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**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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BRIDGEPORT BRASS COMPANY

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EXPERIMENT NO. U-11

EVALUATION OF REDUCTION OF I.D. DEFECTS
IN I&E TUBING WITH VARIOUS BILLET I.D.

J. F. PUTERBAUGH

RECORD COPY
DO NOT DESTROY

JULY 21, 1960

RESEARCH DEPARTMENT

BRIDGEPORT, CONNECTICUT

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F. A. Weukley 13041	3723	AUG 15 '60 [Signature]

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REPORT NO. - JFP-8

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EXPERIMENT NO. U-11

EVALUATION OF REDUCTION OF I.D. DEFECTS
IN I&E TUBING WITH VARIOUS BILLET I.D.

J. F. PUTERBAUGH

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By J E Savelly 11-2-94
Verified By Jerri Mally
11-3-94

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July 21, 1960

D. R. Jefferson
AEC CONTRACT MANAGER

BRIDGEPORT BRASS COMPANY
ADRIAN, MICHIGAN

AEC CONTRACT NO. AT-(30-1)-1405

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EXPERIMENT NO. U-11EVALUATION OF REDUCTION OF I.D. DEFECTS
IN I&E TUBING WITH VARIOUS BILLET I.D.SYNOPSIS

This experiment proved definitely that a reduction in I.D. rejects due to seams and mechanical causes could be effected by a reduction in billet I.D. A conclusive result showed the 1 5/8 I.D. billet to produce the least extruded I.D. rejects. It was also found that extruded I.D.'s of less than .340" would improve the I.D. surface quality; that is, the incidence of the I.D. seam rejects.

In this production run, a new method of packaging the I&E extruded rods resulted in receipt of rods at MCW with superior straightness. Therefore, the method of packaging for shipment in steel pans will be discontinued in the future.

INTRODUCTION

It has been thoroughly documented in previous Bridgeport Brass Company reports that a problem exists in the production of HAP0 I&E "O" size slugs via the extrusion route due to an excessive number of rejects for I.D. seams. As a result of a previous short-run experiment,¹ it was suggested that smaller I.D. billets be employed, thus reducing the reduction ratio on the I.D. It was thought that this factor may contribute to the seam formation in the extreme flow demanded of the metal. It was also thought that the long billets, half of an ingot, could contribute to this defect. Therefore in this extrusion, some short billets, one-third of an ingot, were employed. Other methods or techniques for reducing the incidence of this I.D. defect will be studied later. It was intended to limit the present experiment to a study of the potential reduction involved in the above; namely, billet length and billet I.D., in an extrusion experiment with sufficiently large quantity of billets to give a fairly large number of slugs. By proper design, other contributors to the defect were held constant or randomized.

¹ G.A. Music and D. R. Jefferson, Experiment 176 Effect of Reduction Ratio on I&E Tubing I.D. Defects, Bridgeport Brass Company (GAM-22)

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OBJECT

The object of this experiment was to extrude HAP0 I&E "0" size rods from billets with reduced I.D. and from billets of reduced length to evaluate the effects of these changes upon the surface quality of the extruded I.D.

PROCEDURE

Upon receipt of the billets from National Lead Company of Ohio, all were inspected to the six prints specified for this extrusion. (See Fig. 1-6) This inspection consisted of weight, length, I.D., O.D., and a visual check of O.D. and I.D. Some billets were pulled for use as mandrel positioning checks and the forty-eight billets remaining were divided into six batches of eight billets each. All of the billets of one batch were of the same I.D. and thus could be run on the same tooling. The billet length was randomly mixed as short or long within each batch. In addition, the batches; that is, the billet I.D.'s were randomly mixed so that no two consecutive batches consisted of the same billet I.D. These points in the experimental design assured the randomizing of any effects of the day of extrusion or other such indeterminate factors.

Some new tooling was employed in this extrusion and consisted of smaller mandrels and dummy block I.D.'s. The new mandrels were scaled down versions of the standard M-106 mandrel. This mandrel has a modified projectile tip. Prints of this tooling for use with the reduced I.D. billets are shown in Fig. 7-10.

