



MECHANICAL & PHYSICAL PROPERTIES
OF TWO EPOXY SYSTEMS

Report No. 97SL059B

May 28, 1997

as prepared for

INFRASTRUCTURE REPAIR SYSTEMS,
INC.

3201 28th Street North
St. Petersburg, Fl. 33784

SIGMA TECHNOLOGY LABORATORIES

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CLIENT: INFRASTRUCTURE REPAIR SYSTEMS, INC.
 P.O. Box 60457
 3201 28th Street North
 St. Petersburg, FL 33784

SUBJECT: Mechanical & Physical Properties Of Two Epoxy Systems

SUMMARY

A two gallon pail of Infrastructure Repair Products, Inc. S-301 Spray Epoxy Base, a one gallon pail of Infrastructure Repair Products, Inc. S-301 Spray Epoxy Activator, a five gallon pail of Infrastructure Repair Products, Inc. M-201 Epoxy Base, a one gallon can of Infrastructure Repair Products, Inc. M-201 Epoxy Activator and a high strength concrete block were received from INFRASTRUCTURE REPAIR SYSTEMS, INC. for mechanical and physical properties analysis on epoxy castings. Mechanical testing was performed to determine the tensile, compressive, flexural properties and tensile pull-off strength from steel and concrete substrates. Physical property testing performed was to identify the heat deflection temperature and surface hardness of the epoxy castings.

Putty castings for tensile, compression and flexural testing were prepared at a 3:1 volume ratio and cast in a mold. Tensile pull-off coupons were fabricated by applying each epoxy system to steel tensile blocks and bonding a set of tensile blocks with each epoxy system to the submitted concrete block. Tensile, compression and flexural coupons were post cured for 8 hours at 150°F prior to testing.

Testing was guided by the American Society of Testing and Materials (ASTM) test methods. Mechanical property tests employed were ASTM C 297 Tensile Strength of Flat Sandwich Constructions in Flatwise Plane, ASTM D 638 Tensile Properties of Plastics, ASTM D 695 Compressive Properties of Rigid Plastics, and ASTM D 790 Flexural Properties of Unreinforced and Reinforced Plastics. The Physical property tests employed were ASTM D 648 Deflection Temperature of Plastics Under Flexural Load and ASTM D 2240 Test Method For Rubber Property-Durometer Hardness. ASTM D 648 was performed by an associate laboratory.

A brief description of the test procedures used is given in the "TEST PROCEDURE" portion of the report, observations are reported in the "OBSERVATIONS" portion and data derived from testing is reported in the "DATA" and "DATA SUMMARY" sections of this report.

TEST PROCEDURE

TEST METHOD: ASTM C 297 - Sandwich Panel Test

TITLE: Tension Test of Flat Sandwich Constructions in Flatwise Plane

The samples were fabricated by bonding two steel blocks together (steel/steel) and by bonding a steel block to a concrete block (steel/concrete). After being sanded and wiped with acetone to promote adhesion, the steel blocks were bonded with the submitted epoxy resin samples. One steel block was also bonded to a concrete block. The concrete block was sanded with a coarse grinding wheel prior to bonding. Three assemblies of each resin/substrate combination was prepared. The assemblies were allowed to cure a minimum of 24 hours before testing.

The bonded assemblies were then placed in the tensile holding fixtures. The rate of loading (crosshead speed) was 0.10 inches per minute. Samples which failed in the adhesive were rejected; no data of this type is included in the report.

TEST METHOD: ASTM D 638

TITLE: Tensile Properties of Plastics

The coupons were machined to 9.0" long, with an "overall" width of .750", and "necked" to approximately .50" over the gauge length. A strain gauge extensometer (1" gauge length) was mounted flatwise on the smooth or "mold" side of the coupons for the purpose of strain measurement during the test. The instrument was removed prior to coupon failure. The crosshead speed (speed of testing) was 0.1 inches per minute.

TEST METHOD: ASTM D 695

TITLE: Compressive Properties of Rigid Plastics

Coupons were machined to 1½" long and 0.50" by 0.50" (prism). The strain measuring instrument (compressometer) was positioned edgewise on the test specimens. The coupons themselves were supported in a test "jig" also described in the procedure. The crosshead speed was 0.05 inches per minute.

TEST PROCEDURE, continued

TEST METHOD: ASTM D 790

TITLE: Flexural Properties of Unreinforced and Reinforced Plastics (Method I, Procedure A)

This property was tested using a 16:1 support span : depth ratio. A three-point bending apparatus was used (D 790 Method I, Procedure A). Coupon deflection under load was measured using a deflectometer positioned under the middle of the coupon. Radii of the loading nose and end supports was $\frac{1}{8}$ ". All coupons were tested with the mold side "up". The crosshead speed (speed of testing) was 0.05 inches per minute. As a result the pressure applied could be considered "normalized" to the loads seen in actual usage.

TEST METHOD: ASTM D 2240

TITLE: Test Method for Rubber Property - Durometer Hardness

Each epoxy casting was tested for hardness using a PTC Instruments Model 307L Type D Durometer. Sixteen readings were taken from one surface of the casting. The highest and the lowest readings were thrown out, and the remaining fourteen were averaged.

OBSERVATIONS

ASTM C 297
COUPON 1-3

M-201 EPOXY/CONCRETE
100% failure of concrete substrate.

COUPON 1-3

S-301 EPOXY/CONCRETE
100% failure of concrete substrate.

COUPON 1

M-201 EPOXY/STEEL
85% cohesive failure of epoxy and 15% adhesion failure at steel block surface.

COUPON 2

80% cohesive failure of epoxy and 20% adhesion failure at steel block surface.

COUPON 1

S-301 EPOXY/STEEL
40% cohesive failure of epoxy and 60% adhesion failure at steel block surface.

COUPON 2

60% cohesive failure of epoxy and 40% adhesion failure at steel block surface.

ASTM D 638
COUPON 1,3,4

M-201 EPOXY
Plastic deformation followed by brittle tensile failure at bottom of gage section.

COUPON 2,5

Plastic deformation followed by brittle tensile failure at middle of gage section.

COUPON 1,4,5

S-301 EPOXY
Plastic deformation followed by brittle tensile failure at middle of gage section.

COUPON 3,6

Plastic deformation followed by brittle tensile failure at bottom of gage section.

OBSERVATIONS

<u>ASTM D 695</u>	<u>M-201 EPOXY</u>
COUPON 1-5	Compressive shear deformation.

	<u>S-301 EPOXY</u>
COUPON 1-5	Compressive shear deformation.

<u>ASTM D 790</u>	<u>M-201 EPOXY</u>
COUPON 1-3,5,6	Lateral brittle failure at midspan.

	<u>S-301 EPOXY</u>
COUPON 2-4,6,7	Lateral brittle failure at midspan.

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INFRASTRUCTURE REPAIR SYSTEMS, INC.
M-201 & S-301 EPOXY SYSTEMS
DATA SUMMARY

TEST METHOD <u>ASTM D 638</u>	<u>EPOXY</u>	TENSILE STRENGTH (psi)_____	TENSILE MODULUS (psi)_____	ELONG. (%)_____
	M-201	7,491	498,656	1.946
	S-301	8,228	463,516	1.886

TEST METHOD <u>ASTM D 695</u>	<u>EPOXY</u>	COMPRESSIVE STRENGTH (psi)_____	COMPRESSIVE MODULUS (psi)_____
	M-201	13,095	582,629
	S-301	13,627	542,290

TEST METHOD <u>ASTM D 790</u>	<u>EPOXY</u>	FLEXURAL STRENGTH (psi)_____	FLEXURAL MODULUS (psi)_____
	M-201	13,875	547,776
	S-301	16,917	465,306

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INFRASTRUCTURE REPAIR SYSTEMS, INC.
M-201 & S-301 EPOXY SYSTEMS
DATA SUMMARY

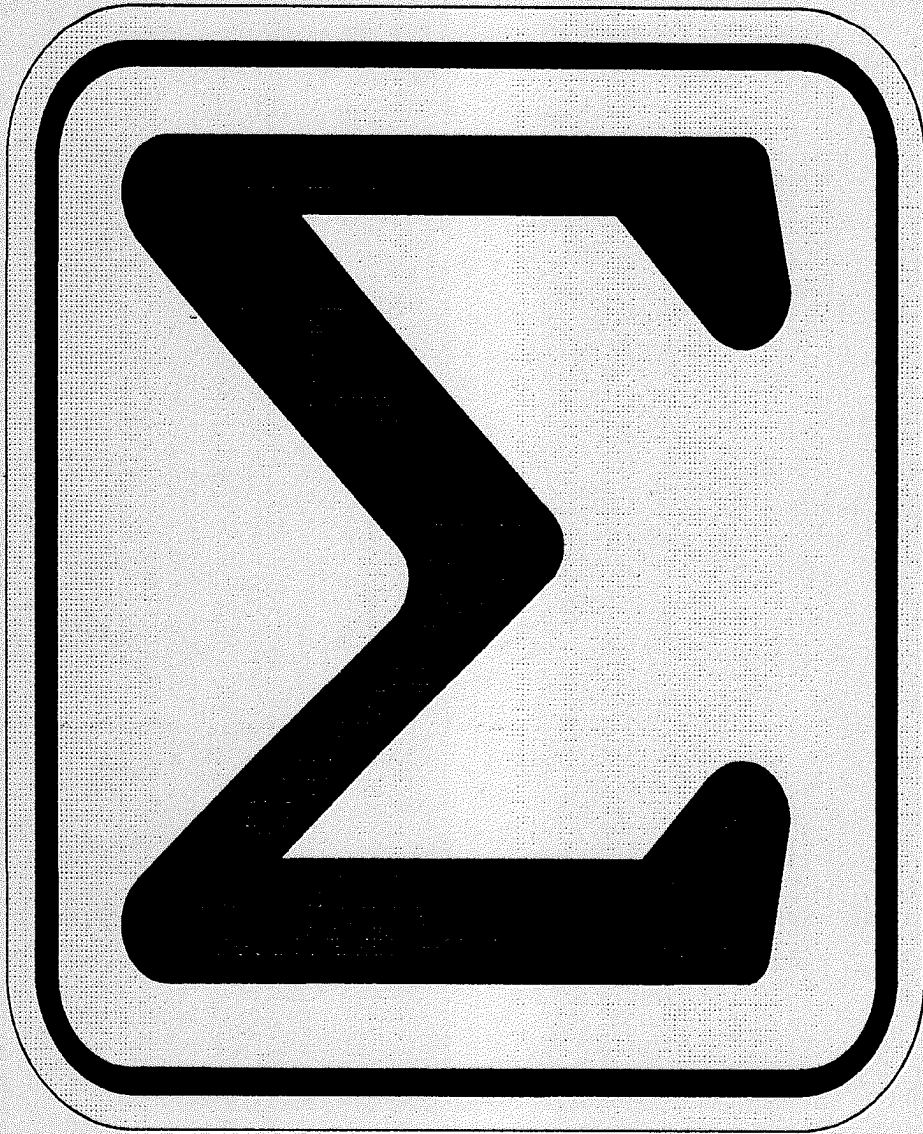
<u>TEST METHOD</u> <u>ASTM D 2240</u>	<u>EPOXY</u>	<u>HARDNESS</u> <u>MOLD SIDE</u>
	M-201	86.6*
	S-301	84.7*

* Figures represent the average of remaining readings after high/low readings have been discarded.

<u>TEST METHOD</u> <u>ASTM C 297</u>	<u>EPOXY</u>	<u>SUBSTRATE</u>	<u>COUPON</u>	<u>TENSILE PULL-OFF</u> <u>STRENGTH</u> <u>(psi)</u>
	M-201	STEEL	1	2,608
			2	2,487
		CONCRETE	1	>414*
			2	>430*
			3	>405*
	S-301	STEEL	1	845
			2	1,357
		CONCRETE	1	>453*
			2	>466*
			3	>472*

* Figures represent Substrate failure, refer to ASTM C 297 Observations.

DATA



Sigma Labs

Generic Test, Group Summary

Tues., May 27, 1997

Group Population Count = 2

Sample type identification:

C 297,

M-201 EPOXY/STEEL

English Units

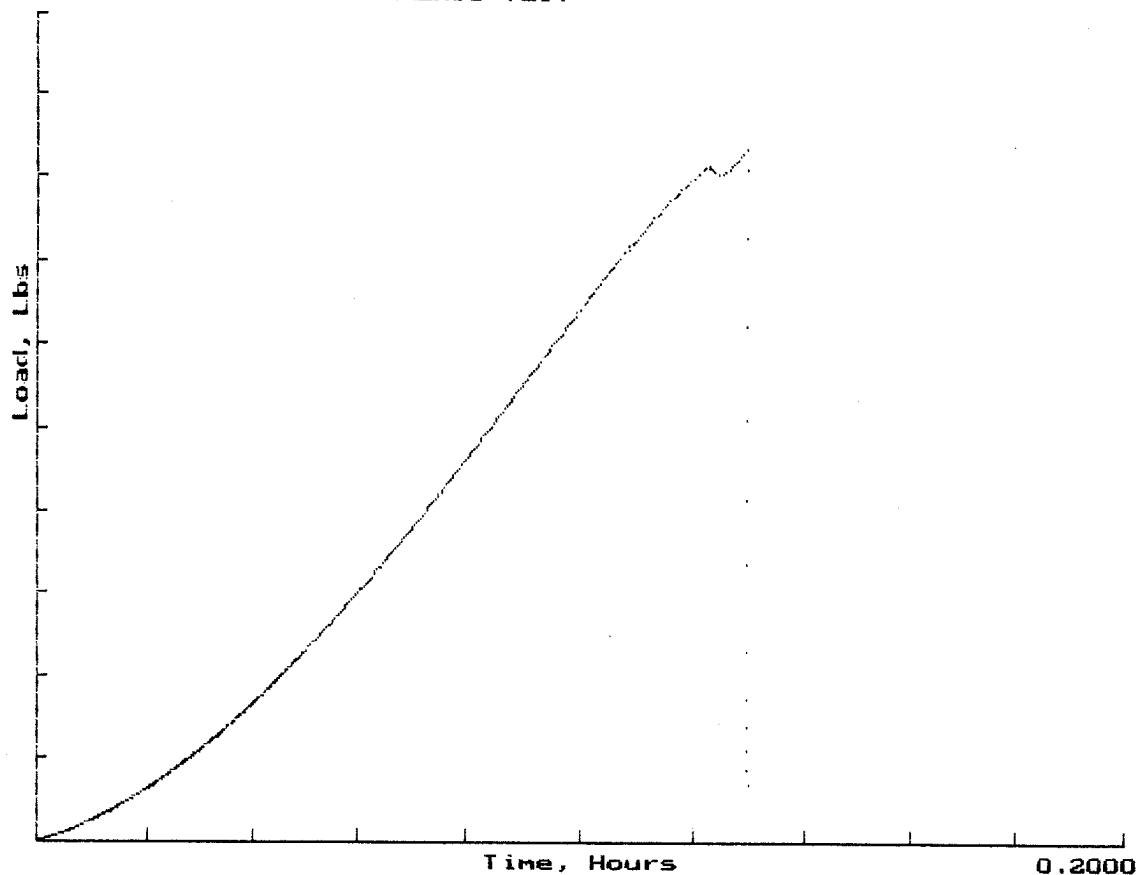
File Set Names:

P7059001 P7059002

	Avg.	Std. Dev.	Coef. of Var. (%)
LOAD (Lbs)	12212.550	502.12	4.11
STRESS (PSI)	2547.35	85.77	3.37
STRAIN (%)	0.000	0.000	0.00

15000.0000

GENERIC TEST

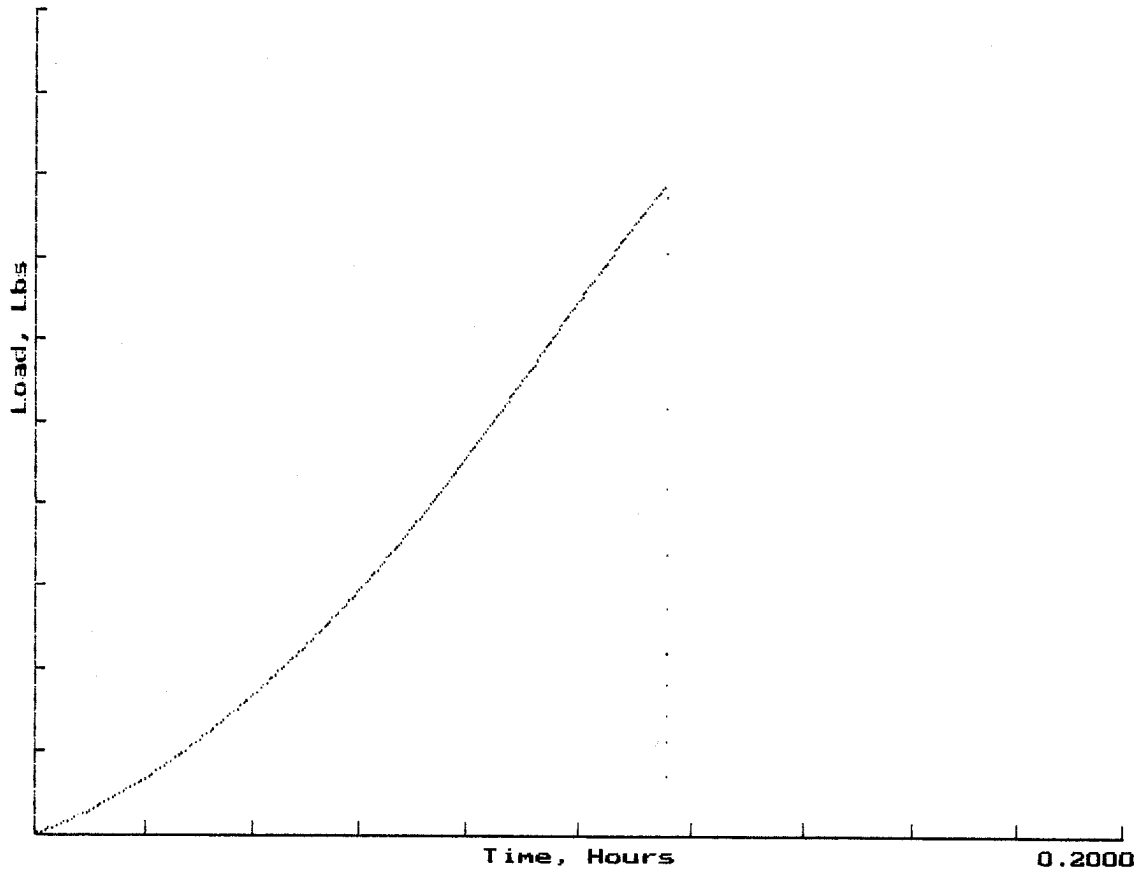


Generic Test Results

Specimen Number => 1 Tue., May. 27, 1997 STEEL
Sample type identification: C 297, M201
File Set Names: P7059001 P7059001
Diameter = 2.48 In AREA = 4.819 In^2
Values at Peak Load: 12567.6 Lbs, 2608.0 PSI, 0.727 In, 0.000 %
Values at Break Load: 927.8 Lbs, 192.5 PSI, 0.998 In, 0.000 %

15000.0000

GENERIC TEST



Generic Test Results

Specimen Number => 2 Tue., May. 27, 1997
Sample type identification: C 297, M201
File Set Names: P7059001 P7059001
Diameter = 2.46 In AREA = 4.768 In^2

Values at Peak Load: 11857.5 Lbs, 2486.7 PSI, 0.077 In, 0.000 %
Values at Break Load: 677.3 Lbs, 142.0 PSI, 0.346 In, 0.000 %

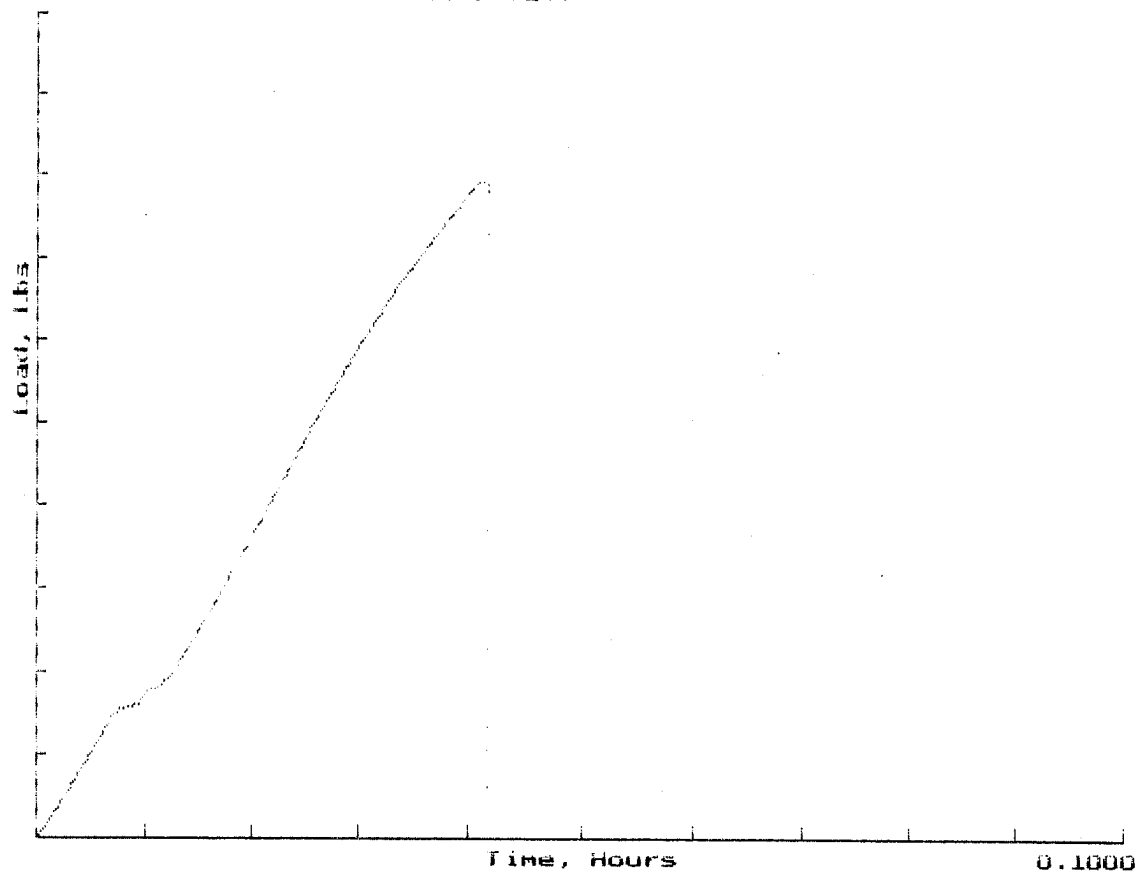
Generic Test, Group Summary
Wed., May. 28, 1997
Group Population Count = 3

Sample type identification: C297, M201 EPOXY/CONCRETE
ENGLISH Units
File Set Names: Y7059001 Y7059002

	Avg.	Std. Dev.	Coef. of Var. (%)
LOAD (Lbs)	2000.3079	62.2044	3.11
STRESS (PSI)	416.11	12.83	3.08
STRAIN (%)	0.00000	0.00000	0.00

