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TECHNICAL DEPARTMENT
REPORT ON PRODUCTION TEST NO. 313-78-M
Study for Evaluation of Slug Dimensions

Introduction

The present system of classifying slugs intended for canning provides for individual measurement of dimensions on first-run MZ material, but not for their individual weighing. While the total and average weights of this type of material are determined on batches of twenty, this operation is for purposes of accounting only, and no concern is normally attached to the functional aspects of varying weights.

Recovered slugs, on the other hand, are classified solely according to individual weight, there being no established procedure for measuring and classifying them according to dimensions, although a somewhat arbitrary minimum acceptable diameter of 1.338 inches has been tentatively established by calculation from known weight and average density of the slug metal. While this dimensional limit has never been regularly applied to recovery inspection practices, experimental evidence shows that recovered A or Z slugs seldom reached the minimum diameter of 1.338 inches. However, it appears probable that this minimum will be encountered more frequently with the use of the smaller diameter MZ material. Since the suitability of slugs having a diameter as small as 1.338 inches with respect to satisfactory canning has not heretofore been investigated, it is thought desirable to obtain information relative to this problem. Collection of such information constitutes one of the purposes of the present test. Other purposes include collection of information which will aid in (a) evaluating the improvement in overall yield brought about by adoption of the MZ diameter slugs; (b) establishment of more suitable minimum diameter limits for recovered slugs if the present ones prove unsatisfactory; and (c) setting up inspection procedures, if indicated, to cover measurement of dimensions as well as of weights of recovered slugs.

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Summary and Conclusions

Part I

Part I of this test, in which 95 slugs were turned to a diameter of 1.338 inches and canned in the normal manner, yields the following conclusions:

1. The density range of the material was 18.952 to 18.704 g/cm³; 18.882 g/cm³ average.
2. The weight range of the 1.338 inch diameter slugs was 7.60 pounds to 7.70 pounds, average 7.68 pounds. Statistical limits: 7.63 pounds to 7.72 pounds; i.e. 99% of 1.338 inch diameter material of this density range may be expected to weigh between the limits of 7.63 pounds and 7.72 pounds. 5.81% of pieces of 1.338 inches diameter having this density range may be expected to fall below the weight limit for X material of 7.65 pounds. If the density should show a downward trend (as it does at the present time) the number meeting the dimensional tolerance of 1.338 inches but falling below 7.65 pounds will be increased.
3. Canning results on this particular test were exceptionally good. There were only two Frost Test rejects, both caused by poor can-wetting. This is not in accord with plant experience involving a large number of pieces of X material, whose behavior has led to the conclusion that smaller diameter slugs are more prone to produce Frost Test failures than larger diameter slugs. The evidence of the present test in this respect must, therefore, be tempered, and the good results attributed to partially uncontrolled variables such as can surfaces, techniques, etc.
4. Though the Frost Test results were good, self-radiograph examination of 48 of these canned pieces showed the bonding layers to be sprinkled with an unusual number of small voids. (Average number voids per piece in Zone I, 5.7; in Zone II, 7.6; total 13.1.) This indicates a tendency toward discontinuity of bond which, in case of slight variations in uncontrolled factors, might easily have resulted in increased Frost Test rejections.
5. It appears that no advantage is to be gained by establishing a dimensional inspection after Recovery. Present practices appear to be satisfactory.

Part II

1. Of 256 pieces of recovered X material examined, 59 pieces or 23% were rejected because their weight fell below the minimum for X material (7.65 pounds).
2. Two pieces were found that should have been in the Z class, weighing respectively, 7.68 pounds and 7.69 pounds.
3. Fifty-eight pieces were found weighing 7.65 ± 0.1 pounds. Of these, the minimum, maximum, and average diameters were, respectively, 1.334 inches, 1.345 inches, and 1.338 inches. The data sheet showing the distribution of weight vs. diameter on this group was inadvertently destroyed, and measurements

and weights were taken on another group of forty-nine recovered X pieces weighing 7.64 - 7.66 pounds. On these pieces the distribution was as indicated in Table IV.

