**Quarterly Report on the Strontium
Heat Source Development
Program and the Beneficial
Isotopes Utilization Program,
Nuclear Research and Applications
Division for July-September 1976**

October 1976

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QUARTERLY REPORT ON THE STRONTIUM HEAT SOURCE
DEVELOPMENT PROGRAM AND THE BENEFICIAL ISOTOPES
UTILIZATION PROGRAM, NUCLEAR RESEARCH AND
APPLICATIONS DIVISION FOR JULY-SEPTEMBER 1976

H. T. Fullam and K. M. Harmon

October 1976

BATTELLE
Pacific Northwest Laboratories
Richland, Washington 99352

SUMMARY

STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

The long-term compatibility tests are continuing on schedule. Analysis of the specimens from the 1000-hr tests with $^{90}\text{SrF}_2$ is underway at ORNL. Metallographic examination of the test specimens was limited to a low-level effort during August and September because of other commitments. The 6000-hr tests with nonradioactive SrF_2 have been completed and analysis of the test specimens is underway.

Tests are also underway to measure the oxidation resistance and seawater corrosion resistance of Hastelloy C-4 and Hastelloy S. At 900°C or less Hastelloy C-4 forms an adherent oxide scale and the oxidation rate apparently follows a parabolic time dependence. At temperatures of 1000°C and higher spalling of the oxide scale occurs and the oxidation rate increases drastically. Initial results with solution heat-treated Hastelloy S indicates that it oxidizes at a slower rate than Hastelloy C-4. Both Hastelloy C-4 and Hastelloy S in the solution heat-treated forms appear to be very resistant to attack by seawater, and welding apparently has little effect on the seawater corrosion resistance of the two alloys.

BENEFICIAL ISOTOPES UTILIZATION PROGRAM

A draft report concerning the flowsheets and costs for a fission product recovery plant was prepared and is being reviewed. Contacts for potential application of isotope systems in Cold Regions are being maintained. Heat transfer studies related to the potential use of high-level waste canisters to fuel an Army steam plant have been completed. The licensing and safety aspects of such a steam plant have been reviewed.

Support to the Sandia Sewage Sludge Irradiation Program was provided including study of sludge handling alternative costs and methods, and an odor analysis of sludge samples from various treatment methods.

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STRONTIUM HEAT SOURCE DEVELOPMENT PROGRAM

J. H. Jarrett, 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 $^{90}\text{SrF}_2$

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

The first draft of a topical report summarizing the studies on the dissolution behavior of $^{90}\text{SrF}_2$ has been sent to NRA for review and comment. As soon as NRA's comments are received they will be incorporated in the report and the report will be issued.

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

Long-Term Compatibility Tests

The long-term compatibility tests are continuing. Although the original schedule called for the couples to be tested for 1000, 7500, 15,000, 22,500 and 30,000 hr, the intermediate time periods have been shortened slightly. The new schedule calls for test periods of 1000,

6000, 12,000, 20,000 and 30,000 hr. These changes will not affect the technical quality of the tests, but will permit a more effective use of program funds in FY-1977-78.

Evaluation of the test specimens from the 1000-hr tests with $^{90}\text{SrF}_2$ is underway at ORNL. Metallographic examination of the 12 TZM specimens has been completed. Work is continuing on the Hastelloy C-276 and Haynes 25 specimens, but unfortunately, other commitments restricted the level of effort expended during August and September to a low level.

The estimates of metal attack, based on photomicrographs, for the 1000-hr TZM specimens are given in Table 1 (the results from the 1000-hr tests with nonradioactive SrF_2 are also given for comparison purposes).