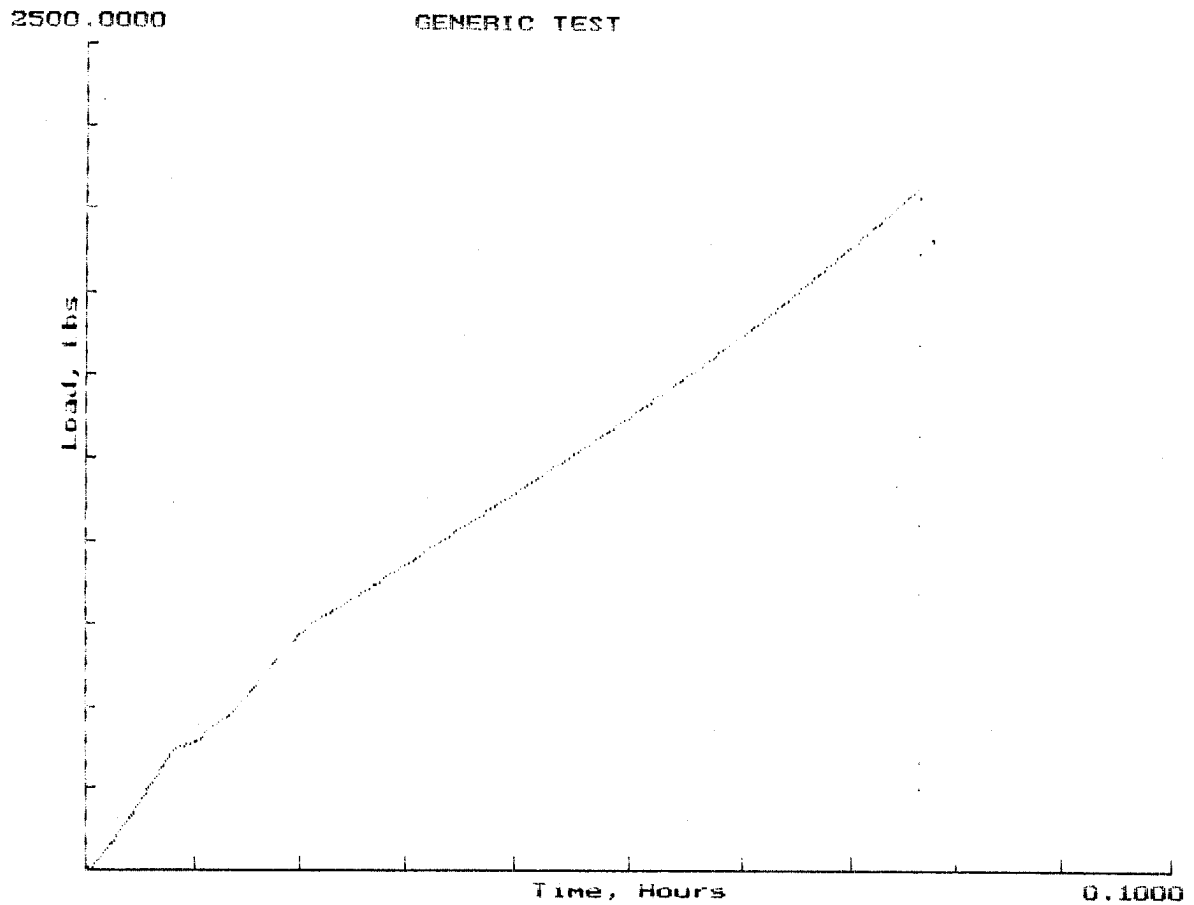
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GENERIC TEST



Generic Test Results

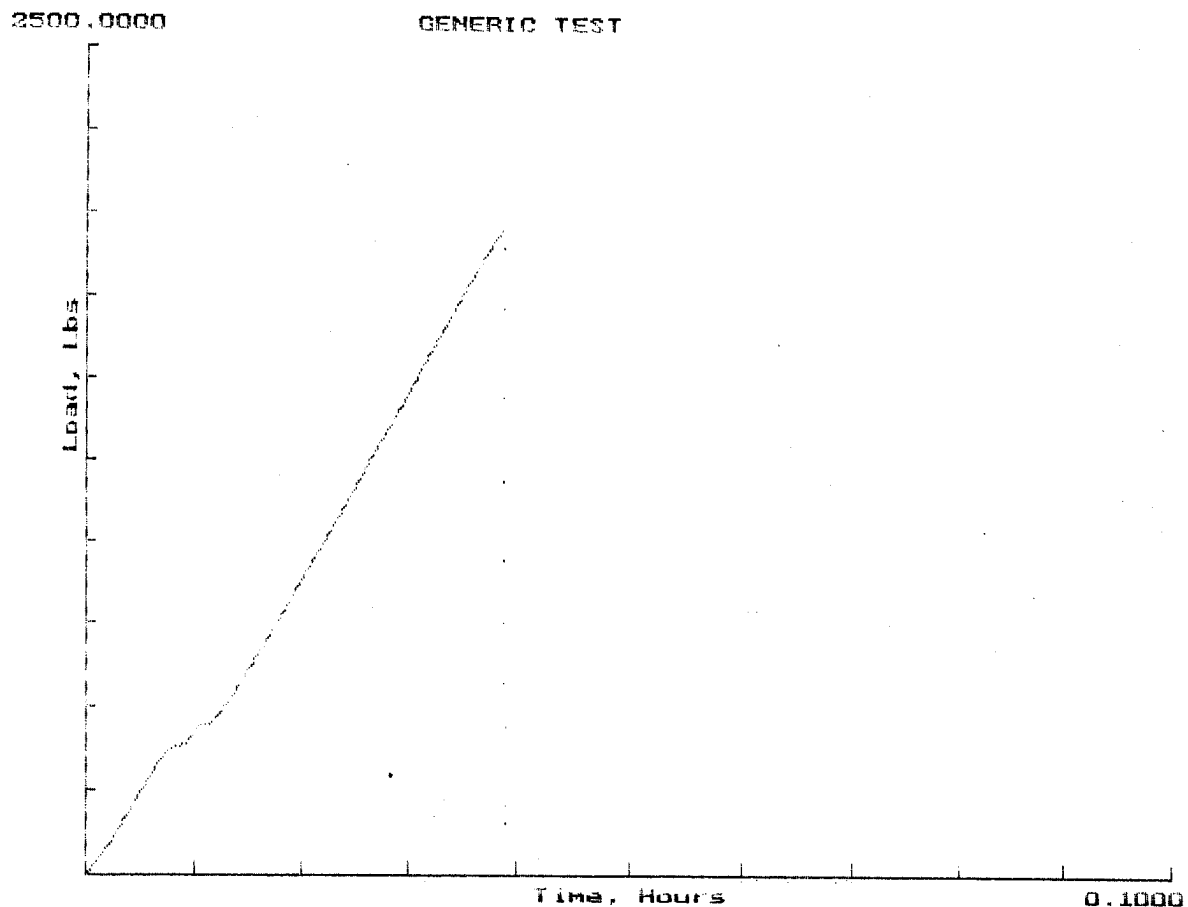
Specimen Number => 1 Wed., May. 28, 1997
Sample type identification: C297, ,M201 EPOXY/CONCRET
File Set Names: Y7059001 Y7059001
Diameter = 2.47 In AREA = 4.799 In²
Values at Peak Load: 1985.9 Lbs, 413.8 PSI, 0.193 In, 0.000 %
Values at Break Load: 488.8 Lbs, 101.9 PSI, 0.281 In, 0.000 %



Generic Test Results

Specimen Number => 2 Wed., May. 28, 1997
Sample type identification: C297, M201 EPOXY/CONCRETE
File Set Names: Y7059001 Y7059001
Diameter = 2.47 In AREA = 4.811 In²

Values at Peak Load: 2068.4 Lbs, 429.9 PSI, 0.079 In, 0.000 %
Values at Break Load: 419.2 Lbs, 87.1 PSI, 0.131 In, 0.000 %



Generic Test Results

Specimen Number => 3 Wed., May. 28, 1997
 Sample type identification: C297, ,M201 EPOXY/CONCRET
 File Set Names: Y7059001 Y7059002
 Diameter = 2.47 In AREA = 4.811 In²

Values at Peak Load: 1946.6 Lbs, 404.6 PSI, 0.087 In, 0.000 %
 Values at Break Load: 437.1 Lbs, 90.8 PSI, 0.174 In, 0.000 %

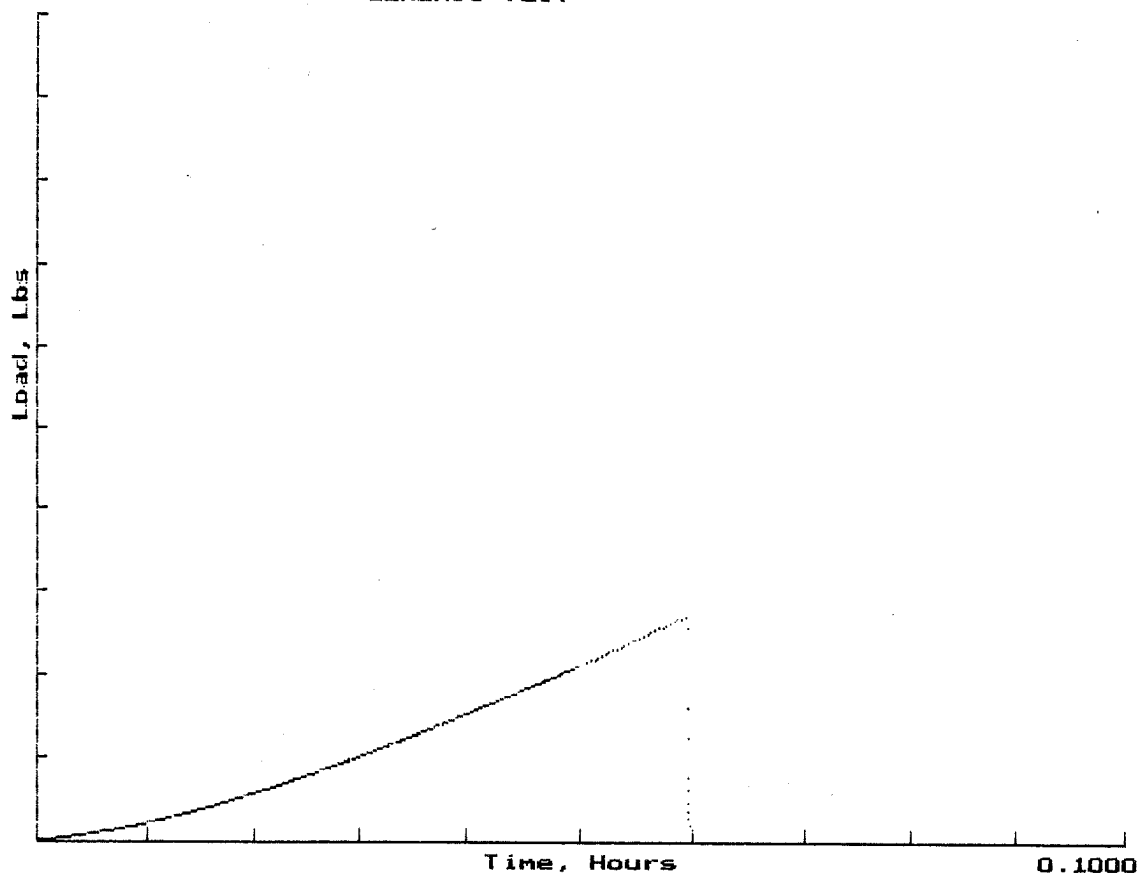
Generic Test, Group Summary
Tues., May 27, 1997
Group Population Count = 2

Sample type identification: C 297, S-301 EPOXY/STEEL
English Units
File Set Names: Q7059001 Q7059002

	Avg.	Std. Dev.	Coef. of Var. (%)
LOAD (Lbs)	5293.900	1729.02	32.66
STRESS (PSI)	1100.80	361.90	32.88
STRAIN (%)	0.000	0.000	0.00

15000.0000

GENERIC TEST



Generic Test Results

Specimen Number => 1

Tue., May. 27, 1997

STEEL

Sample type identification:

C297,

S301

File Set Names:

Q7059001

Q7059001

Diameter = 2.48 In

AREA = 4.819 In²

Values at Peak Load: 4071.3 Lbs, 844.9 PSI, 0.356 In, 0.000 %

Values at Break Load: 628.7 Lbs, 130.5 PSI, 0.421 In, 0.000 %

Q7059002

Max Load= 6506.15 Lbs Max Stress = 1354.5 PSI

Max Disp= 0.207 inches Max Strain = 0.00 %

C 297, S-301/STEEL

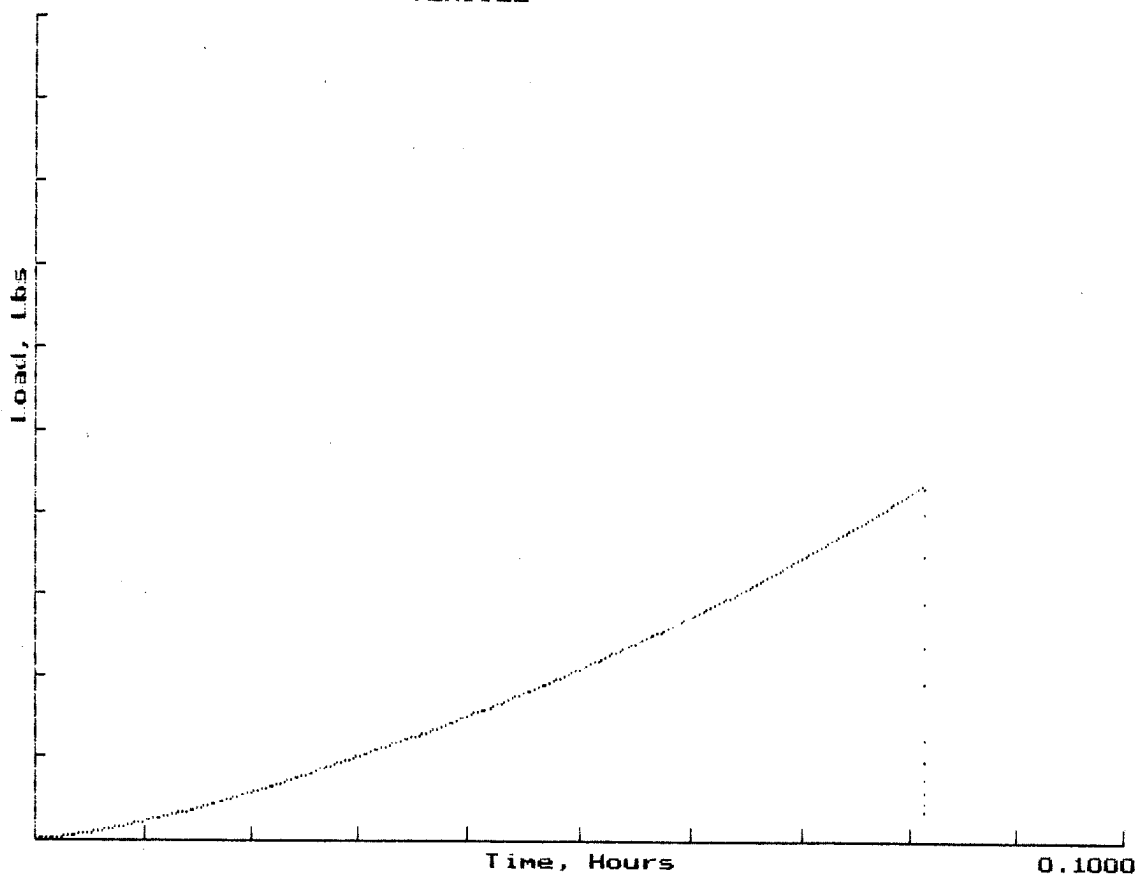
Post Processing Group Summary

Group Population Count = 1

	Avg.	Std. Dev.	Coef. of Var. (%)
LOAD (Lbs)	6506.15	0.00	0.00
STRESS (PSI)	1354.52	0.00	0.00
YIELD (PSI)	0.00	0.00	0.00
MODULUS (PSI)	0.00	0.00	0.00
STRAIN (%)	0.000000	0.000000	0.00
POISSONS RATIO	0.000	0.000	0.00

15000.0000

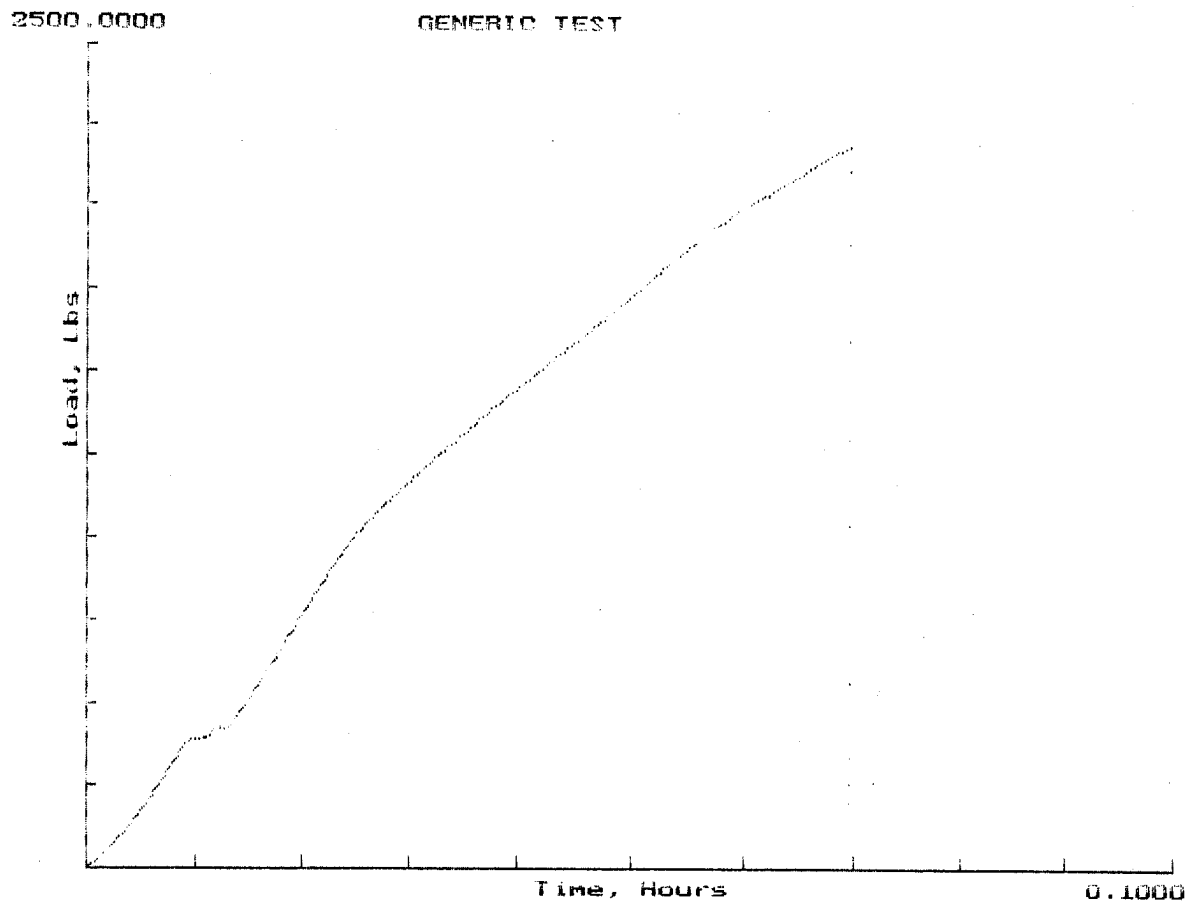
TENSILE



Generic Test, Group Summary
Wed., May. 28, 1997
Group Population Count = 3

Sample type identification: C297, S301 EPOXY/CONCRETE
ENGLISH Units
File Set Names: X7059001 X7059002

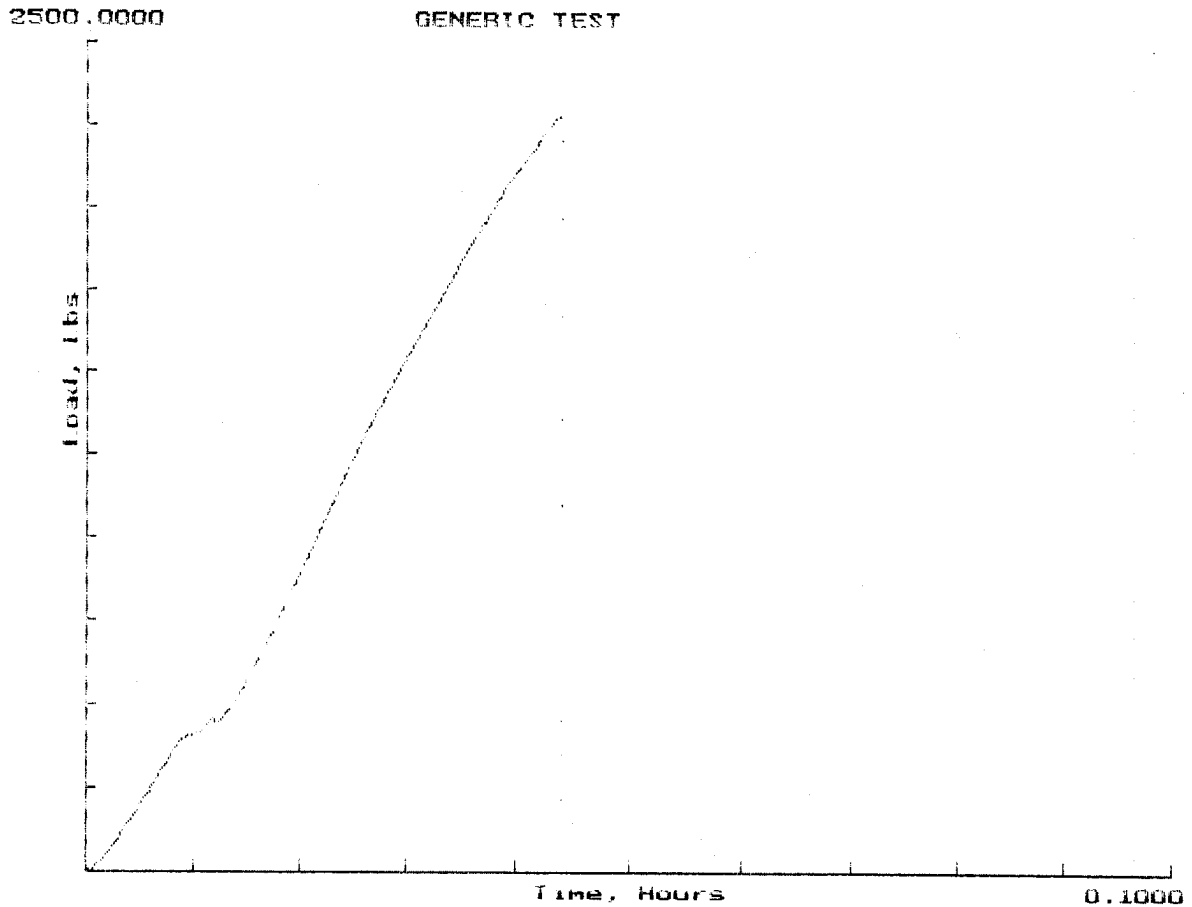
	Avg.	Std. Dev.	Coef. of Var. (%)
LOAD (Lbs)	2236.2501	47.7793	2.14
STRESS (PSI)	463.44	9.57	2.07
STRAIN (%)	0.00000	0.00000	0.00



Generic Test Results

Specimen Number => 1 Wed., May. 28, 1997
Sample type identification: C297, S301 EPOXY/CONCRE
File Set Names: X7059001 X7059001
Diameter = 2.48 In AREA = 4.823 In²

Values at Peak Load: 2184.5 Lbs, 453.0 PSI, 0.090 In, 0.000 %
Values at Break Load: 421.6 Lbs, 27.4 PSI, 0.202 In, 0.000 %



Generic Test Results

Specimen Number => 3 Wed., May. 28, 1997
Sample type identification: C297, S301 EPOXY/CONCRE
File Set Names: X7059001 X7059002
Diameter = 2.48 In AREA = 4.831 In²

Values at Peak Load: 2278.8 Lbs, 471.7 PSI, 0.075 In, 0.000 %
Values at Break Load: 425.4 Lbs, 88.1 PSI, 0.138 In, 0.000 %

