THE SEABROOK CONVERSION

"The Volume Reduction Decision"

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ABSTRACT

Radioactive Waste Management at commercial power facilities has come under extreme pressure to develop new process systems for the treatment of liquid and resin waste streams. This pressure arose from the elimination of all but three of the commercial radioactive waste burial sites, the increasing costs of transport and burial of the wastes and the elimination of urea-formaldehyde as an acceptable solidification agent. Nuclear plants (operating and under construction) have been forced to reassess their policies and programs regarding waste management. Seabrook Station under construction in Seabrook, New Hampshire, is no exception. Re-evaluation of the radwaste system at Seabrook and the subsequent choice of a new generation system took over three years to make. This paper presents a brief history of this effort and describes the system ultimately chosen as a replacement for the original urea-formaldehyde system. This integrated system features an asphalt extruder-evaporator, a forced circulation crystallizer-evaporator and a resin centrifuge to effect maximum volume reduction of both liquid and spent resin wastes. The full system also includes a supporting drum handling system to move drums throughout process and storage areas and a box compactor for DAW volume reduction. A single vendor was selected as prime contractor to supply this integrated radwaste plant. By choosing a single vendor as prime contractor, PSNH gained the added benefits of having a single contract to manage, uniformity in parts such as instrumentation and controls, and obtained an integrated system warranty.

INTRODUCTION

Seabrook is a two unit 1150 MWe Westinghouse PWR with a common Waste Processing Building servicing both units. Designed in the early 1970's the original liquid radwaste treatment philosophy was similar to most plants of the era - collection, filtration, evaporation and demineralization. The solid waste system design consisted of collection tanks for evaporator bottoms (12 wt% boric acid design maximum) and spent resin and a urea formaldehyde (UF) solidification system. A standard drum compactor was planned for Dry Active Wastes. At the time, this state-of-the art technology for solid waste was considered quite acceptable.

Construction and engineering for Seabrook proceeded through the 70's but was beset by delays and slowdowns due to environmental and licensing concerns. Because of these slowdowns, the original urea formaldehyde equipment, delivered in 1977, was far ahead of the construction need date and placed into longterm storage.

By late 1979, the problems associated with urea-formaldehyde were becoming well known to industry and the regulatory agencies. Also, within this time frame, the burial sites were gradually closing-up which in effect put burial site space at a premium. The Seabrook project then undertook a study to identify all available solidification options and potential suppliers. This study lead to a general specification for a system to replace the UF system and reuse as much equipment as possible. In the later part of 1980 Congress passed the Low-Level Radioactive Waste Policy Act which established the framework for regional burial sites. This policy action was designed to resolve concerns about low level waste disposal, but led to a greater concern about the availability of burial space for Seabrook's waste in the Northeast after the act becomes effective in 1986. This set the stage for Seabrook's next action.

INITIAL STUDIES

The study performed in 1980 identified several systems that might be viable options for the Seabrook Station, although no one single system appeared as the front runner. The study also identified both asphalt and the "DOW" binder coupled with volume reduction as the most cost effective systems with developed hardware supply. Incineration of DAW appeared marginal from a cost savings viewpoint and licensing aspects were unclear.

With this basic knowledge in hand, bids were solicited for various systems and binders to allow a more detailed technical and cost evaluation. At this time also the decision was made to delay construction of the solid waste portion of the Waste Processing Building while at the same time continuing construction of the balance of the building and other systems. It was also decided that the selection of any new volume reduction or solidification system must be accomodated within the existing Waste Processing Building envelope. The cost penalty of a new building was to be avoided.

Evaluation of the first, and subsequently second round of bids did not yield any system with a clear advantage from both a technical and economic viewpoint. This evaluation did however, identify the need to re-establish the criteria for system selection and supported the decision to delay system procurement as long as possible.

