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# JAR RINGS FOR USE IN HOME CANNING THEIR TESTING AND A PROPOSED SPECIFICATION

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# JAR RINGS FOR USE IN HOME CANNING: THEIR TEST-ING AND A PROPOSED SPECIFICATION

## By Rolla H. Taylor, Helen G. Wheeler,<sup>1</sup> and Frances Benedict<sup>1</sup>

#### ABSTRACT

Canning tests were made on 20 rings from each of 50 different samples. The rings were analyzed for rubber content, and measurements were made of their tensile strength, ultimate elongation, stress at 100-percent elongation, swelling on processing, indentation by a ring simulating a jar cap, and hardness. The canning failures in tests by the pressure-cooker method bore no relation to rubber content or tensile properties, of the rings but were related to swelling, indentation, and hardness, and to the change of these properties with processing. The relations was not exact because some failures probably resulted from excessive variations in jars and tops. Apparatus was developed for accurately measuring profiles of sealing surfaces. The results of the investigation are expressed in terms of a proposed specification for jar rings.

#### CONTENTS

		rage
I.	Introduction	1
II.	Variations in jars and tops	2
III.	Laboratory processing of jar rings	5
IV.	Methods of measuring physical properties of jar rings	5
	1. Tensile strength and ultimate elongation	6
	2 Tensile stress at an elongation of 100 percent	6
	3 Swelling	6
	4 Indentation	7
	5 Hardness	8
v	Chemical analysis of jar rings	8
VI	Taste imparted to canned food by jar rings	ğ
VII	Aging of jar rings	12
TTT.	Canning tests as a basis for development of a jar-ring specification	12
IV.	Correlation of properties and composition of iar rings with results of	
177.	conning tests	13
	1 Method of correlating results	13
	2 Effortiveness of limits in evoluting rings showing compine	. 10
	2. Enectiveness of mints in excluding rings showing canning	5 14
	2 Polation of composition to properties	15
17	Dremond englification for jor rings	16
27.	Proposed specification for jar ings	. 10

## I. INTRODUCTION

An investigation of jar rings was undertaken in the spring of 1941 by the Bureau of Human Nutrition and Home Economics, United States Department of Agriculture, in collaboration with manufacturers and the National Bureau of Standards. The original purpose of the investigation was to determine whether satisfactory jar rings could be made from reclaimed rubber without the admixture of new

<sup>1</sup> Detailed by the Bureau of Human Nutrition and Home Economics, United States Department of Agriculture, to the National Bureau of Standards for work on this project. natural rubber, which at that time was becoming increasingly scarce. The results indicated that, for the experimental rings studied, there was no evident correlation between the performance of the rings and the relative percentages of new and reclaimed rubber entering into their composition.

In the course of the work, a study was made of the relation between the properties of the rings as measured in the laboratory and their performance in canning experiments. A brief study was also made of the irregularities of the sealing surfaces of jars and tops in order to ascertain the amount that a jar ring might have to be compressed in order to insure a satisfactory seal.

As a result of these studies, a proposed performance specification for jar rings was formulated, which is thought to be applicable to all jar rings regardless of whether they are made from mixtures of new and reclaimed rubber, reclaimed rubber alone, or from synthetic rubber.

## **II. VARIATIONS IN JARS AND TOPS**

The function of a jar ring is to form a seal between a jar and the cap, or top. As the surfaces to be sealed do not fit perfectly, it is necessary to determine the approximate magnitude and distribution of the irregularities to know how much capacity for indentation a jar ring must have to insure a satisfactory seal. The occurrence of a failure in canning does not necessarily mean that the jar ring was unsatisfactory or defective. It may be that the irregularities in the sealing surfaces exceeded those that the ring was designed to overcome.

The profiles of the sealing surfaces of jars and tops were accurately measured by means of a Last Word dial gage graduated to 0.0001 inch and accurate to about plus or minus 0.0001 inch. The apparatus is



FIGURE 1.—Apparatus for measuring irregularities of sealing surfaces.

2

shown in figure 1. The procedure employed was as follows: The jar or top was placed on the turn table and was carefully centered and leveled with reference to the axis of the table. The foot of the gage was then so set that readings could be taken at any point around a circle in the sealing surface by rotating the table. The surface to be measured was arbitrarily divided into 16 equal radial sectors, starting with a molding seam or some other mark that could be subsequently identified.

The table was then rotated and readings of the gage were taken at each of the 16 points. Any irregular variations between the points were also noted. The readings thus obtained showed the departure of the surface from a true surface. As a matter of convenience, the lowest point of the contour was taken as the reference point.

Figure 2 shows typical profiles that were found for two jars and two tops of the bail type. The 16 sectors are plotted as abscissas and the gage readings as ordinates. In this figure the maximum departure of the sealing surface of jar 14 from a true surface is 0.0086 inch and that of top 14 is 0.0073 inch. The maximum irregularity, then, which a ring would have to overcome would be the sum of these, or 0.0159 inch. Obviously, if the relative positions of the jar and the top are changed, the irregularity to be overcome may be somewhat less than this amount, but in practical canning it would not be possible to pick the best position of the top relative to the jar. The worst condition that might occur must, therefore, be considered. Furthermore, for bail-type jars the relative position of the top to the jar is determined by the design, within narrow limits. The profiles of the sealing surfaces are therefore shown approximately as they would come together.

The sealing surface of jar 2 departs much less from a true surface than does that of jar 14. As may be seen from the figure, however, the surface of jar 2 has sharp, narrow depressions at the molding seams. These depressions might lead to failures in canning on account of the difficulty in forcing rubber into such narrow spaces. Thus, both the shape and the magnitude of the irregularities are important from the standpoint of potential failures.

Measurements made on several different types of jars and tops showed variations in the departures of the sealing surfaces from true surfaces ranging from approximately 0.002 inch to 0.015 inch. These measurements are given primarily for purposes of illustration and are not to be regarded as fully or adequately representing the jars in common use throughout the country. The collection and measurement of a sufficient number of jars and tops to give a generally valid figure for the magnitude of the irregularities and the frequency of their occurrence would be a major investigation in itself.

It was decided from the foregoing measurements and information furnished by manufacturers of jars, that rings should be designed to take care of irregularities of the order of 0.020 inch. On this basis, rings cut 12 to the inch would have to be capable of being indented nearly one-fourth of their thickness under the stresses usually applied in canning, and rings cut 16 to the inch would have to compress about one-third of their thickness.