TABLE 1. Attack of TZM Specimens Exposed to Strontium Fluoride for 1000 hr

Temperature, °C	S/V Ratio, ^(b) cm ⁻¹	Depth of Metal Affected, ^(a) mils			
		WESF-Grade SrF_2		WESF $^{90}\text{SrF}_2$	
		Chemical Attack	Change in Microstructure	Chemical Attack	Change in Microstructure
600	4.5	0	0	1	0
600	4.5	<1	0	2	0
600	2.5	<1	0	3	0
600	0.9	<1	0	-	-
600 ^(c)	4.5	-	-	1	0
800	4.5	<1	0	2	0
800	4.5	<1	0	2	0
800	2.5	<1	0	3	0
800	0.9	1	0	-	-
800 ^(c)	4.5	-	-	1	0
1000	4.5	<1	0	2	0
1000	4.5	<1	0	1	0
1000	2.5	<1	0	2	0
1000	0.9	<1	0	-	-
1000 ^(c)	4.5	-	-	1	0

(a) Attack estimated from micrographs

(b) S/V - the test couples' exposed metal surface to SrF_2 volume ratio

(c) The $^{90}\text{SrF}_2$ was spiked with ZrF_4 and Zr metal powder to simulate decay product buildup equivalent to 10 yr decay

The micrographs show that attack of the TZM specimens consisted entirely of chemical attack, and there was no visual indication of microstructural changes in any of the test specimens. At 600 and 800°C the chemical attack consisted principally of pitting and grain boundary attack at isolated locations (see Figure 1). At 1000°C the attack was more uniform across the metal surface and pitting and grain boundary attack were much less extensive (Figure 1).

The results show that attack of the TZM was much more extensive in the $^{90}\text{SrF}_2$ couples than in the equivalent nonradioactive couples. Also, TZM attack in the $^{90}\text{SrF}_2$ couples was much greater than was observed in the earlier short-term compatibility tests with $^{90}\text{SrF}_2$ (see BNWL-1967). Chemical attack of the TZM did not increase with increasing exposure temperature, and may even have been slightly less at 1000°C than at 600 or 800°C. The addition of ZrF_4 and Zr metal powder to the $^{90}\text{SrF}_2$, to simulate the buildup of decay products, produced a marked decrease in metal attack. The pitting and grain boundary attack observed in the other couples tested at 600 and 800°C was almost completely absent in the couples which contained ZrF_4 and Zr metal powder. The data indicate that decreasing the exposed metal surface-to- $^{90}\text{SrF}_2$ volume ratio (S/V) of the test couples results in increased metal attack. A similar effect was observed in the 1000-hr tests with nonradioactive SrF_2 and Haynes 25 and Hastelloy C-276. The increased attack in couples having smaller S/V ratios is to be expected if impurities in the strontium fluoride are the primary cause of metal attack.

The 6000-hr tests with nonradioactive SrF_2 have been completed. The test couples have been sectioned and metallographic examination of the test specimens is now underway. The 6000-hr tests with reference tensile and Charpy V notch specimens have also been completed. In these tests multiple TZM, Haynes Alloy 25 and Hastelloy C-276 specimens were held under vacuum at 600, 800 and 1000°C without SrF_2 present. Identical specimens are being tested for 6000 hr with $^{90}\text{SrF}_2$ present. These tests will be completed in December.

FIGURE 1. TBM Specimens Exposed to $^{90}\text{SrF}_2$ for 1000 hr

Testing of Full Size WESF $^{90}\text{SrF}_2$ Capsules

Compatibility testing of two full-size WESF capsules filled with fuel-grade $^{90}\text{SrF}_2$ is continuing on schedule. Because of the strike it was impossible to measure capsule surface temperatures for a period of several weeks. The surface temperature measurements were resumed at the end of July when the strike ended. The latest measurements show a maximum $^{90}\text{SrF}_2$ -metal interface temperature of 827°C for one capsule and 818°C for the second. The temperature gradient over the length of the capsule was 51°C with the first capsule and 40°C with the second capsule. Some slight temperature fluctuations have been observed; and the maximum $^{90}\text{SrF}_2$ -metal interface temperatures have varied by about 12°C during the course of the test.

Testing of one capsule will be completed in October after 4400-hr of exposure. The capsule will then be sectioned and $^{90}\text{SrF}_2$ -metal interaction at various locations in the capsule will be determined.

Thermal Gradient Test

The thermal gradient test with WESF-grade SrF_2 and Hastelloy C-276 is continuing. The temperature gradient of 560°C (from 360 to 920°C) along the length of the capsule is being maintained as planned. The capsule temperatures have been very stable and the maximum fluctuation at any location has been $\pm 6^\circ\text{C}$. The test will be completed in November.

