INSPECTION OF DUMMY FUEL LOADING
USED DURING THE NON-CRITICAL TEST RUN

CONTRACT NO. AT (11-1)-318
ISSUED JUNE 3, 1957

AUTHOR - E. C. EDGAR

ALCO PRODUCTS, INC.
POST OFFICE BOX 414
SCHENECTADY, NEW YORK

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISTRIBUTION

COPIES

- 1 U. S. Atomic Energy Commission
Schenectady Operations Office
P. O. Box 1069
Schenectady, New York
Attention: J. D. Anderson
- 2-6 U. S. Atomic Energy Commission
1901 Constitution Avenue
Washington 25, D. C.
Attention: Classified Technical Library for J. B. Lampert
- 7-31 U. S. Atomic Energy Commission
Reference Branch, Technical Information Service Extension
P. O. Box 62
Oak Ridge, Tennessee
Attention: M. Day
- 32-33 Nuclear Power Branch
Engineer Research and Development Laboratories
Fort Belvoir, Virginia
Attention: Major J. A. Bacci
- 34-35 Union Carbide Nuclear Co.
Oak Ridge National Laboratory
X-10 Laboratory, Records Department
P. O. Box "P"
Oak Ridge, Tennessee
- 36-50 Alco Products, Inc.
P. O. Box 414
Schenectady, New York

INSPECTION OF DUMMY FUEL LOADING USED DURING THE NON-CRITICAL TEST RUN

This memo covers the inspection of the dummy fuel loading before and after the non-critical test runs as called for in Appendix D, (Test Requirements) contract No. AT (11-1)-318 and explained in letter of October 16, 1956 from E. C. Edgar to J. K. Leslie.

Part I, Before Non-Critical Test Run

Control Rod Fuel Elements:

The eight control rod fuel elements were examined visually. The braze metal stop-off had not been removed after the brazing operation leaving a stripe of black material (titanium dioxide, Rutile) along side of each braze joint. This condition is illustrated by Figures 1 and 2. This material appears to be removable only by an abrasive method and on the interior fuel plates was impossible to remove with the equipment available. The titanium dioxide is quite inert chemically so it may not be effected by the primary system water.

The braze metal joints are very poor, but appear adequate for the few days these elements will be in the reactor. The following is a report of visual examination by eye and with a 30 power binocular stereo microscope:

Element No.	Remarks
CR-3	Poor braze throughout.
CR-4	Fair braze, 1/8" spot braze splatter on top plate, 2". No braze fillet.
CR-5	1/2" no fillet on top plate, bottom plate good braze.

Element No.	Remarks
CR-6	Too large fillet, 5" no braze metal fillet on top plate, bottom plate rattles.
CR-7	Fair braze, some braze metal run out on bottom plate.
CR-8	Poor braze, braze metal did not flow evenly, several inches of joint without fillet.
CR-9	Poor braze, 12 inches of joint on top plate without fillet.
CR-10	Very poor braze, heavy general pitting. H_2SO_4 used in attempt to clear off stop off. Element tagged not to be used in reactor.

Control rod fuel elements 3, 4, and 6 were measured and all measurements were within the dimensional tolerances. All the width of assembly measurements were on the low side. The measurements from fuel plate to edge of side plates were all within the tolerances set for this dimension. Some local minor rippling of the top and bottom fuel plates was noticed.

Stationary Fuel Elements

The stationary fuel elements had been cleaned after brazing and very little braze stop off was left.

The width dimensions of the elements were within the extra tolerances that Alco had given Sylvania in Mr. R. D. Robertson's letter of January 31, 1957 to Mr. Garth Edwards of Sylvania.

Some localized rippling of the top and bottom fuel plates was found and in some cases a distortion of .030" was measured.

The visual inspection of the braze points indicated very poor brazing techniques throughout the entire loading. The following notes represent the visual inspection results. The typical brazing flaws are represented by Figures 2, 4, 5 and

Element Ser. No.	Remarks
S-11	Fair braze, unmelted braze metal scattered along plate 3" from outlet end.
S-12	Very poor braze on one side, 10" of joint not brazed, 8" of other side not brazed.
S-13	Top plate rippled badly, braze good but fillet a little small.
S-15	Good braze flow. Pitting at both ends.
S-16	Good braze, slight pitting throughout.
S-17	Heavy pitting first 3" from outlet end both sides. Good fillet, some braze metal run out inlet end.
S-18	Good braze but practically no fillet.
S-19	Very good braze, slight pitting throughout.
S-20	Very good braze.
S-23	Very good braze, slight pitting throughout.
S-25	Good braze, some pitting 10 inches of outlet end.
S-26	Good braze.
S-27	Good braze, slight run out or splatter 11 inches from inlet end.
S-28	Fair braze, 2 spots 1/2" no braze fillet on outlet end.
S-29	Very good braze, ripple on top plate, nice fillet.