From this group, 16.3% having a diameter 1.338 inches or greater would have been rejected because of low weight (below 7.65 pounds). Ten per cent having acceptable weight (7.65 pounds or greater) would have been rejected because of a diameter less than 1.338 inches.

4. Since the weight factor is known to be of considerable importance from the reactivity standpoint, and since the dimensions were shown by this test to be relatively unimportant, the weight classification appears to be the better basis for acceptance or rejection of recovered material.

Part III

The rate of loss of first-run MZ material to solid scrap increased from 3.2% in January to 7.3% in June, average 4.2%; for A material, 3% average. Rate of loss of MZ-Z material to solid scrap was 17.1% based on the 275 pieces recovered during this period; for A-Z material, 4.2%. Rate of loss of MZ-X material to solid scrap was 22.6%, based on the 624 pieces recovered during the six months period, January 1 - July 1; for A-X, rate was 24.8%.

Total loss of MZ material to solid scrap after final recovery (some had been recovered once, some twice, and some three times) was 5.3% average during the period January 1 - July 1. The trend is toward increased rejection to solid scrap, the increase on first-run pieces being from a minimum of 2.8% in February to 7.3% in June.

At present, the increased rate of rejection to solid scrap and the degradation to lower weight classifications occasioned by the use of the smaller diameter material considerably diminishes the average gains made in canning yield brought about by the smaller diameter. However, an item in favor of the use of the MZ material is the fact that first-run yields are improved, thus eliminating the expense of re-handling the material.

The complete data covering this part of the test are given under "Details" in Tables V, VI, and VII.

Details

Part I

In this portion of the test, approximately 100 scrap slugs were machined to a diameter of 1.338 $\pm$.003 - .001 inches. Slugs in this group were weighed individually and the weights were recorded, after which they were canned according to standard process. The canning yields were exceptionally good, there being only two rejects out of the 95 pieces involved in this portion of the test. These unusually good results can be explained only by ascribing them to some uncontrolled variable, since plant experience has shown that slugs of smaller than normal diameter are especially prone to non-wetting troubles. However, it is indicated that under suitable conditions, unusually small slugs can be satisfactorily canned. The data obtained from this portion of the test are given in the following table:

Statistical limits: A weight of 7.6775 $\pm$.0464 pounds may be expected in 99% of the cases involving material of this density range with a lower limit of 7.63 pounds; an upper limit of 7.72 pounds. 5.81% of the cases may be expected to weigh less than 7.65 pounds.

Part II

The 256 pieces of X material which had been put through the recovery process were weighed and classified according to weight. The frequency rate is indicated in Table II.

TABLE II

<u>Wt.Lb.</u>	<u>Frequency</u>	<u>Per cent</u>	<u>Wt.Lb.</u>	<u>Frequency</u>	<u>Per cent</u>
7.56	2	0.78	7.68	28*	10.92
7.57			7.69	21	8.20
7.58	3	1.14	7.70	28*	10.92
7.59	3	1.14	7.71	24	9.38
7.60	4	1.56	7.72	13	5.08
7.61	8	3.12	7.73	6	2.34
7.62	16	6.25	7.74	3	1.14
7.63	6	2.34	7.75	2	0.78
7.64	17	6.65	7.76		
7.65	17	6.65	7.77		
7.66	24	9.38	7.78	1	0.39
7.67	29	11.13	7.79	1	0.39
			7.80		

* One piece from each of these weight groups was rejected because of damaged surface.

The 58 pieces out of this group weighing 7.64 to 7.66 pounds, inclusive, were individually measured for diameter, and the maximum, minimum, and average diameters were as follows:

Maximum - 1.345 inches
Minimum - 1.334 inches
Average - 1.338 inches

Fifty-nine pieces or 23% were found to weigh less than the minimum acceptable weight of 7.65 pounds and were, therefore, rejectable on a weight basis.

