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FEASIBILITY STUDY OF A SONAR DOME WINDOW FOR THE AN/SQS-26 SONA--ETC(U)

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SUPPLEMENTARY REPORT FOR FEASIBILITY STUDY OF A SONAR DOME WINDOW FOR THE AN/SQS-26 SONAR DOME

This report covers the period 8 June 1964 to 11 December 1964

Prepared for

Navy Department, Bureau of Ships, Electronic Division

Contract NObsr-91065, Modification No.1
8 June 1964

GOODYEAR AEROSPACE CORPORATION

AKRON, OHIO

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CORPORATION

AKRON 15, OHIO

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ABSTRACT

The technical information obtained from the tests that were conducted in this supplemental program will be useful in the design and fabrication of pressurized reinforced-elastomer sonar domes of the near future. Although the program was designed around the requirements of the AN/SQS-26 sonar dome, the data obtained can be used in the design and fabrication of almost any type or configuration of reinforced-elastomer sonar dome. This program was not designed to establish a fabrication procedure for a sonar dome.

Model test results demonstrated that it is feasible to fabricate sonar domes of the size of the AN/SQS-26 in one piece, using polyester tire cord and air-cured polyurethane.

The acoustical properties of the polyurethane and polyester tire-cord type construction are not equal to those of natural rubber and polyester tire-cord constructions.

Antifoulant coatings and the physical properties of the polyester and steel wire were not degraded by high-power acoustic energy. Likewise the sound transmission values of the panels were not degraded due to the application of the antifoulant coatings or by prolonged operation. Acoustic tests showed that db loss increases as the frequency increases. These tests also established that the db loss decreased as the pressure on the panel was increased.

Deflection tests that were conducted on polyester-cord, reinforced-rubber panels established the percentage of elongation at 25, 50 and 75 psi, and the burst pressure. At 50 psi, the inherent creep of the reinforcement material stabilized within 48 hr, and the range of elongation was only 2.18 to 3.60 percent. Burst pressures were 18 to 43 times 50 psi on the five specimens that were tested.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I - PURPOSE

The purpose of this supplement to the sonar dome feasibility study program was to obtain answers to the following questions:

1. Can a model sonar dome, the size and shape of the AN/SQS-26, be fabricated in one piece using Goodyear's modified filament winding technique and an air-curing polyurethane?
2. What will be the acoustical properties of a flat panel using the same type of construction as that used in the model dome?
3. Will submitting flat panels, of polyester-reinforced conventional rubber dome construction to a prolonged environment of high-power acoustic energy be detrimental to their physical and acoustic properties?
4. What transmission losses will be encountered over a frequency range of 2 through 150 kc with polyester-reinforced conventional rubber dome constructions? Also what effect will hydrostatic pressure have on the acoustic properties of these constructions?
5. What will be the percentage of elongation of polyester-cord-reinforced conventional rubber constructions at 25, 50 and 75 psi in both the wet and dry condition?

SECTION II - GENERAL FACTUAL DATA

1. SPECIMENS

To obtain the answers to the questions listed in Section I the following specimens were fabricated and tested:

1. One 1/16-scale model of the AN/SQS-26 dome to evaluate the fabrication technique and over-all feasibility.
2. One panel, No. 830, 6 by 6 ft by 1-9/16 in., using polyester tire cord and polyurethane, subjected to acoustic transmission tests at U.S. Navy Underwater Sound Research Laboratory (USNUSRL).
3. Two panels 5 by 5 ft from two existing 6 by 6 ft panels, both panels containing a natural rubber compound. Panel No. 375-3/2 had polyester tire-cord reinforcement and was 1.66-in. thick. Panel No. 378-3/1 had steel wire tire-cord reinforcement and was 0.85-in. thick. Sections of both panels were coated with two different antifoulant coatings.
4. Ten panels, 30 by 30 in., of various reinforced conventional rubber constructions and thicknesses to establish transmission losses over a frequency range of 10 through 150 kc at varying temperatures and pressures. Seven of these panels were cut from seven of the nine original six-foot panels and three were made new.

5. Five panels 34-in. diameter using three different sizes of polyester tire cord with different safety factors to establish the actual percentage of elongation at 25, 50 and 75 psi. These panels were cut from five of the nine original six-foot panels.

2. FABRICATION PROCEDURES

a. Scale-Model Dome

The 1/16-scale-model dome was made on a male wooden form. A release agent was applied to the form. Pins were located strategically along the attachment edge of the form. An inner liner of polyurethane was applied to the form and cured at room temperature.

The method used in applying the polyester reinforcement cord on this model was developed by Goodyear for the fabrication of large products in conjunction with an air-curing rubber. This technique is called modified filament winding. A continuous cord was used in laying up each ply. The cord was wound back and forth around the strategically located pins at prescribed angles to carry the loads that were defined by a previous stress analysis. When the dome was removed from the form holes were left along the attaching edge for securing the dome to the ship. Because the cord is continuous the applied loads will be carried directly to the attachment hardware. Hence it will not be necessary to depend on adhesion or mechanical clamping.

After each complete ply was wound on the form, the cord was covered and encapsulated with polyurethane which was air-cured at room temperature before the next ply of cord was applied. Four plies of cord were wound on the model. Another coat of polyurethane was applied over the final cord ply to obtain a smoother outside surface finish.

When the model had cured, the pins along the attachment edge were removed and the model was easily slid off the form.

b. Six-Foot Panel

The six-foot-square panel of polyester tire-cord and polyurethane was made on a flat building table. A release agent was applied to the table prior to the application of the polyurethane inner liner. The polyester tire cord was layed one ply at a time, each followed by the application of polyurethane.

The cord plies were layed 45 deg to each other until a total of 17 plies was obtained. The finish layer of polyurethane was applied over the final cord ply for a total panel thickness of 0.25 to 1.56 in.

After the panel was air-cured a 100-percent X-ray inspection was performed. The panel was then trimmed to the six-foot size and holes were drilled along all four edges for mounting in the test fixture at USNUSRL.

c. Five-Foot Panels

The two five-foot panels were cut from six-foot panels which were layed up on a steel plate. Natural rubber was calendered onto the polyester and steel tire-cord fabrics. In both panels the cord plies were layed up 45 deg to each other. The polyester cord panel, No. 375-3/2, had 17 plies and the steel wire cord panel, No. 378-3/1, seven plies. A 0.25-in.-thick layer of rubber was applied over the last cord ply on each panel. The panels were cured in an autoclave using a vacuum blanket.

The cured panels were marked off on both sides into thirds and two different antifoulant coatings were applied on each side, leaving one third of the panel surface uncoated.

d. Thirty-Inch Panels

Ten 30-in.-square panels were made using the same method as defined for the five-foot-square panels, except that no antifoulant was applied to these panels. In this group there were seven panels reinforced with polyester cord and three nonreinforced natural rubber panels. Three different natural rubber compounds and three different sizes of polyester cord were represented in the ten panels. The physical makeup of the ten panels is given in Table I. Seven of the ten panels were cut from seven of the nine original six-foot-square panels and three were new.

e. Deflection Test Specimens

The five 34-in. -diam deflection test specimens were fabricated using the same method defined for the five-foot square panels less the antifoulant coatings. The physical make-up of these five panels is described in Table II. These panels were cut from five of the original nine six-foot-square panels.

3. TEST PROCEDURES

a. Scale-Model Dome

Physical testing was not planned for the scale-model dome. Therefore only a visual inspection was made of the completed model on which the final results are based.

b. Acoustic Transmission Tests

The entire surface area of the six-foot-square polyurethane and polyester cord panel, Panel No. 830, was X-rayed, prior to shipment to the USNUSRL for acoustic transmission tests. The results of the acoustic tests on Panel No. 830 were compared with the results on Panel No. 375-3, because both panels had the same type of reinforcement and number of plys and the specific gravities of the elastomers were equal.

TABLE I - DESIGNATION, ORIENTATION, AND STRENGTH OF THIRTY-INCH-PANELS

Panel number	Rubber code	Fabric code	Thickness (in.)	Number of plies			Cord		Strength			Safety factor at 50 psi
										Panel		
				Straight	Bias	Total plies	Number per inch	Cord strength (lb)	Per ply (lb/in.)	Maximum (lb/in.)	Minimum (lb/in.)	
373-3/1	4799	3171	1.715	9	8	17	10	182	1820	16380	14560	4.1
374-2/1	G265	3171	1.138	6	5	11	10	182	1820	10920	9100	2.7
374-3/1	G265	3171	1.655	9	8	17	10	182	1820	16380	14560	4.1
374-4/1	G265	3171	2.170	12	11	23	10	182	1820	21840	20020	5.5
375-3/1	T113	3171	1.705	9	8	17	10	182	1820	16380	14560	4.1
376-3/1	G265	3185	1.508	12	11	23	20	80	1600	19200	17600	4.8
377-3/1	G265	3161	1.155	5	5	10	12	264	3168	15840	15840	4.0
4799-0/1	4799	None	1.700	7	...	...	...	...	...	...	...	...
T113-0/1	T113	None	1.705	7	...	...	...	...	...	...	...	...
G265-0/1	G265	None	1.703	7	...	...	...	...	...	...	...	...

TABLE II - DEFLECTION TEST PANELS - DESIGNATION, ORIENTATION, AND STRENGTH OF 34-IN.-DIAMETER PANELS

Panel number	Stock code	Number of plies			Cord		Strength			Panel thickness (in.)	Safety factor at 50 psi
								Panel			
		Straight	Bias	Total plies	Number per inch	Cord strength (lb)	Per ply Lb/in.	Maximum Lb/in.	Minimum Lb/in.		
374-2/2	XA28A-374	6	5	11	10	182	1820	10920	9100	1.14	2.7
374-3/2	XA28A-374	9	8	17	10	182	1820	16380	14560	1.65	4.1
374-4/2	XA28A-374	12	11	23	10	182	1820	21840	20020	2.17	5.5
376-3/2	XA28A-376	12	11	23	20	80	1600	19200	17600	1.51	4.8
377-3/2	XA28A-377	5	5	10	12	264	3168	15840	15840	1.15	4.0

c. Acoustic Energy Effects

The two 5-ft panels were first subjected to high acoustic energy at the U.S. Navy Underwater Sound Laboratory (USNUSL) for 200 hr to determine if this type of environment would remove the anti-foulant coating or cause degradation of the acoustic and structural properties on this type of construction under prolonged operation. The panels were again subjected to acoustic tests at USNUSRL to determine if the transmission loss characteristics had been changed.

d. Hydrostatic Pressure Effects

The ten 30-in.-square panels were tested at the USNUSRL in a pressurized acoustic chamber over a frequency range of 10 through 150 kc at 0 and 1000 psi. These tests were conducted to establish the db loss of conventional constructions at higher frequencies and to establish the effect of increased pressure in relation to transmissibility.

e. Deflection Tests

(1) Preparation

The five 34-in.-diam deflection test specimens were tested at Goodyear's Wingfoot Lake test facility. Each panel had 40 holes around the edge to accommodate the 40 studs around the edge of the pressure test fixture. A clamping ring, held by stud nuts, torqued to 450 in. lb, held the reinforcing cords to prevent them from slipping during testing. Each panel was orientated on the test fixture with its maximum strength vertical and its minimum strength horizontal.

(2) Stabilization

Prior to conducting the deflection tests, one panel in the dry state was installed on the fixture and pressurized to 25 psi. Deflection measurements were made immediately after the 25-psi pressure was obtained and every 15 min thereafter to establish the elapsed time of creep to initial stabilization. Once the necessary elapsed time period was established, all panels were permitted to stand for that time period prior to taking readings.

(3) Dry Tests

All five panels were first tested in the dry condition at 25, 50, and 75 psi.

(4) Wet Tests

After the dry test was completed on a panel, it was placed in a fresh water tank for a minimum of seven days (168 hr), prior to conducting the wet deflection tests. For the wet test, the panel was removed from the water soak tank and immediately installed on the test fixture. The panel was then pressurized to 75 psi and its deflection measured. The pressure was then reduced and maintained at 50 psi for six days. Deflection measurements were recorded each day.

Water was used as the pressurizing medium in all of these test as a precautionary measure.

SECTION III - DETAIL FACTUAL DATA

1. SCALE-MODEL DOME

The completed scale-model dome shows that the modified filament-winding process using polyester cord encapsulated with polyurethane could be used to fabricate a sonar dome for the AN/SQS-26 sonar. Figure 1 shows the model dome during the preliminary stage and Figure 2, the completed model dome with a typical metal edge attachment. The model dome has been viewed by personnel of the Bureau of Ships in Washington, D. C.

Because of reservations on the part of BuShip personnel concerning polyurethanes for sonar applications, further Navy-sponsored development work on this process has been discontinued.

2. SIX-FOOT PANEL

The six-foot-square polyester cord and polyurethane Panel No. 830, was X-rayed for physical defects and foreign material prior to shipment to the USNUSRL for acoustic transmission testing.

The X-rays showed that the panel was free of foreign material. However, 45 of the 48 X-rays, showed scattered light gray areas that were entrapped-air pockets between the plys of cord. These areas varied in size from that of a pin-head to 15/16 in. in diam and from 0.010 to 0.030-in. thick. The average diameter of the airpockets was 0.25 in. The voids were not dispersed uniformly throughout the panel. For comparison purposes it should be noted that all the other panels made, using conventional elastomers, were X-rayed and found to be free of foreign material and air pockets.

