

SECURITY

MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.

Separate page printouts **MUST** be marked accordingly.

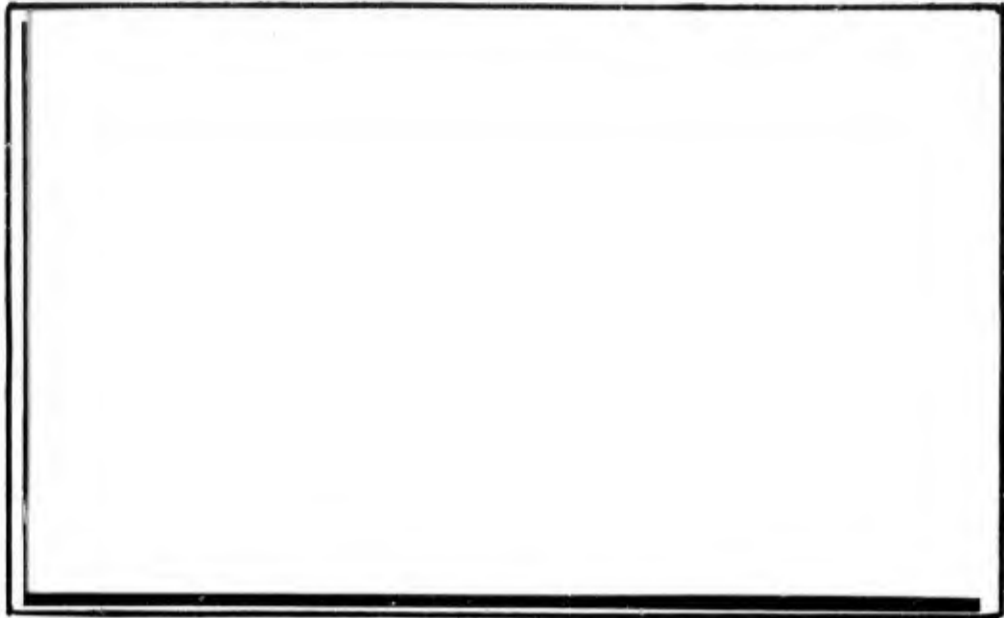
THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.



CATALOGED BY: DDG

AS AD NO. 470542



U.S. NAVAL APPLIED SCIENCE LABORATORY
NAVAL BASE
BROOKLYN , NEW YORK 11251

SEP 30 1955
LIBRARY
U.S. NAVAL APPLIED SCIENCE LABORATORY



STANDARDIZATION PROGRAM
ON
SHELF AGING OF NATURAL
AND
SYNTHETIC RUBBER MATERIALS

Lab. Project 5974 Supplementary Report
R 007 03 04 Identification No. 30-909-1

28 SEP 1965

MATERIAL SCIENCES DIVISION

Approved:


D.H. KALLAS
Associate Technical Director

U.S. NAVAL APPLIED SCIENCE LABORATORY
Naval Base
Brooklyn, New York 11251

ABSTRACT

Test specimens made from butadiene-styrene, Buna N, natural rubber and neoprene were subjected to shelf aging and low temperature conditioning for periods up to 7 years while in packaged and unpackaged states. Following the aging period, the tensile strength, elongation, tensile product, modulus at 300% elongation, swelling ratio, compression set and stress relaxation of the specimens were determined. Tensile product, modulus at 300% elongation and swelling ratio were found to be the parameters which best indicated the trend in the deterioration of the elastomers. The results of shelf aging in a packaged condition were compared with the results obtained in accelerated heat aging tests, reported previously, and it was found that accelerated heat aging for 10 weeks at 140F would cause a greater deterioration in the physical properties of butadiene-styrene and Buna N specimens than shelf aging for a period of 5 years and a greater deterioration in the physical properties of natural rubber and neoprene specimens than shelf-aging for a period of 6 years. There was comparatively little additional deterioration in the physical properties of butadiene-styrene and Buna N specimens despite an increase in the period of shelf aging from 1½ years to 3½ years and even to 5 years, and for the natural rubber and neoprene specimens despite an increase in the period of shelf aging from 2½ years to 4 years and even to 6 years. Recommendations were made to increase the shelf life of end-items made from butadiene-styrene and Buna N to 5 years, to reduce the shelf life of end-items made from natural rubber to ½ year and to increase the shelf life of end-items from neoprene to 6 years.

