UNCLASSIFIED

MASTER

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

CF 58-1-118

~~Internal Use Only~~

COPY NO. 75

DATE: January 30, 1958

SUBJECT: Preliminary Zirconium Alloy Data
from Loop L-2-17

TO: G. H. Jenks

FROM: J. E. Baker 6897

LEGAL NOTICE

This report was prepared as a result 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. Accepts any liability 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, or employee of such contractor, to the extent that each employee or contractor of the Commission, or employee of such contractor, prepares, disseminates or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

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.

RELEASE APPROVED
BY PATENT BRANCH

76-59

DATE

SIGNATURE

UNCLASSIFIED

123 001

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.

Preliminary Zirconium Alloy Data from Loop L-2-17

In-pile loop experiment L-2-17 was the fourth experiment to contain core coupon specimens of zirconium alloys other than, and in addition to, Zircaloy-2 and crystal bar zirconium. Correlations of the zirconium and zirconium alloy radiation-corrosion data obtained from the three previous experiments (L-4-11, L-4-16 and L-2-14) have been reported^(1,2). Reported here are similar, preliminary correlations of the data obtained in loop L-2-17.

A brief summary of operating conditions for these four experiments is presented in Table I.

Experiment L-2-10⁽³⁾ employed a solution similar to that used in the present experiment, but was operated at 280°C. Experiment L-2-10 contained CC and CA coupons of Zircaloy-2 but did not contain coupons of other zirconium alloys. The radiation-corrosion behavior of the Zircaloy-2 coupons from that experiment is described by the equation:

$$(I) \quad R = 2.45 P (1 - e^{-95/R^{1.5}})$$

where: R = corrosion rate, mpy (based on exposed specimen area and radiation time)

P = fission power density in solution, w/ml

Corrosion rates observed on the CC and CA Zircaloy-2 coupons contained in L-2-17, listed in Table II, are also reasonably well described by eq. (I). The rates are shown plotted against the fission power density in solution adjacent to the specimens, in Fig. 1. Also plotted for comparison are the corrosion rates observed on the CC and CA Zircaloy-2 coupons from L-2-10.

TABLE ILoop Operating Conditions

	L-4-11	L-4-16	L-2-14	L-2-17
Original Solution:				
UO ₂ SO ₄ , <u>m</u>	0.17	0.17	0.17	0.04
CuSO ₄ , <u>m</u>	0.031	0.015	0.15	0.005
H ₂ SO ₄ , <u>m</u>	0.04	0.025	0.40	0.025
Make-up Solution:				
UO ₂ SO ₄ , <u>m</u>	0.17	0.17	0.17	0.04
CuSO ₄ , <u>m</u>	0.031	0.015	0.015	0.005
H ₂ SO ₄ , <u>m</u>	0.04	0.07	0.07	0.06
Cr, ppm	---	100	100	100
Mean H ₂ SO ₄ concentration, <u>m</u>	0.022	0.024	0.39	0.024
Main Stream Temperature, °C	250	280	280	300
Average Power Density in Core, w/ml				
Cesium	2.38	2.11	7.74	1.67
Specimen Activity	4.34	3.80	14.30	3.98

ZIRCALOY-2 CORE COUPON CORROSION RATES VS. SOLUTION FISSION POWER DENSITY

Core channel coupons Core annulus coupons

●

L-2-17

○

▲

L-2-10

△

FIG. 1

CRNL-IR-Eng.-27291
UNCLASSIFIED

Rate factor approx 2.5 and radiation time

TABLE IIL-2-17 CC and CA Zr-2 Coupon Corrosion Rates

CC Coupons			CA Coupons			Array No.
Corrosion Rate* (mpy)	Power Density (w/ml)	Velocity (fps)	Corrosion Rate* (mpy)	Power Density (w/ml)	Velocity (fps)	
11.3	6.03	9.4	19.5	5.79	1.0	ZB-1
11.9	5.68	10.2	19.0	5.46	"	SA-6
6.8	4.14	18.2	15.4	4.48	"	"
4.2	2.85	41.2	12.7	3.76	"	"
3.5	2.68	37.3	11.6	3.09	"	ZB-1
3.8	1.96	13.8	11.4	3.09	"	SA-6
3.6	1.63	10.0	9.6	2.56	"	"

* Based on exposed coupon area and radiation time.

Corrosion rates observed on the core annulus coupons of crystal bar zirconium-15% Nb, 15% Nb-2% Pd and 15% Nb-1% Fe, sponge zirconium-15% Nb, and crystal bar zirconium-20% Nb, contained in L-2-17, are compared in Table III with the corrosion rates observed on the Zircaloy-2 core annulus coupons for the same experiment. The data are presented as ratios of the observed zirconium alloy corrosion rate to the observed Zircaloy-2 corrosion rate, (all rates based on exposed coupon area and radiation time) at similar power densities. The Zircaloy-2 rates used for the comparisons are the averages of the rates observed on the coupons in annulus arrays 2B-1 and 5A-6. The results are plotted in the usual manner in Fig. 2. Alloys subjected to the Beta quench heat treatment exhibited the best corrosion behavior, and the rates for all alloys with this heat treatment are about 70% of those for Zircaloy-2.

TABLE III

Ratio of Zirconium Alloy CA Coupon Corrosion Rates to Zircaloy-2 CA Coupon
Corrosion Rates at Similar Power Densities

Alloy	Power Density (w/ml)	Heat Treatment				
		A	B	C	D	E
Xtal Bar - 20% Nb	3.09					1.03
	5.79					0.84
Xtal Bar-15% Nb-1% Fe	2.40					0.86
	2.56					
	2.74		0.94	1.34		
	2.90	0.70				
	3.29					1.03
	3.48			1.34		
	3.76		0.87			
	3.96	0.71				
Xtal Bar-15% Nb	3.29					0.85
	3.49			1.35		
	3.76		0.93			
	3.97	0.79				
	4.48					0.82
	4.80			1.25		
	5.10		0.88			
	5.46	0.72				
Sponge Zr-15% Nb	2.40					0.82
	2.56			1.29		
	2.73		0.95			
	2.90	0.74				
	4.48					0.85
	4.80			1.24		
	5.10		0.95			
	5.46	0.71				

A - Beta quenched (1000°F for 2 hr, water quenched)
 B - 600°C for 2 weeks - air cooled
 C - 500°C for 2 weeks - air cooled
 D - 400°C for 2 hr. - water quenched
 E - Beta quenched - pre-oxidized

ZIRCONIUM ALLOY CORROSION RATES VS. FISSION POWER DENSITY (L-2-17)

CORE CHANNEL COUPONS

CORE ANNULUS COUPONS

FIG. 2

OFNL-LR-DWG-27292
UNCLASSIFIED

REFERENCES

1. J. E. Baker, Zirconium Alloy Data from Loops L-4-11 and L-4-16, ORNL CF-57-7-84.
2. J. E. Baker, Preliminary Zirconium Alloy Data from Loop L-2-14, ORNL CF-57-8-121 (Revised), August 28, 1957.
3. G. H. Jenks et al., HRP Quar. Prog. Rep., Jan. 31, 1957, ORNL-2272, p 104.