RETROFIT OF A VOLUME REDUCTION AND SOLIDIFICATION SYSTEM AT THE FERMI 2 NUCLEAR PLANT

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ABSTRACT

The retrofit of a Volume Reduction and Solidification (VRS^{TM}) System has been completed at the Fermi 2 plant. The new system was retrofit into existing space making substantial use of existing equipment. Technical, scheduler and performance considerations of the system are discussed in this paper.

INTRODUCTION

A retrofit of a radwaste Volume Reduction and Solidification (VRS) System has been completed at Detroit Edison's Fermi 2 nuclear station. The retrofit should provide savings in operator doses and waste disposal and storage costs. This paper describes the design considerations, project execution and performance expectations of the retrofit system.

Fermi 2 is a nominal 1100-MW BWR-4 for which detailed engineering began in 1968. The low level radwaste systems (liquid and solid) purchased as part of the overall plant were typical for that generation of BWR plants and represented the existing, state-of-the art technology. Included as part of the original plant were early-generation liquid processing and solidification systems. In addition to being plagued by many operating problems, those early systems were not necessarily compatible with the changing economic climate in which waste disposal and handling costs have increased dramatically (Reference 1).

These changes caused Detroit Edison to reexamine its radwaste systems with the intent of updating them to incorporate cost-effective and proven advances in technology and to comply with changing regulatory requirements. This reexamination was performed after most of the radwaste systems had been installed, but prior to initial checkout and pre-operational testing.

The conclusions reached from this reexamination resulted in changes to the liquid and solid waste processing system, and to additional on-site waste storage facilities. As regards waste solidification, the following decisions were made:

1. Remove the original cement solidification system from the plant's radwaste building.
2. Retrofit an extruder-evaporator VRS system into the existing radwaste building, utilizing as much existing upstream liquid and solid feed system equipment as possible.
3. Modify container handling facilities to provide an efficient means of transporting the 55 gallon solidified and drummed radwaste from the radwaste building to a new on-site storage facility.

The system supplier's primary responsibility to the overall radwaste redesign was equipment supply, process design, and general arrangement of the VRS system, while interfacing with the Architect Engineer for the container handling system and building design modifications. The system supplier and Architect Engineer were additionally engaged to study the design and expected performance of existing equipment at the plant and its continued utilization.

PROCESS DESCRIPTION

The VRS system for Fermi 2 is a one-step volume reduction and solidification process which utilizes an extruder-evaporator to evaporate water from radioactive process wastes and thereby achieve a volume reduction. Dried waste residues are encapsulated by the extruder-evaporator into a thermoplastic matrix (asphalt). The end product is a monolithic, free standing solid with no free water. 55 gallon drums are used to contain the encapsulated waste for temporary storage, transport and burial. The system was designed to process the following waste types and annual quantities:

Evaporator Concentrates	13,000 gal.
Bead IX Resins	33,000 gal.
Resin sludges	68,600 lb.

The VRS system is composed of the following primary sub-systems:

Waste Feed System

The waste feed system includes a centrifuge as the primary method for feeding spent resins to the extruder-evaporator. It feeds a dewatered resin cake to the extruder-evaporator by gravity. One of the two original radwaste system centrifuges is utilized as well as a 6,000 gallon agitated feed tank and recirculation pump. A metering pump was added to provide back-up slurry feeding capability to the extruder.

The waste concentrates feed system collects concentrate and chloride waste from the radwaste evaporator and chloride waste tank into a common concentrates feed tank from which it is fed directly to the extruder-evaporator. The system consists of:

- A 1500 gallon heat traced storage tank
- Recirculation pump
- Concentrates metering pump

Extruder-Evaporator and Fill Station

The extruder-evaporator is the heart of the VRS processing system. It is used to mix the radioactive wastes with an asphalt binder while evaporating free water from the mixture. After dispensing the waste residues homogeneously in the asphalt matrix, the extruder then discharges the product into a 55 gallon drum container. The utility manifold skid distributes steam to the extruder-evaporator to heat each barrel section and cooling water to the feed and discharge barrels. The drive section of the extruder-evaporator provides co-rotating torque to the screw shafts. It comprises a 100HP DC motor with variable speed capability.

The drum filling operation takes place in a shielded area to minimize radiation exposure to the operator and other personnel. Filling is observed by the operator through shielded windows and/or a closed circuit television system. The operator will monitor and control all aspects of filling from the system local control panel. The turntable holds six 55 gallon drums. It positions the drums under the extruder-evaporator discharge port, permitting these drums to be filled sequentially while the extruder operates continuously. It also provides temporary storage and cooling of drums.

Asphalt Storage and Metering System

The Asphalt Storage System stores and maintains the asphalt binder in a pumpable state and provides suction pressure to the metering pumps. Asphalt is metered to the extruder to match the solids content of the waste stream so that the product is approximately 50% solids by weight.

Drum Handling System

The Drum Handling System consists of two principal devices: the monorail hoist drum grab and the capper-seamer. The hoist and drum grab are used to transport filled drums from the turntable to the capper-seamer. The capper-seamer adds the lid and seams the lid on the 55 gallon drum. A shield window located at the capping station provides visual monitoring of drum capping and monitoring operations. The seamed drums are then conveyed onto the existing transfer cart for storage.