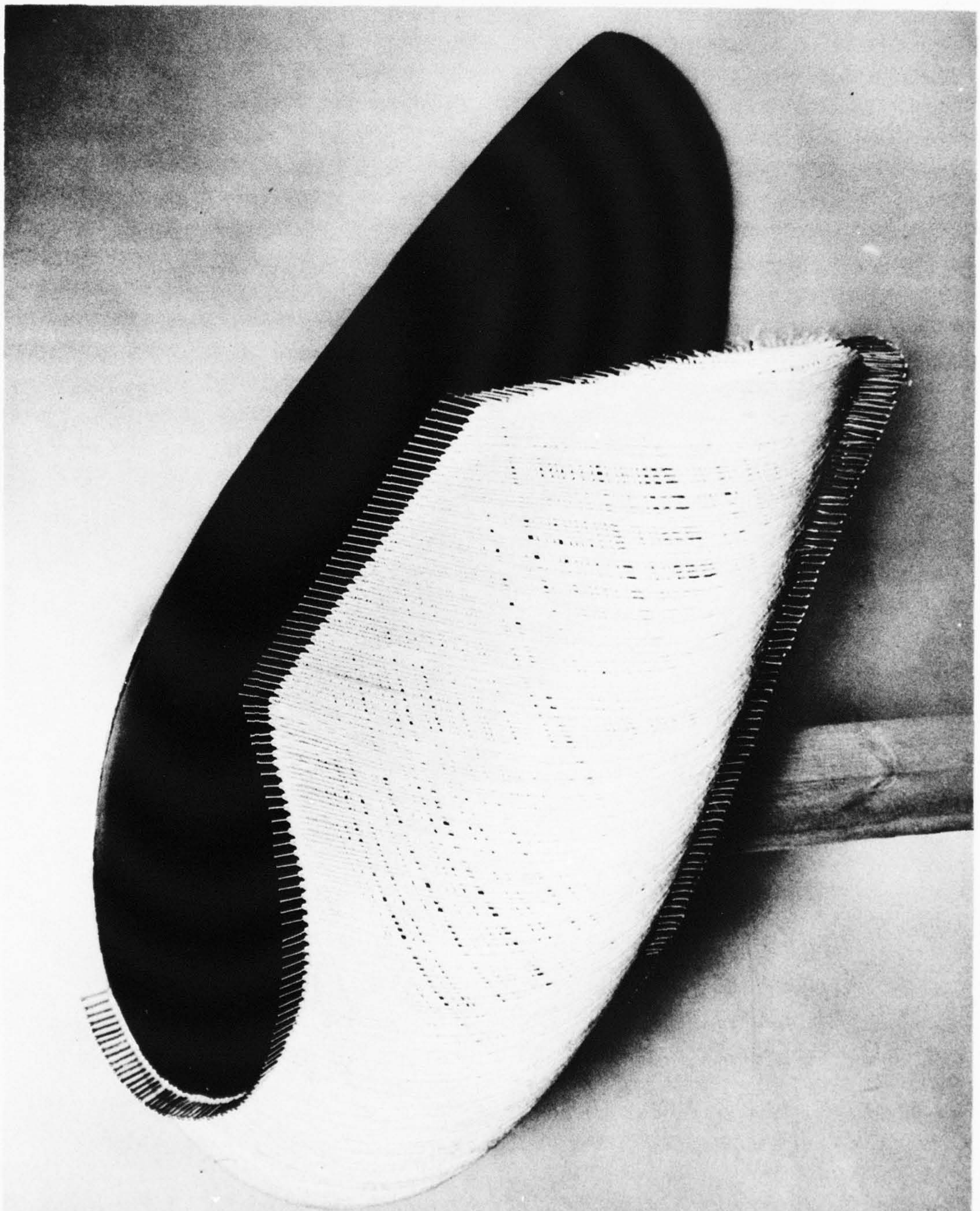


Figure 1 - Scale-Model Sonar Dome during Construction

Figure 2 - Scale-Model Sonar Dome with Typical Edge Attachment

There was no established pattern or apparent reason for the voids. No attempt was made to establish the percentage or volume of entrapped air.

The panel was shipped to the USNUSRL for acoustic tests. The results of these tests are recorded in the USNUSRL report, Reference 1.

In comparing the db loss of Panel No. 830 with the db loss on Panel No. 375-3/2, which is approximately equal in construction and was tested using the same test procedure, it can be readily seen that the db loss on Panel No. 830 is higher in the frequency range from 6 kc through 60 kc. This is attributed to the entrapped air in Panel No. 830.

Because of BuShips reservations mentioned above concerning polyurethane for sonar applications, Navy-sponsored development-work to improve the acoustic properties of this type of construction has been discontinued.

3. FIVE-FOOT PANELS

The two 5-ft panels that were coated with two different antifoulants, were coded No. 375-3/2 and No. 378-3/1. These panels were subjected to acoustic tests before portions were coated with two antifoulants. The results of these tests are recorded in the USNUSRL report, Reference 2. At that time the panels were six-feet square and were coded No. 375-3 and No. 378-3.

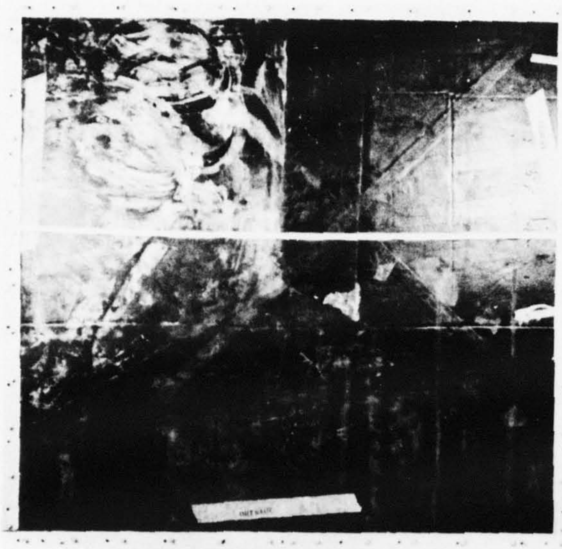
With the antifoulant coatings applied the two panels were subjected to 200 hr of high-power transmission by USNUSL at the Dodge Pond Field Station.

The results of this test showed that the rubber-base antifoulant maintained adhesion and that physical degradation was not apparent visually. Temperature checks showed that the internal temperature did not change appreciably (see Figure 3). The results of these tests are recorded in Reference 3.

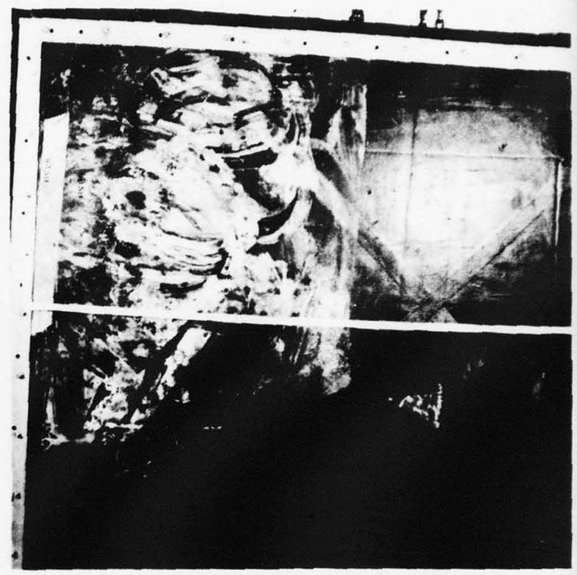
The panels were returned to USNUSRL for transmissibility tests to determine if prolonged exposure to high-power sound transmission or the addition of antifoulant coatings degraded the acoustic transmission qualities. The results of these tests are recorded in Reference 1. In comparing the results in References 2 and 1, it is immediately observed the second test results are better than the first. However, there were variations in the test conditions. The temperature during the second test was 27 C while during the first test it was 15 C.

The velocity of sound at 15 C is equal in both sea water and natural rubber. At 27 C the velocity of sound in water increases while in natural rubber it decreases and thereby creates a slight impedance mismatch.

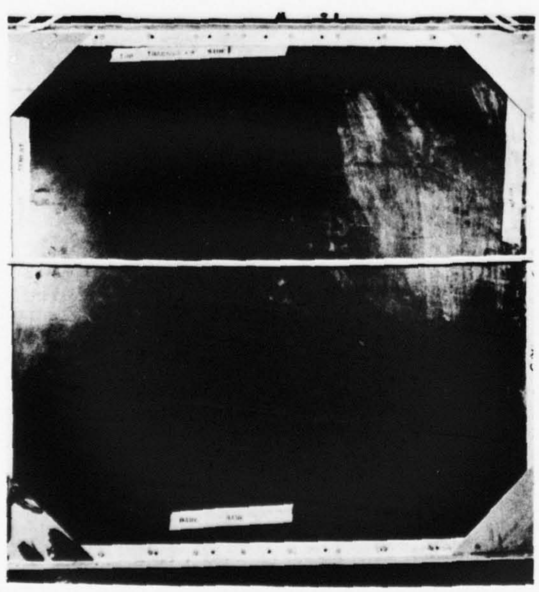
Therefore, it appears that the first test results should have been better than the second.



ENTIRE PANEL



UPPER LEFT CORNER, WASH



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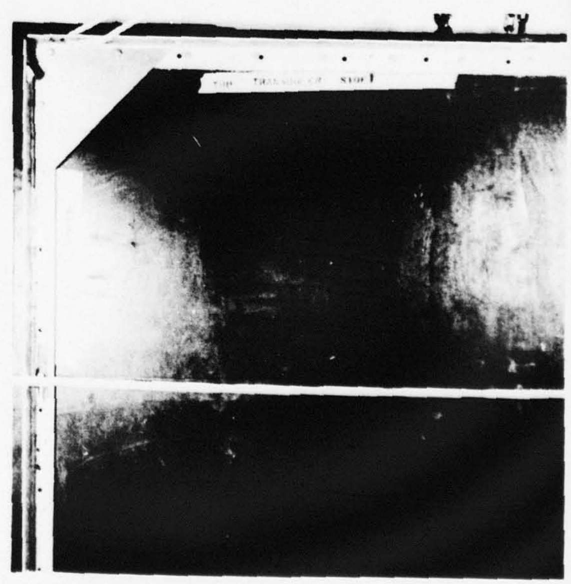
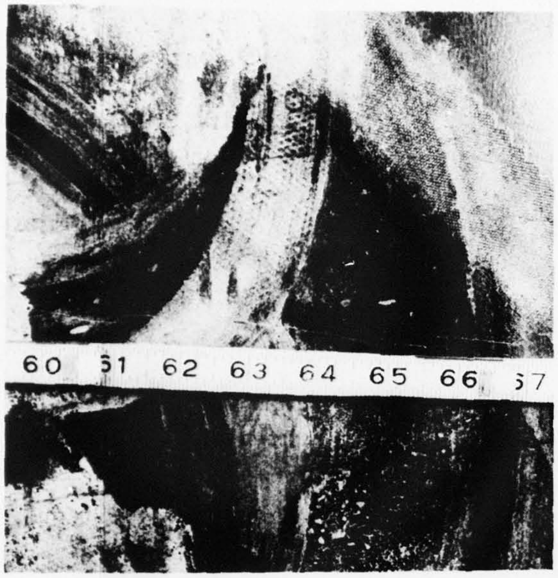


TOP LEFT, CEMENT

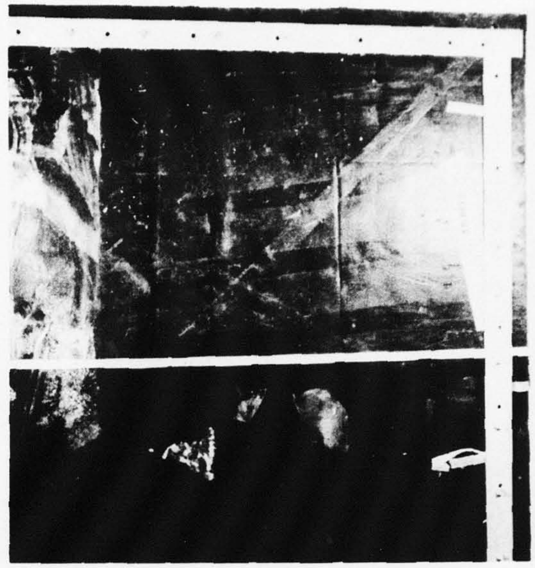
BA

TRANSDU

BACK SIDE

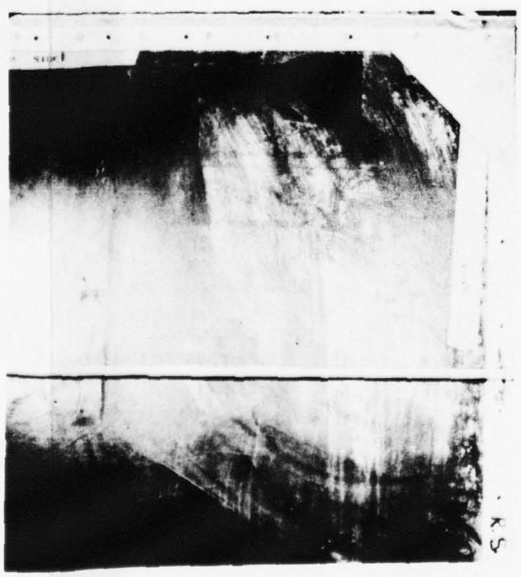


CLOSE-UP OF WASH

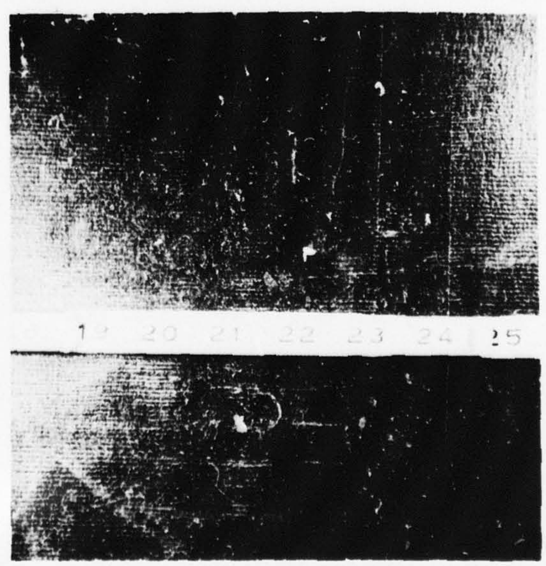


TOP RIGHT, CEMENT

TRANSDUCER SIDE



TOP RIGHT, WASH



LOWER, BARE, CLOSE-UP

Figure 3 - Wire-Reinforced Panel after High-Power Transmission

However, in comparing the actual recorded db-loss difference at 20 kc, the maximum difference was on Panel No. 378-3 and was only 0.5 db. According to personnel at the USNUSRL the accuracy of this type of measurement is ±0.2 db. The remaining 0.3-db loss could easily be consumed by the other variations in the testing.

The second tests were conducted at a greater depth than the first and consequently a difference of approximately 6 psi existed between the two. This increase in pressure would have the tendency to reduce the db loss. Also the two panels had the ends of the reinforcement cords exposed to the water, which permitted the water to wick into the cord and improve the transmissibility.

4. THIRTY-INCH PANELS

The ten 30-in. panels were tested at the USNUSRL. The results of these tests are contained in Reference 4. Although seven of the ten panels were cut from panels tested and recorded in Reference 2, a comparison of the test data is not practical because the test setup and procedure was completely different.

An analysis of the test data recorded in Reference 4 revealed the following facts. On the reinforced panels, over a frequency range of 10 kc through 150 kc, at 0 psi, the losses ranged from $<$0.5 db to 29.0 db. The db-loss increased with frequency. When the testing temperature was changed 21 C the difference in db loss varied from 0.0 db to 6.3 db. Panel No. 374-2/1 was not considered in this latter analysis due to special handling noted in Reference 4.

