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WASTE ENCAPSULATION AND STORAGE
FACILITIES AT HANFORD

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MASTER

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INTRODUCTION

This paper describes a facility planned to encapsulate and to store the radionuclides, strontium-90 and cesium-137. This plant will be operated by the Atlantic Richfield Hanford Company, a wholly owned subsidiary of the Atlantic Richfield Company. This subsidiary is a prime contractor to the United States Atomic Energy Commission. The company is responsible under its contract for research and development, engineering, operation, and maintenance of Hanford's chemical processing and waste management facilities.

The radioactive waste liquids generated by the chemical processing operations at Hanford during the past 25 years are stored in large underground tanks of one-half to one million gallon capacity each. The specific program for the inventory of these stored sludges and supernatants, and for currently generated high level waste, features fractionization of the long-lived high heat producing radionuclides, strontium-90 and cesium-137 from these wastes, followed by their high integrity packaging and storage in water cooled basins. Strontium is separated from the waste volumes in a battery of four simple pulsed solvent extraction columns and cesium is separated in a fixed bed ion exchange column. The Fractionization Plant started operating early in 1968.

The waste volume which remains after this separation contains the short-lived radionuclides and sodium salts. This volume is then converted to a solid salt cake in existing storage tanks by direct in-tank heating and evaporating techniques. Conversion of waste volumes to a solid salt cake has been in operation since 1967.

FACILITY DESCRIPTION

The Encapsulation and Storage Plant is planned as an addition to the operating Fractionization Plant which is an existing concrete shielded canyon type, aqueous processing facility, 244 meters long by 21 meters high, and 20 meters wide.

The new plant will be comprised of two processing sections; a hot cell facility and a capsule storage facility. A plot plan of the encapsulation facility is attached and shows the plant layout of the cells, storage, and service areas. (Figure No. 1) The hot cell facility will contain seven shielded cells, all 2.5 meters square, by 4 meters high, except for the final packaging and load-out cell. This cell will be a double cell, 2.5 meters wide by 5 meters long, and 4 meters high. The cells planned for this facility have been designed for the following functions:

Cells

A	Waste Handling
B & C	Strontium Processing
D & E	Cesium Processing
F	Decontamination
G	Final Packaging and load-out

The front and rear faces of the cells, as shown in Figure 2 - Section through the Process Cells, will be 89 centimeters thick and constructed of high density concrete. These shielding barriers have been designed so that one megacurie of either cesium or strontium can be handled in the cells and the radiation levels would not exceed one milliroentgen per hour when measured in the operating gallery. Viewing of the cell interiors will be accomplished from the operating gallery through 71 centimeter thick lead glass windows. Each viewing window will be serviced by two master slave manipulators to perform the specified in-cell operations. An in-cell bridge hoist will be provided in each cell to assist processing operations, material handling, and maintenance.

Removable cover blocks provide access through the top to all cells. A 13,400 kilogram capacity overhead crane will service the cells. Top entry, on a routine basis, will be required only for two of the seven cells--the waste cell and the final packaging cell. Routine crane entry to the final packaging cell will be made to transfer finished capsules to the storage basin. The transfer will

be accomplished employing a lead shielded water cooled cask. These two cells will be kept clean to permit personnel entry through a large shielding door at the rear of the cells. Sufficient high density concrete shielding will be provided in the side walls to protect personnel from radiation sources in the adjacent cells.

Waste from the cells will be packaged in small cans and passed down the line of cells to the waste cell where the cans will be loaded into a drum. The drum will be placed in a shielded cask and transported by truck to storage in a vertical underground caisson.

The area above the hot cells is called the canyon. In this area, a series of shielding windows are strategically located around the canyon perimeter to furnish complete viewing of the canyon. The crane can be operated from a set of remote controls that can be moved from one window to another, as required. A closed circuit television system will be employed for supplemental viewing on the more difficult equipment repair and cell modification operations.