The processing steps following the extrusion operation are shown in Figure 11. The basic difference in this process outline as compared with previous I&E extrusions lies in the order in which the sections were straightened. It will be noted that following cutting to sections, the rods were degreased, washed, rinsed, dried and then transferred to the oil bath for straightening with final inspection, weighing, and packing and shipping following. The oil bath was maintained at a temperature of not over 125°F. This was basically a cold roll operation. The increase in oil temperature was merely to improve the viscosity so the oil would penetrate all parts of the rods. The reason for the oil was to provide a protective coating against further corrosion following the cleaning operation. This change in processing was made on Experiment 185 and continued with this run. The reason being that if straightened in original order following cutting, the pieces warped in the cleaning operation. The present process eliminates this difficulty.

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It should also be noted that all extrusion sections were banded - twelve sections maximum - into a columnar structure. Figure 12 shows the banding jig designed to hold the rods in the column until banded. This column was then placed in a wooden packing box for shipment. The purpose of the packing box is to reduce and prevent contamination from occurring in non-contaminated areas between the press and shipping areas and while enroute to the machining site. This method of packing is being used instead of the previous standard, steel-tray method.

DISCUSSION OF RESULTS

Table I notes the experimental design layout for batches as mentioned in the procedure above. Copies of the Extrusion Data Sheets which give information on pressures encountered, extrusion times, as well as temperatures, etc. used in this experiment are attached as Table II. Nothing unusual was noted about the extrusion except that difficulty was experienced in holding the extruded I.D. within specification. The I.D. as measured on extruded rods, varied from a minimum of .318" to a maximum of .400". This is attributed to a lack of close control on the mandrel, since most efforts were concentrated on the order in which the billet batches were run. Future extrusions should show a marked improvement as less experimenting is done and the process is standardized.

In the laboratory examination of the samples, the analysis was made along the lines conducted in Experiment 176. At this time, no correlation exists between machining results and the laboratory examination results other than to confirm the fact that seams and cracks are present in the as-extruded product. Further work will be necessary to check the possibility of a correlation along these lines.

The type of machining inspection given the slugs produced from these extruded rods at Mallinckrodt Chemical Works was not the usual one-defect or sudden death inspection method. The method used for this experiment was to inspect the core slugs in the normal manner and sequence, but to not reject a slug for a previous defect. In other words, all slugs were inspected for all types of defects. Thus, any reduction of any one type of defect was readily apparent from the data because it was not obscured by being rejected for some other cause. Table III shows a summary of the inspection results of this experiment as taken from information furnished by the Mallinckrodt Chemical Works. This summary has been broken down into the three billet I.D. sizes employed in the original extrusion. In addition, cores

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from rods with extruded I.D.'s greater than .360 and greater than .340" have been subtracted for a comparison. The data in the last column of Table III has been plotted as Figure 13. The data in this column is that resulting after subtraction of extruded I.D.'s over .340". The comparison between the billet I.D.'s is 34.2% rejects for I.D. seams from the 1 1/2" billets, 50.5% from the 1 3/4" billets and 25.4% from the 1 5/8" billets. This data clearly shows the superiority of a 1 5/8" I.D. billet as producing the least number of extrusion I.D. defects in the core slugs. It also shows that extruded I.D.'s less than .340" have a much better chance of cleaning up in the final machining. It is hoped that other tests will enable us to raise this limit to the .360 considered ideal by the machining site. These results compare with previous results of 50% rejects for I.D. seam defects from 2" I.D. billets.

There was no apparent difference in the number of I.D. seam rejects between long and short billets, so all were analyzed together.

CONCLUSIONS

It is concluded that a reduction in billet I.D. results in an improved I.D. quality of the extruded rod in producing I&E "0" size slugs via the extruded route. A surprising development is that apparently the billet I.D. is a critical size in that the 1 1/2" billet I.D. produced a greater number of defective slugs than did the 1 5/8". This leads to the belief that the phenomenon is directly related to the amount of reduction the metal receives in going from the billet size to the extruded size. Also definitely proved is the relationship between the extruded I.D. size and the number of defects; the smaller the extruded size, the lesser number of defective slugs produced. A second conclusion unconnected with the other part of this experiment was in the straightness of the rods upon receipt at the machining site. Previously, extruded rods were arriving at the machining site with 50 to 85% out of straightness, and thus could not be fed into the blanking machines in the core machining area without additional cropping at that site; thus necessitating an additional operation. It was thought that this lack of straightness was due to the movement of the rods within the steel packing tray during transportation to the machining site. On this experiment, the rods were banded into a columnar structure. This produced a very high incidence of straight rods arriving at the machining site with no rods having to go through an extra cropping operation before being machined.