Then, in November 1981 the NRC issued generic letter No. 81-39 titled NRC Volume Reduction Policy. This policy, which supported maximum volume reduction, combined with the ever increasing burial and transportation costs, aided in the establishment of new system criteria:

1. The solid waste system must be of proven design, must have previous in-plant or prototype experience and should have NRC Topical Report approval.
2. The system must be flexible enough to fit into existing space in the Waste Processing Building and must reuse components of the previous UF system wherever applicable.
3. System must proviide maximum volume reduction for liquid waste and spent resin.
4. System must demonstrate industry acceptance-A a one-of-a-kind system will not be accepted.
5. Total system capabilities must not be tied to a single solidification binder only.

These criteria were established to assure Seabrook would not become a test facility for a system trying to break into the market, and potentially jeopardize plant startup with unforseen problems of a new system.

These criteria then became the basis for a new study into available systems and component combinations with the decision to delay final selection until all five criteria could be met established as the final criteria.

FINAL STUDY

From the systems evaluated in 1981 it was clear that no single system could meet all these new criteria. However, there were several combination systems that could meet these criteria and two of these systems combinations were chosen for further evaluation. These systems combinations were:

1. Asphalt evaporator-extruder coupled with a fluidized bed incinerator and liquid preconcentrator, and a spent resin centrifuge.
2. Asphalt evaporator-extruder, coupled with a forced circulation evaporator/crystallizer, and a spent resin centrifuge.

In addition to the major components listed above, both system combinations included provisions for a cement fill station for large containers and a High Integrity Container resin dewatering station.

Although the full system combinations had not been tried before, sufficient interface information between the various systems existed from other projects to allow both systems to be deemed acceptable for the Seabrook plant. By mid-1982 several other plants had purchased various portions of the combination of the systems under consideration. The fluidized bed incinerator had undergone full scale prototype testing and both the crystallizer and resin centrifuge were considered proven technology. Only the in-plant experience requirements for the asphalt extruder-evaporation had not been met, although several systems had been sold and extensive European operating data was available. However, because of this lack of in-plant U.S. experience the decision to further delay a system purchase was again made.

SYSTEM CHOSEN

Finally in December 1982, the extruder-evaporator installed at Palisades was operated on simulated waste and test data gathered. This operation and subsequent data completed the in-plant experience criteria for the extruder-evaporator. Now that all of the technical criteria had been met, an extensive economic study was undertaken to determine the most cost effective system for Seabrook. This study also considered the use of mobile solidification systems and cement solidification with no VR. Based on this evaluation, the system which presented the most cost effective system was the integration of an asphalt extruder, crystallizer and centrifuge combination.

The final system, chosen in May 1983, combines an asphalt extruder/evaporator, a forced circulation evaporator/crystallizer, a resin centrifuge, drum handling equipment and a box compactor. This integrated system and the variety of waste processing paths within it provides PSNH with optimum reliability and flexibility in operation.

SEABROOK SOLID WASTE MANAGEMENT SYSTEM DESCRIPTION

An integrated solid waste management system is provided at Seabrook to serve two nuclear (PWR) generating units. This system provides the following functions:

a. Volume reduce to the maximum extent practical all liquid and spent resins produced by the generating units.
b. Solidify this volume reduced waste, as necessary, for off-site disposal in accordance with the requirements of 10 CFR 61.
c. Provide for encapsulation/solidification of non-volume reduced waste such as spent filter cartridges, contaminated tools and equipment, and like items generated during plant operation and maintenance.
d. Volume reduce dry active wastes for on-site storage or off-site burial.
e. Provide onsite storage for low level waste.

The Solid Waste System (WS) is located in the Waste Processing Building (WPB) and is common to both units.

The Solid Waste System is comprised of several subsystems, as follows:

1. Waste Concentrates Handling
2. Spent Resin Handling

3. Liquid Waste Volume Reduction
4. Volume Reduction and Solidification
5. Container Handling
6. DAW Volume Reduction
7. Alternate Solidification Station

These systems are all integrated with the exception of the DAW volume reduction system, which operates completely independent of any other system. The alternate solidification station is provided only for emergency purposes and would allow for the quick hookup of mobile or temporary solidification services including resin dewatering in High Integrity Containers.