ADMINISTRATIVE INFORMATION

- Ref: (a) BUSHIPS ltr R 007 03 04, Ser 634C1-854 of 22 Oct 1963
(b) BUSHIPS ltr All/NSS-033-200, Ser 344-558 of 24 Jul 1957
(c) MATLAB NAVSHIPYDNYK Project 5974, Parts 1 and 2, Progress Report 2 of 18 May 1959
(d) MATLAB NAVSHIPYDNYK Project 5974, Parts 3 and 4, Progress Report 2 of 3 Dec 1959
(e) NAVAPLSCIENLAB ltr 9370:CPC:eew, Lab. Project 5974, Final Report of 11 Sep 1963
(f) Specification MIL-B-131B of 16 Jul 1952
(g) Fed. Test Method Std. No. 601 of 12 Apr 1955
(h) Article, "Degree of Cure in Filler-Reinforced Vulcanizates by the Swelling Method" by Gerard Kraus. Rubber World, Oct 1956
(i) ASTM Method D1390-56T, Method of Test for Stress Relaxation of Vulcanized Rubber in Compression

TABLES:

- 1 - Data Sheet, - Recipes of the Butadiene-Styrene, Buna N, Natural Rubber and Neoprene Stocks Used in the Shelf Aging and Low Temperature Conditioning Program
- 2 through 5, - Data Sheets, - Summary of Results Obtained on the Synthetic and Natural Rubber Materials Subjected to Shelf Aging and Low Temperature Conditioning in Packaged and Unpackaged States
- 7 - Data Sheet, - Deterioration in Physical Properties of Synthetic and Natural Rubber Materials Subjected to Shelf Aging in a Packaged State

1. The U.S. Naval Applied Science Laboratory was authorized in reference (a) to continue the standardization program on shelf aging of synthetic and natural rubber materials to completion in Fiscal Year 1965. This program was originally authorized by reference (b). In accordance with the information in reference (a), no tests were made on the specimens during Fiscal Year 1964 in order to reduce the work load. In references (c) and (d), the Laboratory reported the results of accelerated heat aging tests made on the specimens. This report supplements the information previously reported in reference (e); which contained the results of shelf aging and low temperature conditioning of the butadiene-styrene and Buna N specimens for 5 years and of the natural rubber and neoprene specimens for 4 years.

OBJECTIVE

2. The objectives of this standardization program are to determine whether the shelf life of synthetic and natural rubber end-items can be extended beyond 3 years and to determine the correlation between shelf aging and accelerated heat aging of end-items made from elastomeric materials.

SAMPLES

3. The samples consisted of a butadiene-styrene low temperature gasket material, a Buna N O-ring material, a natural rubber door hatch gasket material and a neoprene GR-T shock mount material. The recipes of the synthetic and natural rubber materials are tabulated in Table 1.

PROCEDURE

4. Tensile slabs and compression set buttons of the above materials were made by the Laboratory and specimens prepared therefrom were allocated on the basis of a random selection plan to accelerated heat aging in a Geer oven at 140F for various periods of time, up to 18 weeks. In addition, specimens were also allocated to shelf aging and low temperature conditioning for various periods of time, up to 7 years. Duplicate sets of specimens were subjected to identical aging conditions except that one set was packaged in barrier material conforming to specification, reference (f), and the other set was unpackaged.

5. The specimens subjected to shelf aging were stored in a room maintained at $73 \pm 2F$ and $50 \pm 3\%$ relative humidity, while those exposed to low temperature were conditioned at the temperature of dry ice (about -100F) in an atmosphere composed primarily of carbon dioxide. During the period of shelf aging and low temperature conditioning, the specimens were subjected to essentially static conditions and were not stressed.