In the factory, jars and tops are usually inspected with a metal ring having an accurately finished surface. This ring is placed against the sealing surface, and if any rocking can be detected by a skilled operator, the jar or top under test is rejected. It is possible, however, for the profile to be such that significant irregularities cannot be detected by this means.





## III. LABORATORY PROCESSING OF JAR RINGS

The properties of jar rings may be affected considerably by the temperature and the action of the steam encountered in canning. It is important, therefore, that laboratory tests of the rings be designed to show the effect on the rings of a standard canning procedure. Inasmuch as the pressure-cooker method seemed likely to have the greatest effect on the rings of any of the common methods, a uniform procedure was developed for processing the rings so as to simulate the effect of canning in the pressure cooker.

In this procedure the jar rings to be processed were placed on clean absorbent paper on horizontal grids in a pressure cooker of the type used for home canning. The number of rings processed at one time was no more than could be tested for swelling and indentation within 1 hour. The rings were placed well above the level of the water and were distributed so that steam had access to all surfaces.

The water in the pressure cooker was brought to boiling in approximately 15 minutes, and steam was allowed to escape from the vent for 7 minutes to displace all air from the cooker. The vent was then closed, and the temperature was brought to  $121^{\circ}\pm1^{\circ}$  C in approximately 15 minutes and held for 120 minutes at that temperature. The cooker was then cooled to 100° C in approximately 15 minutes. The rings were then removed from the cooker.

The rings for the measurement of swelling were placed in water at room temperature, care being taken that their surfaces did not become dry, even momentarily. The rings for the indentation measurements likewise were placed at once in water that was kept boiling. The measurements described below were made as quickly as possible, and in no case more than 1 hour after the removal of the rings from the pressure cooker. No significant difference was found between measurements of swelling immediately on removal from the pressure cooker and after the lapse of 1 hour, during which the rings were kept in water at room temperature. The measurements of indentation were found to change considerably if the rings were kept for any length of time in water at room temperature between removal from the pressure cooker and testing. It was found, however, that they could be kept in boiling water for an hour without significant change.

## IV. METHODS OF MEASURING PHYSICAL PROPERTIES OF JAR RINGS

Several different types of measurements were made on jar rings for the purpose of finding characteristics that might be correlated with the behavior of the rings in canning experiments. Tensile strength and ultimate elongation were measured because they were used as criteria of quality in Federal Specification ZZ-R-351 for Jar Rings, which was in effect at the time this investigation was initiated. Measurements of load at an elongation of 100 percent were made at the suggestion of a manufacturer who had found them useful as an index of quality. The swelling that took place during processing was measured because it had been observed that some rings took up

## 6 MISC. PUBLICATIONS, NATIONAL BUREAU OF STANDARDS

moisture to such an extent that they changed significantly both in dimensions and in properties. Inasmuch as sealing by the rings depends directly upon their behavior in compression, measurements of indentation were made both before and after the rings were processed. At the suggestion of one of the jar-ring manufacturer's, measurements of hardness by means of the Shore Durometer were also made. The hardness and indentation measurements are related, as they both measure the same property. The measurements of indentation, however, were much more sensitive and simulate service conditions much more closely than the measurements of hardness.

## 1. TENSILE STRENGTH AND ULTIMATE ELONGATION

Measurements of tensile strength and ultimate elongation were made on the rings as a whole by the method described in Federal Specification ZZ-R-351 for Jar Rings. This method involved the stretching of the rings by the procedure commonly employed for ring specimens.

## 2. TENSILE STRESS AT AN ELONGATION OF 100 PERCENT

The force measured was that required to stretch a jar ring until the mean circumference had doubled. In making this measurement the ring was placed over two %-inch mandrels and stretched within a few seconds to the required elongation by means of a hand-operated device. The force was registered by an accurate spring scale. As the force decreased considerably with time, readings were made at regular intervals over a period of several minutes. When these readings were plotted as a function of the logarithm of the time they gave a linear relation, which was extrapolated to give the value of the load at approximately 1 second after stretching.

Measurements were made at room temperature, about  $25^{\circ}$  or  $30^{\circ}$  C, and at  $100^{\circ}$  C. The latter temperature was obtained by stretching the rings in a bath of boiling water.

Measurements were also made on some rings that had been processed for 2 hours at 121° C, but the number of observations was not sufficient to warrant their inclusion in the present report.

#### 3. SWELLING

In the study of the swelling, the weight and volume of a ring were found before and after processing, and from these the percentages of water absorbed by weight and by volume were calculated. In making the determinations the rings were cleaned, dried, and weighed to the nearest milligram, first in air and then in water. They were then processed as described above and kept under water until they could be reweighed but not longer than 1 hour. Each ring was then reweighed in water and in air. It was found that rings could be weighed in air with sufficient accuracy if they were blotted and allowed to dry superficially and were weighed within 1 minute after their removal from the water. The use of a weighing bottle was not found necessary.

From the four weights of each ring the percentage increase in weight and in volume were calculated as follows: Let

 $w_1$  = weight of ring in air before processing  $w_2$  = weight of ring in water before processing  $w_3$  = weight of ring in water after process $w_4$  = weight of ring in air after processing  $\frac{w_4 - w_1}{100}$  = increase in weight, percent  $\frac{w_1}{(w_4-w_3)-(w_1-w_2)}$ 100=increase in volume, percent.

A correction for the temperature of the water used for weighing the rings before and after processing is necessary if the temperatures differ by more than 5° C. In the present work, however, the difference was never more than 2° C.

At the beginning of the investigation the swelling was measured only in percentage increase in weight. The percentage increase in volume, however, was found from the increase in weight and the spe-cific gravity of the rings which had been measured on different specimens from the same lots. In this case,

$$100d\left(\frac{w_4}{w_1}-1\right) = \text{percentage increase in volume},$$

where d is the specific gravity. This relation is based on the assumption that the volume of a swollen ring is the sum of the volume of the ring and the volume of the water separately.

The increases in thickness and diameter of rings that resulted from processing were found from direct measurements on the rings made by the methods described in Federal Specification ZZ-R-601a. The precision, however, was considerably less than that of the swelling measurements, and although there were indications of pronounced grain effects with certain rings, little information was secured that was not obtainable from the swelling measurements.

