USE OF VOLUME REDUCTION AND SOLIDIFICATION SERVICES AT ARIZONA NUCLEAR POWER PROJECTS PALO VERDE NUCLEAR GENERATING STATION

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ABSTRACT

The first liquid waste Transportable Volume Reduction and Solidification System (TVR-III) began processing of radioactive material in August 1986 at the Palo Verde Nuclear Generating Station. This paper summarizes the operation of the system during the first campaign.

The TVR-III initiated its second campaign of processing wastes at Palo Verde on January 31, 1987. During this second campaign we will be processing boric acid concentrates, sodium sulfate concentrates, and spend bead resins. It is expected that approximately 56,775 liters (15,000 gallons) of these waste will be processed during this campaign. Results of this processing were not available at time of preparation of this paper but preliminary results will be discussed during the presentation.

INTRODUCTION

The process used in the TVR-III was developed over twenty years ago in France by Societe Generale Pour Les Techniques Nouvelles (SGN) as a licensee of the French Atomic Energy Commission (CEA). The one-step volume reduction and bitumen solidification process is well proven with many systems operating in both BWR and PWR nuclear power plants in Europe and Japan. The first system operation began in 1971 at the Cadarache Nuclear Research Center followed in 1975 by the first unit operating in a power station at Barseback Nuclear Power Station. Since these early beginnings, the process system has achieved over 85 unit operating years and produced over 10,000 drums of solidified waste (See Table I - System Reference List).

TECHNICAL DESCRIPTION

The TVR-III, designed and operated by Associated Technologies, Inc. (ATI) of Charlotte, NC, is under multi-year contract to Arizona Public Service Company to process wet radioactive waste. The TVR-III system is mounted on a 3 M (10 ft.) wide by 14 M (46 ft.) long double low-boy trailer that requires minimal space and interface connections within the plants thereby minimizing the impact on plant operations.

The TVR-III is a complete stand alone system with enclosed weather protected modules with spill containment and drainage, filtration, rad monitoring, shielding, HVAC control and includes mobility and ALARA considerations. ATI is providing a complete system and all necessary equipment, operators, supervisors, and consumables to receive, volume reduce and solidify the waste generated at Palo Verde. All work is done in accordance with an approved Topical Report utilizing an approved Process Control Procedure.

TABLE I

SYSTEM REFERENCE LIST

Facility	Type of Facility	Bitumen System Startup Date	Drums of Solidified Waste
Barsebeck	Two 590 MWe BWRs	1975	4700
Mihama	Three PWRs 320, 470, & 780 MWe	1978	1000
Tsuruga	340 MWe BWR	1977	900
ATR, Tsuruga	200 MWe LWCHWR	1977	100
Cadarache	R & D	1971	No Record
Saclay	R & D	1975	2000
Valduc	Military Weapons	1971	1000
Monts d'Arree	70 MWe GCHWR	1980	1500
Brennilis	Waste processing facility	1981	
Oconee	Three 860 MWe PWRs	1983	-
Clinton	933 MWe BWR	1986	31
Palo Verde	Three 1270 MWe PWR's	1986	100

The TVR-III was designed to meet all appropriate nuclear station radwaste system requirements and the applicable regulatory codes and standards. These