6. The physical properties of the specimens subjected to accelerated heat aging, shelf aging and low temperature conditioning were determined in accordance with the methods tabulated below.

<u>Type of Test</u>	<u>No. of Specimens Tested</u>	<u>Method</u>
Tensile strength	3	4111 of reference (g)
Elongation (1)	3	4121 of reference (g)
Tensile product (1)	3	Tensile strength multiplied by elongation value
Modulus at 300% (1)	3	4131 of reference (g)
Swelling ratio	3	Described in reference (h)
Compression set	2	3311 of reference (g)
Stress relaxation	1	Described in reference (i) except that the specimens were compressed 20% and heat aged for 22 hours at $158 \pm 2F$.

Note: (1) Data obtained on same specimen used to determine the tensile strength.

RESULTS

7. The results of shelf aging and low temperature conditioning of specimens prepared from butadiene-styrene and Buna N for periods up to 7 years are summarized in Tables 2 and 3, respectively. Comparable results obtained on specimens prepared from natural rubber and neoprene for periods up to 6 years are summarized in Tables 4 and 5, respectively.

ANALYSIS

8. Examination of the data on shelf aging and low temperature conditioning of the elastomeric materials reported in Tables 2,3,4, and 5; and the data on accelerated heat aging previously reported in references (c) and (d), indicated the following:

- a. Shelf aging in a packaged condition for 5 years had a significant effect on specimens prepared from butadiene-styrene and Buna N as the tensile product of these elastomers decreased from 7.95×10^5 to 5.36×10^5 and from 29.0×10^5 to 22.6×10^5 , respectively.
- b. Shelf aging in a packaged condition for only 1/2 year had a very deleterious effect on specimens prepared from natural rubber, as the tensile product decreased from 18.7×10^5 to 10.4×10^5 . Thereafter, the decrease in tensile product for this elastomer was nominal, as the tensile product was 7.9×10^5 after shelf aging for 6 years. Also, shelf aging in a packaged condition for 6 years had comparatively little deleterious effect on specimens prepared from neoprene, as the tensile product decreased from 20.4×10^5 to 17.8×10^5 .
- c. The parameters which best indicated the trend in the deterioration of elastomers with period of shelf aging were tensile product, modulus at 300% elongation and swelling ratio.
- d. Packaging had comparatively little effect in retarding the deterioration of elastomeric materials subjected to shelf aging.
- e. Conditioning at -100°F in an atmosphere of carbon dioxide had no significant effect on the materials.

Lab. Project 5974
Supplementary Report

f. The values of tensile product, modulus at 300% elongation and swelling ratio of the butadiene-styrene and Buna N materials which were shelf aged in a packaged condition for 5 years and of the natural rubber and neoprene materials which were shelf aged in a packaged condition for 6 years were used to determine the equivalent period of accelerated heat aging in a Geer oven at 140F. The best average line drawn on the graphs for these parameters reported in references (c) and (d) was used. The results of this comparison between the period of shelf aging and the equivalent period of accelerated heat aging at 140F are tabulated in Table 6 below:

TABLE 6

Type of Elastometer	Tensile Product		Modulus at 300%		Swelling Ratio	
	Period of Shelf Aging, yrs	Equivalent Time at 140F, weeks	Period of Shelf Aging, yrs	Equivalent Time at 140F, weeks	Period of Shelf Aging, yrs,	Equivalent Time at 140F, weeks
Butadiene-styrene	5	3.7	5	2.2	5	7.1
Buna N	5	8.7	5	4.2	5	10.8
Natural rubber	6	18+	6	2.5	6	3
Neoprene	6	7.5	6	10.5	6	18

9. The per cent change in tensile product, modulus at 300% elongation and swelling ratio of the elastomers subjected to shelf aging in a packaged state are tabulated in Table 7. As noted in this table, there was no significant additional deterioration in the physical properties of specimens prepared from butadiene-styrene and Buna N despite an increase in the period of shelf aging from 1 1/2 years to 3 1/2 years and even to 5 years; and for the natural rubber and neoprene specimens despite an increase in the period of shelf aging from 2 1/2 years to 4 years and even to 6 years. Thus, continuation of this program offers small potential for obtaining significant data. This information confirms that previously reported by the Laboratory in reference (e).