The storage area as shown in Figure No. 3 - Section through Storage Basins, will consist of a series of water cooled basins, each 1.5 meters by 6 meters by 4.5 meters deep. The waste capsules will be transferred inside a shielded cask into this area from the canyon through an access hatch. A 13,400 kilogram capacity pendant operated hoist will be installed above the basins to handle the cask and underwater transfer operations.

Each water basin section will be lined with an 18 percent chromium and 8 percent nickel stainless steel AISI-316-Low Carbon. Lighting will be provided for viewing the capsules underwater. Each section will be equipped with thick cover blocks to provide additional contamination control and radiation protection. Normally, 4 meters of water covering the capsules will provide sufficient shielding to limit the radiation exposure to the operating personnel in the storage area to less than 0.2 milliroentgen per hour.

STRONTIUM PROCESS

Concentrated strontium nitrate solution will be transferred from the Fractionization Plant to the Encapsulation Facility for conversion to solid strontium fluoride. This operation and the following packaging steps will be performed in a series of four shielded hot cells.

Processing will be performed on a batch basis, handling up to 150,000 curies per batch. The strontium flow diagram for conversion and packaging process steps are shown in Figures 4, 5, 6 & 7, attached. The feed is transferred into the 150 liters precipitator tank, neutralized to a pH of 7 to 10 with sodium hydroxide and the strontium nitrate is converted to strontium fluoride by the addition of solid sodium fluoride. This reaction is relatively rapid, and is conducted at a moderate temperature range.

The strontium fluoride slurry is vacuum transferred from the precipitator through two porous ceramic or two stainless steel filters in series. Air is then drawn across the filter cake, and due to the cake's self heating characteristics, dries rapidly and readily pours out of the filter when tilted. The powder cake is emptied from the filter, screened to break up large lumps and deposited in a pan. The powder is transferred to ceramic boats and is placed in a furnace to be sintered at 1100°C. The sintered strontium fluoride is then packed into a container which has a 6.3 centimeter outside diameter; is approximately 33 centimeters long, and has a wall thickness of approximately 0.3 centimeter. The sintered powder is packed into the container using an air operated compactor to obtain a 70 to 80 percent theoretical density. The loaded capsule will weigh approximately 4.8 kilograms. This inner container is fabricated from Hastelloy C-276, a 16 percent chromium, 16 percent molybdenum, 4 percent tungsten, and 2.5 percent cobalt alloy.

The container is sealed by welding the end cap to the cylinder. The tungsten inert gas welding process is used. The container, now called a capsule, is then checked in a helium leak detection system to determine the integrity of the closure. The capsule is decontaminated in a series of ultrasonic and steam cleaning steps prior to performing final encapsulation. The capsule is then placed in an outer container which is 7.3 centimeter outside diameter by 38 centimeter long, and with a 0.3 centimeter wall thickness. The outer container is also fabricated from Hastelloy C-276. The final cap is also welded using tungsten inert gas process. Ultrasonic inspection is used to verify the capsule closure weld penetration with a readout of the data for the record. A calorimetry check is performed on the completed capsules to determine the heat output which is used for inventory and surveillance purposes. The capsule is designed to maintain the centerline temperature of the capsule

below 920°C when containing 150,000 curies cooled in air. The capsule is now ready for storage in the water basin.

CESIUM PROCESSING

The feed for the cesium process is transferred from the Fractionization Plant as a concentrated cesium carbonate solution in a 480,000 curie batch. As shown in the attached Cesium Flow Diagrams, Figures 8, 9 & 10, the batch is collected in a 75 liter reactor where hydrochloric acid with the carbonate salt is extracted, thus the reaction is conducted at ambient pressure and temperature.

The cesium chloride solution is transferred to small Hastalloy C-276 melt pots in which the cesium chloride is evaporated to dryness and then melted at 675°C. An inert gas purge will be employed to minimize the oxidation of the steel.

The molten cesium chloride will be transferred through heated lines by vacuum to 316-Low Carbon stainless steel containers in which the salt will solidify to form a cesium chloride "slug". The containers will be 5.1 centimeters outside diameter by 60.7 centimeters long with a 0.24 centimeter wall thickness.

