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WAPD-FE-456

METALLURGY AND CERAMICS

Atomic Power Division
Fuel Element Subdivision
Mr. W. J. Hurford

FROM R. W. Tombaugh
DATE September 29, 1954
SUBJECT Report on Experiment
7c4: "Extrusion of
Natural Uranium and
Molybdenum-Natural
Uranium Rod for TRX"

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Attached is a report on Experiment 7c4: "Extrusion of
Natural Uranium and Molybdenum - Natural Uranium Rod for TRX".

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108-001

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EXTRUSION OF UNCLAD NATURAL URANIUM
AND MOLYBDENUM-NATURAL URANIUM ROD FOR TRX

Synopsis

Extrusion of unclad billets of both natural uranium and 12 w/o molybdenum-natural uranium was employed for producing unclad rods subsequently machine finished to .600" diameter and to random lengths which were fitted into assembly 4' long. Because of the health hazard in handling the bare uranium, Industrial Hygiene worked closely with the experiment. Indications are that the extrusion of unclad natural uranium and its alloys is feasible within certain qualifications.

Background

The prime purpose of this experiment was to furnish usable material for the TRX Project within a definite short time limit; therefore, changes in procedure were to this end rather than to follow an ideal evaluation pattern from the standpoint of an extrusion study. Much of the data presented in this report should be considered as indicative rather than conclusive, but nevertheless, may be complementary in evaluating similar work.

Equipment

The 500-ton Lake Erie horizontal extrusion press was used with a 2-1/2" container. The carbonate salt bath was used for the pure uranium, while the chloride bath was used for the molybdenum-uranium alloy. The Medart rod straightener (using one pair of askew rolls), forge press, swager, and special plates were used for straightening.

Procedure

Billets: Billets for the natural uranium rods, Item 1 through 5, were all machined from HEW stock and not jacketed or protected in any way.

Billets for the 12 w/o molybdenum-uranium were all cast by induction melting and in most cases only one billet was obtained from each cast; some yielded two billets each, as indicated in Table I. These billets also were not clad for extrusion.

Graphite blocks were used with all in order to extrude to completion.

Extrusion: The extrusion operation data are tabulated in Table II. Additional information and comments follow in this paragraph. The actual die openings were within .005" of the fractional dimension shown. The lubrication shown, excluding salt, was suspended in motor oil and applied to the die face and to the container bore. The starting and running tonnages shown in Items 1 through 9 are not reliable. It was discovered that there was a discrepancy between the indicating pressure gage and the recording instrument; consequently, an additional tested indicating pressure gage was installed. Starting with Item 10, both gages and recorder were compared and the original indicating gage was found to coincide with the additional gage. All tonnages shown with the single asterisk are direct gage readings (2 gages) and all other readings from Item 10 through Item 27 were recordings corrected by a factor determined by one or more actual gage readings for the same day.

Dies: Cone faced hardened steel dies were used up through Item 9 and flat faced hardened steel dies, both sharp and radius openings, were used for the remaining part of the experiment. The die opening diameter for the first 14 items was nominally 5/8" and the remainder was nominally 11/16" diameter.

Straightening: It was anticipated that these rods should be finished to 4' long sets with as few pieces as possible, therefore, straightening the as-extruded rods was essential. The pure uranium rods were straightened cold with the Medart rod straightener. The 12 w/o molybdenum-uranium rods were first tried in the Medart, the swager and the forge press, cold, without success as all broke into short pieces.

The rods were then heated to 1700°F in the carbonate bath and tried in both the swager and forge press. Neither process straightened the rods, but they did not break.

Manual hammering on a firm plate was also tried at this temperature, but the rebounding seemed only to increase the distortions. Finally, at 1700°F the rods were placed in the forge press and allowed to remain under pressure until cooled. This procedure improved the straightness but still was not entirely satisfactory. At this time the longer lengths appeared to be a detriment to straightening, so all rods were cut to a maximum length of 13-1/2".

Two square steel plates, 18" x 18" x 1", were prepared and tried in the rod straightening. Several 13-1/2" long rods were heated to 1900°F in the chloride bath, placed and rolled between these steel plates. The rods, however, were too resistant even at this temperature to respond to such a treatment. In additional straightening trials, one rod was partially straightened at 1900°F with a 4-pound hammer, but even this took many heavy blows to produce any effect.

