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CHARACTERIZATION STUDY OF RUBBER-PLASTIC COMPOSITE MATERIALS FO--ETC(U)  
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CHARACTERIZATION STUDY  
OF  
RUBBER-PLASTIC COMPOSITE MATERIALS  
FOR DEEP SUBMERGENCE SONAR BAFFLES.

SR 007-03-03 <sup>9</sup> Task 1003  
Lab. Project 9300-7, Technical Memorandum #3

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ABSTRACT

Load vs deflection tests in flexure were made on rubber-plastic composite materials intended for deep submergence sonar baffles, as part of the project to characterize the mechanical and acoustical properties of these materials. The specimens consisted of a two layered composite, a four layered composite, the rubber and plastic components by themselves and two and four parallel layers of the plastic component separated at the specimen supports only by strips of rubber material having the same thickness as in the two and four layered composites, respectively. Analysis of the load-deflection data indicated that the rubber layer by itself had little load bearing capacity. In a composite, the rubber layers contribute to load bearing capacity by keeping the layers of plastic apart and further away from the neutral axis. However, the composite specimens did not behave as conventional beams because of the low shearing rigidity and high compression under load of the relatively soft rubber layers. Load vs deflection tests in flexure were found to be useful empirical indices for characterizing the mechanical properties of composites. Further work is underway to determine the acoustic properties of composite samples using the pulse tube facility at the U. S. Navy Underwater Sound Laboratory and the acoustic impedance tube at the U. S. Rubber Co. Research Center at Wayne, New Jersey.

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ADMINISTRATIVE INFORMATION

- Ref: (a) NAVAPLSCIENLAB Program Summary for Sub. Project SR 007-03-03,  
Task 1003 of 1 Nov 1964  
(b) NAVAPLSCIENLAB Project 9300-7, Technical Memorandum No. 1 of 17 Jun  
1964  
(c) Military Standard MIL-P-18177C of 25 May 1960  
(d) Proposed Federal Test Method Standard No. 406, Draft of 1960, Method  
1031 "Flexural Properties of Plastics"  
(e) "Engineering Laminates" by Albert G. H. Dietz. Published by John  
Wiley and Sons, Inc. 1949  
(f) NAVAPLSCIENLAB ltr 9360:CDF:nr, Lab. Project 9300-7 of 10 Aug 1964  
to NAVUWTRSOUNDLAB  
(g) NAVAPLSCIENLAB ltr 9360:SAE:nr, Lab. Project 9300-7 of 3 Nov 1964  
to NAVUWTRSOUNDLAB

Figures:

- 1 - Graph Sheet, - Flexural Characteristics of Composites, Rubber and  
Plastic Layers Tested on a 2 in. Span
- 2 - Graph Sheet, - Flexural Characteristics of Composites, Rubber and  
Plastic Layers Tested on a 3 in. Span
- 3 - Graph Sheet, - Flexural Characteristics of Composites, Rubber and  
Plastic Layers Tested on a 4 in. Span

Table 1- Data Sheet-Recipe of NASL-C663 and Method of Fabrication of a Two-  
Layered Composite

1. As authorized by reference (a), the U. S. Naval Applied Science Laboratory has been engaged in a program to develop rubber-rigid material composites for sonar baffles for deep submergence use. This project is a continuation of the characterization study of the mechanical properties of rubber-plastic composites which was reported in reference (b).

BACKGROUND

2. As noted in reference (b), the NAVAPLSCIENLAB has demonstrated the feasibility of integrally molding and bonding together layers of rubber and rigid plastic into composites having an all-rubber envelope. These composites would be expected to combine the strength and structural rigidity of the plastic material with the water resistance, corrosion resistance and the inherent noise-attenuating property of the rubber. This combination of properties make the composites potential candidates for deep submergence applications as baffles

for sonar domes. However, before these composites may be specified for use in sonar baffles, it is necessary to determine both their mechanical and acoustical behavior. Flexural strength was selected as a readily measurable significant index of total composite behavior. Flexural strength data also provides background information for possible future use of these materials in the window areas of sonar domes. The investigation of the acoustical properties of composites is underway and will be reported in a future report.