Waste Concentrates Handling Subsystem

Function and Design Requirements

The waste concentrates system provides the following functions:

a. Collects and stores concentrated wastes - up to 12 wt% boric acid - from the existing plant evaporators.
b. Collects misc. chemical wastes from the Chemical Drain Treatment Tanks.
c. Transfers waste to the Waste Feed Tanks and provides chemical adjustment.
d. Provides feed to the Liquid Waste Volume Reduction system, the Volume Reduction and Solidification system, and the Alternate Solidification Station.

Process and Component Description

The system consists of the following major components.

a. Waste Concentrates Tank
b. Waste Feed Tanks(2)
c. Bottoms Collection Tank
d. Concentrates Pump
e. Waste Feed Pumps(2)

The Waste Concentrates Tank is located in the WPB at elevation -31' and collects the evaporator bottoms and chemical drains from the existing evaporators. Concentrates are transferred to the Waste Feed Tanks on elevation 53'. Once in these tanks, pH is adjusted and the concentrates can be fed to the evaporator/crystallizer, or directly to the extruder-evaporator or to the alternate solidification station. The normal design operating mode is to process these concentrates through the crystallizer/evaporator producing a concentrated bottoms of 35 wt% solids. These bottoms are then fed to the extruder-evaporator for further volume reduction by the removal of all water, and the solidification of the radsalts.

Spent Resin Handling Subsystem

Function and Design Requirements

The spent resin handling system provides the following functions:

a. Transfers spent resin from the Spent Resin Sluice Tanks to the Resin Hopper.
b. Dewaters resin in the Resin Hopper.
c. Provides resin feed from the Hopper to:
    1) Resin centrifuge
    2) Extruder/evaporator
    3) Alternate solidification station

Process and Component Description

This subsystem consists of the following major components:

a. Spent Resin Transfer Pump
b. Spent Resin Hopper
c. Spent Resin Dewatering Pump
d. Resin Recirc. Pump
e. Resin Centrifuge

The Resin Sluice Tanks, located in the WPB at elevation 31'-Q" provide the collection point for spent resins. The Spent Resin Transfer Pump takes suction on either of these tanks and transfers resin to the Resin Hopper at elevation 53'-0". After the Resin Hopper is filled, resin is processed by dewatering via the Resin Dewatering Pump. The Hopper fill operation is repeated until the proper resin slurry density is obtained in the Resin Hopper.

The normal resin process path is to the Resin Centrifuge. All transport water is driven from the resin in the centrifuge and the "dry" resin free falls into the extruder. The prime function of the centrifuge is to quickly remove all transport water from the resin slurry, and thereby increase the system throughput by reducing the evaporative demand on the extruder. As an alternative, resin slurry can also be fed directly to the extruder via the resin pump. Resin slurries can also be pumped to the alternate solidification station located in the truck bay.

Liquid Waste Volume Reduction Subsystem

Function and Design Requirements

The Liquid Waste Volume Reduction subsystem provides for the concentration of various liquid wastes from a nominal 5 to 10 wt% TDS to 35 to 50 wt% TDS. This concentration is accomplished by a forced circulation evaporator/crystallizer operating on plant steam.

The prime function of the crystallizer is to provide the required system throughput capacity by quickly removing excess water from the liquid waste stream prior to feeding the asphalt extruder-evaporator, which has a comparatively low evaporation rate. The crystallizer also provides for a means of volume reduction independent of the extruder operation and, in addition, allows for a reduced demand on the station's existing upstream evaporators.

Process and Component Description

This subsystem consists of the following major components:

a. Crystallizer Vapor Body
b. Crystallizer Heater
c. Entrainment Separator
d. Crystallizer Condenser

The crystallizer vapor body is located above elevation 55'-0" in the WPB along with the heater and entrainment separator. The remainder of the equipment is located on elevation 53'.