Supplemental Short-Term Compatibility Tests

The 4400-hr tests have been completed on 24 of the 32 materials being evaluated (the remainder will be completed in October). The couples have been sectioned, and metallographic examination of the test specimens is underway. When the samples were sectioned it was found that the Hafnalloys 2525 and ductile cast iron specimens had completely reacted with the SrF_2 . Visual examination of the SrF_2 in the couples showed no evidence of a reaction product except for the discoloration of the SrF_2 . The complete reaction of the ductile cast iron specimen is surprising considering the limited attack observed with ingot iron. The tests will be repeated using a different source of ductile cast iron.

Analysis of the test specimens from the 1500-hr tests have been completed. Estimates of metal attack based on photomicrographs are presented in Table 2. The results indicate that none of the additional nickel and cobalt base alloys being evaluated are as resistant to SrF_2 attack as the Haynes Alloy 25 and Hastelloy C-276 which were evaluated in the initial short-term tests. However, several of the refractory metal and noble metal alloys appear to be quite resistant to SrF_2 attack and may offer potential as a clad material for $^{90}\text{SrF}_2$ in special applications. Micrographs of the test specimens and discussions of attack mechanisms were provided in an earlier report (BNWL-1845-26).

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	Change in Microstructure
Hastelloy C-276 ^(a)	3	7
Haynes Alloy 25 ^(a)	2	3
TZM ^(a)	1	0
Hastelloy C-4	5	12
Hastelloy B	4	15
Hastelloy B-2	10	18
Hastelloy S	7	15
Haynes Alloy 556	5	6
Inconel 617	7	14
Inconel 671	15	25
Incoloy 800	8	0
Rene 41	10	14
Udimet 700	>25	0
Monel 400	5	8
Nickel 200	7	10
Ingot Iron	3	0
Ductile Cast Iron	CR	CR ^(c)
316L SS	6	0
JS 777	6	7
Copper	>25	0
Titanium	>25	(b)
Hafnialloy 2525	>25	-
Molybdenum	2	0
Niobium	3	2
Ta-10% W	10	0
Mo-50% Re	2	
W-26% Re	2	0
Rhenium	<1	0
Iridium	0	0
Ir-0.3% W	0	0
Platinum	>25	-
Gold	>15	-

(a) Tested as reference specimen

(b) - could not be determined because of extensive chemical attack

(c) CR-complete reaction

TASK 3 - CAPSULE QUALIFICATION AND LICENSING

Program Plan

An outline of the program plan for Task 3 was submitted to NRA for review and comment. The program plan was aimed specifically at qualifying a $^{90}\text{SrF}_2$ heat source for use in the NASS 2 kW(e) power generator for terrestrial applications. The final version of the program plan, incorporating ERDA/DOD thoughts on capsule qualification, will be submitted to NRA in October.

Capsule Material Selection

Hastelloy C-4 and Hastelloy S are currently being considered as secondary (outer) cladding materials for $^{90}\text{SrF}_2$ capsules to be used in terrestrial heat source applications. The primary (inner) capsule would be the standard Hastelloy C-276 WESF capsule. Hastelloy C-4 and Hastelloy S were selected because they appear to suffer less from adverse thermal aging effects than most other superalloys. However, additional information is needed on the effects of thermal aging on the corrosion resistance of the two alloys; and tests are now underway to measure the oxidation resistance and seawater corrosion resistance of "as received" and thermally aged alloy specimens.

Oxidation Resistance of Hastelloy C-4

The rate of oxidation of Hastelloy C-4 was measured at temperatures of 600, 700, 800, 900, 1000 and 1100°C. The test specimens were fabricated from solution heat treated 1/8 in. sheet. Specimen size was 1.00 x 2.00 x 0.129 in. The specimens were degreased prior to use but the mill scale was not removed. The cleaned specimens were weighed and 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 720 hr, and duplicate specimens were tested at each temperature. Metallographic examination and electron microprobe analysis of the test specimens is planned.

At 900°C or less the Hastelloy C-4 specimens formed an adherent oxide scale and the weights of the specimens increased continuously with time at temperature. The oxidation rates at 600 and 900°C are shown in Figure 2. The rates at 700 and 800°C fall between those at 600 and 900°C, as expected.