Element Ser. No.	Remarks
S-30	Very good.
S-31	Very poor braze, intermittant fillet throughout.
S-51	Very poor braze, several small spaces throughout fillet, heavy pitting, see Photo 2-2.
S-52	Very poor braze, braze splatter 5/8" out on fuel plate.
S-53	Poor braze, about 10" one side leak of braze metal; some pitting.
S-54	Poor braze, intermittant braze fillet.
S-55	Poor braze, general pitting as much as 3/16" from side plate.
S-56	Poor braze, some pitting and intermittant braze flow.
S-57	Poor braze, general pitting one side top fuel plate.
S-58	Poor braze, throughout.
S-59	Poor braze, pitting each side of fuel plate.
S-60	Poor braze, about 10" no braze fillet.
S-62	Very poor braze, top plate rattles only brazed about 1/3 of total plate.
S-63	Very poor braze, 2 large lumps of braze metal 11" from outlet end, braze metal splatter out to 3/8" from side plate about 20" of splatter on one side. See Photo 2-11.
S-64	Fair braze joint but continuous pitting.
S-65	Poor braze, not sufficient braze metal.

Element Ser. No.	Remarks
S-66	Fair braze, run out spot 1/4" wide, 5" from inlet end.
S-67	Good braze, but not enough braze metal to give a good fillet.
S-68	Braze metal fillet too wide, pitting on outside of fillet.
S-69	Braze joint very poor over 1/2 of braze joint not brazed. Top and bottom plates badly rippled.
S-70	Poor intermittent braze joint. Two spots of braze metal run out.
S-71	Poor braze, 7" of open joint, lights pitting throughout.
S-73	Poor braze, five spots where braze metal puddled 3/16". Six inches no braze fillet, see Photos 2-4 and 2-9.
S-77	Poor braze, severe pitting throughout.
S-78	Poor braze.

Of the 40 stationary elements examined only about 6 fuel elements had brazed joints satisfactory for a live element that would be in the reactor for a fuel loading life.

A sheet showing the dimensional variations of a random sampling of both the control rod and stationary fuel elements is included in this report. The same elements measured before the hydraulic test were also measured after the test completion.

Embrittlement Tests:

Specimens of the fuel plates after the same heat treatment as the brazed assemblies are on hand for comparison with the fuel plates from an element that has been through the test run. These specimens will be given bend tests and photomicrographs will be prepared.

Control Rod Absorber Sections:

The eight absorber sections were all within the drawing tolerances. The weld joints joining the four sections together was a good heliarch weld. Several spots of arc strike made small depressions on the edge of the box. The absorber sections were acceptable in reference to the dimensions and fabrication process.

Conclusions:

The condition of the braze joints was called to the attention of Mr. John Mezas of Sylvania and the elements were accepted only because of the expediency of finishing this loading of dummy elements for use in the non-critical test run at Ft. Belvoir. The unsatisfactory conditions of this dummy loading should not affect the non-critical test run because of the short duration of test.

Part II A, After Non-Critical Test Run

2 (a) Control Rod Fuel Elements:

After discharge from the reactor into the spent fuel storage pit, six control rod fuel elements were removed from the pit for examination. The six fuel elements were examined visually. The braze metal stop-off that had remained on the fuel plates was practically removed by the primary coolant during the test. The appearance of one control rod fuel element shown in figure 2 before test, and again in figure 8 after removal from the reactor following the test. The bending of the two long fuel plates resulted from a manufacturing error, and occurred during the many scrambling cycles during the rod drop tests. The long fuel plates extended about .010" beyond the side plates instead of being flush and are not strong enough to support the fuel and absorber section within the control rod basket. This load should be taken by the side plates.

No change in surface appearance of the braze joints was noticed. A slight overall deposit covered the fuel elements. This deposit was of a reddish brown color and could be rubbed off with a damp cloth.

The specimens for the embrittlement and microstructure study were removed from control rod fuel element #8.

Measurements were made of the width of fuel elements and the space from the top of top fuel plate to the top edge of side plate and the same for the bottom fuel plate to the bottom edge of the side plate. These measurements before and after test are presented in figure 9. The difference in several measurements was caused by the hitting of the top or bottom fuel plates by the handling tool in the

spent fuel pit. The diameter of the tool allowed it to enter the storage rack in the spent fuel pit and press in the outside fuel plates. This is illustrated by the scratch marks on the fuel elements as shown in Figure 10.