When the same panels were tested over the same frequency range but at 1000 psi, the losses varied from $<$0.5 to 7.2 db. When the temperature was changed 21 C the difference in db loss varied from 0.3 db to 1.5 db.

An analysis of the data on Panel No. 374-2/1 shows a 12-db loss at at 150 kc, 25 C and 0 psi. At 150 kc, 25 C, and 1000 psi the loss was only 3.0 db, an improvement of 9 db due to pressure. However, when held at 10 psi for 15 hr prior to conducting the test at 0 psi a 3.6-db-loss was obtained at 150 kc at 4 C. When the pressure was increased to 1000 psi and at 4 C the db-loss at 150 kc was 3.3 db, an improvement of only 0.3 db. Therefore, db loss decreases as pressure increases, and low pressure (10 psi) appears to benefit this condition almost as much as high pressure.

The test data on the nonreinforced elastomer panels revealed that the db-loss over a frequency range of 10 kc through 150 kc at 0 psi, and 25 C varied from 0.5 db to 0.9 db. By changing only the pressure to 1000 psi the db-loss dropped to 0.5 db in all specimens.

When the temperature was changed 21 C the db-losses changed slightly at 0 psi and when the pressure was increased the db-loss decreased in general.

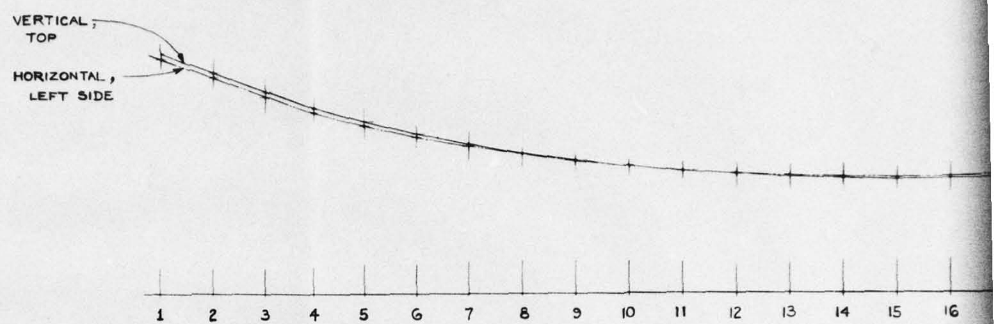
5. DEFLECTION TEST SPECIMENS

The five 34-in. -deflection test specimens were tested by the Goodyear Tire and Rubber Company.

Prior to conducting the main tests a pretest check was run to establish the amount of time required for the specimens to obtain initial set at the lowest testing pressure. The test was conducted on Panel No. 374-2/2, at 25 psi in the dry condition. Deflection measurements were taken immediately after the 25 psi was obtained and every 15 min thereafter until the readings duplicated. The percentage of elongation was calculated and is recorded in Table III. The actual measurements and curves are given in Figure 4.

As a precautionary measure, a drum test was conducted on Panel No. 374-3/2 in the wet condition to establish if any slippage was occurring when under test and if so to what degree. The actual measurements and curves are recorded in Figure 5. The compiled data calculated

CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
HORIZ.	4.391	4.047	3.703	3.406	3.156	2.938	2.766	2.625	2.484	2.375	2.281	2.234	2.188	2.156	2.141	2.156
VERT.	4.500	4.141	3.797	3.500	3.234	3.000	2.797	2.625	2.500	2.375	2.297	2.234	2.172	2.141	2.109	2.125



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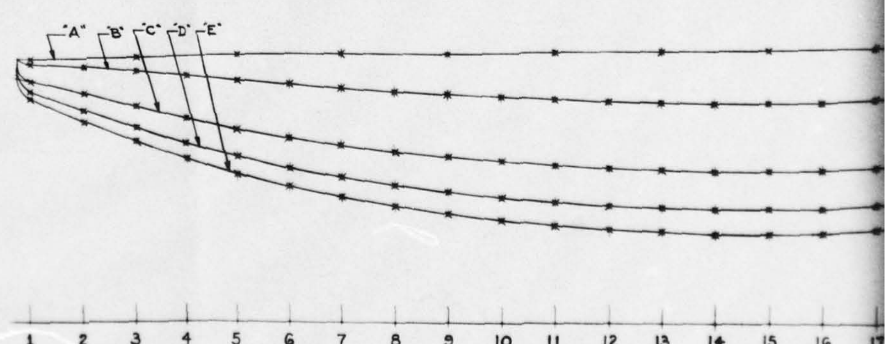
CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
"A"	4.906		4.938		5.000		5.016		5.031		5.047		5.062		5.078		5.12
"B"	4.812	4.766	4.688	4.594	4.516	4.453	4.375	4.312	4.266	4.219	4.172	4.125	4.109	4.094	4.094	4.109	4.17
"C"	4.500	4.266	4.016	3.797	3.594	3.438	3.297	3.172	3.094	3.016	2.938	2.891	2.859	2.828	2.828	2.844	2.9
"D"	4.312	3.953	3.625	3.328	3.094	2.875	2.703	2.562	2.438	2.344	2.250	2.188	2.156	2.125	2.125	2.125	2.2
"E"	4.172	3.750	3.375	3.047	2.766	2.531	2.344	2.172	2.031	1.922	1.812	1.750	1.703	1.656	1.656	1.672	1.75



13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	TIME
2.188	2.156	2.141	2.156	2.203	2.234	2.312	2.39'	2.516	2.656	2.812	3.000	3.219	3.484	3.797	4.141	4.547	IMMEDIATLY ADD .015 TO NO's FOR 30 MINUTES
2.172	2.141	2.109	2.125	2.141	2.188	2.250	2.328	2.438	2.562	2.734	2.906	3.125	3.391	3.688	4.031-	4.375	30 MIN & 45 MIN SAME

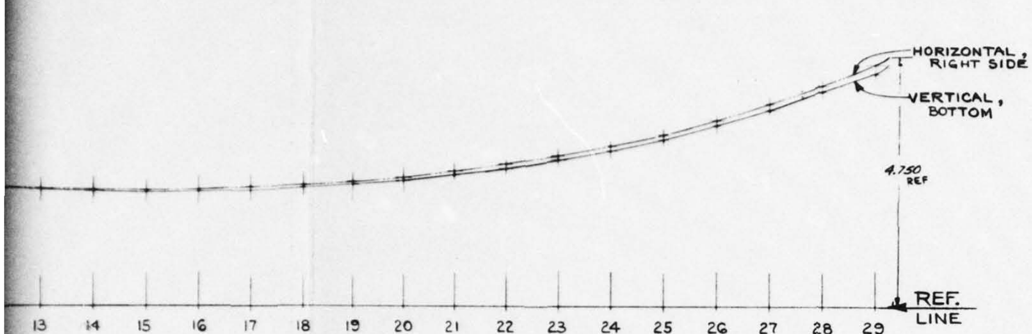


Figure 4 - Pretest Pressure versus Deflection Data, Panel No. 374-2/2, Dry

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	PRESSURE
.062		5.078		5.125		5.125		5.094		5.078		5.047		4.969		4.797	0
.109	4.094	4.094	4.109	4.172	4.219	4.250	4.281	4.328	4.391	4.453	4.516	4.578	4.656	4.734	4.781	4.781	FILLED GAGE 5.5 PSI
.859	2.828	2.828	2.844	2.906	2.953	3.000	3.062	3.156	3.281	3.391	3.531	3.703	3.891	4.125	4.375	4.578	25
.156	2.125	2.125	2.125	2.203	2.250	2.312	2.406	2.516	2.656	2.812	2.984	3.234	3.484	3.781	4.109	4.438	50
.703	1.656	1.656	1.672	1.750	1.812	1.875	1.984	2.109	2.266	2.453	2.672	2.922	3.188	3.531	3.938	4.328	75

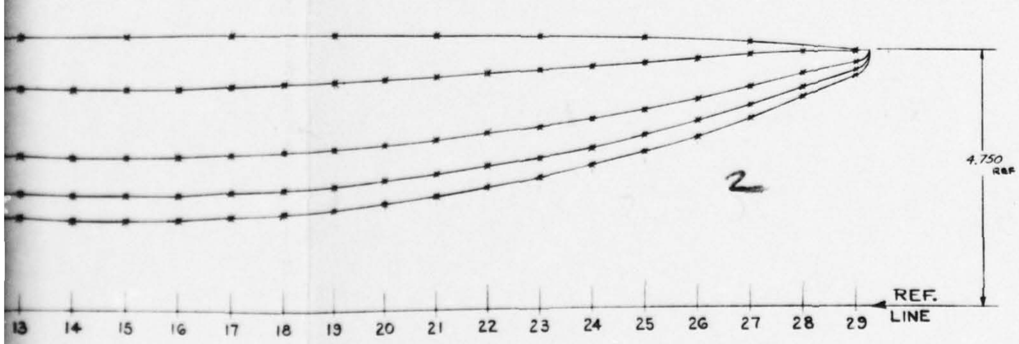


Figure 5 - Pretest Pressure versus Deflection Data, Panel No. 374-3/2, Wet

TABLE III - PRETEST CHECK DATA TIME VERSUS INITIAL SET ON DRY PANEL AND ELONGATION VERSUS PRESSURE ON WET PANEL

Time versus elongation for Panel No. 374-2/2, (dry) at 25 psi		Elongation versus pressure data on Panel No. 374-3/2, (wet)			
Condition* and position+	Elongation (percent)	Position	Pressure (psi)	Time§ (min)	Elongation (percent)
Immediate (horizontal)	2.07	Horizontal	0	Immediate‖	. . .
15 Min (horizontal)	2.09	Horizontal	Gage 5.5‡	30	0.125
30 Min (horizontal)	2.10	Horizontal	25	30	1.13
30 Min (vertical)	2.11	Horizontal	50	30	2.10
45 Min (vertical)	2.11	Horizontal	75	30	2.90

*Condition refers to elapsed time prior to taking reading.

+Position refers to direction in which the reading was taken.

‡Gun was filled with water and gage reading is considered static.

§ Time pressure was on panel prior to taking readings.

‖ With zero pressure time was of no importance.

from these measurements are given in Table III. The results did not indicate any slippage.

With the initial set-time established at 30 min, all subsequent deflection measurements were made after a specimen had been at the testing pressure for 30 min or more.

All five specimens were first tested in the dry condition at 25 psi, 50 psi, and 75 psi. These deflection measurements are shown in Figures 6 through 10 for Panels No. 374-2/2, 374-3/2, 374-4/2, 376-3/2, and 377-3/2 respectively. All measurements shown in these figures were taken from the reference line. Hence to obtain deflection values it is necessary to subtract the measurement data from the constant 4.750-in. dimension.

Although the specimens were 34 in. in diameter, the testing area was 29.50 in. in diameter.

The percentage of elongation was calculated using the following formula:

$$E = \frac{L}{C} 100 - 100$$

where

E = elongation in percent

L = length of arc

C = chord length (29.50-in., constant)

The arc length was calculated using the following formula:

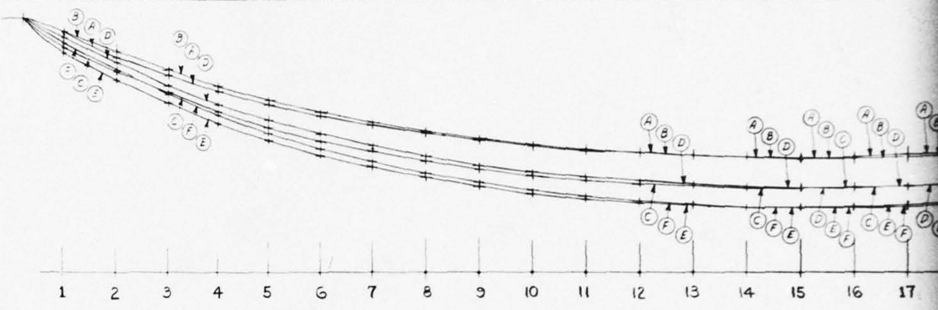
$$L = \frac{8\sqrt{2Rm} - C}{3}$$

where:

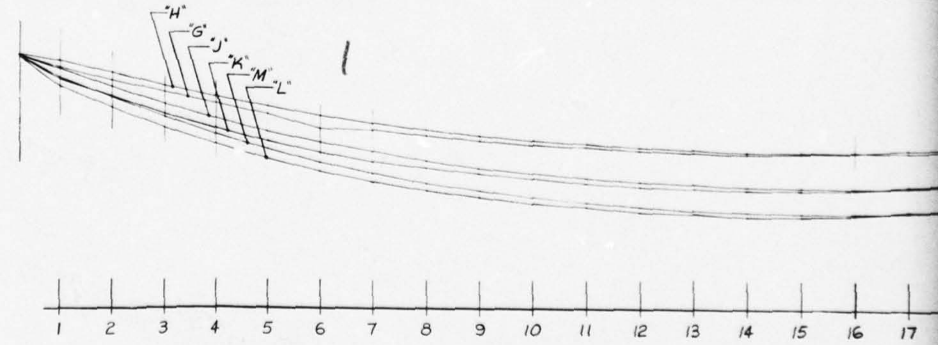
R = radius

m = deflection at C/2 point

PIN / CURVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
G	4.406	4.031	3.688	3.391	3.141	2.922	2.750	2.609	2.469	2.359	2.266	2.234	2.172	2.141	2.125	2.141	2.188
H	4.500	4.141	3.797	3.500	3.234	3.000	2.797	2.625	2.500	2.375	2.297	2.234	2.172	2.141	2.109	2.125	2.141
J	4.203	3.766	3.375	3.016	2.719	2.453	2.266	2.078	1.922	1.797	1.703	1.641	1.609	1.562	1.562	1.562	1.609
K	4.391	3.938	3.500	3.156	2.859	2.594	2.375	2.172	2.000	1.875	1.781	1.719	1.641	1.594	1.562	1.578	1.594
L	4.109	3.609	3.172	2.797	2.469	2.188	1.969	1.781	1.609	1.453	1.359	1.297	1.250	1.203	1.203	1.219	1.250
M	4.297	3.797	3.344	2.953	2.609	2.312	2.078	1.859	1.688	1.531	1.422	1.328	1.266	1.203	1.203	1.203	1.219



