**A Research Report for the
Atlantic Richfield Hanford Company**

**Preliminary Concept of Waste
Retrieval System - Tank Wall Access
Using Underground Mining
Techniques for Removal of Radioactive
Waste (Sludge, Saltcake and Liquid)**

by
R. C. Lawrence

February 1977

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PRELIMINARY CONCEPT OF WASTE RETRIEVAL
SYSTEM - TANK WALL ACCESS USING UNDER-
GROUND MINING TECHNIQUES FOR REMOVAL
OF RADIOACTIVE WASTE (SLUDGE, SALTCAKE
AND LIQUID)

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February 1977

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ABSTRACT

Preliminary evaluation of conceptual underground mining systems to retrieve solidified high-level radioactive waste stored in the Hanford underground waste storage tanks was performed at the request of Atlantic Richfield Hanford Company. The remotely-controlled mining concept presented herein is designed to handle all forms of waste (solid objects, saltcake, sludge, liquid, and combinations thereof) from all sizes of waste tanks (500,000 to 1,000,000 gal) at a rate greater than 50 tons/day. It will be fully capable of remote operation, and would be equipped to clip or saw internal metal components for tank access or structural component removal as required. The system is designed to transport waste material directly from the subsurface storage tanks to a surface waste transporting process.

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INTRODUCTION

A concept for retrieving radioactive waste from underground storage tanks has been developed. The equipment, primarily consisting of a remotely-operated modified tunneling machine called a "waste spade," approaches each tank from the side and removes waste from an opening in the tank wall. Waste is removed from the tank by the operation of a specialized waste spade powerhead extended through the resulting access hole on a boom capable of reaching all parts of the waste tank. The waste tank risers accommodate lighting and a remote viewing and sound observation system, in addition to ventilation and off-gas handling equipment.

Development of the present concept evolved after a review of various underground mining and tunneling methods and equipment which could either be directly applied without modification or easily adapted to the needs of this project. The study involved the following steps:

- A total of fifty vendors and consultants were contacted to determine if mining equipment is available to perform underground mining capable of retrieving radioactive waste materials of the type(s) currently stored at Hanford.
- Battelle Northwest Laboratories and Atlantic Richfield Hanford Company personnel observed equipment at vendors' shops and discussed potential problems associated with available tunneling and underground mining equipment.
- Consultants were brought to Hanford for a first-hand review of the above-ground layout, the potential problems with radioactive contamination control, and to acquaint the consultants with the physical size of the waste area. Simulated waste materials were observed at a test area near 271-T Bldg., 200-West.
- The feasibility of underground mining of waste materials was discussed in depth with the vendors, and their conclusions were subsequently documented.

After completion of these tasks, it was determined that equipment now under commercial production could be adapted to operate under the conditions at Hanford.

CONCEPT FOR WASTE MINING

Operation of the conceptual mining equipment will involve several steps: site preparation, equipment placement and containment precautions, and mining.

SITE PREPARATION

The first work to be performed is removal of piping and structural steel which could interfere with construction of a pit at the side wall for entry into the waste tanks. A pit is constructed at the side of each waste tank to be mined. The pit may service one waste tank (per drawing # SK-2-22751 Sht. 1 and SK-2-22752 Sht. 1) or several (drawing # SK-2-22752 Sht. 2). The pit is totally enclosed to maintain radiation contamination control. All hydraulic piping and electrical connectors are attached to the inner pit wall with hangers.

The next step involves placing TV viewing equipment down through the existing tank risers along with audio equipment to monitor the work being performed inside the tank. The TV, audio, and lighting equipment will meet all codes and specifications required for combustible mixtures and withstand the existing radiation levels in waste tanks.

The site of the control trailer where power supply and operations personnel work is established at the tank site after reviewing the layout of piping risers, outer perimeter fence lines, and radiation zones, typically per drawing #SK-2-22752 Sht. 1.

The last phase of setup is connecting the control room unit's power supplies, TV, audio, and lighting, and testing all components. The personnel certified to operate the equipment for removing waste from tanks

shall complete acceptance testing and certify as operable all equipment prior to commencing waste removal from the tanks.