## 4. INDENTATION

The apparatus shown in figure 3 was designed to give a test simulating the conditions of pressure and loading to which jar rings are subjected in canning. It consisted essentially of two parts—a plane metal bearing plate to represent the jar and a Duralumin indentor plate with a flange to represent the top. The indentor used for shoulder rings had a flange 0.2 inch high, 2.70 inches in mean diameter, and 0.050 inch wide, with a flat bearing surface. A vacuum pump was connected to a hole in the bearing plate, and a dial gage graduated to read 0.0001 inch was so mounted as to indicate the changes in the height of the cover plate above the bearing plate.

In making a test the jar ring was placed over the guide on the bearing plate, and the indentor was lightly placed concentrically on the ring. The dial gage, which was supported rigidly with reference to the bear-

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## 8 MISC. PUBLICATIONS, NATIONAL BUREAU OF STANDARDS

ing plate, was mounted in such a position that its stem rested on the center of the indentor plate and was adjusted to read zero. The small chamber formed by the bearing plate, the ring, and the indentor was then evacuated through the hole in the bearing plate. This procedure caused the indentor flange to press against the jar ring with a force approximately equal to that resulting from a pressure of 1 atmosphere acting over the area inside the indentor flange. This condition gave a pressure of  $190 \pm 4 \text{ lb/m.}^2$  on the indentor flange.



FIGURE 3—Indentation apparatus.

A, Indentor plate; B, indentor flange; C, center guide; D, bearing plate; E, jar ring; F, vacuum line.

The pressure on the ring was equivalent to that sustained in canning. This pressure was maintained for 1 minute, at the end of which the indentation was read from the dial gage. Measurements were made on the original rings and on rings that had been processed as described above. The latter were kept in boiling water up to the time of measurement. They were then cooled quickly, blotted dry, lubricated with castor oil, and tested.

#### 5. HARDNESS

Measurements of hardness were made by means of the Shore Durometer according to the procedure outlined in ASTM Specification D-676-42T. As the jar rings were not as thick as the specimens called for by this procedure, the rings were mounted for measurement on a rubber pad having a Shore hardness number of 60.

## V. CHEMICAL ANALYSIS OF JAR RINGS

One of the objects of the initial investigation was to determine how much new rubber, if any, it was necessary to add to reclaimed rubber in order to produce satisfactory jar rings. To this end each manufacturer collaborating in the work furnished a series of jar rings made from compounds containing different percentages of new rubber, usually 0, 2.5, 5, and 10 percent. The kinds and amounts of ingredients other than new rubber were left to the discretion of the manufacturers.

It was soon found that there was no correlation between the percentage of new rubber used and the properties or performance of the rings. As a matter of fact, no correlation should be expected because the larger part of the rubber in the rings was derived from reclaimed rubber, and hence variations in the kinds and amounts of reclaim would overshadow the relatively small differences in the percentage of new rubber. The principal reason for using new rubber was not to improve the properties of the finished rings so much as to facilitate the processing and manufacturing operations.

Some of the manufacturers stated the percentage of reclaimed rubber used, but as they did not give its hydrocarbon content. it was necessary to analyze the rings to reduce them to a common denominator.<sup>2</sup>

About 40 different rings were analyzed by the method described in Federal Specification ZZ-R-601a. This method gave the total rubber content but did not differentiate between rubber that had been derived from new crude and that which had been derived from reclaim. The total rubber content thus found was expressed in percent by volume because it is the proportion of rubber by volume not by weight that determines the physical properties of a compound. The results are summarized in table 1 and are discussed in a subse-

quent section in relation to the performance of the rings.

## VI. TASTE IMPARTED TO CANNED FOOD BY JAR RINGS

Oral reports have indicated that taste imparted to the canned food by jar rings has been a prolific source of complaints regarding wartime jar rings. Unfortunately, taste cannot be dealt with by direct, objective measurements, such as are employed for evaluating other characteristics and properties of the jar rings. The present investigation did not include an evaluation of taste.

Taste imparted by jar rings does not come from the rubber itself but from minor constituents that are present in such small amounts that they cannot be readily detected by the usual chemical tests. As mentioned in a preceding section, most jar rings are made from reclaimed rubber produced from discarded tires, inner tubes, and various other scrap-rubber articles. These articles, of course, are made for mechanical purposes without regard to taste or odor, and are likely to contain tars, asphaltic substances, organic accelerators and antioxidants, and various other materials unpleasant to the taste. These offending materials can be avoided to a considerable extent in normal times by a careful selection of the scrap, which is not possible under present conditions. The reclaiming processes remove the offending constituents to a greater or lesser extent, but at the present stage of the art do not produce a tasteless and odorless product.

The synthetic rubber GR-S is being used to some extent in the production of jar rings. As ordinarily produced, GR-S has an appreciable taste and odor due to the residual styrene. The styrene can be

<sup>&</sup>lt;sup>2</sup> Reclaim, or reclaimed rubber, contains most of the fillers and other compounding ingredients that were in the original scrap and, in addition, softeners and other materials added during reclaiming. The constit-uent of principal value is the rubber hydrocarbon, and this is commonly used as an index for comparing different reclaims.