FIGURE 2. The Oxidation of Hastelloy C-4 as a Function of Time at 600 and 900°C

At 1000 and 1100°C an adherent oxide scale formed initially, but once a certain oxide layer thickness was reached spalling of the oxide layer began with a corresponding loss of weight (see Figure 3). At 1100°C once spalling began specimen weight loss was linear with time (Figure 4). The critical thickness where spalling of the oxide layer began corresponded to a weight increase of approximately 1.2 mg/cm^2 of metal surface.

FIGURE 3. Oxidation of Hastelloy C-4 at 1000 and 1100°C

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

Spalling of the oxide layer was undoubtedly affected by, or was the result of, stresses which developed when the specimens were cooled for weighing and then reheated. Tests are now underway in which several Hastelloy C-4 specimens will be held at 1100°C for different times and then weighed. This will give some indication of the effect which thermal cycling has on the spalling of the oxide layer.

Analysis of the test results indicate that formation of the adherent oxide layer follows a parabolic time dependence, except for an initial period where the oxidation rate is very rapid. The integral form of the parabolic rate equation can be written as

$$(\Delta w)^2 = k_p T + C_p$$

where Δw is the weight change per cm^2 of specimen surface, T is time, k_p is the parabolic rate constant and C_p is the integration constant. In Figure 5 $(\Delta w)^2$ is plotted as a function of time for various test temperatures; and it is apparent that the rate of formation of the adherent scale follows a parabolic time dependence.

Similar tests are planned using Hastelloy C-4 which has been thermally aged at various temperatures.

Oxidation Resistance of Hastelloy S

Tests are underway to measure the oxidation resistance of Hastelloy S. The test temperatures and procedures used are identical to those used with the Hastelloy C-4. The test specimens were fabricated from solution heat-treated sheet and their dimensions are 2.00 x 1.00 x 0.063 in. Initial results, after 216 hr of exposure, indicate that Hastelloy S oxidizes at a slower rate than Hastelloy C-4 at all temperatures. At 1100°C spalling of the oxide scale occurs as was the case with the Hastelloy C-4. The experimental results will be reported when the tests are completed.

FIGURE 5. Parabolic Plots of the Oxidation of Hastelloy C-4 at Various Temperatures

Seawater Corrosion Resistance of Hastelloy C-4

Laboratory tests are underway to measure the seawater corrosion resistance of Hastelloy C-4. The tests are being carried out at $23 \pm 1^\circ\text{C}$ using natural seawater with and without aeration. The test specimens were fabricated from solution heat treated sheet; the same material as used in the oxidation tests. Specimen dimensions were 2.00 x 1.00 x 0.129 in. Some specimens were used 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 experimental procedure used was as follows:

The test specimens were degreased, rinsed, dried and weighed. Each specimen was then suspended in a flat bottom flask containing

2 l of natural seawater; giving a solution volume-to-specimen surface area of approximately 60 ml/cm^2 . The seawater in each flask was stirred using a Teflon-coated magnetic stirring bar. No attempt was made to control solution velocity, although the stirring rates in the flasks were approximately the same. Some test solutions were aerated, and care was taken to see the air stream did not impinge on the specimens. The test specimens were supported in the flasks using plastic lines. Periodically, the specimens were removed from the flasks, examined visually for evidence of corrosion, cleaned using a bristle brush and detergent, rinsed, dried, weighed and returned to the flask.

The tests lasted up to 1000 hr and 2 or 3 specimens were tested at each set of conditions.

Visual examination of the test specimens showed no evidence of attack, and microscopic examination of specimen surfaces showed no indication of pitting. Micrometer measurements showed no changes in specimen thickness occurred. All of the specimens suffered a very slight but definite weight loss initially, but after a few hundred hours exposure began to increase in weight. After 500 to 800 hr of exposure the specimen weights had increased to about their initial value and remained relatively constant thereafter. The aerated specimens suffered a slightly greater weight loss than the ones which were not aerated. The maximum weight loss observed with any specimen was 3.2 mg, which corresponds to a weight loss of about 0.1 mg/cm^2 of surface.

