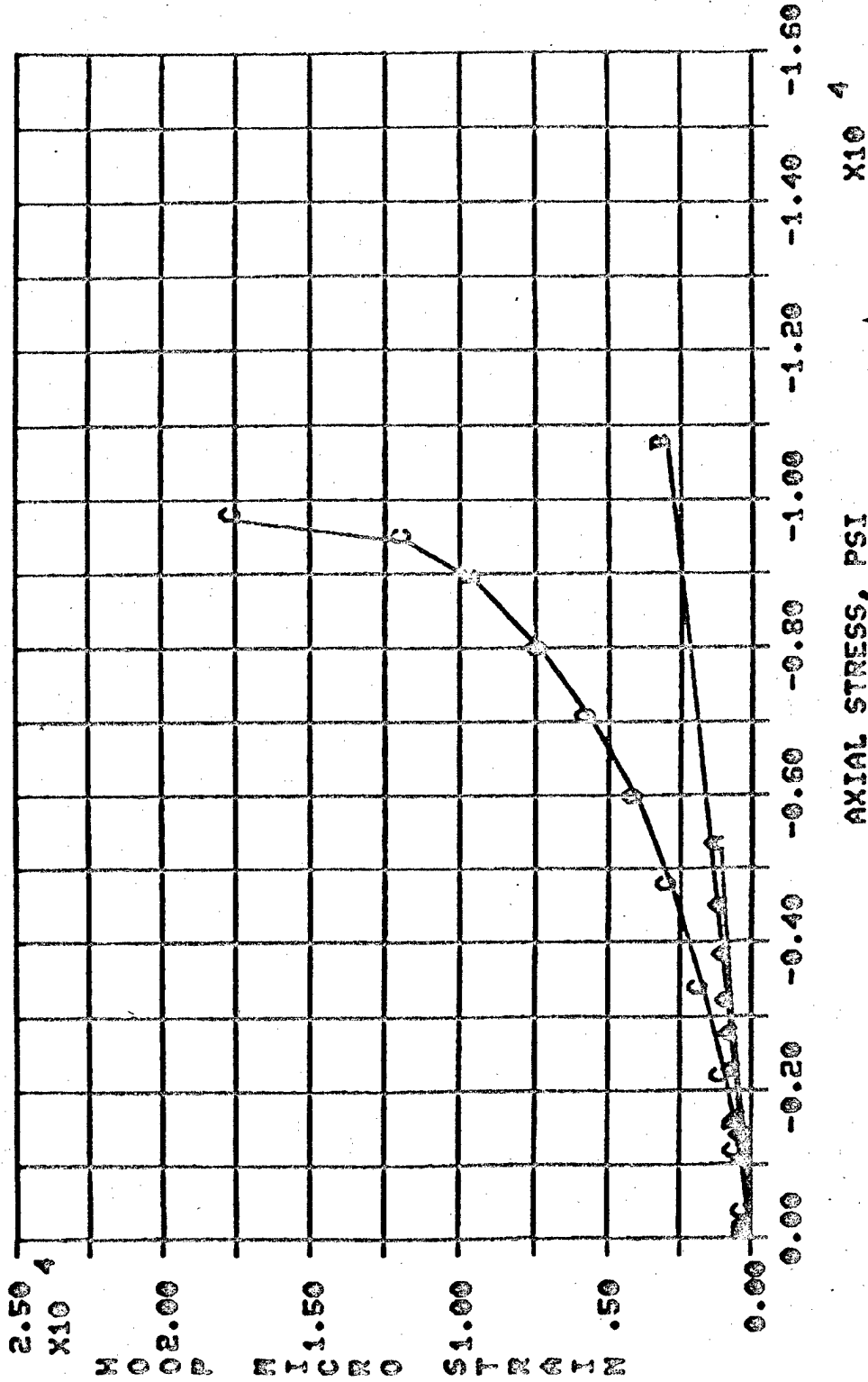


Figure 67 Tests 4-A, B, C. Layout  $\pm 45^\circ$  Axial Only  
 Hoop Response, Rosette No. 4  
 A - Test 4-A  
 B - Test 4-B  
 C - Test 4-C

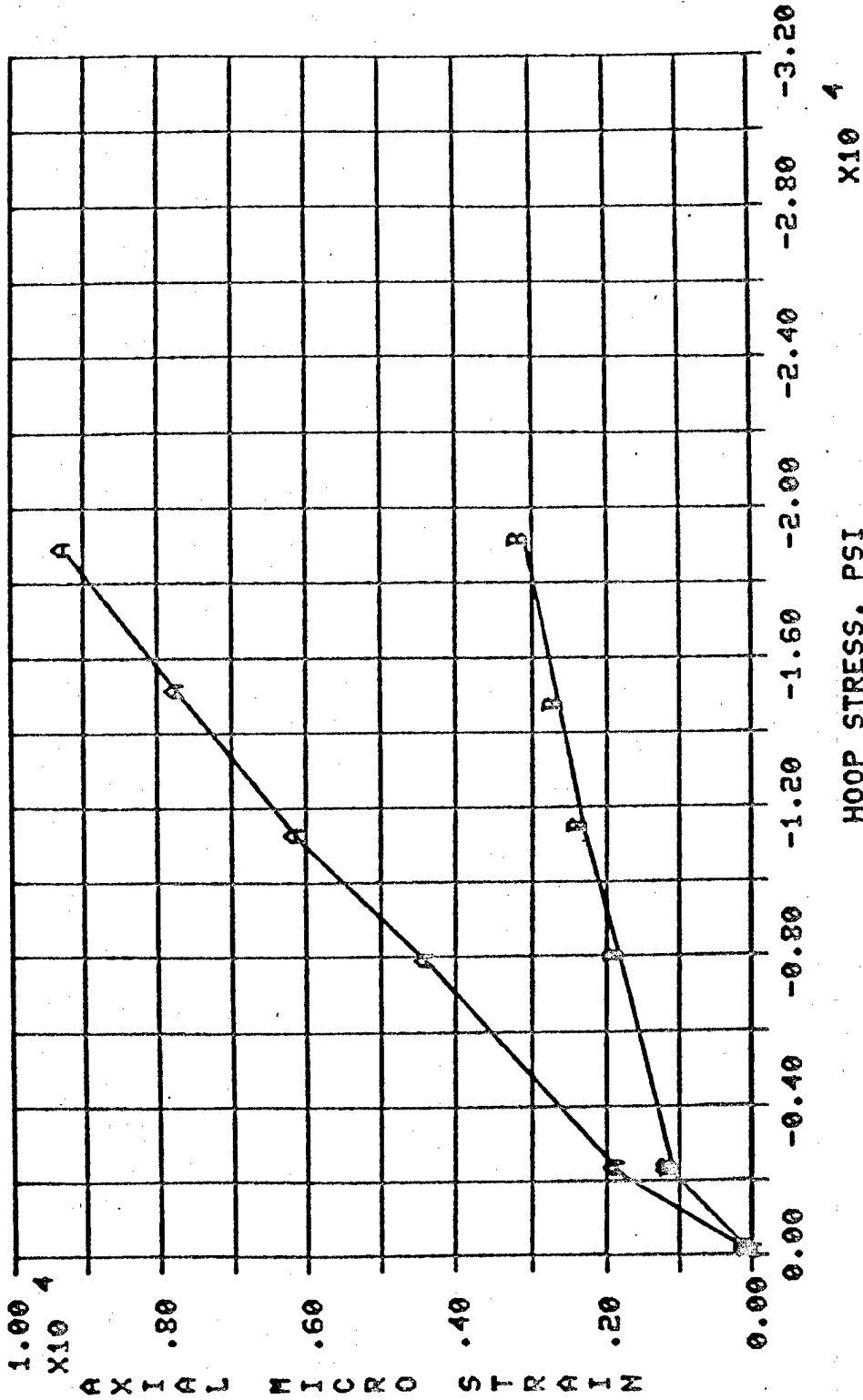


Figure 68 Test 5. Layout  $\pm 45^\circ$  Ext. Pressure  
Axial Response

A - Rosette No. 5  
B - Rosette No. 6

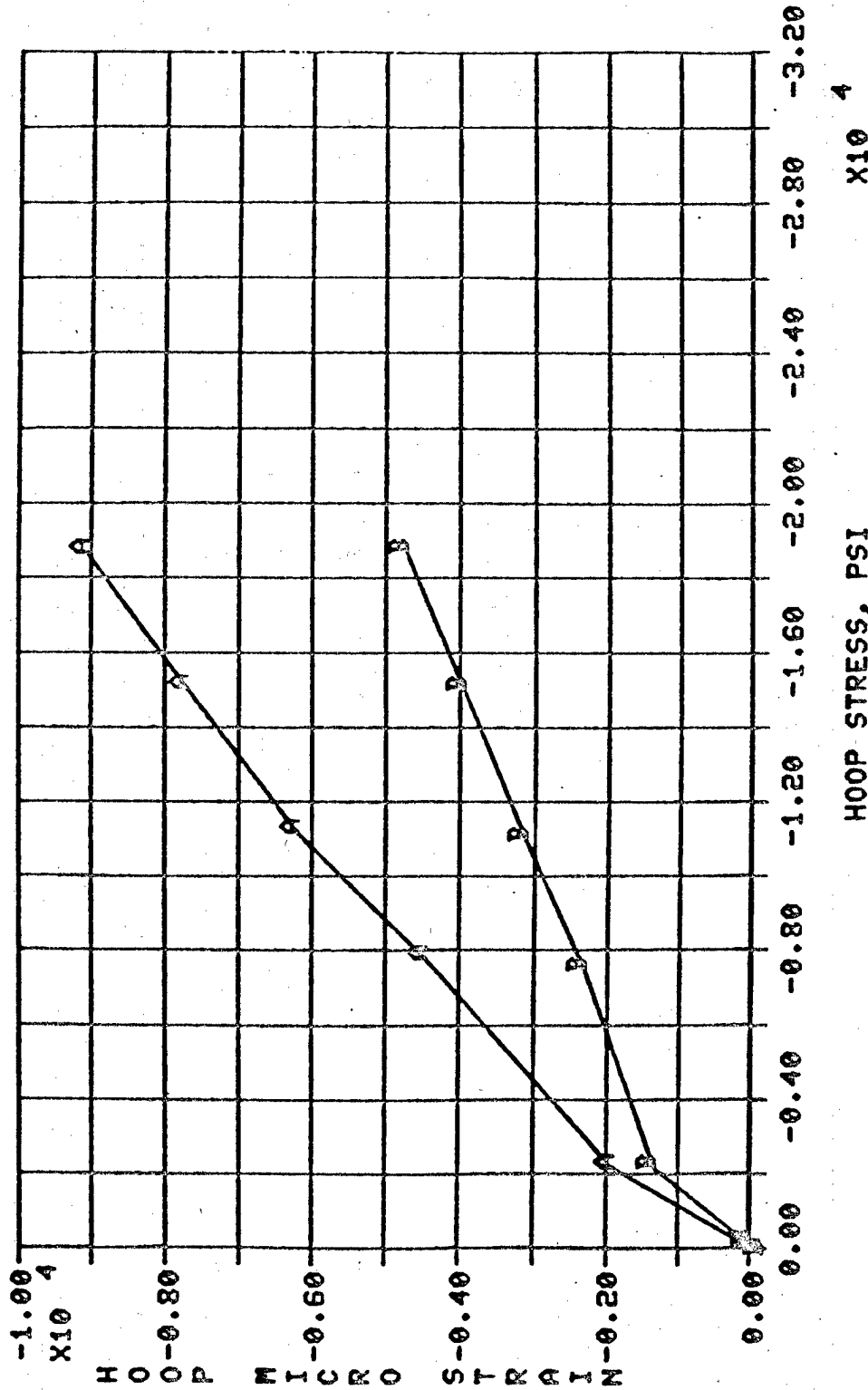


Figure 69 Test 5. Layout  $\pm 45^\circ$  Ext. Pressure  
 Hoop Response

A - Rosette No. 5  
 B - Rosette No. 6

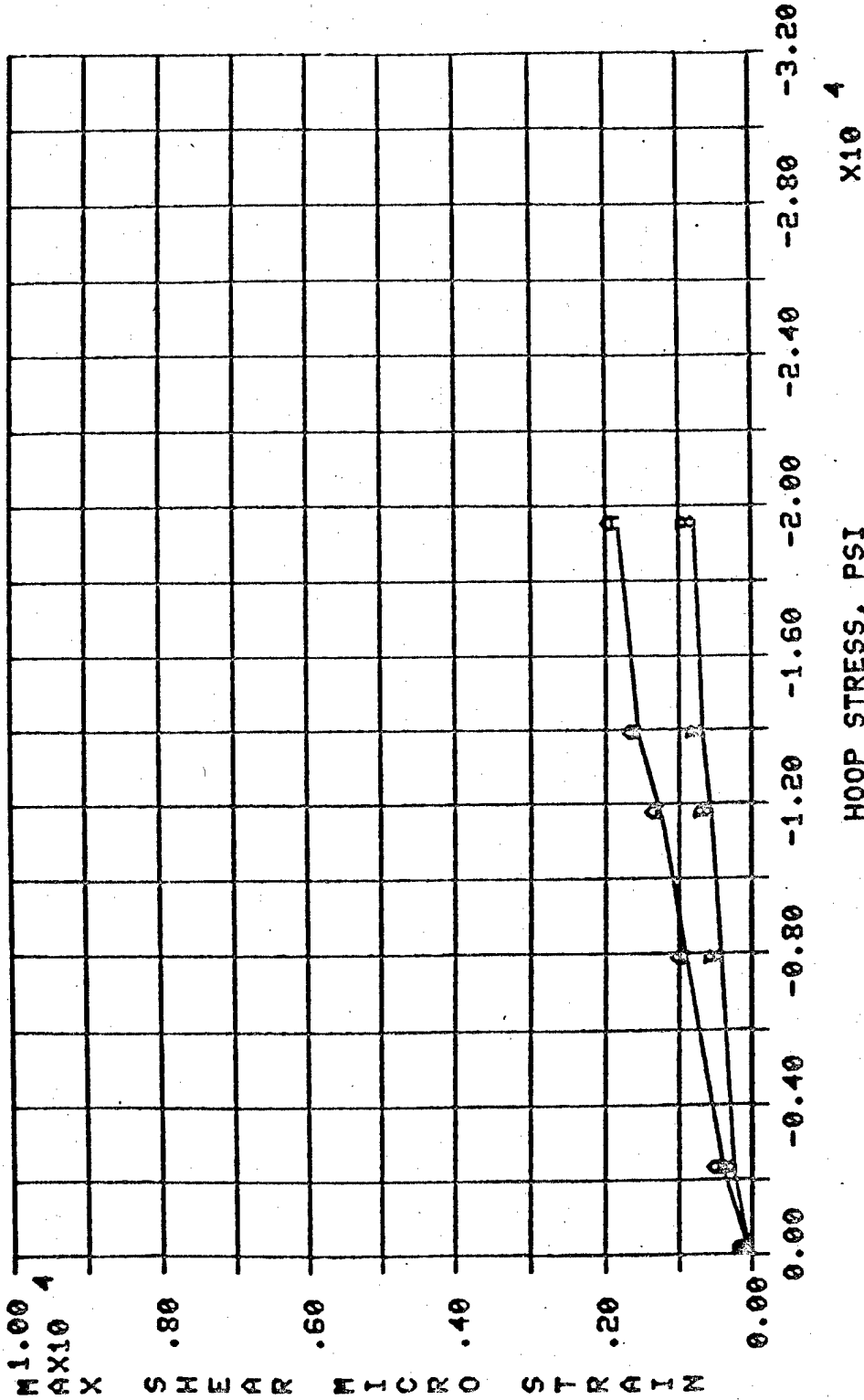


Figure 70 Test 5. Layout  $\pm 45^\circ$  Ext. Pressure  
 Max. Shear

A - Rosette No. 5  
 B - Rosette No. 6

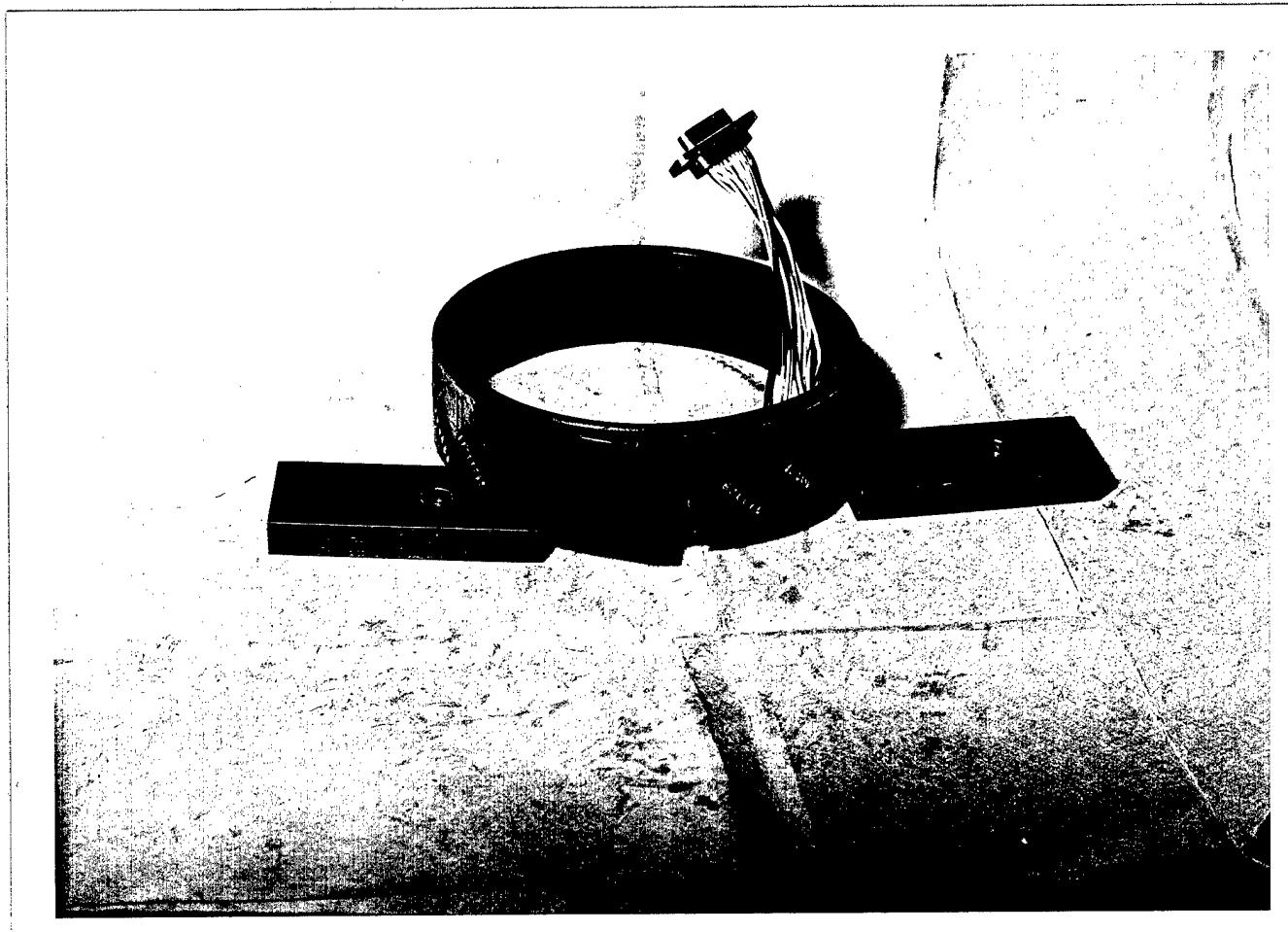


Figure 71 Test Specimen Used in Tests 4-A, 4-B, 4-C and 5 After Fracture from External Pressure. Ply Layup is  $\pm 45^\circ$ .