PIN / CURVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
"G"	4.531	4.281	4.047	3.829	3.625	3.369	3.344	3.234	3.141	3.078	3.016	2.953	2.922	2.891	2.906	2.922	2.984
"H"	4.656	4.421	4.172	3.953	3.781	3.609	3.469	3.344	3.234	3.141	3.078	3.016	2.984	2.938	2.922	2.922	2.938
"J"	4.500	4.141	3.828	3.547	3.313	3.109	2.938	2.766	2.625	2.531	2.438	2.375	2.328	2.281	2.266	2.250	2.281
"K"	4.297	3.969	3.641	3.359	3.125	2.922	2.750	2.625	2.516	2.422	2.344	2.281	2.250	2.219	2.219	2.234	2.297
"L"	4.172	3.750	3.375	3.063	2.797	2.563	2.375	2.203	2.078	1.969	1.891	1.813	1.781	1.734	1.734	1.750	1.844
"M"	4.328	3.953	3.578	3.250	2.984	2.734	2.531	2.344	2.203	2.078	1.984	1.906	1.844	1.813	1.781	1.781	1.828



5	16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
25	2.141	2.188	2.219	2.312	2.375	2.500	2.641	2.797	2.984	3.203	3.469	3.781	4.125	4.562	H	25 PSI
09	2.125	2.141	2.188	2.250	2.328	2.438	2.562	2.734	2.906	3.125	3.391	3.688	4.031	4.375	V	25 PSI
62	1.562	1.609	1.656	1.750	1.844	1.984	2.156	2.328	2.547	2.828	3.125	3.500	3.906	4.438	H	50 PSI
2	1.578	1.594	1.641	1.719	1.812	1.938	2.094	2.281	2.484	2.734	3.047	3.391	3.797	4.312	V	50 PSI
03	1.219	1.250	1.312	1.406	1.500	1.672	1.844	2.031	2.281	2.578	2.906	3.328	3.781	4.312	H	75 PSI
03	1.203	1.219	1.281	1.359	1.453	1.594	1.781	1.969	2.188	2.484	2.812	3.188	3.656	4.141	V	75 PSI

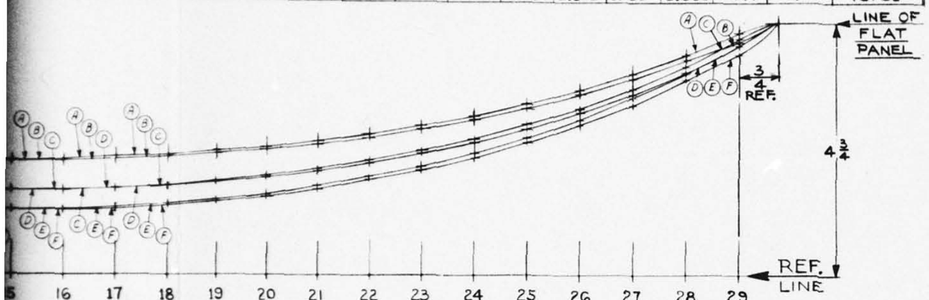


Figure 6 - Pressure versus Deflection Data for Panel No. 374-2/2, Dry

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
906	2.922	2.984	3.016	3.063	3.125	3.203	3.328	3.438	3.563	3.734	3.922	4.156	4.391	4.625	H	25 PSI
922	2.922	2.938	2.969	3.031	3.078	3.172	3.266	3.375	3.500	3.672	3.859	4.094	4.266	4.531	V	25 PSI
266	2.250	2.281	2.328	2.391	2.469	2.563	2.688	2.813	2.984	3.203	3.438	3.734	4.063	4.328	H	50 PSI
219	2.234	2.297	2.359	2.422	2.516	2.609	2.750	2.906	3.094	3.297	3.406	3.828	4.172	4.484	V	50 PSI
734	1.750	1.844	1.875	1.969	2.063	2.187	2.344	2.516	2.734	2.969	3.250	3.578	3.984	4.375	H	75 PSI
781	1.781	1.828	1.859	1.938	2.031	2.141	2.297	2.453	2.656	2.891	3.172	3.500	3.906	4.328	V	75 PSI

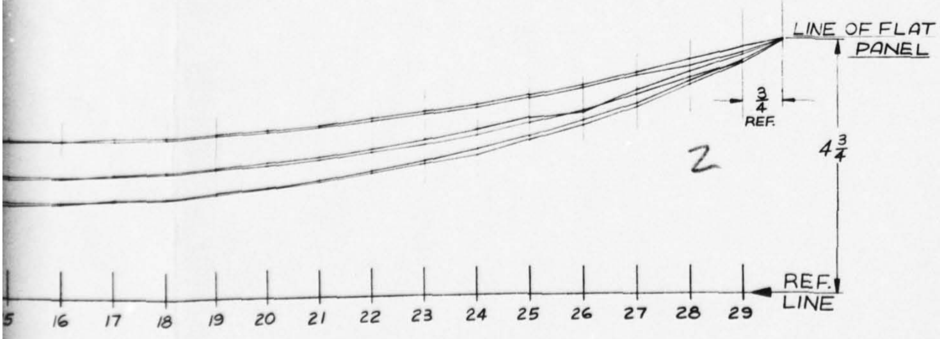
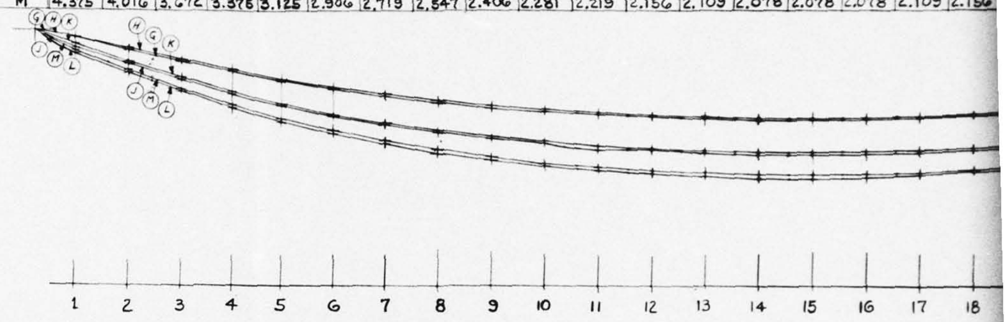
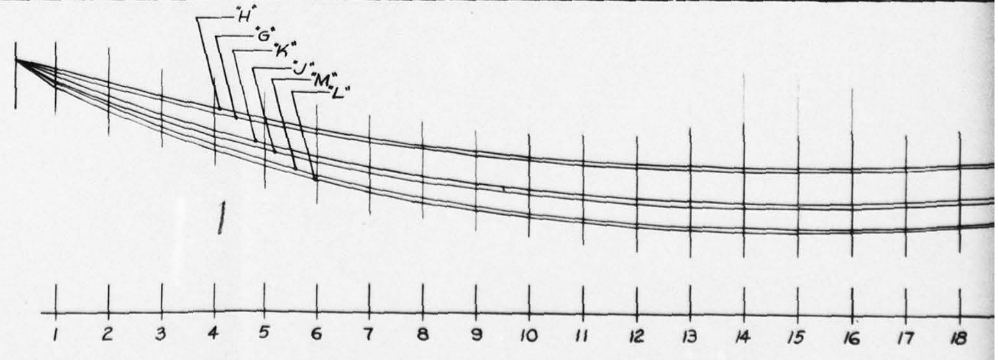


Figure 7 - Pressure versus Deflection Data for Panel No. 374-3/2, Dry

CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
G	4.625	4.391	4.187	4.000	3.828	3.672	3.547	3.422	3.313	3.250	3.203	3.156	3.109	3.094	3.094	3.094	3.125	3.172
H	4.625	4.430	4.219	4.031	3.859	3.703	3.594	3.469	3.359	3.297	3.234	3.187	3.156	3.125	3.125	3.125	3.156	3.203
J	4.430	4.141	3.844	3.578	3.375	3.172	3.016	2.875	2.750	2.656	2.609	2.531	2.469	2.438	2.438	2.438	2.484	2.516
K	4.500	4.172	3.891	3.625	3.406	3.203	3.047	2.906	2.781	2.703	2.625	2.563	2.516	2.500	2.500	2.500	2.516	2.563
L	4.328	3.969	3.625	3.313	3.063	2.844	2.656	2.469	2.344	2.234	2.156	2.094	2.031	2.000	2.000	2.000	2.063	2.125
M	4.375	4.016	3.672	3.375	3.125	2.906	2.719	2.547	2.406	2.281	2.219	2.156	2.109	2.078	2.078	2.078	2.109	2.156



CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
"G"	4.516	4.234	3.984	3.719	3.516	3.344	3.187	3.078	2.938	2.859	2.781	2.734	2.688	2.656	2.656	2.672	2.688	2.750
"H"	4.578	4.328	4.047	3.813	3.609	3.422	3.266	3.125	3.016	2.922	2.859	2.797	2.766	2.734	2.734	2.734	2.766	2.797
"J"	4.328	3.953	3.594	3.281	3.031	2.813	2.609	2.453	2.328	2.219	2.125	2.047	2.000	1.984	1.984	1.984	2.016	2.078
"K"	4.437	4.063	3.703	3.391	3.141	2.906	2.719	2.563	2.422	2.313	2.234	2.156	2.109	2.078	2.063	2.078	2.109	2.156
"L"	4.219	3.766	3.375	3.016	2.719	2.469	2.250	2.063	1.922	1.797	1.703	1.625	1.563	1.531	1.531	1.547	1.578	1.641
"M"	4.313	3.875	3.469	3.125	2.828	2.563	2.344	2.156	2.000	1.859	1.766	1.688	1.625	1.609	1.594	1.594	1.625	1.688



15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
3.094	3.094	3.125	3.172	3.203	3.281	3.359	3.453	3.563	3.703	3.844	4.031	4.219	4.453	4.656	H	25 PSI
3.125	3.125	3.156	3.203	3.250	3.313	3.391	3.484	3.578	3.719	3.859	4.016	4.219	4.430	4.625	V	25 PSI
2.438	2.438	2.484	2.516	2.563	2.641	2.750	2.875	3.000	3.172	3.375	3.594	3.859	4.156	4.484	H	50 PSI
2.500	2.500	2.516	2.563	2.625	2.703	2.797	2.922	3.047	3.203	3.391	3.609	3.875	4.156	4.484	V	50 PSI
2.000	2.000	2.063	2.125	2.156	2.250	2.375	2.500	2.656	2.844	3.078	3.328	3.641	3.984	4.406	H	75 PSI
2.078	2.078	2.109	2.156	2.219	2.313	2.422	2.563	2.703	2.891	3.094	3.344	3.656	3.984	4.359	V	75 PSI

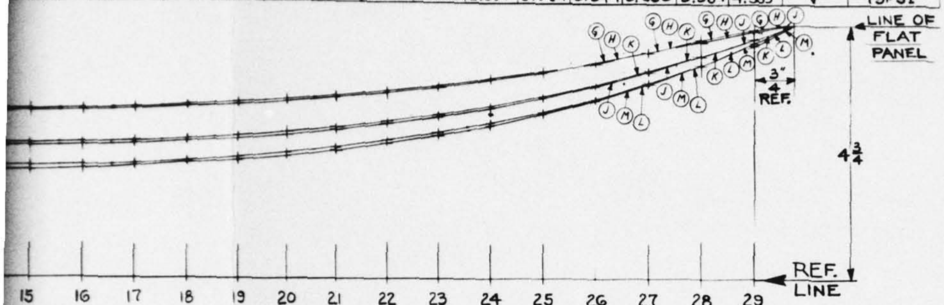


Figure 8 - Pressure versus Deflection Data for Panel No. 374-4/2, Dry

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
2.656	2.672	2.688	2.750	2.797	2.875	2.969	3.094	3.219	3.375	3.563	3.781	4.047	4.344	4.641	H	25 PSI
2.734	2.734	2.766	2.797	2.859	2.938	3.016	3.141	3.250	3.406	3.594	3.797	4.047	4.297	4.609	V	25 PSI
1.984	1.984	2.016	2.078	2.141	2.234	2.328	2.500	2.656	2.859	3.094	3.359	3.688	4.063	4.469	H	50 PSI
2.063	2.078	2.109	2.156	2.219	2.313	2.438	2.578	2.734	2.906	3.141	3.391	3.688	4.047	4.453	V	50 PSI
1.531	1.547	1.578	1.641	1.719	1.828	1.953	2.125	2.313	2.531	2.859	3.094	3.469	3.906	4.375	H	75 PSI
1.594	1.594	1.625	1.688	1.766	1.875	2.000	2.156	2.328	2.547	2.813	3.094	3.453	3.844	4.313	V	75 PSI

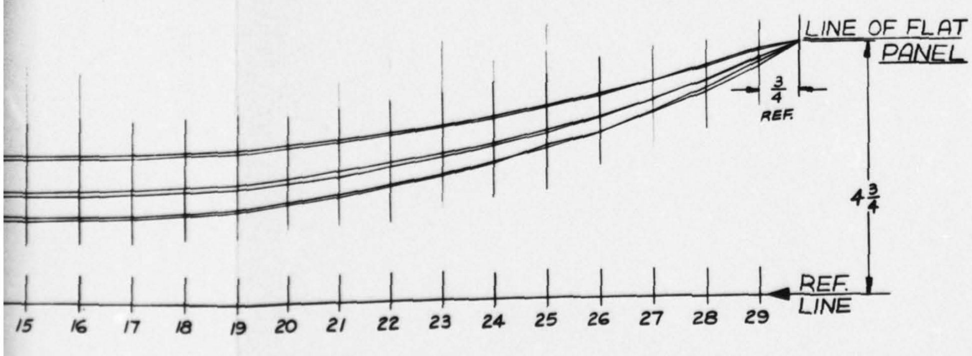
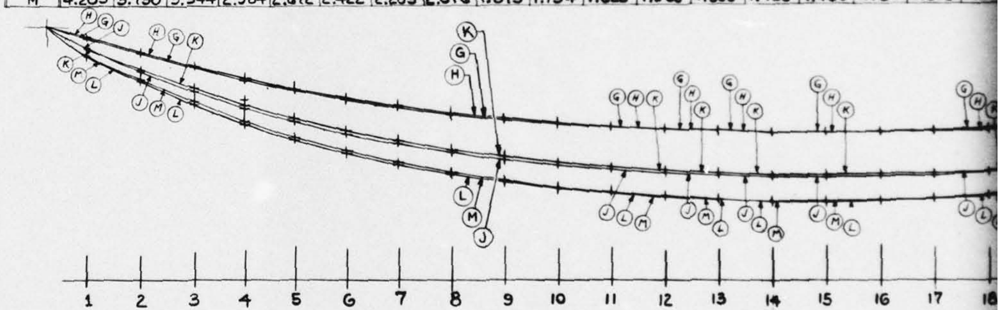