The Medart rod straightener was then used with the rods again heated to 1900°F with moderate success. One of the difficulties encountered, which has since been corrected, was having no indicator on the roll straightener to reveal the distance-between-rolls setting and consequently, a setting could not be duplicated or predicted accurately in successive operations. This disadvantage made it necessary to pass the rod through the machine several times, each time making adjustments closer to the optimum condition. Even though the rod was reheated each time, it was found that after approximately five passes the rod no longer responded to corrective treatment. It was also obvious that repeated exposures to the hot salt were having a very detrimental effect upon the rod surface. At first the rods were being heated for as much as 15 minutes for each pass, but this period was finally

reduced to 2 or 3 minutes each. This short period did not change the corrective ability, but did make it possible for a good surface to be fairly well retained.

Finishing: Following the straightening, the rods were cleaned, machined on the diameter, faced and cut off, then centerless ground. Cutting to a particular length was done as required to make up 4' lengths of rod stock for subsequent insertion into tubes.

Results

Definitions: Data on resulting rod stock are shown in Table III. Notice the comments following the qualified condition of the rod surface, e.g., striations following "G" (good). This is shown only on the rods where that particular description was predominant. Examples of all the descriptions are shown in Figures 1, 2, and 3, except longitudinal cracks and surface eruptions. Longitudinal cracks may be described by their origin, i.e., a surface crack running parallel with the rod axis, being narrow and probably caused by some function within the rod itself rather than being formed by a "loading-up" on the die surface. The latter causes a groove to form in the rod surface. A surface eruption is apparently caused from some layer effect on the outside breaking loose from the main body of the rod and often a turned-up edge will protrude from the surface. These usually are not deep and not particularly detrimental if a moderate amount of stock is allowed for machining.

Natural Uranium: Figure 1 reveals little difference in the front end samples on all the uranium rods. However, on 7cl-4, grooves developed when the rod was about half extruded causing the rod surface to distort considerably. This was the only rod using "Oil Dag" lubrication.

Since these rods straightened quite successfully cold in the Medart rod straightener, the surface was in good condition. The extruded diameter of .616" to .620" was adequate to finish machine the 13-1/2" lengths to .600" diameter except for the rod with the grooves.

Figures 6 and 7 show an extrusion die after use with some "pick-up" and pits.

Molybdenum-Uranium: On the molybdenum-uranium rods, the first extrusion, Item 6 of Tables II and III (Figure 2) indicates a mechanically segregated surface quite likely caused by non-homogeneous portions having different extrusion characteristics. The chemical analysis of this billet (Table I) reveals the top sample as having 16.7% molybdenum instead of the 12% specified; the bottom sample showed only 11.1%. The die for this rod is shown in Figure 8. It is to be noted that the surface at the entrance radius shows some spiral effect, likely caused by a turbulent action. This type of activity could be accounted for by extruding a non-homogeneous material. Die C-92 in Figures 6 and 9 also indicates this condition on another rod. Item 7 was extruded under the same conditions as Item 6, but the available information (tail end only) indicates a good surface. No usable rod was produced in Items 7 through 14 because of the inability to straighten the rods enough to machine a full size diameter on the full length of each piece. Item 8 was only partially extruded because of an inadequate press set-up. However, the nose showed a poor surface. The remaining portion of the billet was remachined and re-extruded as Item 26.

Flat Dies (for molybdenum-uranium): Since most of the molybdenum-uranium rods extruded up to Item 10 exhibited an inferior surface, it was decided that flat faced dies would be used. The purpose, of course, was to change the uniform flow to a center flow, whereby the salt-corroded outside surface of the billet would accumulate in a butt to be discarded. The butt samples of 7c4-10 in Figure 4 shows an etched and unetched sample. Note the rough surfaces which came from the outside of the billet and were retained there. Also notice the broken butt of 7c4-14 exhibiting a macroscopic grain structure showing the coarseness of the relatively unworked area.