#### ACKNOWLEDGMENT

3. This work was performed under the guidance of Mr. M. Hanok, Senior Task Leader.

#### OBJECTIVE

4. The overall objective of this project is to develop rubber-rigid material composites for deep submergence sonar baffles. The immediate objective of the work reported herein is to characterize the flexural strength of composite materials and to determine the contribution of the rubber and plastic layers.

#### MATERIALS

5. The composite materials used in this investigation consisted of heat and pressure cured and bonded laminates of rubber and rigid plastic sheets, having an outer rubber envelope. The composites were prepared at the NAVAPLSCIENLAB, as previously described in reference (b). The plastic used as the rigid component of the composites was commercially prepared glass reinforced precured epoxy resin material type GEE of specification, reference (c). Additional details concerning the materials are given below:

a. A two layered composite which measured 7 3/4 in. by 6 in. by 1/4 in. thick formed by embedding two layers of the epoxy resin plastic sheet between three layers of styrene-butadiene rubber compound NASL-C663. The recipe of NASL-C663 compound and the method of fabrication of the composite are given in Table 1.

b. A four layered composite which measured 7 3/4 in. by 6 in. by 1/4 in. thick which was made from the same materials and using the same procedure as for the two layer composite except that four layers of the plastic sheet were embedded in five layers of the styrene-butadiene rubber compound, NASL-C663.

c. A 7 3/4 in. by 6 in. by 1/4 in. thick sheet of all styrene-butadiene rubber, NASL-C663 material.

d. A 36 in. by 48 in. by 1/32 in. thick sheet of the glass reinforced epoxy resin plastic material.

#### PROCEDURE

6. The above composite materials were cut into specimens 1/2 in. wide by 6 in. long by the thickness of the material. These specimens were then tested in flexure to determine load vs deflection when they were positioned as simple beams having spans of 2 in., 3 in. and 4 in. in accordance with the procedures specified in Method 1031 of specification, reference (d).

7. In addition, in order to determine the effect of the rubber in the composites, the load vs deflection of two parallel layers (each layer 1/2 in.) by 6 in. by 1/32 in.) of the epoxy resin plastic material was determined on spans of 2 in., 3 in. and 4 in. using the procedure specified in Method 1031 of specification, reference (d). However, in this latter test, the two layers of plastic material were separated at the supports only by a spacer thickness of rubber equivalent to that used in the two layer composite. This test was performed in a similar manner on four parallel layers of the epoxy resin plastic material separated at the supports only by rubber spacers having a thickness equivalent to that used in the four layer composite.

#### RESULTS

8. The load vs deflection curves obtained on the two layer composite, the four layer composite, the rubber layer, one layer of plastic material and the two and four parallel layers of epoxy resin plastic material separated at the supports only with rubber spacers, when tested in flexure on 2 in., 3 in. and 4 in. spans, are plotted on the graph sheets, Figures 1, 2 and 3, respectively. In no case did the rubber in the composites separate from the plastic component, despite the fact that the deflection at the center of the specimen was 1.2 in. (tested on a 4 in. span). Following removal of the load, the specimens recovered to their original shape.

#### ANALYSIS

9. An analysis of the data reported in the graph sheets, Figures 1, 2, and 3 indicates the following:

a. The 1/4 in. thick rubber layer alone had little load bearing capacity, as expected.

b. The insertion of a rubber layer between two layers of epoxy resin plastic material as in the case of a two layer composite, enabled the two layer composite to support more load than two or four parallel layers of epoxy resin plastic material without rubber interlayers. This occurred because the rubber interlayer kept the layers of plastic material apart

and further removed from the neutral axis of the composite beam. However, the load sustained by the two and four layer composites was less than that calculated for conventional beams made from the materials. This is consistent with theory as described in page 59 of reference (e) which states "Early investigations disclosed that the bending rigidity and the buckling load of sandwich structural elements are considerably smaller than may be anticipated on the basis of the conventional formulas of "Strength of Materials". The reason is the small shearing rigidity of the relatively thick core". Furthermore, it is anticipated that the shearing rigidity of the soft rubber layers is very small. In view of this, the equation given in page 62 of reference (e), which is valid for the condition of small shearing rigidity of the core, was used to calculate the deflection of the specimens. In this equation,

$$d = \frac{WL^3}{3(2EI)} \times \frac{1}{16}$$

where d = deflection of specimen, in.