Figure 9 - Pressure versus Deflection Data for Panel No. 376-3/2, Dry

CURVE \ PIN NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
G	4.516	4.250	3.984	3.750	3.563	3.375	3.234	3.109	3.000	2.922	2.859	2.813	2.781	2.750	2.750	2.750	2.781	2.8
H	4.547	4.266	4.000	3.781	3.578	3406	3.266	3.125	3.031	2.938	2.859	2.813	2.781	2.750	2.750	2.750	2.766	2.7
J	4.344	3.906	3.531	3.219	2.969	2.734	2.547	2.391	2.250	2.141	2.063	2.000	1.953	1.922	1.906	1.922	1.938	2.01
K	4.328	3.938	3.594	3.281	3.031	2.797	2.609	2.438	2.313	2.203	2.109	2.047	2.000	1.969	1.953	1.969	1.984	2.0
L	4.187	3.719	3.281	2.922	2.625	2.375	2.156	1.984	1.844	1.719	1.625	1.547	1.500	1.469	1.453	1469	1.516	1.57
M	4.203	3.750	3.344	2.984	2.672	2.422	2.203	2.016	1.875	1.734	1.625	1.563	1.500	1.469	1.469	1.484	1.516	1.5



16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
2.750	2.781	2.828	2.875	2.938	3.031	3.141	3.266	3.422	3.594	3.797	4.047	4.156	4.656	H	25 PSI
2.750	2.766	2.797	2.859	2.922	3.031	3.125	3.250	3.406	3.578	3.781	4.016	4.313	4.625	V	25 PSI
1.922	1.938	2.016	2.078	2.172	2.281	2.422	2.578	2.766	3.000	3.281	3.609	4.000	4.422	H	50 PSI
1.969	1.984	2.031	2.094	2.187	2.313	2.453	2.594	2.813	3.047	3.313	3.625	4.031	4.422	V	50 PSI
1.469	1.516	1.578	1.656	1.750	1.875	2.047	2.219	2.453	2.719	3.016	3.391	3.844	4.297	H	75 PSI
1.484	1.516	1.563	1.656	1.750	1.875	2.047	2.219	2.453	2.719	3.031	3.406	3.844	4.313	V	75 PSI

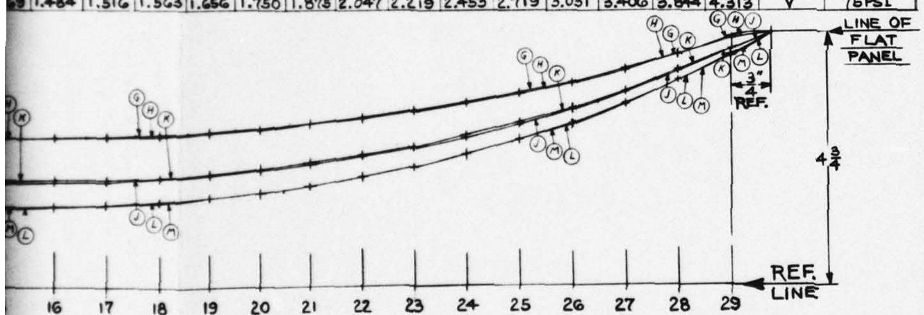


Figure 10 - Pressure versus Deflection Data for Panel No. 377-3/2, Dry

C = chord length (29.50 constant)

L = arc length in inches

The radius was calculated using the following formula:

$$R = \frac{C^2 + 4m^2}{8m}$$

where

R = radius in inches

C = chord length (29.50 constant)

m = deflection A C/2 point (Pin No. 15 on figures)

To obtain true "m" subtract measurement given on figures at Pin No. 15 from 4.750 inch dimension.

Example

$$m = 4.750 - 2.000$$

$$= 2.750$$

The compiled data for the dry test, expressed as pressure versus percent elongation, is given in Table IV.

The calculated burst pressure for the five specimens is also listed in Table IV and is based on the calculated ultimate strength of the panels and the average ultimate elongation of the reinforcement material obtained from test.

The following formula was used to obtain the arc length (in inches) at ultimate elongation:

$$L = CE$$

where

C = chord length (29.50 in.)

E = ultimate elongation in percent

TABLE IV - PRESSURE VERSUS ELONGATION-DRY TEST ON PANELS AT VARIOUS PRESSURES

Panel number	Elongation (percent) At 25 psi		At 50 psi		At 75 psi		At burst pressure		Burst pressure (psi)	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
374-2/2	2.08	2.11	3.07	3.07	3.76	3.76	11.7	11.7	900.2	1080.2
374-3/2	1.04	1.02	1.87	1.94	2.75	2.67	11.7	11.7	1440.3	1620.3
374-4/2	0.84	0.71	1.63	1.53	2.29	2.15	11.7	11.7	1980.4	2160.4
376-3/2	1.34	1.24	2.32	2.20	3.14	3.02	14	14	1837.5	2004.6
377-3/2	1.22	1.22	2.46	2.38	3.29	3.25	13	13	1612.7	1612.7

To find the deflection at the midpoint of the arc length it is necessary to solve for the chord length of one half the arc length.

The following formula was used to determine the 1/2 arc length chord:

$$d = \frac{3L + C}{8}$$

where

d = chord length of L/2 (in.)

L = arc length (in.)

C = chord length (29.50 in.)

The maximum deflection at burst was calculated using the following formula:

$$m = d^2 - \frac{C}{2}^2$$

where

m = deflection at center (in.)

d = chord length of L/2 (in.)

C = chord length (29.50 in.)

Using the new deflection dimension $R = C^2 + 4m^2/8m$ the burst pressure can be calculated using the following formula:

$$P = \frac{2S}{R}$$

where

P = burst pressure (psi)

S = stress (ultimate) taken from Table II

R = radius at maximum deflection

31

The percentages of elongation obtained are considered average. As each panel completed the sequence for the dry test, it was submerged in fresh water to soak for a minimum of seven days. Past experience has established that synthetic fibers soaked in water experience their greatest change within the first 48 hr. Because the wet tests were time consuming, the soak period for the panels varied from 8 to 38 days. However, tests conducted by Goodyear on synthetic fibers, exposed to 5000 psi in simulated sea water over a period of 763 days, revealed that polyester fibers still had 96.5 percent of their quick-break strength after this period of soaking. Therefore the variation in soak time on these panels was considered to have little or no effect on the end test results.

The deflection measurements are shown in Figures 11 through 15 for Panels No. 374-2/2, 374-3/2, 374-4/2, 376-3/2 and 377-3/2 respectively.

The compiled data for the wet test, expressed as pressure versus elongation, is given in Table V.

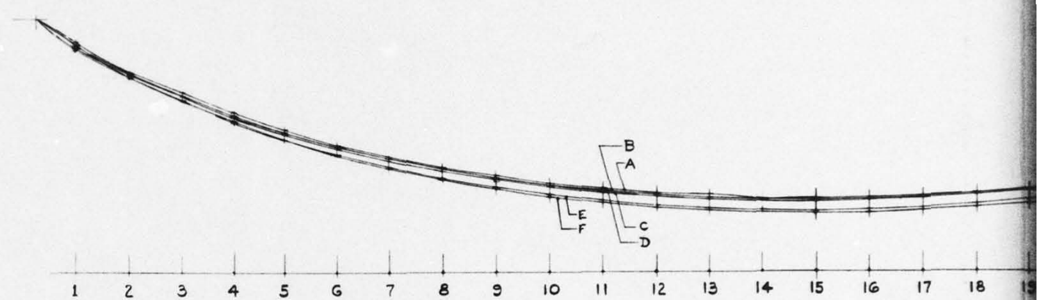
The percentage of elongation was calculated as defined for the dry test.

No attempt was made to establish the burst pressure in the wet condition. The percentage of elongation in the wet condition increased only 0.28 to 0.66 percent over the dry test.

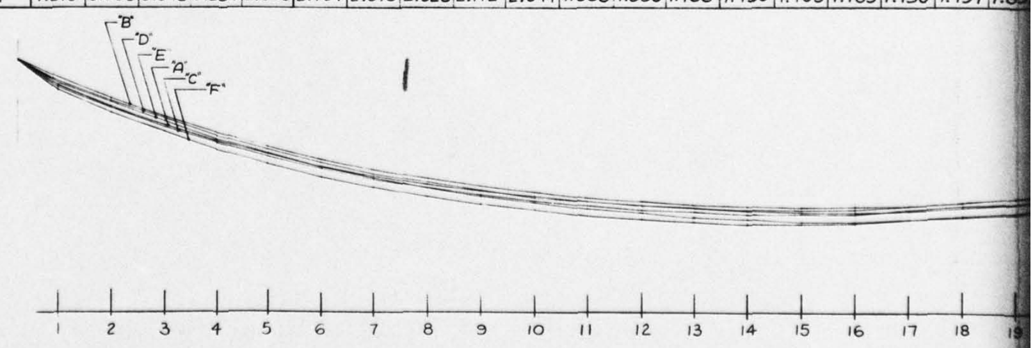
In Table V the percentage of horizontal elongation under prolonged conditions at 50 psi is given in the first three columns which show elongation at the end of 24, 48, and 144 hr. Horizontal data only are given because they are the highest values.

In all cases except one, the percentage of elongation at the end of 48 hr was equal to the elongation at the end of 144 hr. The calculated radii at 50 psi after 144 hr on Panel No. 374-3/2 are 39.073 in. and 39.274 in. for the horizontal and vertical respectively. The stresses involved are 976.82 lb/in. and 981.85 lb/in. respectively. These stresses, when compared to the ultimate strengths given in Table II, were found to be

CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
A	4.219	3.734	3.312	2.953	2.625	2.359	2.141	1.938	1.766	1.625	1.531	1.453	1.391	1.359	1.344	1.344	1.391	1.453	1.5[illegible]
B	4.312	3.750	3.391	3.000	2.688	2.391	2.172	1.969	1.812	1.656	1.562	1.469	1.453	1.359	1.359	1.375	1.406	1.453	1.5[illegible]
C	4.188	3.703	3.297	2.906	2.594	2.328	2.094	1.891	1.734	1.594	1.484	1.422	1.359	1.328	1.297	1.328	1.359	1.422	1.50[illegible]
D	4.250	3.719	3.312	2.922	2.641	2.359	2.125	1.938	1.688	1.625	1.500	1.422	1.391	1.328	1.328	1.344	1.375	1.422	1.50[illegible]
E	4.156	3.656	3.219	2.844	2.500	2.219	1.984	1.766	1.594	1.453	1.344	1.250	1.188	1.156	1.125	1.156	1.188	1.250	1.3[illegible]
F	4.250	3.641	3.234	2.812	2.500	2.188	1.953	1.750	1.562	1.406	1.297	1.203	1.156	1.109	1.094	1.094	1.141	1.188	1.2[illegible]



CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
"A"	4.266	3.875	3.516	3.203	2.953	2.734	2.547	2.391	2.266	2.172	2,078	2.000	1.969	1.922	1.922	1.938	2.000	2.047	2.12[illegible]
"B"	4.406	4.016	3.672	3.359	3.094	2.859	2.656	2.500	2.359	2.250	2.141	2.078	2.016	1.984	1.969	1.984	2.000	2.063	2.14[illegible]
"C"	4.234	3.844	3.484	3.172	2.922	2.688	2.484	2.328	2.203	2.094	2,000	1.922	1.891	1.844	1.859	1.859	1.938	2.000	2.06[illegible]
"D"	4.328	3.984	3.641	3.313	3.047	2.813	2.594	2.438	2.281	2.156	2.078	2.000	1.953	1.906	1.875	1.875	1.906	1.969	2.04[illegible]
"E"	4.172	3.750	3.375	3.047	2.766	2.531	2.344	2.172	2.031	1.922	1.813	1.750	1.703	1.656	1.656	1.672	1.750	1.813	1.87[illegible]
"F"	4.313	3.953	3.578	3.234	2.969	2.734	2.516	2.328	2.172	2.047	1.938	1.859	1.766	1.750	1.703	1.703	1.750	1.797	1.8[illegible]



16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
1.344	1.391	1.453	1.531	1.656	1.797	1.969	2.156	2.406	2.719	3.062	3.406	3.859	4.359	H	50 PSI
1.375	1.406	1.453	1.531	1.625	1.766	1.938	2.109	2.344	2.609	2.922	3.312	3.750	4.250	V	50 PSI
1.328	1.359	1.422	1.500	1.625	1.766	1.953	2.141	2.375	2.672	3.000	3.375	3.844	4.344	H	50 PSI
1.344	1.375	1.422	1.500	1.609	1.750	1.922	2.094	2.312	2.594	2.891	3.281	3.719	4.203	V	50 PSI
1.156	1.188	1.250	1.344	1.453	1.594	1.781	2.000	2.250	2.516	2.891	3.281	3.766	4.281	H	75 PSI
1.094	1.141	1.188	1.266	1.375	1.531	1.703	1.891	2.125	2.406	2.734	3.141	3.594	4.125	V	75 PSI

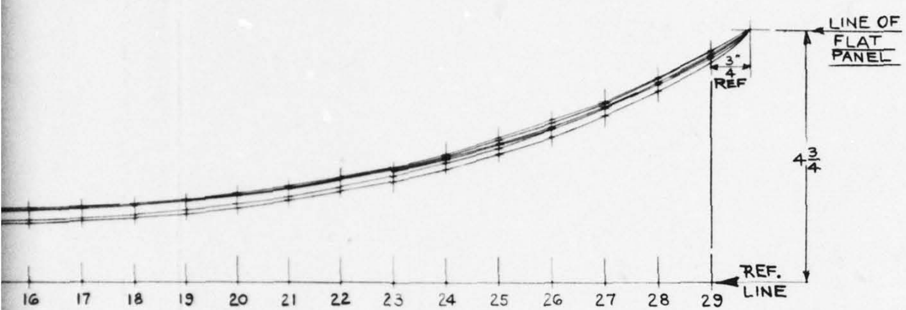


Figure 11 - Pressure versus Deflection Data for Panel No. 374-2/2, Wet

16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
.938	2.000	2.047	2.125	2.203	2.313	2.469	2.625	2.828	3.063	3.328	3.656	4.016	4.375	H	50 PSI
.984	2.000	2.063	2.141	2.219	2.344	2.500	2.656	2.875	3.094	3.359	3.688	4.047	4.391	V	50 PSI
.859	1.938	2.000	2.063	2.141	2.281	2.438	2.594	2.797	3.016	3.281	3.609	3.969	4.359	H	50 PSI
.875	1.906	1.969	2.047	2.125	2.234	2.375	2.531	2.734	2.969	3.250	3.563	3.953	4.328	V	50 PSI
.672	1.750	1.813	1.875	1.984	2.109	2.266	2.453	2.672	2.922	3.187	3.531	3.938	4.328	H	75 PSI
.703	1.750	1.797	1.859	1.953	2.063	2.250	2.391	2.609	2.844	3.109	3.453	3.859	4.281	V	75 PSI

