UNCLASSIFIED

X-822

OAK RIDGE NATIONAL LABORATORY

Operated by

UNION CARBIDE NUCLEAR COMPANY

Division of Union Carbide Corporation

Post Office Box X

Oak Ridge, Tennessee

ORNL
CENTRAL FILES NUMBER
58-3-28

External Transmittal Authorized

COPY NO. 82

DATE: March 3, 1958

SUBJECT: Decrease in HRE-3 Breeding Ratio Caused by
Absorptions in Core Tank and Shroud

TO: Distribution

FROM: M. W. Rosenthal, T. B. Fowler, and M. Tobias

SUMMARY

The decrease in HRE-3 breeding ratio due to the presence of the Zircaloy core tank and shroud has been examined as a function of metal thickness and spacing. For the case of a 1/2-in. thick core vessel and a 1/2-in. thick shroud spaced 5 in. apart, the breeding ratio would be 0.047 less than if there were no Zircaloy present. The absorption cross section used for Zircaloy-2 is consistent with an experimentally measured value and an estimate based on spectrographic and chemical analysis of HRT core tank material. The fraction of blanket power generated in the space between core tank and shroud has also been determined.

NOTICE

This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report.

UNCLASSIFIED

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, 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.

DISTRIBUTION

1. HRP Director's Office
Rm. 259, 9204-1	42. R. H. Nimmo
2. G. M. Adamson	43. L. E. Parsly
3. S. E. Beall	44. R. N. Peebles
4. L. L. Bennett	45. H. S. Pomerance
5. E. G. Bohlmann	46. B. E. Prince
6. E. S. Bomar	47. R. C. Robertson
7. F. R. Bruce	48. A. M. Rom
8. W. D. Burch	49-51. M. W. Rosenthal
9. R. H. Chapman	52. H. C. Savage
10. R. D. Cheverton	53. C. L. Segaser
11. H. C. Claiborne	54. I. Spiewak
12. E. L. Compere	55. R. W. Stoughton
13. J. S. Culver	56. J. A. Swartout
14. D. E. Ferguson	57. E. H. Taylor
15. C. H. Gabbard	58. D. G. Thomas
16. W. R. Gall	59-61. M. Tobias
17. E. H. Gift	62. D. S. Toomb
18. J. C. Griess	63. W. E. Unger
19. P. A. Haas	64. R. Van Winkle
20. P. H. Harley	65. C. E. Winters
21. P. N. Haubenreich	66. F. C. Zapp
22. J. W. Hill	67. ORNL Document
Reference Library, Y-12
23. S. Jaye	68. Central Research Library
24. G. H. Jenks	69-70. REED Library
25. S. I. Kaplan	71-72. Laboratory Records
26. P. R. Kasten	73. F. C. Moesel, AEC,
Washington, D. C.
27. R. B. Korsmeyer	74. M. J. Skinner
28. K. A. Kraus	75-81. Westinghouse PAR Project
29. N. A. Krohn	82-96. TISE-AEC
30. J. A. Lane	97. E. Volk
31. R. E. Leuze	98. ORNL-RC
32. M. I. Lundin	
33. R. N. Lyon	
34. W. L. Marshall	
35. T. H. Mauney	
36. J. P. McBride	
37. H. F. McDuffie	
38. H. M. McLeod	
39. R. A. McNees	
40. W. R. Nixon	
41. C. S. Morgan	

DECREASE IN HRE-3 BREEDING RATIO CAUSED BY
ABSORPTIONS IN CORE TANK AND SHROUD

M. W. Rosenthal, T. B. Fowler, and M. Tobias

The breeding ratio reductions which result from neutron absorptions in the Zircaloy-2 core tank and shroud have been estimated using a two-group multi-region code for spherical reactors.¹ In Fig. 1 the effect of core-wall thickness on breeding ratio is shown for a spherical 4-ft. I.D. core in a 9-ft. I.D. pressure vessel, with a blanket containing 1000 g Th/liter and 3 g U²³³/kg Th. The additional loss in breeding ratio by absorptions in a concentric, spherical Zircaloy shroud is plotted in Fig. 1 as a function of shroud thickness for three spacings of shroud from core tank ("gap" is distance from O.D. of core vessel to I.D. of shroud).

