OPERATIONAL EXPERIENCE OF THE PALISADES VOLUME REDUCTION SYSTEM - THE FIRST 12 MONTHS

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ABSTRACT

The operating experience of the first extruder-evaporator volume reduction and solidification system in the United States is discussed. The performance of the system during its first year of operation is presented. The labor and maintenance requirements for the system during the first year are also discussed.

INTRODUCTION

The first operating advanced volume reduction (VR) system in the United States is at Consumers Power Company's Palisades Nuclear Plant. The Palisades Nuclear Plant is an 811.7-MWe pressurized water reactor, which began commercial operation in December 1971. A WasteChem Volume Reduction and Solidification (VRS™) system was retrofitted at the plant and commenced operation in January 1984. The VR system at Palisades consists of an extruder-evaporator that utilizes an asphalt binder.

This paper is the fourth in a series of progress reports on operating volume reduction systems and is part of a study on "Advanced Low-Level Radioactive Waste Treatment Systems" carried out under EPRI Contract RP-1557. The first report covered the installation and initial startup testing of the Palisades VR system. Subsequent reports covered the results of the performance tests and the initial operation of the system. This paper will present the operating experiences with the system for the first 12 months of operation.

VOLUME REDUCTION SYSTEM DESCRIPTION

The volume reduction system consists of an extruder-evaporator that simultaneously evaporates water from liquid waste while encapsulating the residual solids in an asphalt binder (see Fig. 1). The extruder-evaporator consists of seven connected steel barrels. Within the barrel walls there are closed-loop passages for cooling water and process heating steam. Two corotating kneading and conveying screws are contained within the connected barrels. These screws are driven by a 100-hp variable speed d-c motor through a gear box.

Molten asphalt is fed into the extruder-evaporator upstream of the waste inlet. Low-pressure steam is delivered to the barrels through flow rate controllers, which allow the temperature of each barrel to be adjusted.

The process heating steam does not come in contact with the waste and is condensed and returned to the auxiliary boiler.

As the asphalt/waste mixture is conveyed through the extruder by the screws, water is evaporated. This vapor exits the extruder through three volatilization domes located along the top of the barrels. The vapor is condensed, filtered, passed through an oil separator, and sent to the plant floor drain system. Remote cleaning of the domes is accomplished through steam spray nozzles located inside the volatilization domes.

The asphalt/waste mixture exits the end of the extruder and flows into a 200-liter (55-gallon) drum, solidifying upon cooling. Drums are positioned under the fillport by a remotely controlled conveyor system. A remotely operated drip pan is provided to prevent asphalt spills when indexing empty drums under the fillport. A vent hood is located above the fillport. Air from the vent hood and gases from the distillate collection tank pass through a prefilter and a HEPA filter prior to discharge.

Filled drums are conveyed from the fill station to the capper station where they are remotely capped and seamed. Capped drums are conveyed through a radiation monitoring station to a pickup point on the conveyor.

EQUIPMENT LAYOUT AND LOCATION

The volume reduction system at Palisades was retrofitted into the existing radwaste packaging area (see Fig. 2). The process components (e.g., extruder-evaporator, waste feed pumps, distillate roughing filters) were located in a shielded room.

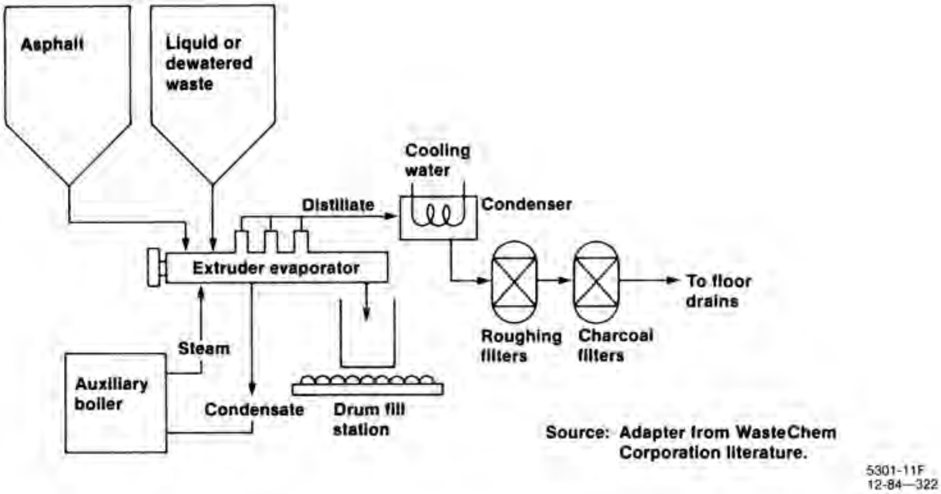

Fig. 1. Extruder-evaporator radwaste solidification system.

