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EVALUATION OF STRUCTURAL PROPERTIES OF GLASS REINFORCED PLASTIC CONSTRUCTION AFTER PROLONGED EXPOSURE TO 325°F.

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(FORT WORTH)

REPORT FZM-2024

MODEL

DATE 13 January 1961

TITLE

EVALUATION OF STRUCTURAL PROPERTIES OF GLASS REINFORCED PLASTIC CONSTRUCTION AFTER PROLONGED EXPOSURE TO 325°F

Approved by: A C Wilson
for E. R. Collinsworth
Senior Design Group Engineer

1. INTRODUCTION

The elevated temperatures encountered in long range supersonic aircraft have created a need for high temperature resistant glass reinforced plastic construction which will provide the required strength, light weight, and radar transparency. The objective of this program was to determine the effect of prolonged exposure to 325°F on various reinforced plastic material combinations.

2. APPROACH

The present materials used on the B-58 were known to have useful properties at temperatures up to 300°F for short periods of time. However, little if any data was available on their properties at 325°F after prolonged exposure. Since time and funds were not available for an extensive development program for new materials and some of the present B-58 materials appeared capable of operating under this condition, it was decided to evaluate B-58 materials only. The present production processing techniques such as curing agents, finish of glass reinforcements, fabrication methods and curing cycles were used. In the case where the material is used by a sub-contractor of B-58 parts, the vendor's processes were used.

Two test requests were written to initiate the fabrication and testing of panels. F-9684 was issued for G.R.P. faced sandwich construction and F-9636 was issued for solid laminate G.R.P. construction.

Materials Tested.

Phenolic - Conolon 506 FMS0031 CLASS VI *
Epoxy Epon 828 FMS0031 CLASS IV **
Modified Polyester - Laminac 4232 FMS0031 CLASS II***

3. FABRICATION - MATERIALS AND PROCESSES

3.1 SANDWICH CONSTRUCTION

Two (2) resin systems were evaluated. Phenolic and Epoxy Panel fabrication details were as follows:

*Room Temperature value		*	**	***
Compression	KSI	35	48	30
Tensile	KSI	40	47	35
Flexual	KSI	50	65	48

3.1.1 Phenolic Glass Reinforced Plastic Faced Sandwich Construction

(Representative of the General Structural non-electrical sandwich construction on the B-58)

3.1.1.1 Construction and Materials

One (1) panel size .560" ± .015" x 38.0" x 38.0" was fabricated as follows:

A. Faces were composed of 3 plies of number 181 style Conolon 506 preimpregnated glass cloth per specification FMS-0031 (B) Class VI

B. Core was a 5.5 lb/cu.ft. nominal density glass fabric reinforced plastic honeycomb core material for Specification FMS-0013 (B) Type IV.*

C. Faces were bonded to the core using adhesive per Specification FMS-0015-1.**

3.1.1.2 Processing

A single stage lay-up was used and the panel cured as follows:

a. Cure cycle under vacuum pressure of 26" ± 3" of Hg.

3/4 hour at 200°F ± 10°F

1/2 hour at 250°F ± 10°F

1/2 hour at 275°F ± 10°F

b. Post cure cycle with no vacuum

1/2 hour at 300°F ± 10°F

2 hours at 350°F ± 10°F

3.1.1.3 The completed panel was painted using prime per FMS-0003 and paint per FMS-0004.

* $\frac{3}{16}$ hex cell configuration. Room temperature values: compression 700 psi core shear L 360 psi core shear W 210 psi

** typical epoxy-phenolic resin adhesive.

3.1.2 Epoxy Glass Reinforced Plastic Faced Sandwich Construction (Simulating radome construction)

3.1.2.1 Construction and Materials - Two (2) panel size .602" ± .010" x 38.0" x 38.0" were fabricated as follows:

a. Faces were composed of 5 plies of number 181 style Volan "A" finish glass fabric with Epon 828 resin and 13 phr MPD curing agent. Faces were finished to a thickness of .045" ± .005" with a cured resin content of 34% ± 3%. They met the requirements of Specification FMS-0031B Class IV.

b. Core was a 4.75 lb/cu.ft. nominal density glass fabric reinforced plastic honeycomb core material per Specification FMS-0013 (B) Type II* spliced and vented as required.

c. Parent resin as outlined above was used to bond the faces to the core.

3.1.2.2 Processing - A three stage lay-up was used as follows:

a. 1st stage - Both faces were laid up and rubbed out at 150°F. The cure under vacuum pressure of 26" ± 3" of Hg was as follows:

3/4 hour at 200°F ± 5°F

1/2 hour at 250°F ± 5°F

1 hour at 300°F ± 5°F

b. 2nd stage - One face was parent resin bonded to the core under vacuum pressure of 26" ± 3" of Hg.

2 hours at 150°F ± 5°F

3/4 hours at 200°F ± 5°F

1/2 hour at 250°F ± 5°F

1 hour at 300°F ± 5°F

*$\frac{3}{16}$ hex cell configuration. Room temperature values. Compression 535 psi shear L 310 psi shear W 190 psi.

c. 3rd Stage - The remaining face was parent resin bonded to the core under the same conditions of the 2nd stage.

d. The completed panels were post cured without vacuum as follows:

1/2 hour at 200°F ± 10°F

1 hour at 300°F ± 10°F

4 hours at 350°F ± 10°F

3.2 Solid Laminate Construction

Three (3) resin systems were evaluated. Phenolic, Epoxy, and Modified Polyester. Panel fabrication details were as follows:

3.2.1 Phenolic Glass Reinforced Plastic Laminate Construction

(Representative of the general structural non-electrical laminated construction on the B-58)

3.2.1.1 Construction and Materials - One (1) panel size .125" ± .010" x 38.0" x 38.0" was fabricated. This panel was composed of 12 plies of number 181 style Conolon 506 preimpregnated glass cloth per Specification MMS-0031 (B) Class VI.

3.2.1.2 Processing - A single stage lay-up was used and the panel cured as follows:

a. Cure cycle under vacuum pressure of 26" ± 3" of Hg.

3/4 hour at 200°F ± 10°F

1/2 hour at 250°F ± 10°F

1/2 hour at 275°F ± 10°F

b. Post cure cycle with no vacuum

1/2 hour at 300°F ± 10°F

2 hours at 350°F ± 10°F

3.2.1.3 The completed panel was painted using prime per FMS-0003* and paint per FMS-0004.**

3.2.2 Epoxy Glass Reinforced Plastic Laminate Construction - (Simulating radome and antenna construction on the B-58).

3.2.2.1 Construction and Materials - Two (2) panels size .170" ± .005" x 38.0" x 38.0" were fabricated. These panels were composed of approximately 17 plies of number 181 style Garan finish glass cloth with Epon 828 resin and 15 phr RP-7A curing agent. Cured resin content was 34% ± 2%.

3.2.2.2 Processing - A three stage lay-up was used and cured as follows:

A. 1st stage - Six (6) plies of cloth were impregnated with resin, rubbed out and cured under vacuum pressure of 26" ± 3" Hg as follows:

1/2 hour at 150°F ± 5°F

1 hour at 200°F ± 5°F

1/2 hour at 250°F ± 5°F

B. 2nd Stage - Six (6) plies were added to the 1st stage lay-up using the same processing method.

C. 3rd Stage - the remaining plies were added to the 2nd stage lay-up as necessary to meet the thickness requirement using the same processing methods as used in the 1st stage.

D. The completed panel was post cured without vacuum as follows:

1/2 hour at 250°F ± 10°F

1 hour at 300°F ± 10°F

4 hours at 350°F ± 10°F

3.2.3 Modified Polyester Glass Reinforced Plastic Laminate Construction - (Simulating the search radome construction on the B-58).

* Typical Epoxy Primer
** Typical Epoxy Paint.

3.2.3.1 Construction and Material - Two (2) panels size .183" ± .005" x 38.0" x 38.0" were fabricated. These panels were composed of approximately 16 plies of number 181 style Garan finish glass cloth with Laminac 4232 resin and 2 phr ATC curing agent. Cured resin content was 38% ± 3%.

3.2.3.2 Processing - A three stage lay-up was used and cured as follows:

A. 1st stage - Seven (7) plies of cloth were impregnated with resin, rubbed out and cured under vacuum pressure of 26" ± 3" Hg at 180°F ± 5°F for 4 hours. (One ply was used for a peel ply.)

B. 2nd Stage - Seven (7) plies were added to the 1st stage using the same processing methods. (One ply was used for a peel ply).

C. 3rd Stage - The remaining plies were added to the 2nd stage as necessary to meet the thickness requirement using the same processing methods as for the 1st stage.

D. The completed panel was post cured without vacuum as follows:

12 hours at 200°F ± 5°F

5 hours at 225°F ± 5°F

4 hours at 250°F ± 5°F

4 hours at 275°F ± 5°F

4 hours at 300°F ± 5°F

4 hours at 325°F ± 5°F

72 hours at 350°F ± 5°F

4.0 TESTING

4.1 MECHANICAL TESTING

4.1.1 Testing was accomplished under the following environmental conditions.

a. Room temperature control tests
b. At 325°F after 1/2 hour exposure to 325°F
c. At 325°F after 200 hours exposure to 325°F
d. At 325°F after 1000 hours exposure to 325°F
e. At room temperature after 3000 hours exposure to 325°F
f. At 325°F after 3000 hours exposure to 325°F

4.1.2 The following mechanical tests were conducted.

4.1.2.1 Glass reinforced plastic faced sandwich construction.

a. Column compression specimens - prepared and tested per Specification FZS-4-071 (A) Type XII.*

b. Pi Tension specimens - prepared and tested per Specification FZS-4-071 (A) Type III**

c. Load - Deflection (P/Δ) Beams - prepared and tested per Figure 1 and Table I.

d. Beam - Column creep tests were run on epoxy and phenolic faced sandwich constructions for 3000 hours. The specimens were prepared and tested in accordance with Figure 2.

4.1.2.2 Glass Reinforced Plastic Solid Laminate Construction

a. Tensile specimens - prepared and tested per Specification LP-406b Method 1011 Type 1.

b. Compression specimens - prepared and tested per Specification LP-406b Method 1021.1 using Convair modified specimens(with flared ends).

c. Flexure specimens - prepared and tested per Specification LP-406b Method 1031.1

*See Supplementary Sheet S-1
**See Supplementary Sheet S-2.

4.2 PHYSICAL TESTING

4.2.1 The following physical tests were accomplished on the glass reinforced plastic solid laminates and faces of the sandwich panels.

a. Specific gravity per Specification LP-406b Method 5011.
b. Resin content per Specification LP-406b Method 7061.
c. Hardness test using a Barcol Impressor Model GYZ-934-1.

4.2.2 The physcial tests were performed at room temperature after the following exposures:

a. Prior to exposure to 325°F
b. After 200 hours at 325°F
c. After 1000 hours at 325°F
d. After 3000 hours at 325°F

4.3 Electrical Tests

Identical panels using the Epoxy and Modified Polyester resin systems were fabricated for electrical tests. The electrical tests were run at room temperature after the test panels had been exposed to 325°F for 3000 hours. The panels were tested for dielectric constant, loss tangent, transmission and I.P.D. at 8.5 KMC.