There did seem to be a general improvement in the rod surface as a result of the flat faced dies, however, because of this type flow, other problems developed. Sample 7c4-12 (nose end) in Figure 2 shows that the internal type flow does not confine itself to the container, but has continued on through the die opening giving evidence that the rod has extruded within itself. This internal extrusion in the rod was confined to the extreme condition of a flat faced die, i.e., the one with no radius on the opening. The sharp faced die could not endure this drastic flow phenomena and part of the face extruded through the orifice, progressively building up a new orifice which resulted in a rod tapered from .575" diameter on the nose end to .545" diameter on the tail end. The die action was similar to that shown in Figure 5, as explained under a latter item. Also, due to this center flow the diameters of the rods were less than those from the cone die, although the orifice diameters were the same. The same type of center flow also manifested itself in using the graphite cut-off block behind the billets where, as shown in butt 7c4-14 (Figure 4), it extruded through the butt instead of displacing it and then on into the rod.

11/16" Dies (for molybdenum-uranium): The dies used with Item 15 on had an orifice opening of 11/16" diameter. It can be seen from Table III that usable rod was realized with the increased die opening. It is also interesting to note the graphite inclusion in the 5/8" rod, shown in 7c4-10 (Figure 2), is 10" long, whereas the inclusion in the 11/16" rod, shown in 7c4-20 (Figure 3), is only 3" long. The 7c4-10 tail end sample was broken open to show the inclusion. The 7c4-20 tail end graphite inclusion terminated in the saw-cut.

Heating Time (for molybdenum-uranium): Through an unavoidable delay in the press operation, the Item 19 billet was heated 45 minutes, which was much more than intended. Notice 7c4-19, (shown in) Figure 3, the nose of the rod seemed fair for about 2", then the rest of the rod shows large portions which crumbled as dust.

It is most likely that the prolonged exposure to the salt created this condition. Heating the next rod was reduced to 30 minutes, leading to a great improvement. As the heating time was reduced still further to the minimum of 12 minutes, the extruded rods progressively improved. The inches of "usable material" listed in Table III indicates this fact quite directly, and yet, according to the tonnages required, the short heating time was not only adequate, but actually reduced the tonnage required. Apparently, the products of the greatly deteriorated billet surface obstructed the lubricative functions. Another salt contact deterioration is evidenced in Figure 4. Notice the deep erosion on the back of the broken half and quarter (one quarter is turned edgewise to show flow lines) of 7c4-19, heated 45 minutes, in contrast to the back of the butt from 7c4-27, heated 12 minutes. The dark part is oxidized molybdenum-uranium and the lighter part is salt.

Long Billets (molybdenum-uranium): Since the billets were extruding easier, longer billets were used starting with Item 23 (excluding the rerun, Item 26), however, the optimum length of billet was exceeded because in the use of each of these long billets the dies distorted. The quantity of heat in the longer billets plus that generated in the longer extrusion plus a longer time for the die to absorb this heat caused the die to be overheated. In Figure 2 the tail end and butt of 7c4-24, and in Figure 3 the tail end of 7c4-23 show the effects on the rod; the cross sectioned die used on one of these long billets is shown in Figure 5. This photograph shows part of the displaced die material (right side of photograph) still joined to the forming edge and curled in. This accounts for the rods reducing in diameter so drastically near the tail end. The left side of the photograph shows that the displaced part of the die has apparently broken loose and discharged. On the two rods exhibited, from the minimum diameter to the extreme tail end, the diameter again increases to normal size. This likely

happened when the extrusion slowed down and the curled part of the die apparently straightened out to where the original orifice of the die could be utilized.

Rerun (molybdenum-uranium): Item 26 was a rerun as mentioned in comments on Item 8. It is possible that the upsetting induced many fine cracks in the billet which were severely attacked by the salt and in turn prevented any bonding during the extrusion. Therefore, the extruded rod was shattered.

Health: Industrial Hygiene collected and analyzed samples of the immediate breathing zone, general air vicinity, exhaust from the vacuum cleaner on the extrusion, and general air samples from subsequent operations of the bare extruded rods. Of the 37 analyses made of samples taken on 9 different days, only 3 samples of the same day exceeded the desired limit. This happened when the rods were being dumped from the run-out tube causing an oxide dust condition. This was corrected by leaving the vacuum cleaner running with hose attached to the run-out tube while dumping the rods.

Conclusions

Useful natural uranium can be successfully extruded without cladding in a safe manner. Although no cost analysis has been attempted in comparing the bare extruded natural uranium and alloys with the same material cladded (assuming that bare rod is desired as an end product), there are many other comparisons both tried and theoretical which are listed as follows:

Advantages

1. Billet preparation simplified.
2. No problem of entrapped gas or cutting oil.
3. No uncertainty of heat transfer between jacket and fuel because of machine fit or gas expanded jacket.
4. No fusion zone between fuel and cladding.