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FUTURE WORK

In subsequent experiments, it is planned to try approximately the same number of billets in a heat treatment comparison to check and evaluate the effect of this treatment upon the reduction of this I.D. defect and general quality of the extrusion. Also, pressed salt follower blocks will be evaluated and the process improved in other minor ways. Finally, a yield optimization extrusion of semi-production quantity of billets will be run to check the over-all yield of this process.

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BILLET RUN
ORDER BATCH LAYOUT

TABLE I

<u>Run</u> <u>No.</u>	<u>Billet</u> <u>Length</u>	<u>Billet I.D.</u> <u>Mandrel No.</u> <u>Dummy No.</u>	<u>Run</u> <u>No.</u>	<u>Billet</u> <u>Length</u>	<u>Billet I.D.</u> <u>Mandrel No.</u> <u>Dummy No.</u>
<u>Batch 1</u>			<u>Batch 4</u>		
1	Short	1 3/4 I.D.	25	Short	1 1/2 I.D.
2	Short	M-157	26	Long	M-155
3	Long	DU-160	27	Long	DU-160
4	Short	Type 3	28	Short	Type 1
5	Long		29	Long	
6	Long		30	Long	
7	Long		31	Short	
8	Short		32	Short	
<u>Batch 2</u>			<u>Batch 5</u>		
9	Short	1 1/2 I.D.	33	Short	1 3/4 I.D.
10	Long	M-155	34	Long	M-157
11	Long	DU-160	35	Long	DU-160
12	Short	Type 1	36	Short	Type 3
13	Long		37	Long	
14	Long		38	Long	
15	Short		39	Short	
16	Short		40	Short	
<u>Batch 3</u>			<u>Batch 6</u>		
17	Short	1 5/8 I.D.	41	Short	1 5/8 I.D.
18	Short	M-156	42	Long	M-156
19	Long	DU-160	43	Long	DU-160
20	Short	Type 2	44	Short	Type 2
21	Long		45	Long	
22	Long		46	Long	
23	Long		47	Short	
24	Short		48	Short	

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EXTRUSION DATA TABLE II
 BRIDGEPORT BRASS CO.
 ALUMINUM DIVISION—ADRIAN, MICH.

BB NUMBER BB-10600
 EXTR. NO. U-11

PRESS NO. 6

EXTR DATE 1/27/60
 MATERIAL Normal 'U'
 SHAPE Tube
 CUSTOMER Experiment

LINER NO. 7.125
 LINER TEMP. 800°F
 HTG. UNIT Salt Bath
 TOOL OVEN TEMP. 800°F

PERSONNEL:
 ENGINEER J. F. Puterbaugh
 TECHNICIAN D. Scheuerman
 PRESS OPER. D. Smith

LUBRICATION:
 MANDREL Fiske 604
 DIE Fiske 604
 LINER Dag - 170 - 01

Pos.	WUN NO	BILLET NUMBER	BILLET WEIGHT	FURNACE TEMP °F	HEAT TIME Hr - Min	TRANS. TIME Min	PRESSURE P S.I.	Start/Run EXTR. TIME Min	CALC. "K" VALUE-T.S.I.	CALC. SPEED Rom "/Min	EXT. "/Min	EXT. LENGTH Ft. - In.	TOOL NUMBERS			CLOCK TIME	REMARKS	Date
													CONE	DIE	MAND.			
1	91312B	301	1150	1:58	.83	2600 2300		.56	13.2 11.6	15/-	--	162-7	226-2 T-1	157-2	1435	Mandrel Set 4T-2F Billet I.D. 1 3/4	1/27/6	
1	91315B	302	1150	2:12	.87	2800 2500		1.00	14.2 12.6	15/-	--	162-7	226-2 T-1	157-2	1529	3T-5 1/2F		
2	91310B	501	1150	3:42	1.20	2900 2500		1.07	14.7 12.6	15/-	--	162-7	226-2 T-1	157-2	1550	3T-5 1/2F		
3	91313T	510	1150	3:57	.98	2900 2500		1.50	14.7 12.6	15/-	--	162-7	226-2 T-1	157-2	1609	3T-3F		
4	91307T	336	1150	4:59	1.02	2700 2400		1.20	13.7 12.1	15/-	--	162-7	226-2 T-1	157-2	1715	3T-3F		
5	91307B	510	1150	5:26	1.01	2850 2500		1.63	14.4 12.6	15/-	--	162-7	226-2 T-1	157-2	1742	2T-5F		
6	91308B	500	1150	2:32	1.00	2900 2500		1.50	14.7 12.6	15/-	--	162-7	226-2 T-1	157-2	1805	2T-5F		
7	91309B	505	1150	2:15	1.00	2900 2500		1.53	14.7 12.6	15/-	--	162-7	226-2 T-1	157-2	1810	2T-5F		
8	91317B	326	1150	2:06	1.00	2800 2500		.95	14.2 12.6	15/-	--	162-7	226-2 T-1	157-2	1819	2T-5F		
2	91295B	333	1150	2:53	.83	2800 2000		.59	13.8 9.9	15/-	--	162-7	226-2 T-1	155-1	0956	4T-2F Billet I.D. 1 1/2	1/28/6	
9	91293B	343	1150	3:14	.82	2800 2500		1.00	13.8 12.4	15/-	--	162-7	226-2 T-1	155-1	1019	3T		
10	91289B	470	1150	3:23	.83	2800 2400		1.30	13.8 11.9	15/-	--	162-7	226-2 T-1	155-1	1031	3T		
11	91290B	513	1150	3:46	.89	2800 2400		1.50	13.8 11.9	15/-	--	162-7	226-2 T-1	155-1	1057	3T		