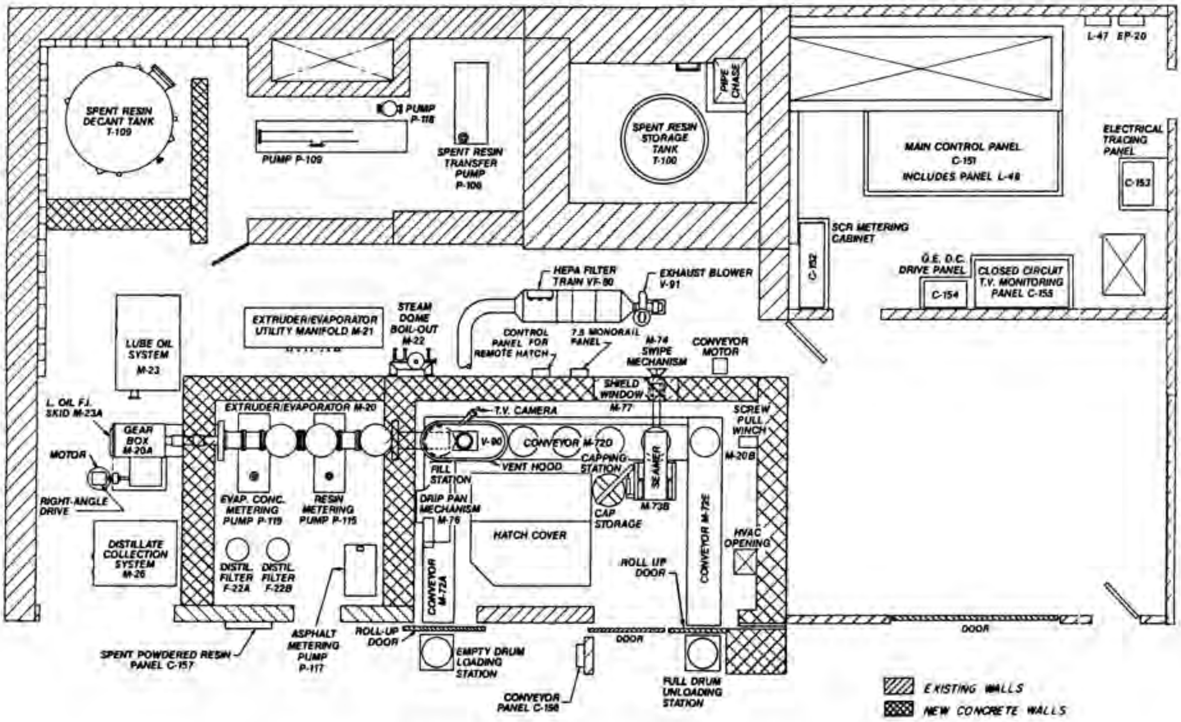

Fig. 2. Volume reduction system equipment location.

The drum conveyor system was also located in a shielded room adjacent to the extruder room. A portion of an adjoining storage room was used to house the VR system control room. A metal-sided building was constructed adjacent to the storage room to house the asphalt storage tank, the electric boiler, and other auxiliary equipment.

PERFORMANCE TESTING

During performance testing of the VR system at Palisades, several simulated waste streams were processed. The results of this testing demonstrated that neutralized boric acid concentrates, spent resin, and cartridge filters could be solidified with the system. Liquid wastes were desired to be processed by the VR system at 120 liters/hr (0.53 gpm). Test results confirmed that concentrated 12 wt.% boric acid solutions could be processed at 120 liters/hr. A sectioned product of a 140 liters/hr boric acid run is shown in Fig. 3.