WASTE SPADE

- Equipment Description

The waste spade (drawing # SK-2-22751 Sht. 1-2) is in a pit approximately 20 ft wide x 40 ft long, lying alongside the tank to be mined. The waste spade unit appears to be uniquely suited for mining of the underground waste storage tanks. Experience with this type of equipment in digging tunnels throughout the world, for example, has demonstrated the need for very little maintenance. The waste spade unit must perform with minimal maintenance because it is inside the tank, and it must be made of materials structurally heavy and strong enough to perform the work required in tanks having hard concrete-like layers of saltcake or sludge formations. The arm has the versatility of motion to reach every part of the tank to remove material. The boom has a 30° vertical movement with a 180° horizontal turn on the articulating arm, 150° at the joint section, and 180° on the power head. The waste spade has approximately 11 ft of horizontal movement on the turret machine base for removal of the boom from the tank in the fully retracted position.

In operation, the powerhead is forced into the waste by hydraulic actuators. If required, the spade breaks up the waste prior to pulling it up on the apron into the double-roll crusher. If waste is semi-liquid, the spade operation may be unnecessary. Water is mixed with the fragmented waste, if required, to promote the pumping of the slurry into the waste effluent hose to the transfer point.

- Support Equipment

The support equipment is not more than 100 ft from the pit, as manufacturer specifications require. The hydraulics are placed in a trench or are on top of the ground, at field personnel

discretion. The electrical control cables and coaxial cables for control trailer, TV, audio and lighting circuits are shielded by trays or left lying on top of ground for easy access.

- Control Trailer

The control trailer (per drawing # SK-2-22753 Sht. 1 of 1) contains all electrical, electronic, and control equipment for waste spade, hydraulic power supply, TV, audio, and lighting. It also contains the computers for programming equipment operation and navigation, and has facilities for personnel who operate the waste spade, including lunchroom and rest rooms, files, two sets of ground line telephones, and a two-way radio system for backup. The emergency power supply is on a separate trailer near the control trailer for ready use if needed. The control trailer is the largest single unit and is approximately 10 ft wide x 60 ft long.

Operating the waste spade requires three people. Operators are certified through a training period to operate all of the different systems. Operations personnel perform duties as noted on drawing # SK-2-22753 Sht. 1 of 1. The team leader is in charge of machine motion, spade operation, and manipulator operation. No. 2 operator is in charge of navigation, maintains the sensors, and monitors position for backup of No. 1. No. 2 operator "navigates" and monitors waste radioactivity by means of remote sensors. He also maintains observation for piping, structural steel and foreign objects which No. 1 personnel might overlook. The No. 3 operator assumes maintenance of the electrical and hydraulic systems operation. He also monitors the slurry pumping, i.e., the flow rates; keeps records of materials moved to the transfer point, and maintains communications with the tank farm operations manager.

- Containment

Containment for the waste spade inside the pit is maintained by both a portable pit containment building (drawing # SK-2-22752

Sht. 1-2) and a radiation and decontamination shield located between the waste spade and the tank side wall (drawing # SK-2-22755 Sht. 1-2). This radiation shield and spray ring unit per drawing # SK-2-22754 Sht. 1-2 primarily keeps dust, muck, or other airborne materials from coming into the waste spade pit area from the waste tank. The pit has spray nozzles mounted on its sidewalls so that any radioactive contamination which might result from a broken or leaky waste transfer pipe may be washed directly into the pit sump.

The waste spade is transported to a new waste tank using a waste spade machinery box (see drawing # SK-2-22752, Sht. 1). The waste spade machinery box is moved inside the prefabricated building to maintain containment and containment control at all times. The pit containment building permits pit operations to continue during windy or inclement weather conditions.

EXHAUSTER

The portable exhaustor unit is on top of the tank being mined to control the flow of air inside the tank during the mining operation. The purpose of the portable exhaustor is to maintain negative air pressure differential inside the tank and to maintain the tank air as contamination-free as possible. Redundant controls are included to assure that tank air negative pressure would not exceed operating limits. Alarms sound if the exhaustor should fail to operate properly.