4.4 Exposure and Tests at Temperature

Room temperature and short time exposure (1/2 hour) test specimens were removed from the panels and remaining sections of the panels were exposed to 325°F in a closely controlled oven. All open edges of the sandwich panels were sealed with Mylar tape during the exposure. At the end of each time period the panels were removed and inspected. Sufficient material for the required test specimens was removed; and the panels were re-sealed and returned to the oven for continued exposure.

5.0 TEST RESULTS AND DISCUSSION

5.1 TEST RESULTS

The mechanical and physical test results are summarized in Tables II and III and detailed in Tables IV through Table XXII.

5.2 DISCUSSION

When reinforced plastic materials are exposed to elevated temperatures, two reactions simultaneously take place. One reaction is the additional curing of the resin which increases the mechanical strength of the material. The other reaction is oxidation which causes a deterioration of the resin which results in a decrease in mechanical strength.

Epoxy and Modified Polyester laminates are practically non-porous and only the outer surfaces are primarily affected by oxidation. Phenolic laminates are noted for their porosity and exposure to high temperature for an extended period of time creates a serious oxidation problem. The effect of oxidation of phenolic material can be reduced by painting the surfaces or by impregnating the porous laminate with a high temperature material.

The Phenolic panels (solid and sandwich) were painted in an effort to reduce the effect of oxidation but the panels were substantially affected by oxidation during the long exposure to 325°F.

The low specific gravity of the solid laminate phenolic part (1.57) is another indication that it was more porous than the Epoxy laminate (1.86) or the modified polyester laminate (1.89).

The mechanical values for the Epoxy sandwich panel were lower than a typical Epoxy sandwich panel. This apparently was caused by the low bond strength of the parent resin. The panel tested had an ultimate tension value of 1057 pounds, while a typical panel should have a value of 1300 pounds.

The test results showed that there was a definite increase in strength of all materials as the exposure time at 325°F was increased from 1/2 to 200 hours. This increase can be attributed to the additional curing of each type of resin with a minimum effect of oxidation.

At some point between 200 and 1000 hours exposure, the effect of oxidation began to overtake the effect of curing and resulted in a decrease of mechanical properties of the solid and sandwich phenolic parts. During this same period of exposure the epoxy material increased in strength and the modified polyester leveled off with slight increases in some properties and some decreases in others.

Between 1000 and 3000 hours exposure at 325°F the Phenolic material continued to deteriorate at a more rapid rate. The epoxy material reached its peak strength during this period of exposure and started to decrease in mechanical strength. The Modified Polyester material continued to show a small increase in mechanical properties during the entire exposure time from 1000 to 3000 hours.

6.0 CONCLUSIONS

These test results show that all three resin systems tested can satisfactorily operate at 325°F for 1000 hours. It can also be concluded that the present design allowable based on acceptance values for 300°F for 1/2 hour exposure are realistic for 1000 hours exposure at 325°F without reductions.

Based on this data Modified Polyester appears to be the best resin for applications where the material is exposed to 325°F for 3000 hours. During this 3000 hours period of exposure at 325°F the mechanical properties remained almost constant which would indicate that Modified Polyester material useable life is greater than 3000 hours. See Figure 3.

Although the mechanical properties of Epoxy resin began to decrease sometime between 1000 hours and 3000 hours they were still within a practical range after 3000 hours exposure. See Figures 4 and 6.

Phenolic material was definitely affected by the long exposure at 325°F and its mechanical properties after 3000 hours exposure were unsatisfactory. See Figures 5 and 7.

The electrical properties of the Epoxy and Modified Polyester laminates were satisfactory for all practical purposes after 3000 hours exposure at 325°F. The dielectric constant and loss tangent properties at 8.5 KMC of the epoxy laminate were within the requirements of MIL-S-0031 B. The loss tangent properties of the Modified Polyester laminate was within the the specification value but the dielectric constant value was just outside of specification requirements. See Table XXII.

The Epoxy and Phenolic laminated faced sandwich specimens had very similar creep characteristics when exposed at 325°F. The initial creep rate (during exposure from 2 hours to 200 hours) was approximately .00022 inches per hour. As the exposure time increased the creep rate decreased. The average creep rate between 200 hours and 3000 hours was approximately .00001 inches per hour. Although the creep rate continues to decrease during the entire 3000 hour exposure the specimens never stopped creeping. See Tables X and XI.

7.0 RECOMMENDATIONS

Modified Polyester (Laminac 4232) and Epoxy (Epon 828) are the best resin systems currently being used at Convair for applications at 325°F for 3000 hours.

Although these materials will do a satisfactory job, they have the following disadvantages; Modified Polyester resin presents a fabrication problem because of excessive flow during cure; the strength of Epoxy (Epon 828) drops off rather sharply above 325°F.

Therefore, in order to improve the reinforced plastic materials for long time duration at 325°F the following additional work is recommended.

1. New available epoxy materials should be tested. These materials have higher heat distortion points than Epon 828 tested in this program.
2. A method should be developed to preimpregnate a Modified Polyester resin to reduce fabrication problems.
3. A material and method should be developed to impregnate Phenolic parts to reduce the effect of oxidation.

LOAD DEFLECTION SPECIMEN

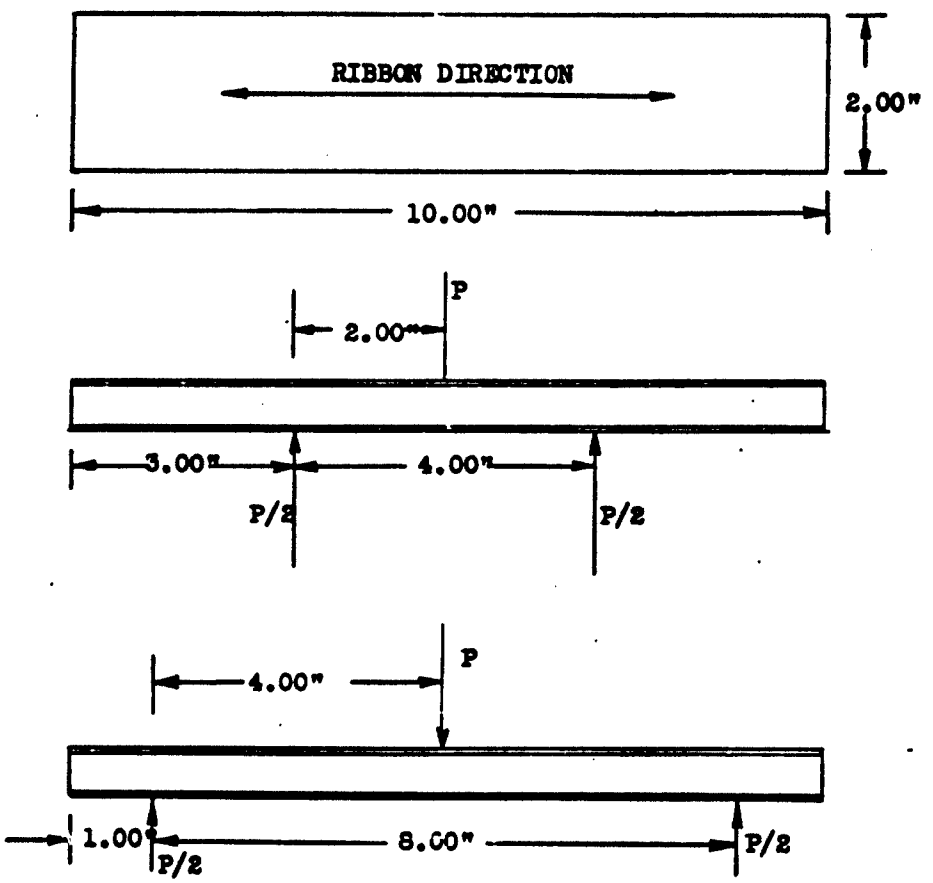
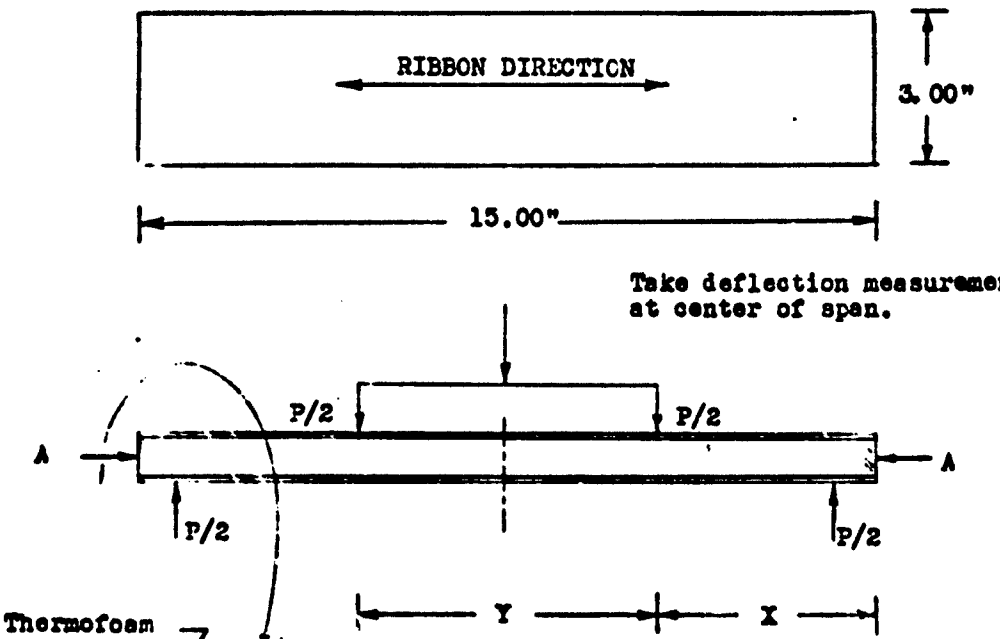


