RETROFIT AND OPERATION OF LOW-LEVEL RADWASTE SOLIDIFICATION SYSTEM

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ABSTRACT

The West Valley Demonstration Project has selected cement as the solidification medium for the disposal of liquid and wet solid low-level radioactive waste (LLW) as well as for Transuranic Waste (TRU).

To accomplish this objective, a Cement Solidification System (CSS) was designed around a High-Shear Cement Mixing System that was developed for radwaste and constructed as a nonradioactive demonstration unit in 1980. The High-Shear Mixing System was developed to overcome the chemical and physical impediments to proper mixing and curing inherent in the waste liquor. The components of this system were dismantled, upgraded to allow for remote operation and increased capacity in radioactive service, and installed in an existing building at West Valley.

Because the original system had operated as a nonradioactive demonstration unit, it had the capacity to fill 208-litre drums but did not have the capability to remotely and automatically handle the full containers of solidified waste. West Valley is also using standard 208-litre drums for disposal, and procured a drum handling system to convey, cap, smear, and decontaminate drums. A second major procurement was for a bulk cement storage and transfer system to provide cement to the mixing system.

It also is a Project objective to minimize the amount of new construction at the site which is a former spent fuel reprocessing plant. To meet this objective, the cement system and its two support systems were installed in part of an existing building originally constructed to house an acid fractionator system. The amount of space available was very limited resulting in a compact arrangement. This leads to some operating and maintenance problems which are discussed. System background, design and retrofit problems, and operating experience to date will also be discussed.

INTRODUCTION

Two of the many objectives of the West Valley Demonstration Project (WVDP) are; (1) Dispose of low-level radioactive and transuranic wastes generated during the project as regulated by DOE Order 5820 - Management of Radioactive Waste,[1] and (2) make maximum use of existing plant facilities.

A Cement Solidification System was installed in an existing building to satisfy both objectives.

SYSTEM DESCRIPTION

Functional and Operational Requirements

To meet the WVDP Functional and Operational Requirements for such a system, the Cement Solidification System (CSS), must be able to:

1. Accurately and reproducibly meter known quantities of Radwaste into a mixer;
2. Dewater ion exchange resins and reslurry with a known quantity of water prior to metering to a mixer;
3. Accurately and reproducibly meter known quantities of Cement into a mixer;
4. Accurately and reproducibly meter known quantities of Chemical additives into a mixer, if required;
5. Blend the ingredients to form a homogeneous monolith capable of meeting disposal criteria adopted by the WVDP, as required by DOE Order 5820. The WVDP plans for its waste forms for low-level waste to meet the intent of the requirements in Sections 55 and 56 of 10 CFR 61;[2]
6. Fill 208 litre drums at a rate of 6 drums/hr;
7. Allow flushing of mixers prior to system shutdown, and recycling of the flush water for solidification;
8. Cap the drums of cement/radwaste mixture after filling;
9. Allow for smearing of drums to check for surface contamination, monitor drums to determine radiation level, and weigh drums;
10. Decontaminate drums should the smear results indicate surface contamination above release limits;

11. Move drums between processing stations;

12. Be remotely operated from the control room;

13. Be operated with minimal of operator attention.

The Cement Solidification System designed to meet these requirements is divided into three (3) subsystems;

The Waste Encapsulation Subsystem
The Material Handling Subsystem
The Cement Storage and Transfer Subsystem

Waste Encapsulation Subsystem

The Waste Encapsulation Subsystem is depicted in Fig. 1. Waste is received in the Waste Dispensing Vessel (WDV) through one of four pipelines, depending on the source. Possible waste feeds are, evaporator concentrates, ion exchange resins, filter backwash sludge, Uranyl Nitrate Hexahydrate (temporary), and plant drains. Once in the Waste Dispensing Vessel, the waste can be dewatered, if necessary, as in the case of ion exchange resins. The dewatering pump is used to pump water through a screen located in the discharge of the WDV. A level reading is obtained on the dewatered solids, and used to calculate a water addition volume for a known water/solids ratio.

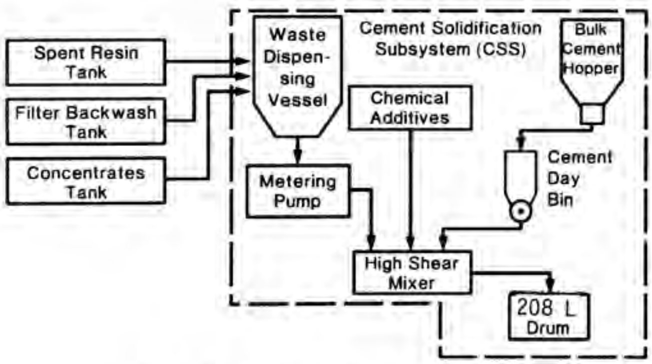

Fig. 1. CSS block flow diagram.

Waste is agitated in the Waste Dispensing Vessel, and recirculated through two (2) three-way valves using the waste dispensing vessel pump. This pump is a positive displacement, progressive cavity pump with a constant flow rate.

Waste solidification operations are controlled by a Programmable Logic Controller (PLC). When the Waste Encapsulation Subsystem is started in automatic, one of the two (2) three-way valves in the recirculation line changes position to discharge waste into Mixer No. 1 with the mixer running on low speed. The valve is held in this position for a preset time by the programmable logic controller to accurately feed a known quantity of waste to the mixer. Following the waste addition, chemical additives are added, if required, using the same technique with a metering pump and a preset discharge time. The last addition to the mixer is cement, which is added using a gravimetric "loss-in-weight" solids feeder. When all the ingredients have been added, the mixer switches to high speed for a preset mix time which completes one batch mix cycle. The batch is then discharged to a 208 litre drum through the drum fill head.