DISCUSSION

10. The following discussion is provided based on the data reported herein, on the data previously reported in references (c) and (d), and on the experience

of the Laboratory in evaluating end-items made from synthetic and natural rubber materials.

a. Despite the significant decrease in the tensile product of the butadiene-styrene and Buna N specimens after shelf aging for 5 years, noted in paragraph 8.a. above, these specimens appear to be serviceable and to have a shelf life of at least 5 years.

b. The very significant decrease in the tensile product of the natural rubber specimens after shelf aging for 1/2 year indicated that this elastomer should not be specified for end-items which must be shelf aged for periods beyond 1/2 year.

c. The fact that shelf aging for 6 years had little apparent effect on the tensile product of specimens compounded from neoprene indicated that end-items made from this elastomer have a shelf life of at least 6 years.

d. As noted in paragraph 8.c., the parameters which best indicated deterioration of elastomers with shelf aging were tensile product, modulus at 300% elongation and swelling ratio. However, it should be noted that swelling ratio has disadvantageous features as special solvents and a large number of man-hours are required to determine this parameter.

e. The data in Table 6 (paragraph 8.f., above) indicated that there was no overall consistent relationship between the period of shelf aging and the equivalent period of accelerated heat aging for the butadiene-styrene, Buna N, natural rubber and neoprene materials. However, on the basis of most of the parameters tabulated, it appeared that accelerated heat aging in a packaged condition in a Geer oven for 10 weeks at 140F would cause a greater deterioration in the physical properties of the butadiene-styrene and Buna N materials than shelf aging for a period of 5 years, and a greater deterioration in the physical properties of the natural rubber and neoprene materials than shelf aging for a period of 6 years.

f. Packaging, although not effective in retarding the deterioration of elastomers subjected to shelf aging, is desirable to facilitate identification of elastomer end-items and to protect them during storage from harmful materials such as ozone, dirt and solvents.

RECOMMENDATIONS

11. Based on the information contained herein, it is recommended that:

a. Consideration be given to increasing the shelf life of end-items made from butadiene-styrene and Buna N to 5 years, to reducing the shelf life of end-items made from natural rubber to 1/2 year and to increasing the shelf life of end-items made from neoprene to 6 years.

Lab. Project 5974
Supplementary Report

b. Consideration be given to the use of accelerated heat aging in a packaged condition in a Geer oven for 10 weeks at 140F to simulate the effects of shelf aging for 5 years of end-items made from butadiene-styrene and Buna N and for 6 years for end-items made from neoprene. No accelerated heat aging test is recommended for end-items made from natural rubber in view of its relatively short shelf life.

FUTURE WORK

12. No future work is required as this supplementary report completes this standardization program. In addition, continuation of the program offers small potential for obtaining significant data.

Principal Investigator,

Saul A. Eller
SAUL A. ELLER

TABLE 1

RECIPES OF THE BUTADIENE-STYRENE, BUNA N,
NATURAL RUBBER AND NEOPRENE STOCKS
USED IN THE SHELF AGING AND LOW TEMPERATURE CONDITIONING PROGRAM