Tensile Test, Group Summary

Wed., May 28, 1997

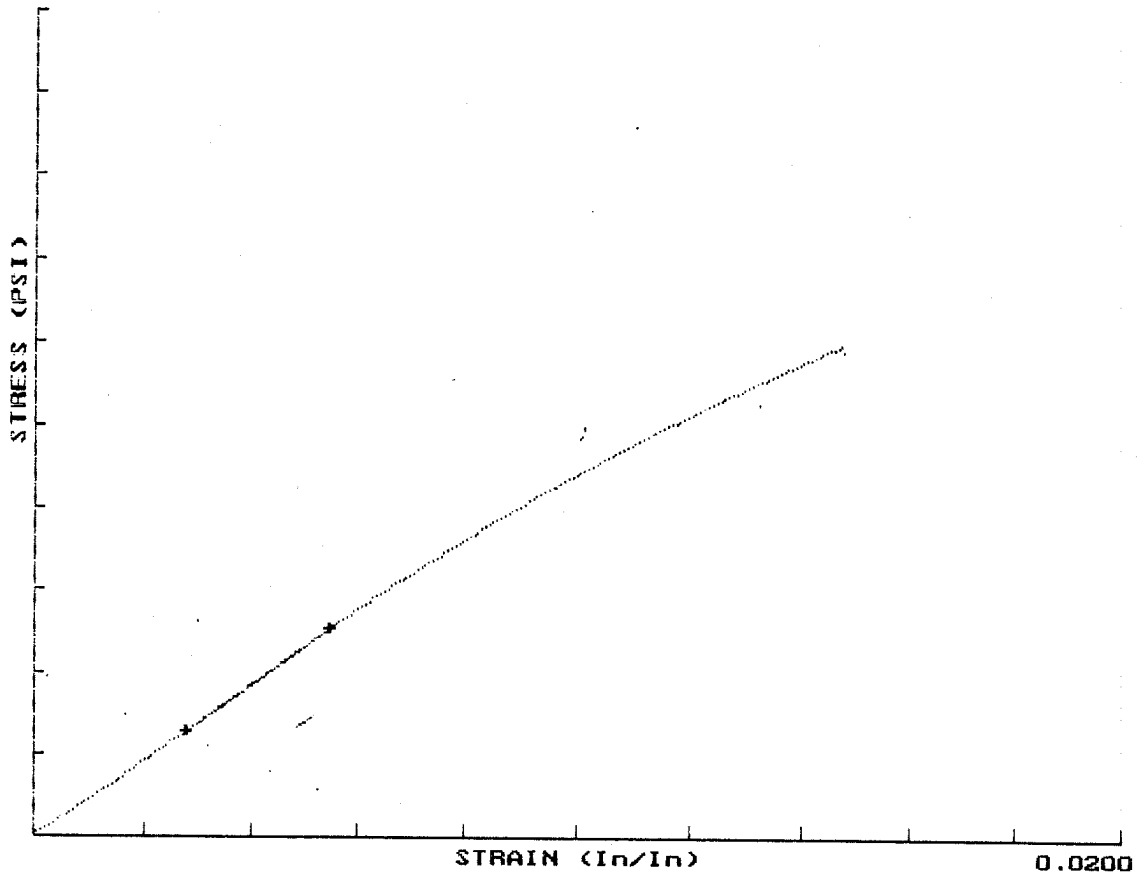
Group Population Count = 5

Sample type identification: D-638, M-201 EPOXY CASTING
Gage Length: 1 In
Extensometer type: Other Type Extensometer
ENGLISH Units
File Set Names: T7059001 T7059005

	Avg.	Std. Dev.	Coef. of Var. (%)
MODULUS (PSI)	498656.00	33437.85	6.71
LOAD (LBS)	462.0400	49.7101	10.76
STRESS (PSI)	7490.82	880.85	11.76
STRAIN (%)	1.94600	0.06730	3.46

10000.0000

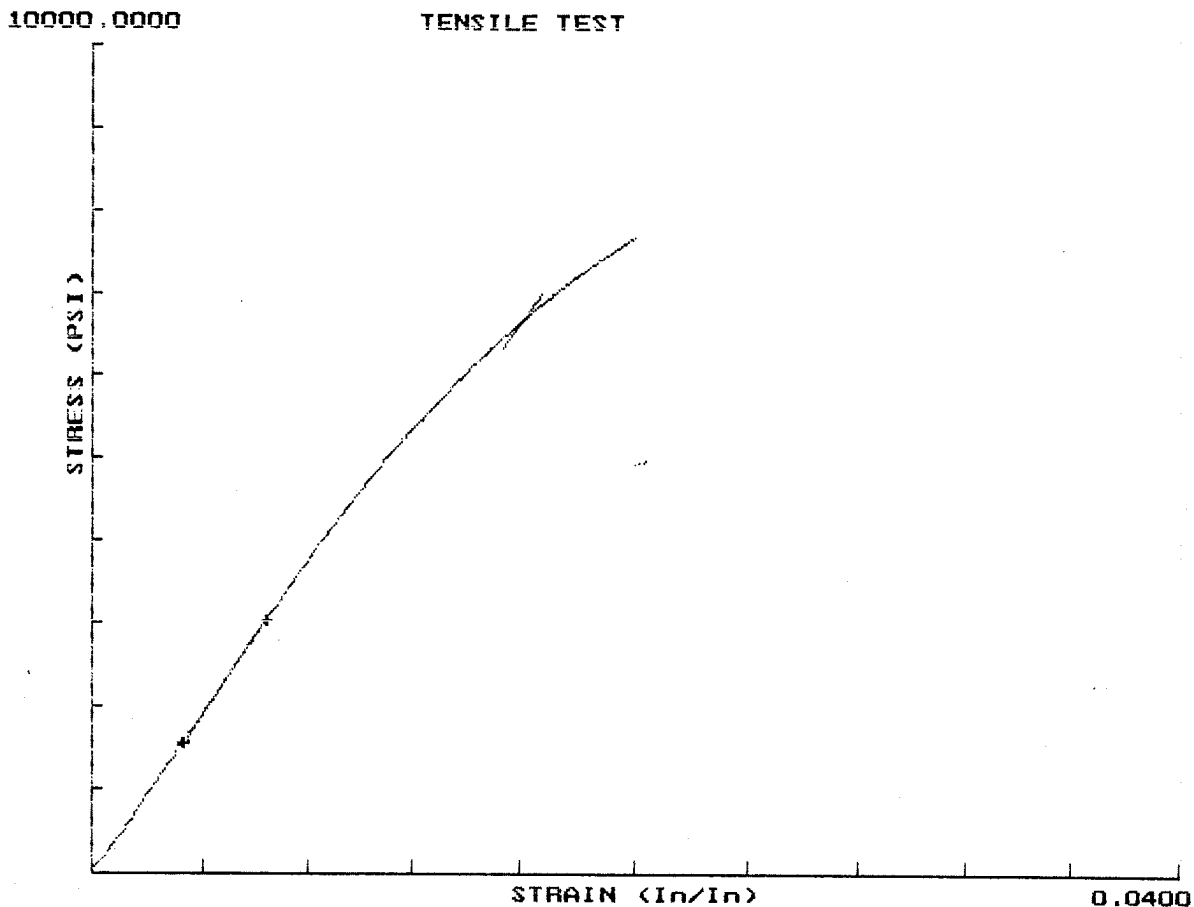
TENSILE TEST



Tensile Test Results

Specimen Number => 1 Wed., May. 28, 1997
 Sample type identification: D638, ,M-201 EPOXY CASTING
 Gage Length 1.0 In
 Extensometer type: Other Type Extensometer
 File Set Names: T7059001 T7059001
 Width = 0.492 In Thickness = 0.128 In AREA = 0.063 In²

 Youngs Modulus = 462689 PSI
 Yield Stress = 1400 PSI
 Yield Strain = 0.436 %
 Values at Peak Load: 376.5 Lbs, 6004.2 PSI, 0.348 In, 1.473 %
 Values at Break Load: 68.6 Lbs, 1094.1 PSI, 0.349 In, 0.317 %

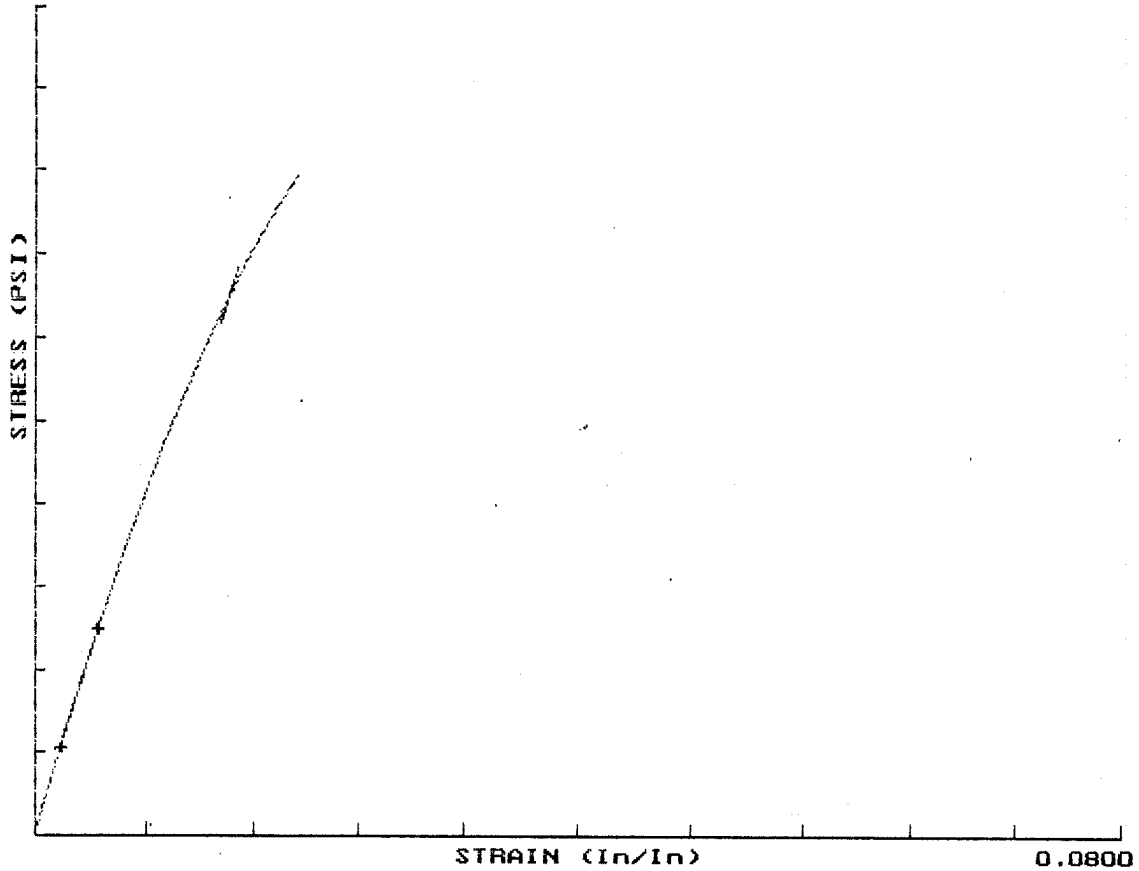


Tensile Test Results

Specimen Number =>	2	Wed., May. 28, 1997	
Sample type identification:	D638,		M-201 EPOXY CASTING
Gage Length	1.0 In		
Extensometer type:	Other Type Extensometer		
File Set Names:	T7059001 T7059001		
Width = 0.489 In	Thickness = 0.129 In	AREA = 0.063 In ²	
Youngs Modulus	=	474683 PSI	
Yield Stress	=	6666 PSI	
Yield Strain	=	1.605 %	
Values at Peak Load:	484.8 Lbs,	7690.3 PSI,	0.134 In, 2.001 %
Values at Break Load:	312.2 Lbs,	4952.6 PSI,	0.145 In, 1.094 %

10000.0000

TENSILE TEST



Tensile Test Results

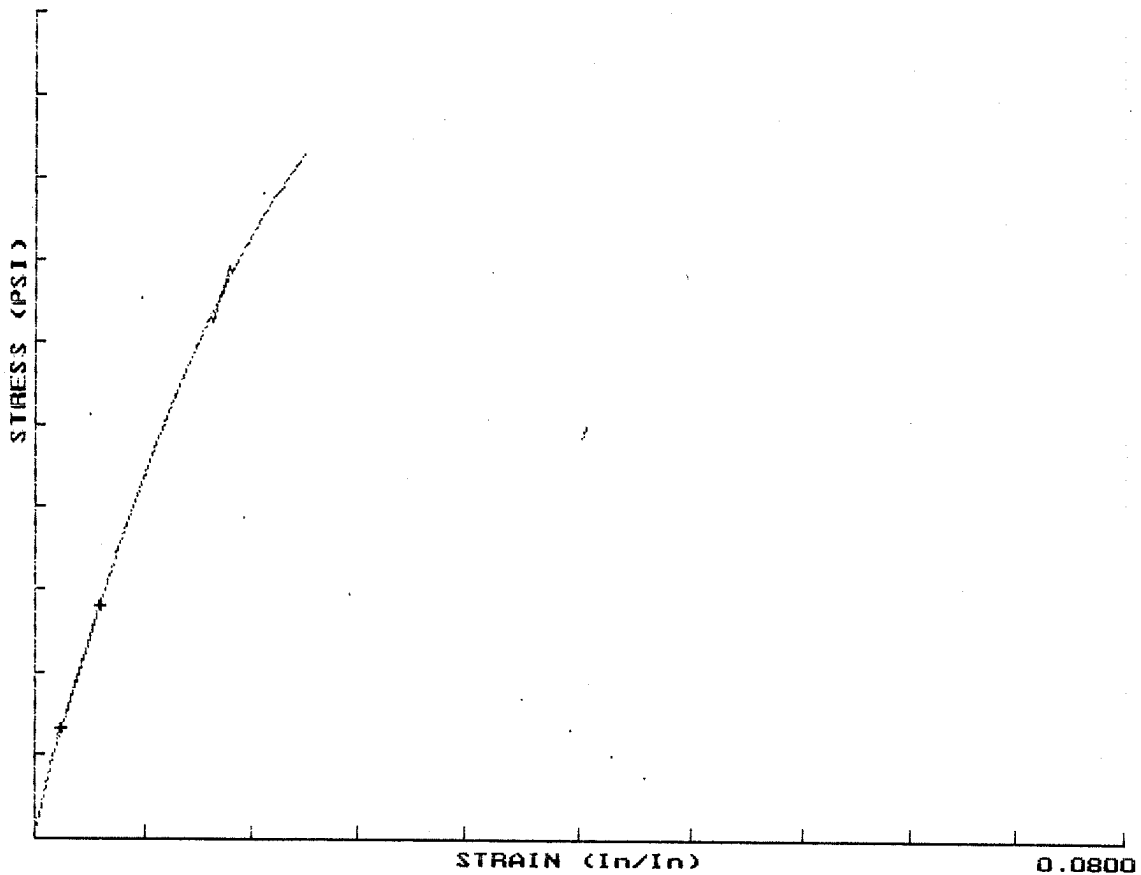
Specimen Number => 3 Wed., May. 28, 1997
Sample type identification: D638, M-201 EPOXY CASTING
Gage Length 1.0 In
Extensometer type: Other Type Extensometer
File Set Names: T7059001 T7059002
Width = 0.478 In Thickness = 0.127 In AREA = 0.061 In²

Youngs Modulus = 527253 PSI
Yield Stress = 6513 PSI
Yield Strain = 1.417 %

Values at Peak Load: 481.8 Lbs, 7940.7 PSI, 0.170 In, 1.923 %
Values at Break Load: 339.7 Lbs, 5597.7 PSI, 0.178 In, 1.155 %

10000.0000

TENSILE TEST

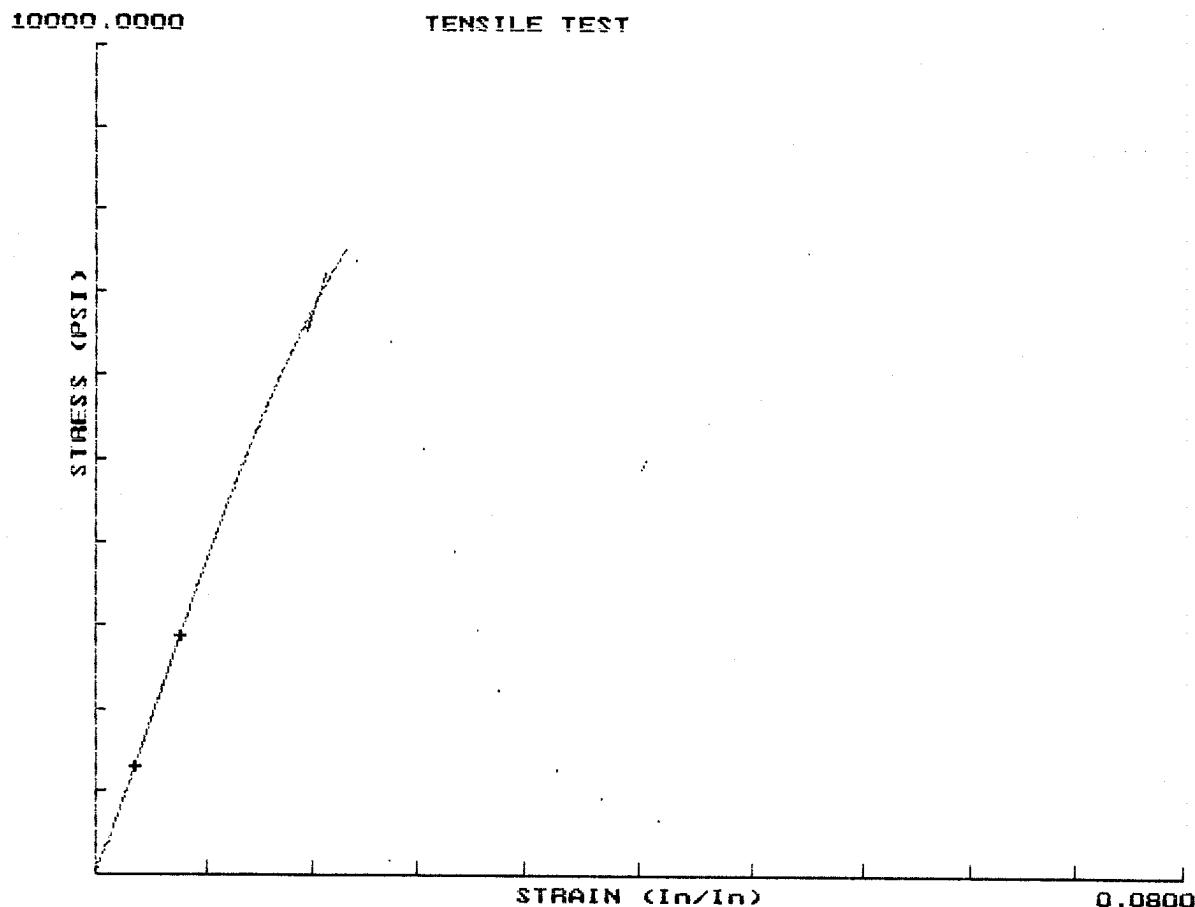


Tensile Test Results

Specimen Number => 4 Wed., May. 28, 1997
 Sample type identification: D638, M-201 EPOXY CASTING
 Gage Length 1.0 In
 Extensometer type: Other Type Extensometer
 File Set Names: T7059001 T7059003
 Width = 0.479 In Thickness = 0.127 In AREA = 0.061 In²

Youngs Modulus = 539774 PSI
 Yield Stress = 6579 PSI
 Yield Strain = 1.366 %

Values at Peak Load: 502.7 Lbs, 8297.3 PSI, 0.140 In, 1.999 %
 Values at Break Load: 308.6 Lbs, 5094.4 PSI, 0.154 In, 0.963 %



Tensile Test Results

Specimen Number =>	5	Wed., May. 28, 1997	
Sample type identification:	D638,		M-201 EPOXY CASTING
Gage Length	1.0 In		
Extensometer type:	Other Type Extensometer		
File Set Names:	T7059001 T7059004		
Width = 0.484 In	Thickness = 0.128 In	AREA = 0.062 In ²	

Youngs Modulus	=	488881 PSI		
Yield Stress	=	6867 PSI		
Yield Strain	=	1.624 %		
Values at Peak Load:	464.4 Lbs,	7521.6 PSI,	0.109 In,	1.861 %
Values at Break Load:	303.4 Lbs,	4912.7 PSI,	0.117 In,	1.066 %

Tensile Test, Group Summary

Wed., May 28, 1997

Group Population Count =

5

Sample type identification:

D-638,

S-301 EPOXY CASTING

Gage Length:

1 In

Extensometer type:

Other Type Extensometer

ENGLISH Units

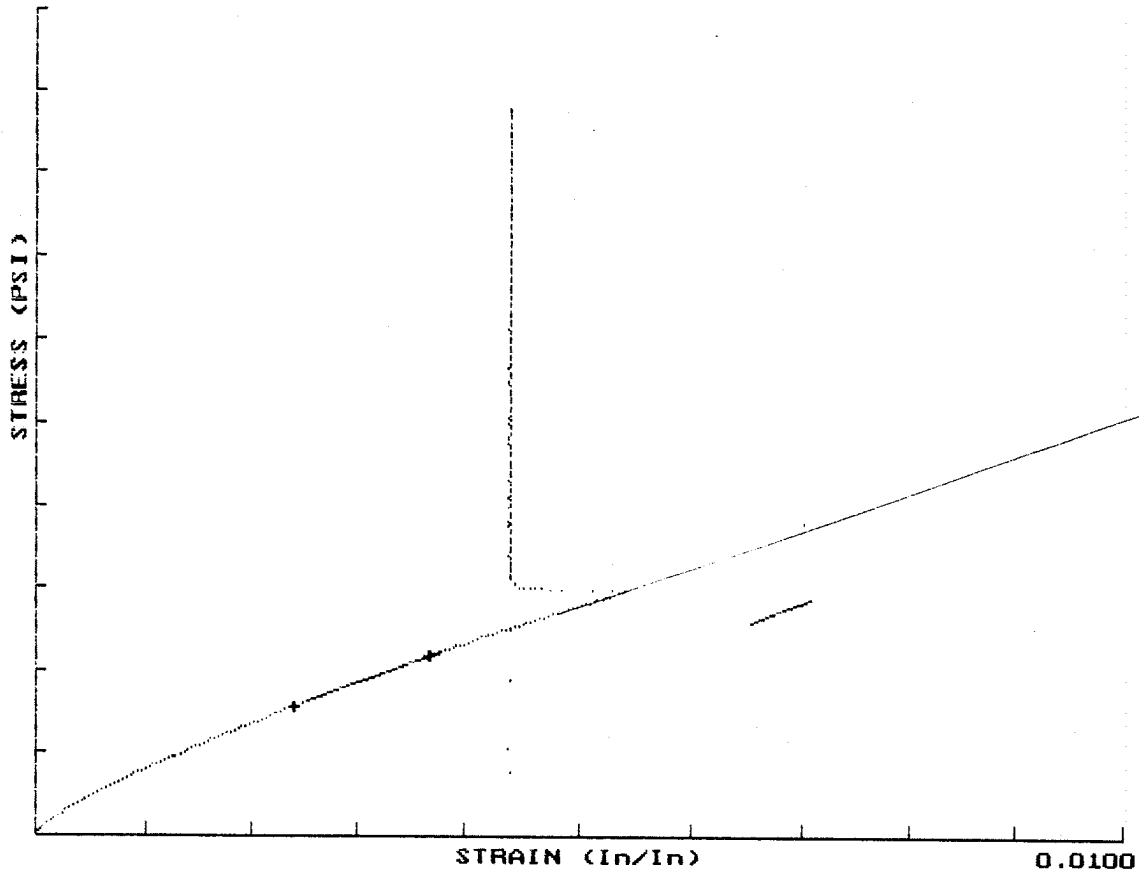
File Set Names:

U7059001 U7059005

	Avg.	Std. Dev.	Coef. of Var. (%)
MODULUS (PSI)	463516.40	19511.73	4.21
LOAD (LBS)	483.6600	36.8630	7.62
STRESS (PSI)	8228.08	648.08	7.88
STRAIN (%)	1.88588	0.17513	9.29

10000.0000

TENSILE TEST



Tensile Test Results

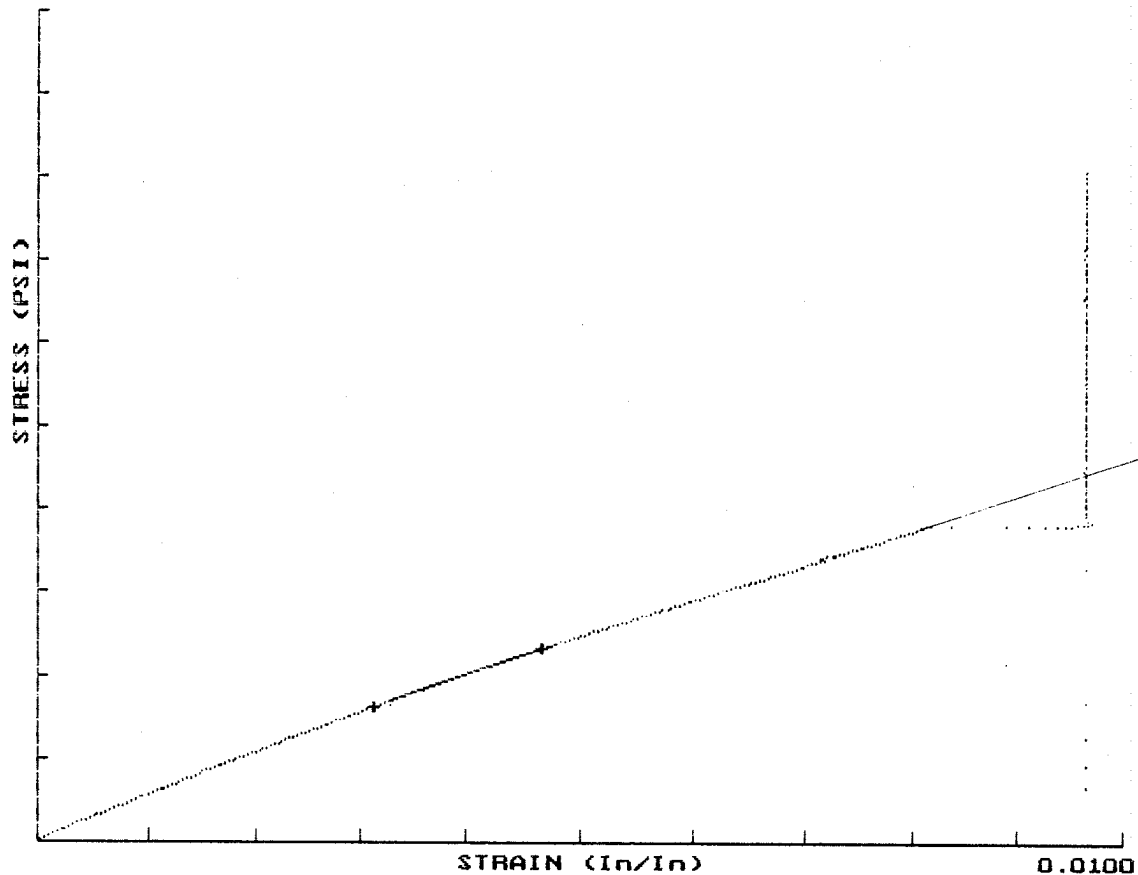
Specimen Number => 1 Wed., May. 28, 1997
 Sample type identification: D638, S-301 EPOXY CASTING
 Gage Length 1.0 In
 Extensometer type: Other Type Extensometer
 File Set Names: U7059001 U7059001
 Width = 0.478 In Thickness = 0.122 In AREA = 0.058 In²

Youngs Modulus = 486096 PSI
 Yield Stress = 2729 PSI
 Yield Strain = 0.441 %

Values at Peak Load: 514.1 Lbs, 8818.3 PSI, 0.940 In, 0.441 %
 Values at Break Load: 110.4 Lbs, 1892.9 PSI, 0.941 In, 0.440 %

10000.0000

TENSILE TEST



Tensile Test Results

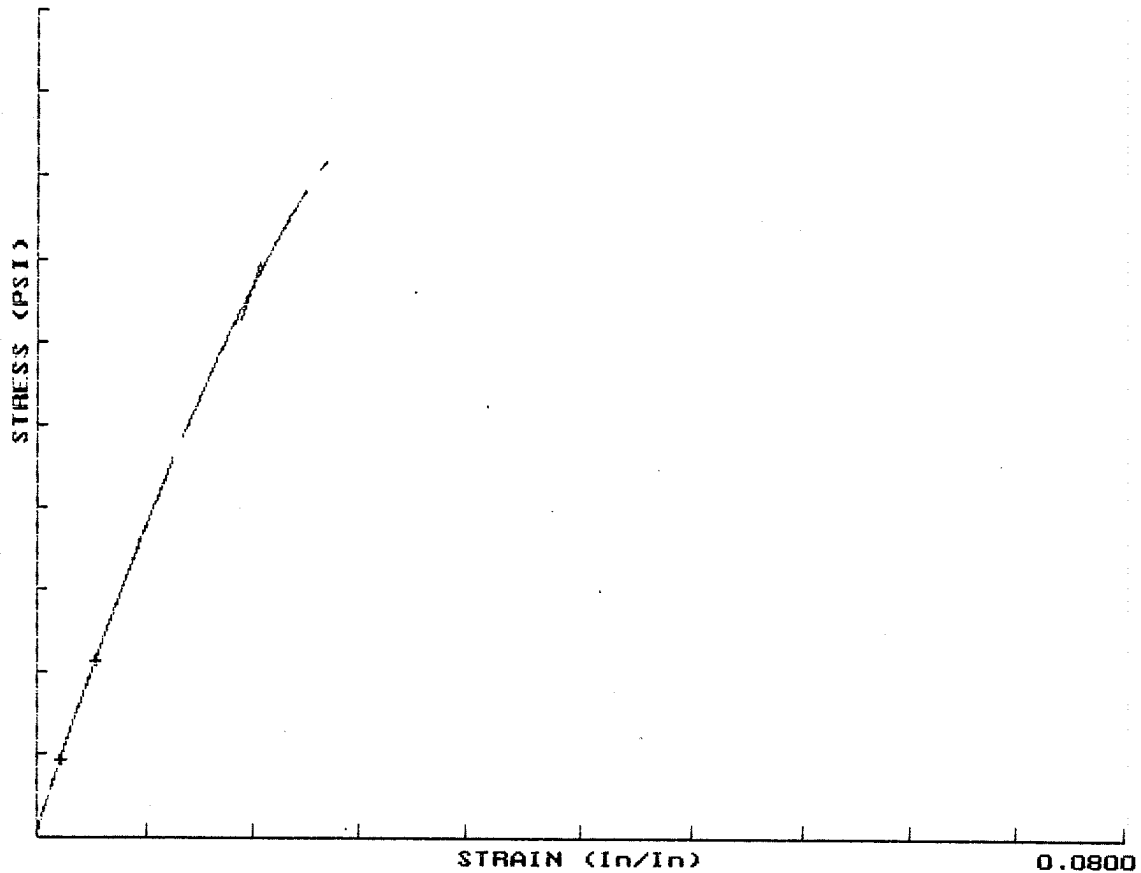
Specimen Number => 3 Wed., May. 28, 1997
Sample type identification: D638, S-301 EPOXY CASTING
Gage Length 1.0 In
Extensometer type: Other Type Extensometer
File Set Names: U7059001 U7059002
Width = 0.486 In Thickness = 0.121 In AREA = 0.059 In²

Youngs Modulus = 451536 PSI
Yield Stress = 5431 PSI
Yield Strain = 0.966 %

Values at Peak Load: 478.1 Lbs, 8134.8 PSI, 0.174 In, 0.966 %
Values at Break Load: 348.4 Lbs, 5928.1 PSI, 0.178 In, 0.966 %

10000.0000

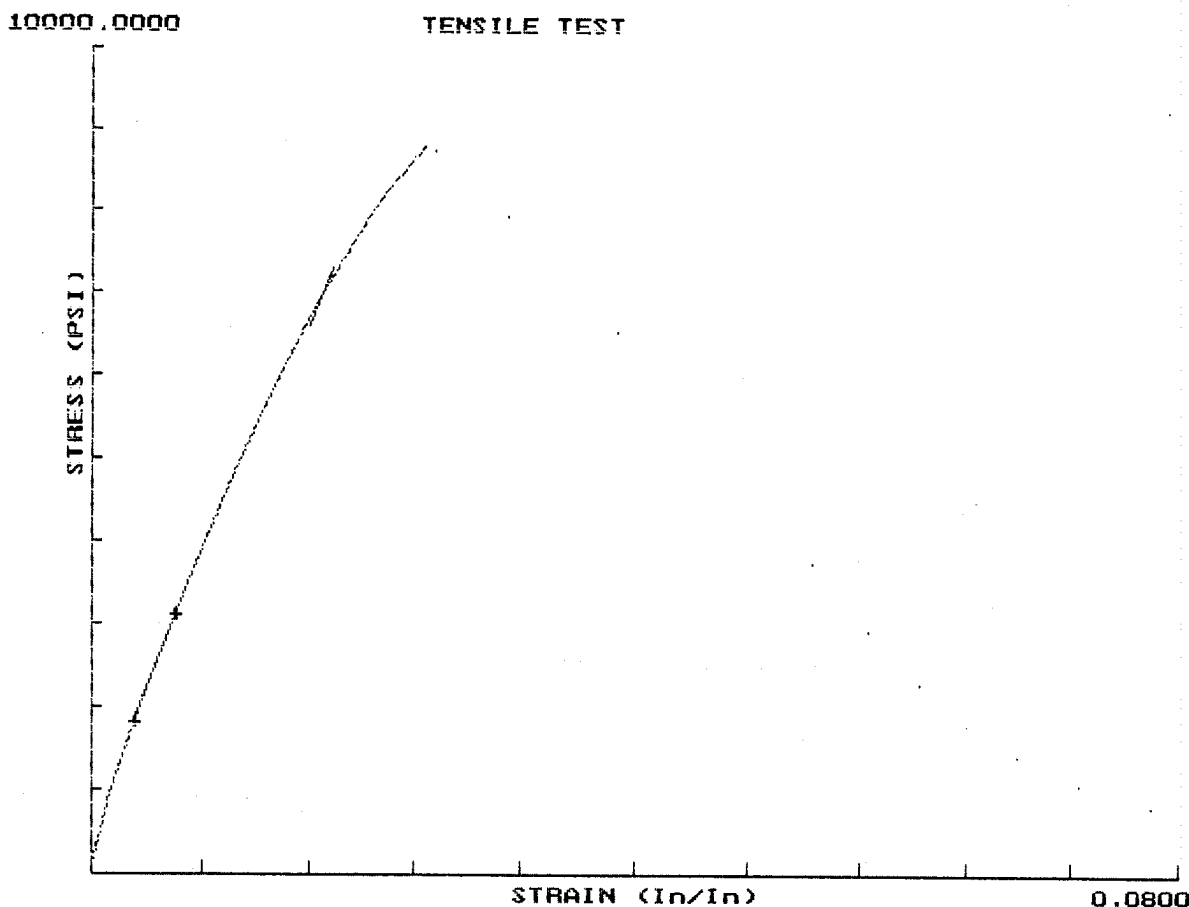
TENSILE TEST



Tensile Test Results

Specimen Number => 4 Wed., May. 28, 1997
Sample type identification: D638, S-301 EPOXY CASTING
Gage Length 1.0 In
Extensometer type: Other Type Extensometer
File Set Names: U7059001 U7059003
Width = 0.489 In Thickness = 0.120 In AREA = 0.059 In²

Youngs Modulus = 472634 PSI
Yield Stress = 6627 PSI
Yield Strain = 1.573 %
Values at Peak Load: 478.2 Lbs, 8158.0 PSI, 0.142 In, 2.143 %
Values at Break Load: 264.6 Lbs, 4514.5 PSI, 0.156 In, 0.979 %

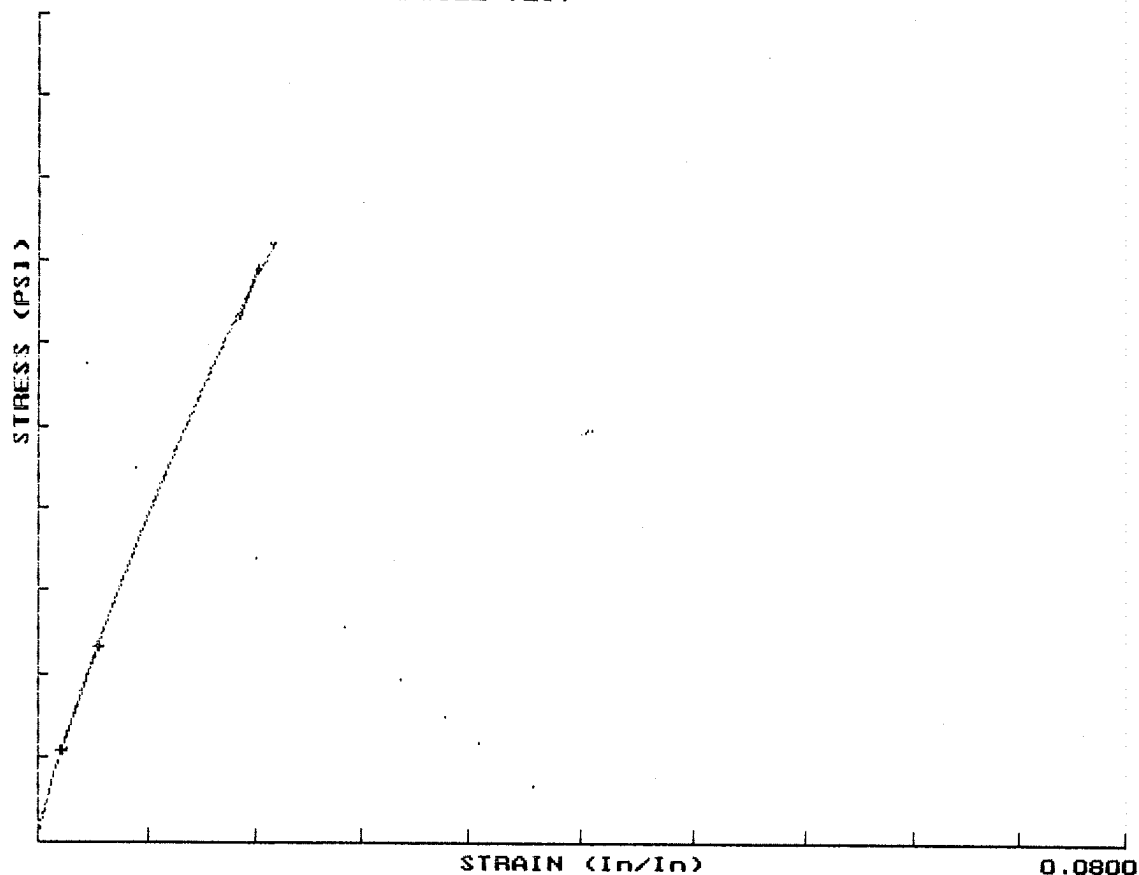


Tensile Test Results

Specimen Number =>	5	Wed., May. 28, 1997	
Sample type identification:	D638,		,S-301 EPOXY CASTING
Gage Length	1.0 In		
Extensometer type:	Other Type Extensometer		
File Set Names:	U7059001 U7059004		
Width = 0.481 In	Thickness= 0.123 In	AREA = 0.059 In ²	
Youngs Modulus	=	436454 PSI	
Yield Stress	=	6958 PSI	
Yield Strain	=	1.688 %	
Values at Peak Load:	520.1 Lbs,	8797.9 PSI,	0.107 In, 2.483 %
Values at Break Load:	257.6 Lbs,	4358.1 PSI,	0.127 In, 0.918 %

10000.0000

TENSILE TEST



Tensile Test Results

Specimen Number => 6 Wed., May. 28, 1997
Sample type identification: D638, ,S-301 EPOXY CASTING
Gage Length 1.0 In
Extensometer type: Other Type Extensometer
File Set Names: U7059001 U7059001
Width = 0.489 In Thickness= 0.121 In AREA = 0.059 In^2

Youngs Modulus = 470862 PSI
Yield Stress = 6619 PSI
Yield Strain = 1.547 %

Values at Peak Load: 427.8 Lbs, 7231.4 PSI, 0.208 In, 1.752 %
Values at Break Load: 310.5 Lbs, 5249.5 PSI, 0.213 In, 1.146 %

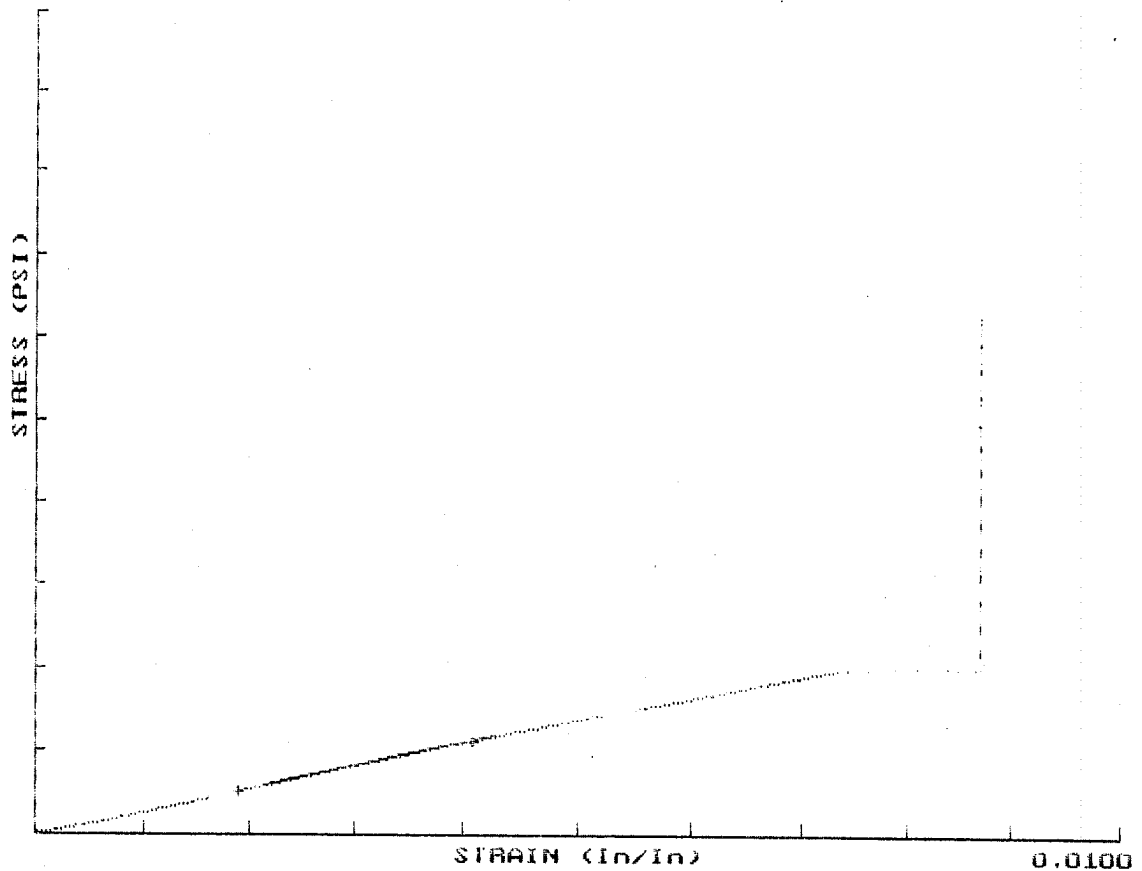
Compression Test, Group Summary
Wed., May. 28, 1997
Group Population Count = 5

Sample type identification: D695, , M201 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
ENGLISH Units
File Set Names: V7059001 V7059004

	Avg.	Std. Dev.	Coef. of Var. (%)
MODULUS (PSI)	582628.68	37969.30	6.52
LOAD (Lbs)	3356.3051	90.8084	2.71
STRESS (PSI)	13095.45	347.78	2.66
STRAIN (%)	1.37038	0.47424	34.61

20000.0000

COMPRESSION TEST

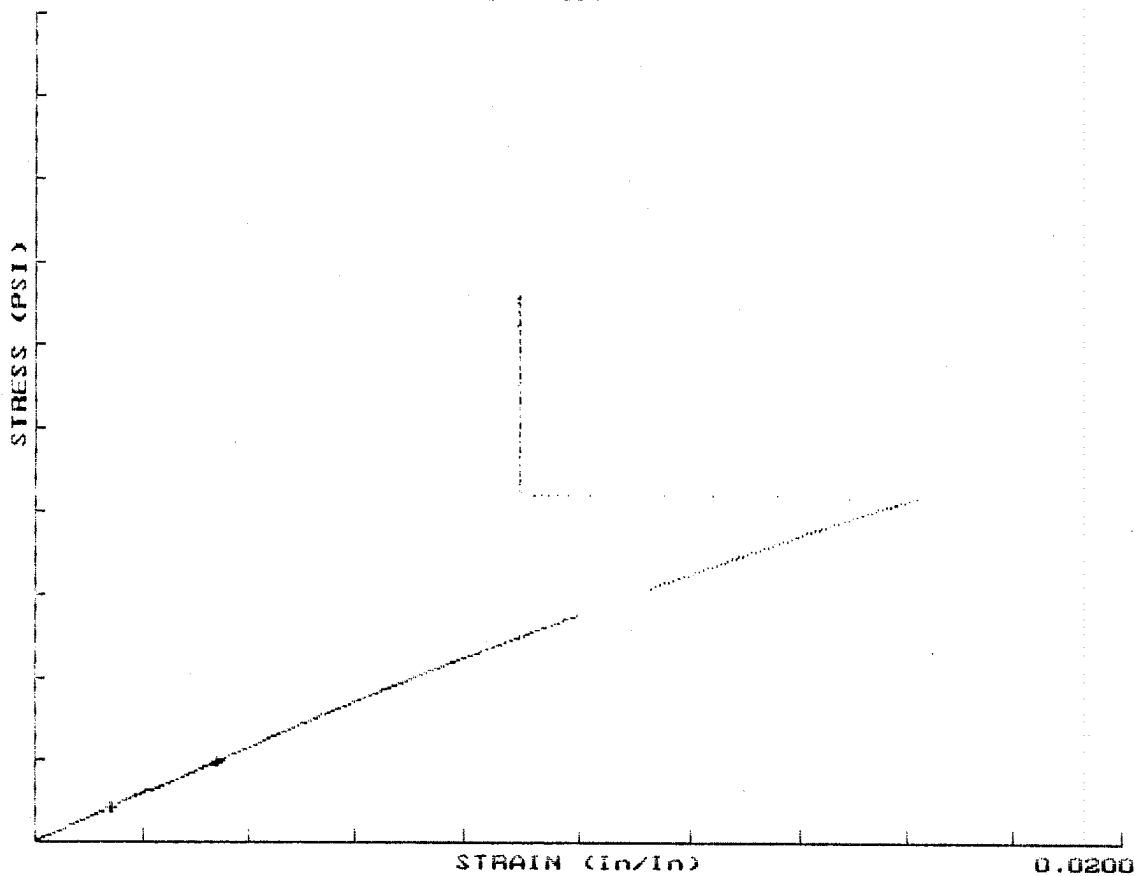


Compression Test Results

Specimen Number => 1 Wed., May. 28, 1997
Sample type identification: D695, M201 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
File Set Names: V7059001 V7059001
Width = 0.488 In Thickness = 0.526 In AREA = 0.257 In²
Youngs Modulus = 559223 PSI
Yield Stress = 0 PSI
Yield Strain = 0.000 %
Values at Peak Load: 3225.4 Lbs, 12565.5 PSI, 0.877 In, 0.870 %
Values at Break Load: 3147.5 Lbs, 12262.1 PSI, 0.885 In, 0.870 %