FIGURE 1

BEAM COLUMN CREEP SPECIMEN



Test for 3000 hours at 325°F

Beam Type*	A (Lbs)	P (Lbs)	X (in.)	Y (in)
I	62	100	4	7
II	0	80	4	7

*Ref. Table I Key

FIGURE 2

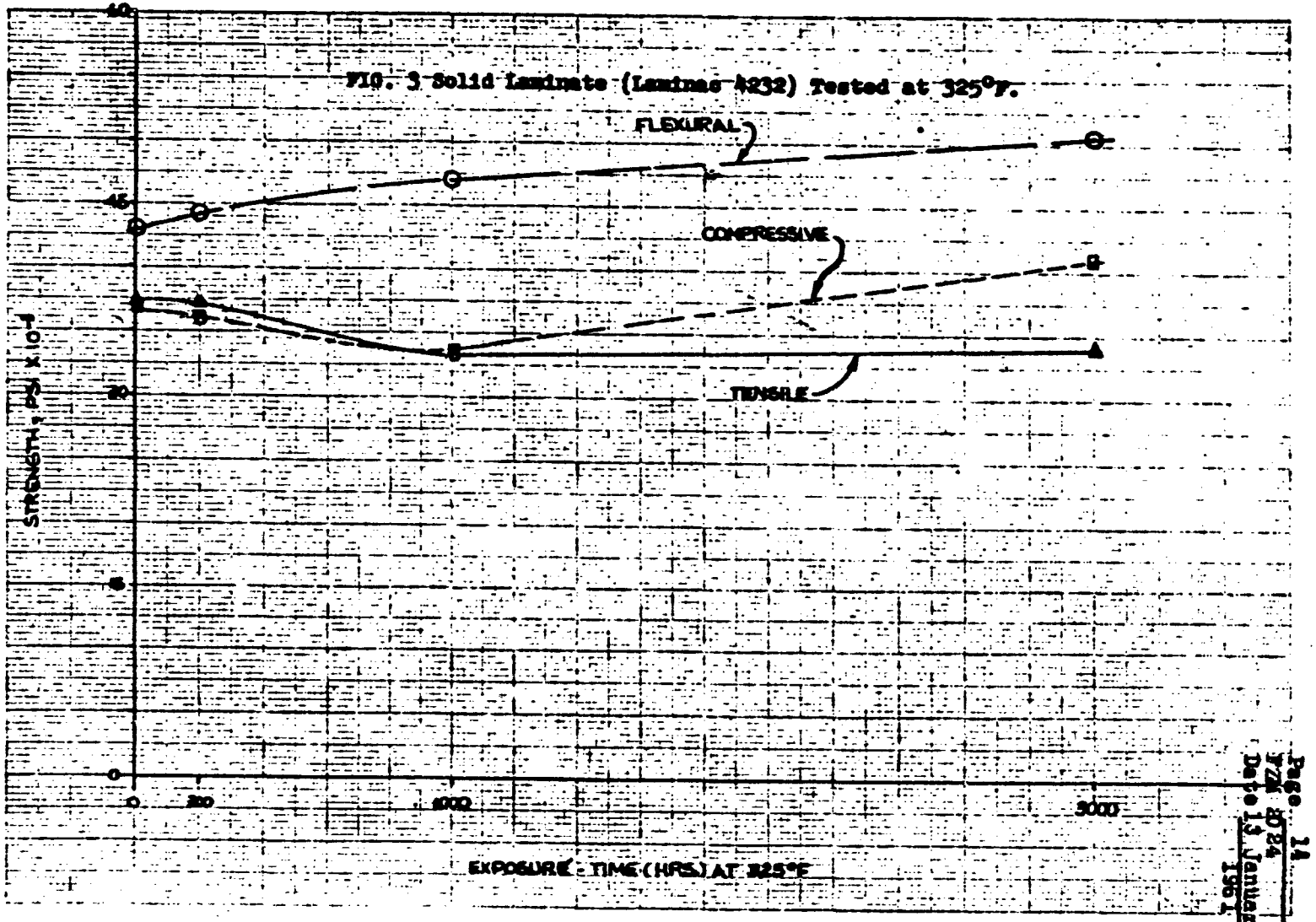


FIG. 3 Solid Laminate (Laminae 4232) Tested at 325°F.

