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Pacific Northwest Laboratory Monthly Report to the Nuclear Research and Applications Division for April 1976

H. T. Fullam

May 1976

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Battelle
Pacific Northwest Laboratories

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PACIFIC NORTHWEST LABORATORY MONTHLY REPORT TO THE NUCLEAR RESEARCH AND APPLICATIONS DIVISION FOR APRIL 1976

H. T. Fullam

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Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

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PACIFIC NORTHWEST LABORATORY

MONTHLY REPORT TO THE

NUCLEAR RESEARCH AND APPLICATIONS DIVISION

FOR APRIL 1976

STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

At Hanford, strontium is separated from the high-level waste, then converted to the fluoride, and doubly encapsulated in small, high-integrity containers for subsequent long-term storage. The fluoride conversion, encapsulation and storage take place in the Waste Encapsulation and Storage Facilities (WESF). This encapsulated strontium fluoride represents an economical source of ^{90}Sr *if the WESF capsule can be licensed for heat source applications under anticipated use conditions. The objectives of this program are to obtain the data needed to license* $^{90}SrF_2$ *heat sources and specifically the WESF* $^{90}SrF_2$ *capsules. The information needed for licensing can be divided into three general areas:*

1. *Long-term* SrF_2 *compatibility data.*
2. *Chemical and physical property data on* $^{90}SrF_2$.
3. *Capsule property data such as external corrosion resistance, crush strength, etc.*

The current program is designed to provide the required information.

LONG-TERM COMPATIBILITY TESTS

The long-term compatibility tests are continuing as scheduled. The 1000-hr tests have been completed and the $^{90}SrF_2$ couples are now being sectioned. The test specimens will be shipped to ORNL for evaluation. The specimens will be shipped in two batches with the first batch of 12 TZM specimens to be shipped by the end of April. The second batch of 12 Haynes Alloy 25 and 12 Hastelloy C-276 specimens will be shipped about the end of May. Visual examination of the TZM specimens gave no indication of unexpected metal attack.

Metallographic examination of the 1000-hr nonradioactive test specimens has been completed and the specimens are now being examined using scanning electron microscopy (SEM) and the electron microprobe (EM). Preliminary estimates of metal attack, based on evaluation of the photomicrographs, are given in Table 1. As is the case with most compatibility specimens, the metal attack was nonuniform and the values given in Table 1 represent the maximum attack observed. The value given may have to be revised as SEM and EM data become available.

Various types of metal attack were observed with the different specimens but in general the attack could be divided into two basic types: chemical attack and changes in the alloy microstructure. Chemical attack is defined as those attack mechanisms which can be directly attributed to reactions between the alloy and the fluoride, and includes such mechanisms as surface dissolution, grain boundary attack, pitting, subsurface void formation, etc. Microstructural changes are defined as those affected areas where the alloy morphology differs significantly from that of the bulk of the test specimen, and includes such structural changes as the disappearance of normal alloy precipitates, the formation of abnormal precipitates and marked changes in grain size. The microstructural changes can also be attributed to fluoride attack since they do not occur in control specimens tested without fluoride present. However, no direct evidence can be obtained from the photomicrographs to show the changes are due to fluoride attack. Additional analytical data (SEM, EM, chemical analysis, etc) will be needed to show the interrelationship.

The 1000-hr test results show the TZM was much more resistant to fluoride attack than the other two alloys. For the case of the Hastelloy C-276 and Haynes Alloy 25, changes in alloy microstructure generally occurred to much greater depths than did the chemical attack. These results agree quite well with those obtained in the short-term compatibility tests. The results also indicate that the metal attack increased slightly as the surface to volume ratio of the test couples was decreased. This is to be expected

TABLE 1. Estimates of Metal Attack for Test Specimens Exposed to Nonradioactive SrF_2 for 1000 hr

Material Tested	Temperature, °C	Couple S/V Ratio,[a] cm^{-1}	Depth of Metal Affected, mils	
			Chemical Attack	Change in Microstructure
Hastelloy C-276	600	4.5	<1	0
	600	4.5	1	5
	600	2.5	<1	2
	600	0.9	1	4
	800	4.5	<1	<1
	800	4.5	1	2
	800	2.5	<1	2
	800	0.9	10	15
	1000	4.5	2	4
	1000	4.5	3	4
	1000	2.5	3	5
Hastelloy C-276	1000	0.9	4	6
Haynes Alloy 25	600	4.5	<1	5
	600	4.5	<1	3
	600	2.5	<1	2
	600	0.9	1	2
	800	4.5	<1	3
	800	4.5	<1	1
	800	2.5	<1	1
	800	0.9	1	2
	1000	4.5	2	1
	1000	4.5	2	1
	1000	2.5	2	0
Haynes Alloy 25	1000	0.9	3	2
TZM	600	4.5	0	0
	600	4.5	<1	0
	600	2.5	<1	0
	600	0.9	<1	0
	800	4.5	<1	0
	800	4.5	<1	0
	800	2.5	<1	0
	800	0.9	1	0
	1000	4.5	<1	0
	1000	4.5	<1	0
	1000	2.5	<1	0
TZM	1000	0.9	<1	0

(a) Couple metal surface to fuel volume ratio, cm^{-1}

if impurities in the fluoride are the principal cause of metal attack. A more detailed discussion of the attack mechanisms will be given in future reports when all the analytical data are available.

ADDITIONAL SHORT-TERM COMPATIBILITY TESTS

Additional short-term compatibility tests are underway to evaluate materials not covered in the original tests. A total of 32 materials are being tested at 800°C for 1500 and 4400 hr using nonradioactive SrF_2 similar in composition to WESF $^{90}SrF_2$. A portion of the 1500-hr tests have been completed and the test specimens (24) are now being examined. Visual examination of the test specimens indicated some of them were badly corroded. A Hafnalloy specimen (Hf-0.25% Pt-0.25% Pd) had completely reacted with the fluoride, while samples of platinum and gold were almost completely consumed. Samples of copper, iridium and rhenium appeared to be completely unaffected by the fluoride.

THERMAL AGING OF HASTELLOY C-4

The effect of thermal aging on the impact strength of Hastelloy C-4 is being investigated over a temperature range of 600 to 1000°C. The 5000 hr tests have been completed, and the impact strength of the aged specimens obtained using a Baldwin Charpy impact machine. The specimens were impacted at room temperature and 250°C and the results obtained are shown in Table 2. The 5000 hr results confirm those obtained with the 1000-hr test specimens, and show a sharp decrease in the impact strength of the alloy when aged at 600°C. Aging at higher temperatures had less effect on the alloys, and the specimens aged at 900 and 1000°C had a higher impact strength than the "as-received" material. Metallographic examination of the specimens is now underway to determine the effect of thermal aging on alloy morphology.

TABLE 2. The Effect of Thermal Aging on the Impact Strength of Hastelloy C-4[a]

Test Temp, °C	Exposure Time, hr	Charpy Impact Strength, ft-lb[b] Room Temp	250°C
As-Received[c]	-	61.8	64.2
600	1000	38	41
	5000	19.7	21.7
800	1000	56.1	59.0
	5000	53.7	57.5
900	1000	76.3	78.5
	5000	64.7	67.5
1000	1000	81.5	83.0
	5000	70.6	70.1

a. Specimens were 0.145 in. (3.7 mm) thick x 0.394 in. (10 mm) wide.

b. Values given for 600, 800 and 900°C are the average of triplicate specimens. Values given for 1000°C are the average of duplicate specimens.

c. The alloy received from the vendor had been solution heat treated at 1950°F and rapid quenched.

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