20000.0000

COMPRESSION TEST



Compression Test Results

Specimen Number => 2

Wed., May. 28, 1997

Sample type identification:

D695,

M201 EPOXY

Gage Length

.5 In

Extensometer type:

Other Type Extensometer

File Set Names:

V7059001 V7059001

Width = 0.485 In

Thickness = 0.525 In

AREA = 0.255 In²

Youngs Modulus = 576440 PSI

Yield Stress = 0 PSI

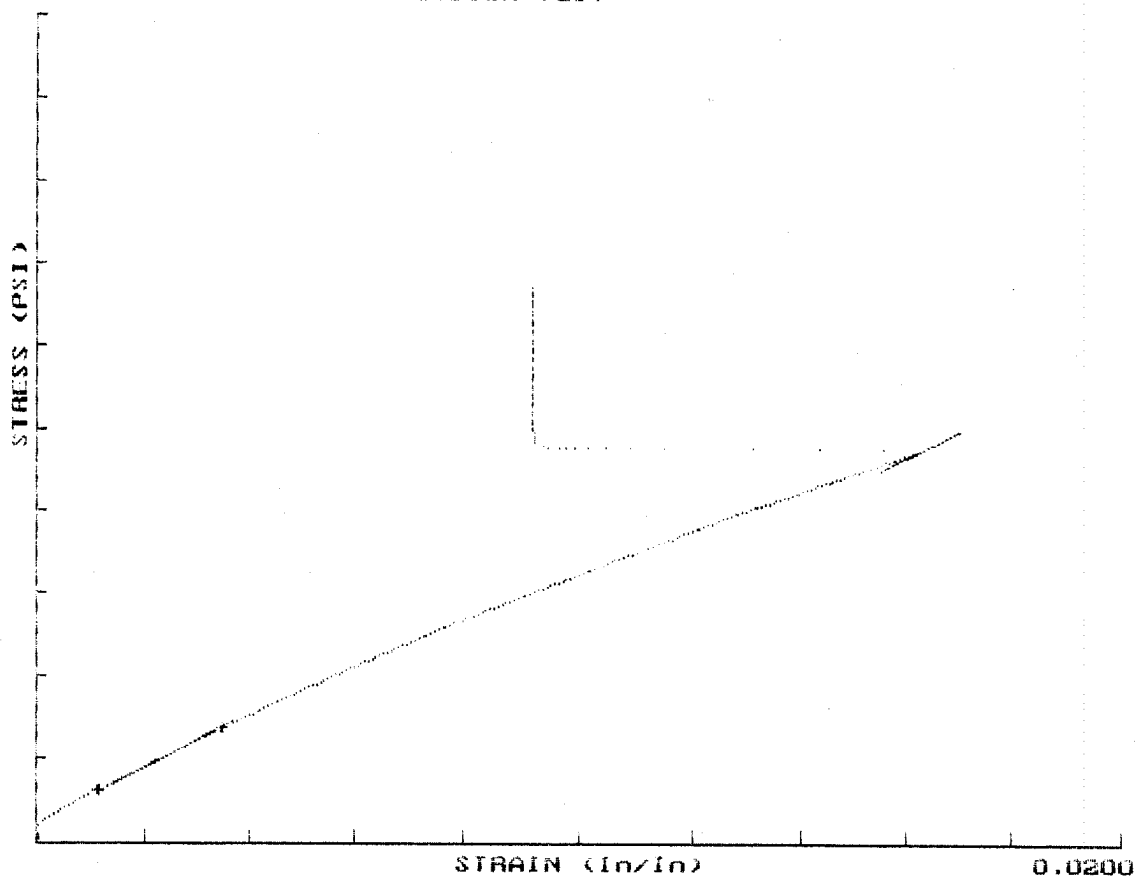
Yield Strain = 0.000 %

Values at Peak Load: 3364.3 Lbs, 13212.7 PSI, 0.110 In, 0.895 %

Values at Break Load: 3241.9 Lbs, 12732.0 PSI, 0.111 In, 0.895 %

20000.0000

COMPRESSION TEST



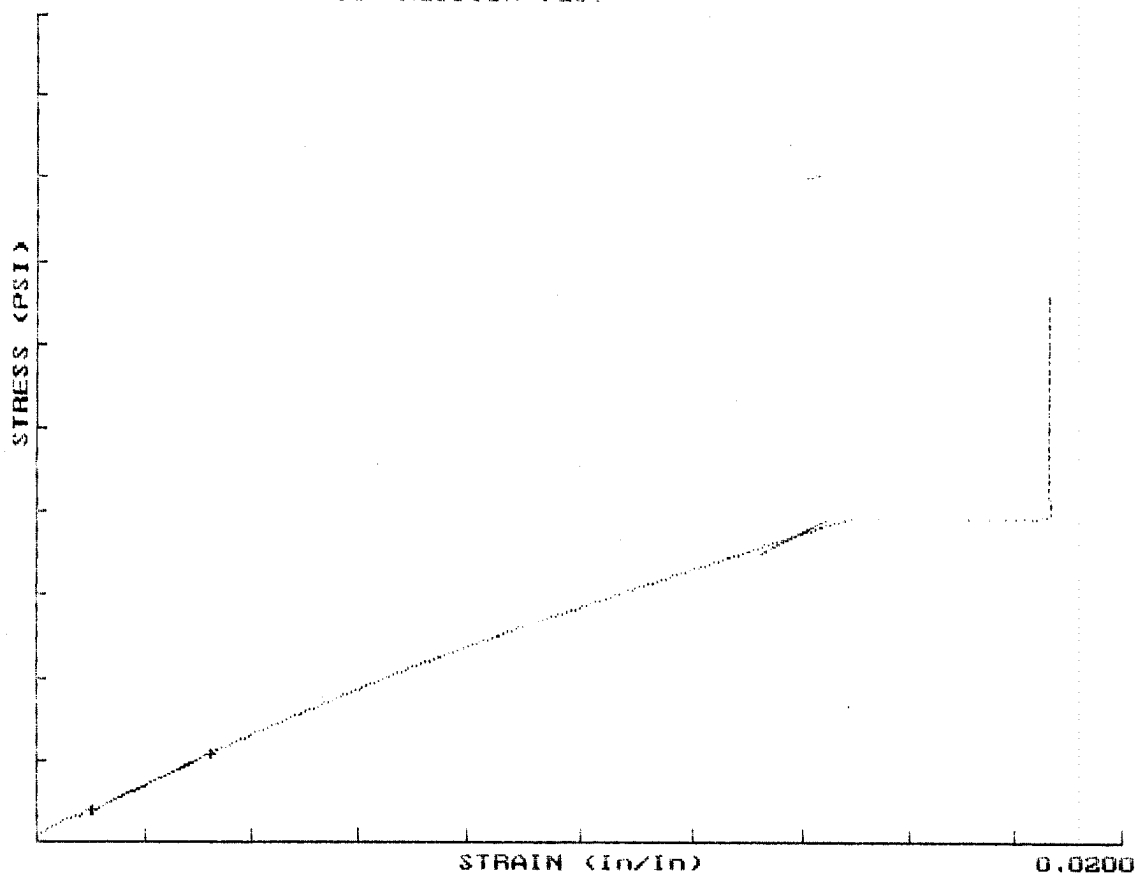
Compression Test Results

Specimen Number => 3 Wed., May. 28, 1997
Sample type identification: D695, M201 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
File Set Names: V7059001 V7059002
Width = 0.489 In Thickness= 0.526 In AREA = 0.257 In²

Youngs Modulus = 629888 PSI
Yield Stress = 9506 PSI
Yield Strain = 1.625 %
Values at Peak Load: 3459.3 Lbs, 13449.2 PSI, 0.077 In, 0.920 %
Values at Break Load: 2454.3 Lbs, 9541.9 PSI, 0.081 In, 1.434 %

20000.0000

COMPRESSION TEST

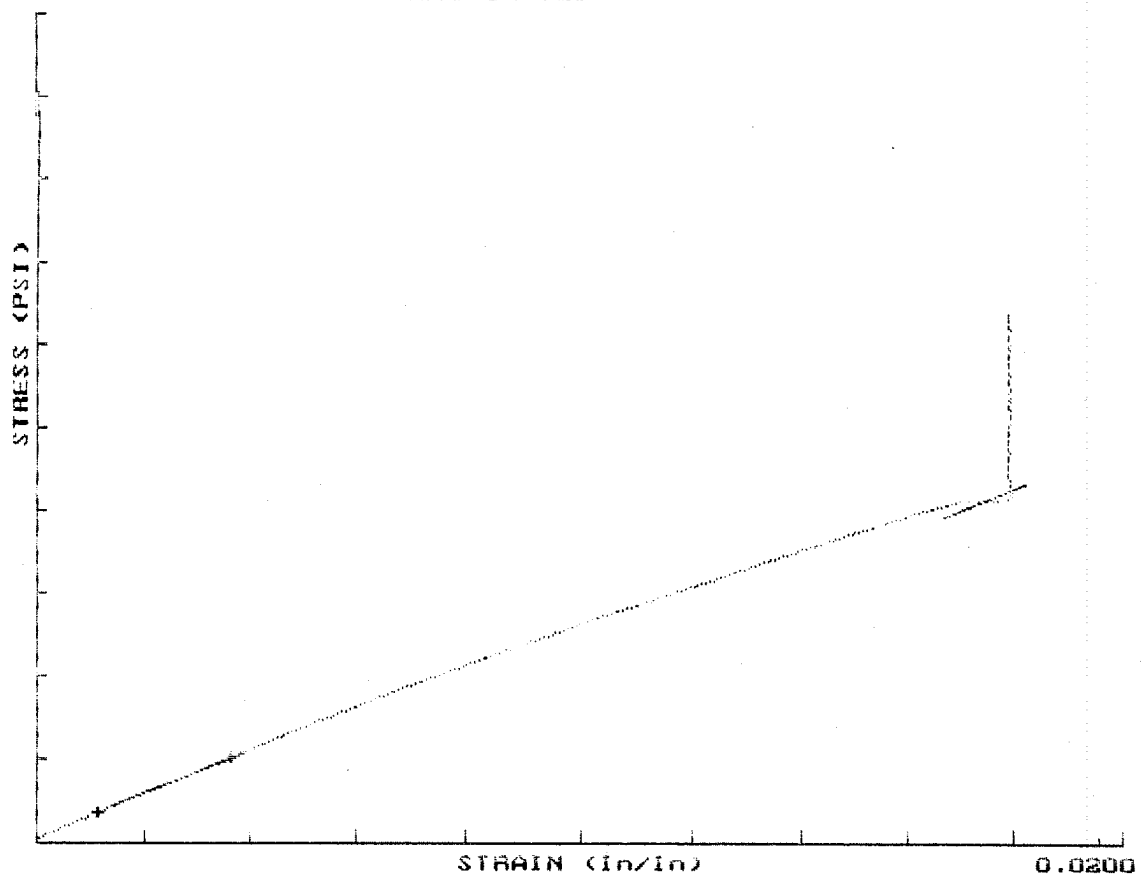


Compression Test Results

Specimen Number => 4 Wed., May. 28, 1997
Sample type identification: D695, M201 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
File Set Names: V7059001 V7059004
Width = 0.492 In Thickness = 0.522 In AREA = 0.257 In²
Youngs Modulus = 611154 PSI
Yield Stress = 7399 PSI
Yield Strain = 1.381 %
Values at Peak Load: 3416.1 Lbs, 13301.4 PSI, 0.113 In, 1.864 %
Values at Break Load: 3385.5 Lbs, 13182.3 PSI, 0.113 In, 1.865 %

20000.0000

COMPRESSION TEST



Compression Test Results

Specimen Number => 5

Wed., May. 28, 1997

Sample type identification:

D695,

M201 EPOXY

Gage Length

.5 In

Extensometer type:

Other Type Extensometer

File Set Names:

V7059001 V7059004

Width = 0.486 In Thickness = 0.527 In AREA = 0.256 In²

Youngs Modulus = 536439 PSI

Yield Stress = 8373 PSI

Yield Strain = 1.747 %

Values at Peak Load: 3316.4 Lbs, 12948.4 PSI, 0.043 In, 1.789 %

Values at Break Load: 3252.4 Lbs, 12638.6 PSI, 0.049 In, 1.788 %

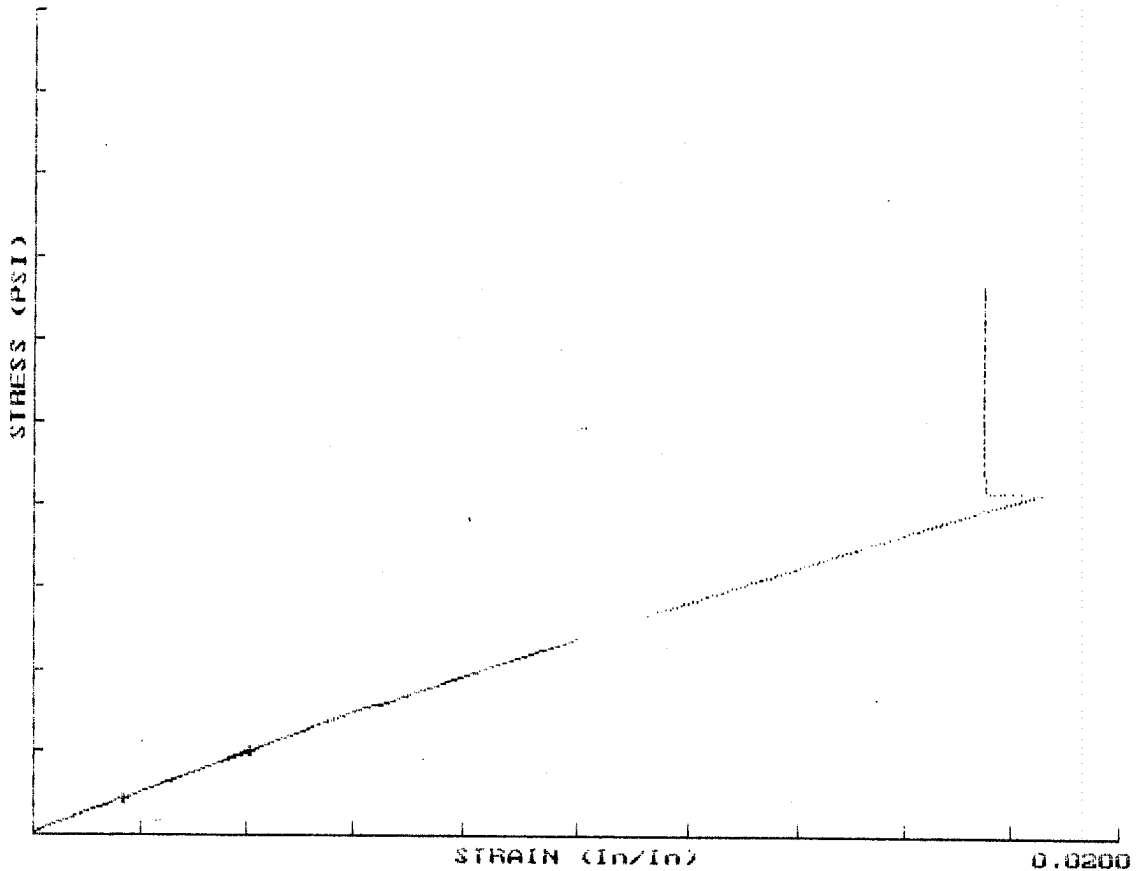
Compression Test, Group Summary
Wed., May. 28, 1997
Group Population Count = 5

Sample type identification: D695, S301 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
ENGLISH Units
File Set Names: W7059001 W7059004

	Avg.	Std. Dev.	Coef. of Var. (%)
MODULUS (PSI)	542289.81	65198.09	12.02
LOAD (Lbs)	3351.3981	78.1023	2.33
STRESS (PSI)	13626.55	166.32	1.22
STRAIN (%)	1.75705	0.03566	2.03

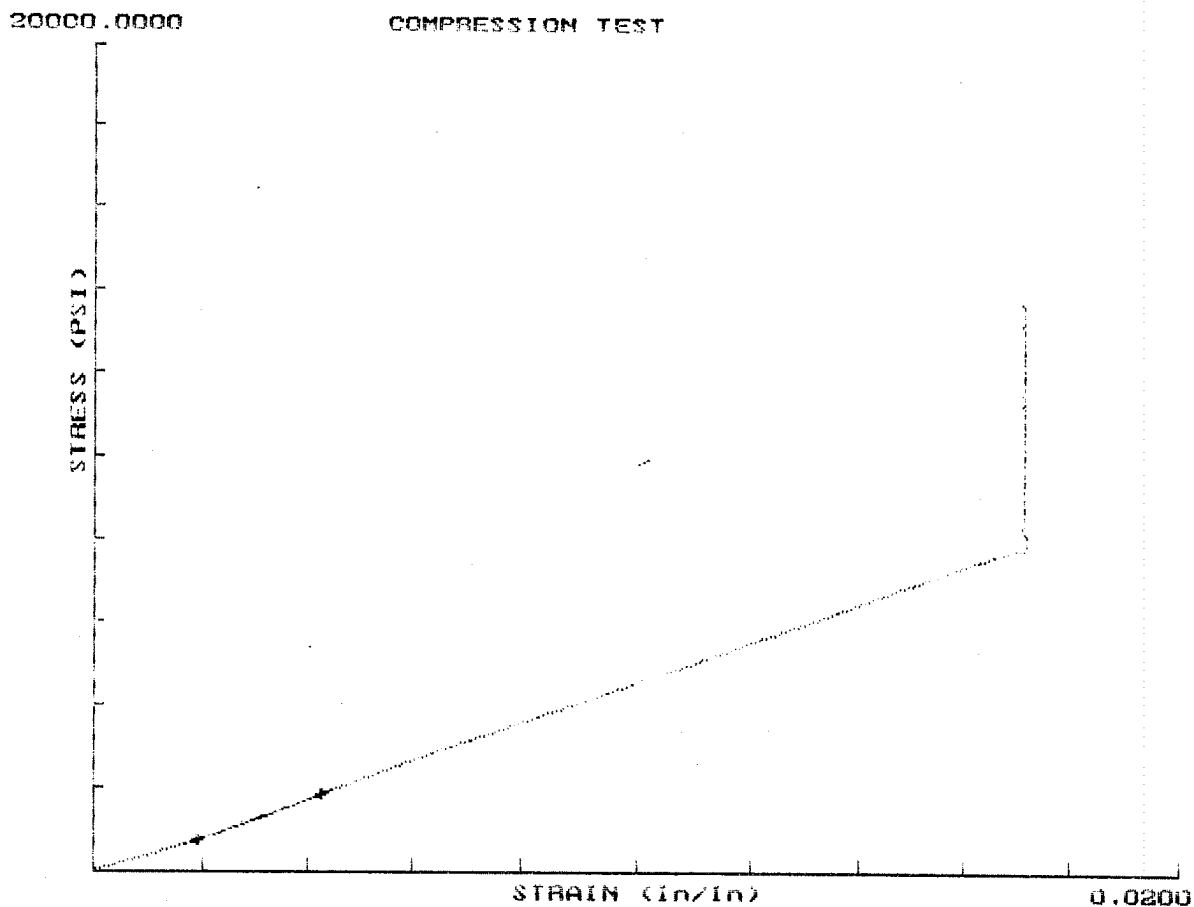
20000.0000

COMPRESSION TEST



Compression Test Results

Specimen Number => 1 Wed., May. 28, 1997
Sample type identification: D695, S301 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
File Set Names: W7059001 W7059001
Width = 0.512 In Thickness = 0.480 In AREA = 0.246 In²
Youngs Modulus = 480231 PSI
Yield Stress = 0 PSI
Yield Strain = 0.000 %
Values at Peak Load: 3301.3 Lbs, 13432.9 PSI, 0.157 In, 1.747 %
Values at Break Load: 3253.1 Lbs, 13236.7 PSI, 0.158 In, 1.747 %



