Radioactive Waste Encapsulation and Storage Facility

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July 1972

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AND

STORAGE FACILITY

July 1972

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To Be Presented At The
Topical Meeting on Advances in Remote Operations
In the Nuclear Industry

20th Remote Systems Technology Conference
Idaho Falls, Idaho

September 19-21, 1972

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RADIOACTIVE WASTE ENCAPSULATIONANDSTORAGE FACILITY

The radioactive aqueous wastes, generated by the chemical processing operations at Hanford during the past 28 years, are stored in large underground tanks of one-half to one million gallon capacity. These wastes contain the various fission products including the isotopes ^{90}Sr , which has a 28-year half life, and ^{137}Cs , which has a 30-year half life. These two isotopes are being separated from the wastes and stored in a concentrated liquid form in the Waste Fractionization Plant. This plant is a former separations plant which has been specifically converted to waste fractionization service. It is planned to process and convert these concentrated solutions of strontium and cesium to the solid strontium fluoride and cesium chloride salts. These salts are then doubly encapsulated and stored underwater for a number of years as a confinement measure.

This paper describes the processes and the facility, which is now under construction, that will be used to encapsulate and store the isotopes ^{90}Sr and ^{137}Cs . Previous discussions of this facility were presented during the conceptual design stage in references 1 and 2. The facility will be located near Richland, Washington on the Hanford Reservation, adjacent to the Waste Fractionization Plant in the 200 East Area. This new plant is called the Radioactive Waste Encapsulation and Storage Facility. The Waste Fractionization Plant (B Plant) and the new plant will be operated by the Atlantic Richfield Hanford Company (ARHCO) under contract to the U. S. Atomic Energy Commission.

Kilocurie amounts of ^{90}Sr and ^{137}Cs will be routinely processed. Each capsule produced will contain from five to seven pounds of strontium fluoride (SrF_2) or cesium chloride (CsCl) salt. They will be 2-5/8" in diameter by about 21" long.

The new plant, shown in Figure 1, is located at the west end of B Plant and is comprised of two sections; namely, a hot cell encapsulation facility and a capsule storage facility. Figure 2 shows a section through the hot cell facility. You will note that the hot cell is toward the right at the bottom of the figure. To the rear of the cell is a service gallery; above it is the canyon area serviced by an overhead crane; below it is located the ventilation duct servicing the cells and fixed process piping called the hot pipe trench. To the left of the

operating gallery is the ventilation equipment room, offices, lunch room and change room. Above the operating gallery is the aqueous chemical makeup area and the instrument transmitter rooms.

As shown in Figure 3, the hot cell facility contains six shielded cells, all approximately 13' high: Cell A, the Waste Loadout Cell, 8' deep by 10' wide; Cells B and C, the two Strontium Fluoride Processing Cells, each 8' deep by 8' wide; Cell D-E, the Cesium Chloride Processing Cell, 8' deep by 19' wide; Cell F, The Decontamination Cell, 8' deep by 8' wide; and Cell G, the Final Packaging and Loadout Cell, 8' deep by 16' wide. The front and rear faces of the cells are constructed of 35 inches of high density (235 lbs/ft^3) concrete. This amount of shielding will permit handling of one megacurie of either isotope in the cells with radiation readings in the operating gallery of less than one milliroentgen per hour (mr/hr). As shown in Figure 4, viewing of the cell is accomplished from the operating gallery through lead glass windows. The three cells which are 8' wide are each equipped with one lead glass shielding window; the other cells each have two windows. Each window station is equipped with two manipulators; one Central Research Laboratory (CRL) Model E and one Model F. All normal in-cell operations will be performed by the manipulators. These will include: piping changes, valve replacements, handling process filters and capsules, and cell cleaning. A 500 pound capacity in-cell bridge hoist is installed in each cell and will be used for both processing operations and maintenance.

The process piping, service piping and electrical services are routed to the cells through the rear and side walls. The terminals of these lines inside the cells are called wall connectors. Jumpers are used to connect the in-cell equipment nozzles, or connections, to the wall connectors. Swagelock tubing fittings are used for all piping connections, and these are located within reach of the manipulators. All equipment is designed to be remotely removable from the cells.

Concrete cover blocks are installed over the top of each cell. These are removed by a 15-ton capacity overhead bridge crane which services the canyon area, the area above the cells. Large equipment that needs to be removed or installed in the cells will be handled through the top of the cells by the canyon crane. Top entry to the cells, on a routine basis, will only be made in the Waste Loadout Cell.

In this cell solid waste will be received that has been packaged in small cans and passed down the line, cell by cell. A 14" x 14" pass-through is installed in the wall between each cell for passage of materials from cell to cell. The waste

cans will be remotely loaded into a 55-gallon drum, which is lined with heavy plastic. When the drum has been filled, the plastic liner will be heat-sealed and folded into the drum. The drum will be closed with a lid and then pulled up into a shielded cask at the top of the cell. The cask will be moved by the canyon crane to the truck lock and transported by truck to the solids disposal area. The Waste Loadout Cell and the Final Packaging Cell will be kept clean so as to permit personnel entry through a shielded door at the rear of each cell.