A spent powdered resin slurry (30 wt.% wet resin) was satisfactorily solidified at 90 liters/hr feed rate. Spent bead resin slurries (33 wt.% wet resin) were satisfactorily solidified at a feed rate of 80 liters/hr. Cartridge filters were encapsulated, one filter per drum, in asphalt. The filters were required to drip dry prior to encapsulation and a wire mesh basket had to be used to support the filter within the drum.

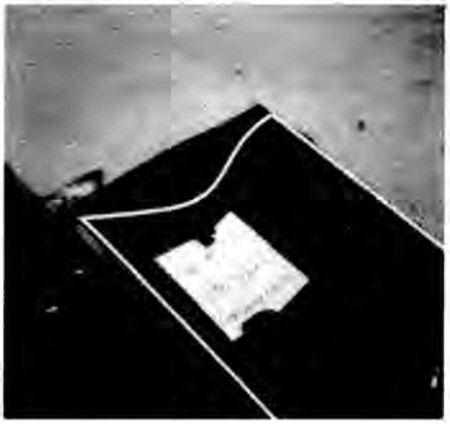

Fig. 3 Solidified boric acid.

OPERATING EXPERIENCES

Radioactive concentrates were first processed by the VR system on January 31, 1984. As of January 1985, 150 drums of solidified boric acid waste have been produced by the system. Neither contaminated bead resin nor cartridge filters have been processed to date. The use of powdered resin at Palisades has been discontinued and no contaminated powdered resin has been solidified with asphalt.

The system is operated on a batch basis. The waste boric acid tank is segmented into two parts providing capacity for two batches. Each batch of waste, about 2650 liters (700 gallons), is neutralized with sodium hydroxide. This waste is sampled for solids content and nuclide content prior to processing.

Approximately two 200-liter (55-gallon) drums result from processing a batch of boric acid waste (the previous cement process would have produced about 20 drums). A drum fill requires about 10 hours. Operators utilize a walk-pass method to run the VR system. An operator starts up the system and begins processing. Every hour, a walk-pass is performed to examine the control board and the drum level indicator. During the last hour of the drum fill, an operator spends 30 to 40 minutes in the control room to insure a proper fill. Thus, about 2.5 man-hours are required per drum. Twenty-five operators have been trained on the system at Palisades. One of six operators per shift is assigned to the VR system.

It is anticipated that drum labeling requirements for asphalt will be reduced by 1 hour per drum versus the previous cement process. This is due to the Asphalt Process Control Program, which eliminates the previously required quality control check for freestanding water in each drum.

Three asphalt spills have occurred at the fill station with the system so far. These spills were allowed to cool, scraped off the floor, and loaded into an empty drum prior to filling with asphalt. Two of the spills were caused by misinterpretation of the drum level indication.

Two redundant ultrasonic level detectors are provided to determine the asphalt level within a drum at the fill station. A TV camera is also provided to view the asphalt level, since mounding of the asphalt surface can disturb the ultrasonic level indication. Two spills resulted when the level detectors did not indicate a mounded overflow. The third spill resulted because a switch, which indicates when a drum is positioned under the fillport, was broken during the cleanup of asphalt on the conveyor. The switch was repaired and the operating procedures have been revised to require the level meter and the TV camera both be viewed during the last 30 minutes of the drum fill.

Minimal residual activity remains in the extruder after shutdown. The extruder room radiation field remains at less than 1 mR/hr.

Some asphalt buildup in the volatilization domes has been experienced. It is believed that this buildup resulted because the steam cleaning nozzles were clogged with rust and dirt that obstructed the cleaning steam flow. The installation of a strainer in the steam piping upstream of the nozzles is being investigated.

The replacement of HEPA filters in the VR system has been required every 2 to 3 months, rather than once a year as anticipated. It is believed that carryover of boric acid crystals from the fillport are passing through the prefilter and are building up on the HEPA filter. No radioactivity has been carried over. A smaller mesh size prefilter will be installed on the next prefilter changeout to prevent crystals from traveling to the HEPA filter.

The blowdown rate from the auxiliary boiler has been 10 times the anticipated volume. The blowdown rate has been 1900 liters/day (500 gal/day), whereas 190 liters/day (50 gal/day) was expected. The blowdown was originally routed to the floor drains for radwaste processing. A divert valve has been installed in the drain line to enable the direct discharge of blowdown, which meets release standards, to Lake Michigan.

The annual boiler inspection required about 2 man-hours. The extruder gear box lube oil was replaced (annual event) and required about 4 man-hours.