<u>Butadiene-Styrene</u>		<u>Buna N</u>	
<u>Ingredient</u>	<u>Pphr</u>	<u>Ingredient</u>	<u>Pphr</u>
GR-S (1002)	80.0	Paracril "C"	100.0
GR-S Std (1000)	20.0	Standard micronex	60.0
Zinc oxide	5.0	Zinc oxide	5.0
Philblack A (HMF)	40.0	Stearic acid	1.0
Heliozone	1.0	Methyl Tuads	3.0
Flexol TOF	20.0	Captax	2.0
Methyl Tuads	1.0	Vandex	0.1
Sulfur	1.0	Pine Tar	5.0
	<u>168.0</u>		<u>176.1</u>
<u>Natural Rubber</u>		<u>Neoprene GR-T</u>	
<u>Ingredient</u>	<u>Pphr</u>	<u>Ingredient</u>	<u>Pphr</u>
Smoked sheet	100.0	Neoprene GR-T	100.0
Zinc oxide	5.0	Zinc oxide	5.0
Pelletex (SRF)	2.0	Pelletex (SRF)	2.0
Stearic acid	3.0	Phenyl alpha naphthylamine	2.0
Agerite resin D	1.0	Stearic acid	1.0
Heliozone	3.0	Circo L.P. oil	15.0
Phenyl beta naphthylamine	1.0	XLC Magnesia	7.0
Califlux 510	10.0		<u>132.0</u>
Captax	1.0		
Thionex	0.1		
Sulfur	2.0		
	<u>128.1</u>		

TABLE 2
DATA SHEETSUMMARY OF RESULTS OBTAINED ON SPECIMENS OF BUTADIENE-STYRENE SUBJECTED TO SHELF
AGING AND LOW TEMPERATURE CONDITIONING IN PACKAGED AND UNPACKAGED STATES

Condition	Aging Period	Tensile Strength, psi	Elongation, %	Product x 10 ⁵	Physical Property					
					Tensile Modulus at 300%, psi	Swelling Ratio	Compression Set, %	Stress Relaxation, %	Specimens Shelf Aged at 73 ± 2F and 50 ± 3% Relative Humidity	
Packaged	Initial	1500	530	7.95	750	0.164	11.0	21.3		
	1/2 year	1410	460	6.49	850	0.172	8.1	24.2		
	1 year	1490	430	6.41	880	0.170	7.5	31.8		
	1 1/2 years	1390	395	5.50	1040	0.176	6.9	24.2		
	3 1/2 years	1490	380	5.66	1070	0.190	5.5	25.4		
	5 years	1375	390	5.36	990	0.195	(1)	(1)		
	7 years	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
Unpackaged	Initial	1500	530	7.95	750	0.164	11.0	21.3		
	1/2 year	1510	490	7.40	820	0.167	7.6	23.5		
	1 year	1620	440	7.13	900	0.168	8.1	27.6		
	1 1/2 years	1440	400	5.75	1070	0.173	7.5	20.1		
	3 1/2 years	1470	380	5.59	1110	0.189	5.6	30.1		
	5 years	1510	415	6.26	985	0.191	(1)	(1)		
	7 years	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
Packaged	Initial	1500	530	7.95	750	0.164	11.0	21.3		
	1 year	1490	480	7.15	870	0.164	7.5	24.2		
	3 1/2 years	1530	470	7.19	870	0.174	6.1	21.6		
	5 years	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
	7 years	1260	410	5.17	790	0.175	9.3	22.0		
	Unpackaged	Initial	1500	530	7.95	750	0.164	11.0	21.3	
		1/2 year	1360	440	5.98	790	0.164	7.4	36.5	
3 1/2 years		1480	450	6.66	890	0.172	7.9	23.4		
5 years		(1)	(1)	(1)	(1)	(1)	(1)	(1)		
7 years		(1)	(1)	(1)	(1)	0.174	7.4	18.0		

Note: (1) Data not obtained.