Feed from the Waste Feed Tanks enters the recirc loop of the crystallizer and mixes with the recirc flow prior to entering the heater. This stream then enters the vapor body where part of the flow flashes to steam. The flashed steam then enters the entrainment separator whereit passes through distillation trays and a demister pad and then enters the condenser skid and ultimately returns to the plant liquid waste system.

Bottoms from the crystallizer are pumped from the main recirc loop to the crystallizer bottoms tank by the crystallizer drain pump.

System operation is dependent upon the amount of waste available for volume reduction. System is capable of continuous operation with periodic bottoms blowdown. However, the crystallizer will normally be run on a batch basis, concentrating to the maximum extent practical and then shutting down. This is due to the limited upstream storage capacity (5000 gallons) for concentrates from the other plant evaporators. The hold up volume of the crystallizer vapor body, heater and recirc pipe is 1000 gallons. Therefore, the entire contents of the 5000 gallon concentrates storage tank can be volume reduced in the crystallizer and stored in the crystallizer bottoms tank prior to processing through the extruder-evaporator.

Volume Reduction and Soldification

Function and Design Requirements

The volume reduction and solidification subsystem provides the following functions:

a. Accepts a variety of feed concentrations to allow for flexibility in upstream subsystems.
b. Removes all water from the various waste streams - concentrates and resin.
c. Mixes the dried waste with an asphalt binder.
d. Deposits the asphalt/waste mix into disposable containers.
e. Provides steam and asphalt supply to support the solidification process.

Process and Component Description

This subsystem consists of the following major components:

1. Evaporator/Extruder
2. Auxiliary Steam Boiler
3. Asphalt Storage Tank
4. Asphalt Pumps

The extruder is the main component of this subsystem and the heart of the entire volume reduction and solidification process. It is located in the WPB at elevation 42'-5". In the extruder the waste stream (concentrates or resin) mixes with asphalt which is then heated (by steam) to evaporate the remaining water in the mix. The resulting matrix contains approximately 50% dried residual waste and 50% asphalt by weight and is deposited into either 55 gallon drums or 85 ft^3 containers. As the matrix cools from the operating temperature, solidification takes place due to thethermoplastic properties of asphalt. Water evaporated from the waste during volume reduction is condensed in the extruder-evaporator steam domes and is gravity drained to the liquid waste floor drain tanks.

Steam for this process is supplied by an electric auxiliary boiler at 410°F and 275 psig. Asphalt is supplied from the 7000 gallon asphalt storage tank located in a separate building at grade just south of the WPB.

The asphalt tank and asphalt lines are steam jacketed and maintained at 325° F through use of steam supplied by the solid waste auxiliary boiler. The asphalt storage tank is designed for normal delivery about once every two months of 3500 gallons of asphalt. At the design level of usage, a full asphalt tank contains approximately 4 months of asphalt supply.

All asphalt lines are steam traced using the high temperature steam from the solid waste auxiliary boiler. Plant auxiliary steam is provided as a backup system in case the solid waste system auxiliary boiler needs to be shut down for maintenance. This plant steam will only serve to keep the asphalt tank and lines warmed and is not sufficient to keep the asphalt molten for extended periods.

Drum Handling Subsystem

Function and Design Requirements

The drum handling subsystem provides the following functions:

a. Provides empty containers for solid waste product.
b. Places empty containers on turntable.
c. Provides for continuous operation of extruder while rotating containers on turntable.
d. Removes filled containers from turntable, caps containers and provides for swiping to check for surface contamination.
e. Removes filled containers from fill aisle and places in storage area.
f. Removes containers from storage area to truck area for off-site removal.

