**Quarterly Report on the
Strontium Heat Source
Development Program,
Advanced Nuclear Systems
and Projects Division for
April-June 1980**

H. T. Fullam

July 1980

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
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QUARTERLY REPORT ON THE STRONTIUM HEAT SOURCE
DEVELOPMENT PROGRAM, ADVANCED NUCLEAR SYSTEMS
AND PROJECTS DIVISION FOR APRIL-JUNE 1980

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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

Oak Ridge National Laboratory completed metallographic examination of the metal specimens from the 30,000-h compatibility tests with $^{90}\text{SrF}_2$. Electron microprobe analysis of the specimens is now under way. Results show that chemical attack of the 30,000-h specimens was not much greater than that observed in the 6,000- to 20,000-h tests.

Work continues on qualification testing of the as-fabricated prototype outer capsules. As-fabricated Hastelloy S and Hastelloy C-4 outer capsules passed the hydrostatic pressure, percussion, thermal, and thermal-quench tests without difficulty.

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STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

H. H. Van Tuyl, Program Manager

H. T. Fullam, Principal Investigator

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 $^{90}\text{SrF}_2$

No activity this quarter.

TASK 2 - $^{90}\text{SrF}_2$ COMPATIBILITY STUDIES

Metallographic examination of the metal specimens from the 30,000-h tests with $^{90}\text{SrF}_2$ has been completed at the Oak Ridge National Laboratory (ORNL). Estimates of metal attack, determined from photomicrographs of the test specimens, are given in Table 1, together with the results of the earlier tests. The results show that chemical attack of metal specimens exposed to $^{90}\text{SrF}_2$ at 600° and 800°C for 30,000 h was not much greater than that observed in tests lasting 6,000 to 20,000 h. Some of the 30,000-h specimens did show a substantial increase, however, in the depth of metal affected by microstructural changes. Electron microprobe analysis of the 30,000-h specimens is now under way at ORNL to determine the reaction mechanisms involved in both the chemical attack and microstructural changes.

The compatibility coupons being tested at 1000°C for 30,000 h were lost because of the catastrophic oxidation of the Inconel-600 protective jacket containing the test couples. Since the failure occurred just shortly before the tests were scheduled to be completed, it was impossible to repeat the tests. Reason for the failure of the Inconel-600 jacket was not determined, but the monitoring equipment showed that the oxidation of the jacket was not due to a furnace malfunction and overheating.

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

Material	Temp., °C	Depth of Metal Affected, mils									
		Chemical Attack					Changes 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
Hastelloy C-276	600	3	3	5	8	3	4	4	7	10	22
Hastelloy C-276	600	3	3	7	4	10	5	5	10	6	28
Hastelloy C-276	800	7	8	12	7	12	12	20	25	10	20
Hastelloy C-276	800	6	(b)	11	10	14	11	(b)	18	12	36
Hastelloy C-276	1,000	7	8	20	35	(c)	15	24	>60	>40	(c)
Hastelloy C-276	1,000	10	12		30	(c)	15	>30		>40	(c)
Haynes 25	600	1	3	4	3	5	0	0	4	5	20
Haynes 25	600	2	5	3	7	5	0	0	4	8	20
Haynes 25	800	5	10	6	5	12	10	16	8	8	12
Haynes 25	800	4	11	7	7	10	6	18	10	12	15
Haynes 25	1,000	6	12	10	10	(c)	8	18	25	30	(c)
Haynes 25	1,000	7	10		13	(c)	9	10		25	(c)
TZM	600	1	4	1	2	2	0	0	0	3	4
TZM	600	2	1	2	3	1	0	0	0	3	0
TZM	800	2	2	2	2	2	0	0	2	3	0
TZM	800	2	2	2	2	2	0	0	0	3	3
TZM	1,000	2	2	3	2	(c)	0	35	0	>30	(c)
TZM	1,000	1	2		3	(c)	0	35		4	(c)

(a) S/V = metal surface-to- $^{90}\text{SrF}_2$ volume ratio of the test capsule.

(b) Specimen lost due to furnace malfunction.

(c) Specimen lost due to catastrophic oxidation of the Inconel-600 jacket containing the test capsule.

TASK 3 - CAPSULE QUALIFICATION AND LICENSING

Work continues on qualification testing of the prototype outer capsules in the as-fabricated condition. The following section lists the qualification tests to which the capsules are subjected.

