**Quarterly Report on the
Strontium Heat Source
Development Program,
Advanced Nuclear Systems
and Projects Division for
July-September 1979**

H.T. Fullam

October 1979

**Prepared for the U.S. Department of Energy
under Contract EY-76-C-06-1830**

**Pacific Northwest Laboratory
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SOURCE DEVELOPMENT PROGRAM, ADVANCED
NUCLEAR SYSTEMS AND PROJECTS DIVISION
FOR JULY-SEPTEMBER 1979

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Pacific Northwest Laboratory
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SUMMARY

Metallographic examination of the metal specimens exposed to $^{90}\text{SrF}_2$ for 20,000 h was completed, as was the examination of the specimens exposed to nonradioactive SrF_2 for 30,000 hours.

Fabrication and welding of the prototype capsules to be used in the qualification testing program was completed.

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STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

H. H. Van Tuyl, Program Manager
H. T. Fullam, Principal Investigator
D. G. Atteridge
F. A. Simonen

At Hanford, strontium is separated from the high-level waste, 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). The 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 $^{90}\text{SrF}_2$ heat sources, and specifically the WESF $^{90}\text{SrF}_2$ capsules. The information needed for licensing can be divided into three general task areas:

Task 1 - Chemical and Physical Properties of $^{90}\text{SrF}_2$

Task 2 - $^{90}\text{SrF}_2$ Compatibility Studies

Task 3 - Capsule Qualification and Licensing

Efforts are proceeding concurrently on all three tasks to obtain the required information.

TASK 1 - CHEMICAL AND PHYSICAL PROPERTIES OF $^{90}\text{SrF}_2$ (H. T. Fullam)

No activity this quarter.

TASK 2 - $^{90}\text{SrF}_2$ COMPATIBILITY STUDIES (H. T. Fullam)

Metallographic examination of the metal specimens from the 20,000-h tests with $^{90}\text{SrF}_2$ has been completed by Oak Ridge National Laboratory (ORNL). Estimates of metal attack based on the photomicrographs obtained are given in Table 1, together with the results of the shorter-duration tests. Micrographs of the various metal specimens are shown in Figures 1 through 3. Attack of the 20,000-h metal specimens was not significantly greater than that observed in the 12,000-h tests, except for the two Hastelloy C-276 samples tested at 1000°C . Attack of the two specimens was much greater than anticipated based on earlier results, since all of the other compatibility test results show a marked decrease in the rate of metal attack after 6000- to 12,000-h exposure. Reasons for the increased attack of the two Hastelloy C-276 samples have not been determined.

Metallographic examination of the metal specimens exposed to nonradioactive SrF_2 for 30,000 h has been completed. The results obtained are presented in Table 2, and micrographs of the various specimens are shown in Figures 4 through 6. The extent of metal attack was very similar to that observed in the 6000-h, 12,000-h and 20,000-h tests.

Samples from the inner capsule of the WESF $^{90}\text{SrF}_2$ storage capsule, which was held at 800°C for 3 yr, were shipped to ORNL. Metallographic examination of the samples is now under way.

TABLE 1. Estimated Attack of Metal Specimens Exposed to $^{90}\text{SrF}_2$, Capsule S/V^(a) = 4.5 cm⁻¹

Material	Temperature, °C	Depth of Metal Affected, mils							
		Chemical Attack				Changes in Microstructure			
		1,000 h	6,000 h	12,000 h	20,000 h	1,000 h	6,000 h	12,000 h	20,000 h
Hastelloy C-276	600	3	3	5	8	4	4	7	10
Hastelloy C-276	600	3	3	7	4	5	5	10	6
Hastelloy C-276	800	7	8	12	7	12	20	25	10
Hastelloy C-276	800	6	(b)	11	10	11	(b)	18	12
Hastelloy C-276	1,000	7	8	20	35	15	24	> 60	> 40
Hastelloy C-276	1,000	10	12		30	15	> 30		> 40
Haynes 25	600	1	3	4	3	0	0	4	5
Haynes 25	600	2	5	3	7	0	0	4	8
Haynes 25	800	5	10	6	5	10	16	8	8
Haynes 25	800	4	11	7	7	6	18	10	12
Haynes 25	1,000	6	12	10	10	8	18	25	> 30
Haynes 25	1,000	7	10		13	9	10		25
TZM	600	1	4	1	2	0	0	0	3
TZM	600	2	1	2	3	0	0	0	3
TZM	800	2	2	2	2	0	0	2	3
TZM	800	2	2	2	2	0	0	0	3
TZM	1,000	2	2	3	2	0	35	0	> 30
TZM	1,000	1	2		3	0	35		4

(a) S/V = metal surface-to- $^{90}\text{SrF}_2$ volume ratio of the test couple.
(b) Specimen lost due to furnace malfunction.