5. Better control of shape since only one "K" factor is involved.
6. Shape of the die face can be varied for special flow conditions or other considerations, whereas a clad rod die must always have a 45° cone face for uniform flow.
7. No cladding to remove.
8. Shapes, other than round, are more easily obtained.
9. Flat dies are probably less expensive, especially those with special facing material.

Disadvantages

1. Detrimental action from salt in heating bath creating uranium waste and tending to yield poor surface.
2. Extra care must be exercised for personnel safety from radiation.
3. More rapid accumulation of contamination in salt and on equipment.
4. Wear on dies is more severe, however, it is possible that more recent developments in die materials will minimize this point.
5. If flat face dies are used, more pressure is required.

R. W. Tombaugh/jab
9-29-54

TABLE I

Extrusion Billet Stock

Billet Casting Record of 12 w/o Mo-U ⁿ			Weight, lbs.			Number of Billets	Sample No.	Chemistry, Top			Chemistry, Bottom		
Date	Cast No.	Items	Charge	Gross Cast	Cast Scrap			% Mo	% C	% N	% Mo	% C	% N
3/8/54	Y-81	6	22	21.9	0.45	1	U-450	16.9	.112	.0017	11.1	.51	.0040
3/9/54	Y-83	9	22	21.4	0.58	1	U-449	12.2	.116	.0045	12.4	.098	.0035
3/10/54	Y-84*	8 & 26	22	N.A.	N.A.	1	U-452	12.9	.060	.0025	4.9-6.8	.049	.0010
3/11/54	Y-88	7	20	19.9	N.A.	1	U-484	11.9	.52	N.A.	N.A.	N.A.	N.A.
3/11/54	Y-88	7	20	19.9	N.A.	1	U-485	9.6	.54	.0034	9.5	.53	.0027
3/12/54	Y-89	10 & 15	28	27.95	N.A.	2	U-445	12.0	.39	.0072	12.0	.21	.0031
3/13/54	Y-92	12	28			1	U-444	12.4	.114	.0014	12.4	.31	.0019
3/15/54	Y-93	--	28	25.2	2.8	Scrap							
3/15/54	Y-94	13 & 16	28	27.91		2	U-446	12.1	.014	.0026	12.1	.074	.0014
3/16/54	Y-95	--	28			Scrap							
3/16/54	Y-96	--	28	26.3		Scrap							
3/17/54	Y-97	17 & 18	28	27.80	0.035	2	U-451	11.1	.112	.0017	11.3	.51	.0040
3/17/54	Y-98	11 & 14	28	27.9	0.05	2	U-452	9.3	.60	.0049	9.4	.32	.0018
3/18/54	Y-99	19	28	24.90	2.99	1	U-496	12.3	.31	.0020	12.1	.34	.0026
3/19/54	Y-101	--	28			Scrap							
3/20/54	Y-103	--	28			Scrap							
3/22/54	Y-104	20	20	19.80		1	U-495	12.0	.31	.0017	11.7	.38	.0019
3/22/54	Y-105	--	28			Scrap							
3/23/54	Y-106	--	28			Scrap							
3/23/54	Y-107	--	28			Scrap							
3/24/54	Y-108	21 & 22	28	27.9	0.022	2	U-494	11.3	.63-.71	.0067	11.9	.55	.0052
3/24/54	Y-109	--	28	27.8		Scrap	U-493	11.7	.35	.0059	12.2	.33	.0049
3/25/54	Y-110	23	28	28.0		1	U-528	11.2	N.A.	N.A.	11.9	N.A.	N.A.
3/25/54	Y-111	24	28	28.0		1	U-529	11.6	N.A.	N.A.	11.6	N.A.	N.A.
3/26/54	Y-112	25	28	27.95		1	U-530	11.5	N.A.	N.A.	11.9	N.A.	N.A.
3/26/54	Y-113	27	28	27.8		1	U-488	11.5	.42	.39	11.8	.39	.0053

*Upset only, remachined and re-used in Item 26.

