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MOTHER LIQUOR FROM SALT CAKES

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INTRODUCTION

Radioactive salt wastes from the Hanford production facilities are being solidified in massive salt cakes in large underground storage tanks. The solidification is being done by the Atlantic Richfield Hanford Company, under contract to the United States Atomic Energy Commission, to improve the reliability of environmental isolation of these wastes. Solidification greatly decreases the mobility of these wastes and assures their safe containment for decades or centuries.

The solidification system concentrates the wastes by thermal evaporation, followed by cooling methods that result in salt supersaturation and crystal precipitation in underground storage tanks. The crystalline salts build up in the tanks until the usable tank space is filled with salt cake. However, the salt cake contains associated saturated mother liquor filling the crystalline void space. This mother liquor must be solidified in order to meet the AEC Waste Management criterion for waste immobility. This paper discusses the use of wells with pumps, for removal of mother liquor, thereby producing a drained immobile salt cake.

WASTE IMMOBILIZATION

Figure I is a sketch of a crystallizer tank system. This tank system receives the bottom stream from a waste evaporator. The waste stream is near saturation and is held and air cooled in the tank. Cooling the waste causes supersaturation and crystal precipitation in the tank. Tank supernatants are pumped to the next cooling tank for further cooling and crystallization.

Two 750,000-gallon capacity tanks, designated 116-TX and 117-TX by the Hanford system of nomenclature, were the first waste tanks filled with salt cake. Both tanks are 75 feet in diameter and their construction features a reinforced concrete shell with a carbon steel liner on the bottom and side walls. The salt cake in the tanks has been sampled (Plates I and II). The salt cake analysis showed the usual array of inorganic salt wastes which are stored at Hanford: nitrates, nitrites, aluminates, sulfates, carbonates, and hydroxides, with relatively very small amounts of mixed fission product isotopes, strontium-90, cesium-137, ruthenium-106, promethium-147, and cerium-144.

The salt cakes of tanks 116-TX and 117-TX contained about 30 percent free mother liquor. Waste immobilization criteria require that the intercrystalline mother liquor be converted to an immobile form. One way to immobilize this mother liquor is to remove it for

additional reprocessing. A process test was proposed to remove the interstitial liquor for reprocessing by using a "salt well." Tank 117-TX was chosen for the first test well; the well for tank 116-TX would follow later with improvements gained from the first well incorporated into the second well.

SALT WELL DESIGN

The design for the salt well was complicated by the consideration of potential environmental hazards and personnel safety requirements. The well design required that installation or drilling, operation, and observation be done remotely so that personnel and environmental contamination could be avoided and radiation exposure would be minimized. The solubility of the salt being "drilled" aided in the over-all well design. Since the salt cake was water soluble, the well could be jetted or sluiced into place; this avoided the usual drilling operation of removing tailings from inside the well.

The first well design consisted of an 8-inch pipe casing with 4 feet of 0.050-inch screen, with a solid steel-pointed end. A steam-water sluice line was run to the point to facilitate the well installation. (See Plates III and IV.) The 8-inch well was chosen to accommodate an available 5 hp pump. The nominal well design was for a flow rate of about 100 gpm.

The first well was drilled 13.5 feet into the salt cake in tank 117-TX using the steam-water sluice to soften and/or dissolve the salt cake. (See Plates V through X.) After the well casing was in place, the 5 hp pump and effluent piping was connected (see Plate XI). Figure II is a sketch of the tank with well; Plate XII shows the well in place in the tank. For measurement of liquid level, a conductivity probe was inserted into the well with the pump.

The second salt well was used in tank 116-TX. The design of this well was generally similar to the first salt well. However, to facilitate installation or drilling, additional sluicing capabilities and cutting edges were added to the well point. In order to increase the well capacity, a well screen six feet long was used, and the well was sluiced to the bottom of the tank. Plates XIII and XIV show the second salt well. A 2-inch observation well was sluiced into the tank; liquid level was measured by a conductivity probe in this well. Figure III is a sketch of 116-TX with the installed wells.