Process and Component Description

This system consists of the following major components:

a. Empty drum conveyor
b. Drum turntable
c. Full drum conveyor
d. Drum hoist & grab
e. Drum capper & hoist
f. Transfer cart
g. Radwaste crane w/drum grab & rotator

The components of this subsystem are all located within the WPB at floor elevation 25'-0" except for the radwaste crane which sits at el. 73'-7". The empty drum conveyor is loaded from the Solid Waste Control Room with empty drums (6 minimum, 10 maximum) prior to the start of solidification operations. The drum hoist and grab lifts empty drums from the empty drum conveyor and places them on the turntable prior to fill operation. If an extended run is anticipated drums can be placed on the empty drum conveyor at this time.

The extruder-evaporator is a one-step volume reduction and solidification process that operates continuously. The drum handling system is designed to allow continuous flow of drums through the process area so as to take full advantage of the benefits that continuous system operation provides.

Operation of the extruder will cause a drum to fill with the asphalt/waste mixture. After a drum has been filled, the turntable rotates an empty drum into the fill position and the filled drum into the pickup position on the turntable. The drum hoist and grab lifts the full drum and places it on the full drum conveyor. At this time an empty drum may be placed on the turntable if continuous operation beyond the six drum capacity of the turntable is anticipated.

On the full drum conveyor the drum moves to the capping station where the capper is activated to pick up a cap from the cap stack and place it on the drum and crimp it in place. After capping, the drum moves to the capper turntable where a swipe is taken to check for external contamination. The drum is then transferred to the end of the full drum conveyor where the overhead radwaste crane can pick it up and place it in the storage area.

All drum handling and process operations can be visually monitored via the CCTV system. A lead glass window on the fill aisle wall also provides visual observation of the capping and swipe operations.

As an alternative to filling drums, the extruder-evaporator will also fill 85 ft^3 liners. Liners will be located under the extruder discharge by the transfer cart. The cart also moves liners to the capping and crane pickup positions. The use of liners or drums will be dictated by disposal economics.

Daw Volume Reduction System

Function and Design Requirements

The DAW Volume Reduction System provides the following functions:

a. Provides a central location for the accumulation of dry active waste.
b. Volume reduces this waste through use of a box compactor with an expected volume reduction factor of 4:1 to 6:1.
c. Provides for packaging the DAW into containers suitable for off-site disposal.

Process and Component Description

This subsystem consists of a single major component, a box compactor. The compactor is located in the WPB at el. 25'-0", and uses boxes with external dimensions of 44" x 48" x 88".

System Controls

The entire volume reduction, solidification and drum handling system is controlled remotely from two control panels in the shielded control room of the WPB elevation 25'.

Radwaste processing is controlled from a single panel which integrates all the process subsystems mentioned above. A programmable controller provides for automatic operation after manual startup of the system. Interlocks and permissives prohibit inadvertent or improper operation of subsystems and also form the basis of the solidification Process Control Program.

All drum handling and closed circuit television operations are controlled from the Drum Handling Panel. All drum movement operations on the drum conveyors and turntable are manual start with automatic stop. All drum lifting and capping operations are manually controlled. Crane operation is manually controlled with specific lockouts to prevent crane travel with load in down position and to prevent collisions with walls and other obstacles. Two small panels in the truck bay supplement the main control panel by providing limited functional control over waste flow to the alternate solidification station and control of critical crane movements to provide close-up crane operation during cask loading operations.

An independent control panel is provided for operation of the box compactor.

Report on Project Progress

From contract award in May, 1983, through March 1, 1984, the following progress has been achieved:

1) System design and integration has been substantially completed by the prime contractor.

2) UE&C/PSNH building design and plant interface engineering is substantially complete.

3) Procurement for all major and most minor items is complete by the prime contractor, and fabrication of major components is in progress.

4) Construction of the interior walls and floors of the WPB is well under way with completion expected by March 1984.

5) The first equipment will arrive on site in March 1984, with completion of deliveries in July 1984.

6) Equipment installation and interconnecting piping and wiring is scheduled to begin in Summer 1984.

7) Preoperational tests will be performed in 1985.