**Pacific Northwest Laboratory
Monthly Report on Strontium
Heat Source Development
Program, Nuclear Research
and Applications Division
for October 1976**

H. T. Fullam

November 1976

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PACIFIC NORTHWEST LABORATORY
STRONTIUM HEAT SOURCE DEVELOPMENT
PROGRAM, NUCLEAR RESEARCH AND
APPLICATIONS DIVISION FOR OCTOBER 1976

H. T. Fullam

January 1976

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STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

J. H. Jarrett, Program Manager
H. T. Fullam, Principal Investigator
D. G. Atteridge

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

Dissolution Behavior of $^{90}\text{SrF}_2$

The first draft of the topical report on the dissolution behavior of $^{90}\text{SrF}_2$ has been reviewed by NRA. The revised final draft of the report is now being typed and will be ready for printing in November.

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

Long-Term Compatibility Tests

All of the compatibility tests are continuing on schedule. Metallographic examination and electron microprobe analysis of the 6000 hr tests with nonradioactive SrF_2 is continuing and should be completed in November.

The 6-month test with the full-size WESF capsule filed with fuel-grade $^{90}\text{SrF}_2$ has been completed. Arrangements have been made with ARHCO to section the capsule. Test specimens will be taken from several locations along the length of the inner Hastelloy C-276 capsule and analyzed to determine the extent of metal-fluoride interaction.

TASK 3 - CAPSULE QUALIFICATION AND LICENSING

D. G. Atteridge of the Metallurgy Research Section has been assigned to the Strontium Heat Source Development Program. He will assume responsibility for Task 3 of the program.

Capsule Material Selection

The oxidation assistance and seawater corrosion resistance of Hastelloy C-4 and Hastelloy S are being determined using both solution heat-treated and thermally-aged test specimens.

Oxidation Resistance of Hastelloy S and Hastelloy C-4

The oxidation resistance of solution heat-treated Hastelloy S was determined at temperatures of 600, 700, 800, 900, 1000 and 1100°C. The test specimen was cut from a 0.063-in. sheet and was 2.00 in. x 1.00 in. The specimens were degreased prior to testing but the mill scale was not removed. The cleaned specimens were weighed and then placed in preheated air atmosphere muffle furnaces. Periodically, the specimens were removed from the furnaces, cooled to room temperature, weighed, and then returned to the furnaces. The tests lasted for 1000 hr. At 1000°C or less the specimens formed an adherent oxide scale and specimen weights increased continuously with time at temperature (see Figure 1). The formation of the adherent oxide scale followed a parabolic time dependence. At 1100°C an adherent oxide scale formed initially; but spalling of the oxide scale began after about 50 hr exposure with a corresponding loss of weight (see Figure 2). Only slight spalling was observed up to 550 hr exposure, but then the samples began to lose weight very rapidly.

FIGURE 1. Oxidation of Hastelloy S

FIGURE 2. Oxidation of Hastelloy S at 1100°C

Comparison of the oxidation data for Hastelloy S with the data previously reported for Hastelloy C-4 (BNWL-1845-28) shows that the Hastelloy S oxidizes at a much slower rate than the Hastelloy C-4. However, both alloys suffer the problem of oxide spalling at the higher temperatures.

It was reported earlier (BNWL-1845-28) that when solution heat-treated Hastelloy C-4 was heated in air at 1000°C and higher for extended periods of time the specimens lost weight because of the spalling of the oxide layer. At 1100°C the weight loss of the Hastelloy C-4 exhibited a linear time dependence (see Figure 3). It was felt that the spalling of the oxide layer may have been due to the thermal stresses produced when the test specimens were removed periodically from the furnace, cooled to room temperature, weighed, and then returned to the furnace for additional exposure. Therefore, a second series of tests was carried out in which several solution heat-treated Hastelloy C-4 specimens were held at 1100°C for different times and then removed from the furnace and weighed. This eliminated the thermal cycling the specimens in the first series of tests were subjected too. The results of the second series of tests showed that spalling of the oxide layer occurred at 1100°C even when the specimens were not thermally cycled (see Figure 3). Without thermal cycling a much larger exposure time was required before spalling began; but once spalling began the weight loss exhibited a linear time dependence.

Seawater Corrosion Resistance of Hastelloy S

Laboratory tests were carried out to measure the corrosion resistance of solution heat treated Hastelloy S to natural seawater. The test specimens were cut from the same sheet as the specimens used for the oxidation tests. Specimens dimensions were 2.00 x 1.00 x 0.063 in. Some specimens were in the "as received" condition with mill scale on the major surfaces. Other specimens were polished to remove the scale prior to testing. TIG welded specimens were also evaluated. The tests were carried out at 23°C ± 1°C with and without aeration. The tests lasted 1000 hr, and the

FIGURE 3. Oxidation of Hastelloy C-4 at 1100°C

Hastelloy S was found to be very resistant to attack by the seawater. Microscopic examination of the specimens showed no evidence of attack; and the maximum weight loss observed with any specimen was less than 1 mg, which corresponds to a weight loss of $<0.04 \text{ mg}/\text{cm}^2$.

Material Property Testing Equipment

An instrumented Tinius Olsen Universal Impact Testor having a capacity of 240 ft-lb was recently obtained. Efforts are now underway to fabricate a specimen heating chamber and transfer apparatus which will permit testing of Charpy impact specimens at temperatures up to 1000°C.

A helium leak detector has been obtained; and a test chamber is now being designed which will permit leak testing of full size WESF strontium capsules. The chamber and leak detector will be used in qualification testing of the WESF capsule.

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