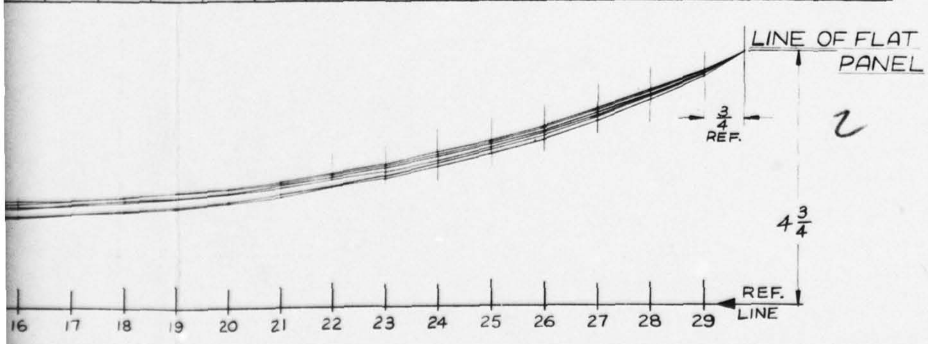
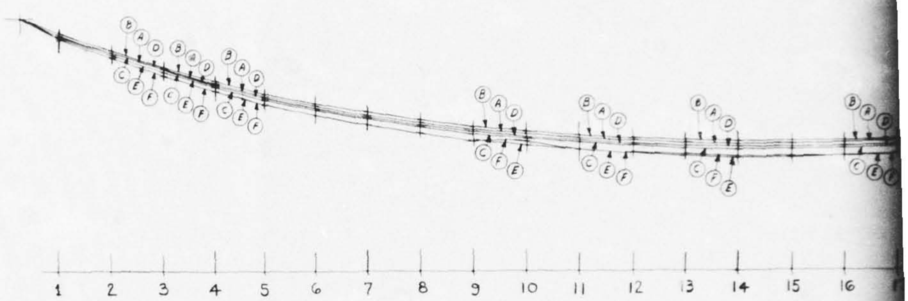
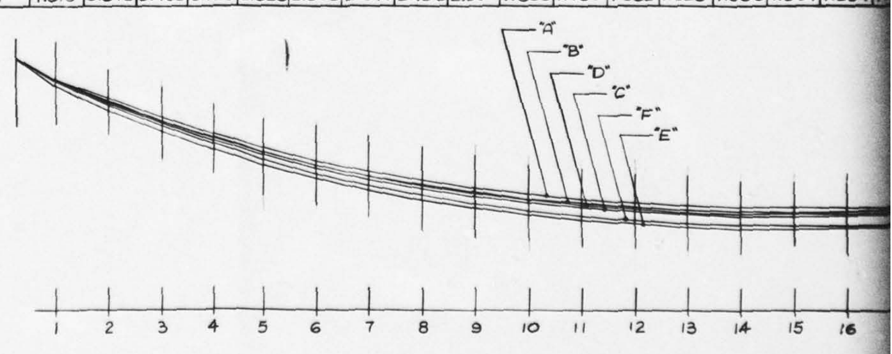


Figure 12 - Pressure versus Deflection Data for Panel No. 374-3/2, Wet

CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	4.430	4.109	3.813	3.547	3.313	3.125	2.938	2.797	2.672	2.578	2.500	2.458	2.406	2.375	2.375	2.391
B	4.469	4.156	3.844	3.594	3.359	3.156	3.000	2.844	2.719	2.625	2.547	2.484	2.453	2.422	2.422	2.422
C	4.391	4.078	3.750	3.484	3.250	3.047	2.875	2.719	2.578	2.484	2.422	2.359	2.297	2.266	2.266	2.281
D	4.422	4.109	3.813	3.531	3.281	3.078	2.906	2.750	2.625	2.516	2.453	2.391	2.344	2.328	2.313	2.328
E	4.359	4.016	3.688	3.406	3.156	2.938	2.750	2.594	2.453	2.344	2.281	2.219	2.156	2.125	2.125	2.141
F	4.375	4.031	3.688	3.406	3.156	2.938	2.750	2.594	2.469	2.359	2.281	2.219	2.187	2.141	2.141	2.141



CURVE \ PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
"A"	4.344	3.922	3.547	3.234	2.969	2.734	2.516	2.359	2.219	2.094	2.016	1.938	1.875	1.869	1.844	1.859
"B"	4.344	4.000	3.625	3.313	3.047	2.813	2.609	2.438	2.297	2.187	2.094	2.016	1.969	1.938	1.922	1.938
"C"	4.328	3.875	3.516	3.187	2.906	2.656	2.453	2.281	2.141	2.016	1.938	1.859	1.813	1.766	1.766	1.781
"D"	4.328	3.953	3.531	3.250	2.969	2.719	2.516	2.344	2.187	2.078	1.984	1.906	1.844	1.813	1.813	1.813
"E"	4.219	3.766	3.375	3.016	2.719	2.469	2.250	2.063	1.922	1.797	1.703	1.625	1.563	1.531	1.531	1.547
"F"	4.313	3.875	3.469	3.125	2.828	2.563	2.344	2.156	2.000	1.859	1.766	1.688	1.625	1.609	1.594	1.594



16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
391	2.438	2.484	2.531	2.625	2.719	2.844	2.984	3.172	3.375	3.594	3.875	4.187	4.500	H	50 PSI
422	2.453	2.500	2.563	2.641	2.750	2.875	3.000	3.187	3.359	3.594	3.844	4.141	4.453	V	50 PSI
281	2.328	2.375	2.438	2.516	2.625	2.766	2.906	3.094	3.313	3.531	3.813	4.141	4.422	H	50 PSI
328	2.359	2.406	2.469	2.563	2.656	2.813	2.922	3.109	3.313	3.531	3.813	4.125	4.422	V	50 PSI
141	2.172	2.219	2.281	2.375	2.484	2.641	2.781	2.969	3.187	3.438	3.734	4.063	4.430	H	75 PSI
141	2.187	2.234	2.313	2.391	2.500	2.641	2.781	2.969	3.172	3.422	3.719	4.031	4.359	V	75 PSI

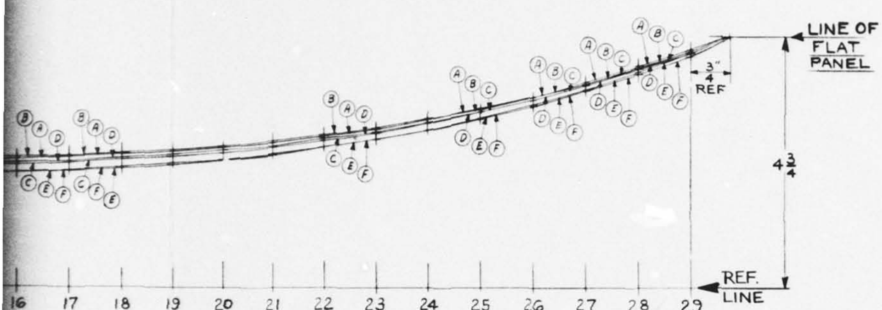


Figure 13 - Pressure versus Deflection Data for Panel No. 374-4/2, Wet

16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
1.859	1.906	1.953	2.047	2.141	2.250	2.406	2.578	2.781	3.031	3.313	3.656	4.047	4.453	H	50 PSI
1.938	1.953	2.000	2.094	2.187	2.313	2.453	2.609	2.813	3.047	3.313	3.641	4.000	4.437	V	50 PSI
1.781	1.813	1.875	1.953	2.063	2.187	2.344	2.500	2.672	2.969	3.281	3.609	4.000	4.406	H	50 PSI
1.813	1.844	1.891	1.984	2.063	2.187	2.359	2.516	2.719	2.969	3.250	3.563	3.953	4.406	V	50 PSI
1.547	1.578	1.641	1.719	1.828	1.953	2.125	2.313	2.531	2.859	3.094	3.469	3.906	4.375	H	75 PSI
1.594	1.625	1.688	1.766	1.875	2.000	2.156	2.328	2.547	2.813	3.094	3.453	3.844	4.313	V	75 PSI

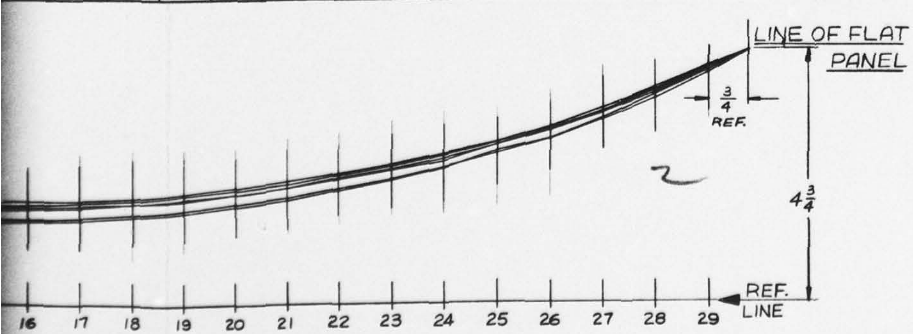
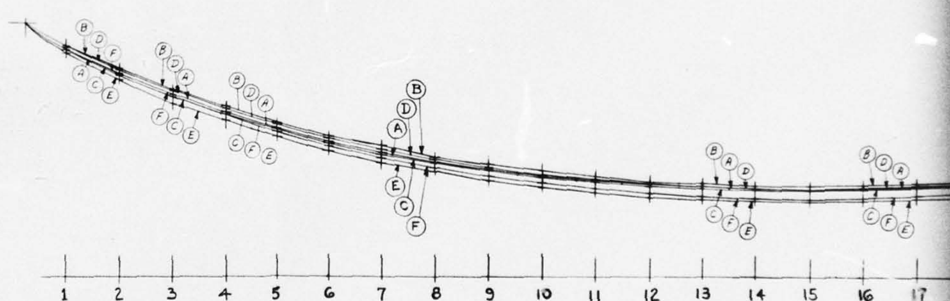


Figure 14 - Pressure versus Deflection Data for Panel No. 376-3/2, Wet

PIN NO / CURVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	4.234	3.797	3.406	3.063	2.766	2.516	2.313	2.141	2.000	1.875	1.797	1.734	1.688	1.641	1.625	1.641	1.672
B	4.313	3.906	3.500	3.172	2.875	2.625	2.453	2.234	2.094	1.969	1.875	1.766	1.734	1.688	1.688	1.703	1.719
C	4.234	3.766	3.375	3.016	2.750	2.484	2.281	2.125	1.969	1.844	1.766	1.688	1.641	1.625	1.609	1.625	1.656
D	4.313	3.875	3.484	3.125	2.844	2.578	2.375	2.187	2.031	1.891	1.813	1.750	1.688	1.641	1.625	1.656	1.688
E	4.172	3.688	3.250	2.906	2.609	2.344	2.109	1.969	1.781	1.656	1.563	1.484	1.438	1.406	1.391	1.406	1.438
F	4.281	3.813	3.406	3.016	2.703	2.438	2.219	2.031	1.875	1.750	1.641	1.563	1.500	1.453	1.438	1.469	1.500



15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	PLANE	PRESSURE
625	1.641	1.672	1.734	1.813	1.922	2.031	2.203	2.375	2.594	2.859	3.141	3.500	3.922	4.359	H	50 PSI
688	1.703	1.719	1.781	1.844	1.938	2.063	2.203	2.375	2.594	2.813	3.094	3.438	3.844	4.266	V	50 PSI
609	1.625	1.656	1.719	1.797	1.891	2.016	2.187	2.359	2.578	2.844	3.125	3.484	3.922	4.359	H	50 PSI
625	1.656	1.688	1.734	1.813	1.891	2.016	2.172	2.328	2.531	2.797	3.078	3.406	3.828	4.266	V	50 PSI
391	1.406	1.438	1.500	1.594	1.719	1.844	2.000	2.187	2.438	2.688	3.000	3.375	3.844	4.313	H	75 PSI
438	1.469	1.500	1.563	1.625	1.734	1.859	2.016	2.187	2.406	2.672	2.969	3.328	3.750	4.234	V	75 PSI

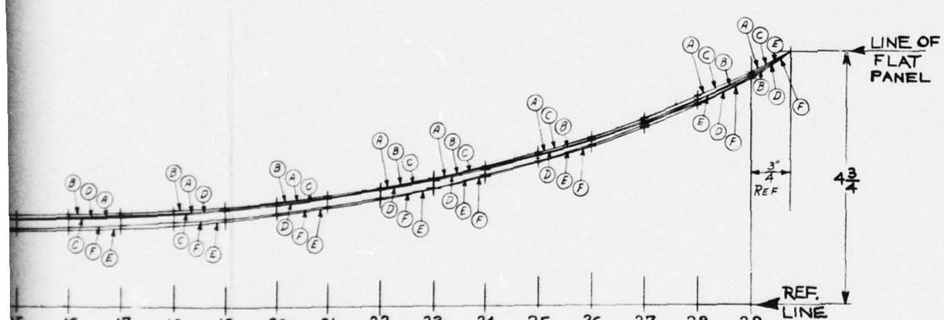


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Figure 15 - Pressure versus Deflection Data for Panel No. 377-3/2, Wet

TABLE V - PRESSURE VERSUS ELONGATION-WET TEST ON PANELS AT VARIOUS PRESSURES

Panel number	Elongation (percent)								
	At 50 psi							After 30 min at 75 psi	
	Prolonged			Minimum		Maximum			
	24 hr	48 hr	144 hr	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
374-2	3.51	3.60	3.60	3.51	3.48	3.60	3.54	3.97	4.03
374-3	2.43	2.50	2.53	2.43	2.35	2.53	2.50	2.90	2.81
374-4	2.02	2.18	2.18	2.02	1.65	2.18	1.81	2.10	2.07
376-3	2.56	2.70	2.70	2.56	2.43	2.70	2.62	3.02	2.84
377-3	2.95	2.99	2.99	2.95	2.84	2.99	2.95	3.42	3.32

only 6.71 and 5.99 percent of the quick-break strength. Goodyear has never conducted time-load tests at such low loads on any type of synthetic fiber. The lowest loading ever used was 60 percent of the quick-break strength, and it was found that polyester fiber could carry 60 percent of the quick-break load for ten years.

Goodyear's test facility was not equipped to subject the panels to burst pressures.

6. PHYSICAL PROPERTIES OF ELASTOMER COMPOUNDS

The physical properties of the elastomer compounds that were used to make both elastomer panels and elastomer-reinforced panels are given, for reference purposes, in Table VI. Pertinent properties of sea water are also listed for comparison.