Both internal pressure and axial load were applied to the specimen for Test 6. The internal pressure was manually servoed to the axial load such that a pure shear condition existed in the specimen. Figure 72 is a plot of the hoop stress versus axial stress. The layup for this specimen was  $0^\circ/\pm 45^\circ/90^\circ$ . Figure 73 is a comparison plot of the axial strain versus axial stress for the rosettes located at the center of the specimen on the outside surface. Strains from Rosette Nos. 1 and 3 are in excellent agreement, and the strain in Rosette No. 2 is very close to these strains. Figure 74 is the axial response of the rosettes located at the edge of the specimen. The strains for these rosettes do not agree with each other. Also, these strains are two to four times higher than the strains recorded at the center of the specimen (see Figure 73). Figures 75, 76 and 77 are comparison plots of hoop strain versus hoop stress with the rosettes located at the center of the specimen on the outside surface, the inside and outside comparison rosettes and the edge rosettes, respectively. The gages at the center on the outside surface are in good agreement, as were the gages at the edge of the specimen. However, the gages recorded strains approximately twice as large as the center gages. The inside-outside comparison gages were in very poor agreement. The maximum shear strain plots for this test were uninterpretable and are not reproduced here. The final failure in Test 6, shown in Figure 78, was from a fracture running approximately half-way across the specimen at a  $45^\circ$  angle. The fracture then changed directions and propagated the remainder of the way across the specimen in an axial direction. The final fracture was accompanied by eight  $45^\circ$  partial fractures distributed around the specimen.

Test 7 was to be conducted such that hoop stress equaled axial stress. The loads were applied using external pressure and axial load. The specimen layup was  $0^\circ/\pm 45^\circ/90^\circ$ . Figure 79

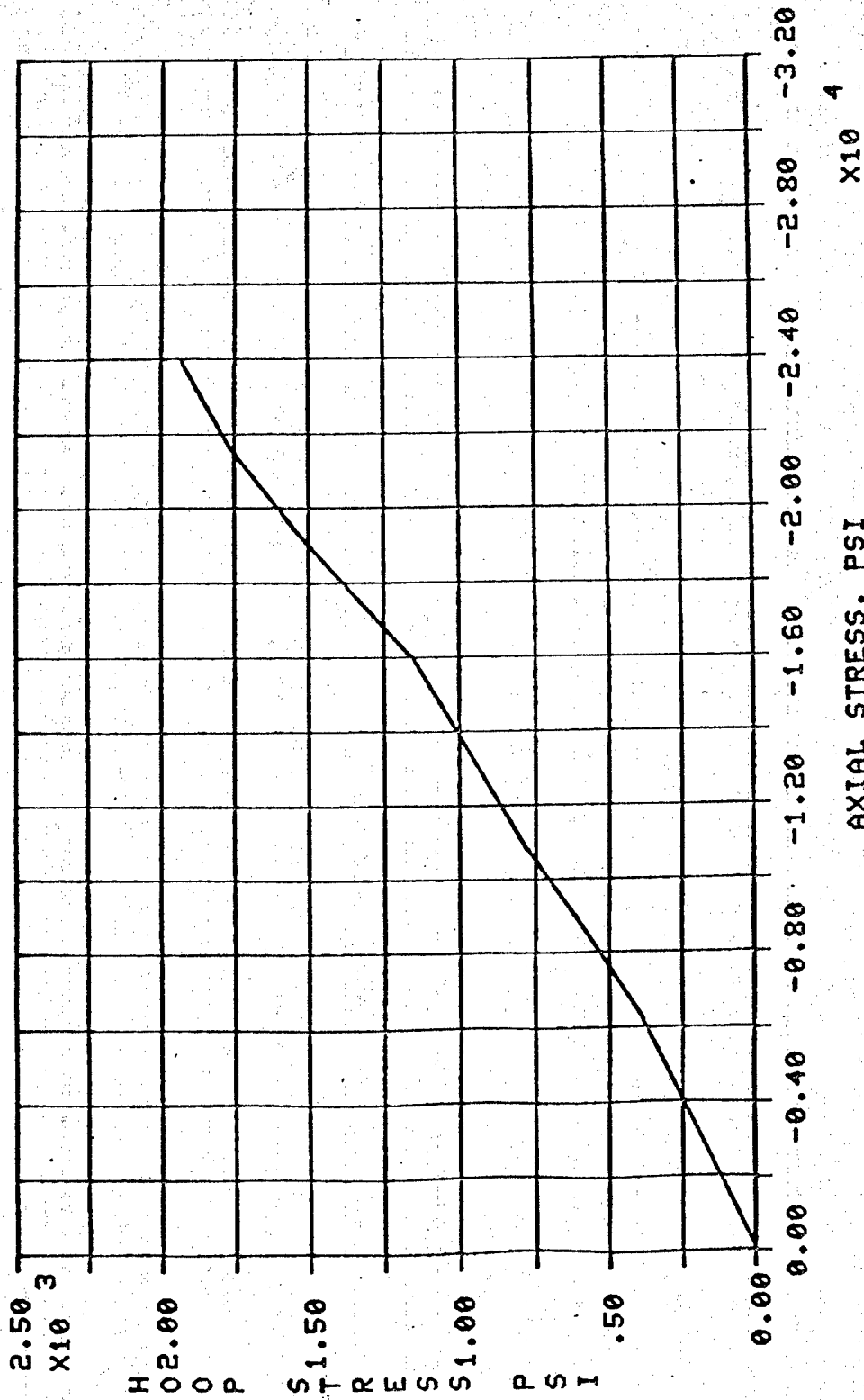


Figure 72 Hoop Stress Versus Axial Stress for  
Test 6

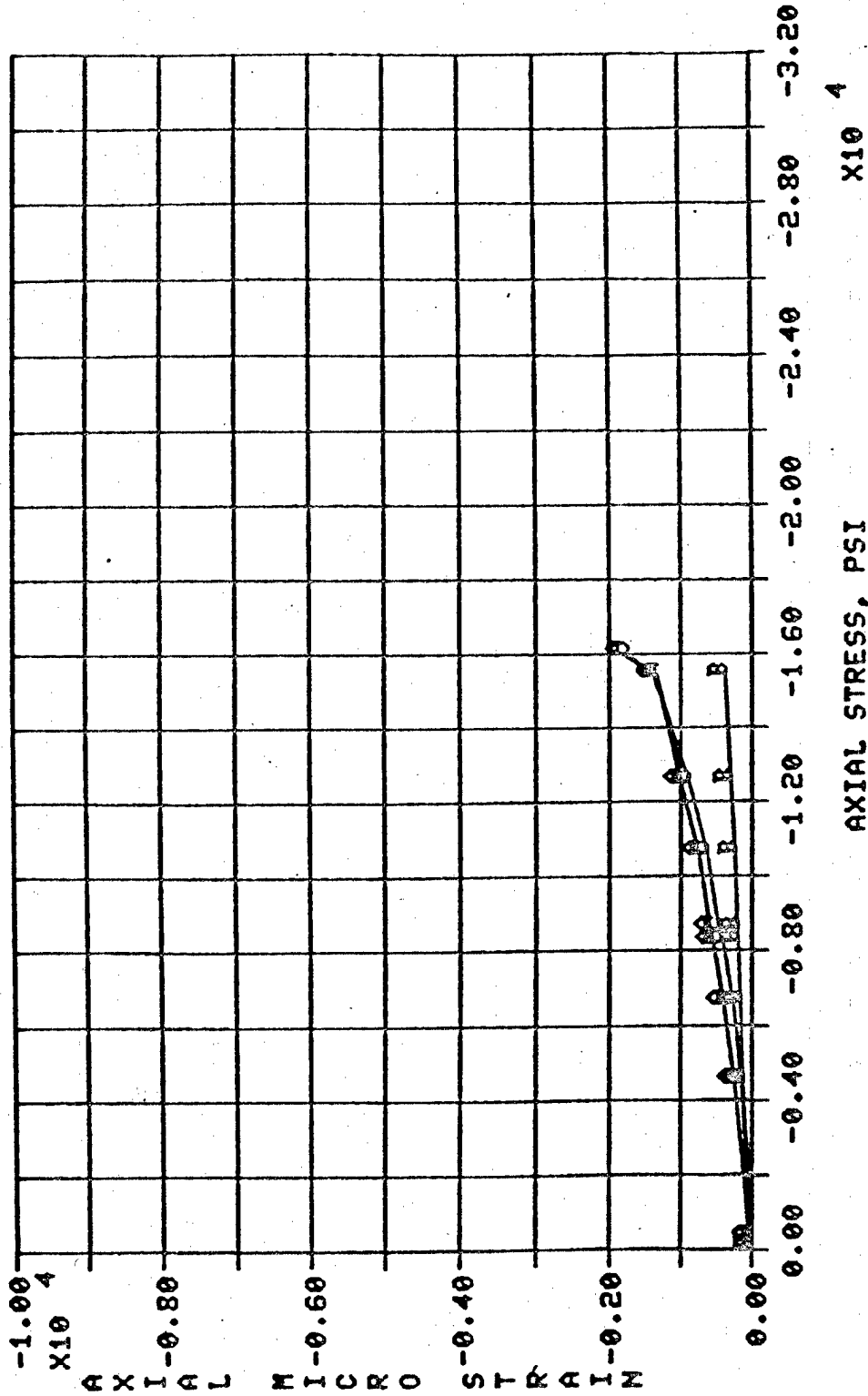


Figure 73 Test 6. Layout  $0^\circ/\pm 45^\circ/90^\circ$  Pure Shear Load  
 Axial Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3

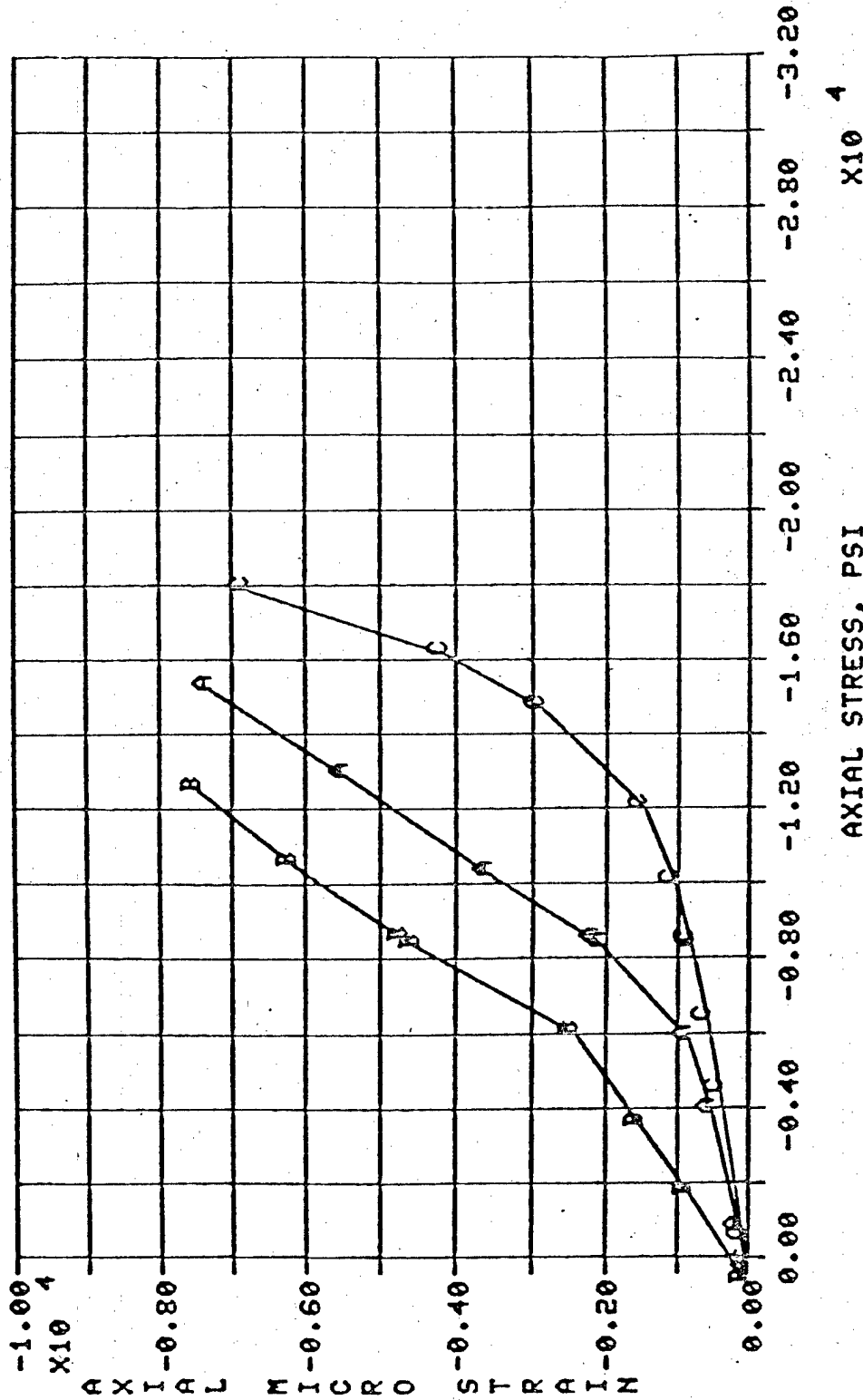


Figure 74 Test 6. Layout  $0^\circ/\pm 45^\circ/90^\circ$  Pure Shear Load  
 Axial Response, Edge Rosettes

- A - Rosette No. 6
- B - Rosette No. 7
- C - Rosette No. 8

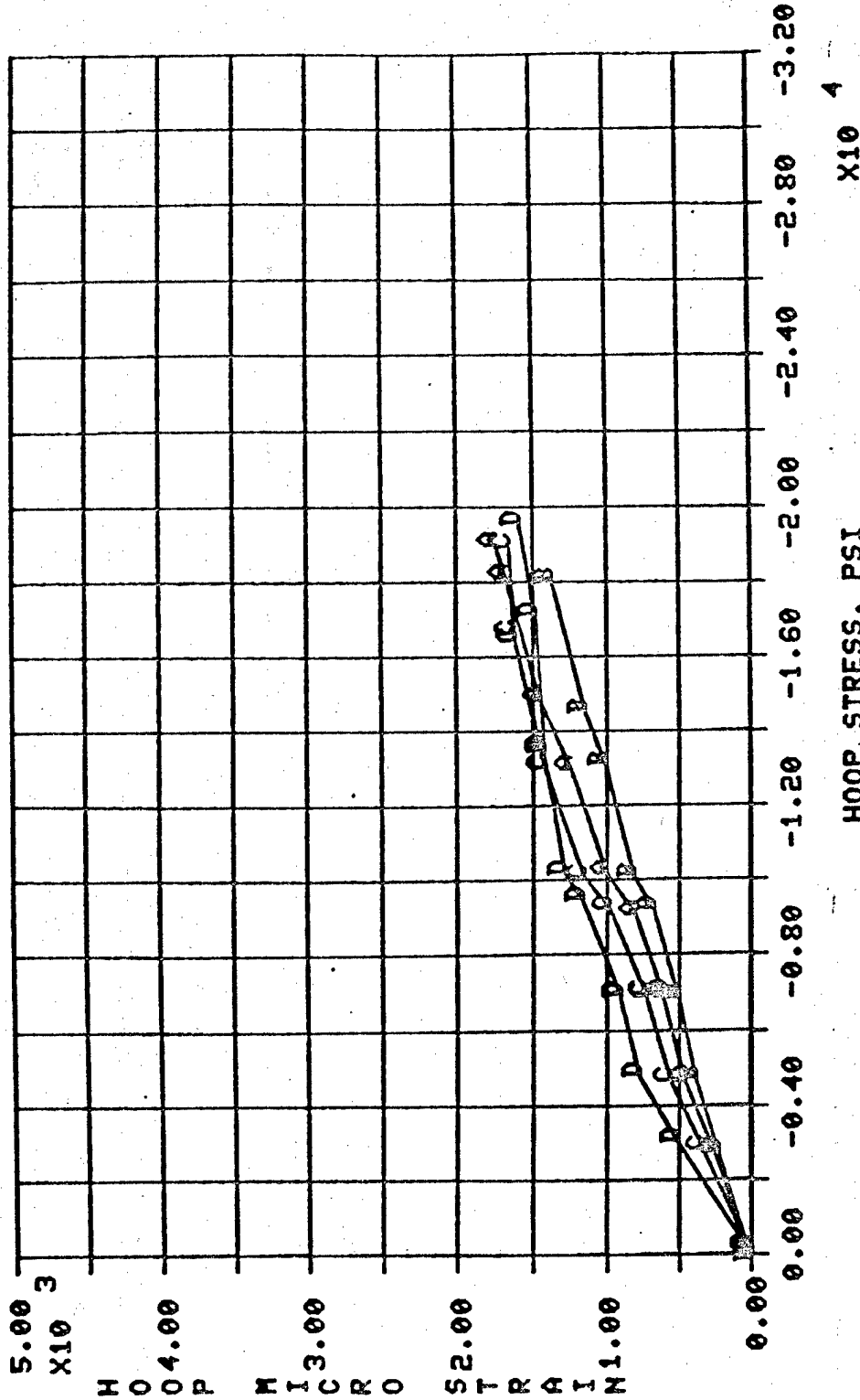


Figure 75 Test 6. Layout  $0^\circ/\pm 45^\circ/90^\circ$  Pure Shear Load  
 Hoop Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