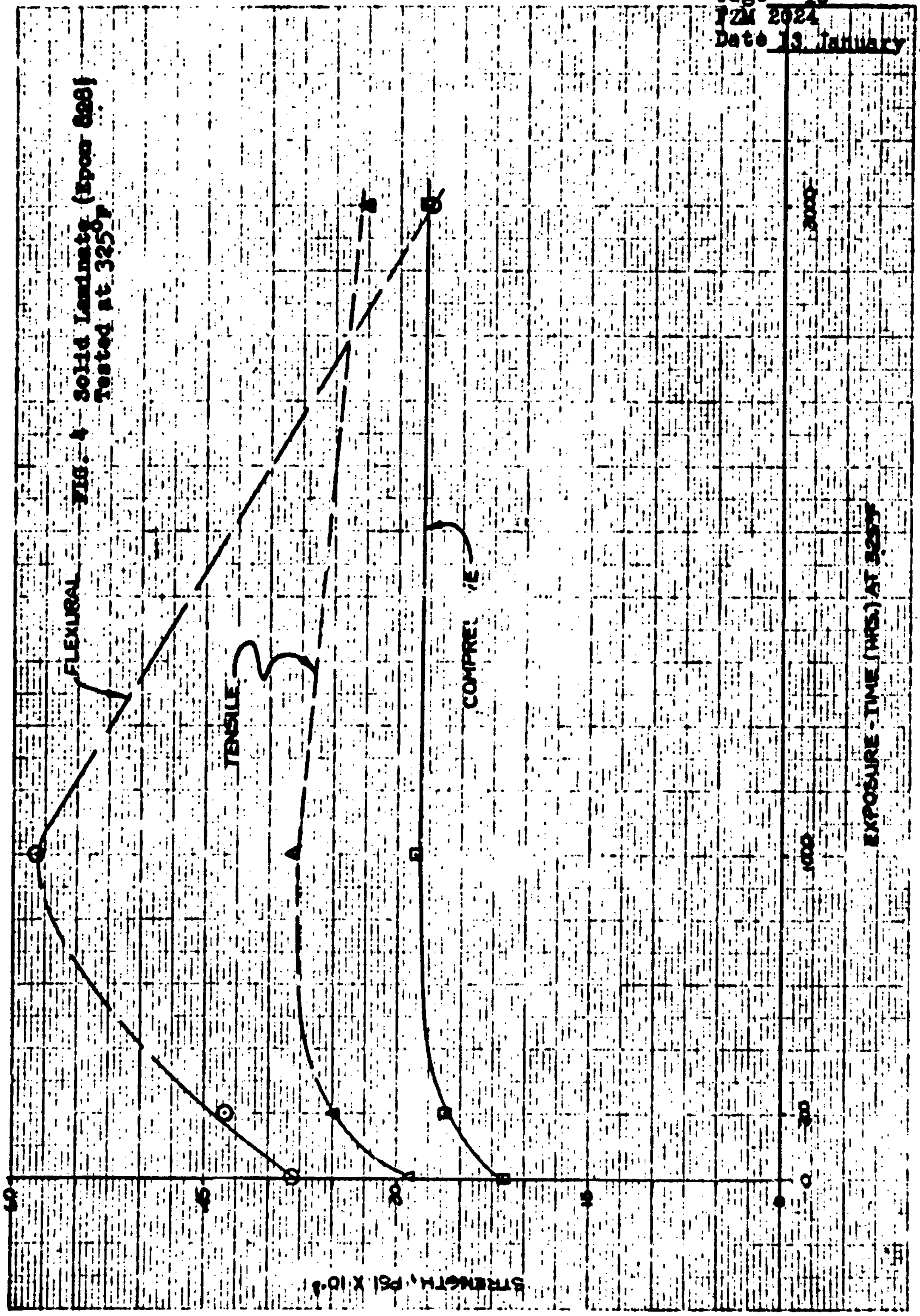


FIG. 4 - Solid Laminate (Epon 828) Tested at 325°F

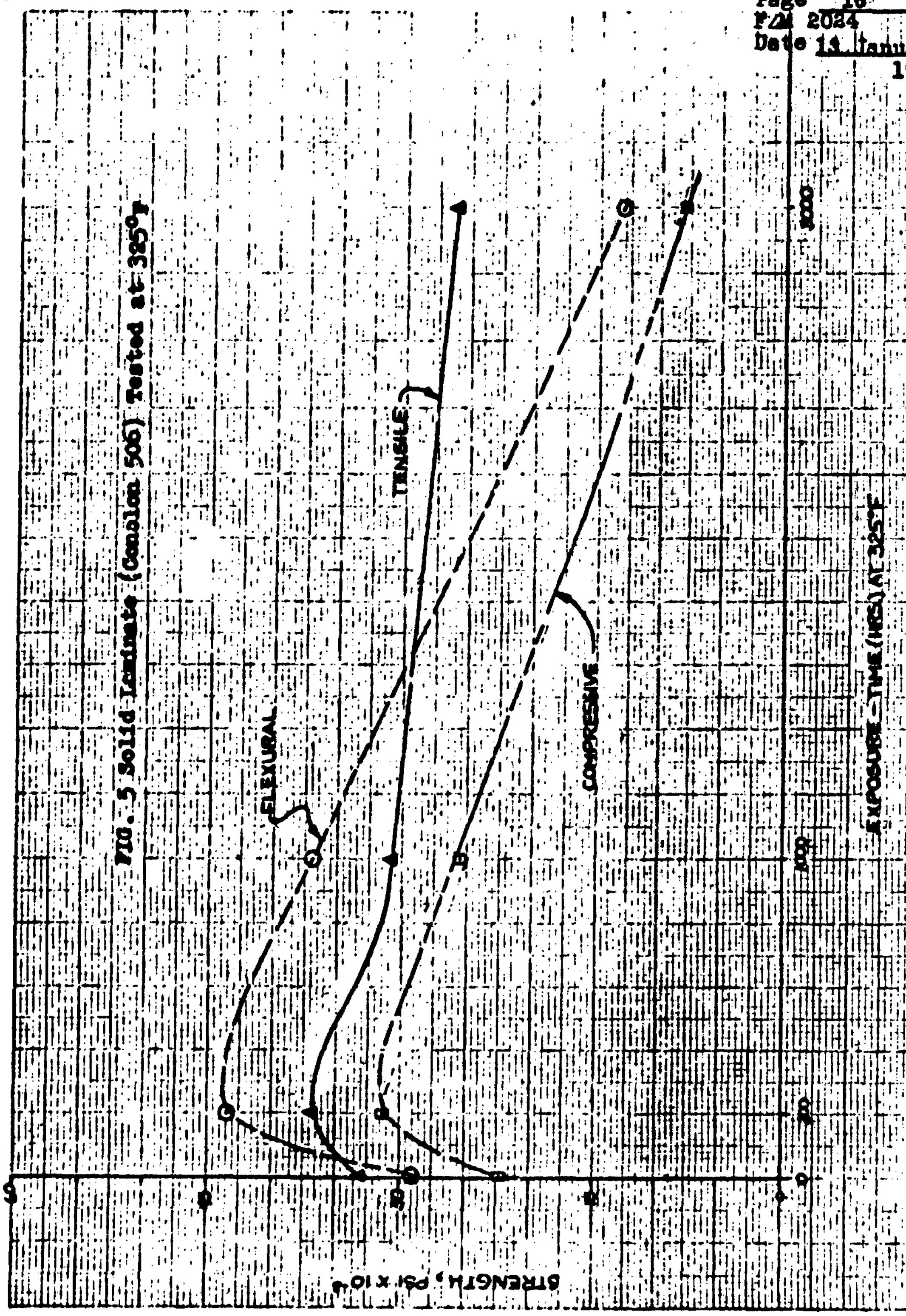


FIG. 5 Solid Laminate (Conolon 506) Tested at 325°F

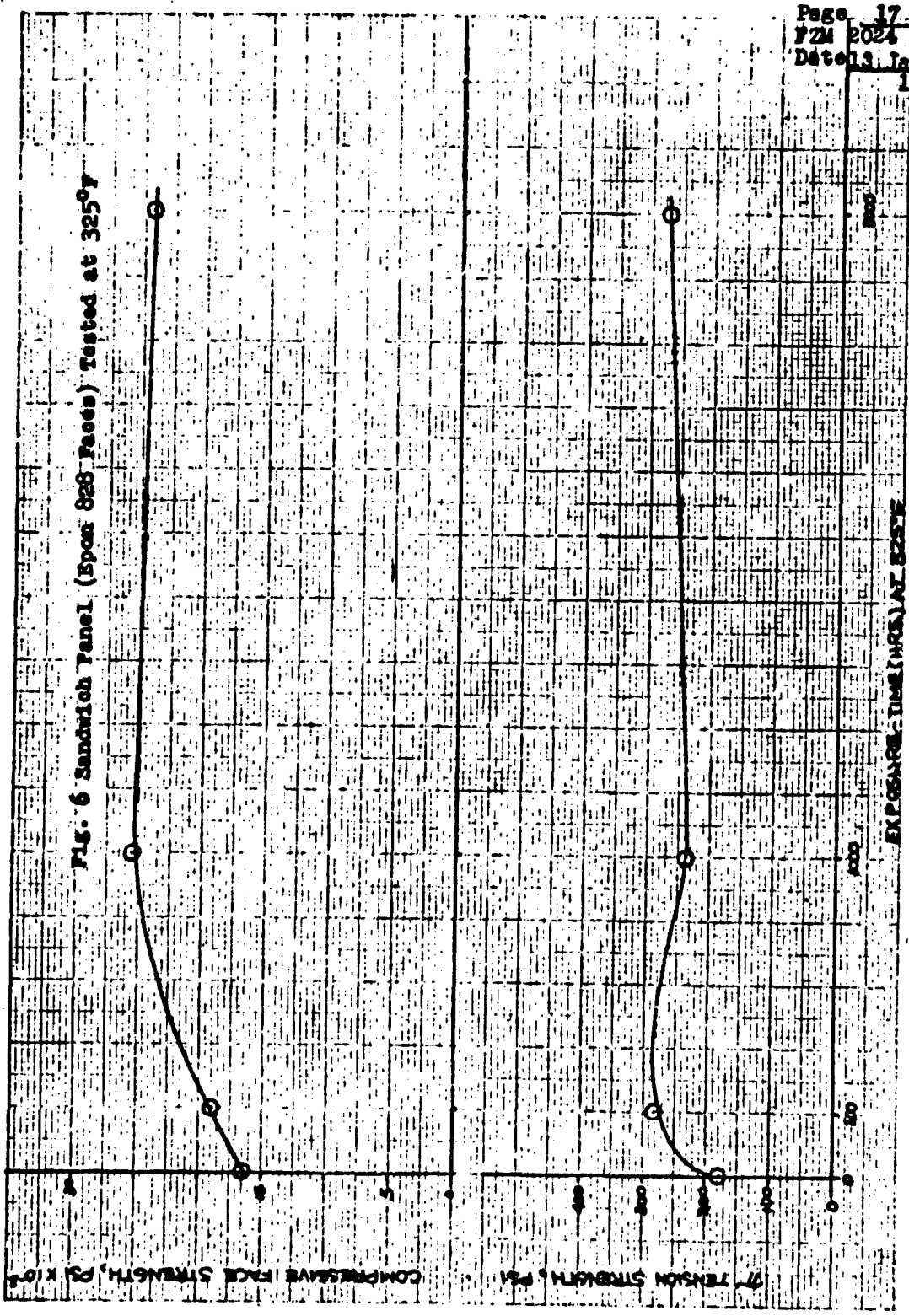


Fig. 6 Sandwich Panel (Epon 828 Facer) Tested at 325°F

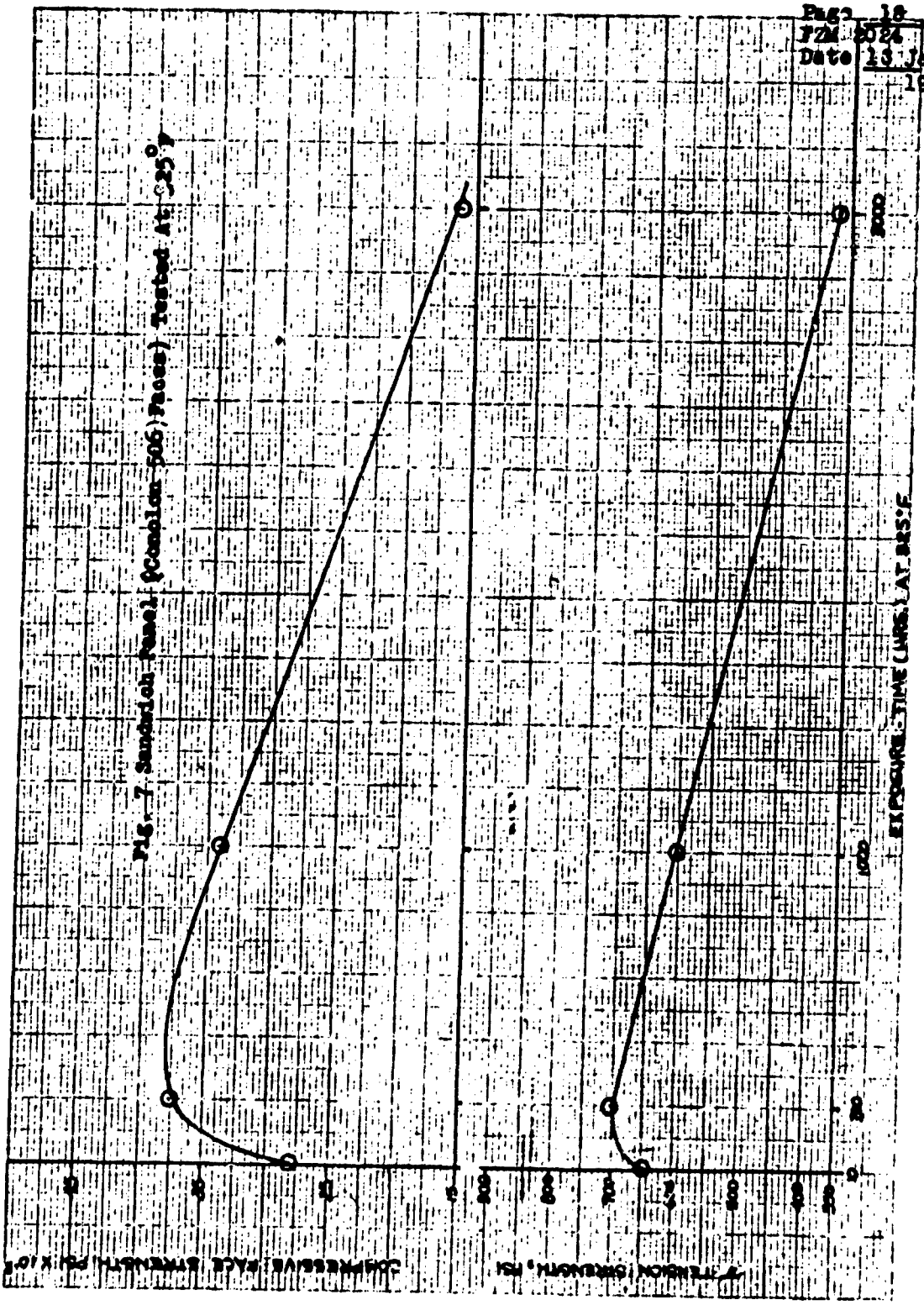


Fig. 7 Sandwich Panel (Combination 506) Tested At 525°F

TABLE I

LOAD-DEFLECTION (P/Δ) BEAM TEST PROCEDURE

MATERIAL	TEST TEMP	1st SPAN (Ins)	2nd SPAN (Ins)	1st* LOAD (Lbs)	BEARING PLATE WIDTHS		HEAD TRAVEL RATES	
					ENDS (Ins)	CENTER (Ins)	4" SPAN (In/Min)	8" SPAN (In/Min)
Conolon 506	R.T.	4.0	8.0	300	0.50	1.00	0.04	0.08
Epon 828	R.T.	8.0	4.0	300	0.75	1.50	0.04	0.08
Conolon 506	325°F	4.0	8.0	300	0.50	1.00	0.04	0.08
Epon 828	325°F	8.0	4.0	150	1.00	1.50	0.04	0.08

* The Epon 828 sandwich was loaded to this value on the 8 in. span and then failed on the 4 in. span.

The Conolon 506 sandwich was loaded to this value on the 4 in. span and then failed on the 8 in. span.

TABLE II

G.R.P. FACED SANDWICH - SUMMARIZED TEST RESULTS

TEST	PHENOLIC (CONOLON 506)						EPON 828					
Test Temp.	RT	325°F	325°F	325°F	RT	325°F	RT	325°F	325°F	325°F	RT	325°F
Exposure at Test Temp.	RT	1/2 Hr.	100 Hrs.	1000 Hrs.	**	3000 Hrs.	RT	1/2 Hr.	200 Hrs.	1000 Hrs.	**	3000 Hrs
Column Compression Face Strength KSI	38.0	28.1	37.7	34.0	15.1	16.3	30.8	16.4	18.9	25.5	43.3	24.2
Pi Tension Strength PSI	873	646	703	602	460	370	336	177	282	237	391	282
Shear Modulus, KSI	22.3	16.8	22.8	27.2	41.4	20.5	*	*	29.5	*	36.9	28.8
Resin Content, Percent	Not Tested						34.2	--	33.6	30.1	30.1	
Specific Gravity	Not Tested						1.81	--	1.89	1.85	1.85	

* Data questionable due to deflection curves.

** 3000 Hours at 325°F , then tested at R.T.

TABLE III

SOLID LAMINATE - SUMMARIZED TEST RESULTS

TEST	PHENOLIC (CONOLON 506)						EPOXY (EPON 828)						MODIFIED POLYESTER (LAMINAC 4232)					
TEST TEMP.	R.T.	325°F	325°F	325°F	R.T.	325°F	R.T.	325°F	325°F	325°F	R.T.	325°F	R.T.	325°F	325°F	325°F	R.T.	325°F
EXPOSURE	R.T.	1/2 Hr @ 325°F	200 Hrs @ 325°F	1000 Hrs @ 325°F	3000 Hrs @ 325°F	3000 Hrs @ 325°F	R.T.	1/2 Hr @ 325°F	200 Hrs @ 325°F	1000 Hrs @ 325°F	3000 Hrs @ 325°F	3000 Hrs @ 325°F	R.T.	1/2 Hr @ 325°F	200 Hrs @ 325°F	1000 Hrs @ 325°F	3000 Hrs @ 325°F	3000 Hrs @ 325°F
FLEXURAL STRENGTH KSI	32.9	28.9	43.4	36.8	16.4	13.2	66.2	38.1	43.3	58.1	69.2	27.2	57.9	43.1	44.2	47.0	56.7	50.6
FLEXURAL MODULUS PSI x 10^{-6}	2.39	2.03	2.59	2.33	1.75	1.63	3.05	2.13	2.60	2.93	3.08	1.75	3.24	2.91	2.64	2.76	3.03	2.42
TENSILE STRENGTH KSI	37.4	33.2	36.7	30.9	26.0	20.1	44.3	28.9	34.8	38.0	45.5	32.5	40.6	37.2	37.2	33.3	30.5	34.0
TENSILE MODULUS PSI x 10^{-6}	3.54	2.58	3.37	3.13	1.99	1.92	2.75	2.46	2.72	2.97	3.42	2.67	2.66	3.16	3.51	3.00	3.34	2.76
COMPRESSION STRENGTH KSI	27.4	22.3	31.3	25.5	7.37*	8.02*	45.8	21.6	26.2	28.6	62.2	27.5	49.8	37.4	36.0	33.4	52.7	41.0
COMPRESSION MODULUS PSI x 10^{-6}	2.69	3.03	3.45	2.79	2.25	2.60	3.61	1.35	1.45	2.83	3.52	2.66	3.60	1.59	3.34	2.78	3.29	3.00
RESIN CONTENT %	28.5	---	28.5	30.5	28.7	---	33.5	---	33.4	33.8	34.2	---	30.4	---	38.5	38.5	37.3	---
SPECIFIC GRAVITY	1.58	---	1.53	1.54	1.51	---	1.86	---	1.85	1.84	1.82	---	1.89	---	19.1	1.88	1.85	---
BARCOL HARDNESS	NOT TESTED						77.8						82.3					