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EXTRUSION DATA

BRIDGEPORT BRASS CO

ALUMINUM DIVISION - ADRIAN, MICH.

PROJECT NO. 4-0000
BB NUMBER BB-10600
EXTR. NO. U-11

PRESS NO #6

EXTR DATE 1/28/60

LINER NO 7.125

PERSONNEL

LUBRICATION:

MATERIAL Normal 'U'

LINER TEMP 800°F

ENGINEER J. F. Puterbaugh

MANDREL Fiske 604

SHAPE Tube

HTG. UNIT Salt Bath

TECHNICIAN D. Scheuerman

DIE Fiske 604

CUSTOMER Experiment

TOOL OVEN TEMP 800°F

PRESS OPER. D. Smith

LINER Dag 170 - Oil

RUN NO.	BILLET NUMBER	BILLET WEIGHT	FURNACE TEMP OF	HEAT TIME Hr - Min	TRANS TIME Min	PRESSURE P.S.I.	Start/Run EXTR. TIME Min	CALC. "K" VALUE-T.S.I.	CALC. SPEED Rom 7/Min	EXT. LENGTH Ft. - In	TOOL NUMBERS			CLOCK TIME	REMARKS	Date
											CONE	DIE	MAND.			
12	91296T	315	1150	3:55	.80	2700 2350	.97	13.3 11.8	15/-	--	162-7	226-2 T-1	155-1	1106	3T	
13	91292	456	1150	4:57	.97	2700 2100	1.35	13.3 11.9	15/-	--	162-7	T-1	"	1212	2T-5F	
14	91291B	471	1150	2:03	.88	2800 2500	1.42	13.8 12.4	15/-	--	"	"	"	1224	2T-5F	1/28/60
15	91293T	315	1150	2:03	.76	2700 2100	.97	13.5 11.9	15/-	--	"	"	"	1235	2T-5F	
16	912987	341	1150	1:48	--	----	--	--	15/-	--	"	"	"	1245	2T-5F	
P3	91314T	316	1150	2:44	.96	2500 2300	.57	12.5 11.5	15/-	--	"	"	156-1	1615	2T-5F	
17	91300T	335	1150	2:56	.95	2700 2100	1.05	13.5 12.0	15/-	--	"	"	"	1629	2T-5F	
18	91302T	311	1150	3:59	.94	2700 2500	1.00	13.5 12.5	15/-	--	"	"	"	1636	2T-5F	
19	91304B	488	1150	3:02	.93	2700 2500	1.46	13.5 12.5	15/-	--	"	"	"	1644	2T-5F	
20	91302B	306	1150	3:27	.90	2600 2100	1.02	13.0 12.0	15/-	--	"	"	"	1706	2T-5F	
21	91304T	445	1150	3:52	1.00	2800 2500	1.40	14.0 12.5	15/-	--	"	"	"	1714	2T-1F	
22	91301T	510	1150	1:46	.98	3000 2500	1.57	15.0 12.5	15/-	--	"	"	"	1815	2T-1F	

PAGE 2 OF 5 PAGES

Mandrel Set REMARKS Date

Billet I.D. 1 1/2

Billet I.D. 1 5/8

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EXTRUSION DATA

BRIDGEPORT BRASS CO.

ALUMINUM DIVISION - ADRIAN, MICH.