# 10

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	ore ness	Proc- essed	48 55 56	49 48 48 49 44 40 44 40 44	, 55 58 66 68	46 52 58	44 40 42	57 59 61 61
1	She	Un- proc- essed	67 73 72	62 62 62 63 64 64 65 65 64 64 65 65 64 64 65 65 64 64 65 65 65 65 65 65 65 65 65 65 65 65 65	66 73 73 73	58 64 64	59 65 65	68 68 67 68
	Suc	In- crease	Percent 146 84 48 56	18 24 62 64 109 81	30 14 8 8	51 63 63 48	148 198 221 202	34 40 16 20
	dentatio	Proc- essed	$Inch \\ 0.0271 \\ 0.0221 \\ 0.0194 \\ 0.0170 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.0100 \\ 0.000 \\ $	$\begin{array}{c} 0.191\\ 0.210\\ 0.289\\ 0.284\\ 0.234\\ 0.207\\ 0.400\\ 0.325\end{array}$	.0218 .0144 .0111	0.0250 0.0250 0.0202 0.0202	0417 0435 0430 0430 0408	$\begin{array}{c} .0141 \\ .0160 \\ .0136 \\ .0136 \\ .0139 \\ .0145 \end{array}$
	In	Un- proc- essed	$\begin{array}{c} Inch \\ 0.0110 \\ .0120 \\ .0131 \\ .0109 \end{array}$	$\begin{array}{c} 0162\\ 0170\\ 0178\\ 0178\\ 0143\\ 0143\\ 0160\\ 0192\\ 0192\\ 0192\\ \end{array}$	0168 0126 0079 0113	.0166 .0145 .0124 .0125	.0168 .0146 .0134 .0135	$\begin{array}{c} .0105\\ .0114\\ .0117\\ .0116\\ .0122\end{array}$
	ng on ssing	In- crease in vol- ume	Percent 15.7 18.0 14.3 13.1	10.5 112.7 111.7 10.7 30.4 30.4	20.6 20.8 17.6 14.2	13.6 16.4 14.3 9.7	65.0 53.1 44.3 37.5	5.6 9.6 7.3 7.3
	Swelli proce	In- crease in weight	Percent 10.4 11.8 9.2 8.6	$\begin{array}{c} 6.8\\ 6.8\\ 7.2\\ 6.4\\ 22.6\\ 4\end{array}$	15.2 15.3 13.1 10.4	9.1 9.3 6.3	45.8 36.4 30.4 26.1	3.5 6.0 7 7 7 7 7 7
	Spe- cific	ity	$\begin{array}{c} 1.514\\ 1.535\\ 1.535\\ 1.560\\ 1.534\end{array}$	$\begin{array}{c} 1.550\\ 1.552\\ 1.524\\ 1.512\\ 1.495\\ 1.501\\ 1.380\\ 1.363\end{array}$	$\begin{array}{c} 1.365\\ 1.369\\ 1.358\\ 1.358\\ 1.370 \end{array}$	$\begin{array}{c} 1.502\\ 1.523\\ 1.523\\ 1.540\\ 1.556 \end{array}$	$\begin{array}{c} 1.\ 421\\ 1.\ 467\\ 1.\ 467\\ 1.\ 443\end{array}$	$\begin{array}{c} 1.615\\ 1.611\\ 1.604\\ 1.600\\ 1.607\\ 1.607\\ \end{array}$
	Rubber bv	volume	Percent	56. 6 55. 6 55. 6 55. 8 56. 3 56. 3	48. 3 49. 6 47. 3	54. 7 54. 6 55. 6 56. 4	47.3 49.8 49.8 52.4	48. 1 47. 2 48. 3 48. 7 48. 7 48. 2
cessed	tt 100- elonga- on)	100° C.	Pounds 6.60 7.60 8.60 11.10	7.65 7.50 7.50 7.60 5.30 6.55	9.30 10.05 9.80 11.35	6. 70 7. 70 8. 10 9. 75	5.55 7.70 7.20	$\begin{array}{c} 8.95\\ 9.30\\ 9.90\\ 9.90\\ 10.35\end{array}$
Unpro	(load s percent tio	Room tem- pera- ture	Pounds 14.85 17.15 17.05 19.90	15.90 14.10 13.10 13.70 14.38 14.38 13.70 13.55	18.70 19.00 17.00 19.65	10.45 10.85 11.60 14.00	$\begin{array}{c} 10.12\\ 15.50\\ 15.00\\ 13.22\end{array}$	$\begin{array}{c} 14.00\\ 15.20\\ 15.80\\ 14.50\\ 15.60\end{array}$
	cessed	Ulti- mate elonga- tion	Percent 260 210 310 310	340 370 370 370 370 390 390 390	180 170 240 190	380 370 330 340	230 210 300 300	160 250 250 250
	Unpro	Tensile	$\begin{array}{c} Lb/in.^{2}\\ 1,060\\ 1,060\\ 1,250\\ 1,250\\ 1,460\end{array}$	$\begin{smallmatrix} 1, \ 060\\ 1, \ 130\\ 1, \ 150\\ 1, \ 230\\ 1, \ 220\\ 1, \ 220\\ \end{smallmatrix}$	$1,050 \\ 1,250 \\ 1,165 \\ 1,280 \\ 1,28$	$1,\ 220\\1,\ 310\\1,\ 060\\1,\ 270$	$ \begin{array}{c} 760 \\ 921 \\ 1, 110 \\ 1, 210 \end{array} $	760 1, 070 1, 070 1, 060
	sure	Num- ber of fail- ures	0400	0.4 00 1 0	0010	ro ri ro co	10001	20110
method	Press	Num- ber canned	10 8 01	10 10 10 10 10 10 10	- 01 9 9	10 10 10	10 10 10	10 10 10
anning	III	Num- ber of fail- ures	0000	0000 10	0101	0000	8000	00000
Ő	Hot	Num- ber canned	10 10 10	10 10 10 10	10100	100110	9 01 10	000000
	sition	Re- clain b	56 52.14 38 38	50 50 40	68 56 43	64.5 60 55 45	70 65 55	54 49 44.8 37.4 35
	Compo	Crude	10.5 2 0	$\begin{array}{c} 212\\ 212\\ 5\\ 10\\ 0\\ 212\\ 212\\ 212\\ 212\\ 212\\ 212\\ 2$	$     \begin{array}{c}       0 \\       5 \\       10 \\       10     \end{array}   $	$ \begin{array}{c} 0 \\ 5 \\ 5 \\ 10 \end{array} $	$ \begin{array}{c} 0 \\ 5 \\ 10 \\ 10 \end{array} $	$ \begin{array}{c} 0 \\ 5 \\ 8.8 \\ 8.8 \end{array} $ 10
	Tvne and color	· ·	' ' M e c h a n i c a 1 blend'' black	Tube red do do do Tire black do	do do do	Ruby red inner- tube	sinau amount or inner tube	Tube red do do do do
	Com-	pany	ৰ বৰব	щщщщщщ	0000	9 9999	AAA	REFER
	NBS	Z	- 0.04	64 64 9 9 10	11 13 14	15 16 17 19	22 22 22	23 25 26 27