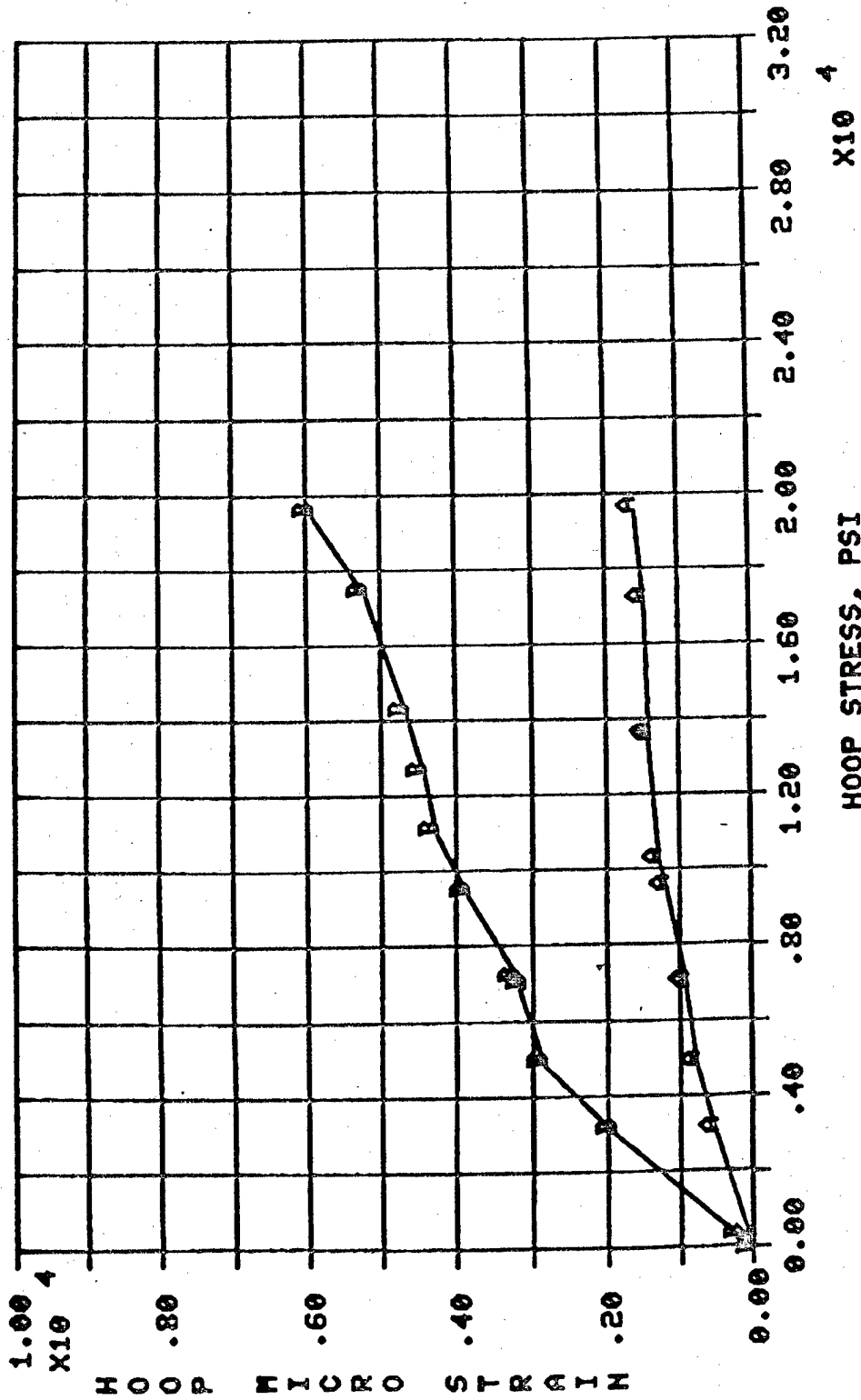


Figure 76 Test 6. Layout 0°/+45°/90° Pure Shear Load  
 Hoop Response, Inside/Outside Rosettes  
 Least Squares Fit

A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

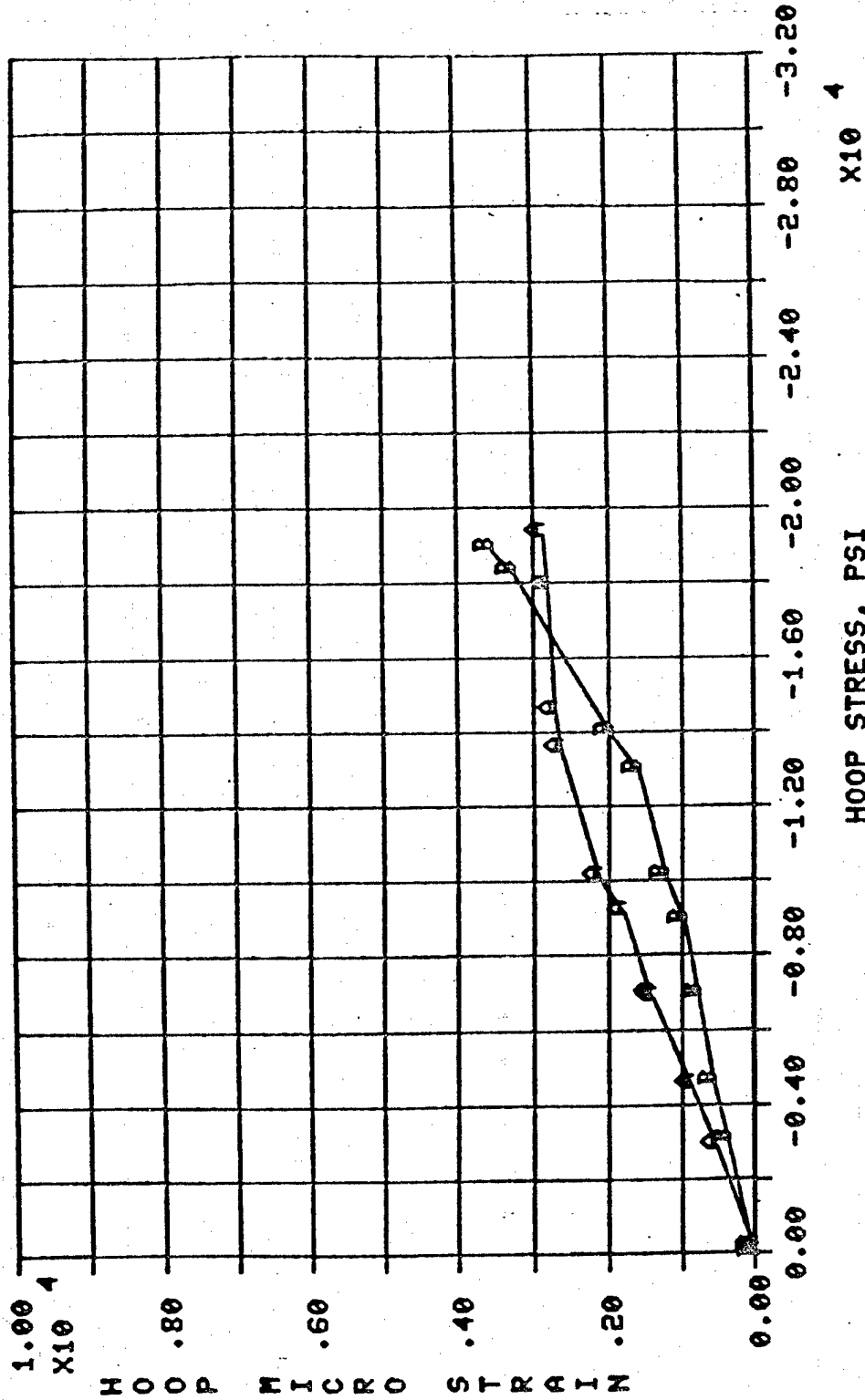


Figure 77 Test 6. Layup 0°/±45°/90° Shear Load  
 Hoop Response, Edge Rosettes

A - Rosette No. 7  
 B - Rosette No. 8

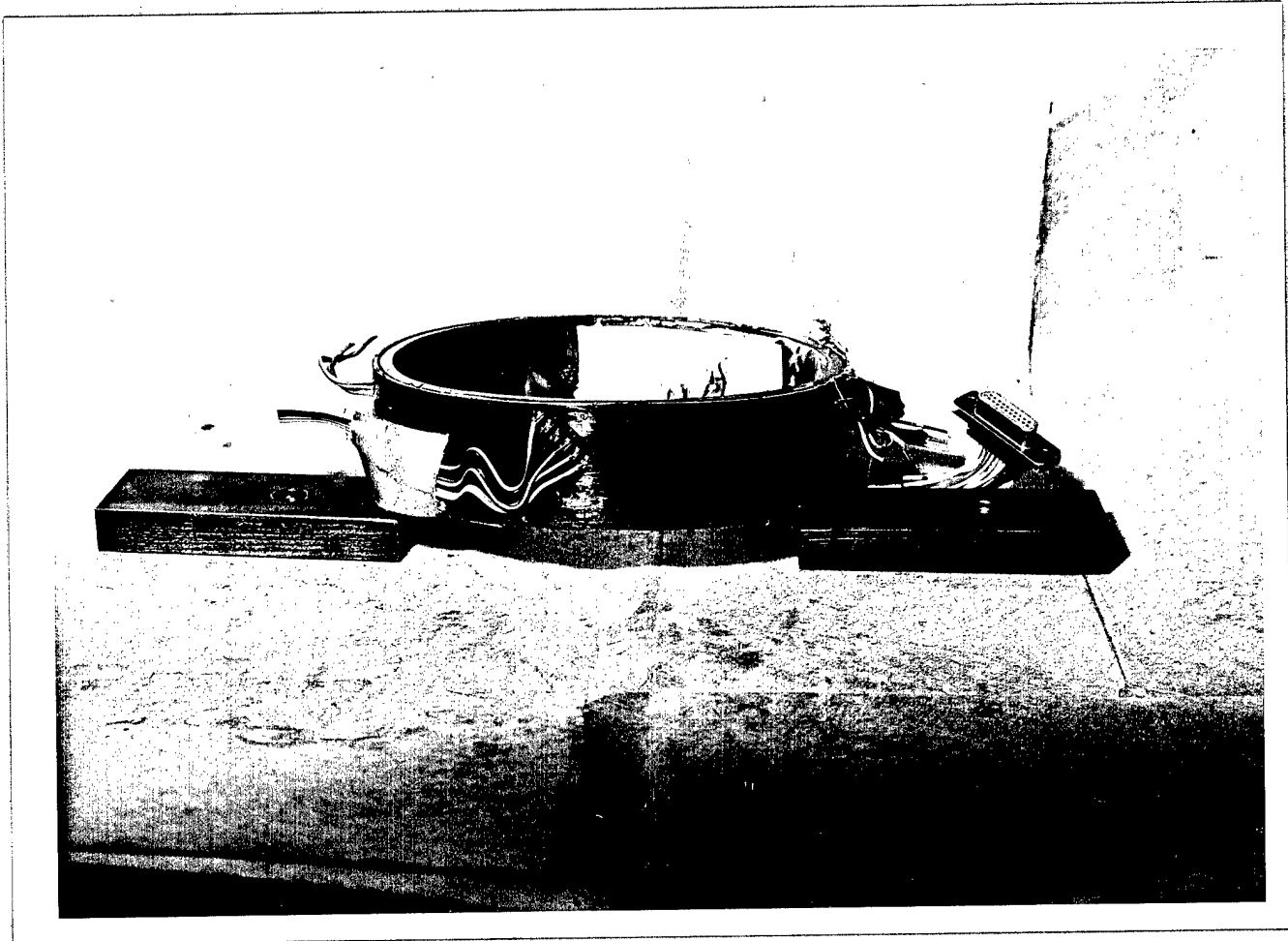


Figure 78 Test Specimen No. 6 After Failure from Internal Pressure and Axial Load. Stress Conditions were Equivalent to Pure Shear. Ply Layup is  $0^\circ/\pm 45^\circ/90^\circ$ .

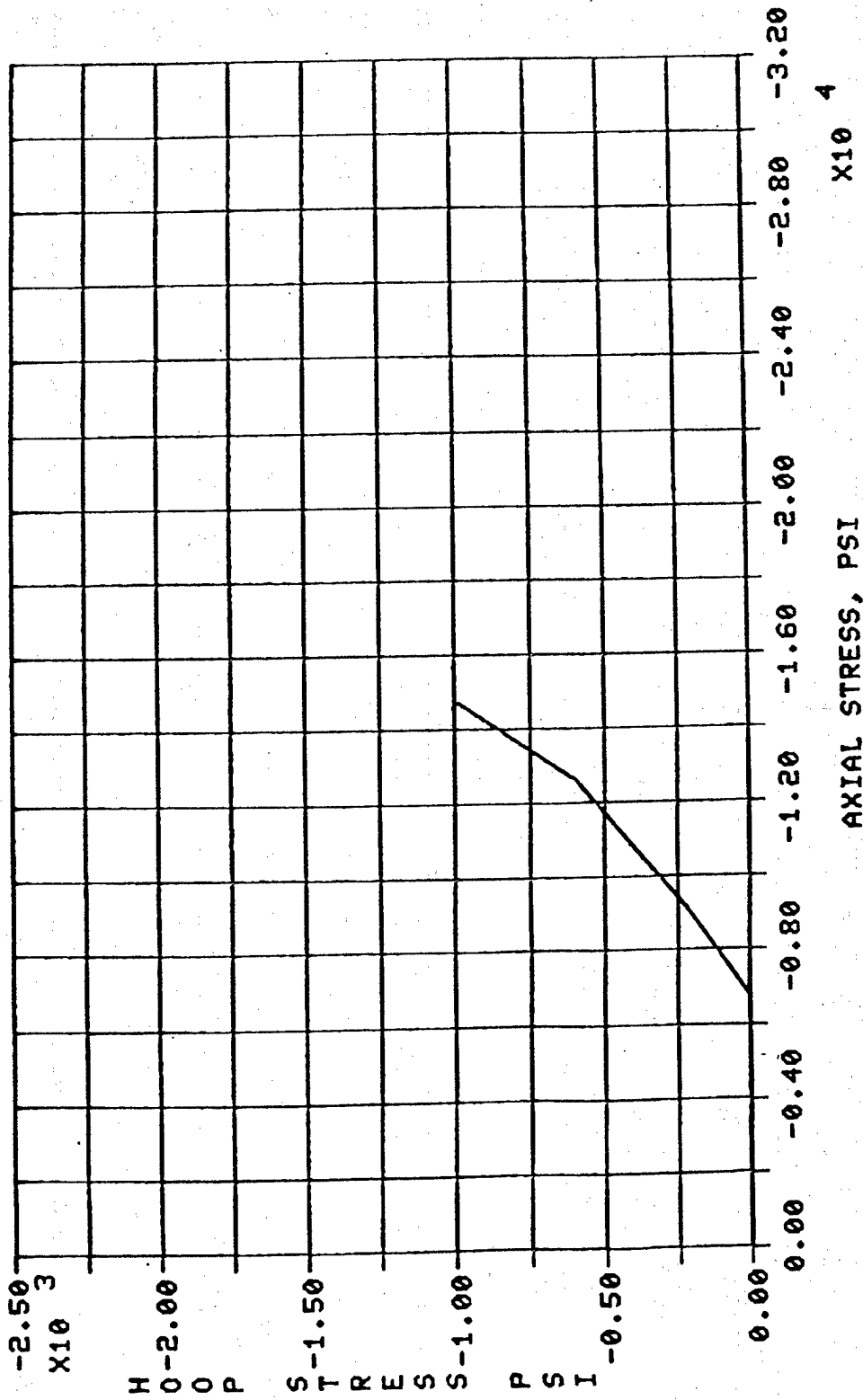


Figure 79 Hoop Stress Versus Axial Stress for Test 7

is a plot of the hoop stress versus axial stress. An axial stress of 7000 psi compression was applied to the specimen before any external pressure was applied. The external pressure was manually servoed to the axial load. In the future, this type of test (test with a loading manually servoed) should be conducted much slower to allow adequate reaction time. Strain gage output during Test 7 was erratic. As the specimen could not be observed through the external pressure collet, it is not known with certainty why the erratic strains arose. Figures 80 through 86 are the comparison strain plots for this test. Very poor agreement was obtained between the gages located along the outside center of the specimen; however, the gages between the inside and outside surfaces produced axial results in agreement. The remaining results from this test indicate that hourglassing or buckling could have been taking place. Figure 87 is a photograph of the specimen used in Test 7 after failure occurred.

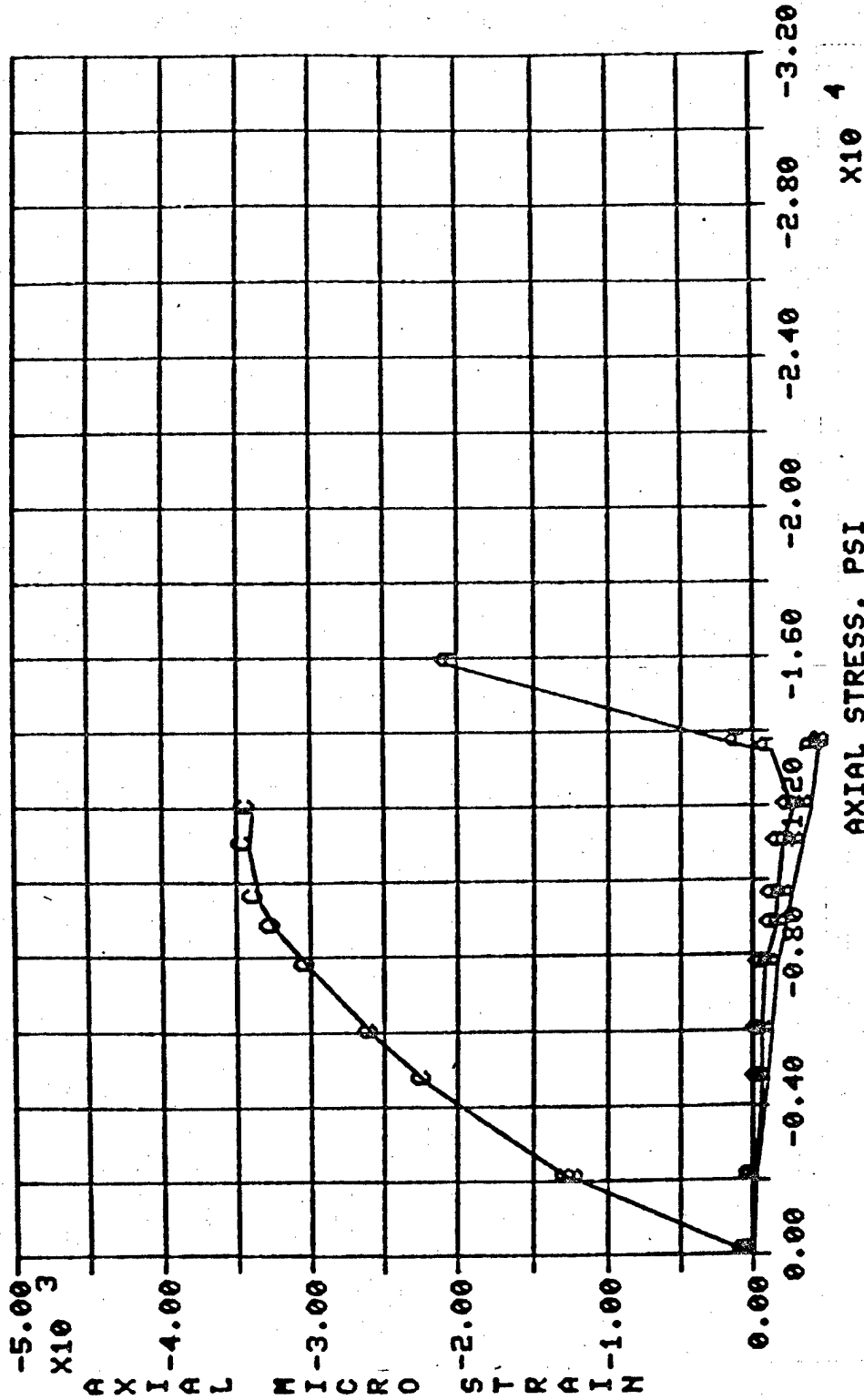


Figure 80 Test 7. Layout 0°/±45°/90° Axial & Ext. Pr.  
 Axial Response, Outside Rosettes  
 A - Rosette No. 1  
 B - Rosette No. 2  
 C - Rosette No. 3