The 15-ton capacity canyon crane is remotely operated by personnel viewing the canyon area through a series of lead glass shielding windows strategically located around the canyon perimeter. The crane is operated by radio controls that are moved from window to window, as needed. A television system is provided to assist viewing in the more difficult areas of crane operation.

The Capsule Storage Area consists of a series of ten water basins, each approximately 4-1/2' wide by 22' long by 18' deep; and one double-sized basin which is approximately 9' wide by 22' long by 18' deep. Figure 5 is a design sketch of the Capsule Storage Area. A transfer aisle, 3' wide by 18' deep, extends the entire length of the Capsule Storage Area and connects to each of the water basins through a 4" ball valve. The capsules will be transferred out of the Final Packaging Cell into the transfer aisle through a capsule transfer device which extends into the water, on a slope, from the floor of the cell. The capsules will then be passed from the transfer aisle to a storage basin through the ball valve, by the operators, using long handled tongs. The storage basins and the transfer aisle are lined with stainless steel, Type 304-L. Submerged drop lights will be used for viewing the capsules underwater. During the capsule handling operations the 13' of water cover over the capsules will shield the operators from radiation.

Two processes will be conducted in the new hot cell facility; namely, the strontium fluoride conversion and packaging process, and the cesium chloride conversion and packaging process. First, we shall discuss the strontium fluoride process.

Concentrated strontium nitrate will be transferred from B Plant to the facility for conversion to strontium fluoride. The chemical conversion operation and the following packaging steps will be conducted in the hot cells.

Processing will be performed on a batch basis, handling up to 150,000 curies per batch. As shown in Figure 6, the feed is transferred into a metering tank and then dropped into the

40-gallon precipitator tank. Solid sodium fluoride is added to convert the strontium nitrate to strontium fluoride. The reaction is relatively rapid and is conducted at moderate temperature.

The strontium fluoride slurry is filtered by drawing the slurry from the precipitator by vacuum through four sintered stainless steel filters in parallel and one back-up filter in series. Then air is drawn through the filter cake, and due to the cake's self-heating characteristic, the cake dries and readily falls out of the filter when it is tilted. As illustrated in Figure 7, a filter dump mechanism is used to empty the cake from the filters into Inconel 600 alloy furnace boats. The boats are placed into a furnace and the strontium fluoride cake is sintered at 1100°C . The furnace is purged with argon gas during sintering. The sintered powder is packed into containers using an air-operated compactor to obtain 70 to 80 percent theoretical density. The containers are 2-1/4" outside diameter, approximately 19" long, 120 mil wall thickness and are made of Hastelloy C-276. As shown in Figure 8, the container is closed by welding an end cap to the top of the container. This operation is performed by using gas tungsten arc (GTA) welding using a remotely-controlled programmed welder. The container will be sealed by plug welding a small purge hole, placed into the top of the end cap, after the purge hole has been flushed with helium. The sealed container, now called a capsule, is then checked in a helium leak detection system by determining enclosure tightness. The capsule is decontaminated in an ultrasonic cleaning bath and then transferred through the Cesium Chloride Processing Cell, using the pass-throughs, to the Decontamination Cell. It is decontaminated further in a series of ultrasonic cleaning baths and then transferred through a pass-through to the Final Packaging Cell where it is placed into the second container. The second and outer container is 2-5/8" outside diameter, approximately 20" long, 120 mil thickness and is made of Hastelloy C-276. As shown in Figure 9, an end cap is welded to the top of the outer container using GTA welding with a remotely-operated programmed welder. This final weld is non-destructively tested for full penetration and continuity through use of remotely-operated ultrasonic testing equipment. A complete readout of the weld penetration will be recorded and kept for each capsule. The capsules will be weighed and the heat output will be measured in a calorimeter. The capsule is then ready for storage in the water basins. Underwater storage of the heat-emitting capsules provides cooling of the capsules and a shielding medium which permits visual observation of the stored capsules.

Here the capsules will be kept for a number of years to allow the self-decay process to proceed until the capsules are at a

level to permit safe transfer to and safe storage at a permanent storage site. Surveillance will be maintained during the storage period. The temperature and the radioactivity level of the water in each storage basin will be continuously monitored. The basin water is cooled by being pumped through a water-to-water heat exchanger installed in each water basin. Should the basin water become contaminated, the water will be jetted to B Plant and processed through existing recovery equipment.

Now let us discuss the cesium process. As shown in Figure 10, the concentrated cesium carbonate feed is transferred from B Plant on a batch basis (about 480,000 curies per batch) into a metering tank. The feed batch is dropped to a 20-gallon reactor where hydrochloric acid is slowly added to convert the cesium carbonate to cesium chloride. The reaction is exothermic and is controlled at 80° C and atmospheric pressure.