Compression Test Results

Specimen Number => 2 Wed., May. 28, 1997

Sample type identification: D695, S301 EPOXY

Gage Length .5 In

Extensometer type: Other Type Extensometer

File Set Names: W7059001 W7059001

Width = 0.509 In Thickness = 0.475 In AREA = 0.242 In²

Youngs Modulus = 468976 PSI

Yield Stress = 0 PSI

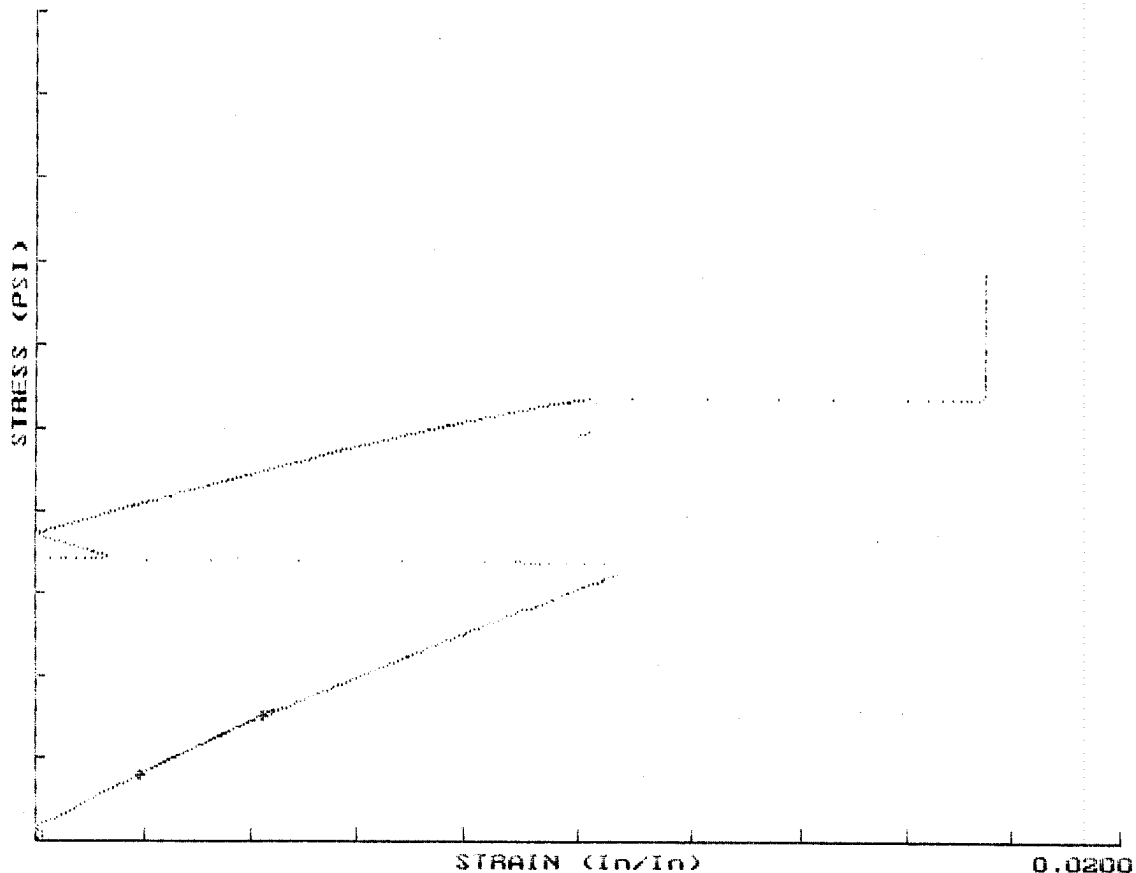
Yield Strain = 0.000 %

Values at Peak Load: 3333.8 Lbs, 13788.9 PSI, 0.051 In, 1.711 %

Values at Break Load: 3259.7 Lbs, 13482.2 PSI, 0.052 In, 1.711 %

20000.0000

COMPRESSION TEST

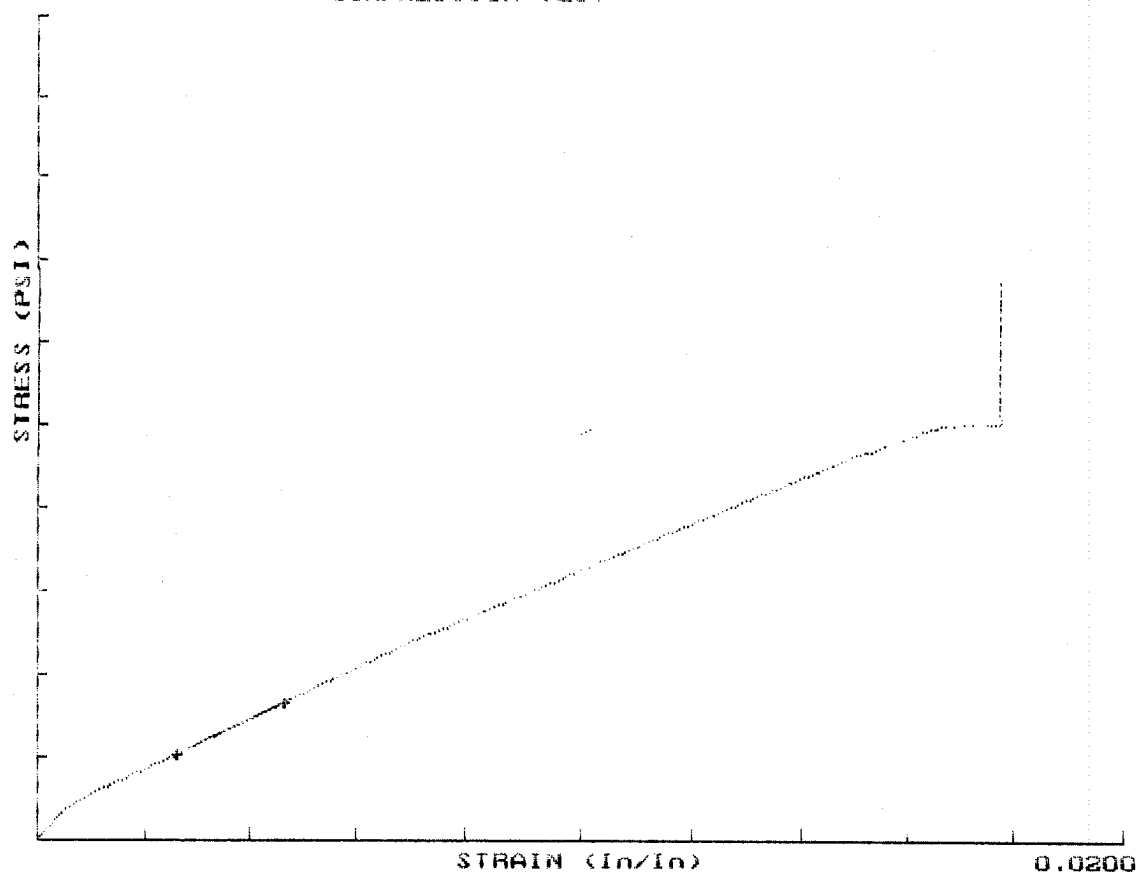


Compression Test Results

Specimen Number => 3 Wed., May. 28, 1997
Sample type identification: D695, S301 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
File Set Names: W7059001 W7059002
Width = 0.509 In Thickness = 0.476 In AREA = 0.242 In²
Youngs Modulus = 593718 PSI
Yield Stress = 0 PSI
Yield Strain = 0.000 %
Values at Peak Load: 3333.6 Lbs, 13759.1 PSI, 0.044 In, 1.747 %
Values at Break Load: 3257.6 Lbs, 13445.3 PSI, 0.045 In, 1.748 %

20000.0000

COMPRESSION TEST



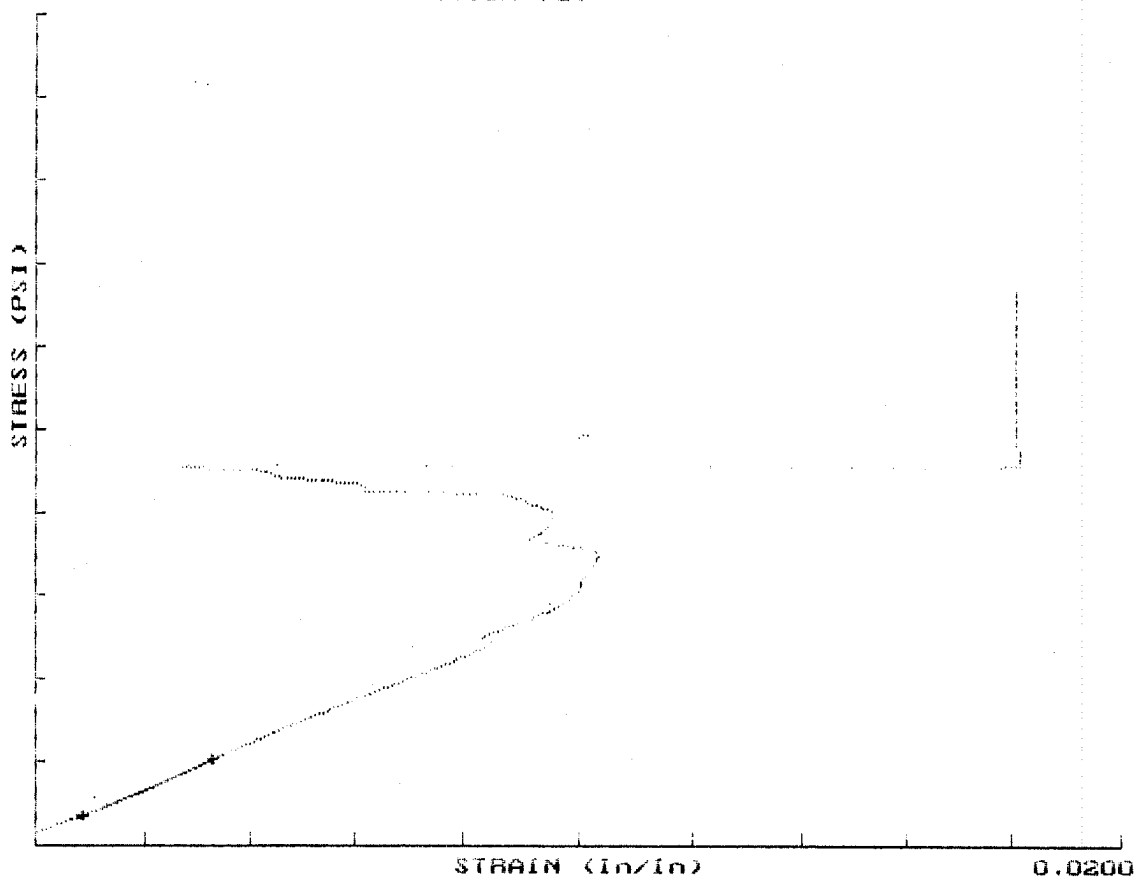
Compression Test Results

Specimen Number => 4 Wed., May. 28, 1997
Sample type identification: D695, S301 EPOXY
Gage Length .5 In
Extensometer type: Other Type Extensometer
File Set Names: W7059001 W7059003
Width = 0.512 In Thickness = 0.471 In AREA = 0.241 In²

Youngs Modulus = 612623 PSI
Yield Stress = 0 PSI
Yield Strain = 0.000 %
Values at Peak Load: 3300.3 Lbs, 13685.6 PSI, 0.033 In, 1.772 %
Values at Break Load: 3256.7 Lbs, 13504.9 PSI, 0.034 In, 1.772 %

20000.0000

COMPRESSION TEST



Compression Test Results

Specimen Number => 5 Wed., May. 28, 1997
 Sample type identification: D695, S301 EPOXY
 Gage Length .5 In
 Extensometer type: Other Type Extensometer
 File Set Names: W7059001 W7059004
 Width = 0.517 In Thickness = 0.501 In AREA = 0.259 In²

Youngs Modulus = 555900 PSI
 Yield Stress = 0 PSI
 Yield Strain = 0.000 %

Values at Peak Load: 3488.0 Lbs, 13466.2 PSI, 0.040 In, 1.807 %
 Values at Break Load: 3420.8 Lbs, 13206.7 PSI, 0.041 In, 1.808 %

3-Point Flexure Test, Group Summary

Mon., May 27, 1997

Group Population Count = 5

Sample type identification:

D-790,

M-201 EPOXY SYSTEM

Span Length:

2

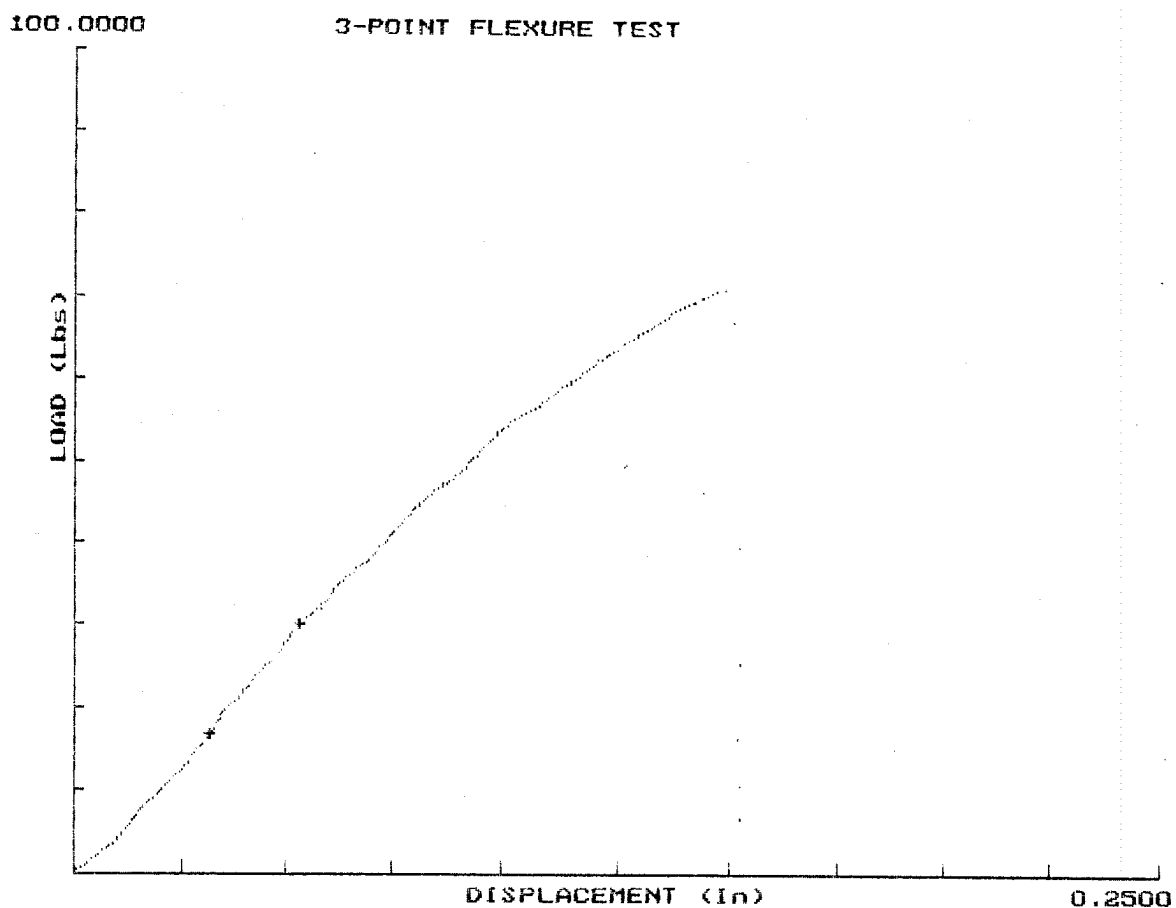
Flexure Test is

3 Point

File Set Names:

S7059001 S7059006

	Avg.	Std. Dev.	Coef. of Var. (%)
MODULUS (PSI)	547776.00	23069.65	4.21
LOAD (Lbs)	74.1400	4.7511	6.41
STRESS (PSI)	13874.96	888.52	6.40
STRAIN (%)	2.85460	0.28078	9.84



