**Quarterly Report on the
Strontium Heat Source
Development Program, Space
and Terrestrial Systems
Division for January-March
1981**

H. T. Fullam

May 1981

Prepared for the U.S. Department of Energy
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CONTENTS

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	1
REFERENCE	8

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

A topical report entitled The Migration of Strontium-90 From a Deep Ocean Source by S. Yabusaki was submitted to the Space and Terrestrial Systems Division for review and comment.

A literature search on the properties of $^{90}\text{SrF}_2$ was completed. Work is now underway on updating the Strontium-90 Fluoride Data Sheet (Fullam 1977) to incorporate the latest published information.

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

The first draft of the final report summarizing all of the Pacific Northwest Laboratory compatibility studies has been prepared and is now being edited.

TASK 3--CAPSULE QUALIFICATION AND LICENSING

Qualification testing of the first set of aged prototype outer capsules was completed. The capsules were aged at 650°C or 725°C for 8000 hours. Each capsule was subjected to one primary qualification test and then to four secondary qualification tests. The testing sequences for the capsules are given in Table 1. The five qualification tests are given in Table 2.

With one exception, the aged capsules passed the five qualification tests without difficulty. The only capsule that failed to pass the qualification tests was No. 4--the Hastelloy C-4 capsule aged at 650°C . This capsule passed the primary pressure test and the secondary impact and percussion tests. After the capsule was subjected to the thermal test, a leak was detected. Examination of the capsule showed a crack in the weld zone immediately above the

TABLE 1. Testing Sequence for the Prototype Outer Capsules Aged
for 8000 Hours

<u>Capsule No.</u>	<u>Capsule Material</u>	<u>Aging Temp., °C</u>	<u>Primary Quali- fication Test</u>	<u>Secondary Quali- fication Tests</u>
S-11	Hastelloy S	725	Percussion	Pressure Thermal Thermal quench Impact
S-19	Hastelloy S	725	Pressure	Impact Percussion Thermal Thermal quench
S-21	Hastelloy S	725	Thermal	Thermal quench Pressure Percussion Impact
S-16	Hastelloy S	725	Thermal quench	Thermal Pressure Percussion Impact
S-23	Hastelloy S	650	Percussion	Pressure Thermal Thermal quench Impact
S-22	Hastelloy S	650	Pressure	Impact Percussion Thermal Thermal quench
S-14	Hastelloy S	650	Thermal	Thermal quench Pressure Percussion Impact
S-18	Hastelloy S	650	Thermal quench	Thermal Pressure Percussion Impact
4	Hastelloy C-4	650	Pressure	Impact Percussion Thermal Thermal quench
6	Hastelloy C-4	725	Pressure	Impact Percussion Thermal Thermal quench
7	Hastelloy C-4	725	Percussion	Pressure Thermal Thermal quench Impact

TABLE 2. Qualification Tests for the Heat Source Outer Capsule

1. Pressure Test

The heat source capsule shall not leak at a rate greater than 10^{-8} cm³/s after being subjected to an external pressure of 14,500 psi (1000 bar).

2. Percussion Test

The capsule shall not leak at a rate greater than 10^{-8} cm³/s after being struck by the flat face of a 2.5-cm-dia (approximately 1-in.) steel billet with an impact energy equivalent to 7 kg-m (approximately 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 possible damage will result.

3. Impact Test

The capsule shall not leak at a rate greater than 10^{-8} cm³/s when dropped from a height of 9 m (approximately 30 ft) onto a steel plate at least 1.25 cm (approximately 1/2 in.) thick that has been wet-floated onto a concrete block with a mass of at least ten 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.

4. Thermal Test

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

5. Thermal Quench Test

The capsule shall not leak at a rate greater than 10^{-8} cm³/s 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 one hour in the circulating solution, which shall at no time exceed 41°F (5°C).

point where the capsule had been impacted in the impact test (see Figure 1). The crack was about one inch long and parallel to the weld line. The endcap was removed from the capsule and sectioned. A section from the crack area and a section from the opposite side of the cap were submitted for metallographic examination.

Visual examination of the endcap indicated that the weld metal was very thin at the point of failure. The capsule design calls for a 0.1-in. penetration weld. Radiography of the capsule, before aging, indicated that the weld penetration was in the range 0.04 to 0.06 in. Therefore, it was decided to age and test the capsule without rewelding. Preliminary indications were that the weld penetration at the point of failure was only 0.01 to 0.02 in., instead of the 0.04 to 0.06 in. indicated by radiography. This lack of penetration is probably why the capsule failed. It appears that stresses developed during the impact test started the crack and thermal stresses during the thermal test extended the crack to the point of failure.

Hastelloy C-4 and Hastelloy S tensile and Charpy V Notch (CVN) specimens were aged at 650°C and 725°C for up to 8000 hours in the same furnaces as the prototype outer capsules.

FIGURE 1. Sketch of Failed Capsule Showing Location of Crack

The test specimens were fabricated from the same lots of metal that were used for fabricating the prototype outer capsules. The tensile specimens were 0.5 in. dia and the CVN specimens were 0.394 in. square. The specimens were sealed in evacuated quartz envelopes to prevent oxidation during the aging operation.

The aged specimens were tested at room temperature and the results are shown in Figures 2 and 3. Aging at 650°C or 725°C had only a slight effect on the tensile properties of the two alloys but produced sharp decreases in their impact energies.

Hastelloy C-276 CVN specimens were aged in a vacuum at 650°C, 725°C, and 800°C for up to 8000 hours. The specimens were subsize specimens 0.197 in. thick. The specimens were impact-tested at room temperature. The results are shown in Figure 4. The data show that aging the Hastelloy C-276 at 725°C and 800°C decreases the impact energy of the alloy by more than 88 . Aging at 650°C had less effect, but the impact energy of the alloy was still decreased by more than 60 .

FIGURE 2. Effect of Thermal Aging on the Room Temperature Properties of Hastelloy C-4

FIGURE 3. Effect of Thermal Aging on the Room Temperature Properties of Hastelloy S

FIGURE 4. Effect of Thermal Aging on the Charpy Impact Energy of Hastelloy C-276

REFERENCE

Fullam, H. T. 1977. Strontium-90 Fluoride Data Sheet. BNWL-2284, Pacific Northwest Laboratory, Richland, Washington.

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