MINING PROCEDURE

To begin mining, the team leader decides how and when to cut in-tank sections of piping or structural steel debris. After initial piping and debris cutting, the waste spade starts digging waste. The tank farm operations personnel decide where in the tank the machine starts digging. The waste is broken into workable pieces, pulled into

the crusher unit, and mixed with water as required to provide a pumpable slurry. The control on the amounts of waste removed are determined by the units (tons or gallons) required for the waste processing plant. The slurried waste are piped to a new underground slurry accumulator tank located centrally to several tanks. The retrieved material is kept agitated in slurry form in the accumulator tank until it is transferred by pipeline to the waste processing facility.

The waste spade is nominally designed to retrieve 50 tons per day or approximately 12,000 gal of slurried liquid, 360 days per year at peak loads. It could produce more volume, if required, by design changes in pumping capability. After the waste has been removed from a tank and the tank has been accepted as clean, the waste spade is retracted into the waste spade pit. As the waste spade is retracted, a spray ring inside the moveable shield will wash gross contamination from the outside of the waste spade boom and powerhead assembly. The spray ring consists of three sections plus a containment sleeve, per drawing # SK-2-22754 Sht. 1. All sections of the sleeve shall be at negative air pressure differential to waste spade machine pit and shall be exhausted to a mobile exhauster built specifically to handle the spray ring. Each time the waste spade is moved to a different waste tank, operations personnel decide whether maintenance is necessary and if the machine needs to be sent to the decontamination facility for further decontamination and maintenance. The manufacturers have indicated that the only parts which generally need replacement on the spade are hydraulic seals, and this work could be done at tank change.

WASTE HANDLING

The equipment has been designed to mine the waste or liquid from all tank sizes (500,000 gal, 750,000 gal, 1,000,000 gal). The operations are expected to last ~15 years, and the total bulk waste is expected to be:

Total Bulk Waste		
Sludge	Saltcake	Total
148×10^6 lb	296.5×10^6 lb	444.5×10^6 lb
11.1×10^6 gal	25.2×10^6 gal	36.3×10^6 gal

The required average retrieval rates will be approximately

$$\begin{aligned}
 \frac{444.5 \times 10^6 \text{ lb}}{15 \text{ years}} &= 29.6 \times 10^6 \text{ lb/year} \\
 &= 82,315 \text{ lb/day} \\
 &= 41.2 \text{ tons/day.}
 \end{aligned}$$

The conceptual waste spade mining machine mines about 50 tons/day (surge) and about 40 tons/day (normal). If required, the waste spade, by design changes, could remove more than 50 tons/day to feed the processing plant(s). More waste spades could also be used to increase tonnage as might be required by operations personnel.

WASTE FORMS

Waste materials presently exist at Hanford in many forms, including liquid, semi-liquid, solid, and concrete-hard. There is little tank-to-tank uniformity in the size of the material or its consistency. Therefore, the mining equipment must be capable of handling many different sizes and consistencies of material. The waste spade is expected to remove irregularly shaped pieces of material from the tanks up to 60 in. in size with the conceptual digging device.

RADIOACTIVITY

Because of the potential for high intensity radiation inside certain waste tanks, the effect of radiation on materials should be a consideration before any equipment is designed or fabricated. Certain materials making

up the hydraulic support systems, the powerhead, the insulation of electrical systems, etc., will have to withstand high radioactivity for long periods of time without undergoing unacceptable degradation. Items expected to undergo radiation damage should be designed to permit easy replacement.

The waste spade is basically a strong, simple design (drawing # SK-2-22751 Sht. 2). The waste spade components can be used initially for the prototype and continue to be used in mining of waste. Another feature of the waste spade is that one control unit and power supply in a tank farm could be used to mine several tanks simultaneously.

If more than one tank had the same type of material, it may be feasible to have a number of waste spade units mounted at tanks and merely change the power supply from tank to tank as required to optimize the waste stream for process materials. This feature could be useful if temporary changes in the process plant feed stream were required.

CONCLUSION

The waste spade unit is straightforward in construction. After review of many different types of equipment, this unit appears to have the features which will allow it to work in a relatively trouble-free manner. The only part of the equipment which will be in radioactive material is the waste spade digger powerhead and boom. The power supply and most of the TV, audio, lighting and control equipment will be on the outside of the tank where it can be maintained as required with minimal or no radiation control procedures.

