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

H. T. Fullam

April 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 JANUARY-MARCH 1980

H. T. Fullam

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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

Sectioning of the capsules from the 30,000-h tests with $^{90}\text{SrF}_2$ has been completed at Oak Ridge National Laboratory, and examination of the test specimens is under way.

Metallographic examination of specimens taken from the WESF $^{90}\text{SrF}_2$ capsule that was held at about 800°C for three years has been completed. Attack of the Hastelloy C-276 was not significantly greater than that observed in the WESF capsule held at 800°C for 5000 hours.

Hydrostatic pressure testing (14,500 psi), puncture (percussion) testing, and thermal testing (800°C) of as-fabricated prototype Hastelloy S and Hastelloy C-4 outer capsules were completed. Preliminary examination of the capsules indicates that none suffered any damage as a result of the tests. Detailed examination of the capsules is under way to ensure these findings are correct.

CONTENTS

SUMMARY	iii
FIGURES	vi
TABLES	vi
STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM	1
TASK 1 - CHEMICAL AND PHYSICAL PROPERTIES OF $^{90}\text{SrF}_2$	1
TASK 2 - $^{90}\text{SrF}_2$ COMPATIBILITY STUDIES	1
TASK 3 - CAPSULE QUALIFICATION AND LICENSING	3

FIGURES

1	Temperature Profile of the WESF $^{90}\text{SrF}_2$ Inner Capsule Tested for Three Years - Showing Locations Where Samples Were Taken	2
2	Prototype Hastelloy S and Hastelloy C-4 Outer Capsules Prior to Testing in the As-Fabricated Condition	4
3	As-Fabricated Prototype Hastelloy S and Hastelloy C-4 Outer Capsules After Pressure Testing at 14,500 psi - Showing Dimensional Grids Etched on Capsule Surfaces	5
4	Autoclave and Auxiliary Equipment Used in the Hydrostatic Pressure Test	6
5	Equipment Used in the Puncture (Percussion) Test	7
6	Sketch Showing Five Locations Where Capsule Was Struck With a 1-in.-dia Steel Billet Having an Impact Energy of 50 ft-lb	8
7	Three-Zone Tube Furnace Used for the Thermal Testing of the Prototype Capsules	8

TABLES

1	Estimated Metal Attack at Various Locations in the WESF $^{90}\text{SrF}_2$ Capsule Held at Temperature for Three Years	2
2	Metal Attack Observed in the WESF $^{90}\text{SrF}_2$ Capsule Held at Temperature for 5000 h	2

STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

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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 report period.

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

Oak Ridge National Laboratory has completed the sectioning of the capsules from the 30,000-h tests with $^{90}\text{SrF}_2$. Metallographic examination of the test specimens is now under way.

Metallographic examination has been completed on the test specimens taken from the WESF $^{90}\text{SrF}_2$ capsule that was held at approximately 800°C for three years. Figure 1 shows the four locations where the test specimens were cut from the Hastelloy® C-276 inner capsule and the metal/ $^{90}\text{SrF}_2$ interface temperature at each location. Estimates of metal attack at each of the four locations, based on the photomicrographs obtained, are given in Table 1. For comparison purposes, the results obtained in a similar test in which a WESF capsule was held at about 800°C for 5000 h are shown in Table 2. The data show that chemical attack of the capsule tested for three years was not significantly greater than that observed in the 5000-h test. This provides additional evidence that the metal attack is due primarily to impurities in the $^{90}\text{SrF}_2$, and the impurities are consumed in a relatively short period of time. Similar results have been observed in the other compatibility tests with $^{90}\text{SrF}_2$. One major difference was observed between the two sets of data. The specimens from the capsule tested for 5000 h showed

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FIGURE 1. Temperature Profile of the WESF $^{90}\text{SrF}_2$ Inner Capsule Tested for Three Years - Showing Locations Where Samples Were Taken

TABLE 1. Estimated Metal Attack at Various Locations in the WESF $^{90}\text{SrF}_2$ Capsule Held at Temperature for Three Years

Section(a)	Approximate Temperature, °C	Depth of Metal Affected, mils	
		Chemical Attack	Change in Microstructure
A	778	5	0
B	831	7	12
C	824	12	22
D	800	9	20

(a) Sections taken from the Hastelloy C-276 capsule at locations shown in Figure 1.