BB NUMBER BB-10600

EXTR. NO. U-11

PRESS NO. #6

EXTR DATE 1/28/60

LINER NO 7.125

MATERIAL Uranium 91

LINER TEMP 800°F

SHAPE Tube

HTG. UNIT

Salt Bath

CUSTOMER Experiment

TOOL OVEN TEMP 800°F

PERSONNEL:

ENGINEER J. F. Puterbaugh

MANDREL Fiske 604

TECHNICIAN E. A. Shorthouse

DIE Fiske 604

PRESS OPER. D. Smith

LINER Dag 170 - Oil

LUBRICATION:

MANDREL

DIE

LINER Dag 170 - Oil

RUN NO	BILLET NUMBER	BILLET WEIGHT	FURNACE TEMP OF	HEAT TIME Hr.-Min.	TRANS TIME Min.	PRESSURE P.S.I.	Start/Run	EXTR. TIME Min.	CALC. "K"	VALUE-T.S.I.	CALC. SPEED Ft./Min.	EXT. LENGTH Ft.-In.	TOOL NUMBERS			CLOCK TIME	REMARKS	Date
													DIE	MAND	CONE			
23	91301B	514	1150	1:43	.94	3000 2600	1.54	15.0 13.0	15/-	15/-	---	---	226-2 T-1	156-11822	2T-1F			
24	91299T	328.5	1150	1:44	.87	2700 2400	1.01	13.5 12.0	15/-	15/-	---	---	"	"	1827	2T-1F		
P4	91295B	333	1150	3:14	1.03	2700 2400	.60	13.5 11.9	15/-	15/-	---	---	"	155-32035	4T-OF		1/28/60	
25	91294B	341	1150	2:36	1.00	2800 2500	1.12	13.8 12.4	15/-	15/-	---	---	"	"	2054	2T-5F		
26	91289T	467	1150	2:47	.95	2700 2475	1.41	13.3 12.2	15/-	15/-	---	---	"	"	2109	2T-5F		
27	91297T	452	1150	2:50	.92	2800 2500	1.32	13.8 12.4	15/-	15/-	---	---	"	"	2115			
28	91296B	319	1150	2:55	.91	2800 2500	.98	13.8 12.4	15/-	15/-	---	---	"	"	2123	2T-5F	Billet I.D. 1 1/2	
29	91292B	458	1150	2:58	.99	2800 2500	1.32	13.8 12.4	15/-	15/-	---	---	"	"	2128			
30	91297B	456	1150	1:48	.88	2900 2500	1.37	14.3 12.4	15/-	15/-	---	---	"	"	2243			
31	91296R	342	1150	1:55	.94	2800 2500	.92	13.8 12.4	15/-	15/-	---	---	"	"	2315			
32	91295F	326.5	1150	2:06	.90	2900 2500	1.02	13.8 12.4	15/-	15/-	---	---	"	"	2323			
P5	91312B	300	1150	1:58	.97	2700 2400	.55	13.7 12.1	15/-	15/-	---	---	"	157-4	1103	2T-4F	Billet I.D. 1 3/4	

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EXTRUSION DATA
BRIDGEPORT BRASS CO.
ALUMINUM DIVISION—ADRIAN, MICH.

PROJECT NO. A-000-1
 BB NUMBER BB-10600
 EXTR. NO. U-11

PRESS NO. #6

EXTR DATE _____ LINER NO. 7.125 PERSONNEL: _____ LUBRICATION. _____
 MATERIAL Normal 'U' LINER TEMP. 800°F ENGINEER J. F. Puterbaugh MANDREL Fiske 604
 SHAPE Tube HTG. UNIT Salt Bath TECHNICIAN E. A. Shorthouse DIE Fiske 604
 CUSTOMER Experiment TOOL OVEN TEMP. 800°F PRESS OPER. D. Smith LINER Dag 170 - OIL