Control System

The VRS system operations are controlled from two panels. The main VRS panel is a graphic control panel which monitors all the feed systems as well as the extruder-evaporator. The drum handling console monitors both drum handling and seamer operations.

As mentioned previously, the retrofit was accomplished within existing building space, replacing the early-design cement solidification system and utilizing as much of existing equipment as possible. The extruder-evaporator was installed next to the filling aisle previously occupied by the cement system. The turntable, monorail hoist with drum grab and the capper-seamer provide the interface between the fill station and the existing drum-transfer cart system, thereby re-using the entire existing filled drum and conveying and storage facilities in the building.

Similar design approaches were taken in retrofitting the balance of the VRS system equipment to minimize changes to existing building shield walls.

PROCESS DEVELOPMENT

In the initial stages of the Fermi 2 retrofit, a study was undertaken to determine the applicability of waste processing and materials handling equipment which already existed at the plant. In particular, two horizontal bowl centrifuges had already been installed which appeared to offer potential advantages for dewatering and feeding of ion exchange resin wastes to the extruder. If a physical dewatering process, such as a centrifuge, is used upstream of the extruder, the extruder throughput will be improved and operating time reduced in proportion to the amount of water removed. The extruder can then be utilized to volume reduce these dewatered sludges by evaporating the remaining moisture and incorporating the dehydrated residue in asphalt. A by-pass system was also installed around the centrifuge.

The centrifuge study was approached from two perspectives:

1. Evaluate operating experience of centrifuges installed in radwaste applications.
2. Establish centrifuge operating characteristics pertinent to this application by actual testing.

The first phase of the problem consisted of a review of operating experience with horizontal bowl centrifuges installed in power plant radwaste applications. Extensive discussions were held with operating and maintenance personnel at 9 plants which had used similar centrifuges. These conversations were aimed at the experiences and operating problems with the centrifuges themselves and the upstream feed and downstream solids collection systems. Most complaints centered around the following problems:

1. Dusting from too low moisture in the dewatered product, and
2. Difficulties with overloading-excess torque.

The first condition (dusting) has been corrected at most installations by resetting weir height within the centrifuge to yield a slightly higher moisture content in the discharge. The excess torque condition is not a centrifuge problem per se, rather it is a generic problem with the installed feed systems. Further discussions revealed that feed mixtures (e.g. from phase separator tanks) were not usually homogeneous and concentrations varied widely. Also, due to generic problems with installed flow instruments, actual feed rates to the centrifuge were unknown. This combination of variations in waste feed concentration and unknown feed flow rate occasionally resulted in exceeding the centrifuges capacity to discharge solids, and resulted in an overtorque condition. Dewatered product flow problems from downstream hoppers were also mentioned frequently; however, like the torque overload problem, they can be traced to problems with interface systems.

Favorable operating experience with centrifuges was reported at many plants. It was concluded that past problems were both readily identifiable and solvable.

The second phase of the program involved determining if the operating characteristics of a centrifuge are compatible with the requirements of an extruder-evaporator and, if compatibility exists, to define the interface requirements about which a system could be designed.

In tests conducted at WasteChem's Ramsey facilities, the results verified that:

1. dewatered product moisture contents are uniform and predictable for all feed materials,
2. if fed a homogeneous slurry at a fixed rate, the dewatered solids are discharged at an equivalent fixed rate without surging or variation with time, and
3. increased extruder solids throughput can be realized via direct discharge from the centrifuge.

From the foregoing operational experiences and test program results, it was concluded that use of one existing horizontal bowl centrifuge at Fermi was a viable and reliable means of increasing extruder efficiency by using the centrifuge to mechanically dewater waste feed slurries. Equipment was then arranged within the plant to provide direct gravity discharge from the centrifuge to the extruder to eliminate intermediate accumulation. A backup system also exists which permits metering of resin slurries directly to the extruder.

PROJECT SCHEDULE

Initial studies by the Architect Engineer and Detroit Edison of alternative systems began in late 1979. Detailed engineering and procurement began in the fall of 1980. At that time a 4 month scheduled completion was projected based on known scope of supply and available manpower resources. However in order to support the then-projected plant start-up of late 1982, a 16 month scheduled completion was required. As a result of this aggressive schedule requirement, an accelerated schedule program was implemented two months after engineering work started. This program focused on consolidation of engineering and procurement activities in addition to a larger project staff. This program also allowed for more direct communication between the engineer, and the client and A/E, resulting in shorter document review cycles and group design reviews.

The program was successfully executed, with final equipment deliveries made in the spring of 1982, some 16 months after the project's inception. The system at present is totally installed with functional testing to begin by mid-1984.

VRS SYSTEM PERFORMANCE

Functional checkout of VRS subsystems at Fermi has already begun. Full system startup and operation on simulated waste is now planned for mid-1984. The results to be expected at Fermi can be projected from European system experience, pilot plant programs and current Palisades experience. Based upon this data it is expected that the total discharges of solidified waste will be 500 drums per year. This represents a 93% reduction in waste volumes when compared to the 7000 drums per year which were expected from the original Fermi 2 cement system (Reference 1).

REFERENCES

1. R. Beaudry, R. Keenan; "Volume-Reduction Radwaste Processing Slashes O & M Costs"; Electric Light and Power, March, 1983.