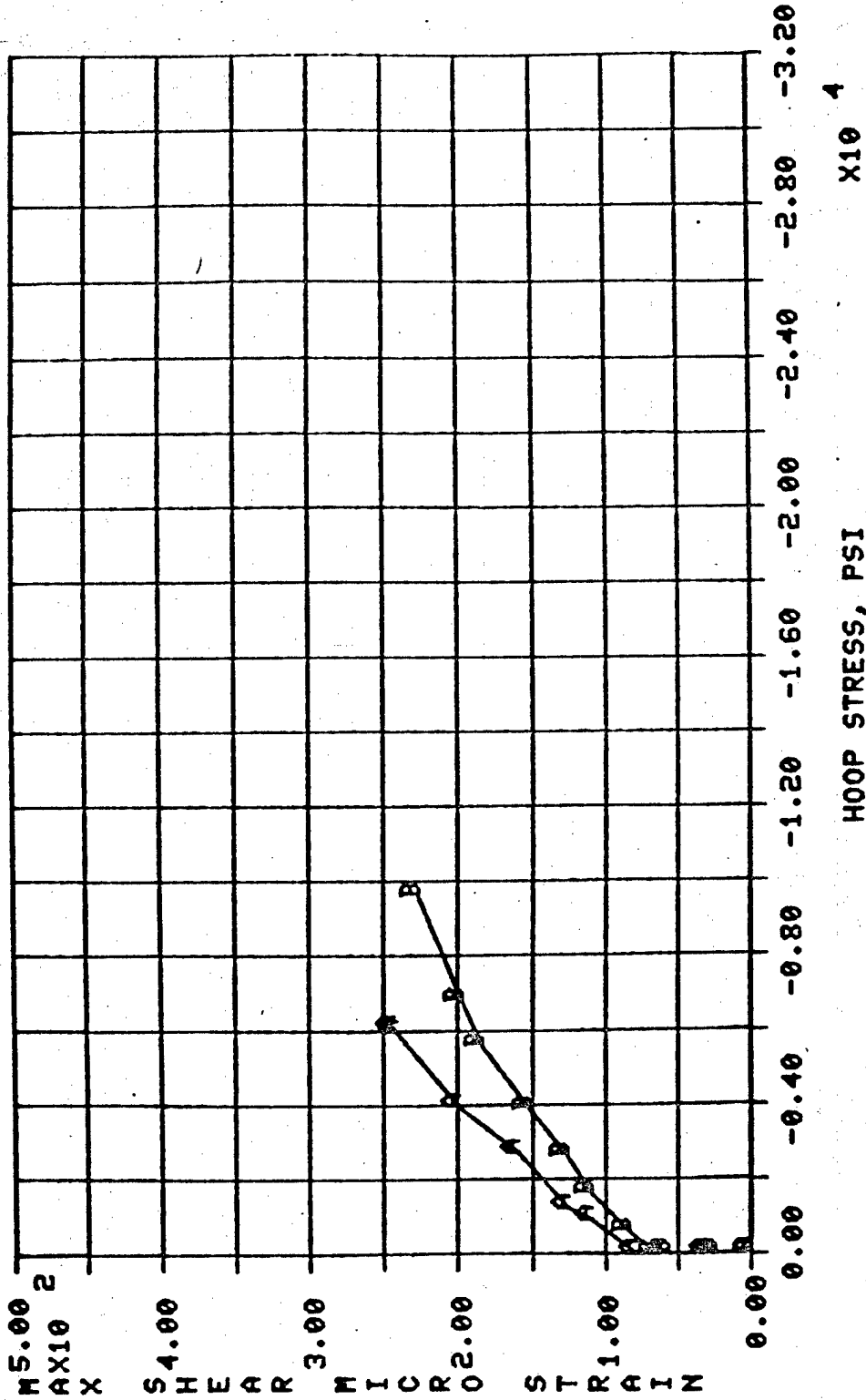


Figure 81 Test 7. Layout 0°/±45°/90° Axial & Ext. Pr.  
 Max. Shear, Outside Rosettes  
 A - Rosette No. 1  
 B - Rosette No. 2

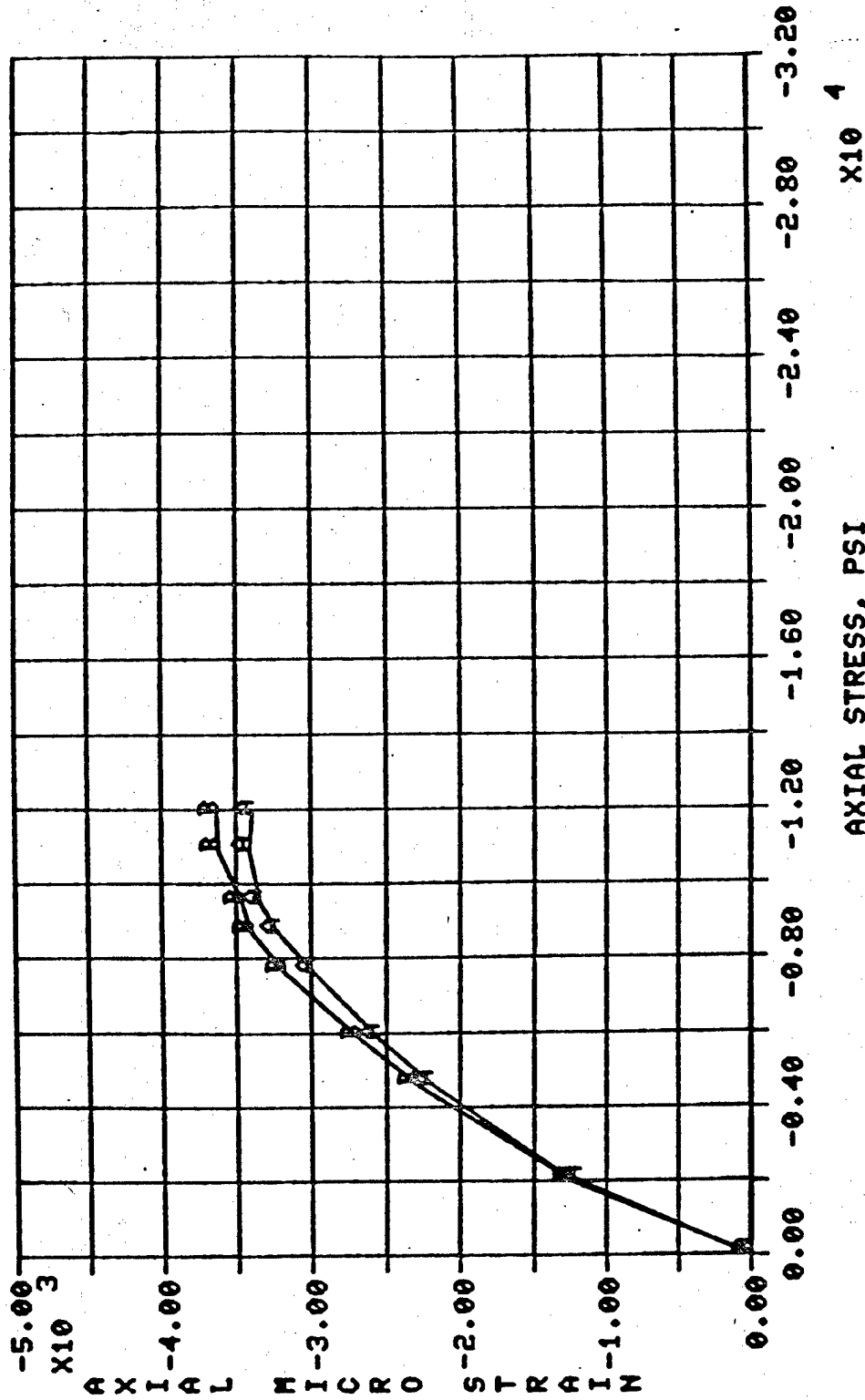


Figure 82 Test 7. Layout 0°/±45°/90° Axial & Ext. Pr.  
 Axial Response, Inside/Outside Rosettes  
 A - Rosette No. 4 (outside)  
 B - Rosette No. 5 (inside)

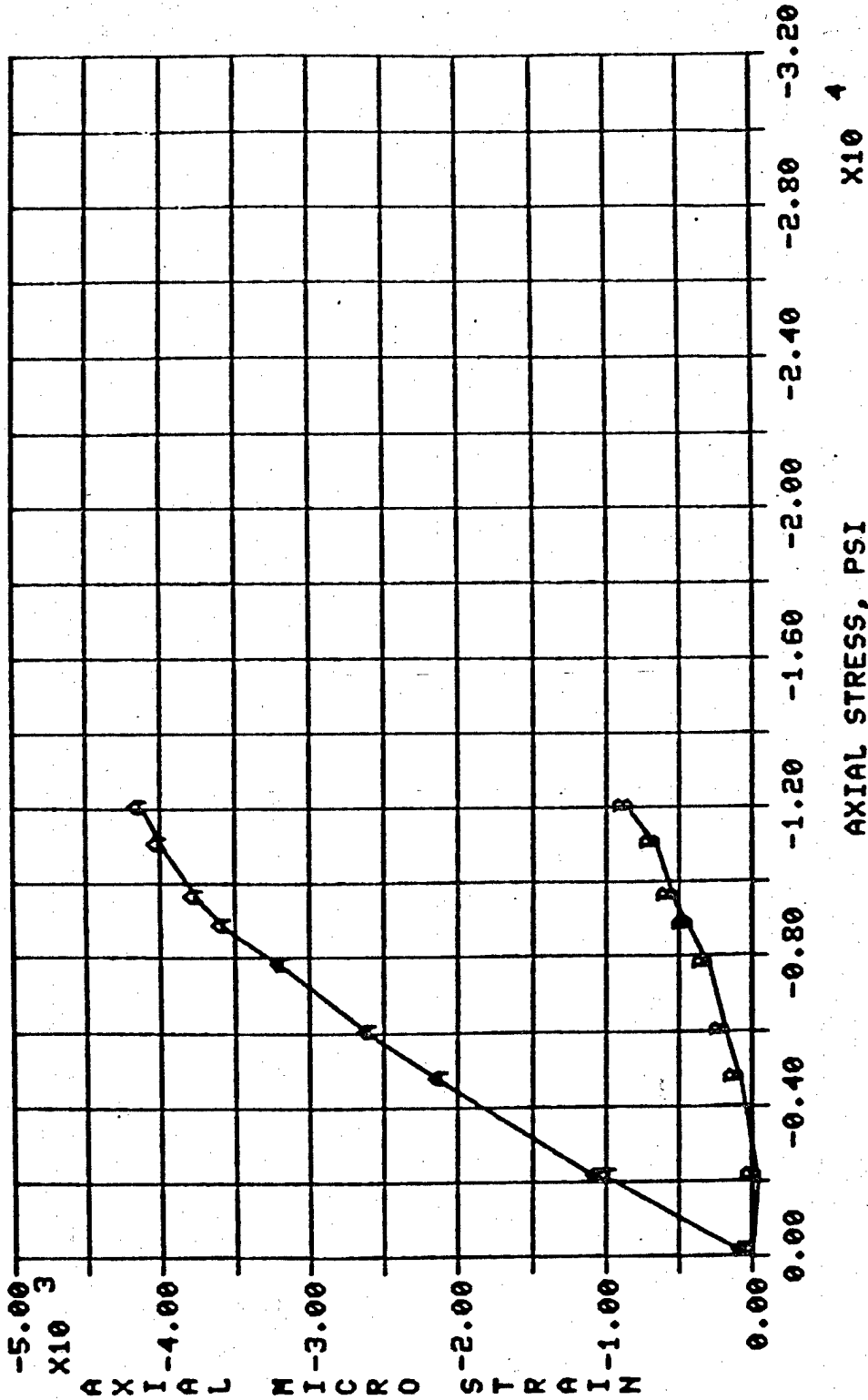


Figure 83 Test 7. Layout 0°/±45°/90° Axial & Ext. Pr.  
 Axial Response, Edge Rosettes  
 A - Rosette No. 7  
 B - Rosette No. 8

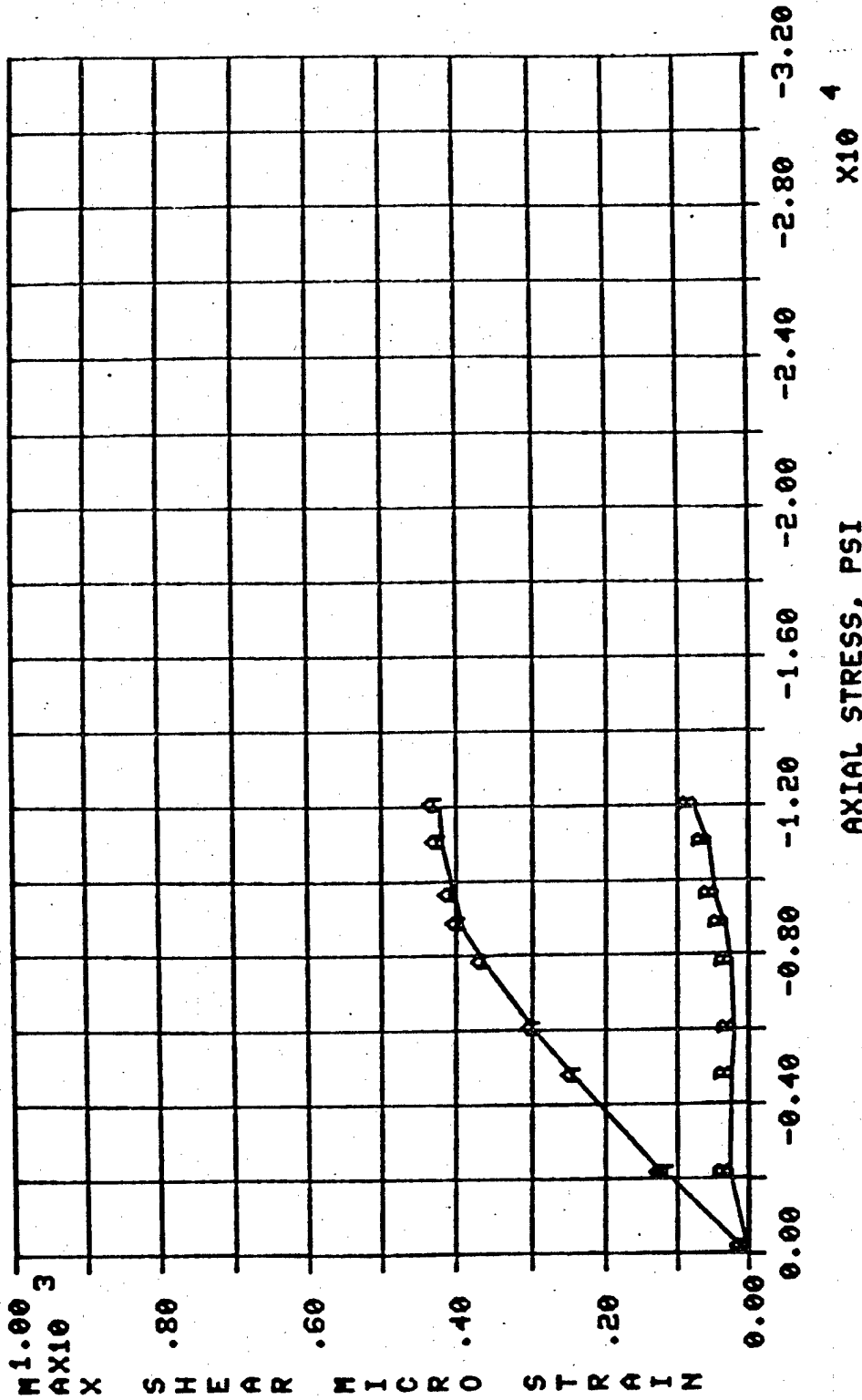


Figure 84 Test 7. Layout  $0^\circ/\pm 45^\circ/90^\circ$  Axial & Ext. Pr.  
 Max. Shear, Edge Rosettes  
 A - Rosette No. 7  
 B - Rosette No. 8

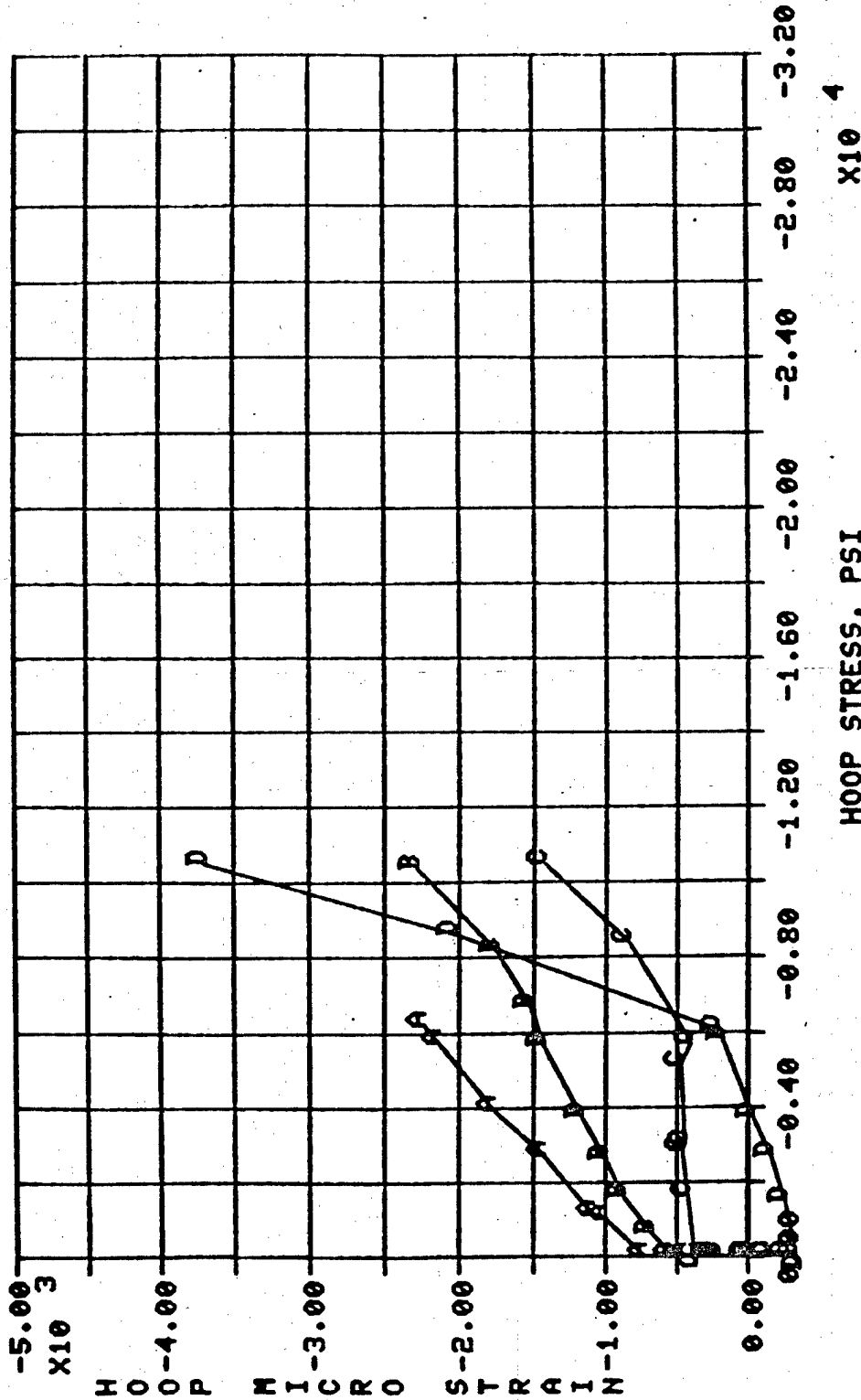


Figure 85 Test 7. Layout  $0^\circ/\pm 45^\circ/90^\circ$  Axial & Ext. Pr.  
 Hoop Response, Outside Rosettes