OPERATING CONSUMABLE COSTS

Consumables for the system include sodium hydroxide for boric acid neutralization, the asphalt binder, and drums. Sodium hydroxide is purchased as a 50-wt.% solution costing $.30/liter ($1.13/gal). For neutralization, about 0.13 kilograms of sodium hydroxide are required per kilogram of boric acid. Therefore, the cost of neutralizing one batch of 12-wt.% boric acid solution, 2650 liters, is about $46. Asphalt is purchased in bulk quantities at 30¢/kg (13.6¢/lb). Since about 136 kg (300 lb) of asphalt are contained in each drum, the binder cost is about $41/drum. New drums have been used and cost $30 each. The total cost of consumables per drum has been about $94/drum ($23 chemicals, $41 binder, and $30 for the container).

SYSTEM PERFORMANCE

The performance of the VR system is dependent on many factors. Of prime interest is the achieved volume reduction factor for the system in the field. Startup testing demonstrated that a VR factor (volume of waste feed ÷ volume of packaged waste product) of 6.3 was achievable. This corresponds to a net VR (volume of packaged waste solidified by cement ÷ volume of packaged waste solidified by asphalt) of approximately 12.

From January 30, 1984 to January 30, 1985, about 41,000 gallons of boric acid were processed, resulting in 150 asphalt drums. The previous cement process (30 gallons of waste per drum) would have produced about 1,370 drums. Therefore, an average net VR of 9 has been achieved with the system. Net VR factors as high as 12 have been observed for individual drums.

The shortfall in the average net VR can be attributed to an inaccurate match of the asphalt feed rate to the extruder with the solids content of the waste feed solution. A 1:1 ratio of asphalt to waste solids in the feed is desired. The solids content of the neutralized boric acid waste feed solution has varied from 3 to 12 wt.%. The initial operating procedures were prepared for the higher concentration. The extruder requires a minimum asphalt feed rate for screw lubrication. For waste feed concentrations below 9 wt.% solids, a 1:1 asphalt-to-waste ratio cannot be met, reducing the VR factor. The volume of waste feed that produced each drum is shown in Figure 4. It is not uncommon for over 300 gallons of waste feed to result in a single drum. The previous cement solidification process was capable of loading approximately 30 gallons of waste boric acid into a drum.

The amount of VR product loaded into a drum also has an effect on the net VR factor. Drum fill factors of over 90% have been readily achieved. Occasionally, however, drums were not filled to capacity. Figure 5 depicts selected VR factors for several drums. Both product and packaged VR factors are shown to demonstrate the effect of drum fill on the net (i.e., packaged) VR factor.

The two trends identified during operation, decreasing VR factor and inconsistent drum filling, are to be addressed in revised procedures and an operator requalification program.

ASPHALT PRODUCT

The average weight of the drums produced was 540 pounds with an average loading of about 240 pounds of sodium borate salts per drum. The surface dose rate of these drums has ranged from a high of 1 R/hr to a low of 12 mR/hr. The average drum surface dose rate was 94 mR/hr. Only Class A waste has been solidified to date. The curie content of the drums will not be determined until the waste is shipped for disposal. The drum curie content will be determined by waste samples taken from each batch prior to processing, which will be correlated by a proprietary computer program.

CONCLUSION

The operation of the Palisades VR system during the first 12 months has demonstrated several important items relevant to the industry.

First, significant volume reduction with the system in the field has been demonstrated. Although only radioactive boric acid has been solidified, nonradioactive bead resin, powdered resin, and cartridge filters were solidified during performance testing.

Second, no major unforeseen operational requirements have been identified to date. The cost of consumables (sodium hydroxide, asphalt and drums) has not been greater than anticipated.

Third, the use of the system has been of great assistance in conforming to the ALARA concepts of radwaste processing at the station by enabling remote operation.