RUN NO	BILLET NUMBER	BILLET WEIGHT	FURNACE TEMP °F	HEAT TIME Hr - Min	TRANS TIME Min	PRESSURE P S I	Start/Run	EXTR. TIME Min	CALC. "K"	VALUE-T.S.I.	CALC. SPEED Rom "/Min.	Ext. "/Min.	EXT. LENGTH Ft. - In.	TOOL NUMBERS			CLOCK TIME	Mandrel Set	REMARKS	Date
														CONE	DIE	MAND.				
33	91312T	313	1150	2:11	.82	2700 2450		.99	13.7 12.1	15/-	--		162-7	226-2 T-1	157-4	1121		3T-OF		
34	91313B	502	1150	2:19	.98	3000 2550	1.56		15.2 12.9	15/-	--		"	"	"	1130				
35	91309T	508	1150	3:04	.99	3000 2600	1.49		15.2 13.2	15/-	--		"	"	"	1216				
36	91312F	301	1150	3:09	.90	2900 2500	.97		14.7 12.6	15/-	--		"	"	"	1224				
37	91310B	501	1150	3:20	1.07	3000 2600	1.50		15.2 13.2	15/-	--		"	"	"	1236		2T-5F		
38	91308T	501	1150	2:43	.85	3100 2700	1.57		15.7 13.7	15/-	--		"	"	"	1412		2T-4F		
39	91315R	299	1150	2:56	.68	2800 2500	.94		14.2 12.6	15/-	--		"	"	"	1425				
40	91317T	316	1150	3:39	.80	2800 2500	.86		14.7 12.6	15/-	--		"	"	"	1456				
46	91311T	316	1150	2:03	.94	2700 2500	.55		13.5 12.5	15/-	--		"	"	156-4	1623		2T-4F	Billet I.D. 1 5/8	
41	91311F	318	1150	2:14	.95	2700 2450	1.02		13.5 12.2	15/-	--		"	"	"	1641		2T-OF		
42	91303B	510	1150	2:19	.90	3100 2700	1.60		15.5 13.5	15/-	--		"	"	"	1647				
43	91303T	430	1150	1:53	.91	3100 2500	1.41		15.5 12.5	15/-	--		"	"	"	1654				

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BRIDGEPORT BRASS CO.

ALUMINUM DIVISION—ADRIAN, MICH.

BB NUMBER. BB-10600

EXTR. NO. U-11

PRESS NO 46

EXTR DATE 1/29/60

MATERIAL Uranium 'N'

SHAPE _____ Tube

CUSTOMER Experiment

LINER NO 7.125

LINER TEMP. 800°F

HTG. UNIT Salt Bath

TOOL OVEN TEMP 800°

PERSONNEL:

ENGINEER J. F. Puterbaugh

TECHNICIAN E.A. Shorthouse

PRESS OPER: D. Smith

LUBRICATION.

MANDREI Fiske 604

DIE Fiske 604

LINER, Dag. 170 - OIL

[illegible]

TABLE III

SUMMARY OF INSPECTION DATA
I.D. SEAM REJECTS

U-11
From MCW Data

Billet I.D. and Extruded Section	Total Slugs	I.D. Seam Rejects	% Rej.	Subtract- ing Extruded I.D. Over .360"			Subtracting Extruded I.D. Over .340"		
				Total	I.D.	% Rej.	Total	I.D.	% Rej.
A	232	104	44.8	202	79	39.1	190	68	35.7
1 1/2" B	211	99	46.7	197	91	46.1	82	26	31.7
C	<u>186</u>	<u>86</u>	<u>46.2</u>	<u>186</u>	<u>86</u>	<u>46.2</u>	<u>26</u>	<u>8</u>	<u>30.7</u>
Total 1 1/2"	629	289	46.0	585	256	43.8	298	102	34.2
A	112	30	26.8	112	30	26.8	84	17	20.3
1 5/8" B	211	71	33.7	211	71	33.7	157	46	29.3
C	<u>221</u>	<u>73</u>	<u>33.0</u>	<u>221</u>	<u>73</u>	<u>33.0</u>	<u>161</u>	<u>39</u>	<u>24.2</u>
Total 1 5/8"	544	174	32.0	544	174	32.0	402	102	25.4
A	115	89	77.2	57	33	57.9	30	18	60.0
1 3/4" B	196	123	62.8	127	77	60.5	60	31	51.7
C	<u>218</u>	<u>126</u>	<u>57.8</u>	<u>162</u>	<u>86</u>	<u>53.0</u>	<u>58</u>	<u>26</u>	<u>44.9</u>
Total 1 3/4"	529	338	64.0	346	196	56.7	148	75	50.5

DECLASSIFIED

EXTRUSION BILLET

FIGURE 1

BOTH ENDS MUST BE
SQUARE WITH ϕ .
MAX. FACE VARIATION $\frac{1}{32}$ "

NOTE:

MAXIMUM WALL VARIATION-.060 INCHES

DECLASSIFIED

REVISIONS		BRIDGEPORT BRASS CO. DEVELOPMENT DEPT. ADRIAN, MICH.		
1/19/60	WALL VARIATION	VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL	G = GRIND	
	WAS .070.		$\mathcal{S}$ = SMOOTH MACH.	
			NONE = MACHINE	
			SCALE $\frac{1}{4}$	DATE 10-27-59
			DWN Q.C.C.	CHK'D <i>[Signature]</i>
		MATERIAL	A DWG. NO.	
		HARDNESS	B-90	
		PART & SERIAL NOS.		
		VENDORS IDENTIFICATION		
		EXT. BILLET.		