Weld quality control procedures for cesium and strontium encapsulation have been standardized and the encapsulation and inspection steps for both are carried out using the same equipment and cell space. The unit operations are as follows:

- The tungsten inert gas welding will also be used to weld the cap to the filled cylinder, and the integrity of the welded seal will be confirmed by a helium leak check.
- The capsule will then be decontaminated in a series of ultrasonic and steam cleaning baths.
- The capsule now will be placed into an outer container, also 316-Low Carbon stainless steel, 5.7 centimeters outside diameter by 65.8 centimeters long with a 0.28 centimeter wall thickness welding.

- The top cap is welded to the capsule using the tungsten inert gas process.
- Ultrasonic leak checking will determine the depth of weld penetration, and also provide a permanent record of the weld.
- Calorimetry will also be utilized to determine the heat output of the capsule for inventory and surveillance purposes.
- Each capsule is designed to contain approximately 60,000 curies and to maintain the centerline temperature of the capsule below 425°C when cooled in air.

*Co. Capsul
0.06 MC*

MATERIAL HANDLING

The manipulator is the heart of the cell operations. The arrangement of the manipulator in the cell complex and some of its operating functions are illustrated in Figure No. 11. Manipulators have been selected to operate valves and equipment, connect and disconnect filter cartridges, make chemical additions, load and unload equipment, operate the cell pass-through devices and hoists, handle powders and capsules, take process control samples, perform routine maintenance on cell equipment, piping, instruments and air filters, and to perform numerous housekeeping assignments. All cells will be equipped with booted mechanical nonsealed master slave manipulators. The manipulators will be installed in pairs, each being capable of an extended reach of approximately 3.4 meters. Collapsed length will be about 1.5 meters, allowing the manipulator to work on the floor in front of the viewing window. For the smaller model the maximum load that can be lifted routinely with the jaws will be 4.5 kilograms, and a load hook will be provided to allow lifting capability up to 45 kilograms. The larger model manipulator will be used where loads over 45 kilograms are to be handled on a routine basis without a load hook.

In the operating gallery there will be a monorail track over the centerline of each manipulator. The track will extend back at least 3.7 meters from the cell wall. Provisions will be made to mount a trolley on anyone of the monorail tracks so that the manipulator can be withdrawn from the cell wall into the operating gallery.

Since the lifting capacity of the manipulators is limited and since it appears desirable to have capability to lift heavy loads without removing the top cover of the cell, 225 kilogram capacity hoists will be provided in each cell. The electric hoist and bridge travel will be controlled from the operating gallery. The bridge will be remotely removable with the assistance of the canyon crane.

Pass-through devices have been located in the walls between adjoining cells, and they are designed for a production rate of 500 capsules of cesium and 200 capsules of strontium annually. The device will consist of a cart mounted on an extending track which can be extended into either cell for loading or unloading. The cart can be moved either directly with the manipulator or remotely from the operating gallery. The cart will be capable of transferring 45 kilograms through a 36 centimeter square opening. Each end of the pass-through is normally covered by a lead filled door which provides half the shielding integrity of the cell. A pass-through device will also be used to pass smear patches from the cell to the service gallery for radioactive counting. These smear patches are used to measure decontamination efficiency.

$$\begin{aligned} & \sim 30 \text{ MC } 10 \text{ min} \\ & \text{Cs } 500 \times 0.06 \text{ MC} \\ & = 30 \text{ MC} \end{aligned}$$

$$\begin{aligned} & \text{Sr } 200 \times 0.15 \text{ MC} \\ & = 30 \text{ MC} \end{aligned}$$

The canyon bridge crane, as illustrated in Figure No. 12, is very important to the logistics of the plant. A remotely operated 13,400 kilogram capacity bridge crane has been designed for the canyon space above the cells. The crane will remove the top hatch cover slabs from the cells and handle heavy equipment installation or removal, as well as the routine capsule and solid waste transfers. The crane has access, from the top, to all cells and to the truck lock, and to one end of the storage basin through strategically located hatches.