L = Span length, in.

W = Actual load applied on specimen, lb.

E = Modulus of elasticity of the epoxy resin plastic layers, lbs. per sq. in.

I = Moment of inertia of the epoxy resin plastic layers, in.<sup>4</sup>

1/16 = Correction factor to convert equation from cantilever beam to simple beam loaded at the center.

Comparison of the deflections obtained using the above equation with the actual deflections given in Figures 1, 2 and 3 herein, indicated that the calculated values of deflection are from 1/5 to 1/10 the actual deflections. One reason for this discrepancy is the high compression under load of the relatively soft rubber layers which reduces the distance of the epoxy resin plastic layers from the neutral axis and thereby reduces rigidity.

c. Load vs deflection data in flexure are a useful empirical index for characterizing the mechanical properties of composites as there was a consistent relationship in the load bearing capacity of specimens made with two and four plastic interlayers.

d. The load bearing capacity of two parallel layers of the epoxy resin plastic material (not in a composite) was twice that of a single layer, and that of four parallel layers was four times that of a single layer. This occurred because application of load to the topmost layer caused it to bend readily until it contacted the lower layer (separated by 0.0625 in. and 0.025 in. for two and four parallel layers, respectively) whereupon the layers acted to mutually support the load.

#### CONCLUSIONS

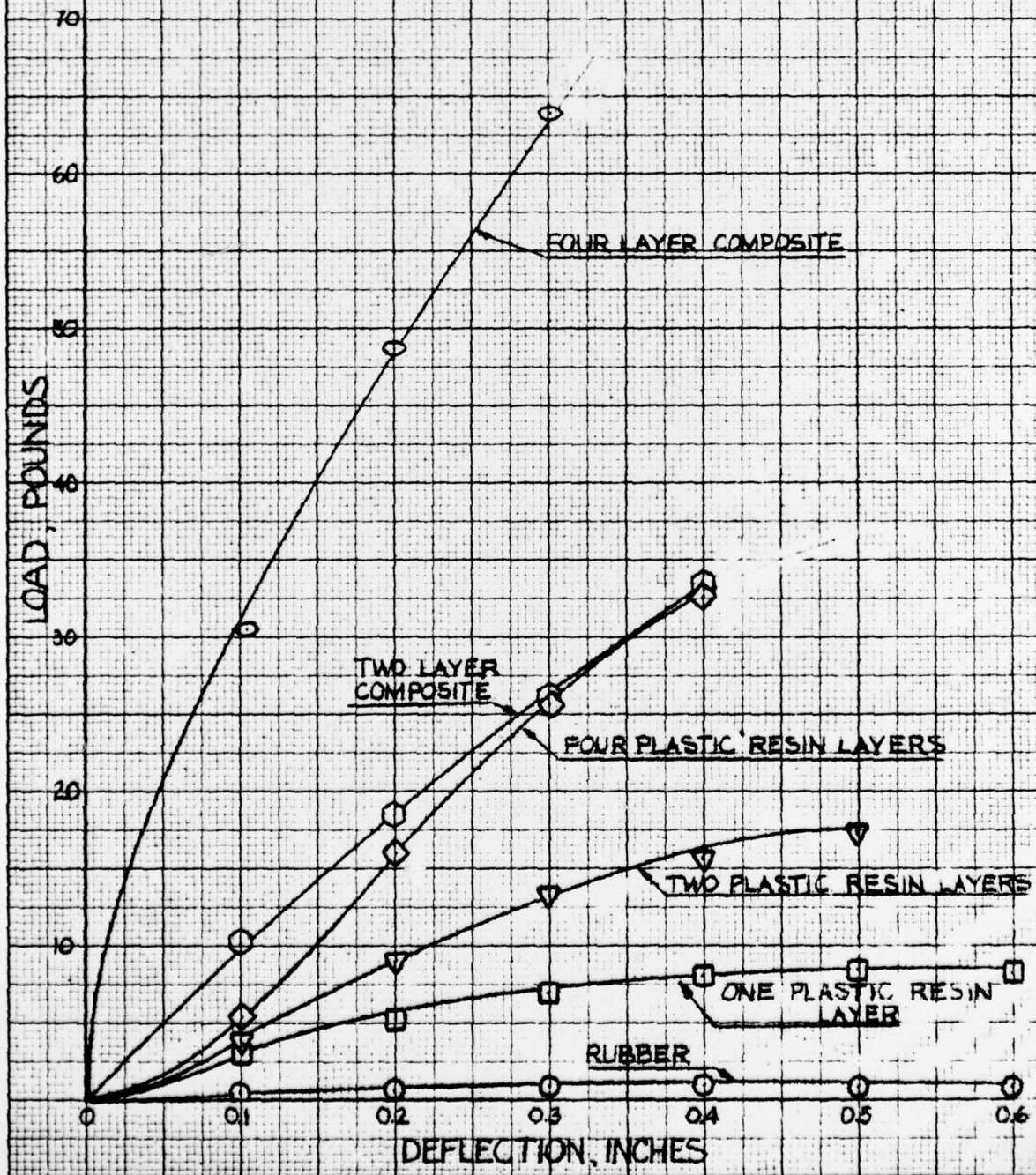
10. Since the rubber layer had little load bearing capacity, it is apparent that rubber layers on the outside surfaces of rigid composites do not contribute significantly to load bearing capacity. It should be borne in mind, however, that the usefulness of the outer rubber layers is dependent mainly on their desirable elastomeric properties rather than on their load bearing capacity.
11. Rubber layers between rigid layers of plastic material serve to keep the plastic layers further away from the neutral axis and enable the composite material to support more load than similarly spaced plastic layers without rubber interlayers.
12. The flexural characteristics of rubber-plastic composites cannot be calculated in accordance with the conventional equations of strength of materials because of the low shearing rigidity and high compression under load of the relatively soft rubber interlayers.
13. Load vs deflection data in flexure is a useful empirical index for characterizing the mechanical properties of composite materials intended for deep submergence sonar baffles.