3-Point Flexure Test

Specimen Number => 1

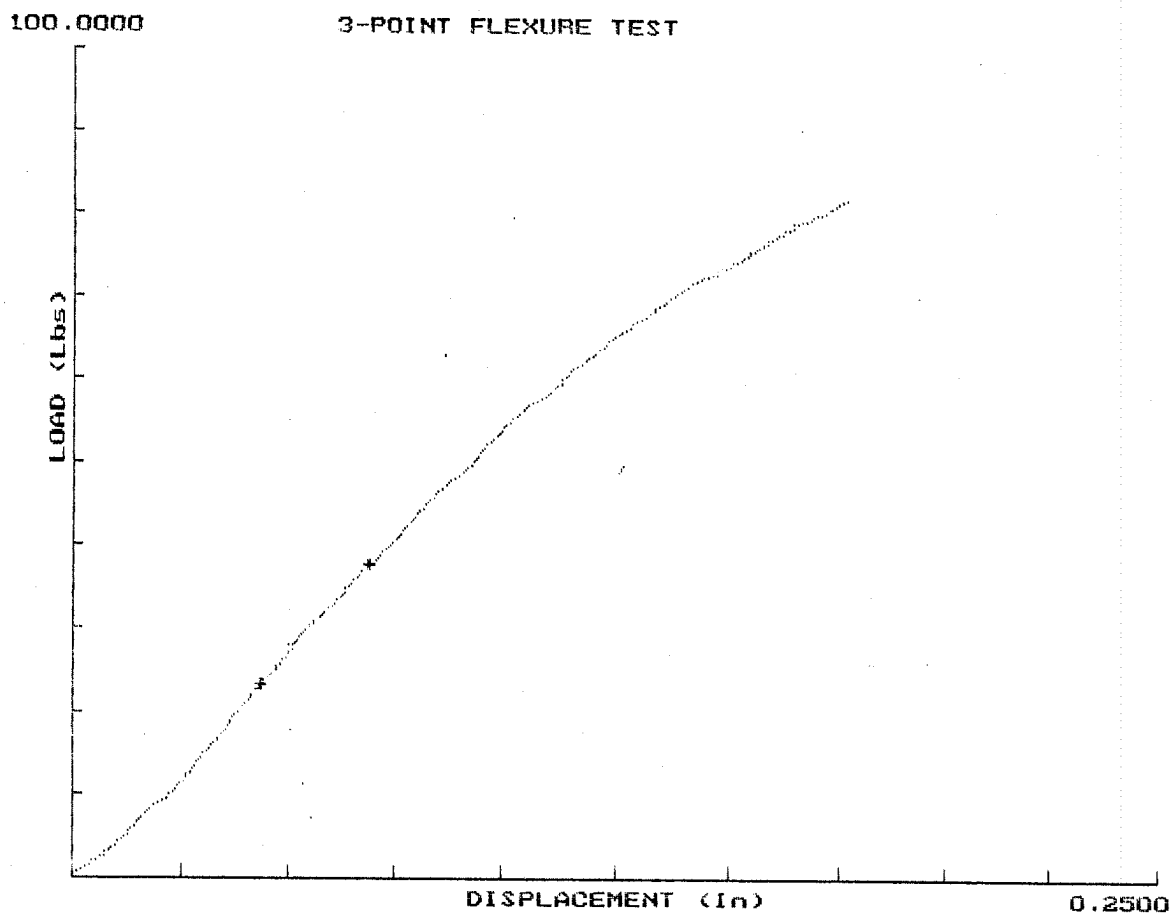
Tue., May. 27, 1997

Width = 1.011 In Thickness = 0.126 In AREA = 0.127 In²

Youngs Modulus = 582506 PSI

Values at Peak Load: 70.9 Lbs, 13258.8 PSI, 0.149 In, 2.821 %

Values at Peak Disp.: 39.5 Lbs, 7381.3 PSI, 0.153 In, 2.886 %



3-Point Flexure Test

Specimen Number => 2

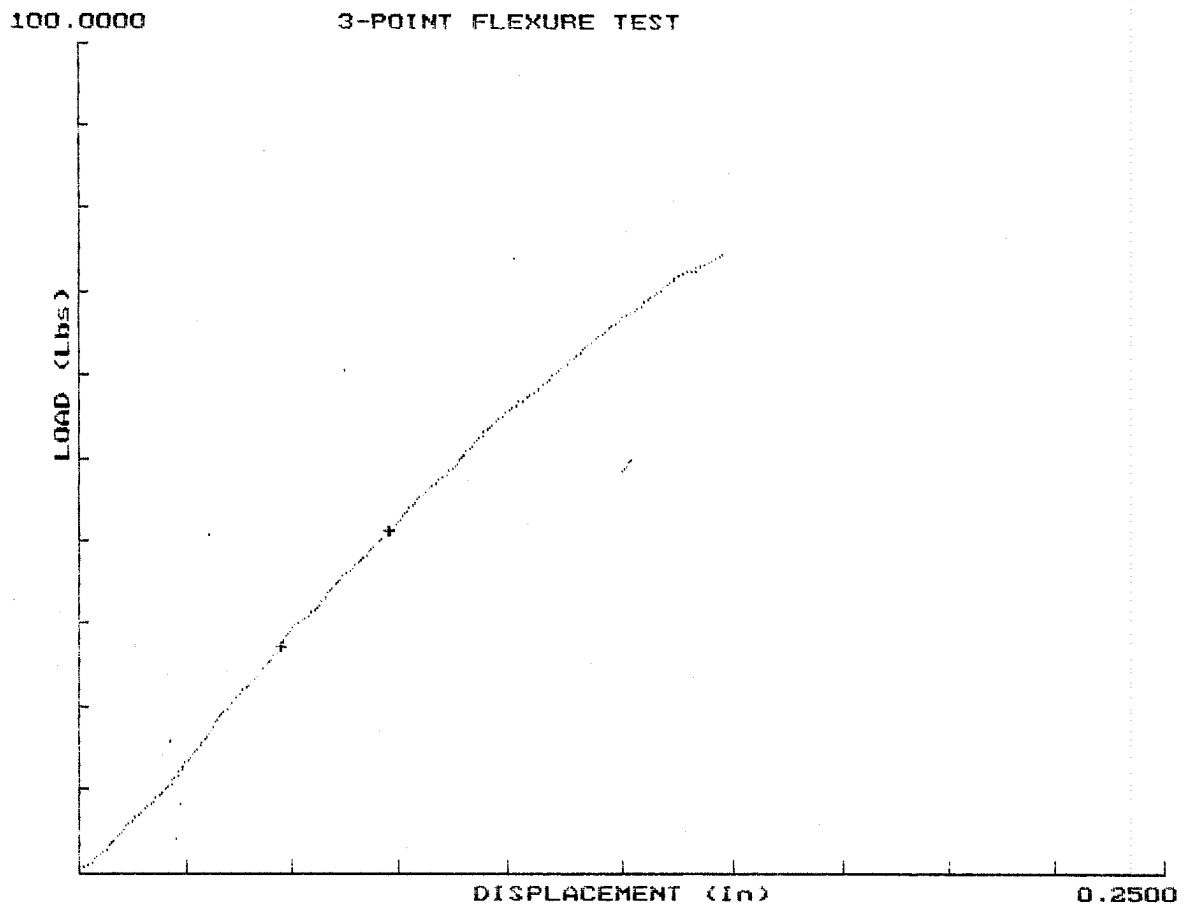
Tue., May. 27, 1997

Width = 1.012 In Thickness = 0.126 In AREA = 0.128 In²

Youngs Modulus = 549608 PSI

Values at Peak Load: 81.8 Lbs, 15274.1 PSI, 0.176 In, 3.324 %

Values at Peak Disp.: 81.5 Lbs, 15206.6 PSI, 0.175 In, 3.301 %



3-Point Flexure Test

Specimen Number => 3

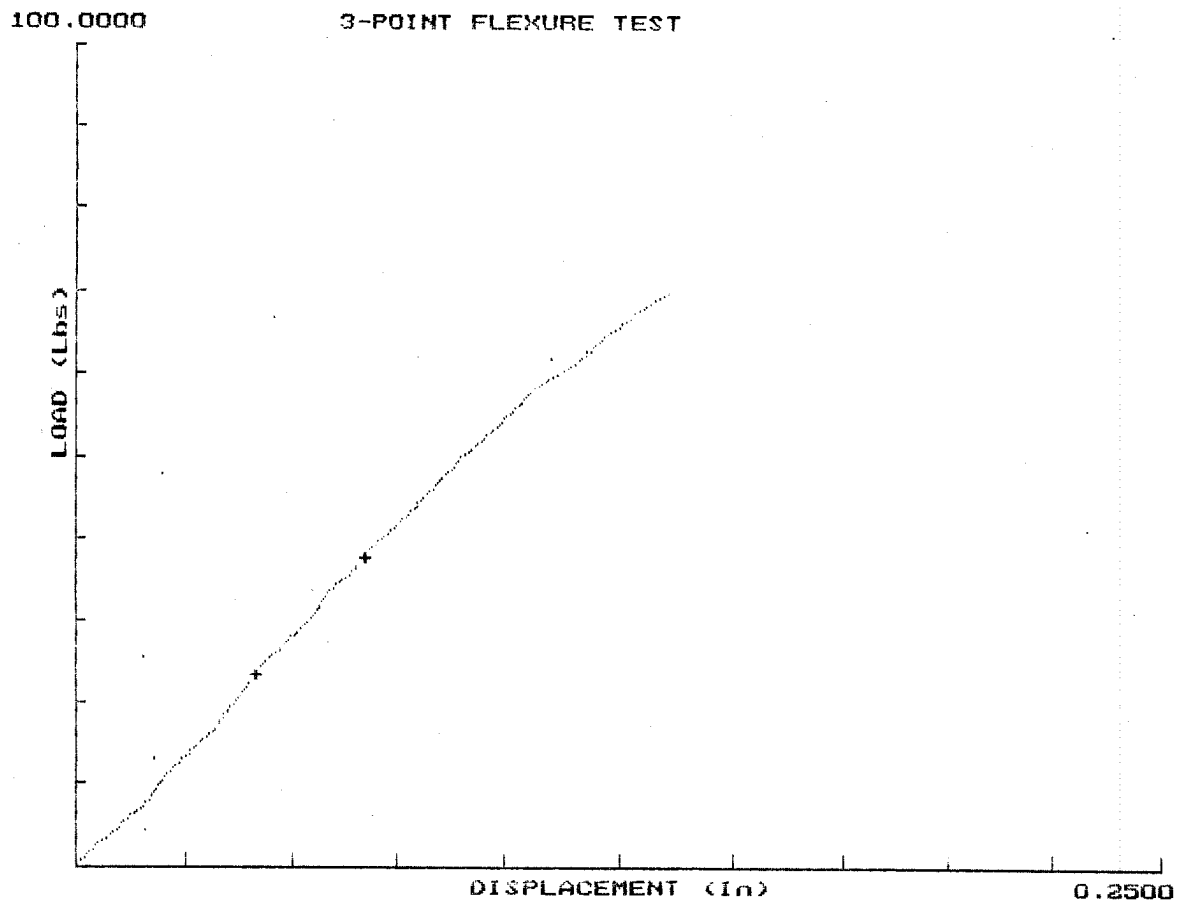
Tue., May. 27, 1997

Width = 1.013 In Thickness = 0.126 In AREA = 0.128 In²

Youngs Modulus = 519791 PSI

Values at Peak Load: 74.7 Lbs, 13933.8 PSI, 0.148 In, 2.790 %

Values at Peak Disp.: 74.4 Lbs, 13866.4 PSI, 0.147 In, 2.781 %



3-Point Flexure Test

Specimen Number => 5

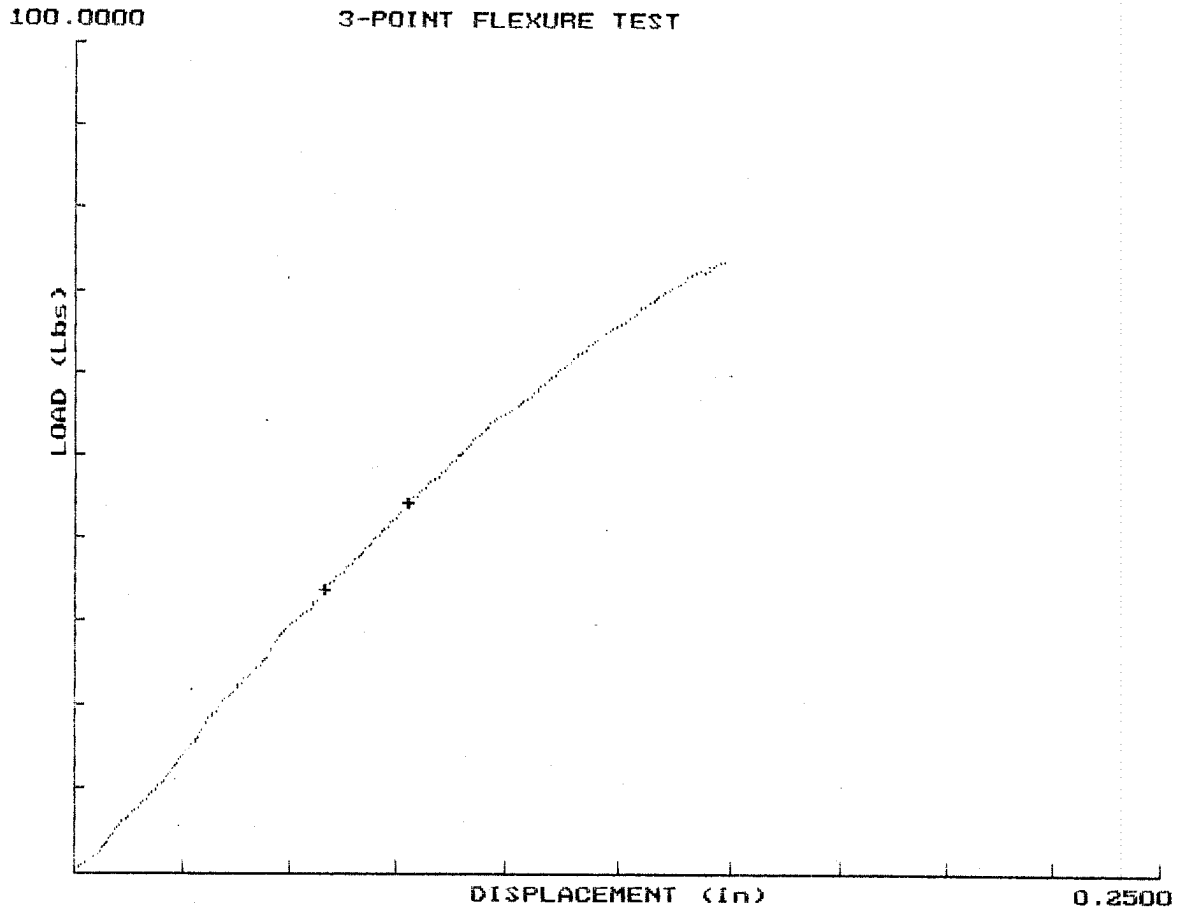
Tue., May. 27, 1997

Width = 1.013 In Thickness = 0.126 In AREA = 0.128 In²

Youngs Modulus = 550536 PSI

Values at Peak Load: 69.6 Lbs, 12973.5 PSI, 0.136 In, 2.567 %

Values at Peak Disp.: 69.0 Lbs, 12875.6 PSI, 0.134 In, 2.532 %



3-Point Flexure Test

Specimen Number => 6

Tue., May. 27, 1997

Width = 1.015 In Thickness = 0.125 In AREA = 0.127 In²

Youngs Modulus = 536439 PSI

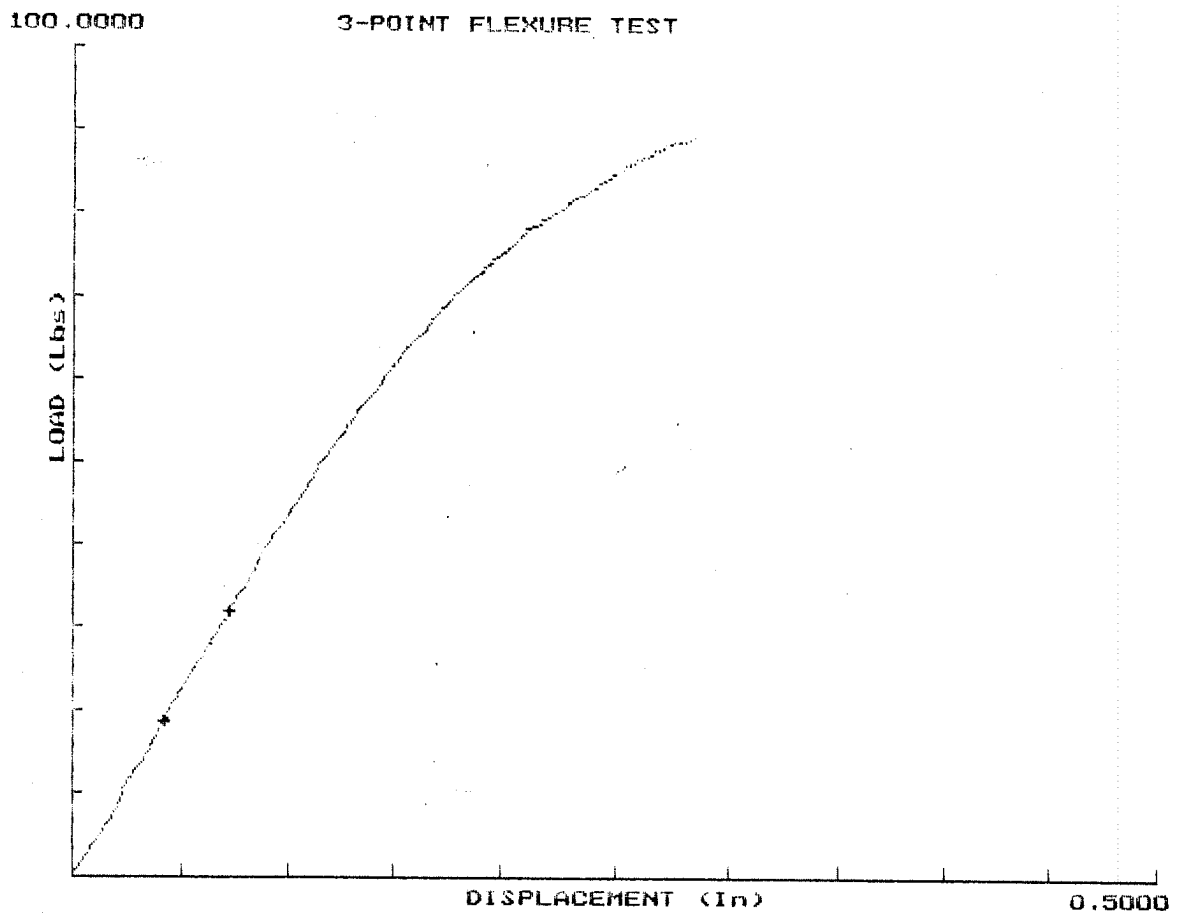
Values at Peak Load: 73.7 Lbs, 13935.1 PSI, 0.148 In, 2.771 %

Values at Peak Disp.: 73.5 Lbs, 13900.9 PSI, 0.148 In, 2.768 %

3-Point Flexure Test, Group Summary
Mon., May 27, 1997
Group Population Count = 5

Sample type identification:	D-790,	S-301 EPOXY SYSTEM
Span Length:	2	
Flexure Test is	3 Point	
File Set Names:	R7059001 R7059006	

	Avg.	Std. Dev.	Coef. of Var. (%)
MODULUS (PSI)	465306.20	8747.35	1.88
LOAD (Lbs)	84.4800	11.4253	13.52
STRESS (PSI)	16917.38	2222.13	13.14
STRAIN (%)	4.80480	0.82603	17.19



3-Point Flexure Test

Specimen Number => 2

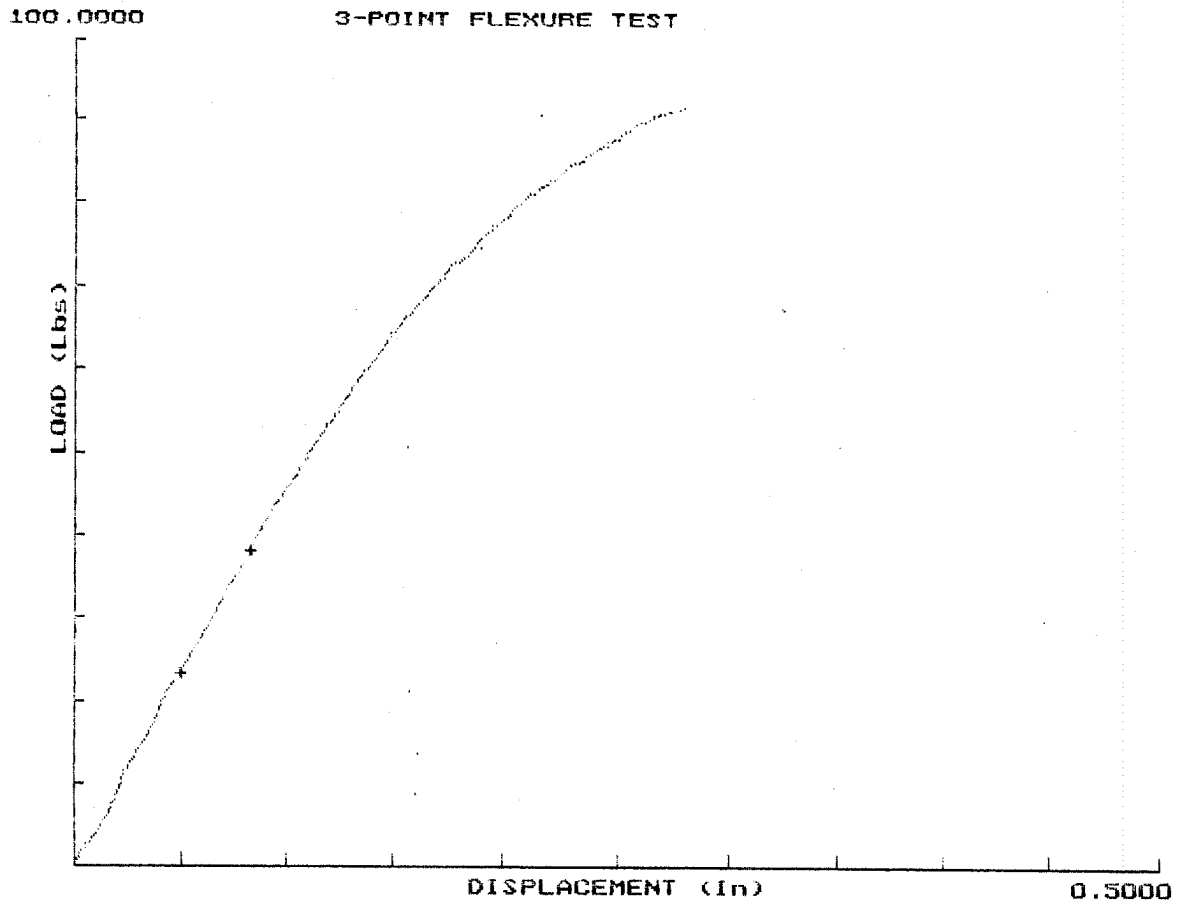
Tue., May. 27, 1997

Width = 1.008 In Thickness = 0.121 In AREA = 0.122 In²

Youngs Modulus = 467746 PSI

Values at Peak Load: 89.4 Lbs, 18167.3 PSI, 0.285 In, 5.167 %

Values at Peak Disp.: 89.0 Lbs, 18093.9 PSI, 0.283 In, 5.133 %



3-Point Flexure Test

Specimen Number => 3

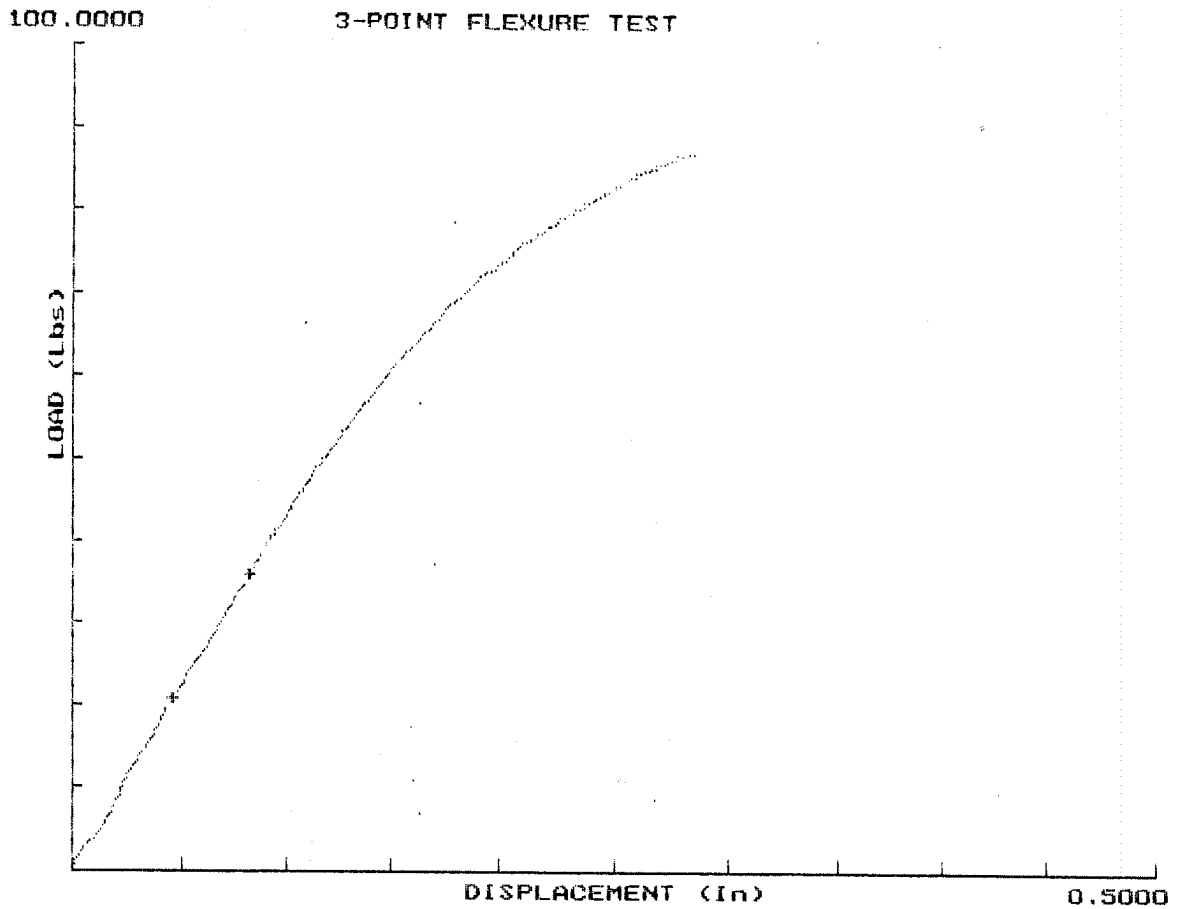
Tue., May. 27, 1997

Width = 1.011 In Thickness = 0.123 In AREA = 0.124 In²

Youngs Modulus = 471201 PSI

Values at Peak Load: 92.0 Lbs, 18035.3 PSI, 0.280 In, 5.162 %

Values at Peak Disp.: 91.6 Lbs, 17973.3 PSI, 0.278 In, 5.125 %



3-Point Flexure Test

Specimen Number => 4

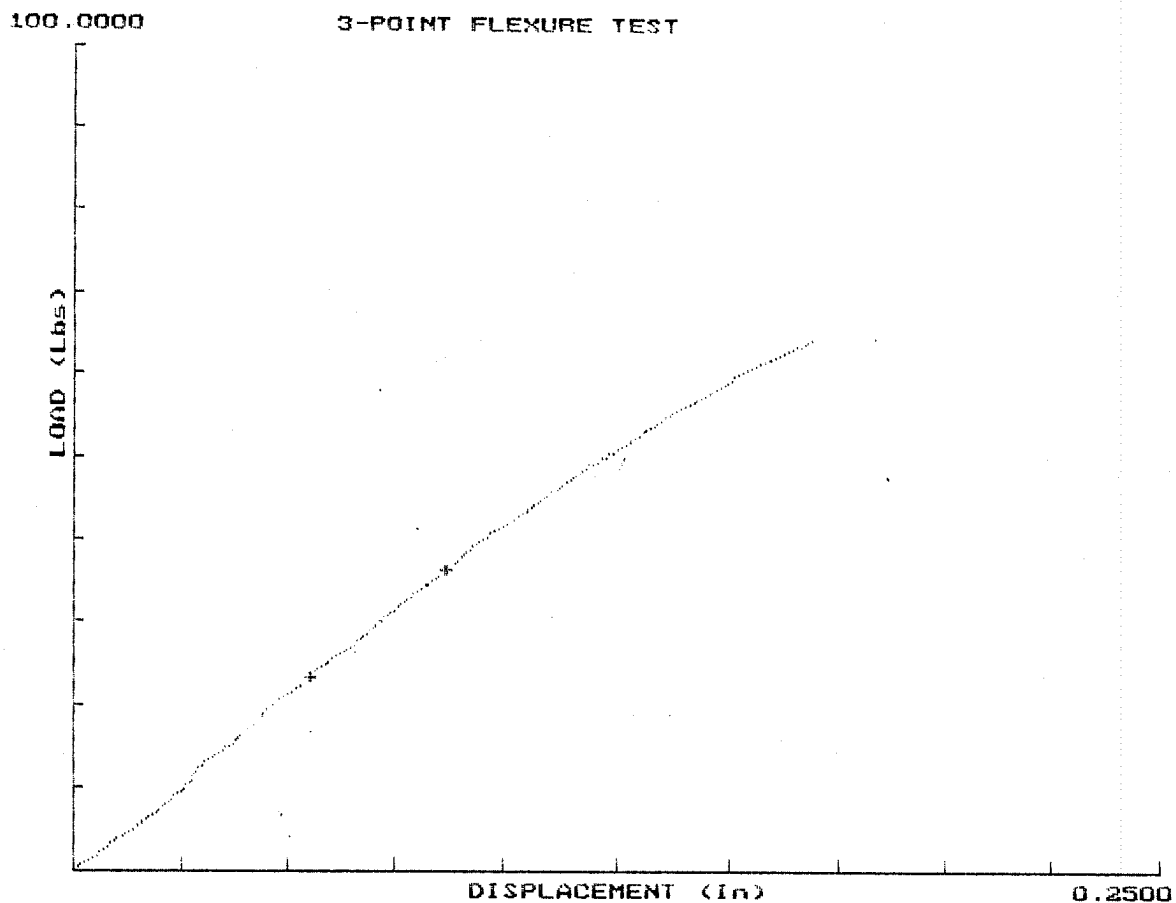
Tue., May. 27, 1997

Width = 1.018 In Thickness = 0.121 In AREA = 0.123 In²

Youngs Modulus = 461905 PSI

Values at Peak Load: 86.9 Lbs, 17492.3 PSI, 0.282 In, 5.126 %

Values at Peak Disp.: 86.8 Lbs, 17465.0 PSI, 0.283 In, 5.139 %



3-Point Flexure Test

Specimen Number => 6

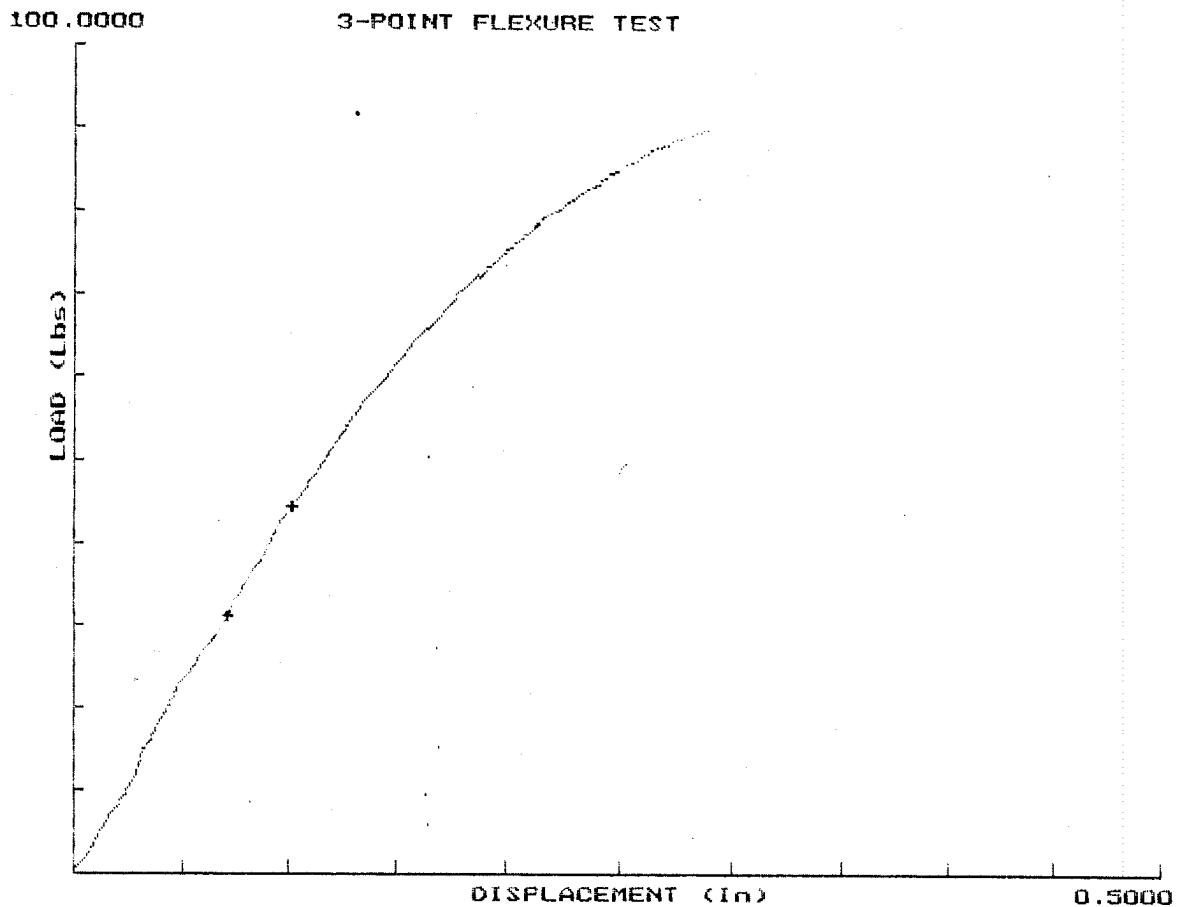
Tue., May. 27, 1997

Width = 1.016 In Thickness = 0.121 In AREA = 0.123 In²

Youngs Modulus = 451848 PSI

Values at Peak Load: 64.3 Lbs, 12968.2 PSI, 0.183 In, 3.329 %

Values at Peak Disp.: 64.0 Lbs, 12905.6 PSI, 0.168 In, 3.047 %



3-Point Flexure Test

Specimen Number => 7

Tue., May. 27, 1997

Width = 1.010 In Thickness = 0.122 In AREA = 0.123 In²

Youngs Modulus = 473831 PSI

Values at Peak Load: 89.8 Lbs, 17923.8 PSI, 0.286 In, 5.240 %

Values at Peak Disp.: 89.8 Lbs, 17923.8 PSI, 0.288 In, 5.271 %

ASTM D 2240 TEST METHOD OF RUBBER PROPERTY
BY MEANS OF A TYPE D DUROMETER

Client:
Report Number: 97SL059
Description: M-201 EPOXY CASTING

<u>READING #</u>	<u>OUTSIDE</u> (MOLD SIDE)	
1	85	L
2	86	
3	85	
4	88	
5	87	
6	85	
7	87	
8	87	
9	86	
10	86	
11	89	H
12	88	
13	86	
14	86	
15	88	
16	88	
Average:	86.64	