TABLE 1.—Comparison of physical properties of jar rings with canning failures

52	53	55	64 59	52 48 52 54 52 54 52 54 52 54 52 54 52 54 52 54 52 54 52 55 52 55 52 55 53 55 54 55 55	$622 \\ 622 \\ 642 \\ 622 \\ 642 $	76 69 58	45 56 57 58 58 58 58 58 57 58 58 57 58 57 58 58 57 58 58 57 58 57 58 58 57 58 58 57 58 57 58 57 58 57 57 58 57 57 57 58 57 57 57 57 57 57 57 57 57 57 57 57 57	57	1
62	60	65	67 68 68	64 63 63	73 74 74	81 75 79 70	69 69 72 69 69	64	
42	41	34	38 37 27	41 27 23	41 43 41 43 41 2	8 29 74	224 127 147 96 75 65	45	
. 0208	.0206	. 0192	.0155 .0149 .0130	0299 0200 0209	.0150 .156 .0139 .0144	.0107 .0130 .0108 .0160	0321 0200 0187 0187 0187 0187 0187 0187 0187 01	.0211	
.0147	.0146	.0143	.0112 .0109 .0102	0154 0163 0164 0170	.0134 .0111 .0097 .0102	$00099 \\ 00099 \\ 00089 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0092 \\ 0000$	.0099 .0088 .0082 .0066 .0067 .0067	.0146	
12.7	13.1	14.9	3.6 7.7 5.4	16.8 13.7 12.7	6.3 4.1 5.1	5.0 5.4 5.0	19.0 10.0 7.1 8.5 10.3 10.3		
8.2	8.4	9.5	2.4 3.7	11.1 8.4 7.8 6.7	4.6 3.54 1.5	∞	11.2 6.7.4.4.7.0 6.1.3 8.1.4 8.1.4 8.1.5 8	2.5	
1. 555	1.570	1.570	$1.541 \\ 1.544 \\ 1.460 \\ 1.460$	$\begin{array}{c} 1.524 \\ 1.645 \\ 1.640 \\ 1.640 \end{array}$	$\begin{array}{c} 1.370 \\ 1.454 \\ 1.454 \\ 1.465 \end{array}$	$\begin{array}{c} 1.339\\ 1.331\\ 1.348\\ 1.348\end{array}$	$\begin{array}{c} 1.702\\ 1.707\\ 1.672\\ 1.665\\ 1.663\\ 1.653\\ 1.674\\ 1.657\end{array}$		
47.2	46.6	47.8		60.9 55.0 54.0	64.8 55.6 54.4		$\begin{array}{c} 46.8\\ 50.9\\ 42.5\\ 43.7\\ 46.1\\ 46.1\end{array}$		
6.90	7.80	8.80	8.45 8.75 8.75 10.55	9.70 8.10 9.30	11.70 10.30 9.80	$(a) \\ 12.70 \\ (a) \\ 10.50$	7.30 9.75 9.75 9.80 8.80 8.80 8.80	5.55	
12.20	13.10	13.10	13.70 13.70 13.70 16.70	20.80 15.40 11.55 12.10	22.00 16.70 14.50	(a) 20.65 (a) 16.10	15.25 13.10 16.75 (a) 15.15 17.70 13.95	8. 70	
300	310	340	370 370 270	320 350 360 360	220 230 250 250	90 160 280 280	180 270 240 1170 1170 110	300	
920	066	1,080	${\begin{array}{c} 1, \ 310 \\ 1, \ 370 \\ 1, \ 360 \end{array}}$	$1,410\\1,160\\1,140\\1,340$	$1, 550 \\ 1, 260 \\ 1, 320 \\ 1, 220 \\ 1$	${}^{1, 250}_{1, 330}$ 1, 330 1, 300 1, 033	820 950 930 930 930 930 930 930 930 930 930 93	720	
0	ŝ	0	000	0000	500H	4021	0051133	0	
10	10	10	10 10 9	10 8 8 9	10 10	10 9 10	010000000	6	
0	0	5	000	0000	0000	-000	0070700	0	
10	6	10	9 10 10	9999	2000	10 10 10	99999999	10	
$\{49.63\\6.20$	{46.19 6.77	$\left\{ {\begin{array}{*{20}c} 42.74 \\ 7.33 \end{array} \right.$	52 47 43	0		61. 2 59. 7 58. 2 30	$\begin{array}{c} 45\\ 42\\ 39\\ 39.0\\ 35.3\\ \end{array}$	4	
0	2.45	4.89	$0 \\ 5 \\ 1 \\ 2 \\ 2 \\ 1 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2$	$ \begin{array}{c} 0 \\ 5 \\ 10 \end{array} $	$     \begin{array}{c}       0 \\       5 \\       10 \\       10     \end{array}   $	0 5 8.6 8.6	10221 00230 10221		
Tube red	do	do	Tube black	Tube red do do do	Tire black (12 cut).	Tire black	Red (tube?) do Tube black do do	Red	
Ĥ	۶ų	μ	000	нннн	нддд	нннн	فر فر فر فر فر فر فر	K	•
28	29	30	33 33	34 35 37 37	41 40 33	45 45	51 51 52 52	53	

• Broke. • The first values for samples 28, 29, and 30 are for red-tube reclaim; the second values are for red custom reclaim.

11

## 12 MISC. PUBLICATIONS, NATIONAL BUREAU OF STANDARDS

removed in large part at some added cost of manufacture, and the production of a special grade of GR-S latex for use by the food processing industries has been authorized by the Rubber Reserve Co.

## VII. AGING OF JAR RINGS

At the outset of the investigation representative rings were subjected to the accelerated aging tests that are commonly applied to rubber goods. Some of the ring were aged in air at 70° C for 7 days, and others were subjected to oxygen at 300-lb/in.<sup>2</sup> pressure at 70° C for periods of 2 days and 4 days. Measurements of tensile strength and ultimate elongation were made before and after accelerated aging. The results obtained indicate that the rubber probably would last for several years without becoming soft and sticky or hard and brittle. Measurements of indentation and hardness, however, as given in

Measurements of indentation and hardness, however, as given in table 2, showed that the rings might undergo appreciable changes in these characteristics as a result of natural aging within a relatively few months. In general, tests on aged rings made before processing showed a decreased indentation and an increased hardness; tests made after processing showed an increased indentation and a decreased hardness. This effect is not necessarily associated with the failure of rubber. It rather represents a change that is of little consequence for many types of rubber articles, but which may be of importance in connection with jar rings, especially if they are near the limits of acceptable performance. A comparison of the changes in indentation shown in table 2 with the number of canning failures shown for the same rings in table 1 indicates that the greater the change in indentation with aging the greater the number of canning failures.