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TABLE II
Extrusion Data

Date	Item	Cast No.	Billet Size	Die Dia. Opening	Type of Die	Lubrication + Salt	Billet Temp. °F	Minutes in Bath	Starting Tons	Running Tons	Speed in/sec	Inches Runout	Container Temp. °F
3/11/54	1	HEW Stock	2-1/2 x 4	5/8"	45° + 3/4" R	Lead Plate	1150	20	336	328	0.66	~66	700
3/11/54	2		2-1/2 x 4	5/8"	45° + 3/4" R	None	1150	20	308	280	0.28	~66	700
3/12/54	3		2-1/2 x 4	5/8"	45° + 3/4" R	None	1150	20	376	288	0.40	~66	700
3/12/54	4		2-1/2 x 4	5/8"	45° + 3/4" R	Oil-Dag	1150	20	360	304	0.40	~66	700
3/12/54	5		2-1/2 x 4	5/8"	45° + 3/4" R	Moly-Sulfide	1150	20	376	300	0.28	~66	700
3/12/54	6	Y-81	2-1/2 x 3-1/2	5/8"	45° + 3/4" R	Lead Plate	1900	20	472	400	0.66	NA	700
3/12/54	7	Y-88	2-1/2 x 4-1/4	5/8"	45° + 3/4" R	Lead Plate	1900	20	384	336	0.66	NA	700
3/15/54	8	Y-84	NA	5/8"	45° + 3/4" R	Lead Plate	1900	20	Press stopped after upsetting - safety preparation incomplete				750
3/18/54	9	Y-83	2-1/2 x 4-1/8	5/8"	45° + 3/4" R	Lead Plate	1900	20	448	416	1.00	NA	720
3/18/54	10	Y-89	2-1/2 x 4-1/8	5/8"	Flat + 1/4" R	Lead Plate	1900	20	688	480	1.00	NA	720
3/23/54	11	Y-98T	NA	5/8"	Flat + 1/4" R	Lead Plate	1900	30	500	370	0.50	48	750
3/23/54	12	Y-92	NA	5/8"	Flat + 0" R	Lead Plate	1900	30	480	380*	0.50	38	750
3/23/54	13	Y-94	NA	5/8"	Flat + 1/4" R	Moly-Sulfide	1900	30	540	400	0.50	35	750
3/23/54	14	Y-98B	NA	5/8"	Flat + 1/4" R	Moly-Sulfide	1900	30	500	400	0.44	35	750
3/25/54	15	Y-89	2-1/2 x 3	11/16"	Flat + 1/4" R	Lead Plate	1900	30	480*	375*	0.33	NA	750
3/25/54	16	Y-94	2-1/2 x 4	11/16"	Flat + 1/4" R	Lead Plate	1900	30	500*	400*	0.44	NA	750
3/25/54	17	Y-97T	NA	11/16"	Flat + 1/4" R	Lead Plate	1900	30	500*	NA	0.60	NA	750
3/25/54	18	Y-97B	NA	11/16"	Flat + 1/4" R	Lead Plate	1900	30	480*	360*	0.66	NA	750
3/26/54	19	Y-99	2-1/2 x 4	11/16"	Flat + 1/4" R	Lead Plate	1900	45	520*	460*	0.55	NA	750
3/26/54	20	Y-104	2-1/2 x 4	11/16"	Flat + 1/4" R	Lead Plate	1900	30	500*	400*	0.60	NA	750
3/26/54	21	Y-108B	2-1/2 x 4	11/16"	Flat + 1/4" R	Lead Plate	1900	20	520*	400*	0.75	NA	750
3/26/54	22	Y-108T	2-1/2 x 2-3/4	11/16"	Flat + 1/4" R	Lead Plate	1900	15	NA	NA	0.80	NA	750
3/29/54	23	Y-110	2-1/2 x 6	11/16"	Flat + 1/4" R	Lead Plate	1870	20	400*	320*	NA	~82	750
3/29/54	24	Y-111	2-1/2 x 6	11/16"	Flat + 1/4" R	Lead Plate	1870	12	440*	390*	NA	~82	750
3/29/54	25	Y-112	2-1/2 x 6	11/16"	Flat + 1/4" R	Lead Plate	1870	12	420*	380*	NA	~82	750
3/29/54	26	Y-84	2-1/2 x 3	11/16"	Flat + 1/4" R	Lead Plate	1870	12	NA	390*	NA	~82	750
3/29/54	27	Rerun Y-113	2-1/2 x 6	11/16"	Flat + 1/4" R	Lead Plate	1870	12	NA	360*	NA	~82	750

*Actual gage readings

NOTE: The material used for Items 1 through 5 was natural uranium heated in carbonate salt.
The material used for Items 6 through 27 was 12 w/o molybdenum-natural uranium heated in chloride salt.
The following were also used: 500-ton press, 2.6" container, graphite cut-offs and preheated dies (700°F).