- A - Rosette No. 1
- B - Rosette No. 2
- C - Rosette No. 3
- D - Rosette No. 4

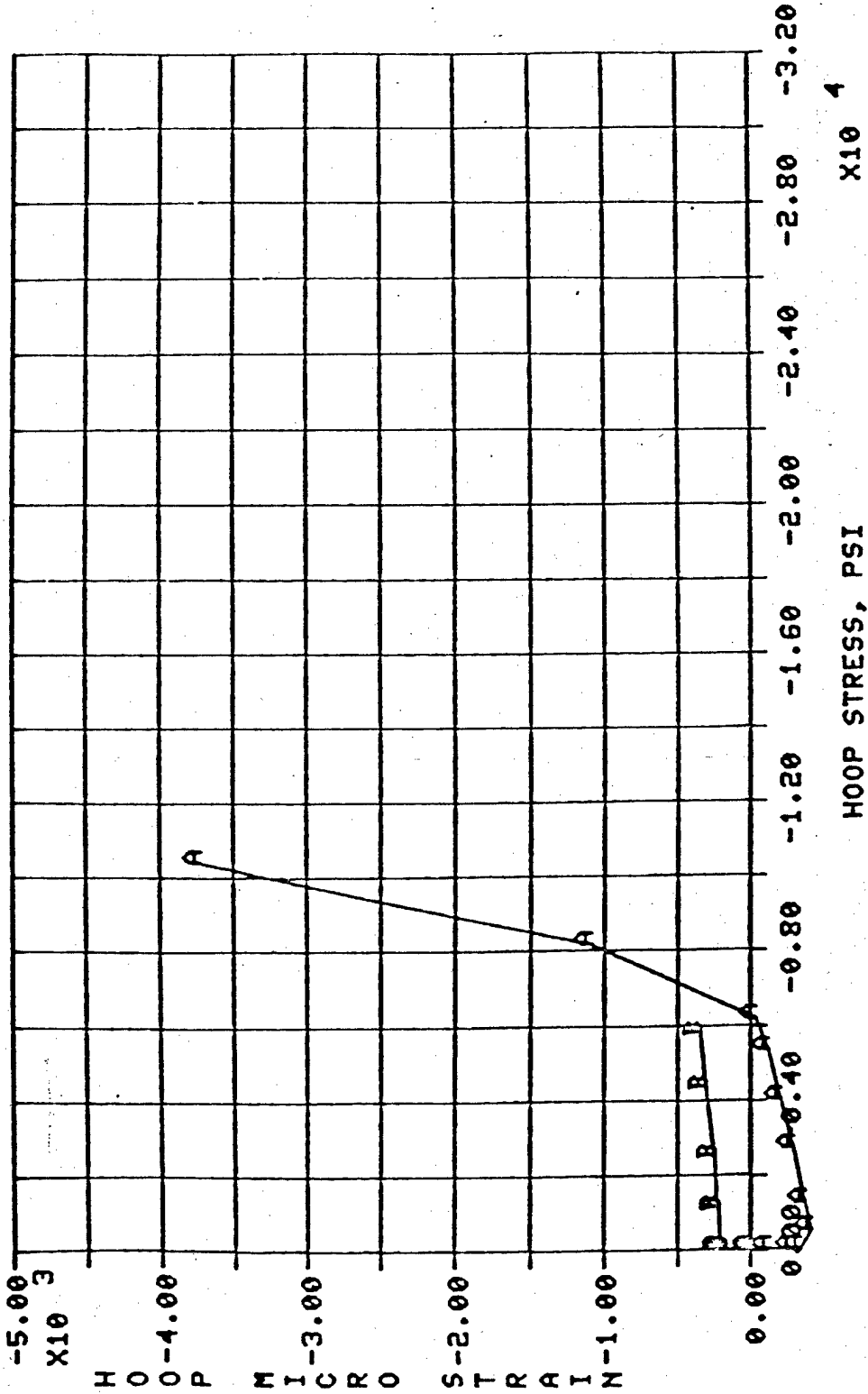


Figure 86 Test 7. Layout 0°/±45°/90° Axial & Ext. Pr.  
 Hoop Response, Edge Rosettes  
 A - Rosette No. 7  
 B - Rosette No. 8

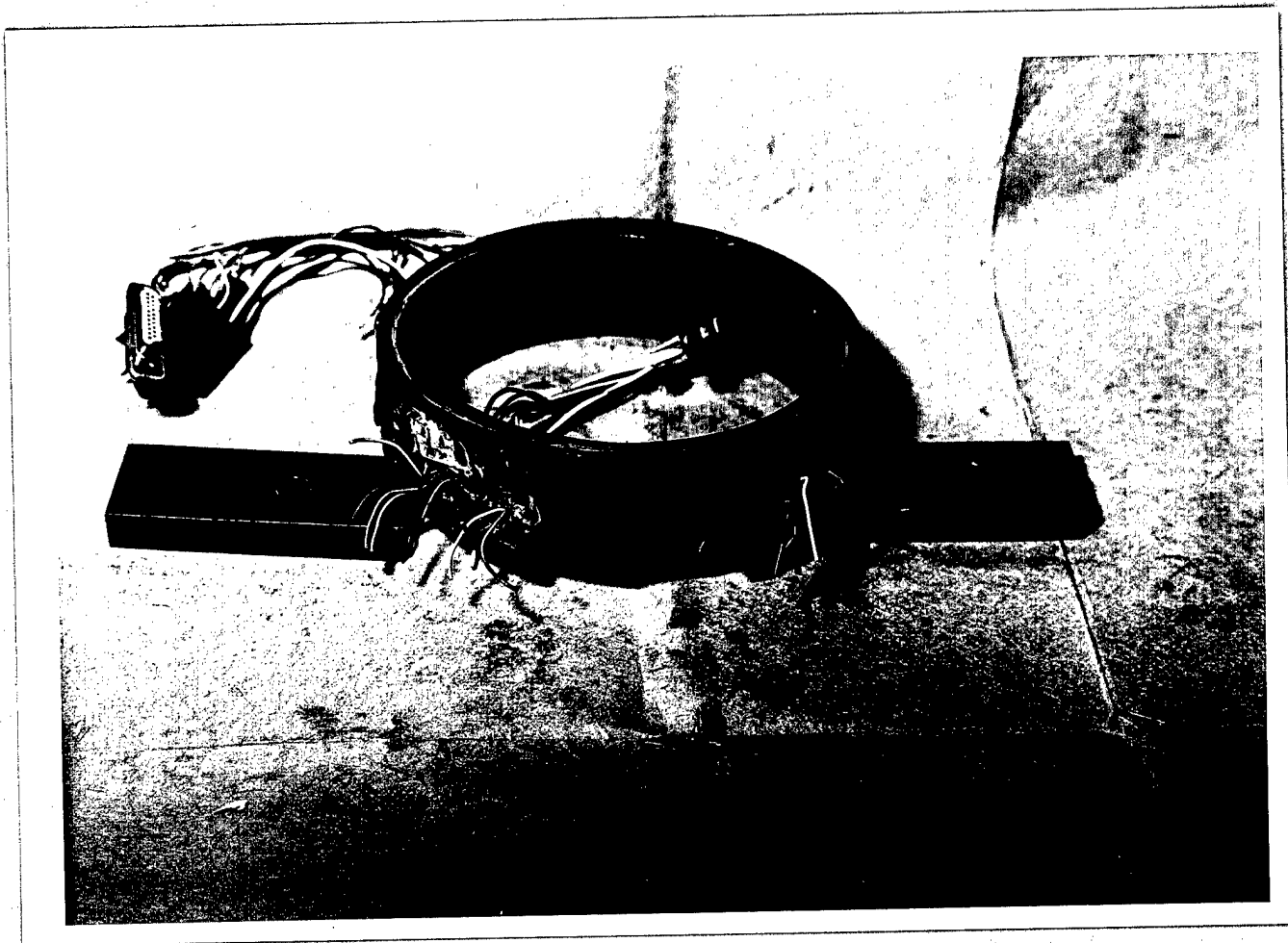


Figure 87 Test Specimen No. 7 After Failure from Axial Load and External Pressure. Stress Conditions Were Such That Axial Stress Equaled Hoop Stress. Ply Layup is  $0^\circ/\pm 45^\circ/90^\circ$ .

V. CONCLUSIONS

Based on the testing, the test technique has been shown to be promising as a simple test system for determining the biaxial properties of materials. In the early elastic regime, elastic properties may be determined for compression-compression, as well as for tension-compression. The fixture has demonstrated its ability to apply axial compression, internal or external pressure, or a combination of loadings. It appears that the solid lubricant system works well in retaining the pressure while allowing the ends to be relatively free of constraint.

Although the fixture was originally designed for biaxial tests, it has been shown to be capable of rupturing high Poisson's ratio tubes under internal pressure. This is possible as the platens may be advanced as the specimen length decreases so that no gap appears and oil pressure is maintained. Prior to the development of this fixture, free end constraint internal pressure tests on high Poisson's ratio tubes could not be performed.

The tests to date have only demonstrated that the testing technique is very promising. Additional tests need to be performed to improve the fixture and demonstrate repeatability of the results on identical specimens. Different length specimens, such as .5 inches and 2.0 inches, should be tested.

APPENDIX A

LISTING OF  
COMPUTER PROGRAM  
"STRAINS"

COMPUTER PROGRAM "STRAIN"

As part of the effort reported here, a computer program was developed for processing strain gage data. The program is specifically tailored to the Sun System used by Anamet for monitoring and digitizing strain gage data readings. It is presently running on Anamet's PDP 11/34 under RSX-11M, in an interactive mode. All the plots reproduced in this report were generated by the computer on a Tektronix 4014 display screen.

STRAIN operates in two phases. First, a raw data file, which has been transferred directly from the Sun System to disk, is read and checked for format errors and for overload or open circuit conditions. The information is sorted by channels and stored in a binary disk file. The user is asked to identify each channel as either a load channel or a strain channel. For strain channels, the rosette number and the leg of the rosette are requested. Raw data files may consist of one or more test runs, each with different assignments of data channels. Once the binary file has been established, the second phase may be executed repeatedly to obtain plots and/or print-outs of reduced data.

In the second phase, the user is asked to supply the constants required to convert load data to stresses, thus making the program independent of the geometry of the specimen. Two load channels are provided for: an axial force channel and a pressure channel. Eight rosettes are allowed. For each plot to be generated, the user may choose to plot either stresses or strains on either axis. These may be direct stresses and strains, or principal stresses and strains, calculated by the program. As many as eight curves may be drawn on a single plot, with the user choosing a different rosette for each curve, and if the data file contains multiple runs, the curves may be selected from different runs. The user is also given the option to print the data that is plotted. The values plotted on the vertical axis are interpolated to agree with the times corresponding to the values on the horizontal axis.

```

0001 PROGRAM STRAIN
C
C PROGRAM TO DIGEST AND PLOT DATA FROM SUN SYSTEM
COMMON/MISC/NRUN, TLD(10,2), TDIR(10,3), JOBIII(60)
BYTE TLD, TDIR, JOBIII
COMMON/CONTROL/REPEAT, JPLI(2)
LOGICAL REPEAT
COMMON/BINARY/ZSTUFF(19932)
BYTE ZSTUFF, FNAME(30)
EQUIVALENCE (ZSTUFF, FNAME)
COMMON/SLD/SL(3,2,2)
LOGICAL WANT, NEW
DATA LSTUFF/19932/
CALL ERASE
CALL CLEAR(SL,24)
CALL DISPLAY
1('ANAMEI SUN SYSTEM STRAIN GAGE DATA REDUCTION & PLOTTING PROGRAM')
REPEAT=.FALSE.
CALL DISPLAY('NOTE: TO SELECT DEFAULT INPUT VALUES, STRIKE RETURN')
CALL PAUSE
NEW=.NOT.WANT
1('HAS A BINARY FILE ALREADY BEEN CREATED FOR THIS JOB')
IF (NEW)
1CALL ASSIGN(1, FNAME, ISREAD('RAW DATA FILE NAME', FNAME, 3, 30))
CALL ASSIGN(2, FNAME, ISREAD('BINARY DATA FILE NAME', FNAME, 3, 30))
CALL DISPLAY
1('IF NO PRINT FILE IS WANTED, TYPE "N:" IN RESPONSE TO THE FOLLOWING:')
CALL ASSIGN(3, FNAME, ISREAD('PRINT FILE NAME', FNAME, 3, 30))
IF (.NOT.NEW) GO TO 30
N=ISREAD('JOB TITLE', JOBIII, 1, 60)
C
C GET INFO FROM USER ON NEW FILE
C
0027 CALL DISPLAY
C 1('PROGRAM ALLOWS TWO LOAD CHANNELS')
0028 CALL DISPLAY
C 2('PLEASE CHARACTERIZE EACH LOAD CHANNEL')
0029 CALL DISPLAY
C 3('E.G. AXIAL OR PRESSURE OR UNUSED')
0030 N=ISREAD('NAME OF LOAD TYPE 1', TLD(1,1), 1, 10)
0031 N=ISREAD('NAME OF LOAD TYPE 2', TLD(1,2), 1, 10)
0032 CALL DISPLAY
C 4('THE PROGRAM ALSO EXPECTS THREE STRAIN CHANNELS PER ROSETTE')
0033 CALL DISPLAY
C 5('PLEASE CHARACTERIZE THE TWO NORMAL STRAIN DIRECTIONS')
0034 CALL DISPLAY
C 6('E.G. AXIAL OR HOOP OR TRANSVERSE')
0035 N=ISREAD('NAME OF STRAIN DIRECTION 1', TDIR(1,1), 1, 10)
0036 N=ISREAD('NAME OF STRAIN DIRECTION 2', TDIR(1,2), 1, 10)
0037 ENCODE(10, 5, TDIR(1,3))
0038 FORMAT(10#5, TDIR(1,3))
0039 CALL PAUSE
C

```

```
C
C READ IN RAW DATA
0040 DO 10 NRUN=1,1000
0041 IF (RANDAT(NRUN).LT.0.0) GO TO 20
0042 CONTINUE
0043 10 NRUN=NRUN+1
0044 20 WRITE(2) NRUN, TLD, TDIR, JUBIII
0045 CALL CLOSE(1)
0046 GO TO 40
0047 30 CALL GETDAT(0)
0048 CALL GETDAT(-1)
0049 CALL REVIEW
0050 C
C KEEP PLOTTING TILL USER WEARS OUT
C
C
0051 CALL PLOTGEN
0052 REPEAT=.TRUE.
0053 50 CALL PLOTIT
0054 IF (.NOT.(WANT TO FIT A CURVE)) CALL CURFIT
0055 IF (.NOT.(WANT TO THRU OUT WILD POINTS)) GO TO 60
0056 CALL WILD
0057 GO TO 50
0058 60 IF (.NOT.(WANT ANY MORE PLOTS)) GO TO 40
0059 CALL DISPLAY('REMINDE: IF YOU GENERATED A PRINT FILE,')
0060 CALL DISPLAY(' PLEASE EITHER DELETE IT:')
0061 CALL DISPLAY(' >PIP FILENAME?#/DE')
0062 CALL DISPLAY(' OR SPOOL IT:')
0063 CALL DISPLAY(' >PIP FILENAME/SP')
0064 CALL CLOSE(1)
0065 CALL CLOSE(2)
0066 STOP
0067 END
0068
0069
```



FORTRAN IV V02.04  
CURE=31K, UIC=(212,1)

```

C
0032 IF (TITLE(1,NTIT),NE,DOLLAR) GO TO 40
0034 TITLE(1,NTIT)=BLANK
0035 NTIT=NTIT-1
0036 GO TO 50
C
C HIT ECF
C
0037 HANDAT=1.
0038 RETURN
0039 CALL DISPLAY(' EDR MISSING UN LAST RUN!')
0040 HANDAT=1.
0041 RETURN
0042 CALL DISPLAY('EDR MISSING UN LAST RUN!')
0043 CALL DISPLAY('YOU ARE FORGIVEN!')
0044 GO TO 200
C
C GET ANOTHER LINE
C
0045 WRITE(5,41) (TITLE(J,NTIT),J=1,60)
0046 NTIT=NTIT+1
0047 WRITE(5,41) (TITLE(J,NTIT),J=1,60)
0048 41 FORMAT (1X,60A1)
0049 IF (NTIT.LE.4) GO TO 20
0051 READ(1,22) X
0052 NTIT=NTIT+1
0053 IF (X.EQ.DOLLAR) GO TO 50
0055 IF (NTIT.GT.10) STOP 'S MISSING AFTER TITLE LINES'
0057 GO TO 45
C
C READ IN RAW DATA AND CHECK FORMAT
C
0058 READ(1,51,END=32) NL,LINE
0059 51 FORMAT (0,20A1)
0060 IF (LINE(1),NE,E) GO TO 100
0062 IF (LINE(2),NE,O) GO TO 100
0064 IF (LINE(3),NE,R) GO TO 100
C
C END OF RECORD, GO PROCESS IT
C
0066 GO TO 200
C
C CHECK DATA FORMAT
C
0067 IF (CHECK(LINE,NL)) GO TO 100
0069 WRITE(5,60) (LINE(1),I=1,NL)
0070 60 FORMAT (' FOLLOWING LINE HAS A FORMAT ERROR: /1X,20A1)
0071 IF (.NOT.WANT('WANT TO DISCARD THIS LINE AND CONTINUE!'))
1 STOP
GO TO 50
C
0073 DECODE CHANNEL NO., TIME, VALUE
C
0074 100 DECODE(20,110,LINE) JCHN,IMIN,ISEC,IFRAC,IVALLE