EXTRUSION BILLET

FIGURE 2

BOTH ENDS MUST BE
SQUARE WITH $\frac{1}{32}"$
MAX. FACE VARIATION $\frac{1}{32}"$

NOTE:

MAXIMUM WALL VARIATION -.060 INCHES

DECLASSIFIED

REVISIONS		BRIDGEPORT BRASS CO.	
1/16" WALL VARIATION		DEVELOPMENT DEPT. ADRIAN, MICH.	
WAS .070		VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL	
		G = GRIND	
		S = SMOOTH MACH.	
		NONE = MACHINE	
		SCALE $\frac{1}{4}$ DATE 102759	
		DWN Q.C.C. CHK'D <i>[Signature]</i>	
		A DWG. NO. B-91	
		EXT. BILLET	

EXTRUSION BILLET

FIGURE 3

BOTH ENDS MUST BE
SQUARE WITH $\frac{1}{32}$ "
MAX. FACE VARIATION

NOTE:

MAXIMUM WALL VARIATION — .060 INCHES

UNCLASSIFIED

BRIDGEPORT BRASS CO.		G = GRIND	
DEVELOPMENT DEPT. ADRIAN, MICH.		F = SMOOTH MACH.	
VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL		NONE = MACHINE	
MATERIAL	SCALE 1/4	DATE 10-28-58	
HARDNESS	DWN W.J.R.	CHK'D	
PART & SERIAL NOS.			
VENDORS IDENTIFICATION			
EXT. BILLET	A DWG. NO. B-92		

EXTRUSION BILLET

FIGURE 4

DECLASSIFIED

MAX. FACE VARIATION $\frac{1}{32}$

TYPE	A	B	C	
1	7"	1 1/2"	12"-14"	

MAX WALL VARIATION $-.000$;
BOTH ENDS MUST BE SQUARE

BRIDGEPORT BRASS CO.
DEVELOPMENT DEPT. ADRIAN, MICH.

VENDOR TO IDENTIFY THE
FOLLOWING ON EACH TOOL

MATERIAL

HARDNESS

PART & SERIAL NOS.

VENDORS IDENTIFICATION

EXT. BILLET.

G GRIND
SMOOTH MACH
NONE MACHINE

SCALE — DATE 1/19/6

DOWN E.F. CHK'D

A DWG NO

B-95

EXTRUSION BILLET

FIGURE 5

MAX. FACE VARIATION $\frac{1}{32}$ "
 BOTH ENDS MUST BE SQUARE
 WITH $\frac{1}{8}$ ".

TYPE	A	B	C	
1	7.000	1.625	12"-14"	

MAX. WALL VARIATION-.000.

DECLASSIFIED

BRIDGEPORT BRASS CO.
 DEVELOPMENT DEPT. ADRIAN, MICH.

VENDOR TO IDENTIFY THE
 FOLLOWING ON EACH TOOL

MATERIAL

HARDNESS

PART & SERIAL NOS.

VENDORS IDENTIFICATION

EXT. BILLET.

G GRIND
 # SMOOTH MACH.
 NONE MACHINE

SCALE — DATE 1-66

DWN E.F. CHK'D

A DWG NO

B-96

EXTRUSION BILLET

FIGURE 6

BOTH ENDS MUST BE SQUARE
WITH $\frac{1}{32}$ MAX. FACE VARIATION

DECLASSIFIED

TYPE	A	B	C	
1	7.000	1.750	12"-14"	

MAX. WALL VARIATION -.000.

BRIDGEPORT BRASS CO.
DEVELOPMENT DEPT. ADRIAN, MICH.

VENDOR TO IDENTIFY THE
FOLLOWING ON EACH TOOL

MATERIAL

HARDNESS

PART & SERIAL NOS.