The test results indicate that solution heat-treated Hastelloy C-4 is very resistant to seawater corrosion. Metallographic examination of the specimens is underway to confirm this conclusion. In addition, the specimens will be subjected to bend tests to see if embrittlement attack has occurred.

Additional tests are planned using Hastelloy C-4 specimens which have been thermally aged at temperatures of 600, 700, 800, and 900°C for various times.

Seawater Corrosion Resistance of Hastelloy S

Tests are underway to measure the seawater corrosion resistance of Hastelloy S. The procedure being used is similar to the one used with Hastelloy C-4. The test specimens were cut from solution heat treated sheet and their dimensions are 2.00 x 1.00 x 0.063 in. "As-received", polished, and TIG welded specimens are being evaluated. The tests are still underway but initial results indicate essentially no attack.

Additional tests are planned with thermally aged Hastelloy S.

BENEFICIAL ISOTOPES UTILIZATION PROGRAM

J. H. Jarrett, Program Manager
K. M. Harmon, Principal Investigator

The objectives of the program for FY-1976 are to identify and develop beneficial uses of nuclear reactor by-products through: 1) estimation of long-term availability and cost of useful isotopes from commercial suppliers, 2) identification and development of beneficial applications of isotopes, including their use in remote regions of the world, 3) identification and evaluation of the actions required to optimize the $^{90}\text{Sr}_2$ and $^{137}\text{CsCl}$ products from the Hanford Waste Encapsulation and Storage Facility (WESF) for beneficial use, and 4) review and evaluate the use of radioisotopes for fueling thermal systems which might be used by the U.S. Army.

The program is divided into four tasks:

- Task I - Isotopes Availability*
- Task II - Cold Regions Applications*
- Task III - WESF Product Utilization*
- Task IV - General Application of Radioisotopes
in Army Thermal Systems*

TECHNICAL PROGRESS

Task I. Isotopes Availability (J. A. Partridge and O. H. Koski)

A rough draft report was completed summarizing the results of a study of flowsheets and associated plant and operating costs for the recovery of various fission products in a commercial isotopes recovery plant. The draft is now being reviewed.

Task II. Cold Regions Applications (W. E. Sande)

During the reporting period, working on this task was primarily maintaining contacts in Alaska. Lyle Perrigo and Wally Sande plan a trip to Alaska in October to meet with the Federal Aviation Administration and Public Health Service concerning future demonstrations of radioisotope thermoelectric generators and low temperature heating systems.

Task III. WESF Product Utilization

Technical support was provided to the Sandia Laboratories sewage sludge irradiation program in two areas: 1) development of cost and other information to be used in evaluating alternative sewage treatment processes, and 2) odor analysis of treated and untreated sludge to assist in process evaluation.

1. Study of Sludge Handling Alternatives (H. E. McGuire, Jr. and G. W. Dawson)

Work was nearly completed on three study areas:

- modification of preliminary treatment sequences,
- development of a brief technical explanation of the alternatives with a breakdown of their operating parameters, and
- development of the cost parameters for each of the treatment unit processes.

The preliminary flow sequences for each of the treatment systems were analyzed both at Battelle and by peer group comment. The processes were modified to insure similarity of final product and consistency with common existing municipal or research operation.

Each of the process sequences was examined closely. The large amount of information available on each has been condensed to brief descriptions of each treatment process. Additionally, a review of operating data has resulted in a reliable set of operating parameters to be used in the cost evaluation.

An extensive analysis of cost studies performed on sludge treatment processes has yielded cost data on each unit operation. These cost analyses are currently being assembled in a graphical and mathematical format to assist in the matrix study.

Future work includes development of the cost matrix and comparative analysis of odor problems, electricity and fuel usage, product value, and treatment efficiency.

2. Sludge Odor Analysis (D. B. Cash)

Sandia Laboratories furnished PNL with digested treated and untreated sewage sludge, and undigested treated and untreated sludge samples. Treatment performed at Sandia Laboratories consisted of a combination of irradiation and heat. A trained panel of six judges used dilution-to-threshold tests to evaluate odor variations of the samples with time. Samples were evaluated for a time span of 1, 2, 3, 4, and 7 days. Three replications were performed for a total of 15 testing days. An analysis of variance was performed to determine the statistical change of the odor, if any, within the samples over the 7-day time period. In addition, gas chromatography analysis, using an electron-capture detector (ECD), was performed on the sewage sample head-space vapor components.