TABLE 2. Metal Attack Observed in the WESF $^{90}\text{SrF}_2$ Capsule Held at Temperature for 5000 h

Section(a)	Approximate Temperature, °C	Depth of Metal Affected, mils	
		Chemical Attack	Change in Microstructure
A	762	3	0
B	821	9	0
C	813	8	0
D	790	11	0

(a) Test specimens were taken from the same capsule locations as is shown in Figure 1.

no evidence of changes in the microstructure of the Hastelloy C-276 due to fluoride attack, whereas specimens from the three-year test exhibited extensive microstructural changes. No reasons for these differences have been identified. Overall, the level of attack suffered by the WESF $^{90}\text{SrF}_2$ capsule after three years at $\sim 800^\circ\text{C}$ was less than one would predict based on the data obtained in the long-term $^{90}\text{SrF}_2$ compatibility tests.

TASK 3 - CAPSULE QUALIFICATION AND LICENSING

Sixteen Hastelloy S and seven Hastelloy C-4 prototype outer capsules were fabricated for the qualification-testing program. Five of the Hastelloy S and three of the Hastelloy C-4 capsules are being qualification-tested in the as-fabricated condition while the remaining capsules are being thermally aged at 650° or 725°C for 8000 h prior to testing.

One Hastelloy S and one Hastelloy C-4 capsule were subjected to the 1000-bar hydrostatic pressure test in the as-fabricated condition. Dimensional grids were etched on the capsules prior to testing. Each capsule was tested at 10,000 psi, 12,000 psi, 13,000 psi and 14,500 psi. The capsules were subjected to a leak check (10^{-4} cm^3/s sensitivity), and their physical dimensions and weights were determined after each pressurization. Figure 2 shows the capsules before the grids were etched on them. Figure 3 shows the capsules after their final pressurization at 14,500 psi and Figure 4 shows the autoclave and accessory equipment used for the pressure tests.

Physical measurements showed that no detectable distortion of the capsules had occurred during the pressure tests. Preliminary leak checks at a sensitivity of 10^{-4} cm^3/s indicated no capsule damage had occurred. The capsules are now being helium leak-checked (10^{-8} cm^3/s sensitivity), and the welds radiographed to ensure no capsule damage was incurred during the hydrostatic pressure testing.

As-fabricated Hastelloy S and Hastelloy C-4 capsules were subjected to the puncture (percussion) test using the equipment shown in Figure 5. Each capsule was placed on a 1/2-in.-thick lead sheet, set on a solid concrete floor, and struck with a 1-in.-dia steel billet at the five locations shown in Figure 6. The impact energy of the billet was 50 ft-lb for each strike. The capsule was repositioned on a fresh lead surface for each strike. Preliminary leak checks, physical measurements, and visual examination indicated that neither capsule had suffered any damage from the puncture test. The capsules are now being radiographed and subjected to a final helium leak check to ensure no damage was incurred.

As-fabricated Hastelloy S and Hastelloy C-4 capsules were subjected to the thermal test at 800°C . The capsules were heated individually to 800°C and held at temperature for 30 min using the three-zone tube furnace shown in Figure 7. Three calibrated, sheathed Cr-Al thermocouples that had been tack-welded to the capsule surface monitored the capsule temperature at various locations. The three-zone furnace permitted the capsule to be maintained at $800^\circ \pm 5^\circ\text{C}$ over its entire length. Preliminary leak checks, visual examination, and dimensional measurements indicated that neither capsule suffered any apparent damage from the test. The capsules are now being helium leak-checked, and the welds radiographed. After the final capsule checks are completed, the two capsules will be subjected to an 800°C thermal-quench test.

FIGURE 2. Prototype Hastelloy S and Hastelloy C-4 Outer Capsules Prior to Testing in the As-Fabricated Condition

FIGURE 3. As-Fabricated Prototype Hastelloy S and Hastelloy C-4 Outer Capsules After Pressure Testing at 14,500 psi - Showing Dimensional Grids Etched on Capsule Surfaces

FIGURE 4. Autoclave and Auxiliary Equipment Used in the Hydrostatic Pressure Test

FIGURE 5. Equipment Used in the Puncture
(Percussion) Test

FIGURE 6. Sketch Showing Five Locations Where Capsule Was Struck With a 1-in.-dia Steel Billet Having an Impact Energy of 50 ft-lb

FIGURE 7. Three-Zone Tube Furnace Used for the Thermal Testing of the Prototype Capsules

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