UNCLASSIFIED

OAK RIDGE NATIONAL LABORATORY

Operated By

UNION CARBIDE NUCLEAR COMPANY

UCC

POST OFFICE BOX P
OAK RIDGE, TENNESSEEEXTERNAL TRANSMITTAL
AUTHORIZED
C-83**ORNL**
CENTRAL FILES NUMBERCF-57-2-34

DATE: February 7, 1957

SUBJECT: Effect of Pressure Differentials on
Deflection of the Outer Fuel Plates of
Braze APPR Fuel Elements.

FROM: J. H. Erwin and R. J. Beaver

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

Photostat Price \$ 1.80Microfilm Price \$ 1.80

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

CLASSIFICATION CANCELLED
DATE 3/1/57
For The Atomic Energy Commission

H. F. Carr
Chief, Declassification Branch

UNCLASSIFIED

REPRODUCED

944 001

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.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to any information pursuant to his employment or contract with the Commission.

0012000000

~~CONFIDENTIAL~~

-2-

INTRODUCTION

CLASSIFICATION CANCELLED
DATE 3/1/57
For The Atomic Energy Commission
H. F. Canale
Chief, Declassification Branch

One of the considerations in designing a flat plate fuel element is the resistance of the fuel plates, especially the outer plates in the fuel plate array, to deflection and permanent deformation as a result of pressure differentials. An investigation was recently initiated with the objective of obtaining preliminary information on the APPR-type fuel element to determine the effect of pressure differentials on the outer plates in the fuel assembly. The APPR-1 fuel element consists of 18 flat composite stainless steel fuel plates, joined to grooved 50 mil thick type 304L stainless steel side plates by brazing with Coast Metals N. P. alloy. Each fuel plate is separated a distance of 133 mils. The brazing cycle requires a heat-treatment which results in a fully annealed stainless steel with a tensile strength estimated at 30,000 psi. Each fuel plate contains a fuel core prepared by powder metallurgy processing, consisting of 26 wt per cent UO_2 - 0.14 wt per cent B_4C - balance stainless steel, which is clad by roll bonding with type 304L stainless steel. The clad-core-clad thickness dimensions are 5-20-5 mils. The overall dimensions of the outer plates are 27 x 2.7 x .030-in. The fuel section is 22 x 2.5 x .020-in. The 16 inner plates are 23-in. in length. The majority of data presented was obtained from a fuel element as described with the exception that the fuel core composition in the plates was 21 wt per cent UO_2 - 0.12 wt per cent B_4C - balance stainless steel.

DISCUSSION

Procedure

Data was obtained by pressurizing fuel elements with air, and measuring the deflection of one of the outer plates. The fuel element was positioned horizontally in a frame, securely clamped, and both ends of the fuel element gasketed to prevent

~~CONFIDENTIAL~~

DECLASSIFIED

944 002

CONFIDENTIAL

-3-

air leakage. The air inlet pipe was equipped with a 0 to 30 psi gage, an air bleeder valve and a Foxboro type 67 air regulating valve.

Measurements were confined to deflection of the top plate of the fuel element. Both a dial gage and a depth micrometer were used in measuring deflection. Shim bars were used in conjunction with the depth micrometer in those instances in which the plate had deflected above the horizontal plane through the top edge of the side plates. Deflections below the horizontal plane were prefixed positive; deflections above this plane were prefixed negative. Measurements were made along the longitudinal centerline of the plate, at three inch intervals in both directions from the transverse centerline. For example, location "A" listed in Table V is at the location nearest the outlet end of the fuel element. The experiments conducted were designed to obtain data on:

- (1) The effect of pressure differentials on deflection of the outer plate.
- (2) The effect of pressure differentials on permanent deflection of the outer plate.
- (3) The effect of cyclic pressure differentials on deflection of the outer plate.
- (4) The effect of a cyclic pressure differential on permanent deflection of the outer plate.
- (5) The effect of 500°F heat-treatment on the plate after an imposed permanent deflection.

The results are listed in Tables I to V. Table I represents data obtained on depleted fuel element No. 44, consisting of plates containing 21 wt per cent UO_2 . In the first three experiments, the fuel element was subjected continuously to pressure differentials varying from 0 to 14 psi and the respective deflections

CONFIDENTIAL

944

000

DECLASSIFIED

CONFIDENTIAL

-4-

recorded. After each experiment the pressure was reduced to zero and permanent set of the plate measured. Prior to both experiment 4 and experiment 5, the plate was forced back to its approximate original position associated with the nominal APPR spacing specification. It is apparent from the data that a differential pressure exceeding 3 psi is sufficient to result in a deflection of the plate which would cause the adjacent spacings in the fuel elements to be beyond tolerance limits. It is significant that a pressure differential of 14 psi will cause a permanent deflection of 17 mils. Pressure differentials of 15 and 16 psi increase this permanent deflection to 24 and 33 mils respectively. Data from experiments 4 and 5 are interesting because of the increase in deflection at the respective pressure differentials used in experiments 1, 2 and 3. The values shown in Table I represent average values of seven longitudinal measurements. The deviations from the average data presented were approximately plus or minus 20%, which is an indication of the complexity of the stress pattern throughout the plate under this type of deformation. Table II is similar data to that listed in Table I, but for an APPR element consisting of plates containing 26 wt per cent UO_2 . In comparing this data with similar data in Table I, it is significant that for corresponding pressure differentials, a greater deflection occurs in fuel plates containing a higher concentration of UO_2 . Table III reveals insignificant changes in the width of the APPR-1 fuel element at pressure differentials as high as 10 psi.