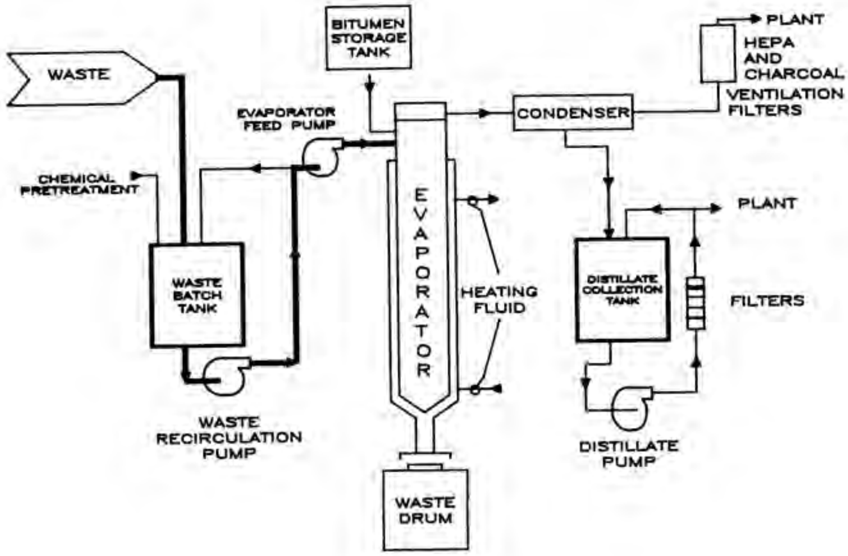

Fig. 1. Basic Flow Diagram, TVR-III System

criteria required the system design basis to be in accordance with NRC Regulatory Guide 1.143 and ANSI 40.35.

The TVR-III is a one-step volume reduction and bitumen solidification concept. A Luwa Thin-Film Evaporator, operating at a waste product temperature of 140°C - 200°C (285° to 390°F), is used to evaporate all free water from the waste influents. The remaining solids are homogeneously dispersed in a bitumen matrix while inside the evaporator. See Fig. 1 for the TVR-III Basic Flow Diagram.

The waste processed is transferred into the Waste Batch Tank where it is chemically pretreated to prepare it for processing and to insure the solidified waste meets the requirements of 10CFR61. When processing resins, water is decanted or added, as required, to obtain the desired feed concentration for improved pumping characteristics and optimizing of processing rate. The Waste Batch Tank is agitated to insure the contents remain a homoeneous mixture.

During processing of boric acid concentrates, the waste is fed at approximately 40 gph into the Evaporator. Molten bitumen is simultaneously metered into the Evaporator through a second feed nozzle. The Evaporator is heated by means of a synthetic heating fluid circulated through an external jacket. As both the radwaste and bitumen are fed into the Evaporator, the rotor blades spread the two streams into a thin, turbulent film against the heated internal surface. The action of the rotor blades and the force of gravity creates a downward spiral flow of the waste/bitumen mixture. As the waste flows downward through the Evaporator, water is evaporated and the vapor flows countercurrently upward and out. The remaining radwaste mixture containing the solids and bitumen exits through the bottom of the Evaporator into 208 L (55-gallon) drums. Upon cooling, the mixture solidifies into a free-standing, monolithic, water-free solid acceptable for storage or disposal.

The vapor leaving the Evaporator is condensed in a shell and tube Condenser and flows into the Distillate Collection Tank. When this tank is filled, the distillate is pumped through a series of filters to the plant liquid waste system.

Any non-condensibles from the condenser are discharged into the process exhaust air system where they pass through HEPA and charcoal filters prior to being discharged to the plant ventilation system.

Figure II is a trailer arrangement and equipment location sketch showing the TVR-III divided into six areas or rooms: Control, Auxiliary, Process, Wastefeed, Distillate, and Loadout. All areas except the Control Room incorporate spill containment capable of controlling the contents of any liquid container located within the area. A spill in the Process, Wastefeed and Distillate Areas can be removed by a sump pump to the Waste Batch Tank or an external tank.

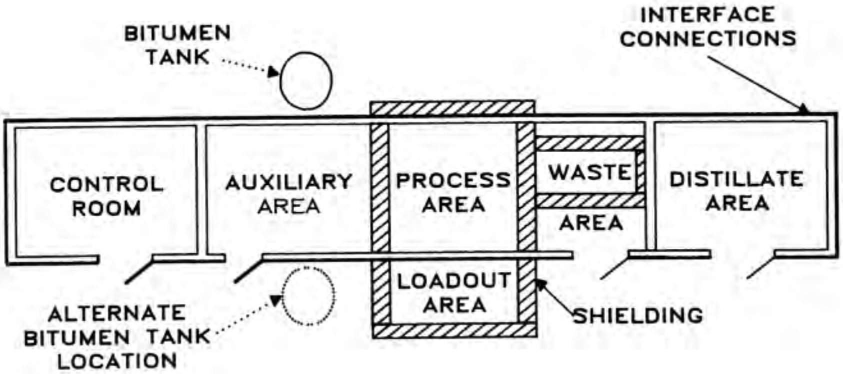

Fig. 2. Trailer and Equipment Layout

The Control Room contains the main control panel (Fig. 3) as well as the electrical and control equipment for operation of the entire system. The Control Room is the only normally occupied area and is separated from the radioactive process areas by the non-active Auxiliary Area and removable shield.