OPERATION AND OBSERVATIONS

The pumping of the 117-TX salt well continued over several weeks and a summary of the data obtained is shown in Table I. Initially, the well yield supported continuous pump-out rates of 40 to 50 gpm. Later, the well supported rates of only 5 to 20 gpm, apparently because of the temporary depletion of the interstitial liquid in the

vicinity of the well. Because of limitations of the probe installation design, well fluid-level drawdown measurements could not be taken during pump operation; only static well liquid-level measurements could be made. Liquid recovery time in the well following pumping varied from a few hours to several days. Because of the limitations in making well drawdown measurements, and the difficulties in interpreting these data, the salt permeability could not be estimated. However, a qualitative permeability observation can be made -- the permeability of the salt cake is low compared to typical formations associated with water wells.

The well in tank 116-TX has been pumped for several months. Pumping rates observed in this second salt well were considerably less than those observed in the first salt well in spite of attempts to increase capacity through design improvements. Pumping rates ranged from 5 to 20 gpm at near total drawdown.

The appendix presents a salt cake permeability estimate from data taken from the 116-TX well. For convenience in making this estimate, simplifying assumptions were made which would not be justified for a rigorous calculation. However, this approximation does demonstrate the feasibility of removing the mother liquor via salt well pumping. In terms of the theoretical hydraulics, illustrated by the sketch, the salt well data define a relatively narrow cone of depression, a condition that is reflected by the relatively

very low permeability estimate. Because of this low value, the salt well pumping rates will be low.

CONCLUSIONS

The wells in tanks 116, 117-TX have demonstrated the capabilities of safely installing and operating a waste tank salt well to remove interstitial mother liquors. If the salt well concept proves to be satisfactory, the technique has a potentially large application in waste tank layaway plans on the Hanford project. As many as 100 tanks could be candidates for this salt well liquor removal method.

FIGURE 1
CRYSTALLIZER TANK SCHEMATIC

FIGURE 2

SALT WELL IN
TK-117-TX

FIGURE 3

SALT WELL IN
TK-116-TX

TABLE I

SUMMARY OF TK-117-TX SALT WELL PUMP DATA

<u>Date</u>	<u>Volume Pumped (Gal)</u>	<u>Static Liquid Level</u> Initial 20'9"
3-1-71	25,000	-
3-3-71	6,000	17'4"
3-7-71	8,000	-
3-9-71	4,100	-
3-9-71	6,200	16'0"
3-12-71	2,000	-
3-13-71	2,700	-
3-15-71	3,450	15'0"
3-16-71	8,300	14'4"
3/19-20/71	21,400	12'7"
3-23-71	5,500	-
3-28-71	1,300	-
3-29-71	2,800	-
3-31 - 4-1	15,300	-
4/3-4/71	3,500	-
4-8-71	7,000	-
4-10-71	10,000	12'0"
TOTAL	132,500	

APPENDIX

Equilibrium well formula for a water table well is:

$$P = 1055 \frac{Q \ln \left(\frac{R}{r} \right)}{(H^2 - h^2)}$$

where P is the permeability or discharge that occurs through a unit area with a unit pressure drop

For the second salt well:

$$Q = 10 \text{ gpm}$$

$$R = 8 \text{ ft}$$

$$r = 4/12 \text{ ft}$$

$$H = 16 \text{ ft}$$

$$h = 2 \text{ ft}$$

$$\text{then } P = 58 \text{ gpd/ft}^2$$

Some simplifying assumptions:

1. No fluid property corrections.
2. Aquifer is not stratified.
3. Uniform permeability.
4. Well is at equilibrium.

PLATE I

BATTELLE-NORTHWEST
PHOTOGRAPHY

PHOTO NO. 705840-6 *en*

PLATE II

BATTELLE-NORTHWEST
PHOTOGRAPHY

PHOTO NO. 710141-7C

PLATE III

710994-2CN

PHOTO NO.

PLATE IV

BATTELLE NORTHWEST

PHOTO NO.

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PHOTO NO.

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PLATE V

BATTELLE-NORTHWEST

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PLATE VI

BATTELLE-NORTHWEST

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PLATE VII

BATTELLE-NORTHWEST

PHOTOGRAPH

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PLATE VIII

BATTELLE MEMORIAL INSTITUTE

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PLATE IX

BATTELLE NORTHWEST

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PLATE X

BATTLE-NORTHWEST

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PLATE XI

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BATTEL-NO. 11
BATTEL-NO. 11

PLATE XII

BATTELLE-NORTHWEST
PHOTOGRAPH

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PLATE XIII

BATTELLE-NORTHWEST

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PLATE XIV

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