TABLE VI - PHYSICAL PROPERTIES OF ELASTOMER COMPOUNDS USED IN ACOUSTIC PANELS

Material compound number	Velocity, c at 22 C (cm/sec)	Density, ρ (grams/cc)	Acoustic impedence, ρc (grams/sq cu/sec)	Tensile strength, ultimate (psi)	300 percent modulus (psi)	Durometer (Shore A)	Compression set (percent)	Tear resistance (lb/in.)	Water absorption in 48 hr at 25 C (percent)
4799 natural rubber, gum	154,000	0.98	151,000	2,200	180	37	62	165	...
T113 natural rubber, black	157,000	1.10	172,700	3,600	1,750	58	18	...	0.8
G 265 natural rubber, black	...	1.01	...	3,000	1,650	50	...	...	1.01
Urethane	156,000	1.107	172,700	5,000	2,400* 1,150+	90	...	...	...
Sea water	156,500	1.03	161,200	...		...	...	...	...

*400 percent.

+200 percent.

LIST OF REFERENCES

1. USRL Calibration Report No. 2218: Goodyear Elastomer Panels: Code Numbers 375-3/2, 378-3/1 and 830; Measurements On. Orlando, Fla., Underwater Sound Reference Laboratory, Office of Naval Research, Department of the Navy, 5 October 1964.

2. USRL Calibration Report No. 2131: Measurements on Goodyear Elastomer-Coated Reinforced Panels. Orlando, Fla., Underwater Sound Reference Laboratory, Office of Naval Research, Department of the Navy, 3 February 1964.

3. USL Technical Memorandum No. 933-341-64: Effects of High-Power Transmissions on Goodyear Elastomeric Dome Panels. New London, Conn., Underwater Sound Laboratory, Department of the Navy, 15 October 1964.

4. USRL Calibration Report No. 2215: Measurement on Goodyear Elastomer Panels: Code No. G265-0/1, 373-3/1, 374-2/1, 374-3/1, 374-4/1, 375-3/1, 376-3/1, 377-3/1, 4799-0/1 and T113-0/1. Orlando, Fla., Underwater Sound Reference Laboratory, Office of Naval Research, Department of the Navy, 22 September 1964.

Copies of References 1, 2, and 4 are included in the following pages as Appendixes A, B, and C, respectively.

40

APPENDIX A - USRL CALIBRATION REPORT NO. 2218

GOODYEAR ELASTOMER PANELS: CODE NUMBERS 375-3/2, 378-3/1, AND 830; MEASUREMENTS ON

Department of the Navy, Office of Naval Research
USN UNDERWATER SOUND REFERENCE LABORATORY
P. O. Box 8337, Orlando, Florida

WLP/hs
RP-2711
5 Oct 1964

CALIBRATION REPORT No. 2218

Subj: Goodyear Elastomer panels Code Numbers 375-3/2, 378-3/1, and 830; measurements on

Ref: (a) Goodyear Aerospace Corp. ltr WS-5053 of 11 Feb 1964 and BUSHIPS endorsement NObsr 91065 Ser 688E-119 of 4 Mar 1964
(b) Goodyear Tire and Rubber Co. ltr Ref AQH764-141 of 20 Jul 1964
(c) USRL Calibration Report No. 2131 (RP-2677) of 3 Feb 1964
(d) USRL Calibration Report No. 2215 (RP-2711) of 22 Sep 1964

Encl: (1) Table 1

1. Three reinforced elastomer panels were evaluated for Goodyear Aerospace Corp. and Goodyear Tire and Rubber Co. as requested and authorized by references (a) and (b) in connection with contract NObsr 91065. Two of the panels were 5 ft square, having been cut from the 6-ft-square panels evaluated in January 1964. The results of that evaluation were reported in reference (c). The third panel, Code No. 830, was 6 ft square and had not been submitted for evaluation previously.

2. The effect of hydrostatic pressure on the transmission of the 30-inch samples, reported in reference (d), indicated that the best results are obtained when maximum hydrostatic pressure is on the samples. Because the 5-ft and larger panels could not be tested in the anechoic tank, they were lowered to the maximum test depth in the open-water facility, placing the centers of the panels at the depth 20 feet. The panels were soaked for more than 12 hours before acoustic measurements were made.

3. The results of the measurements are shown in table 1, enclosure (1). The transmission loss at low frequencies was too small to be measured; the notation " <0.5" indicates a value between 0.0 and 0.5 dB that could not be determined accurately because of the nature of the data. The measurements were extended to the frequency 60 kc where the transmission losses were sufficiently high to indicate that measurements at higher frequencies would be of little value. The test transducer arrangement at this greater-than-usual depth limited the measurements to those for normal-incident sound. The effect of increasing angle of incidence was shown in reference (c) to be essentially equivalent to more loss through a greater thickness of material.

4. Reflection measurements were not made because it has been shown previously for these materials that under conditions of high transmission (low loss), only 1 to 2% of the incident sound energy is reflected.

W. L. Paine
W. L. PAINE

Copy to:
BUSHIPS (Code 688E)(1)
Goodyear Tire & Rubber Co. (G. A. Steffensen, Dept. 474-F)(1)
SUPSHIPS (Tech. Libr. Code 249)(Groton)(1)
USRL (200)(1)

Table 1

TRANSMISSION LOSS
(in decibels)

Normal-Incident Sound
Temperature: 27°C
Pressure: 8.7 psig at panel center

GOODYEAR REINFORCED ELASTOMER PANELS

Freq (kc)	Panel Code No.*		
	375-3/2	378-3/1	830
2	<0.5	<0.5	<0.5
4	<0.5	<0.5	<0.5
6	<0.5	<0.5	0.7
8	<0.5	0.6	1.0
10	<0.5	0.8	1.3
12	<0.5	1.4	1.5
14	<0.5	1.9	1.7
16	0.6	2.5	2.2
18	0.8	2.7	2.5
20	1.0	3.3	3.0
25	1.4	4.2	3.7
30	1.6	4.1	4.4
35	1.8	3.7	5.2
40	2.6	3.6	6.2
45	3.5	3.4	7.3
50	4.5	3.3	8.6
55	5.0	3.2	10.0
60	5.5	3.2	11.5

*Panel 375-3/2 was 5 ft square, 1-5/8 in. thick, cord-reinforced; cord exposed at two cut edges. The original 6-ft-square panel was No. 375-3.

Panel 378-3/1 was 5 ft square, 7/8-in. thick, steel-reinforced; steel exposed at two cut edges. The original 6-ft square panel was No. 378-3.

Panel 830 was 6 ft square, 1-7/8 in. thick cord-reinforced; cord exposed on four cut edges.

APPENDIX B - USRL CALIBRATION REPORT NO. 2131

MEASUREMENTS ON GOODYEAR ELASTOMER-COATED REINFORCED PANELS

Department of the Navy, Office of Naval Research USN UNDERWATER SOUND REFERENCE LABORATORY P. O. Box 8337, Orlando, Florida 32806	CRB/hs RP-2677 3 Feb 1964

CALIBRATION REPORT No. 2131

Subj: Goodyear elastomer-coated reinforced panels; measurements on

Ref: (a) Goodyear Aerospace Corp ltr WS-4916 of 15 Nov 1963 to BUSHIPS
(b) BUSHIPS ltr NObsr 91065 Ser 688E-537 of 16 Dec 1963

Encl: (1) Tables 1 through 10

1. Seven elastomer-coated cord-reinforced panels, one elastomer-coated metal-reinforced panel, and one gum-rubber panel were evaluated for the Goodyear Aerospace Corp. as requested in reference (a) and authorized in reference (b) in connection with contract NObsr 91065. The 6 x 6-ft square panels are described in Table 1, enclosure (1).

2. The transmission loss of each panel was measured at 5° intervals by an "insertion loss" method at orientations from 0° to 45° measured from a line normal to the test panel at the center. The results of these measurements are shown in Tables 2 through 10. For measurements of this type the accuracy is ±0.2 dB. The dimensions of the panels allowed the use of continuous -wave sound at low frequencies, where pulsing is not practical.

3. At the request of Mr. Theodore Underwood, Goodyear representative, the transmission loss was measured on panel serial 377-3 with each side of the panel facing the sound source. The difference was negligible.

4. Reflection from panel serial 265-0, which had a low transmission loss at all frequencies and angles, and serial 377-3 which had the highest transmission loss per inch thickness of the cord-reinforced materials, was measured over the frequency range 5 to 20 kc by both continuous-wave and pulsing techniques. The results by the two methods were substantially the same, and the reflection varied from 2% of incident-sound intensity for panel 265-0 to 7% for panel 377-3. Measurements were limited to normal incidence and frequencies above 5 kc by panel size. The reflection did not appear to be a function of frequency.

5. Reflection measurements on the remaining seven panels could not be made in the time scheduled for these tests, and because of other priority work.

6. On the basis of paragraph 3 of reference (b) the data reported here are unclassified.

Charles R. Bobo
CHARLES R. BOBO
Acoustic Calibration Division

Copy to:
BUSHIPS (Code 688E)(2)
Goodyear Aerospace Corp. (H. Boyd)(2)
Goodyear Tire and Rubber Co (T. Underwood)(1)
USRL (200)(1)

Table 1

PANEL DESCRIPTION*

Goodyear Elastomer Panels

Panel No.	Thickness (inches)	Reinforcement
265-0**	1-3/4	none
373-3	1-7/8	cord
374-2	1-3/16	cord
374-3	1-3/4	cord
374-4	2-5/16	cord
375-3	1-3/4	cord
376-3	1-5/8	cord
377-3	1-1/4	cord
378-3	7/8	cord and steel

* Type of elastomer and of cord not indicated by manufacturer.

** Stated to be gum rubber.

Table 2

TRANSMISSION LOSS
(in decibels)

Goodyear Elastomer Panel No. 265-0
Water temp: 15°C

Freq (kc)	Angle of Incidence 0-45°
2	0.7
3	0.7
4	0.7
5	0.7
6	0.9
7	0.9
8	1.0
9	0.8
10	0.9
12	1.0
14	0.6
16	0.9
18	0.8
20	0.8

Table 3

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 373-3
Water temp: 15°C

Freq (kc)	Angle of Incidence				
	0-25°	30°	35°	40°	45°
2	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.2
4	1.0	1.0	1.2	1.5	1.7
5	1.2	1.2	1.5	1.7	2.1
6	1.3	1.3	1.7	1.9	2.5
7	1.6	1.6	1.9	2.2	2.4
8	1.7	1.7	2.1	2.3	2.6
9	1.9	1.9	2.3	2.6	3.0
10	1.8	1.8	1.9	2.3	2.9
12	1.5	1.8	2.0	2.5	3.2
14	1.7	1.9	2.1	2.5	3.4
16	1.9	1.9	2.3	3.1	3.7
18	1.9	2.2	2.6	3.5	4.5
20	2.0	2.4	3.0	4.1	5.3

Table 4

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 374-2
Water temp: 15°C

Freq (kc)	Angle of Incidence				
	0-25°	30°	35°	40°	45°
2	0.8	0.8	0.8	0.8	0.8
3	0.8	0.8	0.8	0.8	0.8
4	0.8	0.8	0.8	0.8	0.9
5	0.8	0.8	1.1	1.3	1.4
6	1.2	1.2	1.4	1.7	1.9
7	1.2	1.2	1.5	1.7	2.0
8	1.5	1.5	1.7	1.7	1.9
9	1.5	1.5	1.7	1.8	1.9
10	1.4	1.5	1.7	1.9	2.1
12	1.4	1.6	2.1	2.3	2.5
14	1.0	1.2	1.7	1.9	2.2
16	1.2	1.4	1.5	2.0	2.3
18	1.0	1.2	1.8	2.2	3.0
20	1.3	1.5	1.8	2.5	3.1

Table 5

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 374-3
Water temp: 15°C

Freq (kc)	Angle of Incidence					
	0-20°	25°	30°	35°	40°	45°
2	1.0	1.0	1.1	1.4	1.5	1.6
3	1.0	1.0	1.2	1.4	1.5	1.6
4	1.0	1.0	1.2	1.4	1.5	1.7
5	1.0	1.3	1.3	1.7	1.8	2.1
6	1.2	1.4	1.6	2.0	2.2	2.5
7	1.4	1.6	1.8	2.3	2.4	2.7
8	1.7	2.3	2.4	2.6	2.8	3.2
9	1.8	1.8	1.9	2.3	2.5	3.2
10	1.7	1.8	1.9	2.2	2.3	2.5
12	1.2	1.7	1.9	2.4	2.4	2.8
14	1.2	1.5	1.7	2.3	2.5	3.1
16	1.7	1.7	2.2	2.5	2.9	3.6
18	1.7	1.8	2.4	2.8	3.5	4.2
20	2.1	2.2	2.6	3.1	3.7	4.5

Table 6

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 374-4
Water temp: 15°C

Freq (kc)	Angle of Incidence					
	0-20°	25°	30°	35°	40°	45°
2	1.0	1.0	1.0	1.1	1.2	1.3
3	1.0	1.0	1.0	1.2	1.4	1.6
4	1.0	1.2	1.3	1.6	2.0	2.2
5	1.0	1.5	1.7	2.0	2.5	2.8
6	1.4	1.8	2.0	2.4	2.8	3.2
7	1.7	2.0	2.2	2.6	2.9	3.4
8	1.9	2.1	2.2	2.6	3.1	3.4
9	2.1	2.4	2.5	2.8	3.2	3.7
10	2.3	2.6	2.8	2.9	3.3	3.9
12	1.6	2.2	2.5	2.9	3.4	4.0
14	1.3	1.7	2.0	2.6	3.3	4.1
16	1.4	1.8	2.2	2.5	3.4	4.4
18	1.8	2.3	2.7	3.4	4.1	5.0
20	2.1	2.5	2.9	3.7	5.0	5.9

Table 7

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 375-3
Water temp: 15°C

Freq (kc)	Angle of Incidence				
	0-25°	30°	35°	40°	45°
2	0.5	0.5	0.6	0.6	0.6
3	0.5	0.5	0.7	0.7	0.8
4	0.5	0.6	0.8	0.8	0.9
5	0.6	0.6	0.8	1.0	1.2
6	0.7	0.8	0.8	1.0	1.2
7	0.8	0.9	1.0	1.2	1.4
8	1.0	1.1	1.1	1.3	1.5
9	1.3	1.4	1.5	1.6	1.8
10	0.8	0.9	1.1	1.3	1.8
12	0.8	1.0	1.3	1.7	2.2
14	0.7	1.0	1.3	1.9	2.6
16	0.7	1.3	1.6	2.4	3.5
18	0.8	1.4	1.7	2.4	3.5
20	1.2	1.8	2.0	2.9	3.8