```

```

0075 110 FORMAT (1X,13,1X,3(12,1X),15)
0076 C IF (JCHN.LE.0.OR.JCHN.GT.30) GO TO 55
C CHECK FOR OVERLOAD
C
0078 C IF (IABS(IVALUE)-LE.IVMAX) GO TO 130
0080 WRITE(5,120) JCHN
0081 120 FORMAT (' OVERLOAD ON CHANNEL',13)
0082 GO TO 50
0083 130 NRD(JCHN)=NRD(JCHN)+1
0084 NR=NRD(JCHN)
0085 IF (JSEC.GT.59) GO TO 55
0087 TIME(NR,JCHN)=60.*JMIN+JSEC+.01*IFRAC
0088 VALUE(NR,JCHN)=IVALUE
C GO GET ANOTHER LINE
C
C GO TO 50
0089 C DONE READING, NOW HAVE TO RUN THRU EACH CHANNEL
C AND GET MORE INFO FROM USER
C
C
0090 200 MSHORT=30000
0091 MLUNG=0
0092 DO 400 JCHN=1,30
0093 NR=NRD(JCHN)
0094 IF (NR.EQ.0) GO TO 400
MSHORT=MIN0(MSHORT,NR)
MLONG=MAX0(MLONG,NR)
0097 205 WRITE(5,210) JCHN
0098 FORMAT (' PLEASE IDENTIFY CHANNEL',13)
0099 210 N=ISREAD('S' FOR STRAIN; 'L' FOR LOAD; 'X' IF UNUSED',X,1,1)
0100 C STRAIN CHANNEL
C
C
0101 IF (X.NE.'S') GO TO 250
0103 JROS=IREAD('ROSETTE NO.',1,12,'NONE')
0104 WRITE(5,220) IDIR
0105 220 FORMAT (' STRAIN TYPES',1/
1 1 1,1,10A1/
2 1 2,1,10A1/
3 1 3,1,10A1)
0106 JTYPE=IREAD('STRAIN TYPE FOR THIS CHANNEL',1,3,'NONE')
0107 IF (ICHN(JTYPE,JROS).EQ.0) GO TO 240
0109 WRITE(5,230) ICHN(JTYPE,JROS),JROS,(IDIR(J,JTYPE),J=1,10)
0110 230 FORMAT (' CHANNEL',13,1 HAS BEEN IDENTIFIED WITH ROSETTE',13,
12X,10A1,1, STRAIN1')
C GO TO 205
0111 240 ITYPE(JCHN)=JTYPE
0112 IROS(JCHN)=JROS
0113 ICHN(JTYPE,JROS)=JCHN
0114 CALL DISPLAY(ENTER FACTORS A AND B TO CONVERT TO STRAIN UNITS)
0115 CALL DISPLAY(' X=RAW DATA, X=STRAIN UNITS')
0116 CALL DISPLAY(' WHERE X=RAW DATA, X=STRAIN UNITS')
0117

```

```

0116 A(JCHN)=RREAD('A','NONE','NONE','AD)
0119 AD=A(JCHN)
0120 B(JCHN)=RREAD('B','NONE','NONE','BD)
0121 BD=B(JCHN)
0122 GO TO 400
C
C LOAD CHANNEL
C
0123 250 IF (X.NE.'L') GO TO 300
0125 WRITE(5,260) TLD
0126 260 FORMAT (' LOAD TYPES: ',
1 ' 1=',10A1/,
2 ' 2=',10A1)
C
0127 ILD=IREAD('ILDAD TYPE FOR THIS CHANNEL',1,2,'NONE')
0128 IF (LCH(ILD).EQ.0) GO TO 270
0130 WRITE(5,265) LCH(ILD),(TLD(J,ILD),J=1,10)
0131 265 FORMAT (' CHANNEL',13,' HAS BEEN IDENTIFIED WITH ',10A1,' LOAD!')
0132 GO TO 205
0133 270 IROS(JCHN)=ILD
0134 LCH(ILD)=JCHN
0135 CALL DISPLAY('ENTER FACTORS A & B TO CONVERT TO LOAD UNITS')
0136 CALL DISPLAY(' X=AR+B')
0137 CALL DISPLAY(' WHERE K=RAW DATA, X=LOAD UNITS')
0138 A(JCHN)=RREAD('A','NONE','NONE','AD)
0139 AD=A(JCHN)
0140 B(JCHN)=RREAD('B','NONE','NONE','BD)
0141 BD=B(JCHN)
0142 GO TO 400
C
C UNUSED CHANNEL
C
0143 300 IF (X.NE.'X') GO TO 205
C
C NEXT CHANNEL
C
0145 400 CONTINUE
C
C THAT'S ALL! DUMP IT OUT
C
0146 WRITE(2) STUFF
0147 HARDAT=1,
C
C PRINT STUFF OUT
C
0148 IF (.NOT.WANT('WANT TO PRINT OUT RAW DATA')) GO TO 800
0150 WRITE(3,505) TITLE
0151 505 FORMAT (1H1/(1X,60A1))
0152 DO 508 I=1,30
0153 508 NP(I)=NRD(I)
0154 510 CALL BLANK11(LYNE,126*3)
0155 511 WRITE(3,511) LYNE
0156 511 FORMAT (1X,126A1)
0157 520 LTAB=0
0158 DO 610 I=1,30

```

```

0159 IF (NP(I).EQ.0) GO TO 610
0161 ENCODE(21,530,LYNE(21*LTAB+1)) I
0162 FORMAT (6X,7HCHANNEL,13,5X)
0163 IF (IROS(I)) 580,580,535
0164 ENCODE(21,540,LYNE2(21*LTAB+1)) IROS(I)
0165 FORMAT (6X,7HROSETTE,13,5X)
0166 ENCODE(21,550,LYNE3(21*LTAB+1)) (TDIH(J,ITYPE(I)),J=1,10)
0167 FORMAT (2X,10A1,7H STRAIN,2X)
0168 GO TO 600
0169 ENCODE(21,570,LYNE2(21*LTAB+1))
0170 FORMAT (6X,6HUNUSED,7X)
0171 CALL BLANKIT(LYNE3(21*LTAB+1),21)
0172 GO TO 600
0173 ENCODE (21,590,LYNE2(21*LTAB+1)) (TLD(J,-IROS(I)),J=1,10)
0174 FORMAT (3X,10A1,5H LUAD,3X)
0175 CALL BLANKIT(LYNE3(21*LTAB+1),21)
0176 GO TO 575
0177 LTAB=LTAB+1
0178 IF (LTAB.EQ.6) GO TO 620
0180 CONTINUE
0181 IF (LTAB.EQ.0) GO TO 800
0183 WRITE(3,511) LYNE,LYNE2,LYNE3
0184 DO 625 ITAB=1,LTAB
0185 ENCODE(21,626,LYNE(21*(ITAB-1)+1))
0186 WRITE(3,511) LYNE
0187 FORMAT (4X,4HTIME,1X,7HREADING,5X)
0188 LTAB=0
0189 DO 680 I=1,30
0190 IF (NP(I)) 670,680,640
0191 N=NRD(I)-NP(I)+1
0192 IF (N.EQ.0) GO TO 670
0194 ENCODE(21,660,LYNE(21*LTAB+1)) TIME(N,1),VALUE(N,I)
0195 FORMAT (F8.2,F8.0,5X)
0196 NP(I)=NP(I)-1
0197 IF (NP(I).EQ.0) NP(I)=1
0199 GO TO 675
0200 CALL BLANKIT(LYNE(21*LTAB+1),21)
0201 LTAB=LTAB+1
0202 IF (LTAB.EQ.6) GO TO 685
0204 CONTINUE
0205 WRITE(3,511) LYNE
0206 DO 690 I=1,126
0207 IF (LYNE(I).NE.' ') GO TO 630
0209 CONTINUE
0210 L=0
0211 DO 700 I=1,30
0212 IF (NP(I).EQ.-1) NP(I)=0
0214 L=L+NP(I)
0215 CONTINUE
0216 IF (L.NE.0) GO TO 510
0218 CALL PAUSE
0219 RETURN
0220 END
    
```

FORTHAN IV V02.04 PAGE 001  
CURE31K, UIC=(212,1) FBI 04-JAN-80 09147:35 ,CHECK/EXECHECK

0001 LOGICAL FUNCTION CHECK(LINE,N)  
0002 BYTE LINE(20)  
0003 LOGICAL NUM  
0004 BYTE SHOULD(13),CHAR,ZERO,NINE  
0005 DATA SHOULD(2,3,4,6,7,9,10,12,13,16,17,18,19/  
0006 DATA ZERU,NINE/10',19/  
0007 NUM(CHAR)SCHAR,GE,ZERU,AND,CHAR,LE,NINE  
0008 CHECKEN,GE,19  
0009 DU 10 I=1,13  
0010 CHECKCHECK,AND,NUM(LINE(SHOULD(I)))  
0011 RETURN  
0012 END

FORTRAN IV V02.04 FRJ 04-JAN-80 09:47:24 PAGE 001  
CORE=31K, UIC=(212,1) ,REVIEW/EX=REVIEW

```
0001 SUBROUTINE REVIEW
0002 COMMUN/MISC/NRUN, TLD(10,2), TDIR(10,3), JOBTIT(60)
0003 BYTE TLD, TDIR, JOBTIT
0004 COMMUN/BINAHY/NACT, NRDS, MSHURT, MLUNG,
1 LCH(2), ICHN(3,10), TITLE(60,4), MKD(30), INCS(30),
2 ITYPE(50), A(30), B(30),
3 TIME(80,30), VALUE(80,30)
0005 BYTE TITLE
0006 LOGICAL WANT
0007 DATA VMAX/2040./
0008 IF (.NOT. WANT) WANT TO REVIEW RUNS ON FILE!)) RETURN
0009 CALL ERASE
0010 DO 100 I=NRUN,1, NRUN
0011 CALL GETDA(I, RUN)
0012 WRITE(5,10) I, RUN, TITLE
0013 FORMAT (' RUN', I3, '(4X,60A1)')
0014 DO 50 ICH=1, 30
0015 NR=NRD(ICH)
0016 IF (NR.EQ.0) GO TO 50
0017 DO 12 J=1, NR
0018 IF (ABS(VALUE(J, ICH)).GT. VMAX) GO TO 15
0019 CONTINUE
0020 J=NR
0021 NRD(ICH)=J
0022 IF (I, ICHS(ICH)) 40, 50, 20
0023 WRITE(5, 30) A(ICH), B(ICH), ICH, IRDS(ICH), (TDIR(J, ITYPE(ICH)), J=1, 10)
0024 FORMAT ('T50, 'A', E10.4, 5X, 'B', E10.4, 11, ' CHANNEL', I3, '!',
1 ' ROSETTE NO.', I3, 2X, 10A1)
0025 GO TO 50
0026 WRITE(5, 45) A(ICH), B(ICH), ICH, (TLD(J, -IRDS(ICH)), J=1, 10)
0027 FORMAT ('T50, 'A', E10.4, 5X, 'B', E10.4, 11, ' CHANNEL', I3, '!',
1 ' , 10A1, ' LOAD!')
0028 CONTINUE
0029 CALL PAUSE
0030 RETURN
0031 END
0032
0033
0034
```

```

0001 SUBROUTINE GETDAT(IR)
      C
      C HEADS IN DATA FOR ONE RUN INTO COMMON BLOCK "BINARY"
      C EXCEPT IF IRUN=0, READS INTO BLOCK "MISC" FROM LAST REC
      C
      COMMON/MISC/NRUN, TLD(10,2), TDIR(10,3), JUBTIT(60)
      BYTE TLD, TDIR, JUBTIT
      COMMON/BINARY/STUFF(19932)
      BYTE STUFF
      DATA IPUS/-10/
      IRUN=IAHS(IR)
      IF (IRUN.NE.0) GO TO 30
      READ(2,END=20)
      GO TO 10
      BACKSPACE 2
      READ(2) NRUN, TLD, TDIR, JUBTIT
      REWIND 2
      IPUS=1
      RETURN
      IF (IRUN.LI.0.OR.IRUN.GT.NRUN)
      1 IF STUFF 'BAD CALL TO GETDAT'
      IF (IPUS.EQ.-10) GO TO 80
      IF (IPUS.EQ.IRUN+1.AND.IR.GT.0) RETURN
      IF (IR.EQ.1.AND.NRUN.EQ.1) RETURN
      IF (IPUS=IRUN) 40,70,80
      NSKIP=IRUN-IPUS
      DO 60 I=1,NSKIP
      20 READ(2)
      READ(2) STUFF
      IPUS=IRUN+1
      IF (IRUN.LI.NRUN) RETURN
      30 REWIND 2
      IPUS=1
      RETURN
      40 REWIND 2
      50 REWIND 2
      60 REWIND 2
      70 IPUS=IRUN+1
      80 IF (IRUN.LI.NRUN) RETURN
      IF (NSKIP.GT.0) GO TO 50
      GO TO 70
      END
    
```

FUKTHAN IV V02.04 FRI 04-JAN-80 09:47:57 PAGE 001  
CORE=SIK, UIC=(212,1) ,BLANKIT/EX=BLANKIT

0001 SUBROUTINE BLANKIT(LINE,N)  
0002 BYTE LINE(1)  
0003 DO 1 LINE(1),N  
0004 LINE(1)=','  
0005 RETURN  
0006 END



```

0031 C IF (TYPE.NE.'S') GO TO 35
      C
      C PLUT A STRAIN
      C
0033 C IF (WANT('WANT TO PLOT A PRINCIPAL STRAIN')) GO TO 30
      C
      C NOT A PRINCIPAL STRAIN
      C
0035 C WRITE(5,20) TDIR
0036 C 20 FORMAT(' STRAIN TYPES:'/
      C 1 ' 1= ,10A1/'
      C 2 ' 2= ,10A1/'
      C 3 ' 3= ,10A1/'
      C JPLT(JAX)=IREAD('STRAIN KEY',1,3,'NONE')
      C GO TO 90
      C
      C PRINCIPAL STRAIN
      C
0039 C CALL DISPLAY('PRINCIPAL STRAIN KEY:')
0040 C CALL DISPLAY(' 1=MAJOR PRINCIPAL')
0041 C CALL DISPLAY(' 2=MINOR PRINCIPAL')
0042 C CALL DISPLAY(' 3=MAX SHEAR')
0043 C JPLT(JAX)=3+IREAD('PRINCIPAL STRAIN KEY',1,3,'NONE')
0044 C GO TO 90
      C
      C PLOT A STRESS
      C
0045 C 35 IF (TYPE.NE.'T') GO TO 12
0047 C WRITE(5,40) ((TDIR(J,1),J=1,10),TLD,JJ=1,2)
0048 C 40 FORMAT (' ENTER FACTORS A & B REQUIRED TO CALCULATE ',10A1,
      C 1 ' STRESS',1 FROM ',10A1,' AND ',10A1,' LOADS',/
      C 2 ' WHERE:/'
      C 3 ' S=A*L1 + B*L2/'
      C 4 ' S= ,10A1,' STRESS/'
      C 5 ' L1= ,10A1,' LOAD/'
      C 6 ' L2= ,10A1,' LOAD')
      C SL(1,JAX,1)=RREAD('A','NONE','NONE','NONE',SL(1,JAX,1))
      C SL(1,JAX,2)=RREAD('B','NONE','NONE','NONE',SL(1,JAX,2))
0050 C 50 WRITE(5,40) ((TDIR(J,2),J=1,10),TL2)
0051 C SL(2,JAX,1)=RREAD('A','NONE','NONE','NONE',SL(2,JAX,1))
0052 C SL(2,JAX,2)=RREAD('B','NONE','NONE','NONE',SL(2,JAX,2))
0053 C SL(2,JAX,2)=RREAD('B','NONE','NONE','NONE',SL(2,JAX,2))
0054 C WRITE(5,40) (SHEAR,TLD,JJ=1,2)
0055 C SL(3,JAX,1)=RREAD('A','NONE','NONE','NONE',SL(3,JAX,1))
0056 C SL(3,JAX,2)=RREAD('B','NONE','NONE','NONE',SL(3,JAX,2))
0057 C IF (WANT('WANT A PRINCIPAL STRESS')) GO TO 60
      C
      C NOT PRINCIPAL STRESS
      C
0059 C WRITE(5,50) ((TDIR(J,K),J=1,10),KSI,2),SHEAR
0060 C 50 FORMAT (' STRESS KEY',/
      C 1 ' 1= ,10A1/'
      C 2 ' 2= ,10A1/'
      C 3 ' 3= ,10A1/'
      C JPLT(JAX)=IREAD('STRESS KEY',1,3,'NONE')
0061 C
    
```

```

0062 GO TO 90
      C
      C PRINCIPAL STRESS
0063 CALL DISPLAY('PRINCIPAL STRESS KEY:')
0064 CALL DISPLAY(' 1=MAJOR PRINCIPAL')
0065 CALL DISPLAY(' 2=MINOR PRINCIPAL')
0066 CALL DISPLAY(' 3=MAX SHEAR')
0067 JPLI(JAX)=3-IREAD('PRINCIPAL STRESS KEY',1,3,'NONE')
      C
      C GET LABEL FOR THIS AXIS
0068 CALL BLANKIT(LABEL(1,JAX),40)
0069 MLAB(JAX)=ISHEAD('LABEL FOR THIS AXIS',LABEL(1,JAX),1,40)
      C
      C REPEAT FOR Y AXIS
0070 AX='Y'
      C
      C GET TITLE FOR THE WHOLE PLOT
0071 CALL BLANKIT(PLTIT,60)
0072 NPIT=ISHEAD('TITLE FOR THE WHOLE PLOT',PLTIT,1,60)
      C
      C ASK WHAT DATA TO PLOT
0073 CALL DISPLAY('YOU MAY NOW SPECIFY UP TO 8 CURVES')
0074 CALL DISPLAY(' TO BE DRAWN ON ONE PLOT')
0075 CALL REVIEW
0076 IRUN=1
0077 XMAX=0.
0078 XMIN=1.E6
0079 YMAX=0.
0080 YMIN=1.E6
0081 DO 600 I,CURVE=1,8
0082 WRITE(5,110) ABC(CURVE)
0083 FORMAT (' FOR CURVE ',A1,1)
0084 IK=1
0085 IF (NRUN.GT.1) IR=IREAD('RUN NO.',1,NRUN,IRUN)
0086 CALL GETDAT(IR)
      C
      C DU X-AXIS
0087
      C
0088 JPL=JPLI(1)
0089 IF (JPL.LE.0) GO TO 180
      C
      C STRAIN PLOTTED: GET DATA
0090
0091 JROS=IREAD('ROSETTE NO. FOR X AXIS',1,8,'NONE')
0092 IF (JPL.GT.3) GO TO 180
      C
      C NOT PRINCIPAL STRAIN
0093
0094 ICH=ICHN(JPL,JROS)
  
