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by
H. T. Fullam

June 1976

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Pacific Northwest Laboratories

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PACIFIC NORTHWEST LABORATORY
MONTHLY REPORT TO THE
NUCLEAR RESEARCH AND APPLICATIONS DIVISION
FOR APRIL 1976

STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

At Hanford, strontium is separated from the high-level waste, then 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). This 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 $^{90}SrF_2$ heat sources and specifically the WESF $^{90}SrF_2$ capsules. The information needed for licensing can be divided into three general areas:

1. *Long-term SrF_2 compatibility data.*
2. *Chemical and physical property data on $^{90}SrF_2$.*
3. *Capsule property data such as external corrosion resistance, crush strength, etc.*

The current program is designed to provide the required information.

LONG-TERM COMPATIBILITY TESTS

The long-term compatibility tests are continuing as scheduled. The 1000-hr $^{90}SrF_2$ couples have been sectioned and the test specimens shipped to ORNL for analysis. Metallographic examination of the specimens is now underway. Examination of the 1000-hr nonradioactive SrF_2 test specimens by scanning electron microscopy (SEM) and electron microprobe (EM) is continuing. Preliminary results indicate that attack of the Haynes Alloy 25 and Hastelloy C-276 by the SrF_2 involves a general dissolution of the metal surface and selective leaching of chromium from the alloy matrix. Analysis of the SrF_2 shows a high chromium content confirming the leaching of chromium from the alloys. There was little evidence of grain boundary attack of the two alloys. In the case of the TZM there was a general dissolution of the metal surface and no evidence of grain boundary attack. A detailed evaluation of metal attack, including micrographs and X-ray scans, will be provided when all of the SEM and EM data are available.

Testing of the two full-size WESF $^{90}SrF_2$ capsules is continuing. It has not been possible to obtain capsule temperature measurements during the month, however, because of the strike which is curtailing the hot cell operations at ARHCO. How soon it will be possible to resume taking the temperature measurements is unknown.

A test has been started to determine the effect of a thermal gradient on the compatibility of Hastelloy C-276 with nonradioactive SrF_2. A single test couple is being subjected to a thermal gradient of approximately 560°C with a maximum temperature of about 920°C. The test will last for 6 months after which the test couple will be sectioned and examined to determine metal-fluoride interaction at various locations. The test couple consists of a section of Hastelloy C-276 pipe containing SrF_2 compacted to a density of about 70% of theoretical density. The metal surface to fuel volume ratio (S/V) of the test couple is 1.0 cm^{-1} which is slightly greater than that of the WESF $^{90}SrF_2$ capsule. The nonradioactive SrF_2 being used in the test is the same as that used in the long-term compatibility tests. Composition of the SrF_2 is given in Table 1.

The test capsule was fabricated from 1-1/2 in. Sch-40 Hastelloy C-276 pipe and was 26 in. long. The end pieces were 1/8 in. thick Hastelloy C-276 plate. The SrF_2 was compacted into the capsule in increments by cold pressing. The filled capsule was sealed by TIG welding the end plate in place. Chromel-alumel thermocouples were welded to the surface of the capsules at various locations to monitor the capsule surface temperature during the test. The test couple was placed in a jacket of 304L stainless steel and inserted into a three-zone tube furnace. Each of the three heating zones of the furnace could be controlled independently allowing a temperature gradient to be maintained over the length of the capsule.

Figure 1 shows the capsule surface temperature several days after the test was started. A fairly uniform temperature gradient is maintained across approximately two-thirds of the capsule length, but the system is designed to give a nonuniform gradient across the colder third of the capsule.

TABLE 1. Composition of the Nonradioactive SrF_2 Used in the Compatibility Tests

Component	Wt%
SrF_2	94.50
AlF_3	0.55
BaF_2	0.88
CaF_2	0.36
CdF_2	0.003
CrF_3	0.08
FeF_3	0.03
MgF_2	0.24
NaF	2.28
NdF_3	0.92
NiF_2	0.02
PbF_2	0.05
H_2O	<0.01
NO_3^-	<0.01
O^{-2}	<0.01

ADDITIONAL SHORT-TERM COMPATIBILITY TESTS

Additional compatibility tests are underway to evaluate potential containment materials not covered in the original short-term tests. A total of 29 different materials are being tested at 800°C for 1500 and 4400 hr using nonradioactive SrF_2 of the composition shown in Table 1. Hastelloy C-276, Haynes Alloy 25 and TZM are also being tested as reference materials. The 1500-hr tests have been completed and examination of the test specimens is underway. Metallographic examination of most of the specimens has been completed, and estimates of metal attack, based on the micrographs, are given in Table 2. A detailed discussion of the metal attack will be provided at a later date when all the test results are available.