The measurements did not show any significant distortion of the control rod fuel elements during the period of the non-critical test run.

Stationary Fuel Elements:

The visual inspection of the stationary fuel elements was made on the same elements as was reported in the before test section of this report. Photographs of typical flaws in the brazing were rephotographed after removal from the spent fuel pit. The slight difference of angle of view was because the photographs were made at the site with a small camera. No noticeable differences were observed and the flaws of brazing as shown in figures 4, 5 and 6 are shown after testing in figures 11, 12 and 13.

The stationary fuel elements were dimensionally stable as illustrated in the measurements before and after illustrated in figure 14.

2 (b) Embrittlement

Specimens of fuel plates before and after the non-critical test were given a 270° bend test around a 1/8" mandrel. No embrittlement was noted, as shown in figure 15.

The before test specimen was prepared from sections of a fuel plate that had gone through the brazing cycle with an element, giving it the same heat treatment as an element. The after test bend specimens were removed from element CR-8 after removal from the spent fuel pit.

The microstructure specimens of the 304 L material before and after test were identical. A typical section of the fuel plate is shown of figure 16.

The microstructure of the braze joint joining the fuel plate to the side plate is illustrated on figure 17. No corrosion of the plates or braze joint can be seen.

2 (c) Pitting and Deposits

No pitting or gross deposits were observed on the outside or inside fuel plates. A slight over-all layer of brown corrosion product was observed. (1) The stainless steel changed to a slightly brown cast instead of the clean silver color, as is expected in a water environment at the temperature of 450°F.

(1) The analysis of ignited sample of the loose crud was as follows:

Fe_2O_3 - 63.9%

Cr_2O_3 - 20.6%

NiO - 8.5%

S_1O_2 - 0.7%

Mn_3O_4 - 4.2%

Figure #	Illustrations
1 -	Letter explaining test procedure.
2 -	CR-4 Fuel element end view before test.
3 -	CR-10 Fuel element end view, rejected for test.
4 -	Stationary fuel element #51, general pitting, rejected for test .
5 -	Stationary fuel element #73, large pit.
6 -	Stationary fuel element #73, interrupted braze flow.
7 -	Stationary fuel element #63, braze metal didn't flow.
8 -	Fuel elements dimensions before test.
9 -	CR-4 Fuel element end view after test.
10 -	CR- Fuel element dimensional measurements before and after test.
11 -	Top view 3 CR fuel element showing scratches made with handling tools in spent fuel pit.
12 -	Figure 4, after test
13 -	Figure 6, after test
14 -	Figure 5, after test
15 -	Stationary fuel elements dimensions before and after test.
16 -	Bend test of material before and after test.
17 -	Photomicrograph of 304L after test 250X.
18 -	Photomicrograph of braze joint after test 75X.

Schenectady - October 16, 1956

Corrosion Tests on Dummy
Fuel Elements

Mr. J. K. Leslie
Schenectady

In accordance with Appendix D (Test Requirements) Contract No. AT(11-1)-318 the following is suggested as the testing procedure as per paragraph 2 of Corrosion Testing, Page 5.

2. (a) A portion of the dummy fuel elements shall be inspected visually and by binocular microscopes by a member of the Metallurgical Group before insertion into reactor vessel. Any unusual condition of an element shall be recorded for check when the elements have completed the test run. All elements shall be numbered before inspection by a method which will remain for the life of the element.

(b) Embrittlement: Specimens of the material used in fabricating this dummy loading shall be given bend tests. These specimens shall have the exact heat treatment that the fuel elements receive. Typical microstructure examination can be made from these specimens. After the test period sections shall be cut from an element that had been through the test run and bend tests made to compare to the material before the test run.

(c) Pitting and Deposits: Any pitting or braze run-outs recorded in part (a) shall be examined after test period very closely. All outside surfaces of the elements shall be examined under a binocular microscope at about 30 power. Any pitting or build-up shall be noted. One or more elements shall be sectioned up to provide a view of the internal surfaces. Any deposits found should be analyzed for content. Microstructure of the material will be examined on the element or elements cut up, if the need is evident.

ECE:meh

E. C. Edgar

cc: J. F. Haines
H. L. Weinberg
J. L. Meem
R. D. Robertson

Figure 1

Figure - 2 Dummy control rod fuel element #CR-4
2 3/4 X Inlet end view showing braze metal stop off.