Operating of the crane will be performed from various viewing windows located around the canyon at the second level and also from the cell viewing windows at the ground level. In addition, closed circuit television transmitters are installed to assist in the operation of the crane. For television assisted remote crane operation, the operator will be aided by position indicators to show where the crane is located in the canyon and to show the hook elevation. This remote crane will be equipped with one 13,400 kilogram capacity hook and two 900 kilogram hooks.

Developing a solid waste removal concept for such a high production throughput became a most difficult problem to solve.

A compartmented cell concept was selected from a variety of automated and manual design alternatives. This concept is illustrated in Figure No. 13. The compartmented cell is an end cell, and it will be utilized to handle and package contaminated solid waste which is small and can be transferred through the inter-cell pass-throughs.

The waste cell consists of two separate compartments. The smaller compartment, the load-out chamber, is equipped with one master slave manipulator and one viewing window. This load-out chamber and the strontium cell are interconnected with a transfer drawer. The purpose of this enclosed chamber is to allow handling of the waste containers with minimum potential for contamination spread throughout the remainder of the cell. The main section of the waste cell is equipped with two manipulators and one viewing window. In this compartment of the cell, the waste package is remotely sealed and loaded into the transfer cask. In addition, a shielded door allows personnel entry from the service area.

Waste accumulated in the process cells will normally be stored in 3.7 liter cans, or in 30.5 centimeter diameter by 30.5 centimeter high containers. Waste, such as the cell ventilation filters require special containers. The 205 liter drum will hold about 32 cans, or three 30.5 centimeter high containers. The containers will be moved from the processing cells to the waste cell using the manipulators and the inter-cell pass-through.

• When the drum is filled it will be sealed with the aid of the two manipulators in the main section of Cell A, loaded into a transfer cask, and removed through the opening in the top of the cell with the canyon crane. The shielded transfer cask containing the filled drum is then transferred to a truck parked in the truck lock and transported to the storage site.

SUPPLIES

Spare parts, other maintenance supplies, and process supplies, which have dimensions less than 36 centimeters square will be transferred for use into the cells through the load-out chamber via a pass-through between the load-out chamber and the service area at the rear of the cell.

STORAGE

Formulation of a design concept for the long-term storage and management of the radioactive capsules was a formidable task. Storage objectives were determined and careful consideration of the following parameters were undertaken.

- ° The concept must reflect the objective of the United States to immobilize, contain, and isolate radioactive materials for the safety of the environment.
- ° For the long term, the concept must suitably contain the waste materials, with adequate provision for the control, inventory, and recovery in the event of a capsule failure.
- ° For the ultimate disposal, the concept must give consideration to retrieving and transferring the waste forms to storage in deep underground locations.

After considering all the many logistics and safety considerations, a compartmented underwater storage concept was selected.

The storage operation begins with the loading of the transfer rack. The rack is used to receive the finished capsules in preparation for their transfer. The rack is placed in a shielded storage well in the Final Packaging and Load-Out Cell until filled with nine capsules and then removed and secured in the transfer cask which is also positioned in this cell.

The transfer cask will be cooled with water until ready for transfer. It will be necessary to make and break the water connections each time the cask is used. The cask will be removed from the Load-Out Cell using the canyon crane; at this time cooling water will be temporarily interrupted. It is anticipated that the transfer to the storage pool will take less than one hour. The transfer cask will have sufficient heat-sink capacity without external cooling for up to one hour before a pressure buildup becomes likely.

A cutaway section of the Capsule Storage Facility is shown in Figure No. 14. In the storage area a pendant operated hoist is

provided to pick up the cask and lower it into one of the sections of the storage basin. The cask cover is manually removed underwater using long handled tools. Then the storage area hoist is used to remove the rack from the cask and place the rack into its inventory position.