		Swelling, %		I	ndentation	Shore hardness		
Ring number	Date tested	Increase in volume	Increase in weight	Unproc- essed	Proc- essed	Percent- age in- crease	Unproc- essed	Proc- essed
2	June	18.0	11.8	<i>Inch</i> 0. 0120	Inch 0. 0221	84	73	50
9	Nov June Sept	19.0 38.0	$\begin{array}{c} 12.2\\ 27.6\end{array}$	. 0088 . 0192	.0314 .0400	257 109	74 58	40 40
23	June Sept	33.4 5.6	24.1 3.8	$.0143 \\ .0105$	. 0482 . 0141	236 35	$\begin{array}{c} 61 \\ 68 \end{array}$	35 58
28	June Sept	5.8 12.7	3.3 7.5	. 0097 . 0147	. 0141 . 0208	44 42	68 62	56 52
40	June Sept	12.6 5.1	8.0 3,5	. 0120 . 0097	. 0235 . 0139	95 44	• 69 74	44 64
42	Nov June Sept	5.2 5.0	3.5 3.8	. 0083 . 0099	.0140 .0107	68 8	75	55 76
	Nov	4.6	3.4	.0101	. 0128	26	83	66

TABLE 2.—Effect of aging on swelling, indentation and hardness of jar rings

## VIII. CANNING TESTS AS A BASIS FOR DEVELOPMENT OF A JAR-RING SPECIFICATION

Approximately 50 different lots of shoulder rings obtained from 10 different manufacturers were used for canning tests by the Bureau of Human Nutrition and Home Economics. These lots of rings were duplicates of those tested by the National Bureau of Standards. Canning tests were made on 20 rings from each lot. Ten were tested by the hot-fill method and 10 by the pressure-cooker method. In the hot-fill method, preheated jars of the bail type were filled with hot water, sealed immediately, and placed in a gentian violet dye bath to cool. Leakage was determined by the presence of dye inside the jars. In the pressure-cooker method, the jars were filled with a mixture of ground meat, corn, cottonseed oil, and water, partially sealed, and processed at 121°C in a pressure cooker for 2 hours. Immediately upon removal of the jars from the pressure cooker, the seal was completed and the jars were immersed in a cooling bath that was heavily contaminated with the spores of an especially heatresistant strain of *Clostridium sporogenes*. Leakage was determined from spoilage that occurred during an incubation period or the subsequent subculturing of the contents of the jars.

The failures resulting from tests made by the hot-fill method could not be correlated with the failures resulting from the tests made by the pressure-cooker method. In fact, the few random failures that did occur in the hot-fill tests were probably attributable to variables other than the jar rings, such as warped sealing surfaces. Unfortunately, the study of variations in jars and tops described in a previous section of this paper had not been made when these canning tests were conducted.

It seemed desirable therefore to use only the tests made by the pressure-cooker method as a basis for the development of a specification. The results of these canning tests are summarized in table 1, along with the measurements of physical properties and chemical composition on the same rings. The data given in this table were used as described in a later section for establishing the limits to be employed in a specification.

After a tentative specification had been developed a number of additional samples of rings produced in connection with experimental and development work were also tested.

## IX. CORRELATION OF PROPERTIES AND COMPOSITION OF JAR RINGS WITH RESULTS OF CANNING TESTS

The results summarized in table 1 were examined to determine which of the laboratory measurements could be correlated with the failures in canning and what limits should be imposed on each of the significant properties in order to differentiate between satisfactory and unsatisfactory rings.

## 1. METHOD OF CORRELATING RESULTS

Table 3 gives the limits used in the two methods that were employed in correlating the results of the physical measurements with the canning tests. The first method consisted in noting the limits, designated as A limits, of the various physical measurements that were made on the lots of rings showing no canning failures, and in applying these limits to those rings with which canning failures were observed. In the ideal case this method would suffice for the development of limits for the purposes of a specification. The variations in the canning tests, however, are such that reliable conclusions must be based on averages rather than individual observations. Hence in the second method of treating the data, narrower sets of limits, designated as B limits, were established by trial and error methods. In arriving at the B limits consideration was given both to the significance of the individual properties and to the effectiveness of a combination of properties in defining rings that would show the desired performance

Property	Limits re- quired to pass all rings having no canning failures	Sug- gested limits
	(A)	(B)
Tensile strength, lb/in. <sup>2</sup> Elongation, percent Tensile strength   at 100-percent elongation. lb/in. <sup>2</sup> :	720 min 112 min	
At room temperature	198 min	
At 100° C	126 min	
Swelling on processing: Weight, percent Volume, percent	15.3 max 20.8 max	12 max 16 max
Indentation (unit 0.0001 inch):	2010 1111	
Unprocessed	∫168 max	165 max
• #	(69  mm)	$100 \mathrm{mm}$
Processed	121 min	120 max
Increase, percent Shore hardness:	145 max	110 max
Unprocessed	∫ 62 min	60 min
onprocessed	) 75 max	75 max
Processed	48 m m	50 min
Decrease	19 max	15 max
Rubber by volume, percent	43.7 min	
		1

TABLE 3	-Limits of	physical	l requirements
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<sup>1</sup> These values of tensile stress were derived from the values of load at 100-percent elongation given in table 1. The actual values of load given in table 1 were used to show the effectiveness of tensile stress in eliminating poor Jar rings. This procedure is justified by the fact that the cross-sectional area of all rings tested was approximately the same;

The *B* limits were set relatively narrower than the *A* limits. They would eliminate 58 percent of the lots of rings with which no failure occurred, 50 percent of those with one failure, 64 percent with two failures, 66 percent with three failures, and 100 percent of all lots showing more than three failures. It was not possible to devise limits which would pass all the rings showing no failures and at the same time bar a high percentage of those with which failures occurred. It was felt that it would be better to set a specification so as to reject some rings which might give satisfactory results than to pass many rings with which failures are likely to occur.

## 2. EFFECTIVENESS OF LIMITS IN EXCLUDING RINGS SHOWING CANNING FAILURES

The effectiveness of the two sets of limits in excluding rings with which canning failures were found is shown in summary form in table 4. The results of canning tests are given at the top of the table in terms of the number of failures per lot of rings. The table also shows the percentage of rings that would be barred by the A and the B limits for each property.