* End Failures

TABLE IV

PHENOLIC (CONOLON 506) FACED SANDWICH - COLUMN COMPRESSION TESTS

SPECIMEN NUMBER	TEST TEMP	EXPOSURE	WIDTH (Ins)	FACE THICK (Ins)	ULT LOAD (Lbs)	ULTIMATE FACE STRENGTH (Psi)	COMMENTS
1	RT	RT	1.03	.030	2450	39,600	Face Failure
3	RT	RT	1.03	.030	2310	37,400	Face Failure
5	RT	RT	1.03	.030	2280	36,900	Face Failure
Ave.						38,000	
2	325°F	1/2 Hr @ 325°F	1.03	.030	1795	29,000	Face Failure
4	325°F	1/2 Hr @ 325°F	1.03	.030	1775	28,700	Face Failure
6	325°F	1/2 Hr @ 325°F	1.03	.030	1740	26,500	Face Failure
Ave.						28,100	
7	325°F	200 Hr @ 325°F	1.04	.030	2595	41,600	Face Failure
8	325°F	200 Hr @ 325°F	1.07	.030	2400	37,400	Face Failure
9	325°F	200 Hr @ 325°F	1.09	.030	2220	37,000	Face Failure
Ave.						37,700	
10	325°F	1000 Hr @ 325°F	1.05	.030	2140	34,000	Face Failure
11	325°F	1000 Hr @ 325°F	1.05	.030	2135	33,900	Face Failure
12	325°F	1000 Hr @ 325°F	1.05	.030	2140	34,000	Face Failure
Ave.						34,000	
13	RT	3000 Hr @ 325°F	1.00	.030	920	15,400	Face Failure
14	RT	3000 Hr @ 325°F	1.01	.030	1050	17,200	Face Failure
15	RT	3000 Hr @ 325°F	1.00	.030	760	12,700	Face Failure
Ave.						15,100	
16	325°F	3000 Hr @ 325°F	1.01	.030	1235	20,400	Face Failure
17	325°F	3000 Hr @ 325°F	1.00	.030	1030	17,200	Face Failure
18	325°F	3000 Hr @ 325°F	1.00	.030	675	11,200	Face Failure
Ave.						16,300	

TABLE V

EPON 828 FACED SANDWICH - COLUMN COMPRESSION TEST

SPECIMEN NUMBER	TEST TEMP	EXPOSURE	WIDTH	FACE THICK (Ins)	ULT. LOAD (Lbs)	ULTIMATE FACE STRESS (Psi)	COMMENTS
1	RT	RT	1.03	.048	3400	34,400	Face Failure
3	RT	RT	1.03	.048	4250	43,000	Face Failure
5	RT	RT	1.03	.048	1470	14,900	Bond Failure
Ave.						30,800	
2	325°F	1/2 Hr @ 325°F	1.03	.048	2040	20,600	Face Failure
4	325°F	1/2 Hr @ 325°F	1.03	.048	1205	12,200	Face Failure
6	325°F	1/2 Hr @ 325°F	1.03	.048	1630	16,500	Face Failure
Ave.						16,400	
7	325°F	200 Hrs @ 325°F	1.05	.048	1920	19,100	Face Failure
8	325°F	200 Hrs @ 325°F	1.05	.048	1970	19,500	Face Failure
12	325°F	200 Hrs @ 325°F	1.04	.048	1825	18,300	Face Failure
Ave.						18,900	
9	325°F	1000 Hrs @ 325°F	1.07	.048	2410	23,400	Face Failure
10	325°F	1000 Hrs @ 325°F	1.04	.048	2835	28,400	Face Failure
11	325°F	1000 Hrs @ 325°F	1.05	.048	2490	24,700	Face Failure
Ave.						25,500	
13	RT	3000 Hrs @ 325°F	1.01	.048	4420	45,600	Bond Failure
14	RT	3000 Hrs @ 325°F	1.02	.048	4800	49,000	Bond Failure
15	RT	3000 Hrs @ 325°F	1.00	.048	3400	35,400	Bond Failure
Ave.						43,300	
16	325°F	3000 Hrs @ 325°F	1.01	.048	1820	18,800	Bond Failure
17	325°F	3000 Hrs @ 325°F	1.01	.048	3310	34,100	Bond Failure
18	325°F	3000 Hrs @ 325°F	1.00	.048	2860	29,800	Bond Failure
Ave.						24,200	

TABLE VI

PHENOLIC (CONOLON 506) FACED SANDWICH - PI TENSION TEST

SPECIMEN NO.	TEST TEMP	EXPOSURE	AREA	ULT. LOAD	ULT STRENGTH	COMMENTS
			(Ins^2)	(Lbs)	(Psi)	
1	R.T.	R.T.	3.14	2660	847	Bond Failure
3	R.T.	R.T.	3.14	2800	891	Bond Failure
5	R.T.	R.T.	3.14	2770	882	Bond Failure
Ave.					873	
2	325°F	1/2 Hr @ 325°F	3.14	1925	619	Bond Failure
4	325°F	1/2 Hr @ 325°F	3.14	1825	581	Bond Failure
6	325°F	1/2 Hr @ 325°F		2315	737	Bond Failure
Ave.					646	
[illegible]	325°F	200 Hrs @ 325°F	3.14	2130	677	Bond Failure
[illegible]	325°F	200 Hrs @ 325°F	3.14	2110	672	Bond Failure
9	325°F	200 Hrs @ 325°F	3.14	2390	759	Combination Bond and Laminate Failure
Ave.					703	
10	325°F	1000 Hrs @ 325°F	3.14	1830	582	Bond Failure
11	325°F	1000 Hrs @ 325°F	3.14	2265	722	Bond Failure
[illegible]	325°F	1000 Hrs @ 325°F	3.14	1575	501	Bond Failure
Ave					602	
13	R.T.	3000 Hrs @ 325°F	3.14	1315	419	Bond Failure
14	R.T.	3000 Hrs @ 325°F	3.14	1440	452	Bond Failure
15	R.T.	3000 Hrs @ 325°F	3.14	1595	508	Bond Failure
Ave.					460	
16	325°F	3000 Hrs @ 325°F	3.14	1065	340	Bond Failure
17	325°F	3000 Hrs @ 325°F	3.14	1120	357	Bond Failure
18	325°F	3000 Hrs @ 325°F	3.14	1295	413	Bond Failure
Ave					370	

TABLE VII

EPON 828 FACED SANDWICH - PI TENSION TEST

SPECIMEN NUMBER	TEST TEMP.	EXPOSURE	AREA (Ins^2)	ULT. LOAD (Lbs)	ULT. STRENGTH (Psi)	COMMENTS
1	R.T.	R.T.	3.14	1075	342	Parent Resin Bond Failure
3	R.T.	R.T.	3.14	1040	331	Parent Resin Bond Failure
5	R.T.	R.T.	3.14	---	---	Premature Failure
Ave.					336	
2	325°F	1/2 Hr @ 325°F	3.14	560	178	Parent Resin Bond Failure
4	325°F	1/2 Hr @ 325°F	3.14	455	145	Parent Resin Bond Failure
6	325°F	1/2 Hr @ 325°F		655	208	Parent Resin Bond Failure
Ave.					177	
7	325°F	200 Hr @ 325°F	3.14	1100	350	Parent Resin Bond Failure
8	325°F	200 Hr @ 325°F	3.14	755	240	Parent Resin Bond Failure
9	325°F	200 Hr @ 325°F	3.14	810	257	Parent Resin Bond Failure
Ave.					282	
10	325°F	1000 Hrs @ 325°F	3.14	935	297	Parent Resin Bond Failure
11	325°F	1000 Hrs @ 325°F	3.14	640	204	Parent Resin Bond Failure
12	325°F	1000 Hrs @ 325°F	3.14	665	211	Parent Resin Bond Failure
Ave.					237	
13	R.T.	3000 Hrs @ 325°F	3.14	1310	417	Parent Resin Bond Failure
14	R.T.	3000 Hrs @ 325°F	3.14	1145	366	Parent Resin Bond Failure
Ave.					391	
15	325°F	3000 Hrs @ 325°F	3.14	845	270	Parent Resin Bond Failure
16	325°F	3000 Hrs @ 325°F	3.14	985	314	Parent Resin Bond Failure
17	325°F	3000 Hrs @ 325°F	3.14	820	261	Parent Resin Bond Failure
Ave.					282	

TABLE VIII

PHENOLIC (CONOLON 506) FACED SANDWICH - P/Δ BEAM TESTS

SPECIMEN NUMBER	TEST TEMP	EXPOSURE	BEAM THICK IN.	BEAM WIDTH IN.	FACE THICK IN.	ULT. LOAD LBS.	CORE SHEAR @ FAILURE PSI	ULT. FACE STRESS KSI	$(P/\Delta)_L$ (LBS/IN)	(P/Δ) (LBS/IN)	CORE SHEAR MODULUS (PSI)	TYPE FAILURE
1	R.T.		.569	2.00	.030	790	366	25.7	2,770	13,330	23,095	Facing Failure
3	R.T.		.569	2.00	.030	840	389	27.3	2,670	12,200	22,087	Facing Failure
5	R.T.		.569	1.97	.030	815	388	28.7	2,680	14,180	21,720	Facing Failure
Ave.											22,301	
2	325°F	1/2 Hr @ 325°F	.568	1.97	.030	575	271	19.1	2,080	10,750	20,319	Facing Failure
4	325°F		.568	1.99	.030	610	285	20.1	1,940	9,520	16,329	Facing Failure
6	325°F		.566	1.96	.030	600	287	20.1	2,170	9,340	13,655	Facing Failure
Ave.							281	19.8			16,768	
7	325°F	200 Hr @ 325°F	.567	1.99	.030	725	339	24.0	2,280	11,240	19,400	Facing Failure
8	325°F		.567	2.00	.030	720	335	23.6	2,300	13,070	29,748	Facing Failure
9	325°F		.567	2.00	.030	700	326	22.9	2,310	11,110	18,390	Facing Failure
Ave.							333	23.5			22,759	
10	325°F	1000 Hrs @ 325°F	.576	1.98	.030	660	310	41.3	2,400	13,650	31,000	Facing Failure
11	325°F		.576	1.94	.030	655	314	40.4	3,200	12,500	28,900	Facing Failure
12	325°F		.575	2.01	.030	660	329	40.6	2,620	12,900	21,700	Facing Failure
Ave.							317	40.8			27,200	
13	RT	3000 Hrs @ 325°F	.567	1.97	.030	340	152	43.2	2,100	13,700	43,800	Facing Failure
14	RT		.567	1.96	.030	330	149	42.3	2,270	11,700	19,500	Facing Failure
15	RT		.568	1.92	.030	380	174	49.6	2,340	15,900	61,000	Facing Failure
Ave.							158	45.0			41,400	
16	325°F	3000 Hrs @ 325°F	.567	1.97	.030	265	118	33.6	1,750	10,400	24,000	Facing Failure
17	325°F		.568	1.97	.030	310	138	39.4	1,970	10,500	18,600	Facing Failure
18	325°F		.568	1.99	.030	335	148	42.1	2,000	10,700	18,000	Facing Failure
Ave.							135	38.4			20,500	