FIGURE 1. Hastelloy C-276 Specimens Exposed to $^{90}\text{SrF}_2$ for 20,000 h - Capsule S/V = 4.5 cm^{-1}

600°C

800°C

1000°C

AS-POLISHED

ETCHED

FIGURE 2. Haynes Alloy 25 Specimens Exposed to $^{90}\text{SrF}_2$ for 20,000 h - Capsule S/V = 4.5 cm^{-1}

FIGURE 3. TBM Specimens Exposed to $^{90}\text{SrF}_2$ for 20,000 h - Capsule S/V = 4.5 cm^{-1}

TABLE 2. Attack of Metal Samples Exposed to Nonradioactive SrF_2 , (a) Capsule S/V = 4.5 cm^{-1} (b)

Material Tested	Temp., °C	Depth of Metal Affected, mils(c)									
		Chemical Attack					Change in Microstructure				
		1,000 h	6,000 h	12,000 h	20,000 h	30,000 h	1,000 h	6,000 h	12,000 h	20,000 h	30,000 h
Hast C-276	600	<1	3	2	1	1	0	4	8	6	5
Hast C-276	600	1	4	2	1	1	5	5	7	4	3
Hast C-276	800	<1	2	2	3	1	<1	3	3	4	2
Hast C-276	800	1	2	2	2	2	3	3	2	2	2
Hast C-276	1,000	2	2	4	3	3	4	6	7	6	4
Hast C-276	1,000	3	3	2	3	3	4	7	8	5	6
Haynes 25	600	<1	2	2	2	1	5	3	2	0	0
Haynes 25	600	<1	1	2	2	2	3	2	<1	0	0
Haynes 25	800	<1	3	3	2	2	3	6	4	2	3
Haynes 25	800	<1	3	3	3	3	1	4	5	2	4
Haynes 25	1,000	2	3	4	25 ^(d)	22 ^(d)	1	7	4	4	4
Haynes 25	1,000	2	3	3	18 ^(d)	20 ^(d)	1	4	12	5	5
TZM	600	0	<1	0	<1	<1	0	0	0	0	0
TZM	600	<1	<1	-	<1	<1	0	0	-	0	0
TZM	800	<1	<1	<1	<1	<1	0	0	0	0	0
TZM	800	<1	<1	<1	<1	<1	0	0	0	0	0
TZM	1,000	<1	<1	<1	<1	<1	0	0	0	0	<1
TZM	1,000	1	<1	<1	<1	<1	0	0	0	0	<1

(a) The SrF_2 contained impurities similar to those found in WESF $^{90}\text{SrF}_2$.

(b) Each test couple had an exposed metal surface-to- SrF_2 volume ratio (S/V) of 4.5 cm^{-1} .

(c) Estimated from specimen photomicrographs.

(d) Specimen exhibited a few isolated voids to a considerable depth.

FIGURE 4. Hastelloy C-276 Specimens Exposed to Nonradioactive SrF_2 for 30,000 h - Capsule S/V = 4.5 cm^{-1}

FIGURE 5. Haynes Alloy 25 Specimens Exposed to Nonradioactive SrF_2 for 30,000 h - Capsule S/V = 4.5 cm^{-1}

FIGURE 6. TBM Specimens Exposed to Nonradioactive SrF_2 for 30,000 h - Capsule S/V = 4.5 cm^{-1}

TASK 3 - CAPSULE QUALIFICATION AND LICENSING (D. G. Atteridge)

Capsule Design

The initial drafts of two topical reports on the design of the heat-source outer capsule were reviewed and approved by ANSP. The reports are Stress Analysis and Testing of the Outer Capsule Design for the Strontium Heat Source Development Program by F. A. Simonen, R. J. Shippell, and D. G. Atteridge, and Collapse of Experimental Capsules Under External Pressure by F. A. Simonen and R. J. Shippell. The reports will be issued during the first quarter of FY 1980.

Capsule Fabrication and Testing

The prototype capsules to be used in the qualification testing program have been fabricated and welded. Five Hastelloy C-276 inner capsules were obtained from Rockwell Hanford, and are the standard inner capsules used in the WESF $^{90}\text{SrF}_2$ storage capsule. The inner capsules were filled with nonradioactive SrF_2 and seal-welded. The inner capsules were inserted into the outer capsules that are to be subjected to the 30-ft drop test.

A total of fifteen Hastelloy S and seven Hastelloy C-4 prototype outer capsules were fabricated and welded by the Stellite Division of the Cabot Corporation. The fabrication, inspection, and welding at Cabot was arranged and overseen by R. C. Lawrence of Pacific Northwest Laboratory (PNL). He delivered the inner capsules to Cabot, inspected the outer capsule components after fabrication, and was present during capsule welding. All capsules are now welded and have arrived at or are on their way to PNL.

The high-pressure autoclave and the high-temperature capsule-aging furnaces needed for the qualification testing of the prototype capsules were also checked out this quarter. The autoclave to be used for the 1000-bar hydrostatic pressure test was held at 15,000 psi for a week without problems. The high-temperature furnaces to be used for long-term aging of the prototype capsules were brought up to operating temperature and held there without incident.

A total of four Hastelloy S and two Hastelloy C-4 prototype capsules will be qualification-tested in the as-fabricated condition. The testing will begin as soon as the capsule welds have been radiographed. The remaining prototype capsules will be thermally aged in air for 8000 h and then subjected to the qualification tests. The aging temperatures have not been finalized, but will probably be 650°C and 725°C.

Oxidation of Hastelloy S and Hastelloy C-4 (H. T. Fullam)

Electron microprobe analysis of the Hastelloy S and Hastelloy C-4 specimens heated in air at 600°C to 800°C for 10,000 h has been completed. Interpretation of the results is now under way.

The 2500-h tests to determine the effect of air oxidation at 600°C to 800°C on the impact properties of Hastelloy S and Hastelloy C-4 have been completed. Room-temperature testing of the oxidized specimens will be carried out in the first quarter of FY 1980.

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