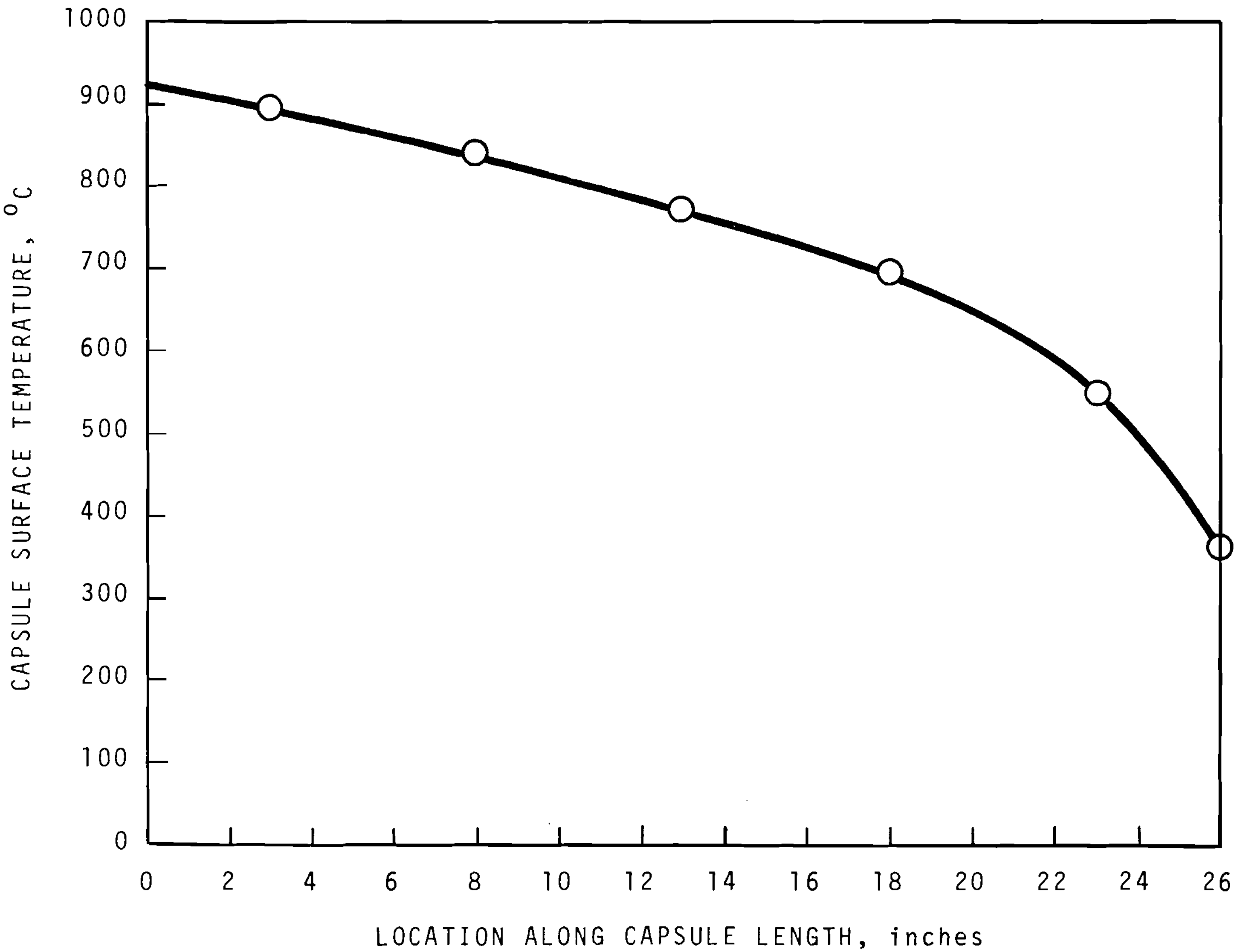

FIGURE 1. Capsule Surface Temperature at Various Locations

TABLE 2. Metal Attack in Test Specimens Exposed to Nonradioactive SrF_2 at 800°C for 1500 Hr

Material	Depth of Metal Affected, mils: Chemical Attack	Depth of Metal Affected, mils: Change in Microstructure
Hastelloy C-276	3	7
Hastelloy C-4	5	12
Hastelloy B	4	15
Hastelloy B-2		
Hastelloy S	7	15
Haynes Alloy 25	2	3
Haynes Alloy 556		
Inconel 617		
Inconel 671	15	25
Incoloy 800		
Rene 41	10	14
Udimet 700	>25	-
Monel 400		
Nickel 200	7	10
Ingot Iron	3	-
Ductile Cast Iron	CR	CR
316L SS	6	-
JS 777		
Copper	>25	-
Titanium	>25	-
Hafnaloy 2525	>25	-
Molybdenum	2	-
TZM	1	-
Niobium	3	2
Ta-10% W	10	-
Mo-50% Re	2	
W-26% Re	2	-
Rhenium	<1	-
Iridium		
Ir-0.3% W		
Platinum	>25	-
Gold	>25	-

\- = no apparent change in microstructure.
CR = complete reaction.

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