In addition to the areas contained within the main truck bed the system also includes a free standing Bitumen Storage Tank (Figure 4) that sits adjacent to the trailer outside of the Radwaste Truckbay. This is a fully insulated tank with double shell construction to prevent possible leaks.

Fig. 3. Section of Control Panel

Fig. 4. Bitumen Storage Tank

Drums were filled using one or two passes. All drums exceeded the 85% drum fill requirement. The waste at Palo Verde was solidified using both oxidized and straight distilled asphalt. Minor surface contamination was encountered on some drums after filling. They were easily decontaminated to below the site levels for contamination prior to movement to storage. Details of the end produce are given in Table II.

TABLE II

END PRODUCT CHARACTERISTICS

Number of Drums Produced	52
Gross Drum Weight, kgs (lbs)	250 (550)
Solids Content of End Product %	50-60
Free Water, %	0
Fill - One Pass, %	88-97
Two Passes, %	94-100
Surface Dose Rate, mR/Hr	60-180

LICENSING

ATI has a U.S. Nuclear Regulatory Commission (NRC) approved Topical Report for the bituminization process and for the TVR III mobile bituminization process. Federal requirements were addressed under 10CFR50.59, "Changes, Tests, and Experiments," which determined that there were no unresolved safety issues.

ATI has submitted an addendum to their Topical Report to meet the requirements of 10CFR61 and address product stability. Interim approval for burial of bituminized waste has been issued by the NRC while the Topical Report addendum is under review. The Palo Verde waste has been shipped to a U.S. Ecology operated Disposal Site as Class A unstable.

ATI has received approval for the disposal of Class A, B, and C wastes at all operating burial sites.

ASPHALT SPECIFICATIONS

The binders used were straight distilled, viscosity graded asphalt commercily available as AC-20 and an oxidized asphalt produced to the specifications of ASTM D312.

TRANSPORTATION AND SETUP

To prepare the unit for shipment involved lowering the Evaporator platform to its lower position, installing the wheels on the trailer, and loading all accessory items onto separate trailers. These accessory items included the Bitumen Storage Tank, the Loadout Area enclosure, the steel shielding plates, and other supplies.

Once the truck was prepared for travel, it was taken to the state weigh station for final weigh-in prior to permitting for transportation (Figure 5). The TVR-III unit with tractor weighed 58,430 Kg (128,700 pounds) and required special permits for overweight shipment.

Fig. 5. TVR-III on the Road

Set up at PVNGS required raising of the Evaporator platform, placement of the Loadout Area enclosure and the Bitumen Storage Tank, and hookup of the systems' utility interface connections once the unit was in place (Fig. 6). At the Palo Verde Station only a portion of the truck, the rear section containing the utility interface connections was within the truck bay.

Fig. 6. TVR-III Installed at Palo Verde

Processing of the first radioactive waste at Palo Verde by the TVR-III was started on August 13, 1986. Processing of the waste concentrates was accomplished over a period of seven weeks. During this time there were several delays due to lack of waste requiring processing and problems described below. A total of 34,000 l (approximately 9,000 gallons) of boric acid concentrates and flush water were processed at a rate of 95-190 lph (25-50 gph). The waste feed stream characteristics are shown in Table III.

TABLE III

WASTE FEED CHARACTERISTICS

Constituent	Design	Actual
Boric Acid Concentrates %	12	18-23
pH, as received	4-7	5.5-7.0
Feed pH (after caustic addition)	-	8.0-8.6
TOC, ppm	-	2,000-9,000
Radioactivity, uCi/cc	-	3×10^{-2}

As can be seen the boric acid concentration was 1.5 to 2.0 times the design value. This higher concentration reduced the volume of waste requiring processing. As a consequence, the volume reduction achieved was only 3.70 versus an expected 5.4 for boric acid wastes. The Total Organic Carbon in the waste feed was extremely high and caused problems in meeting the distillate quality limit during early operations. Table IV shows the distillate quality achieved.

TABLE IV

DISTILLATE CHARACTERISTICS

Constituent	Design	Actual
pH	-	8.7
TOC, ppm	10	3-15
Radioactivity, uCi/cc	-	2×10^{-5}
Decontamination Factor	-	1.5×10^{3}

Any time a mobile system is used that is not specifically designed for your facility some difficulties will be encountered. At Palo Verde our difficulties were loading and unloading drums, shielding for transfer of hotter drums, length of time to set up the system, and space requirements.