The entire equipment package of control trailer, hydraulic power supply, waste spade unit, TV camera, lighting and audio van, and pumps or other support equipment is mounted on special trailers built to handle load requirements. These can be moved from tank to tank or tank farm to tank farm as required for the work.

The waste spade unit parts are shelf items. Units similar to these are operating worldwide, mining and tunneling in both soft and hard materials. It can be readily appreciated that maintaining a unit such as that described herein 5 miles into a tunnel presents real problems. Getting lifting equipment and tools to do it is difficult, so it is necessary to emphasize basic equipment durability through use of oversized parts, fine tolerances, and high quality materials.

After review of many types of equipment, it was found that having all the equipment portable and compartmentalized, i.e., having basic units such as the control trailer power supply and support equipment needing relatively frequent maintenance in low radiation zones could result in a substantial reduction of maintenance costs. Since this equipment is portable, it is possible to maintain the best possible flow rates to the processing plant and control of the feed material by optimizing module position. One control unit could operate many waste spades. Thus the positions of mining machines can be readily changed from one pit to another, allowing maintenance in one tank area while maintaining steady flow to the process plant.

FIGURE 1. Spade in Operation

DRAWING TITLE & INSTRUCTIONS		DRAWING NO.		REFERENCE DRAWINGS	
SICILAND OPERATIONS OFFICE		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION		Atlantic Richfield Hanford Company	
Richland, Washington 99333		PROJECT NO.		SHEET NO.	
ALT. RETRIEVAL CONCEPT		POWER HEAD DETAILS		2	
DATE		REV. BY		REV. DATE	
DRAWN BY		CHECKED BY		DATE	
R. WARD		R.C. LAWRENCE		1/16/76	
SCALE		CLASSIFIED BY		CLASSIFICATION	
NONE		NONE REQ'D		NONE

						DWG NO.	REV NO.	DRAWING TITLE OR INDEX NO.
						REFERENCE DRAWINGS		
						U.S. ATOMIC ENERGY COMMISSION		
						RICHLAND OPERATIONS OFFICE		
						Atlantic Richfield Hanford Company		
						Richland, Washington 99352		
						ALT. RETRIEVAL CONCEPT		
						TYPICAL TANK PLOT PLAN		
REV. NO.	REV. BY	DRAWING STATUS	APPR. BY	FOR	MICRO F.M.B.	DWG NO. SK-2-22752		
DATE	DATE	DATE	DATE	DATE	DATE	SHEET NO. 1		
DATE	DATE	DATE	DATE	DATE	DATE	SHEETS 2		
DRAWN A WARD 1/15/77								
CHKD R. C. LAWRENCE 1/18/77								
INDEX NO. 200 GENERAL								
CLASSIFIED BY								
CLASSIFICATION								
SCALE NONE								
NONE REQ'D								
DATE								
NONE

- NUMBER ONE - DUTIES**
- MACHINE MOTION
 - SPADE OPERATION
 - MANIPULATOR OPERATION
 - OVERALL RESPONSIBILITY

- NUMBER THREE - DUTIES**
- ELECTRICAL & HYDRAULIC SYSTEMS OPERATION
 - SOLIDS SEPARATION BLDG. AND SOLIDS STORAGE OPERATION
 - SLURRY PUMPING OPERATION
 - PIPING & MACHINE DECONTN

- MECHANICAL ROOM**
- WATER HEATER
 - HEATING, VENTILATING AND AIR CONDITIONING EQUIPMENT
 - HUMIDITY CONTROL EQUIP
 - FIRE EXTINGUISHING SYSTEM
 - CHEMICAL STORAGE

**10'x60' CONTROL TRAILER
ARRANGEMENT**

REV. NO.		REV. BY		DATE		DRAWING STATUS		APPRO. BY		DATE		FOR		MICRO		DATE	
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Atlantic Richfield Hanford Company Richland, Washington 99352																	
ALT. RETRIEAL CONCEPT CONTROL TRAILER																	
DWS NO. SK-2-22753																	
SHEET NO. 1																	
SHEETS 1																	

REV. NO.	REV. BY	DATE	DRAWING STATUS	APPRO. BY	DATE	FOR	MICRO	DATE
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BLDG NO.	200			INDEX NO.		0110		
SCALE	NONE			CLASSIFIED BY		CLASSIFICATION		
DATE			NONE

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