VENDORS IDENTIFICATION

EXT. BILLET

G GRIND
SMOOTH MACH
NONE MACHINE

SCALE $\sim$ DATE 1-6

OWN E.F. CHK'D *[Signature]*

A DWG NO

B-97

SECRET

SURFACE FINISH 125 RMS
EXCEPT AS NOTED

TOLERANCES $\pm \frac{1}{32}$ EXCEPT AS NOTED

TYPE	IB
1	1.415
2	1.510
3	1.505

REVISIONS
10/6 5 DIM WERE
1.573
1.573
3.1048

BRIDGEPORT BRASS CO.
DEVELOPMENT DEPT. ADRIAN, MICH.

VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL

MATERIAL H-12

HARDNESS: Bc 44-46

PART & SERIAL-NOS. STAMP ON.

VENDORS · IDENTIFICATION

G . GRIND
FF SMOOTH MA.
NONE - MACHINE

SCALE

DATE 11-5-85

580.24.01

A DWG-160

DUMMY BLOCK

NOTE: HEAT TREATMENT —
 DOUBLE TEMPER TO RC 52-55
 (FURNISH CERTIFICATE OF HEAT TREAT)
 DRILL BACK THDS. TO RC 38-40

FIGURE 8

M-155

REVISIONS		BRIDGEPORT BRASS CO.	
		DEVELOPMENT DEPT. ADRIAN, MICH.	
		VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL	G = GRIND # = SMOOTH MACH. NONE = MACHINE
		MATERIAL T-1	
		HARDNESS SEE NOTE	SCALE — DATE 11-59
		PART & SERIAL NOS.	DWN E.F. CHK'D <i>[initials]</i>
		VENDORS IDENTIFICATION	
		I & E PROJECTILE MANDREL SCALED FROM M-106R BB-10600	A DWG. NO. M-155

NOTE: HEAT TREATMENT—
 DOUBLE TEMPER TO RC 55-57 ^(B)
 (FURNISH CERTIFICATE OF HEAT TREAT)
 DRAW BACK THDS. TO RC 38-40

FIGURE 9

REVISIONS		BRIDGEPORT BRASS CO. DEVELOPMENT DEPT. ADRIAN, MICH.			
A	WAS 33.000%	VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL		G = GRIND	
F	WAS - - -			# = SMOOTH MACH.	
C	WAS T-1 4	MATERIAL T-4 (C)		NONE = MACHINE	
		HARDNESS SEE NOTE		SCALE —	DATE 11-59
		PART & SERIAL NOS.		DWN E.F.	CHK'D
		VENDORS IDENTIFICATION			
		I & E PROJECTILE MANDREL		A	DWG. NO.
		SCALED FROM M-106 R BB-10600		M-156

NOTE: HEAT TREATMENT —
 DOUBLE TEMPER TO RC 52-55
 (FURNISH CERTIFICATE OF HEAT TREAT.)
 DRAW EACH THIS. TO RC 38-40

FIGURE 10

M-157

REVISIONS		BRIDGEPORT BRASS CO.	
A	WAS 33.010	DEVELOPMENT DEPT. ADRIAN, MICH.	
		VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL	G = GRIND # = SMOOTH MACH. NONE = MACHINE
		MATERIAL T-1	
		HARDNESS SEE NOTE	SCALE — DATE 11-59
		PART & SERIAL NOS.	DWN E.F. CHK'D
		VENDORS IDENTIFICATION	
		I & E PROJECTILE MANDREL	A DWG. NO.
		SCALED FROM 106-R BB-10600	M-157

FLOW SHEET FOR I&E PROCESSING

Figure 11

FIGURE 12

REVISIONS		BRIDGEPORT BRASS CO. DEVELOPMENT DEPT. ADRIAN, MICH.			
1/25/60	A. WAS 2 1/2 x 2 1/2 x 1/4	VENDOR TO IDENTIFY THE FOLLOWING ON EACH TOOL	G = GRIND		
	B WAS - 750		F = SMOOTH MACH.		
			NONE = MACHINE		
			MATERIAL	SCALE 2 = 1	DATE 1-60
			HARDNESS	DWN E. F.	CHK'D <i>[Signature]</i>
		PART & SERIAL NOS.			
		VENDORS IDENTIFICATION			
		BANDING RACK FOR I & E TUBES	A	DWG. NO. 174-10600	

A, B, C - EXTRUDED SECTION (RAD)
 X - AVERAGE %

DECLASSIFIED

BILLET I.D.

U-11 SLUG INSPECTION

CORES FROM EXTRUSIONS WITH LESS THAN .340" I.D.

FIGURE 13