In addition to the problems noted with the feedstream chemistry several other incidents created slowdowns and reduced efficiency in processing. The major problem encountered during the first campaign was a minor spill during the second startup and recirculation of the batch tank. This was caused by a logic malfunction that caused a flush valve to open and the batch tank to overflow. The high level indication was not picked up by the operator due to an audible alarm signal malfunction. Approximately fifty gallons of concentrates leaked from the unit onto the concrete pad and into the truck bay. The spill was cleaned up within a few hours and modifications made to the operational procedures and process and alarm logic to prevent reoccurrence. Correction of this problem delayed operation about four days. After this occurrence twenty-three batches of waste were successfully processed prior to leaving the site.

TABLE V

TOTAL DISPOSAL COST AT PALO VERDE

CEMENT SERVICE	ASPHALT SERVICE
Cost	
$\frac{\$138,653}{27,150L\ (7,173\ gal)}$ = \$5.11/L (\$19.33/gal)	$\frac{\$130,540}{27,210L\ (7189\ gal)}$ = \$4.80/L (\$18.16/gal)
283,875L (75,000 gal) x \$5.11/L = \$1,450,600/yr	283,875L (75,000 gal) x \$4.80/L = \$1,362,600/yr
Savings/Year \$88,000	

On the Palo Verde site, due to the outside location of the unit, handling of filled drums was accomplished using a mobile crane (cherry picker). This created delays several times when an operator and cherry picker were not available to off load the TVR-III. The Radwaste department has since acquired its own cherry picker to eliminate this problem in the future.

ECONOMICS

Volume reduction economics are being obtained and further improvements should be secured as operational experience is gained. The expected savings versus other methods of processing have been shown. Results of processing one type of waste, 18-23% Boric Acid, is shown in Table V.

ASSUMPTIONS

All cost and Volume Reduction Factors (VRF) are actual. This includes the cost of the mobile services, consumables, transportation, all burial and surcharges in effect as of 06/01/86 at the U. S. Ecology disposal site in Richland, Washington. Cement service cost based on deducted equipment contract cost. Asphalt service cost based on demand contract cost. The expected annual volume of concentrated waste is 283,875L (10,027 ft^3) of 20 wt.% boric acid.

Table VI shows typical VRFs for a variety of wastes generated at Palo Verde while Table VII shows the expected disposal volume savings for the boric acid waste generated using actual VRFs for both cement and TVR-III processing.

SUMMARY

The economics of use of the TVR-III system will be significant in both reducing the total costs of handling a plant's waste (processing, transportation and burial) and reducing the volume of waste requiring storage or burial.

All in all, the first campaign at the Palo Verde site was a success with a significant volume of waste processed. The second campaign initiated in January 1987 will include processing of additional types of waste and much larger volumes and should provide the plant with significant reduction of volume requiring transportation and burial.

TABLE VI

TYPICAL VOLUME REDUCTION FACTORS FOR VARIOUS WASTES*

	Volume/Yr	Solidified Volume	VR Factor
Powdered Resins	566M (20,000 ft^3)	298M (10,500 ft^3)	1.9
Bead Resins	142M (5,000 ft^3)	100M (3,500 ft^3)	1.4
Boric Acid Conc. 12 w/o	310M (11,000 ft^3)	58M (2,000 ft^3)	5.4
Sodium Sulfate Conc. 25 w/o	198M (7,000 ft^3)	79M (2,800 ft^3)	2.5

* Calculated volume reduction factors where VRF = Inlet volume ÷ Solidified Volume.

TABLE VII

ANNUAL DISPOSAL VOLUME SAVINGS FOR BORIC ACID

CEMENT SERVICE	ASPHALT SERVICE
$\frac{285M\ (10{,}027\ ft^3)}{.66\ VRF^*}$ = 432M (15,192 ft^3)	$\frac{285M\ (10{,}027\ ft^3)}{3.70\ VRF^*}$ = 77M (2,710 ft^3)

Resulting Overall Volume Reduction Improvement = 5.6

Disposal Space Savings/Year

355M (12,482 ft^3)

* Actual VRFs obtained