TABLE 3

DATA SHEET

SUMMARY OF RESULTS OBTAINED ON SPECIMENS OF BUNA N SUBJECTED TO
SHELF AGING AND LOW TEMPERATURE CONDITIONING IN PACKAGED AND UNPACKAGED STATES

Condition	Aging Period	Tensile Strength, psi	Elongation, %	Physical Property					Stress Relaxation, %
				Tensile Modulus at 300%, psi	Product at 50 ± 3% Relative Humidity	Swelling Ratio	Compression Set, %	Relaxation, %	
Packaged	Initial	3880	755	29.0	910	0.241	29.1	56.0	
	1/2 year	3980	710	28.3	1120	0.250	27.3	66.8	
	1 year	4060	660	26.8	1200	0.252	32.7	64.0	
	1 1/2 years	3730	565	21.1	1470	0.250	28.3	53.0	
	3 1/2 years	4080	570	23.3	1610	0.326	32.3	64.0	
	5 years	3900	580	22.6	1620	0.293	(1)	(1)	
	7 years	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
Unpackaged	Initial	3880	755	29.0	910	0.241	29.1	56.0	
	1/2 year	3840	710	27.2	1100	0.246	27.7	68.2	
	1 year	4120	690	28.4	1170	0.246	32.9	62.1	
	1 1/2 years	3820	580	22.2	1430	0.252	20.7	53.2	
	3 1/2 years	3930	580	22.9	1540	0.326	32.3	66.2	
	5 years	4045	605	24.5	1670	0.286	(1)	(1)	
	7 years	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
Packaged	Initial	3880	755	29.0	910	0.241	29.1	56.0	
	1 year	4080	700	28.6	1080	0.239	27.1	60.3	
	3 1/2 years	3740	660	24.7	1050	0.294	28.4	59.2	
	5 years	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
	7 years	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
	Unpackaged	Initial	3880	755	29.0	910	0.241	29.1	56.0
		1/2 year	3790	740	28.0	870	0.243	23.9	64.2
3 1/2 years		3570	675	24.1	1025	0.294	25.2	58.1	
5 years		(1)	(1)	(1)	(1)	(1)	(1)	(1)	
7 years		(1)	(1)	(1)	(1)	(1)	(1)	(1)	

Note: (1) Data not obtained.

TABLE 4

DATA SHEET

SUMMARY OF RESULTS OBTAINED ON SPECIMENS OF NATURAL RUBBER SUBJECTED TO SHELF AGING AND LOW TEMPERATURE CONDITIONING IN PACKAGED AND UNPACKAGED STATES

Condition	Aging Period	Physical Property						
		Tensile Strength, psi	Elongation, %	Tensile Product x 10 ⁵	Modulus at 300%, psi	Swelling Ratio	Compression Set, %	Stress Relaxation, %
Specimens Shelf Aged at 73 ± 2F and 50 ± 3% Relative Humidity								
Packaged	Initial	2575	725	18.7	250	0.192	14.6	38.0
	1/2 year	1790	580	10.4	310	0.195	17.5	40.0
	2 1/2 years	1790	580	10.4	310	0.195	17.5	40.0
	4 years	1465	595	8.7	270	0.198	(1)	(1)
	6 years	1410	565	7.9	300	0.203	25.5	40.0
Unpackaged	Initial	2575	725	18.7	250	0.192	14.6	38.0
	2 1/2 years	1980	600	11.9	310	0.200	18.7	41.0
	4 years	1400	580	8.1	285	0.197	(1)	(1)
	6 years	1310	560	7.3	290	0.199	23.5	43.0
Specimens Conditioned at -100F in Atmosphere of Carbon Dioxide								
Packaged	Initial	2575	725	18.7	250	0.192	14.6	38.0
	2 1/2 years	1320	570	7.5	290	0.201	15.2	33.3
	4 years	1300	605	7.9	240	0.194	(1)	(1)
	6 years	1450	640	9.3	265	0.194	21.0	19.0
Unpackaged	Initial	2575	725	18.7	250	0.192	14.6	38.0
	2 1/2 years	1360	580	7.9	295	0.195	7.2	33.6
	4 years	1300	615	8.2	265	0.190	(1)	(1)
6 years	1030	590	6.1	230	0.199	18.3	23.0	

Note: (1) Data not obtained.