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TABLE III
Rod Stock Data

Extruded Rod Conditions			Surface Condition		Diameter, Inches				At In. From End	Lineal Length, Inches			Remarks
Date	Item	Cast No.	Nose	Tail	Nose	Center	Tail Min.	Tail Max.		Usable	Possibly Usable	Actually Used	
3/11/54	1	HEW Stock	E	G (Striations)	.616	to	.620	--	--	~26	~26	0	
3/11/54	2		G (Striations)	E	.616	to	.620	--	--	~52		20-1/2	
3/12/54	3		E	E	.616	to	.620	--	--	~52		52	
3/12/54	4		E	F (Grooves)	.616	to	.620	--	--	~26		24-1/4	
3/12/54	5		G (Striations)	E	.616	to	.620	--	--	~52		48-1/2	
3/12/54	6	Y-81	P (Segregation)	P (Segregation)	.615	NA	NA	--	--	0	0	0	
3/12/54	7	Y-88	NA	G (Pits)	NA	NA	.615	--	--	0	0	0	
3/15/54	8	Y-84	P (Extrusion Not Complete)		.618	(Ext. not comp.)	--	--	--	0	0	0	
3/18/54	9	Y-83	G	F	NA	NA	NA	--	--	0	0	0	
3/18/54	10	Y-89	G (Pits)	G (Pits)	NA	NA	NA	--	--	0	0	0	Graphite entered 10"
3/23/54	11	Y-98T	NA	F	.590	.590	.581	--	--	0	0	0	
3/23/54	12	Y-92	P (Internal Extrusion)	G	.575	.555	.545	--	--	0	0	0	
3/23/54	13	Y-94	G (Pits)	P (Chatter)	.601	.601	.598	--	--	0	0	0	
3/23/54	14	Y-98B	F (Longit. Cracks)	P	.597	.600	.597	--	--	0	0	0	
3/25/54	15	Y-89	G (Chatter)	F (Grooves)	.670	NA	.665	--	--	39		30	
3/25/54	16	Y-94	E	G (Longit. Cracks)	.673	NA	.668	--	--	38		34	
3/25/54	17	Y-97T	E	G (Longit. Cracks)	.668	NA	.667	--	--	{10*}		{8*}	
3/25/54	18	Y-97B	G-3" only (Lateral Cracks)	G (Eruptions)	.676	NA	.662	--	--				
3/26/54	19	Y-99	F-2" only (Crumbled)		.670	--	--	--	--	0	0	0	
3/26/54	20	Y-104	NA	E	NA	NA	.650	--	--	31	13	28	Graphite entered 3"
3/26/54	21	Y-108B	E	E	.661	NA	.641	--	--	{39*}	{33*}	{32*}	
3/26/54	22	Y-108T	E	E	.670	NA	.657	--	--				
3/29/54	23	Y-110	E	G (Chatter)	NA	NA	NA	--	--	65		13	
3/29/54	24	Y-111	NA	G (Chatter)	NA	NA	.410	.600	10	61		47	
3/29/54	25	Y-112	G	E	.645	NA	.450	.620	5	48		29	
3/29/54	26	Y-84	F-1" only (Shattered)		.675	--	--	--	--	0	0	0	
		Rerun											
3/29/54	27	Y-113	NA	E	NA	NA	.521	.621	10	62		60	

*Quantity identified by cast number only - covers two items.
E = excellent, G = good, F = fair, P = poor.

- 13 -

108 013

DECLASSIFIED

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108-013

Negative No. M1381-1

Figure 1

- 15 -

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108 015

Negative No. M1388-3

Figure 2

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WAFD-FE-156

Negative No. M1388-2

Figure 3

- 17
100 000 000

108 017

Negative No. M1388-1

Figure 4

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WAPD-FE-456

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CONFIDENTIAL

208 018

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Negative No. M1381-2

Figure 5

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WAPD-FE-156

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108 049

Negative No. M1263-1

Figure 6

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WAPD-FE-456

Figure 7

Negative No. M1263-3

Figure 8

Negative No. M1263-4

Figure 9

WARD-FE-156