#### FUTURE WORK

14. The NAVAPLSCIENLAB will continue its investigation to characterize the mechanical and acoustical properties of composites in order to determine their potential for use in the construction of deep submergence sonar baffles. In this connection, the Laboratory:
  - a. Plans to determine the change in flexural strength, adhesion between components and weight after immersion in water at a pressure of 1,000 psi. as an index of the integrity of the materials after conditioning at submergence pressures.
  - b. Has sent samples of composites under references (f) and (g) to the NAVUWTR SOUND LAB for determination of attenuation factor, reflection coefficient, rho-c factor and speed of sound in the material.
  - c. Has sent samples of composite materials to the U. S. Rubber Co. Research Center for determination of acoustic properties using a standing wave impedance tube operated at a pressure of 1,000 psi gage, temperature 40°F and a frequency range of 0.3 to 4.0 kilocycles. The properties to be evaluated include the amplitude reflection coefficient, amplitude absorption coefficient and impedance phase angle of the materials.

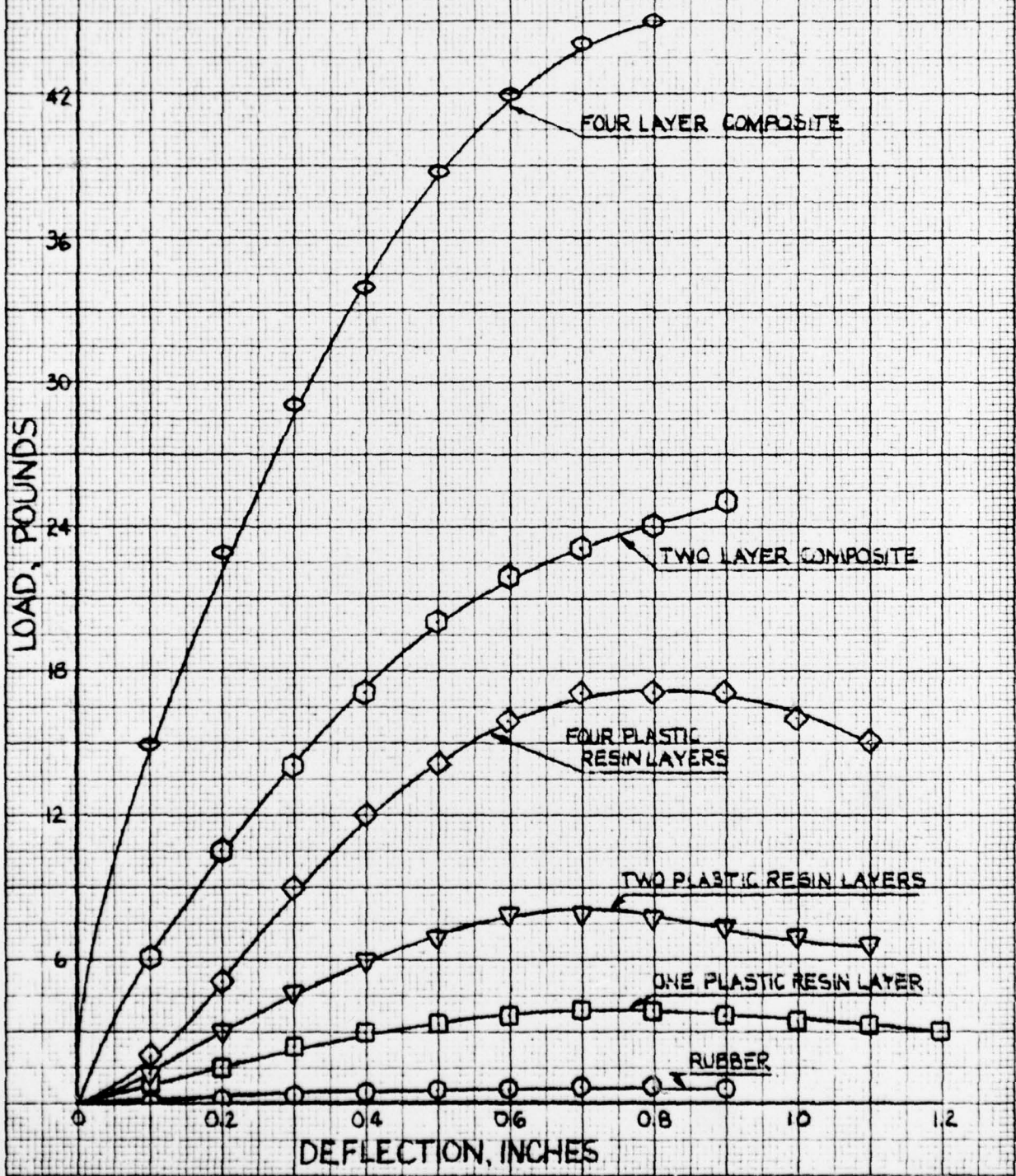
*S. A. Eller*  
S. A. ELLER  
Principal Investigator