The capsules are stored underwater for purpose of cooling, and in addition the water provides a reliable shielding barrier, while permitting the direct viewing of the capsules. The storage basin is divided into a series of 11 individual sections. This compartmentation is intended to provide isolation; thus, a single leaking capsule could only contaminate one small section of the water basin. Ten sections are to be used for storage of capsules and one section is intended to be used for capsule surveillance. Surveillance will consist of storing a certain number of representative capsules and routinely monitoring them for a period of time before placing them in a section for storage. This monitoring will normally consist of temperature, pressure (strain gage), and ultrasonic testing for capsule flaws.

The water in each section will be circulated through individual heat exchanger coolers to remove the isotopic decay heat and maintain a basin temperature of 56°C. Demineralized water is used as the cooling medium. The circulated water will be continuously monitored for radioactivity. Should radioactivity be detected the section can be completely isolated by sealing off the basin top with cover blocks. This will reduce the radiation hazard to personnel during the removal of the contaminated cooling water and the decontamination operations.

SAFETY FEATURES

Throughout the design of this plant, every effort has been made to include features specifically selected for the protection of personnel, the environment and the equipment. The basic design of the plant includes heavy shielding for personnel protection. All areas of the plant will be equipped with radiation detectors and alarms. An air sampling system will be installed throughout the plant to determine that the air is always below the specified safe activity level.

A utility system will be provided to assure the continuity of critical equipment and control system operation. An emergency

electric generator will operate vital equipment during power failures. Battery powered lighting systems will also be installed as additional backup capability. Cooling water capability from wells is provided as backup to the water system, since a continuing supply of cooling water is needed to remove isotopic heat. For fire protection, heat detectors will be installed in all of the processing cells. The service section of the building will be protected with an automatic sprinkling system.

Much study and effort has gone into the design of the ventilation system. For instance, the spread of hot powder by ventilation air flow within the powder handling cells is to be minimized. With a refrigerated supply system it is possible to maintain a low air-flow through the cells and remove heat effectively. High efficiency filters are to be installed in each cell. Four additional filter banks are located in series in the exhaust system. A 61 meter high stack will be installed to furnish adequate exhaust air dispersion. This exhaust stream will be continuously monitored for both flow and activity.

CONCLUSION

The objective of this engineering effort was to provide a design for a hot cell facility that could be capable of handling large quantities of radioactive material at high production rates in the range of 30 megacuries of strontium-90 and 30 megacuries of cesium-137 annually. This objective has been successfully achieved. By combining the best features of the remote canyon and the manipulator cell concepts, the versatility, flexibility and safety of the hot cell is measurably improved and its application extended. By careful attention to the layout of the unit operations and by employing cell mockups to verify the details of the design, the more costly and less certain of success automated operations can be avoided.

The designer should no longer view the manipulator as a tool limited to the time tested laboratory and pilot plant operations, but he should now give careful consideration to its applications where unit costs, short time cycles, continuity of operations, and safety are primary criteria.

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Strontium and Cesium Encapsulation and Storage Facility
View at First Floor - Operating and Process Areas

AEC-RL RICHLAND, WASH.

FIGURE No 1

Waste Encapsulation and Storage Facility
Section Through Process Cell

Fig. No. 8

Figure No. 2

Waste Encapsulation and Storage Facility
Section Through Storage ~~Pool~~

Fig. No. 3 Basin

Figure No. 3

Strontium Fluoride Process

Fig. No. 4

Figure No. 4

Strontium Fluoride Process

Fig. No. 2

Figure No. 5

Strontium Fluoride Process

Fig. No. 9

Figure No. 6 (No 9)

Strontium Fluoride Process

Fig. No. 7

Figure No. 7 (No. 10)

Cesium Chloride Process
Fig. No. 3

Figure No 8

Cesium Chloride Process
Fig. No. 8

Figure No. 9

Waste Encapsulation & Storage Facility
Typical Cell Arrangement
Figure No. 11

WASTE ENCAPSULATION & STORAGE FACILITY
CANYON AND DUCT SECTION

FIGURE NO. 12

WASTE ENCAPSULATION AND STORAGE FACILITY
CAPSULE STORAGE

FIGURE NO. 14

Solid Waste Handling

PROCESS WASTE HANDLING

FIGURE NO. 13