```

```

0095 NH=NRD(ICH)
0096 IF (NR.GT.0) GO TO 140
0098 WRITE(5,130) (TDJK(J,JPL),J=1,10),JROS,IRUN
0099 FORMAT (1X,10A1,' STRAIN NOT RECORDED FOR ROSETTE NO.',13,'', RUN NO.',13)
0100 GO TO 120
0101 DO 150 I=1,NK
0102 XY(I,1,ICURVE)=VALUE(I,ICH)*A(ICH)+B(ICH)
0103 XYT(I,ICURVE)=TIME(I,ICH)
0104 GO TO 300
C
C PRINCIPAL STRAIN
C
0105 DO 170 J=1,3
0106 JCH(J)=ICHN(J,JKUS)
0107 IF (JCH(J).GT.0) GO TO 170
0109 WRITE(5,130) (TDJR(K,J),K=1,10),JROS,IRUN
0110 GO TO 105
0111 CONTINUE
0112 NH=NRD(JCH(1))
0113 NXY(ICURVE)=NR
0114 DO 175 I=1,NK
0115 S(1)=VALUE(I,JCH(1))*A(JCH(1))+B(JCH(1))
0116 S(2)=XTERP(VALUE(I,JCH(2)),TIME(I,JCH(2)),TIME(1,JCH(1)),NRD(JCH(2)))
0117 S(3)=XTERP(VALUE(I,JCH(3)),TIME(1,JCH(3)),TIME(1,JCH(1)),NRD(JCH(3)))
0118 IF (S(3).EQ.OVER) GO TO 176
0120 CALL PRINC(S,T,ANG)
0122 XY(I,1,ICURVE)=T(JPL-3)
0123 XYT(I,ICURVE)=TIME(1,JCH(1))
0124 GO TO 300
0125 NXY(ICURVE)=I-1
0126 GO TO 300
0127
C
C STRESS ON X AXIS
C
0128 JPL=JPL
0129 IF (JPL.GT.3) GO TO 220
C
C NOT A PRINCIPAL STRESS
C
LD=1
0131 IF (NRD(LCH(2)).GT.NRD(LCH(1))) LD=2
0132 DO 200 LD=1,2
0134 IF (SL(JPL,LD).EQ.0) OR (NRD(LCH(LLD)),NE.0) GO TO 200
0135 WRITE(5,190) (TLD(J,LLD),J=1,10),IRUN
0137 FORMAT (' NO DATA FOR ',10A1,' LOAD FOR RUN',12)
0138 GO TO 105
0139 CONTINUE
0140 NH=NRD(LCH(LD))
0141 NXY(ICURVE)=NR
0142 LCH1=LCH(3-LD)
0143 LCH2=LCH(LD)
0144 DO 210 I=1,NK
0145 XLDI=A(LCH1)*VALUE(I,LCH1)+B(LCH1)
0146

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PUMTRAN IV V02.04 FRI 04-JAN-80 09:48:16 , PLTGEN/LX=PLTGEN PAGE 005  
CUMESJK, UIC=(212,1)

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0147 XLD2=TEMP(VALUE(1,LCH2),TIME(1,LCH2),TIME(1,LCH1),NKD(LCH2))
0148 IF (XLD2.EQ.OVER) GO TO 211
0150 XLD2=A(LCH2)*XLD2+B(LCH2)
0151 XY(1,1,ICURVE)=SL(JPL,1,3-LD)*XLD1+SL(JPL,1,LD)*XLD2
0152 210 XY(1,1,ICURVE)=TIME(1,LCH2)
0153 GO TO 300
0154 211 NXY(ICURVE)=I-1
0155 GO TO 300
C
C PRINCIPAL STRESS
C
0156 220 DO 240 LLD=1,2
0157 IF (NRD(LCH(LLD)),NE.0) GO TO 240
0159 WRITE(5,190) (TLD(J,LLD),J=1,10),IRUN
0160 GO TO 105
0161 240 CONTINUE
0162 LD=1
0163 IF (NRD(LCH(2)),GT.NKD(LCH(1))) LD=2
0165 NR=NRD(LCH(LLD))
0166 NXY(ICURVE)=NK
0167 LCH1=LCH(3-LD)
0168 LCH2=LCH(LD)
0169 DO 260 I=1,NK
0170 XLD1=A(LCH1)*VALUE(1,LCH1)+B(LCH1)
0171 XLD2=XERP(VALUE(1,LCH2),TIME(1,LCH2),TIME(1,LCH1),NKD(LCH2))
0172 IF (XLD2.EQ.OVER) GO TO 261
0174 XLD2=A(LCH2)*XLD2+B(LCH2)
0175 DO 250 J=1,3
0176 S(J)=SL(J,1,3-LD)*XLD1+SL(J,1,LD)*XLD2
0177 CALL PRINC(S,1,ANG)
0178 260 XY(I,1,ICURVE)=T(JPL-3)
0179 GO TO 300
0180 261 NXY(ICURVE)=I-1
0181 GO TO 300
C
C Y AXIS
C
0182 300 JPL=JPLT(2)
0183 IF (JPL.LE.0) GO TO 380
C
C STRAIN PLOTTED: GET DATA
C
0185 320 JURSI=HEAD('ROBETTE NO. FOR Y AXIS',1,8,'NONE')
0186 IF (JPL.GT.3) GO TO 360
C
C NOT PRINCIPAL STRAIN
C
0188 ICH=ICHN(JPL,JROS)
0189 NK=NXY(ICURVE)
0190 IF (NRD(ICH).GT.0) GO TO 340
0192 WRITE(5,130) (DIR(J,JPL),J=1,10),JROS,IRUN
0193 GO TO 320
0194 340 DU 350 I=1,NK
0195 XTEXT=ERP(VALUE(1,ICH),TIME(1,ICH),XY(1,1,ICURVE),NRD(ICH))
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```

0196 IF (XI.EQ.OVER) GO TO 351
0198 XY(1,2,ICURVE)=A(ICH)*XI+B(ICH)
0199 GO TO 500
0200 NXY(ICURVE)=1-1
0201 GO TO 500
C
C PRINCIPAL STRAIN
C
0202 DO 370 J=1,3
0203 JCH(J)=ICHN(J,JKOS)
0204 IF (JCH(J).GT.0) GO TO 370
0206 WRITE(5,130) (TOIK(K),K=1,10),JKOS,IRUN
0207 GO TO 105
0208 CONTINUE
0209 NK=NXY(ICURVE)
0210 DO 375 I=1,NK
0211 DO 372 J=1,3
0212 S(J)=TEMP(VALUE(1,JCH(J)),TIME(1,JCH(J)),XY(1,ICURVE),NKD(JCH(J)))
0213 IF (S(J).EQ.OVER) GO TO 376
0215 CONTINUE
0216 CALL PRINC(S,T,ANG)
0217 XY(1,2,ICURVE)=T(JPL=3)
0218 GO TO 500
0219 NXY(ICURVE)=1-1
0220 GO TO 500
C
C STRESS ON Y AXIS
C
0221 JPL=JPL
0222 IF (JPL.GT.3) GO TO 430
C
C NOT A PRINCIPAL STRESS
C
0224 DO 400 LLD=1,2
0225 IF (SL(JPL,2,LD).EQ.0.OR.NKD(LCH(LLD)).NE.0) GO TO 400
0227 WRITE(5,190) (TLD(J,LLD),J=1,10),IRUN
0228 GO TO 105
0229 CONTINUE
0230 NK=NXY(ICURVE)
0231 LCH1=LCH(1)
0232 LCH2=LCH(2)
0233 DO 410 I=1,NK
0234 XLD1=TEMP(VALUE(1,LCH1),TIME(1,LCH1),XY(1,ICURVE),NKD(LCH1))
0235 IF (XLD1.EQ.OVER) GO TO 411
0237 XLD1=A(LCH1)*XLD1+B(LCH1)
0238 XLD2=TEMP(VALUE(1,LCH2),TIME(1,LCH2),XY(1,ICURVE),NKD(LCH2))
0239 IF (XLD2.EQ.OVER) GO TO 411
0241 XY(1,2,ICURVE)=SL(JPL,2,1)*XLD1+SL(JPL,2,2)*XLD2
0242 GO TO 500
0243 NXY(ICURVE)=1-1
0244 GO TO 500
C
C PRINCIPAL STRESS
C

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```

0245 430 DO 440 LLD2=1,2
0246 IF (NRD(LCH(LLD)),NE.0) GO TO 430
0248 WRITE(5,190) (ILD(J,LLD),J=1,10),IRUN
0249 GO TO 105
0250 440 CONTINUE
0251 NR=NY(ICURVE)
0252 LCH=LCH(1)
0253 LCH2=LCH(2)
0254 DO 460 I=1,NR
0255 XLD1=XTEMP(VALUE(1,LCH1),TIME(1,LCH1),XY(1,ICURVE),NRD(LCH1))
0256 IF (XLD1.EQ.OVER) GO TO 461
0258 XLD1=A(LCH1)*XLD1+B(LCH1)
0259 XLD2=XTEMP(VALUE(1,LCH2),TIME(1,LCH2),XY(1,ICURVE),NRD(LCH2))
0260 IF (XLD2.EQ.OVER) GO TO 461
0262 XLD2=A(LCH2)*XLD2+B(LCH2)
0263 DO 450 J=1,3
0264 S(J)=SL(J,2,5-LD)*XLD1+SL(J,2,LD)*XLD2
0265 CALL PRINC(S7,ANG)
0266 XY(1,2,ICURVE)=I(JPL-3)
0267 GO TO 500
0268 461 NY(ICURVE)=I-1
0269 DO 510 I=1,NY(ICURVE)
0270 XMAX=MAXI(XMAX,XY(1,1,ICURVE))
0271 XMIN=MINI(XMIN,XY(1,1,ICURVE))
0272 YMAX=MAXI(YMAX,XY(1,2,ICURVE))
0273 YMIN=MINI(YMIN,XY(1,2,ICURVE))
0274 IF (NRUN.GT.1) WRITE(5,520) TITLE
0275 FORMAT (' TITLE INFO FROM SUB FILE:',(1X,60A1))
0276 CALL BLANKIT(LEGEND(1,ICURVE),40)
0277 NLEGS=READ('A SUMMARY TITLE FOR THIS CURVE',
0278 1 LEGEND(1,ICURVE),1,40)
0280 IF (.NOT.WANT('WANT ANY MORE CURVES ON THIS PLOT')) GO TO /00
0282 CONTINUE
0283 ICURVE=ICURVE
0284 REPEAT=.TRUE.
0285 RETURN
0286 END
    
```

```
0001 FUNCTION XTERP(VALUE,TIME,T,N)  
0002 DIMENSION VALUE(1),TIME(1)  
0003 DATA OVER/OVER/  
0004 WRITE(3,76) (TIME(I),VALUE(I),I=1,N)  
0005 FORMAT (F7.2,F8.2,2X)  
0006 IF (.GT.TIME(1)) GO TO 10  
0007 XTERP=VALUE(1)  
0008 GO TO 30  
0009 DO 15 I=1,N  
0010 IF (.GE.TIME(I).AND,.LT.TIME(I+1)) GO TO 20  
0011 CONTINUE  
0012 XTERP=OVER  
0013 GO TO 30  
0014 S=(VALUE(I+1)-VALUE(I))/(TIME(I+1)-TIME(I))  
0015 XTERP=VALUE(I)+S*(I-TIME(I))  
0016 CONTINUE  
0017 WRITE(3,77) I,XTERP  
0018 FORMAT (' XTERP',F7.2,F10.2)  
0019 RETURN  
0020 END
```

FURTHAN IV VU2.04 FRI 04-JAN-80 09:48:58 PAGE 001  
CORE=31A, UILE(212,1) ,SCALE/EXESCALE )

```
0001 FUNCTION SCALE(X)
0002 DIMENSION XLIM(10)
0003 DATA XLIM/1.,1.25,1.5,2.0,2.5,3.0,4.0,5.0,7.5,10.0/
0004 SCALE=0
0005 IF(X.EQ.0.0) RETURN
0006 I=ALOG10(ABS(X))
0007 YEARS(X)*10.0**(-I)
0008 DO 10 J=1,10
0009 IF(Y.LE.XLIM(J)) GO TO 20
0010 CONTINUE
0011 STOP 'SCALE ERROR'
0012 10 SCALE=SIGN(XLIM(J)*10.0**I,X)
0013 RETURN
0014 20
0015
0016 END
```

```
0001 SURROUTINE PRINC(S,T,ANG)
0002 DIMENSION S(3),T(3)
C
C S(1) S(2)=NORMAL STRAINS
C S(3)=45 DEGREE STRAIN
C T(1),T(2)=PRINCIPAL STRAINS
C T(3)=MAX SHEAR
C
0003 A=(S(1)+S(2))/2.
0004 B=((S(1)-S(3))**2+(S(3)-S(2))**2)/2.
0005 B=SQRT(B)
0006 SUM=A+B
0007 DIFF=A-B
0008 IF (ABS(DIFF).GT.ABS(SUM)) GO TO 10
0009 T(1)=SUM
0010 T(2)=DIFF
0011 GO TO 20
0012 T(1)=DIFF
0013 T(2)=SUM
0014 T(3)=ABS(T(1)-T(2))
0015 RETURN
0016 END
0017
```

```

0001 SUBROUTINE CURFIT
      C
      C DRAW LEAST SQUARES CURVE FIT THRU DATA
      C GENERATED BY PLTGEN AND PLOTTED
      C INDIVIDUALLY BY PLOT11
      C
      COMMON/MISC/MRUN, IJD(10,2), IDIR(10,3), JOB111(60)
      BYTE IJD, IDIR, JOB111
      COMMON/PL1/NCURVE, XMAX, XMIN, YMAX, YMIN, XSC, YSC, XL, YL,
      XY(70,2,8), XY1(70,8), NXY(8)
      1  NLAB(2), LABEL(40,2), NP111, PLT111(60),
      2  LEGEND(40,8)
      3  BYTE LABEL, PLT111, LEGEND
      COMMON/BI/NAKY/X(400), Y(400), Z(400)
      BYTE SYMB
      CALL PLOT5
      CALL PLOT(0,0,0,-3)
      CALL PLOT(2,2,-3)
      CALL AXIS(0,0,0,LABEL(1,1),NLAB(1),XL,0,0,ABS(XSC/XL))
      CALL AXIS(0,0,0,LABEL(1,2),NLAB(2),YL,90,0,ABS(YSC/YL))
      CALL GRID(0,0,16,10,0)
      CALL SYMBOL(10,12.5,'LEGEND',,6)
      SYMB='A'
      DO 20 ICURVE=1,NCURVE
      CALL SG1(XY(1,2),ICURVE),XY(1,1),ICURVE),Z,NXY(ICURVE),IER)
      Z(NXY(ICURVE)+1)=0
      Z(NXY(ICURVE)+2)=ABS(XSC/XL)
      CALL LINE(Z,XY(1,2),ICURVE),NXY(ICURVE),1,1,ICURVE)
      CALL SYMBOL(10,12.5-.4*ICURVE,,SYMB,,1)
      CALL SYMBOL(10.5,12.5-.4*ICURVE,,LEGEND(1,ICURVE),,40)
      SYMB=SYMB*1
      CALL SYMBOL(0,12.5,,JOB111,60)
      CALL SYMBOL(0,12.0,,PLT111,,NP111)
      CALL SYMBOL(0,11.5,,LEAST SQUARES FIT',,17)
      CALL PLOT(,999)
      RETURN
      END
0029
    
```

```

0001 SUBROUTINE PLOTIT
C
C PLOTS DATA GENERATED BY PLGEN
C
0002 COMMON/MISC/NHUN,ILD(10,2),TDIK(10,3),JOBIII(60)
0003 BYTE TLD,TDIK,JOBIII
0004 COMMON/PLT/ACURVE,XMAX,XMIN,YMAX,YMIN,XSC,YSC,XL,YL,
1 XY(70,2,8),XYI(70,8),NXY(8),
2 NLAB(2),LABEL(40,2),NP111,PL111(60),
3 LEGEND(40,8)
0005 COMMON/BINARY/LYNE(128),LYNE2(128),DA1(9),IIM(8)
0006 BYTE LYNE,LYNE2,DA1,IIM
0007 BYTE LABEL,PL111,LEGEND
0008 BYTE SYMB,ABC
0009 LOGICAL WANT
0010 ABC(I)=I00+I
C
C GET SCALE
C
0011 IF (XMIN.LT.-XMAX) GO TO 20
0012 XSC=SCALE(XMAX)
0013 XL=10.
0014 WRITE(5,10) 'X'
0015 FORMAT (' POSITIVE VALUES ON ',A1,' AXIS')
0016 GO TO 40
0017 XSC=SCALE(-XMIN)
0018 XL=10.
0019 WRITE(5,30) 'X'
0020 FORMAT (' NEGATIVE VALUES ON ',A1,' AXIS')
0021 WRITE(5,41) 'X',XSC
0022 FORMAT ('X',A1,' AXIS WILL RANGE FROM 0.0 TO',E10.3/
0023 1 XSC, ' WHICH YOU MAY NOW OVERRIDE IF YOU WISH. ')
0024 XSC=READ('X AXIS RANGE',0.0,'NONE',XSC)
0025 IF (YMIN.LT.-YMAX) GO TO 50
0026 YSC=SCALE(YMAX)
0027 YL=10.
0028 WRITE(5,10) 'Y'
0029 GO TO 60
0030 YSC=SCALE(-YMIN)
0031 YL=10.
0032 WRITE(5,30) 'Y'
0033 WRITE(5,41) 'Y',YSC
0034 YSC=READ('Y AXIS RANGE',0.0,'NONE',YSC)
0035
C
C PRINT STUFF
C
0036 IF (.NOT.WANT('WANT TO PRINT PLOTTED DATA')) GO TO 200
0037 CALL DATE(DAT)
0038 CALL TIME(TIM)
0039 WRITE(5,100) JOBIII,DA1,IIM,PL111
0040 FORMAT (I10,60A1,40X,9A1,2X,6A1/1X,60A1)
0041 WRITE(5,103) LABEL
0042 FORMAT (100,5X,'X=',40A1/6X,'Y=',40A1)
0043 ICURVE=0
0044

```

```

0045 IC2=MINO(NCURVE,4)
0046 CALL BLANKIT(LYNE,2*128)
0047 WRITE(3,101) LYNE
0048 FORMAT (1X,128A1)
0049 JCURVE=ICURVE
0050 DO 130 J=1,IC2
0051 ICURVE=ICURVE+1
0052 WRITE(3,110) AHC(ICURVE),(LEGEND(J,ICURVE),J=1,40)
0053 FUMMAT (1 CURVE',1X,A1,' ',40A1)
0054 ENCODE(30,120,LYNE(30*1-29)) ABC(ICURVE)
0055 FUMMAT (11X,5HCURVE,1X,A1,11X)
0056 ENCODE(30,140,LYNE2(30*1-29))
0057 FUMMAT (11X,1MX,11X,1MY,6X)
0058 WRITE(3,101)
0059 WRITE(3,101) LYNE,LYNE2
0060 DO 180 L=1,10000
0061 ICURVE=JCURVE
0062 DO 160 L=1,IC2
0063 CALL BLANKIT(LYNE(30*(L-1)+1),30)
0064 ICURVE=ICURVE+1
0065 IF (L.LE.NXY(ICURVE))
1 ENCODE (30,150,LYNE(30*1-29)) XY(L,1,ICURVE),XY(L,2,ICURVE)
0067 FUMMAT (E15.5,E12+5,5X)
0068 CONTINUE
0069 WRITE(3,101) LYNE
0070 DO 170 L=1,128
0071 IF (LYNE(L).NE.' ') GO TO 180
0072 CONTINUE
0073 GO TO 190
0074 CONTINUE
0075 IC2=MINO(NCURVE=ICURVE,4)
0076 IF (ICURVE.LT.NCURVE) GO TO 102
0077 C
C
C HERE GOES
C
0079 CALL DISPLAY('READY TO PLOT,')
0080 CALL PAUSE
0081 CALL PLOT(2,,2,,3)
0082 CALL AXIS(0,,0,,LABEL(1,1),NLAB(1),XL,0,0,0,0,ABS(XSC/XL))
0083 CALL AXIS(0,,0,,LABEL(1,2),NLAB(2),YL,90,0,0,0,0,ABS(YSC/YL))
0084 CALL GRID(0,,0,,16,,10,,0)
0085 DO 710 JCURVE=1,NCURVE
0086 DO 500 J=1,NXY(ICURVE)
0087 IF (XL.LT.0.0) XY(J,1,ICURVE)=XY(J,1,ICURVE)
0088 IF (YL.LT.0.0) XY(J,2,ICURVE)=XY(J,2,ICURVE)
0090 XY(J,1,ICURVE)=AMAX1(0.0,XY(J,1,ICURVE))
0092 CONTINUE
0093 XY(NXY(ICURVE)+1,1,ICURVE)=0.0
0094 XY(NXY(ICURVE)+2,1,ICURVE)=ABS(XSC/XL)
0095 XY(NXY(ICURVE)+1,2,ICURVE)=0.0
0096 XY(NXY(ICURVE)+2,2,ICURVE)=ABS(YSC/YL)
0097 CALL LINE(XY(1,1,ICURVE),XY(1,2,ICURVE),NXY(ICURVE),1,1,ICURVE)
0098 CALL SYMBOL(0,,15.5,,JOB111,,60)
0099