For reasonable thickness of Zircaloy, the poisoning effect of the core vessel is approximately independent of the shroud thickness and position, and the shroud absorptions are approximately independent of the core thickness. The effects of each can therefore be added. As an example of the use of Fig. 1, consider a design with a 1/2-in. core tank and a 1/2-in. shroud, five inches apart. The breeding ratio would be $0.035 + 0.012 = 0.047$ less than if there were no absorptions in the Zircaloy structure. Thus, if the breeding ratio were 1.100 without the Zircaloy present, it would be $1.100 - 0.047 = 1.053$ after allowing for absorptions in Zircaloy.

In obtaining the values shown in Fig. 1, the macroscopic absorption cross section of Zircaloy-2 was taken as 0.0059 cm^{-1} , which is 20% above that of pure zirconium. This value is an estimate which includes the effects of various alloying agents and impurities. The results of an analysis² of

HRT material is shown in Table 1 with the ratio of the macroscopic absorption cross section of each constituent to that of zirconium. The cross section of this sample would be 16% greater than that of pure zirconium.

To check the accuracy of the calculated Zircaloy cross section, the absorption cross section of a specimen of the same material used in the HRT core tank was measured with the X-10 Pile Oscillator.³ The value obtained was 1.12 times that of pure zirconium; the accuracy was of the order of $\pm 10\%$, so that the computed value falls within the experimental error. This value is quite typical of earlier measurements made for similar alloys, and is about 10 - 20% greater than the result obtained with crystal bar zirconium.

The values in Fig. 1 suffer both from the limitations of the two-group technique and the assumption of perfect spherical geometry for HRE-3. However, the absorptions in the core tank obtained with the two-group method have been compared with values obtained using the 27-group EYEWASH routine.⁴ For the HRE-3 design with 1/2-in. core tank and no shroud, the two methods agreed within 4%, and the maximum difference was less than 20% for a variety of core sizes and blanket conditions. An approximation with HRE-3 configuration rather than an idealized geometry will be attempted shortly using a computer routine which treats two space variables.

The per cent of total blanket power produced in the gap between the core tank and shroud was obtained from the two-group computations and is plotted in Fig. 2 as a function of gap spacing. No core or shroud thicknesses have been specified on the figure, since the fraction of total power generated in the gap is practically independent of these dimensions. With a core power of 50 Mw and blanket composition of 1000 g Th/liter and 3 g U^{233} /kg Th, the total blanket power is about 10 Mw.

TABLE 1

ANALYSIS AND RELATIVE CROSS SECTION OF HRT CORE-WALL SAMPLE²

<u>Element</u>	<u>Wt. %</u>	<u>Relative Cross Section, %*</u>
N	0.006	0.4
Fe	0.0959	2.2
Cr	0.0915	2.6
Ni	0.0466	1.9
Sn	1.37	3.5
Al	0.0045	< 0.1
Cu	0.0025	0.1
Pb	0.0045	< 0.1
Mg	0.001	< 0.1
Co	< 0.0020	0.6
Mn	< 0.0010	0.1
Si	0.0085	< 0.1
Ti	< 0.0020	0.1
V	< 0.0020	0.1
Mo	< 0.0020	< 0.1
Cd	< 0.000015	0.2
B	0.00002	0.7
Hf	0.0109	3.3
Zr	99.6	<u>100.0</u>
Sum of Relative Cross Sections, %		115.9

* Macroscopic cross section of element in sample divided by cross section of zirconium in sample.

REFERENCES

1. C. W. Nestor, Two-Group Analysis of Thermal One-Dimensional, Multi-Region Spherical Reactors, ORNL CF-57-5-14 (May 1, 1957); Two-Group Analysis of Multi-Region Reactors Part II: Construction and Use of Oracle Code, ORNL CF-57-5-49 (May 14, 1957).
2. R. E. Morris, "Tests of Special Materials," Auburn Research Foundation UCNC Contract No. 547, March 20, 1957.
3. The cross-section measurement was performed through the cooperation of Dr. H. S. Pomerance. The sample was supplied by the HRP Metallurgy Section.
4. B. E. Prince, personal communication.

gcb

FIG. 1

Estimated Reduction in HRE-3 Breeding Ratio
from Neutron Capture in Zircaloy-2 Core
Tank and Shroud

Core I.D.	4 ft
Pressure vessel I.D.	9 ft
Blanket thorium	1000 g/liter
Blanket U^{235}	30 g/kg Th
Core poison fraction	7%