FIG. 1  
FLEXURAL CHARACTERISTICS OF COMPOSITES,  
RUBBER AND PLASTIC LAYERS  
TESTED ON A 2 IN. SPAN



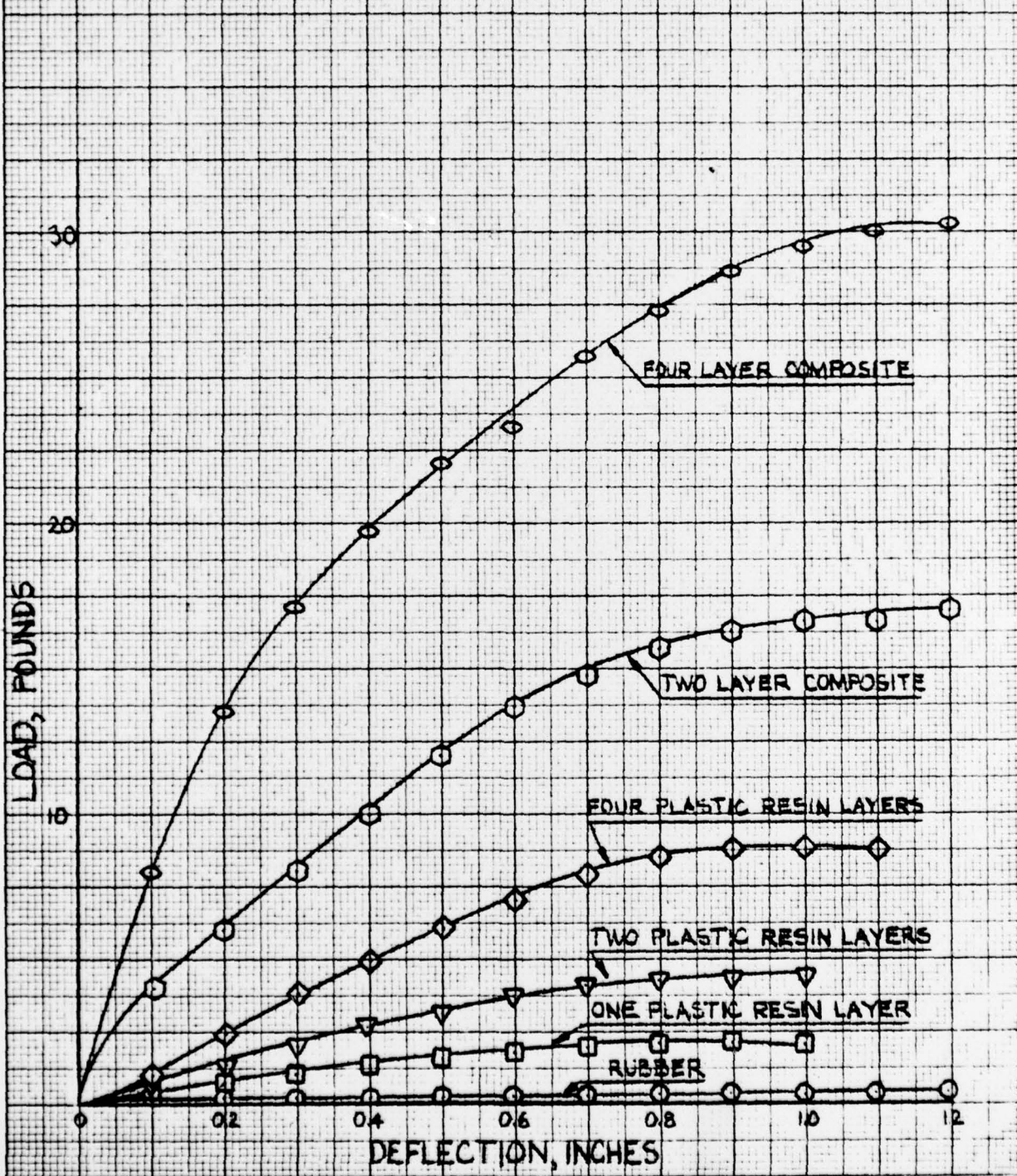
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FIG. 2  
FLEXURAL CHARACTERISTICS OF COMPOSITES,  
RUBBER AND PLASTIC LAYERS  
TESTED ON A 3 IN. SPAN



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GRUPP & PETER, CO.

FIG. 3  
FLEXURAL CHARACTERISTICS OF COMPOSITES,  
RUBBER AND PLASTIC LAYERS  
TESTED ON A 4 IN. SPAN



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TABLE 1

Recipe of NASL-C663 and Method of Fabrication  
of a Two Layered Composite

<u>Ingredients</u>	<u>NASL-C663</u>
SBR 1500 (styrene-butadiene rubber)	100
Bondogen	2.0
Hi Sil 233	54.5
Stearic Acid	2.0
Zinc Oxide	5.0
Sulfur	2.0
Agerite Stalite	1.0
Altax	1.5
Cumate	0.1

Mixing: Band polymer on mill. Add ingredients in the order given.  
Cut, refine and sheet off.

Calendering: Calender mill stock to uniform smooth sheets 3/32 in. thick.

Degreasing: Wipe surfaces of epoxy glass sheets with acetone and allow to dry.

Adhesive: Chemlok 220-(Hughson Chemical Co.)

Application of Adhesive: Brush apply adhesive on both surfaces of epoxy glass sheets and allow to dry.

Tackifying: Brush benzene lightly over adhesion surfaces of calendered rubber sheets and allow to dry until tacky.

Assembling Composite: Ply up three rubber and two 1/32 in. thick epoxy glass sheets alternately to result in a composite having rubber outer layers and a rubber middle layer.

Molding and Curing: Place the assembled rubber-plastic composite in a mold and cure in a steam heated press at 287°F for 1 hour.  
The finished thickness of the composite is 1/4 inch.