Table 8

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 376-3
Water temp: 15°C

Freq (kc)	Angle of Incidence			
	0-30°	35°	40°	45°
2	0.6	0.7	0.7	0.8
3	0.6	0.7	0.7	0.9
4	0.7	0.8	0.9	1.1
5	0.7	0.9	1.1	1.2
6	0.9	1.0	1.2	1.6
7	0.9	1.1	1.3	1.6
8	1.0	1.3	1.4	1.7
9	1.0	1.4	1.6	1.8
10	1.1	1.4	1.6	1.8
12	1.1	1.4	1.6	2.0
14	1.1	1.4	1.5	2.1
16	1.3	1.6	2.0	2.4
18	1.3	1.6	2.0	2.6
20	1.4	1.7	2.4	3.0

Table 9

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 377-3
Water temp: 15°C

Freq (kc)	Angle of Incidence					
	0-20°	25°	30°	35°	40°	45°
2	0.7	0.7	0.7	0.8	0.8	1.0
3	0.7	0.7	0.7	0.9	1.0	1.0
4	0.7	0.7	0.9	1.2	1.4	1.6
5	0.8	0.8	1.2	1.4	1.6	1.9
6	1.3	1.3	1.5	1.8	2.4	2.7
7	1.5	1.5	1.7	2.1	2.3	2.7
8	1.6	1.6	1.9	2.8	2.8	3.1
9	1.6	1.6	2.2	2.2	3.0	3.1
10	1.6	1.6	1.8	2.0	2.4	2.9
12	1.2	1.4	1.8	2.1	2.6	3.2
14	1.4	1.4	1.8	1.9	2.4	3.0
16	2.0	2.2	2.3	2.7	3.1	3.8
18	2.2	2.3	2.7	2.9	3.7	4.5
20	2.2	2.4	2.7	3.1	3.7	4.8

Table 10

TRANSMISSION LOSS
(in decibels)

Goodyear Reinforced Elastomer Panel No. 378-3
Water temp: 15°C

Freq (kc)	Angle of Incidence					
	0-20°	25°	30°	35°	40°	45°
2	0.6	0.6	0.6	0.6	0.6	0.6
3	0.8	0.8	0.8	0.8	0.8	0.8
4	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9
6	1.1	1.1	1.1	1.1	1.1	1.1
7	1.3	1.3	1.3	1.3	1.4	1.5
8	1.4	1.4	1.4	1.4	1.5	1.6
9	1.7	1.7	1.7	1.7	1.8	1.9
10	1.7	1.7	1.8	1.8	1.9	2.1
12	2.0	2.1	2.2	2.2	2.3	2.4
14	2.2	2.3	2.3	2.3	2.4	2.6
16	3.0	3.2	3.3	3.4	3.7	4.0
18	3.5	3.6	3.6	3.9	4.2	4.6
20	3.7	4.1	4.3	4.5	5.0	5.2

APPENDIX C - USRL CALIBRATION REPORT NO. 2215 MEASUREMENT ON GOODYEAR ELASTOMER PANELS; CODE NUMBERS G265-0/1, 373-3/1, 374-2/1, 374-3/1, 374-4/1, 375-3/1, 376-3/1, 377-3/1, 4799-0/1, AND T113-0/1

Department of the Navy, Office of Naval Research
USN UNDERWATER SOUND REFERENCE LABORATORY
P. O. Box 8337, Orlando, Florida, 32806

WLP/lh
RP-2711
22 Sep 1964

CALIBRATION REPORT No. 2215

Subj: Goodyear Elastomer Panels Code Nos. G265-0/1, 373-3/1, 374-2/1, 374-3/1, 374-4/1, 375-3/1, 376-3/1, 377-3/1, 4799-0/1, and T113-0/1; measurements on

Ref: (a) Goodyear Aerospace Corp. ltr WS-5053 of 11 Feb 1964 with BUSHIPS endorsement NObsr 91065 Ser 688E-119 of 4 Mar 1964
(b) Goodyear Tire and Rubber Co. ltr Ref AQH764-141 of 20 Jul 1964
(c) USRL Calibration Report No. 2131 (RP-2677) of 3 Feb 1964

Encl: (1) Photograph USRL EXR 1-1903-8-64
(2) Tables USRL 1 through 3

1. Seven cord-reinforced and three nonreinforced elastomer panels were evaluated for Goodyear Aerospace Corp. and Goodyear Tire and Rubber Co. as requested and authorized by references (a) and (b) in connection with contract NObsr 91065. The panels were 30 inches square, having been cut from the 6-ft-square panels evaluated in January, 1964. The results of that evaluation were reported in reference (c). The purpose of the investigation by Goodyear is to produce reinforced elastomers with high tensile strength but low acoustic transmission loss.

2. The initial test results, reference (c), indicated that additional measurements at frequencies from 20 to 150 kc would be of value. The higher frequency range would permit the use of smaller samples and also make it possible to conduct tests in the USRL anechoic tank at hydrostatic pressures to 1000 psig and at temperatures other than ambient. By endorsement to reference (a), the Bureau of Ships requested that measurements be extended even higher, to the frequency 350 kc, and to low temperatures.

3. Enclosure (1) shows a panel rigged for tests in the anechoic tank. The probe-type hydrophone is placed 34 cm in front of the panel for reflection measurements and is repositioned to 3 cm behind the panel for transmission measurements. The size of the panel limits the lowest frequency for valid data to about 10 kc and to normal-incident sound. Panel descriptions are in table 1 of enclosure (2).

4. The results of the measurements on the reinforced panels are shown in table 2, enclosure (2). At 0 psig, the transmission loss at frequencies of 10 kc and higher depends on prior treatment of the panels. Cleaning the panels with aerosol solution and soaking at shallow depth to eliminate surface-adsorbed air before making acoustic tests was not adequate, as is shown by the large transmission losses in the first part of table 2. Increasing the hydrostatic pressure to 1000 psig decreased the transmission loss to nearly immeasurable values at frequencies below 30 kc. (The notation "<0.5" indicates a value between 0.0 and 0.5 dB that could not be determined accurately because of the nature of the data.)

The transmission losses following release of hydrostatic pressure were small, variable, nonrepeatable, and generally increased with time to approximately the large initial loss at 0 psig. A special test on panel 374-2/1 revealed that soaking the panel for 15 hours at the hydrostatic pressure 10 psig resulted in transmission losses at 10 psig that were almost identical with the losses measured when the sample was tested at 1000 psig. It was not possible to retest the other panels because of other scheduled work; it is expected that the tests will be made at a later date.

5. The measurements at frequencies above 150 kc were made first, before subsequent tests revealed the effect of hydrostatic pressure. These data, taken with the panels in a 4-ft-deep open tank at room temperature with only 2 feet of water head (1 psig) on the panel, have little significance other than to show the large transmission losses that may exist under certain conditions. The transmission loss at the frequency 350 kc, extrapolated from the measured losses in the region 50 to 150 kc at the pressure 1000 psig, varies from 4 to more than 10 dB for the different panels.

6. The results of measurements on the nonreinforced panels are shown in table 3 of enclosure (2).

7. Under conditions of high transmission (low loss), reflection measurements indicate that only 1 to 2% of the incident sound energy is reflected.

8. This report has been prepared and released to show that nonreinforced elastomers have low transmission losses at low frequencies, but that the conditions of use and/or test affect the transmission loss of reinforced elastomers of the type tested.

W L Paine

W. L. PAINE

Copy to:
BUSHIPS (Code 688E)(1)
Goodyear Tire & Rubber Co. (G. A. Steffensen, Dept. 474-B)(1)
SUPSHIPS (Tech. Libr. Code 249) Groton (1)
USRL (Code 200)(1)

Table 1

PANEL DESCRIPTION*

Goodyear Elastomer Panels
Size: 30 x 30 inches

Panel No.	Thickness (inches)	Reinforcement
G265-0/1	1-3/4	none
373-3/1	1-7/8	cord
374-2/1	1-3/16	cord
374-3/1	1-5/8	cord
374-4/1	2-1/4	cord
375-3/1	1-5/8	cord
376-3/1	1-1/2	cord
377-3/1	1-1/4	cord
4799-0/1	2	none
T113-0/1	2	none

* Type of elastomer and of cord not indicated by manufacturer, except that composition of G265-0/1 was stated to be gum rubber. First eight panels were cut from 5 x 5-foot panels. See reference (c). Last two panels not previously submitted.

Table 2

TRANSMISSION LOSS
(in decibels)

Normal-Incident Sound

GOODYEAR REINFORCED ELASTOMER PANELS

Temp (°C)	Press (psig)	Freq (kc)	Panel Code No.						
			373-3/1	374-2/1*	374-3/1	374-4/1	375-3/1	376-3/1	377-3/1
25	0	10	0.6	<0.5	<0.5	0.8	<0.5	<0.5	0.7
		15	1.0	<0.5	0.8	1.3	<0.5	<0.5	1.1
		20	1.8	0.6	1.2	1.9	0.8	0.5	1.7
		25	2.2	0.9	1.8	2.2	1.1	0.9	2.0
		30	2.6	1.1	2.0	3.0	1.4	1.0	2.5
		40	3.0	1.8	3.0	4.4	2.3	1.5	3.5
		50	3.4	2.5	3.8	6.0	3.3	2.0	4.8
		75	7.0	4.8	8.2	14.0	6.0	3.8	7.5
		100	10.5	7.0	11.5	16.0	9.5	5.2	12.5
		125	13.5	9.2	14.5	17.0	13.0	7.5	25.0
		150	15.0	12.0	17.0	22.0	17.0	11.0	29.0
		200	>30.0	18.0	>30.0	>30.0	>30.0	18.0	>30.0
		250	>30.0	27.0	>30.0	>30.0	>30.0	25.0	>30.0
		300	>30.0	29.0	>30.0	>30.0	>30.0	27.0	>30.0
		350	>30.0	>30.0	>30.0	>30.0	>30.0	>30.0	>30.0
25	1000	10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
		15	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
		20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
		25	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
		30	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
		40	0.7	0.6	<0.5	<0.5	0.7	0.6	0.6
		50	0.9	0.9	<0.5	0.7	1.1	0.8	0.9
		75	1.3	1.0	0.9	0.9	2.1	1.2	1.0
		100	1.9	1.5	1.2	1.7	3.2	1.6	1.6
		125	2.2	2.0	2.2	3.0	5.0	2.6	2.0
		150**	2.8	3.0	4.0	4.0	6.2	3.2	2.4
4	0	10	0.8	<0.5	<0.5	<0.5	0.5	<0.5	1.0
		15	1.2	0.5	1.0	1.1	1.0	1.1	1.3
		20	1.7	0.7	1.8	1.7	1.6	1.2	1.8
		25	2.3	0.7	2.0	2.2	2.1	1.5	2.2
		30	2.5	0.7	2.1	2.4	2.4	1.7	2.5

Table 2 (continued)

TRANSMISSION LOSS
(in decibels)

Normal-Incident Sound

GOODYEAR REINFORCED ELASTOMER PANELS

Temp (°C)	Press (psig)	Freq (kc)	Panel Code No.						
			373-3/1	374-2/1*	374-3/1	374-4/1	375-3/1	376-3/1	377-3/1
4	0	40	3.1	0.8	2.7	3.2	2.6	1.9	3.0
		50	3.7	0.8	3.8	4.4	3.0	2.2	3.5
		75	7.7	1.2	8.0	7.7	7.0	4.2	7.3
		100	11.0	1.3	12.0	12.0	11.0	5.3	11.0
		125	14.0	2.5	18.0	18.0	13.0	7.8	16.0
		150	15.0	3.6	20.0	19.0	17.0	11.0	23.0
4	1000	10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
		15	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7
		20	0.5	<0.5	<0.5	0.5	0.8	<0.5	0.9
		25	0.9	<0.5	0.5	0.7	1.2	<0.5	1.0
		30	1.0	<0.5	0.7	0.7	1.2	0.5	1.0
		40	1.1	<0.5	0.7	0.8	1.2	0.6	1.1
		50	1.2	0.9	0.7	0.8	1.3	0.8	1.1
		75	1.4	1.0	1.3	1.4	2.9	1.4	1.3
		100	1.6	1.2	2.2	2.0	4.2	1.5	1.6
		125	2.3	2.2	3.0	3.5	5.4	1.7	2.1
		150***	3.2	3.3	4.7	5.5	7.2	3.5	3.3

* Pressure maintained at 10 psig for 15 hours while being cooled from 25 to 4°C before measurement at 0 psig

** Not measured above 150 kc at pressures other than 0 psig

*** Not measured above 150 kc at temperatures other than 25°C

Table 3

TRANSMISSION LOSS
(in decibels)

Normal-Incident Sound

GOODYEAR NONREINFORCED ELASTOMER PANELS

Temp (°C)	Press (psig)	Freq (kc)	Panel Code No.		
			G265-0/1	4799-0/1	T113-0/1
25	0	10	<0.5	<0.5	<0.5
		15	<0.5	<0.5	<0.5
		20	<0.5	<0.5	<0.5
		25	<0.5	<0.5	<0.5
		30	<0.5	<0.5	<0.5
		40	<0.5	<0.5	<0.5
		50	<0.5	<0.5	0.5
		75	<0.5	<0.5	0.6
		100	0.5	0.5	0.7
		125	0.7	0.5	0.8
		150	0.9	0.6	0.9
		200	1.1	0.6	1.0
		250	1.3	0.8	1.5
		300	1.5	1.0	2.0
		350	2.0	1.2	2.5
25	1000	10 ↓ 150*	All values <0.5		
4	0	10	<0.5	<0.5	<0.5
		15	<0.5	<0.5	<0.5
		20	<0.5	<0.5	<0.5
		25	<0.5	<0.5	1.0
		30	<0.5	<0.5	1.0
		40	<0.5	<0.5	1.0
		50	<0.5	<0.5	1.0
		75	<0.5	<0.5	1.3
		100	0.6	<0.5	1.7
		125	0.7	<0.5	1.8
		150	0.8	0.8	2.0

Table 3 (continued)

TRANSMISSION LOSS
(in decibels)

Normal-Incident Sound

GOODYEAR NONREINFORCED ELASTOMER PANELS

Temp (°C)	Press (psig)	Freq (kc)	Panel Code No.		
			G265-0/1	4799-0/1	T113-0/1
4	1000	10	<0.5	<0.5	<0.5
		15	<0.5	<0.5	<0.5
		20	<0.5	<0.5	0.6
		25	<0.5	<0.5	1.0
		30	<0.5	<0.5	1.0
		40	<0.5	<0.5	1.0
		50	<0.5	<0.5	1.1
		75	<0.5	<0.5	1.1
		100	<0.5	<0.5	1.2
		125	<0.5	<0.5	1.2
		150**	<0.5	<0.5	2.0

* Not measured above 150 kc at pressures other than 0 psig

** Not measured above 150 kc at temperatures other than 25°C