TABLE IX

EPOXY (EPON 828) FACED SANDWICH - P/Δ BEAM TEST

SPECIMEN NUMBER	TEST TEMP	EXPOSURE	BEAM THICK IN.	BEAM WIDTH IN.	FACE THICK IN.	ULT. LOAD LBS.	ULT. CORE SHEAR PSI	FACE STRESS @ FAILURE KSI	$(P/\Delta)_L$ (LBS/IN)	(P/Δ) (LBS/IN)	CORE SHEAR MODULUS PSI	TYPE FAILURE
1	R.T.		.603	1.99	.048	720	326	14.8	3,510	8,250	7,261	Parent Resin Bond Failure
3	R.T.		.609	1.97	.048	545	247	11.1	3,530	10,400	10,212	" " " "
5	R.T.		.607	1.99	.048	500	225	10.2	3,530	9,200	8,536	" " " "
Ave.							266	12.0			8,670	
2	325°F	1/2 Hr @ 325°F	.607	1.98	.048	220	99.5	4.5	---	---	---	Parent Resin Bond Failure
4	325°F		.609	2.02	.048	330	145	6.56	2,090	7,500	7,228	" " " "
6	325°F		.605	2.05	.048	290	127	5.75	1,970	7,240	8,032	" " " "
Ave.							124	5.60			7,630	
7	325°F	200 Hrs @ 325°F	.610	1.99	.048	590	263	11.9	2,630	14,880	31,164	Parent Resin Bond Failure
8	325°F		.611	1.99	.048	550	245	11.1	2,780	14,080	23,466	" " " "
9	325°F		.612	1.98	.048	565	253	11.5	2,620	15,200	33,997	" " " "
Ave.							254	11.5			29,542	
10	325°F	1000 Hrs @ 325°F	.612	2.02	.048	520	[illegible]	11.4	---	---	---	Parent Resin Bond Failure
11	325°F		.612	1.99	.048	595	268	11.2	---	---	---	" " " "
Ave.							249	11.3				
12	R.T.	3000 Hrs @ 325°F	.609	2.01	.048	585	239	21.8	3,940	22,700	41,400	Parent Resin Bond Failure
13	R.T.		.605	2.01	.048	365	150	13.6	3,270	18,400	32,000	" " " "
14	R.T.		.611	1.98	.048	575	238	21.7	3,620	20,800	37,400	" " " "
Ave.							207	19.0			[illegible]	
15	325°F	3000 Hrs @ 325°F	.607	1.99	.048	425	175	16.0	3,240	16,400	22,900	Parent Resin Bond Failure
16	325°F		.609	2.03	.048	410	165	15.1	3,130	15,600	33,200	" " " "
17	325°F		.608	2.01	.048	440	180	16.4	2,980	14,000	30,300	" " " "
Ave.							173	15.5			28,800	

NOTE: Difficulty in interpreting the slope of the load-deflection curves makes the shear modulus calculation questionable.

TABLE X
PHENOLIC (CONOLON 506) BEAM-COLUMN CREEP

SPECIMEN NUMBER tf	WIDTH	THICK-NESS	BEAM LOAD	COLUMN LOAD	STRESS PSI FACE	STRESS PSI CORE SHEAR	DEFL. LOAD NO HEAT	DEFLECTION @ 325°F HOURS 0	1	2	3	4	5	20	24	44	48	116	144
F1 .03	2.99	.566	80	0	3333.3	24.92	.061	.075	.099	.104	.107	.110	.111	.123	.125	.130	.130	.139	.150
F2 .03	3.02	.571	80	0	3265.3	24.46	.031	.055	.071	.074	.076	.079	.079	.089	.091	.094	.095	.100	.107
Hours→	164	188	212	284	308	332	356	380	452	476	500	524	548	620	644	692	716	788	812
F1	.152	.152	.162	.165	.165	.165	.166	.166	.166	.166	.167	.167	.167	.167	.167	.167	.168	.170	.171
F2	.108	.110	.110	.112	.112	.113	.113	.113	.115	.115	.116	.116	.117	.118	.119	.119	.120	.121	.121
Hours→	836	860	884	970	994	1018	1042	1114	1162	1210	1282	1306	1354	1378	1450	1498	1522	1594	1590
F1	.171	.171	.171	.172	.172	.173	.173	*.183	.183	.183	.183	.183	.184	.184	.184	.185	.185	.185	.186
F2	.121	.121	.121	.122	.123	.123	.124	.124	.124	.125	.125	.126	.126	.126	.127	.127	.127	.128	.129
Hours→	1858	1954	1978	2050	2122	2170	2194	2218	2290	2314	2338	2386	2458	2482	2506	2554	2626	2674	2698
F1	.186	.187	.187	.1825	.188	.189	.189	.189	.190	.190	.190	.191	.192	.192	.192	.193	.194	.194	.194
F2	.129	.130	.131	.131	.132	.133	.133	.134	.134	.135	.135	.136	.137	.137	.137	.138	.139	.140	.140
Hours→	2722	2794	2818	2842	2866	2890	3000												
F1	.194	.195	.196	.196	.196	.196	.198												
F2	.140	.141	.141	.142	.143	.143	.144												

	2 Hrs.	200 Hrs.	3000 Hrs.
F1 Deflection	.104	.162	.198 *
F2 Deflection	.074	.110	.144

F1 Change in deflection between 2 hours and 200 = .058"

F1 Change in deflection between 200 Hours and 3000 Hours = .036"

F2 Change in deflection between 2 hours and 200 Hours = .036

F2 Change in deflection between 200 hours and 3000 hours = .034

* Test Equipment was joggled and Extensiometer moved .010.

Av change in deflection of F1 and F2 from 2 hours to 200 hours = .047 or .047 ÷ 198 = .00023 in. per hour.

Av change in deflection of F1 and F2 from 200 hours to 3000 hours = .035 or .035 ÷ 2800 = .0000125 in. per hour.

TABLE XI

EPOXY (EPON 828) BEAM - COLUMN CREEP

SPECIMEN NUMBER t_f	WIDTH	THICKNESS	BEAM LOAD	COLUMN LOAD	STRESS PSI FACE COMP/TEN	CORE SHEAR	DEFL. LOAD NO HEAT	DEFLECTION @ 325°F HOURS											
								0	1	2	3	4	5	20	24	44	68	116	140
E .048	2.99	.606	100	62	2713/2281	29.96	.155	.198	.235	.240	.243	.245	.247	.257	.258	.263	--	.272	.278
E2 .048	3.00	.605	100	62	2709/2280	29.92	.120	.175	.209	.213	.215	.218	.219	.228	.229	.234	--Failed @ approx. 96 Hrs.		
E3 .048	3.00	.607	100	62	2670/2239	29.81	.038	.212	.233	.238	.241	.243	.245	.257	---	.263	.269	---	---
Hours ——→	144	144	168	192	216	240	312	336	360	384	408	480	552	576	648	672	696	720	744
E1	--	.293	Failed @ Approx. 180 Hours																
E2	Failed @ Approx. 96 Hours Bond Failure																		
E3	.280	---	.281	.282	.283	.284	.284	.288	.289	.290	.291	.293	.293	.293	.293	.293	.293	.293	.293
Hours ——→	840	864	888	912	984	1008	1080	1152	1176	1224	1248	1320	1370	1394	1466	1730	1826	1850	1994
E2	.293	.293	.293	.293	.294	.294	.294	.295	.295	.296	.296	.296	.297	.297	.297	.297	.298	.298	.299
Hours ——→	2042	2066	2090	2162	2210	2258	2330	2354	2378	2426	2498	2594	2666	2690	2714	2738	2762	2882	3000
E3	.300	.300	.300	.301	.301	.302	.302	.303	.303	.303	.304	.304	.305	.306	.306	.307	.307	.308	.310

	2 Hr	200 Hrs	3000 Hrs
E3 Deflection	.238	.283	.310

Change in Deflection from 2 hours to 200 hours = .045

Change in Deflection from 200 hours to 3000 hours = .027

Rate of Change in Deflection from 2 hours to 200 hours = .045 ÷ 198 = .00022 inches per hour

Rate of Change in Deflection from 200 Hours to 3000 Hours = .027 ÷ 2800 = .0000096 inches per hour

TABLE XII

SOLID LAMINATE - PHENOLIC (CONOLON 506) - TENSILE TEST

SPECIMEN NUMBER	TEST TEMP.	EXPOSURE	THICK IN.	WIDTH IN.	ULT. LOAD LBS.	ULT STRENGTH KSI	P/Δ #/IN.	MODULUS (10^{-6} PSI)	COMMENTS
1	R.T.	R.T.	.136	.485	2355	35.7	308,000	4.67	
2	R.T.	R.T.	.141	.484	2590	38.0	177,000	2.60	
3	R.T.	R.T.	.141	.485	2630	38.5	230,000	3.36	
4	R.T.	R.T.	.140	.483	---	---	---	---	Not Tested
Ave.						37.4		3.54	
5	325°F	1/2 Hr @ 325°F	.140	.483	2265	33.5	187,000	2.78	
6	325°F		.141	.484	2250	33.0	148,000	2.17	
7	325°F		.140	.485	2245	33.1	190,000	2.79	
Ave.						33.2		2.58	
9	325°F	200 Hr @ 325°F	.125	.493	2220	35.7	169,000	2.75	
10	325°F		.123	.495	2340	38.5	218,000	3.57	
11	325°F		.124	.495	2205	36.0	231,000	3.79	
Ave.						36.7		3.37	
12	325°F	1000 Hr @ 325°F	.127	.513	1930	29.6	267,000	4.10	
13	325°F		.129	.506	2080	31.9	171,000	2.63	
14	325°F		.130	.508	2050	31.1	170,000	2.58	
Ave.						30.9		3.10	
15	R.T.	3000 Hr @ 325°F	.132	.510	1750	26.0	139,000	2.10	
16	R.T.		.131	.511	1775	26.5	137,000	2.04	
17	R.T.		.130	.509	1680	25.4	122,000	1.84	
Ave.	R.T.					26.0		1.99	
18	325°F	3000 Hr @ 325°F	.131	.503	1750	26.6	122,000	1.85	
19	325°F		.130	.502	1600	24.5	129,000	1.97	
20	325°F		.132	.503	1815	27.3	129,000	1.94	
Ave.						26.1		1.92	

TABLE XIII

SOLID LAMINATE - EPON 828 - TENSILE TEST

SPECIMEN NUMBER	TEST TEMP	EXPOSURE	THICK. IN.	WIDTH IN.	ULT. LOAD LBS.	ULT. STRENGTH KSI	P/Δ #/in.	MODULUS (10^{-6} PSI)
1	R.T.	R.T.	.164	.504	3480	42.1	112,275	2.72
2	R.T.	R.T.	.162	.517	3595	42.9	116,279	2.77
3	R.T.	R.T.	.164	.506	3735	45.0	112,782	2.71
4	R.T.	R.T.	.164	.509	3945	47.2	115,562	2.79
Ave.						44.3		2.75
5	325°F	1/2 Hr @ 325°F	.164	.510	2460	29.4	165,000	1.98
6			.163	.516	2310	27.5	220,000	2.62
7			.162	.517	2495	29.8	232,000	2.46
Ave.						28.9		
9	325°F	200 Hrs @ 325°F	.163	.498	2925	36.1	221,000	2.73
10	325°F		.164	.495	2805	34.3	239,000	2.92
11	325°F		.164	.495	2755	34.0	202,000	2.50
Ave.						34.8		2.72
12	325°F	1000 Hrs @ 325°F	.163	.501	3005	36.8	217,000	2.66
13	325°F		.163	.501	3230	39.6	267,000	3.27
14	325°F		.163	.503	3090	37.7	244,000	2.98
Ave.						38.0		2.97
15	R.T.	3000Hrs @ 325°F	.162	.506	3580	43.7	286,000	3.48
16	R.T.		.159	.511	3715	45.7	277,000	3.41
17	R.T.		.162	.508	3875	47.1	276,000	3.36
Ave.						45.5		3.42
18	325°F	3000Hrs @ 325°F	.159	.509	2825	34.9	223,000	2.76
19	325°F		.160	.507	2480	30.6	214,000	2.64
20	325°F		.161	.508	2610	31.9	214,000	2.62
Ave.						32.5		2.67