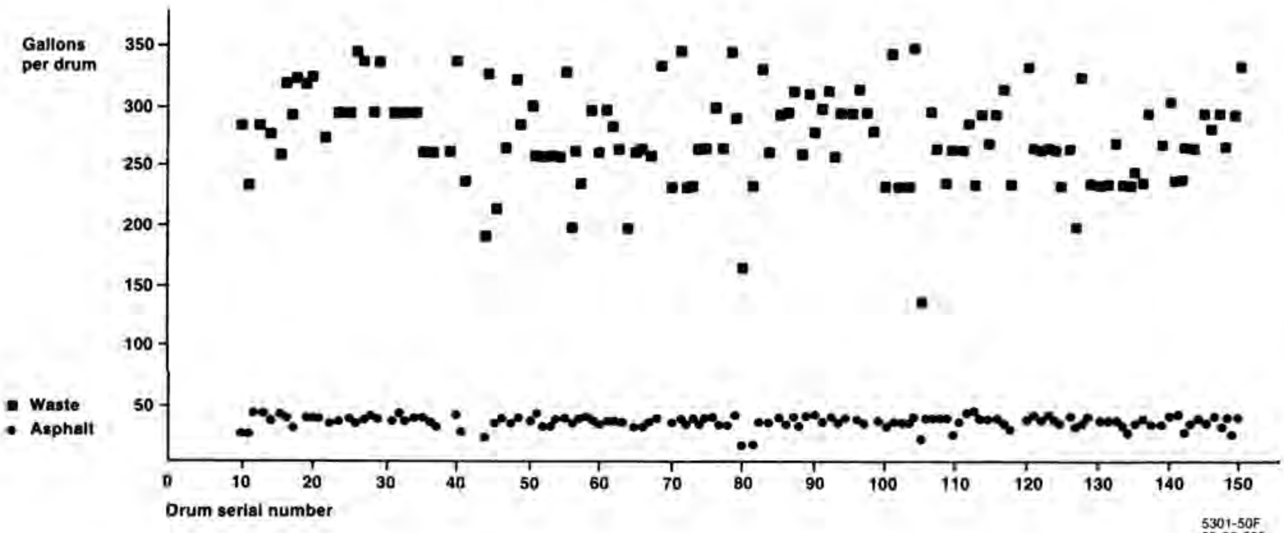

Fig. 4 Total waste and asphalt feed volume per drum.

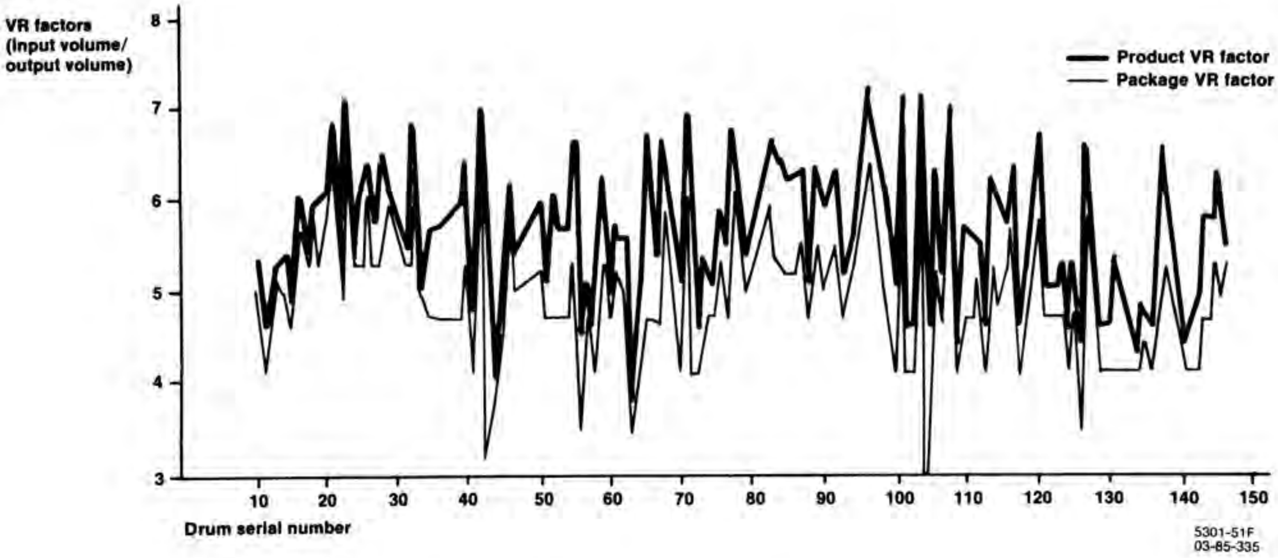

Fig. 5 Volume reduction factors.