The A limits, which were arrived at by a purely mechanical process, would pass all rings with which there were no canning failures, and would bar 30 percent of the lots in which there was one canning failure, 45 percent of the lots with two failures, 66 percent of the lots with three failures, and all lots showing more than three failures.

The application of the A limits shows clearly that certain properties which are commonly used in specifications for rubber goods are not effective in affording a basis for separating rings that are shown to be unsatisfactory from the standpoint of performance. This is particularly true of tensile strength and ultimate elongation, and to a lesser extent of load at 100 percent elongation, or tensile stress which may be calculated from the load.

### 3. RELATION OF COMPOSITION TO PROPERTIES

Likewise, the composition, within the range covered by the present investigation, bore no definite relation to the results of canning tests. It had been expected that the number of canning failures would be less the higher the percentage of rubber in the rings, but such was not found to be the case. The rings may be divided, for example,

$\mathbf{T}_{i}$	ABLE 4	£.—(	Correlation	between	canning	tests	and	physical	propertie	es of	' jar	$\cdot$ rings	;
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	Number of failures per lot							
	0	1	2	3	4	5	6	7
Results of canning tests: Number of lots Number of jars canned Total number of failures (jars)	19 180 0	10 96 10	$\begin{array}{c} 11\\107\\22\end{array}$		$3 \\ 30 \\ 12$	$\begin{array}{c}2\\20\\10\end{array}$	γ 1 10 6	1 10 7
Rings eliminated under (A) maximum limits assigned to physical proper- ties by:								
Tensile strength Elongation	% 0 0	% 0 0	% 0 0	% 0 0	% 0 33	% 0 0	% 0 0	% 0 0
Room temperature 100° C Swelling, percent—	0 0	9 0	. 8 8	0 0	33 67	0 0	0 0	0 0
Weight Volume Indentation—	. 0	0 0	9 9	0 0	33 33	100 100	100 100	$\begin{array}{c} 100 \\ 100 \end{array}$
Unprocessed Processed Increase, percent Rubber by volume	0 0 0 0	20 9 9 9	18 27 9 9	14 17 17 0	33 67 0 0	0 100 100 0	$     \begin{array}{r}       100 \\       100 \\       0 \\       0     \end{array} $	$\begin{array}{c} 0 \\ 100 \\ 100 \\ 0 \end{array}$
Shore hardness— Unprocessed Processed Decrease Total eliminated 1	0 0 0 0	9 0 9 29	8 18 9 45	$34 \\ 48 \\ 34 \\ 66$	$67 \\ 67 \\ 33 \\ 100$	0 100 100 100	0 100 0 100	$     \begin{array}{r}       100 \\       100 \\       0 \\       100     \end{array} $
Rings eliminated under (B) suggested limits assigned to physical proper- ties by:								
Swelling, percent— Weight Volume	11 11	9 9	9 28	0 17	33 67	100 100	100 100	$100 \\ 100$
Unprocessed Processed Increase, percent	$\begin{array}{c} 22 \\ 6 \\ 6 \end{array}$	40 9 20	26 27 9	66 17 34	67 67 0	0 100 100	$\begin{array}{c}100\\100\\0\end{array}$	$100 \\ 100 \\ 100$
Unprocessed Processed Decrease Total eliminated <sup>1</sup>	$0\\21\\16\\58$	9 20 20 50	8 36 28 64	$17 \\ 48 \\ 50 \\ 66$	67 67 33 100	0 100 100 100	0 100 100 100	$100 \\ 100 \\ 0 \\ 100$

<sup>1</sup> The total percentage of rings eliminated is the total number of rings eliminated by 1 or more tests multiplied by 100 and divided by the number used in canning. Sometimes different tests eliminate the same rings, sometimes different rings.

## 16 MISC. PUBLICATIONS, NATIONAL BUREAU OF STANDARDS

into two groups, 1 group of 19 lots containing more than 50 percent of rubber by volume, and the other group of 22 lots containing less than 50 percent. The first group shows a total of 41 canning failures and the second, likewise, 41 canning failures. It should not be concluded from this that the rubber content is immaterial, but rather that within the range of compositions here dealt with there were no differences that could be attributed to the rubber content. The lack of correlation between the number of failures per lot and the percentage of rubber by volume is clearly shown by figure 4.



FIGURE 4.—Relation of canning failures to percentage of rubber by volume.

## X. PROPOSED SPECIFICATION FOR JAR RINGS

The results presented in the foregoing sections of this paper were used as the basis for drawing up a proposed specification for jar rings. This specification deals only with the performance of the rings and hence should be applicable to any rings irrespective of the composition.

### PROPOSED SPECIFICATION

## FOR

### RUBBER RINGS: JAR (FOR HOME CANNING)

#### A. APPLICABLE FEDERAL SPECIFICATIONS

A-1. The following Federal specification of the issue in effect on date of invitation for bids shall form a part of this specification.

ZZ-R-601. Rubber Goods: General Specifications (Methods of physical tests and chemical analysis).

#### **B. TYPES AND GRADES**

**B-1.** Rings shall be of a single grade in each of the two types described below. Type I. Top seal.

Type II. Shoulder seal.

#### C. MATERIAL AND WORKMANSHIP

C-1. Jar rings shall be free from defects in material and workmanship. (See paragraph I-1.)

#### **D. GENERAL REQUIREMENTS**

**D-1.** Jar rings shall be suitable for use in the canning of vegetables, fruits. meats, and other food products by the hot-fill, the water-bath, the oven, and the pressure-cooker methods. Jar rings shall not impart off flavors to the canned food.

#### E. DETAIL REQUIREMENTS

E-1. Dimensions.—Jar rings shall have dimensions within the following limits.