TABLE XIV

SOLID LAMINATE - LAMINAC 4232 - TENSILE TEST

SPECIMEN NUMBER	TEST TEMP.	EXPOSURE	THICK IN.	WIDTH IN.	ULT. LOAD LBS.	ULT. STRENGTH KSI	P/Δ #/ IN.	MODULUS (10-6 PSI)
1	R.T.	R.T.	.183	.505	3565	38.6	123,355	2.67
2	R.T.	R.T.	.185	.506	3955	42.2	123,762	2.64
3	R.T.	R.T.	.186	.509	4025	42.5	123,153	2.61
4	R.T.	R.T.	.184	.512	3675	39.0	128,645	2.73
Ave.						40.6		2.66
5	325°F	1/2 Hr @ 325°F	.185	.505	3430	36.7	270,000	2.89
6	325°F	1/2 Hr @ 325°F	.186	.504	3585	38.3	299,000	3.21
7	325°F	1/2 Hr @ 325°F	.183	.508	3400	36.6	317,000	3.40
Ave.						37.2		3.16
9	325°F	200 Hrs @ 325°F	.187	.497	3310	35.6	373,000	4.03
10	325°F	200 Hrs @ 325°F	.186	.499	3480	37.5	322,000	3.47
11	325°F	200 Hrs @ 325°F	.184	.500	3530	38.4	279,000	3.03
Ave.						37.2		3.51
12	325°F	1000 Hrs @ 325°F	.185	.507	3190	34.0	266,000	2.84
13	325°F	1000 Hrs @ 325°F	.187	.506	3030	32.0	284,000	3.01
14	325°F	1000 Hrs @ 325°F	.187	.507	3220	34.0	298,000	3.14
Ave.						33.3		3.00
15	R.T.	3000 Hrs @ 325°F	.178	.497	2995	33.2	276,000	3.12
16	R.T.	3000 Hrs @ 325°F	.181	.498	3450	38.2	313,000	3.47
17	R.T.	3000 Hrs @ 325°F	.179	.504	3445	38.2	301,000	3.42
Ave.						36.5		3.34
18	325°F	3000 Hrs @ 325°F	.184	.506	3170	34.0	254,000	2.73
19	325°F	3000 Hrs @ 325°F	.182	.504	3160	34.5	252,000	2.75
20	325°F	3000 Hrs @ 325°F	.184	.498	3060	33.4	257,000	2.80
Ave.						34.0		2.76

TABLE XV

SOLID LAMINATE - PHENOLIC (CONOLON 506) - COMPRESSION TEST

SPECIMEN NUMBER	TEST TEMP	EXPOSURE	THICK IN	WIDTH IN	ULT. LOAD LBS	ULT. STRENGTH KSI	P/Δ #/IN	MODULUS (10^{-6} PSI)	COMMENTS
1	R.T.	R.T.	.140	.	35	26.9	192,000	2.71	
2	R.T.	R.T.	.142	.5	30	26.8	180,000	2.50	
3	R.T.	R.T.	.140	.5[illegible]	010	28.4	202,000	2.86	
4	R.T.	R.T.	.139	.511	---	---	---	---	Not tested
Ave.								2.69	
5	325°F	1/2 Hr @ 325°F	.141	.504	1665	23.4	205,000	2.88	
6	325°F	1/2 Hr @ 325°F	.141	.503	1500	21.2	202,000	2.85	
7	325°F	1/2 Hr @ 325°F	.141	.506	1590	22.3	240,000	3.36	
Ave.						22.3		3.03	
9	325°F	200 Hrs @ 325°F	.127	.486	1850	30.0	202,000	3.27	
10	325°F	200 Hrs @ 325°F	.127	.489	1880	30.3	225,000	3.62	
11	325°F	200 Hrs @ 325°F	.123	.486	2005	33.5	---	---	No curve
Ave						31.3		3.45	
12	325°F	1000 Hrs @ 325°F	.129	.499	1640	25.5	172,000	2.67	
13	325°F	1000 Hrs @325°F	.132	.499	1455	22.1	169,000	2.56	
14	325°F	1000 Hrs @325°F	.129	.497	1555	28.9	169,000	3.14	
Ave.						25.5		2.79	
15	R.T.	3000 Hrs @ 325°F	.128	.499	500	7.84	156,000	2.44	End Failure
16	R.T.	3000 Hrs @ 325°F	.129	.504	430	6.62	133,000	2.05	End Failure
17	R.T.	3000 Hrs @325°F	.129	.502	495	7.64	147,000	2.27	End Failure
Ave						7.37		2.25	
18	325°F	3000 Hrs @ 325°F	.127	.505	525	6.18	---	---	End Failure
19	325°F	3000 Hrs @325°F	.128	.505	580	9.25	164,000	2.62	End Failure
20	325°F	3000 Hrs @325°F	.130	.498	430	6.64	167,000	2.58	End Failure
Ave.						8.02		2.60	

TABLE XVI

SOLID LAMINATE - EPON 828 - COMPRESSION TEST

SPECIMEN NUMBER	TEST TEMP	EXPOSURE	THICK IN.	WIDTH IN.	ULT LOAD LBS.	ULT. STRENGTH KSI	P/Δ #/IN	MODULUS (10^{-6}PSI)	COMMENTS
1	R.T.	R.T.	.160	.507	3695	45.6	298,000	3.67	
2	R.T.	R.T.	.163	.510	3630	43.7	294,000	3.54	
3	R.T.	R.T.	.163	.508	3990	48.2	301,000	3.62	
Ave.						45.8		3.61	
5	325°F	1/2 Hr @ 325°F	.161	.509	1810	22.1	118,000	1.44	
6	325°F		.162	.508	1725	21.0	107,000	1.30	
7	325°F		.163	.507	1790	21.7	109,000	1.32	
Ave.						21.6		1.35	
9	325°F	200 Hrs @ 325°F	.163	.486	2070	26.1	114,000	1.44	
10	325°F		.164	.493	2060	25.5	115,000	1.42	
11	325°F		.160	.498	2160	27.1	148,000	1.48	
Ave.						26.2		1.45	
12	325°F	1000 Hrs @ 325°F	.165	.500	2530	30.7	253,000	3.07	
13	325°F		.165	.497	2295	28.0	227,000	2.77	
14	325°F		.165	.500	2230	27.0	219,000	2.65	
Ave.						28.6		2.83	
15	R.T.	3000 Hrs @ 325°F	.164	.503	5440	66.0	289,000	3.49	
16	R.T.		.164	.503	4725	57.3	301,000	3.65	End Failure
17	R.T.		.164	.505	5260	63.4	284,000	3.42	
Ave.						62.2		3.53	
18	325°F	3000 Hrs @ 325°F	.164	.506	2210	26.6	210,000	2.53	
19	325°F		.164	.506	2445	29.5	227,000	2.73	
20	325°F		.164	.507	2205	26.5	225,000	2.71	
Ave.						27.5		2.66	

TABLE XVII

SOLID LAMINATE - LAMINAC 4232 - COMPRESSION TEST

SPECIMEN NUMBER	TEST TEMP.	EXPOSURE	THICK IN.	WIDTH IN.	ULT. LOAD LBS.	ULT. STRENGTH KSI	P/Δ #/IN.	MODULUS (10^{-6} PSI)
1	R.T.	R.T.	.187	.494	4580	49.6	342,000	3.70
2	R.T.	R.T.	.182	.497	4745	52.4	313,000	3.46
3	R.T.	R.T.	.181	.495	4260	47.5	325,000	3.63
Ave.						49.8		3.60
5	325°F	1/2 Hr @ 325°F	.182	.498	3545	40.4	136,000	1.55
6	325°F	1/2 Hr @ 325°F	.181	.496	2995	33.3	139,000	1.55
7	325°F	1/2 Hr @ 325°F	.180	.498	3440	38.4	150,000	1.67
Ave.						37.4		1.59
9	325°F	200 Hrs @ 325°F	.187	.493	2955	32.0	295,000	3.20
10	325°F	200 Hrs @ 325°F	.183	.492	3495	38.8	301,000	3.34
11	325°F	200 Hrs @ 325°F	.182	.488	3290	37.1	309,000	3.48
Ave.						36.0		3.34
12	325°F	1000 Hrs @ 325°F	.185	.501	2840	30.6	260,000	2.80
13	325°F	1000 Hrs @ 325°F	.189	.498	3195	34.0	236,000	2.51
14	325°F	1000 Hrs @ 325°F	.185	.496	3265	35.5	278,000	3.03
Ave.						33.4		2.78
15	R.T.	3000 Hrs @ 325°F	.183	.503	5135	55.8	298,000	3.24
16	R.T.	3000 Hrs @ 325°F	.184	.502	4715	51.0	305,000	3.30
17	R.T.	3000 Hrs @ 325°F	.179	.502	4620	51.3	301,000	3.34
Ave.						52.7		3.29
18	325°F	3000 Hrs @ 325°F	.182	.505	3870	42.0	278,000	3.02
19	325°F	3000 Hrs @ 325°F	.179	.494	3935	44.4	269,000	3.04
20	325°F	3000 Hrs @ 325°F	.178	.493	3205	36.7	258,000	2.95
Ave.						41.0		3.00

TABLE XVIII

SOLID LAMINATE - PHENOLIC (CONOLON 506) - FLEXURAL TEST

SPECIMEN NUMBER	TEST TEMP.	EXPOSURE	THICK IN.	WIDTH IN.	ULT LOAD LBS.	ULT STRENGTH KSI	P/Δ #/IN.	MODULUS 10^{-6} PSI
1	R.T.	R.T.	.140	.985	209	32.5	3007	2.23
2	R.T.	R.T.	.141	.987	217	33.2	3053	2.20
3	R.T.	R.T.	.141	.989	216	32.9	2985	2.14
Ave.						32.9		2.19
5	325°F	1/2 Hr @ 325°F	.139	.986	196	30.9	2759	2.09
6	325°F		.142	.985	185	27.9	2857	2.02
7	325°F		.141	.984	183	28.0	2759	1.99
Ave.						28.9		2.03
8	325°F	200 Hrs.@ 325°F	.124	.906	206	44.1	2198	2.54
9	325°F		.124	.902	192	41.4	2339	2.72
10	325°F		.127	.905	209	44.8	2312	2.50
Ave.						43.4		2.59
11	325°F	1000 Hrs @ 325°F	.129	.749	156	37.7	1940	2.29
12	325°F		.132	.749	160	36.9	1905	2.35
13	325°F		.133	.744	158	35.9	1980	2.35
Ave						36.8		2.33
14	R.T.	3000 Hrs @ 325°F	.129	.751	70	16.8	---	--- No Curve
15	R.T.		.129	.758	66	15.8	1330	1.68
16	R.T.		.129	.758	69	16.5	1460	1.83
Ave.						16.4		1.75
17	325°F	3000 Hrs @ 325°F	.130	.732	52	12.6	1290	1.61
18	325°F		.130	.731	51.5	12.4	1230	1.61
19	325°F		.129	.731	61	14.7	1310	1.67
Ave.						13.2		1.63