The initial digested sludge samples furnished by Sandia were not typical. Therefore, the series on digested treated and untreated sludge was repeated. Because of time constraints and panel availability, only two replications were performed in the second series of tests.

A Threshold Odor Number (TON) was used to evaluate the odor of each sample. The TON is the ratio by which the odor-bearing sample must be diluted with odor-free water for the odor to be just detectable by the panel members. Thus, the higher the TON the greater the dilution required, and therefore the stronger the odor of the sample.

For both digested and undigested sewage sludge, treated samples had higher TON's than untreated samples for each testing day. Digested and undigested samples had a significant odor change over the 7-day period. Undigested sewage sludge samples had the highest overall TON on the fourth day of odor evaluation for both treated and untreated sample. For digested sewage sludge samples, the treated samples had the highest TON on the third day after which a leveling off occurred. The digested control samples peaked on the fourth day.

Table 3 lists average panel TON's for digested and undigested samples. For simplification only one replication is included.

TABLE 3. Average Threshold Odor Numbers for Sewage Sludge Samples Evaluated by Six Trained Judges

<u>Day</u>	<u>Digested^(a)</u>		<u>Undigested^(a)</u>	
	<u>Treated</u>	<u>Untreated</u>	<u>Treated</u>	<u>Untreated</u>
1	32	21	70	41
2	183	72	240	128
3	683	172	350	158
4	213	183	700	237
7	140	85	220	187

(a) Threshold Odor Numbers (TON) are in thousands;
i.e., Day 1, 32,000

Odor-panel data compared favorably with gas chromatographic analyses of the undigested samples. (Analyses of digested samples has not been completed.) Although quantitative results could not be obtained, undigested treated sludge contained somewhat more volatile components than untreated undigested sludge. Components of all samples tended to show an increase with time up to about the fourth day and a decrease by the seventh day, although specific peak concentrations varied for individual components.

Use of WESF ⁹⁰SrF₂ in Heat Engine Applications

The report "SrF₂ Capsule Design for Heat Engine Applications" by D. H. Lester was issued as BNWL-2042 (UC-23).

Task IV. General Applications of Radioisotopes in Army Thermal Systems (W. E. Sande)

Heat transfer studies concerning use of solidified high-level waste canisters in Army steam plants have been completed. The temperature difference between a canister wall (or boiler tube containing a canister) and boiling working fluid is about 10°F when described by pool boiling. This indicates forced or natural circulation will probably not be required to maintain canister temperature limitations. Temperature distributions for

various waste forms and canister diameters have been calculated assuming 2-year-old waste and 350°F to 550°F wall temperatures. The maximum canister diameters are listed in Table 4 for a 1472°F (800°C) maximum centerline temperature.

TABLE 4. Maximum Canister Diameters for a 1472°F Maximum Centerline Temperature

<u>Canister Type</u>	<u>Diameters, in.</u>	
	<u>With Overpack</u>	<u>Without Overpack</u>
Borosilicate Glass	12	16
Borosilicate Glass with Fins	16	20
Calcine with Fins	8	--
Calcine - Al Matrix ^(a)	16	24

(a) Maximum Centerline temperature is 660°C.

The licensing and safety of an Army steam plant fueled with high-level waste canisters was considered from four bases:

- direct reference to the Code of Federal Regulations,
- analysis of past work on licensing requirements for the Retrievable Surface Storage Facility,
- consideration of the requirements for spent fuel storage facilities, and
- licensing from the standpoint of radioisotopic power generators.

Based on the above, it is recommended that the steam plant design closely follow past work on RSSF concepts and spent fuel storage facilities (except for certain capabilities such as hot cell receiving); for example, stainless steel basin liners and the double barrier concept should be maintained. It is expected licensing procedures will follow the requirements for an independent spent fuel storage facility⁽¹⁾ since the amount of contained radioactivity and heat generation are similar. Licensing the canister as a heat source for a power generator⁽²⁾ would be difficult because of a 800°C thermal test.

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