	TYPE	I	TYPE	11
	Max.	Min.	Max.	Min.
Thickness, inch	0. 086	0. 080	0.086	0. 080
Width of flange, inch	. 28	.25	. 28	.25
Internal diameter, inches		2.00		2.20

E-2. Application .--- Jar rings shall have sufficient strength and elasticity to permit application to jars without tearing or other damage to the ring. When applied the rings shall fit snugly without buckling. E-3. Mechanical properties.—Jar rings shall meet the following requirements

when tested in accordance with the methods described in section F:

Property	Max.	Min
NDENTATION:*		•
Indentation of original rings, inch	0.0165	0.010
Indentation of rings after processing, inch	.0250	. 012
Increase of indentation on processing, percent	110	
SWELLING:		
Increase of volume on processing, percent	16	
Increase of weight on processing, percent	12	
HARDNESS:*		
Hardness of original rings, Shore scale	75	60
Hardness after processing, Shore scale	65	50
Decrease of hardness on processing	15	

\*It is not intended that both indentation and hardness shall be made on the same sample of rings since they both measure the same property. Hardness measurements may be made in lieu of indenta-tion at the descretion of the purchaser. Indentation measurements shall be made in all cases of disagreement.

#### F. METHODS OF SAMPLING, INSPECTION, AND TEST.

F-1. Sampling.—Two dozen rings shall be taken at random from each 1,000 gross or fraction thereof.

 $\mathbf{F}$ -2. Indentation.—For purposes of this specification the indentation is that which is produced by a metal circular indentor flange placed concentrically on a jar ring while the jar ring is lying on a flat plate equipped with a center guide. The pressure on the indentor surface shall be  $190 \pm 4$  pounds per square inch. This pressure is approximately equal to that which would result from a pressure of 1 atmosphere acting on the area inclosed within the metal indentor flange specified in F-2a and F-2b.

When jar rings to be tested are of such sizes as to preclude the use of the above indentor, other indentor rings shall be provided and the load shall be adjusted so that the pressure on the indentor surface is 190  $\pm$  4 pounds per square inch.

F-2a. Apparatus.—The apparatus shown in figure 3 for measuring the indentation of jar rings shall consist of a flat metal bearing plate, D, with a center guide, C, an indentor plate, A, with an integral circular indentor flange, B, and a dial gage graduated to 0.0001 inch mounted on the bearing plate in such a way that it will bear in the center of the indentor plate when the indentor plate is placed on the jar ring concentric with the guide on the bearing plate. The bearing plate and the indentor plate shall conform to the following requirements

F-2a (1). For type I jar rings.-The bearing plate, except for the center guide, shall not deviate from a flat surface by more than 0.0005 inch. The center guide on the bearing plate shall be  $2.187 \pm 0.005$  inches in outside diameter, and shall be approximately 0.075 inch high.

The indentor plate including the indentor flange shall weigh approximately 5.3 oz (150 g). The indentor flange shall be  $2.50 \pm 0.005$  inches in mean diameter,  $0.046 \pm 0.001$  inch wide, shall have a flat bearing surface, and shall protrude not less than 0.2 inch from the indentor plate.

F-2 a (2). For type II jar rings.—The apparatus used for measuring the indentation of type II jar rings shall conform to the r-quirements given in F-2a, except that the outside diameter of the guide on the bearing plate shall be 2.325  $\pm 0.005$ inches; the mean diameter of the indentor flange shall be 2.700  $\pm 0.005$  inches, and the width of the flange shall be 0.050  $\pm 0.001$  inch.

F-2b. Procedure.—The indentor ring shall be wiped with castor oil before each measurement.

Indentation shall be measured by means of a gage accurate to within  $\pm 0.0001$  inch, and the indentation reading shall be taken 1 minute after the load has been applied.

In making the indentation test, three jar rings shall be cleaned and dried and the indentation measured in accordance with the above instructions. Three additional rings from the same lot shall then be processed in accordance with paragraph F-4 and the measurements repeated.

graph F-4 and the measurements repeated. **F**-3. Swelling.—Three jar rings shall be cleaned, dried, and weighed in air and in water with an accuracy of  $\pm 0.001$  g. These rings shall be processed as directed in paragraph F-4, and shall again be weighed, first in water, and then in air. The weighing in air shall be made within 30 seconds after the ring has been removed from water and blotted or wiped dry. The drying may also be effected by immersing the rings in alcohol for 5 seconds and quickly shaking off the excess. and allowing the remainder to evaporate within a few seconds.

cess, and allowing the remainder to evaporate within a few seconds. Calculations of the percentage increase in weight and in volume may be made as follows: Let

 $w_1$ =weight of ring in air before processing  $w_2$ =weight of ring in water before processing  $w_3$ =weight of ring in air after processing  $w_4$ =weight of ring in water after processing.

 $\frac{w_3 - w_1}{w_1} \times 100 = \text{increase in weight on processing, percent}$ 

 $\frac{(w_3 - w_4) - (w_1 - w_2)}{w_1 - w_2} \times 100 = \text{increase in volume on processing, percent.}$ 

The temperatures of the water used for weighing the rings before and after processing shall not differ by more than  $5^{\circ}$  C.

**F-4.** Processing.—Jar rings to be processed shall be placed on clean absorbent paper on horizontal racks or grids in a pressure cooker of the type used for home canning. The rings shall be placed above the level of the water and shall be distributed so that steam has access to all surfaces.

The water in the pressure cooker shall be brought to boiling in approximately 15 minutes and steam shall be allowed to escape from the vent for 7 minutes to displace all air from the cooker. The vent shall be closed and the temperature shall be brought to  $121^{\circ} \pm 1^{\circ}$  C in approximately 15 minutes and held for 2 hours at that temperature. The cooker shall then be cooled to  $100^{\circ}$  C in approximately 15 minutes.

The rings shall then be removed from the cooker. Those for swelling measurements shall be placed in water at room temperature and those for the measurement of indentation, in water which is kept boiling. The rings shall be kept in water at the respective temperatures until measurements are to be made. All measurements shall be completed within 1 hour after the removal of the rings from the pressure cooker.

Rings for indentation test shall be cooled in water and tested within one minute.

F-5. Hardness shall be measured as directed in ASTM Specification D-676, Indentation of rubber by means of the Durometer.

#### I. NOTES.

I-1. This specification is intended to give requirements essential to the performance of jar rings, irrespective of the material from which they are made. Consequently, rings furnished under the specification may be made from any material suitable for the intended purpose.

I-2. It has been found that the results of swelling tests are not significantly altered by keeping the rings in water at room temperature for periods up to 1 hour after processing. Similarly, the results of indentation tests are not changed significantly if the rings are kept in boiling water up to 1 hour.

WASHINGTON, April 10, 1945.

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