Another group of 171 pieces was sorted; 49 pieces weighing 7.64 to 7.66 pounds, inclusive, were found in this group. Of these 49 pieces, eight or 16.3%, having a diameter of 1.338 inches or greater, would have been rejected because of their low weight. Ten per cent, having an acceptable weight of 7.65 pounds or greater, would have been rejected because of small diameter, if the minimum limit of 1.338 inches had been in effect. Table III shows the distribution of these 49 pieces, according to average diameter, average length, average volume, and average density.

TABLE III

Total pieces - 171 X Material	Average Diameter (Inches)	Average Length (Inches)	Average Volume	Average Density
Wt. 7.64 - 14 pieces	1.338	7.984	11.21	18.86
" 7.65 - 15 "	1.338	7.983	11.22	18.87
" 7.66 - 20 "	1.339	7.984	11.24	18.86
	<u>Total Pieces</u>	<u><1.338</u>	<u>1.338</u>	<u>>1.338</u>
Wt. 7.64	14	6	4	4
" 7.65	15	4	5	6
" 7.66	20	1	4	15

Table IV indicates the diameter versus weight and distribution of these same slugs.

TABLE IV

Diameter vs. Wt. Distribution

<u>Diameter</u>	<u>7.64</u>	<u>7.65</u>	<u>7.66</u>
1.335	1		
1.336	2		
1.337	3	4	1
1.338	4	5	4
1.339	4	6	10
1.340			5
<u>Total:</u>	14	15	20

Part III

From production records for the period January 1 to July 1, 1946, the data given in Table V was obtained. This table indicates the number and percentage of first-run MZ material appearing after first recovery, respectively, as solid scrap, as Z material, and as X material. A comparative figure for all A material produced from September 15, 1944 through December 30, 1945, is shown at the bottom of Tables V, VI, and VII.

TABLE V

Reclaims from M-Z Material

<u>Date</u>	<u>Number Inspected</u>	<u>Solid Scrap Rejects</u>		<u>Z</u>		<u>X</u>	
		<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>
Jan. 1946	157	5	3.2	99	63.0	53	33.8
Feb. "	3587	101	2.8	2025	56.5	1461	40.7
March "	5359	178	3.3	2112	39.4	3069	57.3
April "	3806	194	5.1	1913	50.3	1699	44.6
May "	2692	152	5.6	726	27.0	1814	67.4
June "	846	62	7.3	402	47.5	382	45.2
<u>Total:</u>	16447	692	4.2	7277	44.2	8478	51.6
A Material:	61142	1860 = 3%		55471 = 90.7%		3639 = 6%	

Table VI shows the distribution of material recovered from Z slugs originally turned to MZ dimensions.

TABLE VI

Reclaims from Z's that have come from M-Z

<u>Date</u>	<u>Lot No.</u>	<u>Number Inspected</u>	<u>Solid Scrap Rejects</u>		<u>Z</u>		<u>X</u>	
			<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>
5/24	117	145	17		33		95	
5/24	118	108	8		32		68	
5/23	121	22	22		0		0	
<u>Total:</u>		275	47	17.1	65	23.6	163	59.3
Z's from A Material:		13773	582 = 4.2%		8264 = 60%		4816 = 35%	

Table VII shows the distribution of recovered X slugs originally turned to MZ dimensions.

TABLE VII

Reclaims from X's that have come from M-Z

<u>Date</u>	<u>Lot No.</u>	<u>Number Inspected</u>	<u>Solid Scrap Rejects</u>		<u>Z</u>		<u>X</u>	
			<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>
4/26	86	144	19		0		125	
4/23	87	112	22		0		90	
5/7	110- Tech.	256	61		2		193	
5/17	113	100	27		0		73	
5/23	122	12	12		0		0	
<u>Total:</u>		624	141	22.6	2	0.3	481	77.1
X's from A Material:		3047	755 = 24.8%		168 = 5.5%		876 = 61.6%	

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