Reduced 3/4 X for reproduction.

Figure - 3 Dummy control rod fuel element #CR-10
2 3/4 X Inlet end view showing braze metal stop-off.

Reduced 3/4 X for reproduction.

16

16

Figure - 4 Dummy Stationary fuel element #51
5 X View of general pitting caused by braze metal.

Reduced 3/4 X for reproduction

17

17

Figure - 5 Dummy stationary fuel element #73
5 X Large deep pit caused by braze metal
 8 inches from outlet end of top fuel plate.

Reduced 3/4 X for reproduction

18

18

Figure - 6 Dummy stationary fuel element #73
3 X Interrupted braze metal flow, 10 inches
 from inlet end on top fuel plate.

Reduced 3/4 X for reproduction

19

19

Figure - 7 Dummy stationary fuel element #63
5 X 2 masses of braze metal 10 inches
 from outlet end of top fuel plate.

Reduced 3/4 X for reproduction.

20

SPOT CHECK FUEL ELEMENT INSPECTION RECORD

Stat. Fuel Elem. No.	Position	2.844"-.022" + .000"						Top .028"-.007"+.017", Bottom .028" + .007" Distance from edge of side plate to fuel plate Dist. from outlet end						Remarks
		Width-Distance From Outlet End												
		1"	6"	11"	16"	21"	26"	1"	6"	11"	16"	21"	26"	
23	Top	2.817	2.823	2.823	2.825	2.830	2.825	.030	.054	.060	.038	.057	.031	Top Plate Ripple Good Braze
	Bottom	2.826	2.825	2.825	2.824	2.827	2.823	.033	.027	.015	.030	.029	.029	
31	Top	2.828	2.834	2.833	2.828	2.831	2.827	.032	.031	.040	.036	.044	.029	Bottom Plate Ripple Poor Braze
	Bottom	2.832	2.842	2.852	2.841	2.842	2.832	.029	.033	.035	.023	.067	.028	
57	Top	2.837	2.836	2.833	2.845	2.838	2.830	.035	.045	.033	.036	.044	.027	Ripple Top Pl., 12" Top Pl. No Braze, Poor Braze
	Bottom	2.826	2.827	2.828	2.833	2.832	2.824	.025	.026	.025	.029	.032	.027	
77	Top	2.833	2.828	2.829	2.855	2.830	2.817	.036	.050	.035	.038	.049	.034	Ripple Top Plate Poor Braze
	Bottom	2.833	2.830	2.834	2.835	2.836	2.836	.034	.025	.033	.031	.025	.027	

Control Rod Fuel Elem. No.	Position	2.624"-.022" + .000"						Top .069"-.007"+.017", Bottom .069" ± .007" distance from edge of side plate to fuel plate, dist. from outlet end						Remarks
		Width-Distance From Outlet End												
		1"	6"	11"	16"	21"	24"	1"	6"	11"	16"	21"	24"	
3	Top	2.607	2.605	2.607	2.606	2.607	2.613	.073	.076	.078	.074	.080	.074	Poor Braze
	Bottom	2.608	2.607	2.604	2.609	2.609	2.609	.072	.075	.075	.075	.075	.069	
4	Top	2.614	2.612	2.613	2.613	2.607	2.605	.073	.084	.072	.084	.080	.079	Poor Braze 1 3/4" Open Joint
	Bottom	2.625	2.612	2.611	2.612	2.608	2.605	.073	.077	.078	.078	.080	.076	
6	Top	2.606	2.605	2.608	2.607	2.608	2.605	.073	.070	.075	.080	.084	.086	Poor Braze, Bottom Pl. Rattles, Slight Ripple
	Bottom	2.613	2.614	2.613	2.615	2.612	2.606	.066	.069	.069	.068	.066	.066	

Boxed dimensions are out of tolerance

Figure 8

21

Figure - 9 Dummy control rod fuel element #CR-4
2 3/4 X Inlet end view after non-critical test.

Reduced 3/4 X for reproduction.