```

FORTRAN IV V02.04 PAGE 003  
CORE51K, UIC=(212,1) FRI 04-JAN-80 09:50:01 ,PLOT11/EXPLO11

0100 CALL SYMBOL(0,,12.0,,PL111,,APT11)  
0101 CALL SYMBOL(10,,12.5,,LEGEND',,0)  
0102 SYMB='A'  
0103 DD 810 ICURVE=1,NCURVE  
0104 CALL SYMBOL(10,,12.5-.4\*ICURVE,,SYMB,,1)  
0105 SYMB=SYMB+1  
0106 810 CALL SYMBOL(10.5,12.5-.4\*ICURVE,,LEGEND(1,ICURVE),,40)  
0107 CALL PL01(,,999)  
0108 RETURN  
0109 END

```
0001 SUBROUTINE SG13(X,Y,Z,NDIM,IER)
C
C LEAST SQUARES ROUTINE
C
0002 DIMENSION X(NDIM),Y(NDIM),Z(NDIM)
0003 IF(NDIM=2,7,1,1)
0004 DO 6 I=3,NDIM
0005 XM=3333333*(X(I-2)+X(I-1)+X(I))
0006 YM=3333333*(Y(I-2)+Y(I-1)+Y(I))
0007 T1=X(I-2)*XM
0008 T2=X(I-1)*YM
0009 T3=X(I)*XM
0010 XM=T1+T2+T3+T3
0011 IF(XM)3,3,2
0012 XM=(T1*(Y(I-2)-YM)+T2*(Y(I-1)-YM)+T3*(Y(I)-YM))/XM
0013 IF(I=3)4,4,5
0014 H=XM*11+YM
0015 Z(I-2)=H
0016 H=XM*12+YM
0017 Z(NDIM-1)=H
0018 Z(NDIM)=XM*13+YM
0019 IER=0
0020 RETURN
0021 IER=-1
0022 RETURN
0023 END
```

FUKIRAN IV V02.04 FKI 08-JAN-80 09150152 PAGE 001  
CONE=314, UIC=(212,1) ,WILD/EX=WILD

0001 SUBROUTINE WILD  
C  
C THRU8 OUT WILD POINTS  
C  
0002 COMMON/MISC/NKUN, ILD(10,2), IDIR(10,3), JOBIII(60)  
0003 BYTE ILD, IDIR  
0004 COMMON/BIKAKY/NACT, NRDS, MSHORI, PLUNG,  
1 LCH(2), ICHN(3,10), TITLE(60,4), NRD(30), INCS(30),  
2 ITYPE(30), A(30), B(30),  
3 TIME(80,30), VALUE(60,30)  
C  
0005 BYTE TITLE  
0006 CALL DISPLAY('SORRY, HAVEN'T GOT AROUND TO WRITING THIS YET!!')  
0007 RETURN  
0008 END

APPENDIX B

RING TESTER

INTERNAL PRESSURE-ONLY COMPOSITE RING TEST FIXTURE

As part of Problem No. 112, an internal pressure-only tube test fixture was designed and built. The design of the fixture is essentially the same as that of a fixture successfully used by the IIT Research Institute under contract to AFFDL. Technical Report AFFDL-TR-75-11, titled "Analytical-Experimental Correlation of the Biaxial State of Stress in Composite Laminates (T-300/5208)," may be used as a reference.

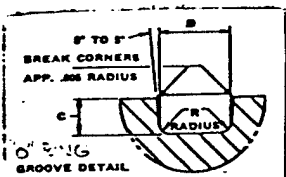
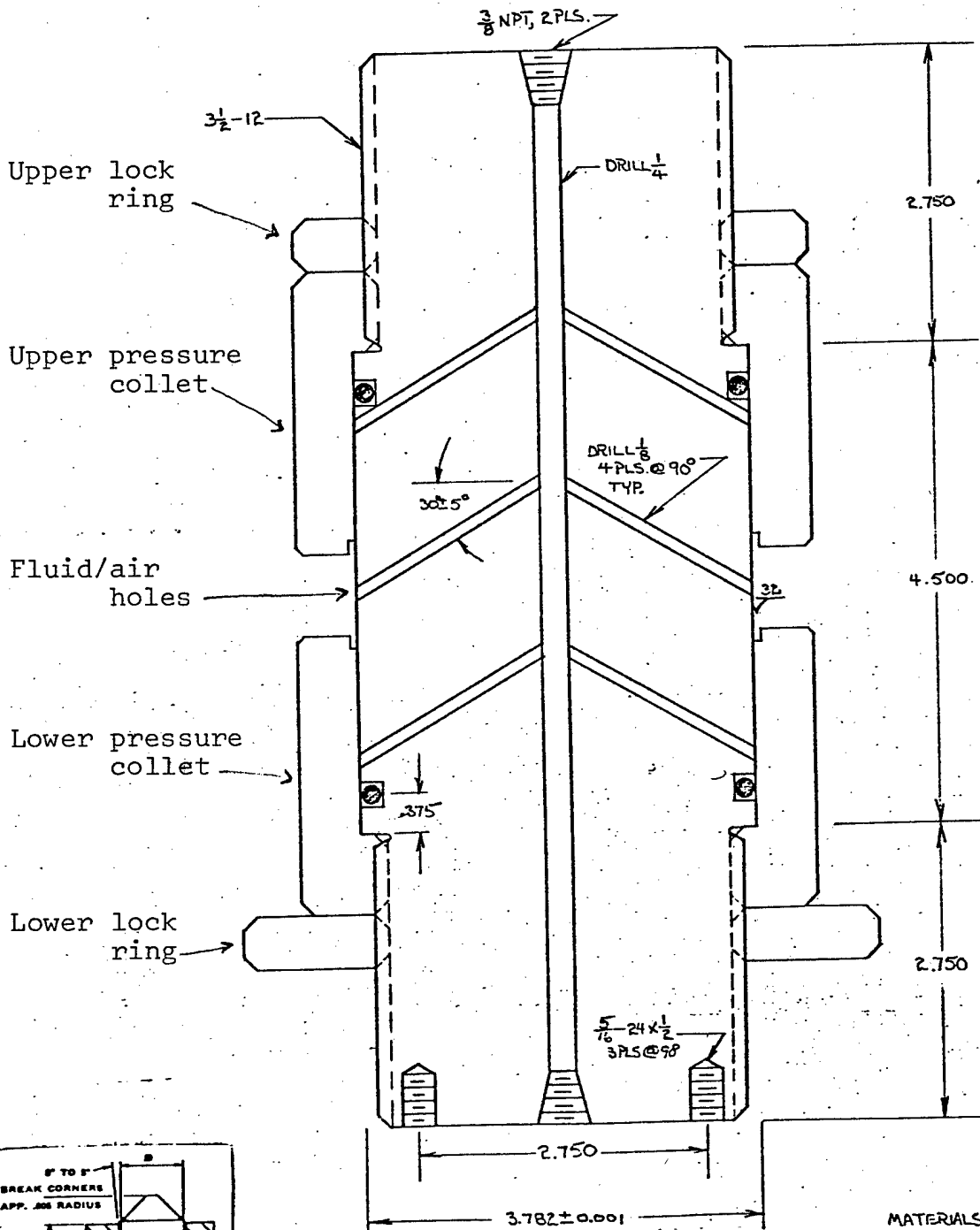
Several uninstrumented  $0^\circ/\pm 45^\circ/90^\circ$  graphite epoxy rings have been successfully ruptured in the fixture. The results are disappointing, however, when specimens having high Poisson ratios, such as  $\pm 45^\circ$  layups, are pressurized. In those tests, the large Poisson contraction in the axial direction allows extrusion of the internal rubber gasket between the specimen end and pressure collet. This destroys the pressure seal and prevents further application of fluid pressure.

A drawing of the fixture showing an assembly view of the main body, lock rings and pressure collets, is given in Figure B.1. A photograph showing the entire assembled fixture is given in Figure B.2. A schematic of the fixture is given in Figure B.3. The maximum pressure of this system is 5,000 psi. The gage accuracy is  $\pm 2\%$  at full scale.

A pressure transducer must be installed in the pipe tee adjacent to the pressure gage. A Daytronic strain gage transducer, Model 502-3000G, has been used successfully with this fixture. If the data from the transducer is not required, a high pressure pipe plug ( $> 5,000$  psi.) may be installed in its place.

To begin operation, fill the reservoir with hydraulic fluid. Open valves designated as Nos. 1, 2, 3 and 4 in Figure B.3. Fill the open reservoir at the end of the priming pump  $3/4$  full with hydraulic fluid. Close the relief valve at the other end of the priming pump. Pump the lever on the

HYDROSTATIC TEST FIXTURE



D = .280  
C = .125  
R = .005 MIN

SUPPLY & INSTALL ETC.,  
3/16 NOM. NEOPRENE O-RINGS

Figure B.1 Dimensioned Drawing of Internal Pressure Only Fixture

MATERIALS: BODY - STEEL  
LOCK NUTS - STEEL  
COLLETS - 4340, R<sub>c</sub> - 45

SCALE - FULL  
TOL. ± 0.005, EXCEPT AS NOTED  
BREAK ALL CORNERS

NLH  
9-8-78

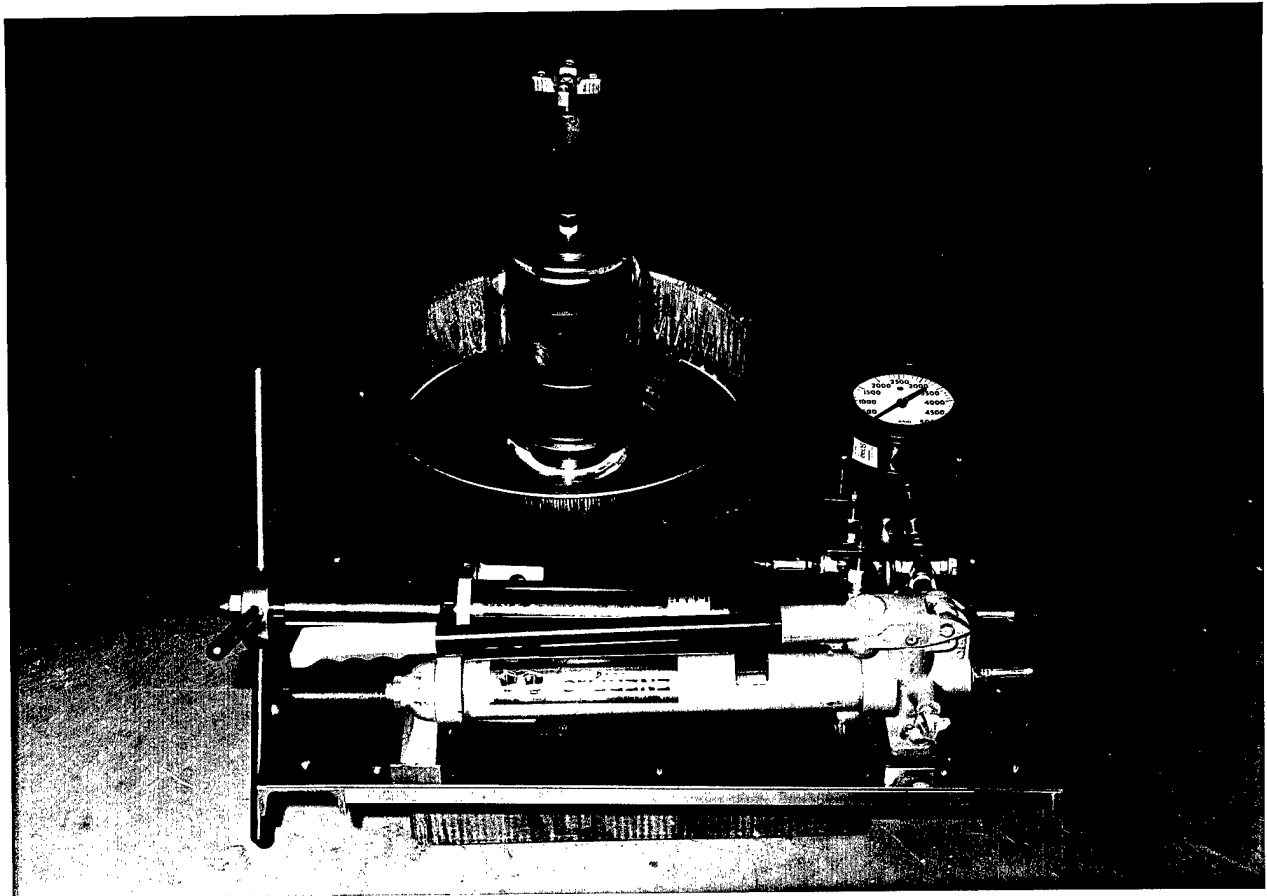


Figure B.2 Internal Pressure Only Test  
Fixture

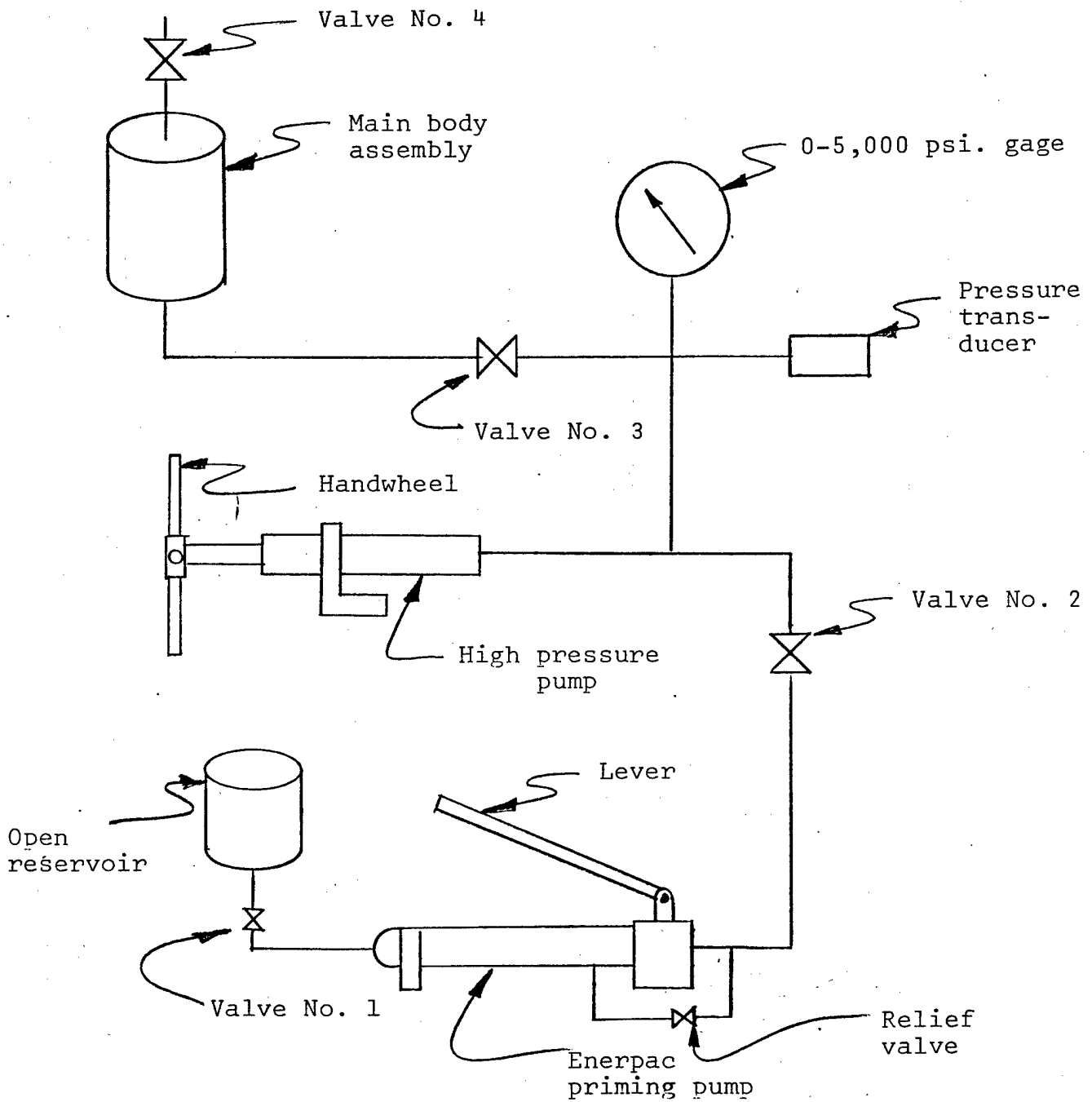


Figure B.3 Schematic of the Internal Pressure-only Composite Ring Test Fixture

priming pump until a steady flow of fluid leaks out of the main body, making sure that the open reservoir is never less than 1/4 full. Crank the handwheel on the high pressure pump clockwise until it stops. Close Valve No. 3. Slowly crank the handwheel counter-clockwise while pumping the lever on the priming pump. Keep a gage pressure of about 300 psi. Continue cranking until the shaft is fully extended. Open the relief valve on the priming pump to release the pressure.

To mount the test specimen, unscrew and remove the upper lock ring and upper pressure collet from the main body. Loosen the lower lock ring and screw the lower pressure collet down about 1.5 inches from its full up position. Cut a piece of the red rubber gasket tube about an inch longer than the specimen. This gasket tube is about 3 5/8" diameter and 0.10 inches thick, and was supplied by the Air Force. Slide the tube around the outside diameter of the main body, down far enough that it is centered around the fluid/air holes. Screw the lower pressure collet up the main body so that it slides over the gasket tube as far as it will go. Lock the lower lock ring. Slide the instrumented specimen over the outside of the gasket tube so that it rests on the lower pressure collet. Screw the upper pressure collet down so that the bottom edge rests on the specimen. The upper pressure collet should slide over the gasket tube just as the lower collet did. The length of the gasket tube may have to be trimmed so that the upper collet will rest on the specimen. Screw down the upper lock ring to lock the pressure collet. A photograph of the specimen in place is shown in Figure B.4.

Now that the specimen has been mounted, set up all of the signal conditioning for the pressure transducer and the specimen strain gages. Open Valves No. 1, No. 2, No. 3 and No. 4. Close the relief valve on the priming pump. As much air as



Figure B.4 Test Specimen Mounted in Fixture

possible must be gotten out of the system. This is done by pumping the priming pump until a steady flow of fluid comes out of Valve No. 4. The air that is trapped around the specimen will leave through the fluid/air holes in the main body.

After all the air is out, the pressure transducer can be calibrated against the pressure gage. Close Valves No. 2 and No. 3. By cranking the handwheel clockwise, a pressure will be produced at the pressure gage and transducer without applying pressure to the specimen. To release the pressure, crank the handwheel counter-clockwise until the shaft is fully extended, and open Valve No. 2 and the relief valve on the priming pump.

To test the specimen, close Valves No. 2 and No. 4. Open Valve No. 3. Place the plexiglass tube over the specimen so that it rests on the lower lock ring. Apply pressure to the specimen by cranking the handwheel clockwise. To release the pressure, open Valve No. 2 and the relief valve on the priming pump. After the specimen has ruptured, drain the fluid out of the drain pan by removing the pipe plug in the bottom of the pan.