Table IV lists results of cycling between zero and 10 psi. There is little tendency for change in plate deflection, although there are indications that some additional permanent set occurs. The data, however, is limited to six cycles.

The effect of soaking an APPR type fuel element at 500°F for 310 hr on

CONFIDENTIAL

944

4

DECLASSIFIED

CONFIDENTIAL

-5-

deflection of the outer plate, is shown in Table V. Depleted element No. 44 was subjected to 21.5 psi and the plate position recorded. The negative prefix indicates the distance above the horizontal plane through the top edge of the side plates. The data reveals a general relaxation of approximately 3 mils, although one measurement shows a localized change of 13 mils. Again, as in previous data, the results indicate a complex stress pattern, which is not fully understood.

The results obtained are of preliminary nature, but do indicate that the APPR-type element as presently manufactured exhibits a marked weakness to pressure differentials. In comparison with aluminum curved plate research reactor fuel elements, the APPR-1 element appears to be weaker than the present Mark XI MTR fuel element by a factor of three. It is slightly weaker than a curved plate aluminum fuel element containing twenty 45 mil thick plates brazed to 0.102-in. thick side plates, in which high strength type 6951 or type 5050 aluminum was substituted for the type 1100 cladding and side plate material.

CONFIDENTIAL

944

005

DECLASSIFIED

CONFIDENTIAL

66-

TABLE I

EFFECT OF INCREASING PRESSURE DIFFERENTIALS AND REPETITIVE INCREASING PRESSURE
DIFFERENTIALS ON THE DEFLECTION AND PERMANENT SET OF THE OUTER PLATE OF
APPR-TYPE FUEL ELEMENT NO. 44

No.	Average Plate Deflection at Designated Pressure, mils									Mils Average Permanent Set
Experiment	3 psi	6 psi	9 psi	10 psi	11 psi	12 psi	14 psi	15 psi	16 psi	at max. Press
1	6	13	20	-	27	32	42	-	-	17
2	-	11	-	18	-	22	-	-	-	17
3	-	10	-	18	-	21	-	-	-	17
4*	-	17	-	31	-	38	45	71	-	24
5*	-	18	-	35	-	44	52	-	63	33

* Plate forced back to approximately original location prior to further pressurization of fuel element.

TABLE II

EFFECT OF INCREASING PRESSURE DIFFERENTIALS ON THE
DEFLECTION AND PERMANENT SET OF THE OUTER PLATE OF ENRICHED APPR-1 FUEL ELEMENT NO. 59

<u>psi Pressure</u>	<u>Average Deflection</u>	<u>Average Permanent Set</u>
2	3	-
3	7	-
4	10	-
5	13	-
6	16	-
7	20	-
8	24	-
9	28	-
10	35	-
0*	-	13

* Pressure removed and permanent set measured.

CONFIDENTIAL

DECLASSIFIED

944 006⁶

CONFIDENTIAL

-7-

TABLE III

EFFECT OF PRESSURE DIFFERENTIAL ON CHANGE IN WIDTH
OF ENRICHED APPR-1 FUEL ELEMENT NO. 59

Pounds Press.	<u>Width of Unit at No. 18 Plate</u>						
	A	B	C	D	E	F	G
0	2.851	2.840	2.847	2.835	2.845	2.840	2.844
2	2.849	2.840	2.846	2.836	2.845	2.839	2.843
3	2.848	2.839	2.846	2.836	2.845	2.839	2.842
4	2.848	2.839	2.846	2.836	2.846	2.839	2.842
5	2.848	2.838	2.845	2.835	2.842	2.839	2.843
6	2.848	2.839	2.846	2.836	2.846	2.839	2.842
7	2.848	2.840	2.847	2.836	2.846	2.840	2.843
8	2.847	2.838	2.846	2.836	2.844	2.839	2.842
9	2.848	2.840	2.844	2.836	2.844	2.838	2.841
10	2.846	2.839	2.846	2.836	2.843	2.840	2.842

CONFIDENTIAL

944 007

DECLASSIFIED

CONFIDENTIAL

-8-

TABLE IV

EFFECT OF PRESSURE CYCLING ON THE DEFLECTION AND PERMANENT SET
OF THE OUTER PLATE OF FUEL ELEMENT NO. 44

Cycle	psi Pressure	Average Deflection	Average Per Set
1	10	34	-
	0	-	13
2	10	34	-
	0	-	13
3	10	34	-
	0	-	13
4	10	34	-
	0	-	14
5	10	34	-
	0	-	14
6	10	34	-
	0	-	14

CONFIDENTIAL

944 008

DECLASSIFIED

CONFIDENTIAL

-9-

TABLE V

EFFECT OF 310 hr SOAK AT 500°F ON DEFLECTION OF THE OUTER PLATE OF
APPR DEPLETED FUEL UNIT NO. 44 WHICH HAD BEEN STRESSED UNDER
A PRESSURE DIFFERENTIAL OF 21.5 psi

Location	Measurement - mils		Difference
	Prior to Heat-Treatment	After Heat-Treatment	
A	-7	-6	1
B	-12	-9	3
C	-7	6	13
D	-14	-12	2
E	-12	-7	5
F	-12	-9	3
G	-12	-9	3

CONFIDENTIAL

944 009

DECLASSIFIED

1-4

100 330

0371229.030