Fuel Element Measurements
Before & After Non-Critical Tests
Control Rod Fuel Element

Fuel Element Number	Time	Location of Measure.	Width of Element Location From Top End of Element						Distance from F.P. to Edge of S.P. Location from top end of element					
			1"	6"	11"	16"	21"	24"	1"	6"	11"	16"	21"	24"
CR-3 ‡	Before	Top	2.607	2.605	2.607	2.606	2.607	2.613	.073	.076	.078	.074	.080	.074
		Bottom	2.608	2.607	2.604	2.608	2.609	2.609	.072	.075	.075	.075	.075	.069
	After	Top	2.609	2.606	2.604	2.606	2.608	2.615	.079	.087	.079	.094	.082	.079
		Bottom	2.609	2.609	2.610	2.609	2.609	2.610	.072	.080	.075	.078	.075	.070
CR-4 ‡	Before	Top	2.614	2.612	2.613	2.613	2.607	2.605	.073	.076	.078	.074	.080	.074
		Bottom	2.625	2.612	2.611	2.612	2.608	2.605	.072	.075	.075	.075	.075	.069
	After	Top	2.612	2.611	2.610	2.614	2.610	2.605	.074	.085	.073	.079	.082	.079
		Bottom	2.623	2.610	2.613	2.612	2.607	2.605	.073	.083	.076	.078	.079	.077
CR-6 ‡	Before	Top	2.606	2.605	2.608	2.607	2.608	2.605	.073	.070	.075	.080	.084	.086
		Bottom	2.613	2.614	2.613	2.615	2.612	2.606	.066	.069	.069	.068	.066	.066
	After	Top	2.608	2.605	2.607	2.608	2.609	2.606	.068	.074	.076	.077	.083	.085
		Bottom	2.613	2.612	2.613	2.612	2.611	2.604	.066	.070	.075	.068	.070	.064

‡ Element bent in handling in spent fuel pit.

Figure 10

23

Figure - 11 Dummy control rod fuel elements #CR-3, 4 & 6.
After removal from spent fuel pits showing marks
made by handling tools in spent fuel pit.

24

Figure - 12 Dummy stationary fuel element #73, after test.
6 X Large deep pit caused by braze metal.
Same area as Figure 5.

Reduced 3/4 X for reproduction.

25

Figure - 13 Dummy stationary fuel element #73, after test.
3 X Interrupted braze metal flow, same area as Figure 6.

Reduced 3/4 X for reproduction.

26

Figure - 14 Dummy stationary fuel element #63, after test.
5 X 2 masses of braze metal, same areas as Figure 7.

Reduced 3/4 X for reproduction

Fuel Element Measurements
Before & After Non-Critical Tests
Stationary Fuel Elements

S-23	Before	Top	2.817	2.823	2.823	2.825	2.830	2.825	.030	.054	.060	.038	.057	.031
		Bottom	2.826	2.825	2.824	2.827	2.827	2.823	.033	.027	.015	.030	.029	.029
	After	Top	2.818	2.823	2.823	2.823	2.829	2.828	.031	.057	.063	.033	.055	.033
		Bottom	2.825	2.824	2.824	2.825	2.828	2.825	.035	.050	.020	.030	.033	.031
S-31	Before	Top	2.828	2.834	2.833	2.828	2.821	2.827	.032	.031	.040	.036	.044	.029
		Bottom	2.832	2.832	2.852	2.841	2.842	2.832	.029	.033	.035	.023	.067	.028
	After	Top	2.829	2.835	2.833	2.834	2.832	2.826	.031	.038	.043	.027	.053	.016
		Bottom	2.831	2.841	2.850	2.837	2.832	2.833	.028	.033	.032	.034	.062	.013
S-57	Before	Top	2.837	2.836	2.833	2.845	2.838	2.830	.035	.045	.033	.036	.044	.027
		Bottom	2.826	2.827	2.828	2.833	2.832	2.824	.025	.026	.025	.029	.032	.027
	After	Top	2.833	2.829	2.833	2.841	2.835	2.831	.031	.043	.034	.039	.043	.029
		Bottom	2.826	2.826	2.825	2.841	2.835	2.831	.025	.025	.026	.025	.029	.028
S-77	Before	Top	2.833	2.828	2.829	2.855	2.830	2.817	.036	.050	.035	.038	.049	.034
		Bottom	2.833	2.830	2.834	2.835	2.836	2.830	.034	.025	.033	.031	.025	.027
	After	Top	2.831	2.832	2.834	2.850	2.828	2.818	.035	.050	.037	.043	.042	.036
		Bottom	2.829	2.835	2.832	2.832	2.832	2.830	.035	.025	.031	.023	.024	.027

Figure 15

Figure - 16 Bend test specimens after bending 270° .
3 X

Reduced $3/4$ X for reproduction

Figure - 17 304L stainless steel fuel plate.
250 X Etched electrolytically in oxalic acid.

Reduced 3/4 X for reproduction

30

Figure - 18 Braze joint top fuel plate to side plate.
75 X after non critical test, etched electrolytically in oxalic acid.

Reduced 3/4 X for reproduction