The cesium chloride solution is transferred to a 20-gallon evaporator-melter in which the cesium chloride is evaporated to dryness and then melted at 675° C. The evaporator-melter vessel is fabricated of stainless steel, Type 18-18-2; an inert gas purge will be used to minimize the oxidation of the metal. Induction heating is used to heat the cesium chloride in the evaporator-melter.

The molten cesium chloride will be vacuum transferred through heated lines to the containers in which the salt will solidify to form a cesium chloride "slug"; each batch will fill eight containers. The containers are 2-1/4" outside diameter, approximately 20" long, 95 mil thickness and are made of stainless steel, Type 316-L. As shown in Figure 11, gas tungsten arc welding will be used to weld the top cap to the filled container. The container will be sealed by plug welding a small purge hole, placed into the top of the end cap, after the purge hole has been flushed with helium. The tightness of the seal will be checked by performing a helium leak check on the capsule. The capsule will be decontaminated in an ultrasonic cleaning bath and transferred to the Decontamination Cell, using a pass-through. It will be decontaminated further in a series of ultrasonic cleaning baths and then transferred to the Final Packaging Cell using a pass-through. As shown in Figure 12, the capsule will be placed into an outer container, also stainless steel, Type 316-L, which is 2-5/8" outside diameter, approximately 21" long, and has a 109 mil wall thickness. The top cap is welded to the capsule using GTA welding with a remotely-controlled programmed welder. Ultrasonic testing will be used to determine the depth of weld penetration, and a permanent record of the measurement will be recorded. Each capsule will be weighed. The heat generation will be measured by calorimetry for one capsule out of the

batch of eight. The capsule will then be ready for transfer out of the cell to the storage basin where it will be stored with the strontium fluoride capsules.

In Figure 13 are listed the dimensions, contents and thermal characteristic of the two capsule designs. The estimated radiation levels emitted from the capsules in air are shown in Figure 14 (reference 3).

In the design of this plant the protection of personnel and the environment have been a prime consideration. The basic design of the plant includes heavy shielding for personnel protection. All areas of the plant are monitored for radiation by a network of radiation detectors and alarms. The level of activity in the air is continuously monitored by an air sampling system installed throughout the plant. Automatic sprinkler systems furnish fire protection to the facility, and heat detection alarms are installed in the hot cells. All contaminated process waste streams are recycled back to B Plant for processing. The stack effluent and the cooling water waste streams are continuously monitored for both flow and activity levels.

Figure 1
RADIOACTIVE WASTE AND ENCAPSULATION FACILITY

References

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2. "Packaging and Storing Radioactive Wastes," by J. R. LaRiviere, Atlantic Richfield Hanford Company, Richland, Washington, published in Chemical Engineering Progress, Vol. 66, No. 2, February 1970.
3. Private communication from J. R. Houston, Atlantic Richfield Hanford Company, May 1971.

WASTE ENCAPSULATION AND STORAGE FACILITY

Figure 2
SECTION THROUGH THE HOT CELL FACILITY

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WASTE ENCAPSULATION AND STORAGE FACILITY

Figure 3

PLAN VIEW - LOWER LEVEL

TYPICAL CELL ARRANGEMENT

Figure 4

SECTION THROUGH A HOT CELL

Figure 5
CAPSULE STORAGE.

STRONTIUM FLUORIDE PROCESS

Figure 6

STRONTIUM FLUORIDE PROCESS

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STRONTIUM FLUORIDE PROCESS

Figure 7

STRONTIUM FLUORIDE PROCESS

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STRONTIUM FLUORIDE PROCESS

Figure 8

STRONTIUM FLUORIDE PROCESS

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STRONTIUM FLUORIDE PROCESS

Figure 9

STRONTIUM FLUORIDE PROCESS

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CESIUM CHLORIDE PROCESS

Figure 10

CESIUM CHLORIDE PROCESS

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ARH-SA-115
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CESIUM CHLORIDE PROCESS

Figure 11

CESIUM CHLORIDE PROCESS

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CESIUM CHLORIDE PROCESS

Figure 12

CESIUM CHLORIDE PROCESS

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Sr & Cs ENCAPSULATION & STORAGE FACILITY PRODUCT FORMS

SrF₂

2-5/8" O.D. × 20" LONG

150 KCi

75% THEORETICAL DENSITY

TEMPERATURE IN AIR

CENTERLINE	860°C
SURFACE	430°C

TEMPERATURE IN WATER

CENTERLINE	660°C
SURFACE	71°C

LOW MELTING EUTECTIC

AT 950°C

CsCl

2-5/8" O.D. × 21" LONG

60 KCi

65% THEORETICAL DENSITY

TEMPERATURE IN AIR

CENTERLINE	450°C
SURFACE	200°C

TEMPERATURE IN WATER

CENTERLINE	327°C
SURFACE	58° C

PHASE CHANGE

AT 440°C

Figure 13
PRODUCT FORMS

CAPSULE DOSE RATES IN AIR

Figure 14

CAPSULE DOSE RATES IN AIR