TABLE XIX

SOLID LAMINATE - EPON 828 - FLEXURAL TEST

SPECIMEN NUMBER	TEST TEMP.	EXPOSURE	THICK IN.	WIDTH IN.	ULT LOAD LBS	ULT STRENGTH KSI	P/Δ #/IN.	MODULUS (10^{-6} PSI)
1	R.T.	R.T.	.163	.873	539	69.7	5780	3.06
2	R.T.	R.T.	.163	.872	533	68.9	5882	3.12
3	R.T.	R.T.	.164	.872	484	61.8	5952	3.11
4	R.T.	R.T.	.163	.872	499	64.5	5494	2.91
Ave						66.2		3.05
6	325°F	1/2 Hr @ 325°F	.163	.872	285	36.9	4040	2.14
7	325°F		.163	.872	322	41.6	4000	2.12
8	325°F		.162	.872	272	35.8	3960	2.14
Ave.						38.1		2.13
9	325°F	200 Hrs @ 325°F	.163	.998	394	44.6	5556	2.56
10	325°F		.159	.997	373	44.4	5479	2.73
11	325°F		.161	.997	353	41.0	5195	2.50
Ave.						43.3		2.60
12	325°F	1000 Hrs @ 325°F	.165	.748	375	55.1	5000	2.94
13	325°F		.166	.752	438	63.2	5000	2.94
14	325°F		.164	.752	378	56.1	4760	2.93
Ave.						58.1		2.93
15	R.T.	3000 Hrs @ 325°F	.159	.757	488	76.1	3440	2.79
16	R.T.		.160	.757	433	66.6	5000	3.22
17	R.T.		.160	.758	421	65.0	5000	3.22
Ave.						69.2		3.08
18	325°F	3000 Hrs @ 325°F	.163	.758	198	29.5	2560	1.57
19	325°F		.161	.758	171	25.3	3450	2.17
20	325°F		.164	.758	182	26.7	2500	1.50
Ave.						27.2		1.75

TABLE XX

SOLID LAMINATE - LAMINAC 4232 - FLEXURAL TEST

SPECIMEN NUMBER	TEST TEMP.	EXPOSURE	THICK IN	WIDTH IN	ULT LOAD LBS	ULT STRENGTH KSI	P/Δ #/IN.	MODULUS 10^{-6} PSI	
1	R.T.	R.T.	.179	.871	580	62.4	8333	3.32	
2	R.T.	R.T.	.178	.872	612	66.6	8621	3.51	
3	R.T.	R.T.	.184	.875	532	54.0	8197	3.00	
4	R.T.	R.T.	.182	.870	543	56.4	8197	3.13	
Ave.						57.9		3.24	
5	325°F	1/2 Hr @ 325°F	.183	.873	415	42.6	8081	3.02	
6	325°F	1/2 Hr @ 325°F	.182	.870	413	42.9	7080	2.70	
7	325°F	1/2 Hr @ 325°F	.178	.874	413	44.7	7273	2.95	
8	325°F	1/2 Hr @ 325°F	.178	.872	387	42.0	7273	2.96	
Ave.						43.1		2.91	
9	325°F	200 Hrs @ 325°F	.184	.996	492	43.8	8000	2.58	
10	325°F	200 Hrs @ 325°F	.181	.990	477	44.1	8000	2.72	
11	325°F	200 Hrs @ 325°F	.185	.963	491	44.7	7843	2.62	
Ave.						44.2		2.64	
12	325°F	1000 Hrs @ 325°F	.185	.747	452	53.2	6230	2.66	
13	325°F	1000 Hrs @ 325°F	.182	.750	357	43.2	5550	2.77	Temp Over-ran to 335°F
14	325°F	1000 Hrs @ 325°F	.185	.748	380	44.5	6667	2.84	
Ave.						47.0		2.76	
15	R.T.	3000 Hrs @ 325°F	.180	.740	428	53.5	6250	2.90	
16	R.T.	3000 Hrs @ 325°F	.180	.740	460	57.6	6670	3.09	
17	R.T.	3000 Hrs @ 325°F	.180	.740	471	58.9	6670	3.09	
Ave.						56.7		3.03	
18	325°F	3000 Hrs @ 325°F	.179	.739	399	50.5	5000	2.35	
19	325°F	3000 Hrs @ 325°F	.178	.739	399	51.1	5130	2.46	
20	325°F	3000 Hrs @ 325°F	.177	.739	394	50.3	5130	2.46	
Ave.						50.6		2.42	

TABLE XXI

PHYSICAL TEST RESULTS AVERAGES

MATERIAL	BARCOL HARDNESS	AFTER CURE		AFTER 200 HR @ 325°F		AFTER 1000 HR @ 325°F		AFTER 3000 HR @ 325°F	
Solid Laminate		R.C. (%)	S.G.	R.C. (%)	S.G.	R.C. (%)	S.G.	R.C. (%)	S.G.
(Conolon 506)	---	28.5	1.58	28.5	1.53	30.45	1.54	28.7	1.51
Epon 828	77.8	33.5	1.86	33.4	1.85	33.8	1.84	34.2	1.82
Laminac 4232	82.3	38.4	1.89	38.5	1.91	38.5	1.88	37.3	1.85
Epon 828 Sandwich									
Skins	---	34.2	1.81	33.6	1.89	33.6	1.82	30.1	1.85

TABLE XXII

ELECTRICAL PROPERTIES - DIELECTRIC CONSTANT AND LOSS TANGENT AT 8.5 KMC

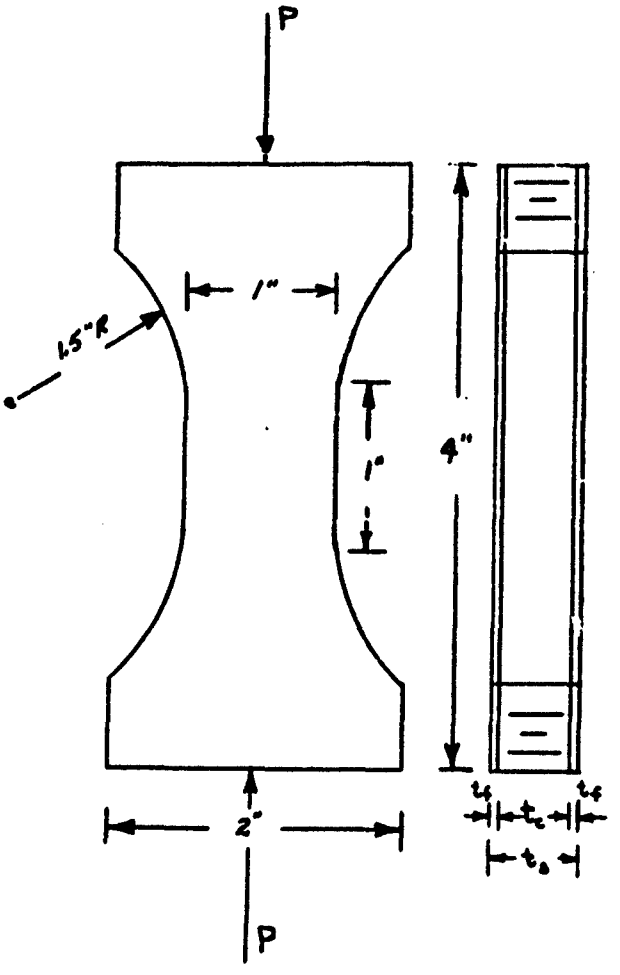
SPECIMEN DESCRIPTION	SPEC. NO.	TEST TEMP.	EXPOSURE	DIELECTRIC CONSTANT	LOSS TANGENT	REQUIREMENTS FMS-0031 DIELECTRIC CONSTANT	REQUIREMENTS FMS-0031 LOSS TANGENT
Solid Laminate Laminac 4232	1	R.T.	3000 Hrs at 325°F	4.46	.02077	4.3	0.025
	2		"	4.55	.02620		
	3		"	4.46	.02473		
	Ave.			4.49 *	.02390*		
Solid Laminate Epon 828	1	R.T.	3000 Hrs at 325°F	4.60 **	.02292**	4.6	0.020
	2		"	4.51	.01245		
	3		"	4.49	.01249		
	Ave.			4.50*	.01247 *		
Sandwich Epon 82C Faces	1	R.T.	R.T.	1.54	.00744		
	2	R.T.	R.T.	1.47	.00683		
	3	R.T.	R.T.	1.37	.00916		
	Ave			1.46	.00781		
Sandwich Epon 828 Faces	1	R.T.	3000 Hrs at 325°F	1.51	.00677		
	2		"	1.50	.00671		
	3		"	1.47	.00603		
	Ave.			1.49	.00650		

* These values determined for unbonded specimen

** These results apparently erroneous; therefore not included in average.

TYPE XII

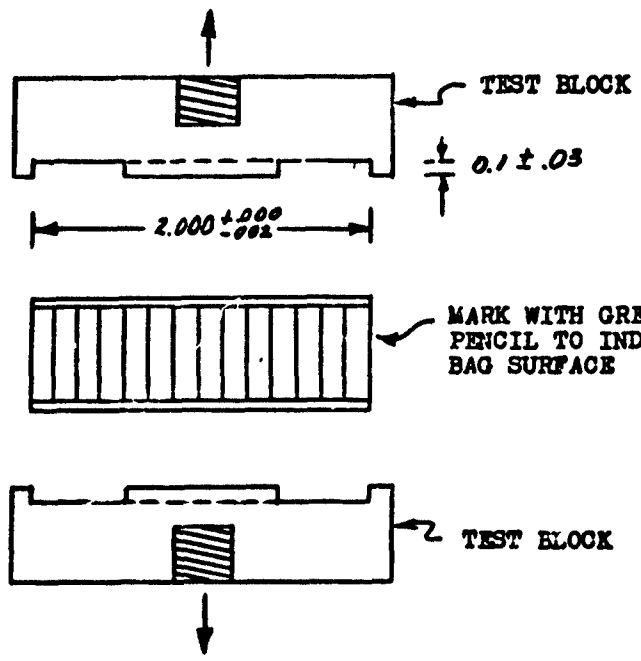
COLUMN COMPRESSION SPECIMEN



4. Ends to be milled flat and parallel within .005".
3. t_c = core thickness, t_s = sandwich thickness, t_f = face thickness.
2. Load Rate (Head Travel) .05 in/min.
1. Record failing load.

TYPE III

FLATWISE TENSION SPECIMEN



5. Note type of failure, failing load and surface on which failure occurs.
4. Load rate to be 4000#/min.
3. Bond the specimen into the test block with 423J adhesive. Cure and bonding pressure to be specified by Process Control.
2. The faces of both test blocks must be flat and perpendicular to the centerline of the test blocks.
1. Both faces of the specimen must be flat and parallel to each other.