Qualification Test Requirements for the $^{90}\text{SrF}_2$ Heat Source Outer Capsule

The outer capsule of the $^{90}\text{SrF}_2$ heat source must meet the following requirements in both the as-fabricated and post-service conditions, without support from the inner capsule.

1. Hydrostatic Pressure Test

The capsule shall not leak at a rate greater than $10^{-8} \text{ cm}^3/\text{s}$ (STP) after being subjected to an external pressure of 14,500 psi (1000 bar).

2. Impact Test

The capsule shall not leak at a rate greater than $10^{-8} \text{ cm}^3/\text{s}$ (STP) when dropped from a height of 9 m (~30 ft) onto a steel plate at least 1.25 cm (~1/2 in.) thick that has been wet-floated onto a concrete block with a mass at least 10 times that of the capsule and set on firm soil. The steel plate shall be flat and horizontal and the capsule shall be dropped in such a manner that the maximum possible damage will result. In order to maximize the severity of the test, the outer capsule shall contain a standard WESF inner capsule filled with nonradioactive SrF_2 .^(a)

(a) Capsules subjected to the impact test as a secondary test do not contain an inner capsule (see text).

3. Percussion Test

The capsule shall not leak at a rate greater than 10^{-8} cm³/s (STP) after being struck by the flat face of a 2.5-cm-dia (~1-in.-dia) steel billet with an impact energy equivalent to 7 kg-m (~50 ft-lb). The billet edges shall be rounded off to a radius of not less than 3 mm, and the capsule shall rest on a lead sheet equal to or less than 25 mm thick with a Brinell hardness of 3.5 to 4.5. The lead sheet shall cover a greater area than the capsule and shall rest on a smooth, solid surface. A fresh lead sheet shall be used for each test, and the capsule shall be struck in such a manner that the maximum damage will result. (The capsule is to be struck at the five locations shown in Figure 1.)

4. Thermal Test

The capsule shall not leak at a rate greater than 10^{-8} cm³/s (STP) after being heated to 800°C and held at that temperature for a minimum of 30 min.

5. Thermal Quench Test

The capsule shall not leak at a rate greater than 10^{-8} cm³/s (STP) after being heated to its maximum operating temperature of 800°C and then plunged into a water-ethylene glycol solution at 32°F (0°C). The capsule shall remain for 1 hour in the circulating solution, which shall at no time exceed 41°F (5°C).

FIGURE 1. Sketch Showing the Five Locations Where the Outer Capsule is to be Struck by the Steel Billet in the Percussion Test

Testing Procedures

A total of five Hastelloy S® and three Hastelloy C-4® as-fabricated capsules are being tested. Each capsule is subjected to a primary test and, if it passes, is then subjected to a series of secondary tests. The testing sequences for the eight capsules are given in Table 2.

® Stellite Division of Cabot Corp., Kokomo, Indiana.

TABLE 2. Testing Sequences for the As-Fabricated Prototype Outer Capsules

<u>Outer Capsule</u>	<u>Material</u>	<u>Primary Test</u>	<u>Secondary Tests</u>
A ^(a)	Hastelloy S	Impact	Percussion Pressure Thermal Thermal Quench
B	Hastelloy S	Pressure	Percussion Thermal Thermal Quench Impact
C	Hastelloy S	Percussion	Pressure Thermal Thermal Quench Impact
D	Hastelloy S	Thermal	Thermal Quench Pressure Puncture Impact
E	Hastelloy S	Thermal Quench	Thermal Pressure Puncture Impact
F ^(a)	Hastelloy C-4	Impact	Puncture Pressure Thermal Thermal Quench
G	Hastelloy C-4	Pressure	Puncture Thermal Thermal Quench Impact
H	Hastelloy C-4	Percussion	Pressure Thermal Thermal Quench Impact

(a) Capsule contained a standard WESF inner capsule filled with nonradioactive SrF_2 .

Each capsule that is subjected to the impact test as the primary test contains a standard WESF inner capsule filled with nonradioactive SrF_2 . The other capsules are tested without an inner capsule.

Primary tests were completed on all of the capsules except for the two subjected to the impact test (capsules A and F). The six capsules passed the primary tests without difficulty. Secondary testing of the six capsules was also completed, except for the impact tests. These capsules also passed the secondary tests without difficulty.

All primary and secondary testing of the as-fabricated capsules, as outlined in Table 2, will be completed by the end of FY 1980.

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