TABLE 5

DATA SHEET

SUMMARY OF RESULTS OBTAINED ON SPECIMENS OF NEOPRENE SUBJECTED TO
SHELF AGING AND LOW TEMPERATURE CONDITIONING IN PACKAGED AND UNPACKAGED STATES

Condition	Aging Period	Physical Property						
		Tensile Strength, psi	Elongation, %	Product at 300%, x 10 ⁵ psi	Modulus	Swelling Ratio	Compression Set, %	Stress Relaxation, %
Specimens Shelf Aged at 73 ± 2F and 50 ± 3% Relative Humidity								
Packaged	Initial	2440	840	20.4	310	0.183	26.3	59.9
	1 year	2370	825	19.6	310	(1)	(1)	(1)
	2 1/2 years	2590	800	20.7	370	0.192	26.7	60.6
	4 years	2485	825	20.5	320	0.204	(1)	(1)
	6 years	2270	785	17.8	370	0.196	44.8	46.0
Unpackaged	Initial	2440	840	20.4	310	0.183	26.3	59.9
	1 year	2310	780	18.0	330	(1)	(1)	(1)
	2 1/2 years	2500	770	19.3	370	0.212	27.2	62.0
	4 years	2200	775	17.1	340	0.193	(1)	(1)
	6 years	2205	735	16.1	400	0.201	50.1	55.0
Specimens Conditioned at -100F in Atmosphere of Carbon Dioxide								
Packaged	Initial	2440	840	20.4	310	0.183	26.3	59.9
	1 year	2420	790	19.1	325	(1)	(1)	(1)
	2 1/2 years	2167	750	16.3	350	0.202	26.3	55.8
	4 years	2170	825	17.9	290	0.186	(1)	(1)
	6 years	2170	830	18.0	260	0.181	37.6	51.0
Unpackaged	Initial	2440	840	20.4	310	0.183	26.3	59.9
	1 year	2420	820	19.8	310	(1)	(1)	(1)
	2 1/2 years	2120	750	16.0	310	0.205	29.7	61.3
	4 years	1835	790	14.5	275	0.190	(1)	(1)
	6 years	2120	830	17.5	260	0.189	43.6	55.0

Note: (1) Data not obtained.

TABLE 7

Deterioration in Physical Properties of Synthetic and Natural Rubber Materials Subjected to Shelf Aging in a Packaged State.

Elastomer	Parameter		
	Tensile Product $\times 10^5$	Modulus at 300% Elongation, psi	Swelling Ratio
Butadiene-styrene			
Initial	7.95	750	0.164
After 1½ years	5.50(-30.8%)	1040(+38.7%)	0.176(+7.3%)
After 3½ years	5.66(-28.8%)	1070(+42.7%)	0.190(+15.8%)
After 5 years	5.36(-32.6%)	990(+32.0%)	0.195(+18.9%)
Buna N			
Initial	29.0	910	0.241
After 1½ years	21.1 (-27.2%)	1470(+61.5%)	0.250 (+3.7%)
After 3½ years	23.3 (-19.7%)	1610(+77.0%)	0.326 (+35.2%)
After 5 years	22.6 (-22.0%)	1620(+78.0%)	0.293 (+21.6%)
Natural Rubber			
Initial	18.7	250	0.192
After 2½ years	10.4(-44.4%)	310(+24.0%)	0.195 (+1.6%)
After 4 years	8.7(-53.5%)	270(+8.0%)	0.198 (+3.1%)
After 6 years	7.9(-57.8%)	300(+20.0%)	0.203 (+5.7%)
Neoprene			
Initial	20.4	310	0.183
After 2½ years	20.7(+1.5%)	370(+19.3%)	0.192 (+4.9%)
After 4 years	20.5(+0.5%)	320(+3.2%)	0.204 (+11.5%)
After 6 years	17.8(-12.7%)	370(+19.3%)	0.196 (+7.1%)

Note: (1) Values in parentheses are the per cent changes from the initial values.