- NOTES:
- 1) "Average" represents the average of the remaining readings after the high and low readings have been thrown out.
 - 2) H= high reading
 - 3) L= low reading

ASTM D 2240 TEST METHOD OF RUBBER PROPERTY
BY MEANS OF A TYPE D DUROMETER

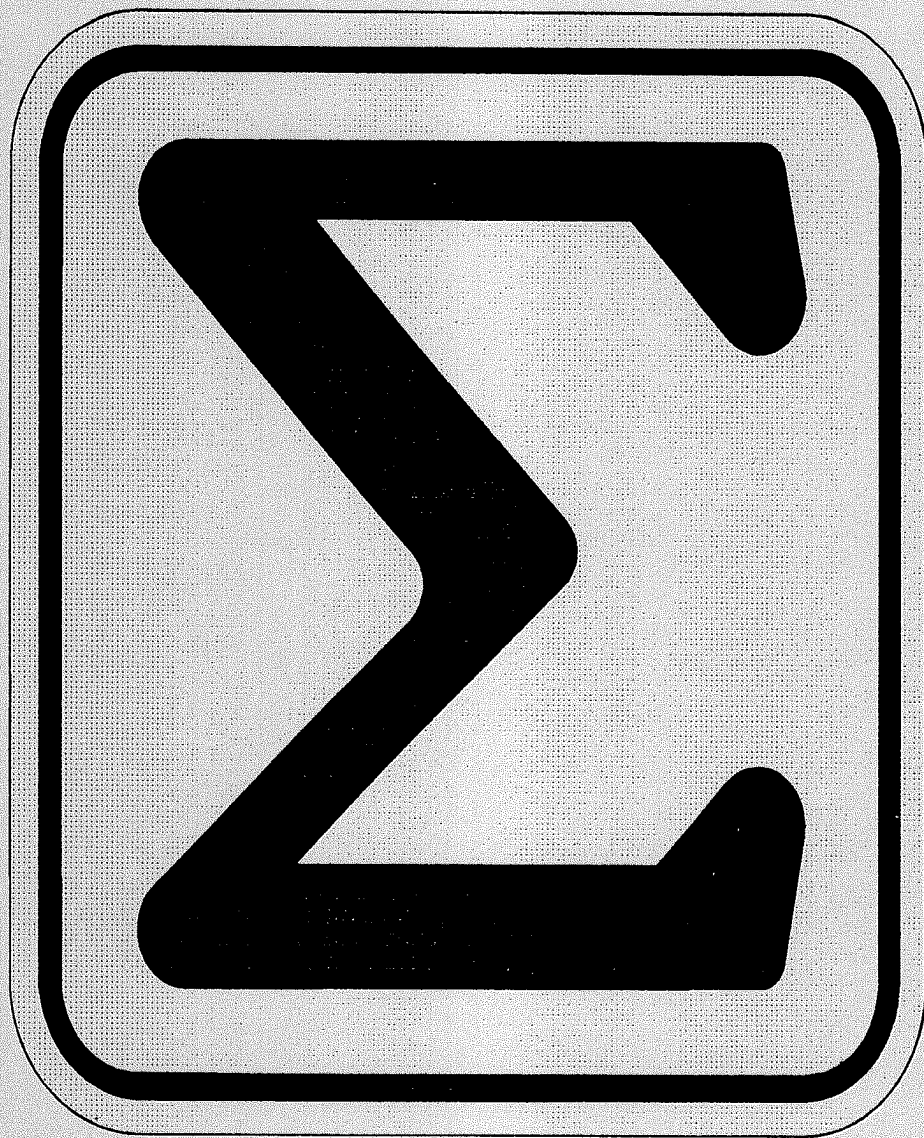
Client:
Report Number: 97SL059
Description: S-301 EPOXY CASTING

<u>READING #</u>	<u>OUTSIDE</u> (MOLD SIDE)	
1	86	L
2	85	
3	83	
4	83	
5	84	
6	83	
7	86	
8	85	
9	87	H
10	87	
11	86	
12	86	
13	82	L
14	83	
15	84	
16	85	

Average: 84.71

NOTES: 1) "Average" represents the average of the remaining readings after the high and low readings have been thrown out.
2) H= high reading
3) L= low reading

CHEMICAL ANALYSIS



Sigma Labs

SPECTRALAB, INC.
Laboratory and Consulting Services
6345 82nd Avenue North
Pinellas Park, FL 33781
813-545-2297

SPL1898

6/2/97

SPECTRALAB TEST REPORT FOR SIGMA LABS

REQUESTED BY: Rocco Ferri (97SL089)

SUBJECT: Heat Deflection Temperature of Epoxy Samples

SUBMITTED SAMPLE: Two cured epoxy formulations ~1/8" thick—designated S301 and M201

SUMMARY OF RESULTS:

Heat deflection temperature @ 264 PSI:

S301 - 87 ± 1 °C.

M201 - 80 ± 1 °C.

PROCEDURES/RESULTS:

Heat deflection temperature (ASTM D 648) using thermomechanical analysis (TMA):

The heat deflection temperature test described in ASTM D648 consists of loading a 1/2" thick test bar in 3 point flexure at a span of 4" to obtain a maximum outer fiber stress of 264 PSI. The loaded test bar is slowly heated in a circulating oil bath while monitoring flexural deflection of the test bar on a dial micrometer. As the material approaches its glass transition temperature, the resulting reduction in modulus of elasticity causes the bar to deflect. When this deflection is sufficient to produce exactly 0.2% flexural strain, the temperature is recorded and the test is discontinued.

Thermomechanical analysis (TMA) provides a means of obtaining data equivalent to that of the ASTM D648 method. The TMA method for heat deflection temperature utilizes a linear variable differential transformer (LVDT) to continuously monitor the micro-deflection (micro-inch sensitivity) of a miniature test sample (~.3" x ~.08" x ~.02") in flexure. The TMA furnace is continuously purged with helium to insure good thermal conduction between the test sample and an adjacent thermocouple. The sample is loaded to produce 264 PSI at room temperature. Temperature and deflection are continuously monitored during heating @ 5°C/minute, producing the TMA curve itself, a plot of temperature vs. deflection. Heat deflection temperature is taken at 0.2% strain. The deflection temperature just precedes the knee of the TMA curve where dramatic deflection of the sample takes place. The extrapolated onset temperature defines the temperature of the thermal knee and is approximately equal to the glass transition temperature in non-reinforced materials.

Method Parameters:

Two 25 mil samples were cut parallel to the wide, flat side of each specimen. The samples were tested in duplicate using a thermomechanical analyzer (TMA) under the following conditions:

Scan Rate: 5°C/minute

Load: 264 PSI

Deflection Temperature (Td): Taken at 0.2% strain per ASTM D648

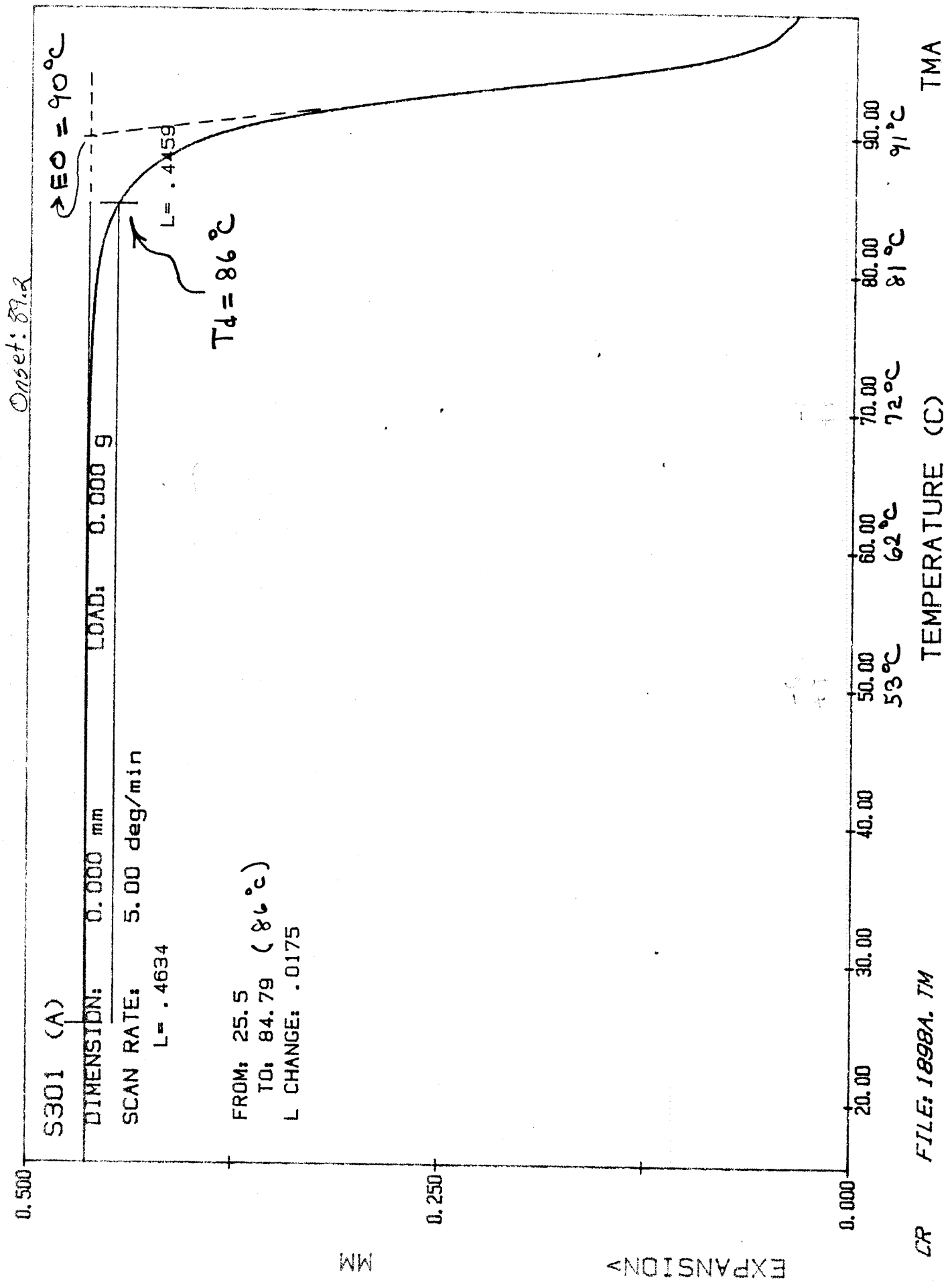
Distortion Temperature (To): Extrapolated onset (comparable to Tg).

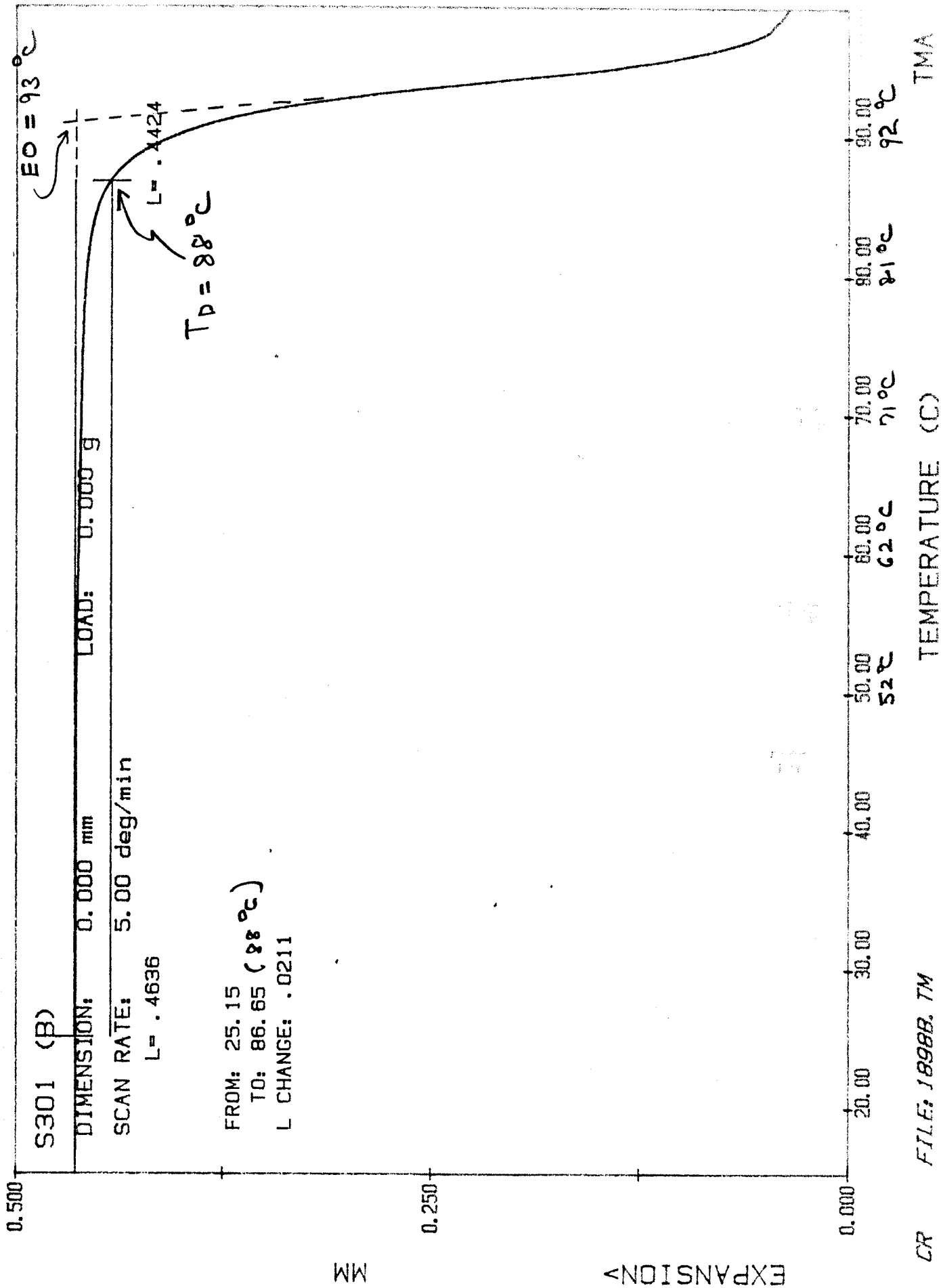
TMA curves for each sample run are presented in Figures #1 and #2. Results are presented in the table below. All temperatures were corrected to compensate for program temperature error.

SAMPLE	Td (°C)	To (°C)
S301A	86	90
S301B	88	93
M201A	81	88
M201B	79	86


Jack Brand
Lab Director

FIGURE #1A

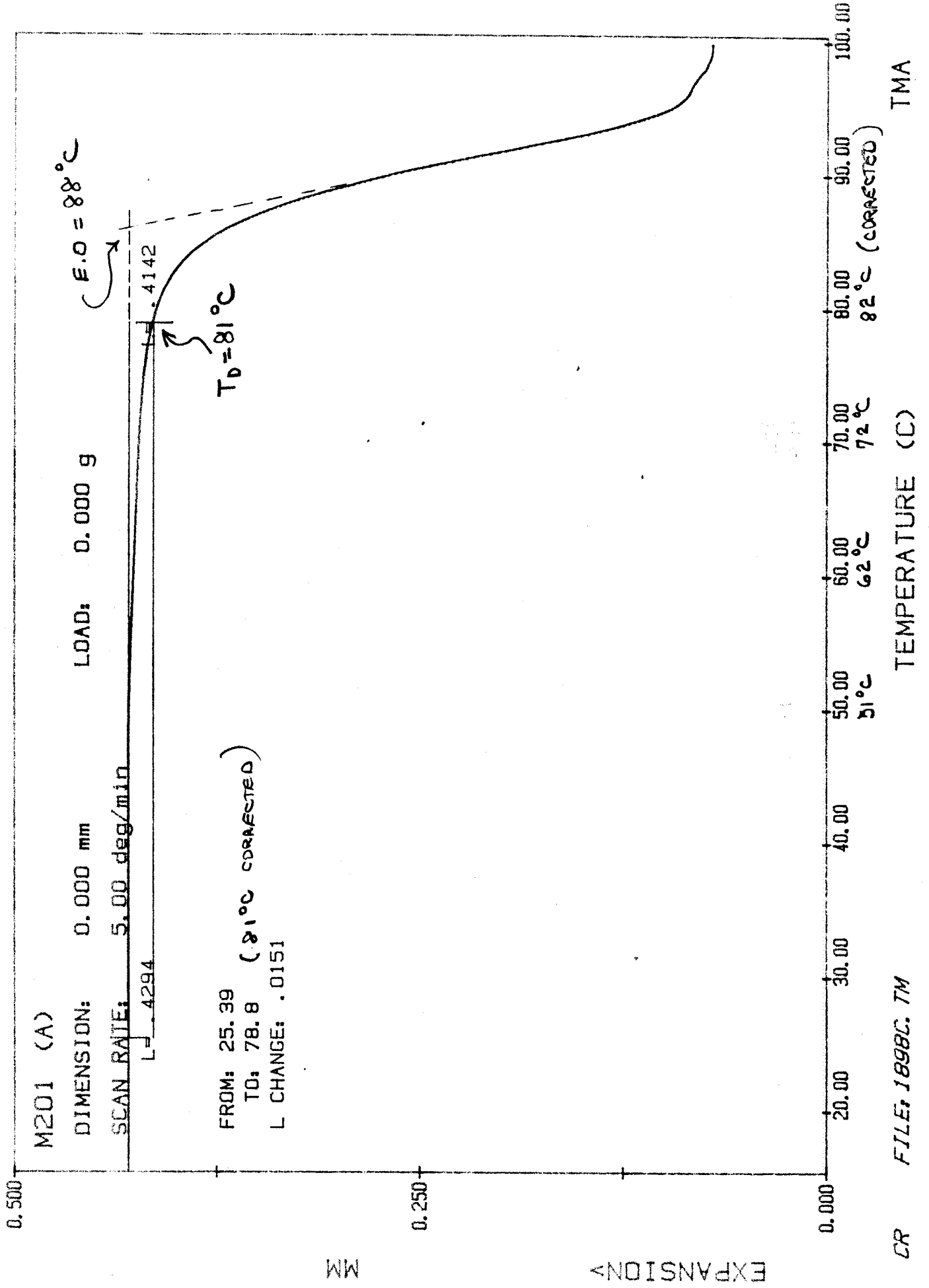




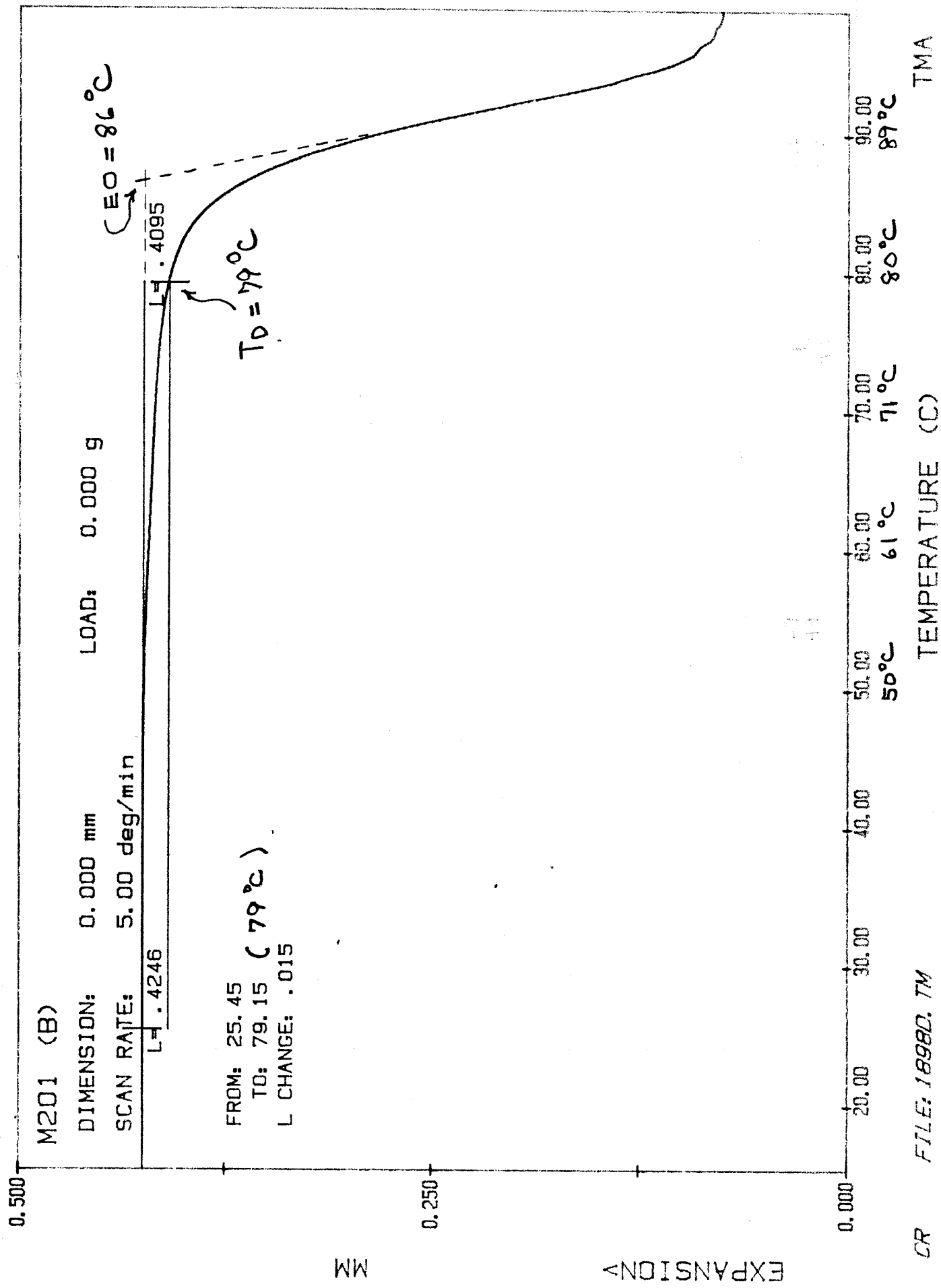
CR FILE: 1898B.TM

DATE: 96/05/29 TIME: 15:16

FIGURE # 2A



11-11-82 205



CR FILE: 18980. TM

DATE: 96/05/29 TIME: 16:26