As soon as the waste addition is complete to Mixer No. I, the second three-way ball valve changes position to start a second batch mix cycle. One batch is 95 to 100 litres, and one discharge is required from each mixer to fill a 208 litre drum. When the drum has been filled, the drum fill head is raised, and a drip pan is extended between the drum and fill head, to catch drips. This drip pan is flushable to prevent buildup of hardened cement. At this point the Material Handling Subsystem, which will be discussed in the next section, takes over.

This same drip pan serves as a dump tank during mixer flushing operations, when sealed to the drum fill head. Flush water from the flush water tank is pumped to the mixers using a positive displacement metering pump, and allowed to agitate at high speed for several minutes. The flush is then discharged through the fill head/dump tank, and pumped to the settling tank with the dump tank pump. This flush solution is agitated in the settling tank to keep the cement from hardening into a monolith. When ready to start the CSS, the agitator is turned off and the solids allowed to settle. The flush water is then decanted back to the flush water tank, and the settled solids are pumped to the mixers for solidification.

Material Handling Subsystem

The Waste Encapsulation Subsystem, described in the previous section, is comprised of equipment that was used as part of a demonstration plant,[3], operating on synthetic waste. To use this system at West Valley, the system required modification to operate more remotely; and to increase capacity. These goals were accomplished by automating all the valves in the system, adding a second high shear mixer, and by providing a remotely operated drum handling system. A layout of this system is depicted in Fig. 2 and Fig. 3.

To save time in the design and installation of the CSS, a performance specification was prepared, outlining the space available for the drum handling system. Detail design, procurement of components, installation and startup, were made the responsibility of the Subcontractor.

The material handling subsystem is also controlled by a programmable logic controller. The control is broken down into six independent sequences:

Empty Drum Room
Empty Drum to Process Room
Filling and Capping
Drum to Swipe Station
Drum to Decon Discharge Conveyor
Decon

Empty drums with lids and crimp rings are loaded manually onto four gravity roller conveyors having a total capacity of 32 drums. Once these conveyors are loaded, drum movement is controlled remotely and automatically from the control panel. The "Empty Drum Room" sequence moves drums from one of the four (4) storage conveyors as selected by the operator, to the air lock door, on powered roller conveyors. The "Empty Drum to Process Room" sequence takes the empty drum through the air lock into the process room. The 17.8 cm thick steel air lock doors also serve as shield doors. Each of the two doors provides enough shielding to allow full time occupancy in the clean drum room.

Once in the process room, the drum is stopped at the lid removal station while the drum at the fill station is being filled. After the drum at the fill station is filled, the Filling and Capping sequence is

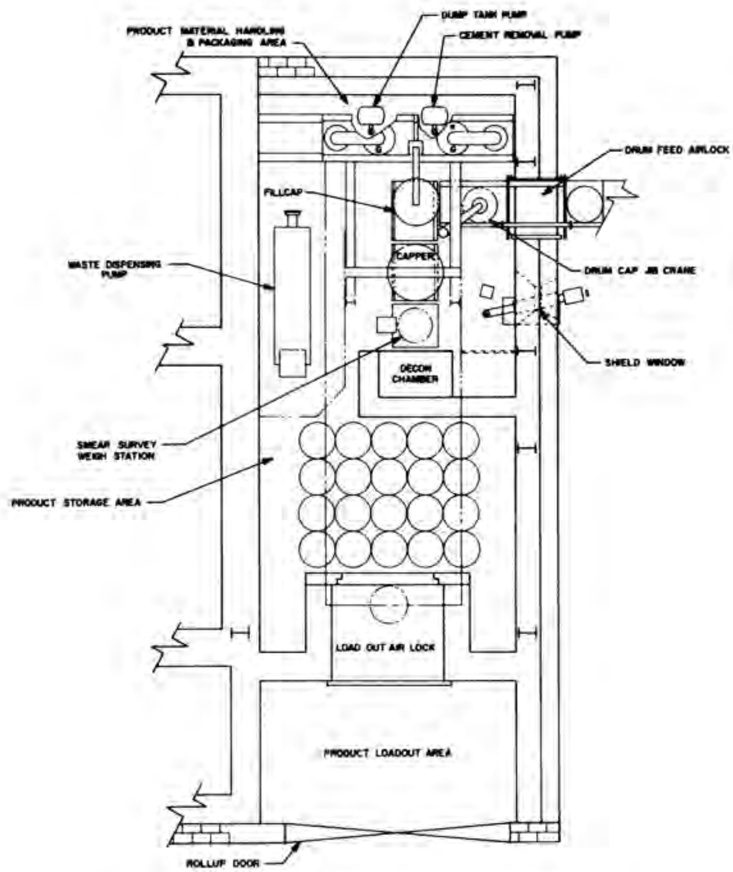

Fig. 2. CSS process room layout.

initiated, causing the drum at the fill station to move to the capping station. A jib crane with a suction pick-up removes the lid and crimp ring from the drum at the lid removal station, and places it on the drum at the capping station. The empty drum then moves to the fill station, as the lid crimper is lowered onto the full drum to seal the lid.

The Drum to Swipe Station sequence moves the full drum from the capping station to the smear station. The smear station consists of a turntable with live rollers, a radiation monitor, a scale, a Master Slave Manipulator (MSM), and a transfer drawer. An operator in the clean drum room obtains a smear by holding a swipe tool against the drum with the MSM, and rotating the smear station turntable. The swipe tool with the smear is passed through the shield wall in the transfer drawer to the clean drum room where the smear is counted. The smear station operator also determines the contact dose rate and drum weight at this station, and prepares a drum label. The label is placed on the applicator, and passed through the wall in the transfer drawer to the process room where the applicator is picked up with the MSM and the label is applied to the drum.

If the smear count indicates that the drum is clean, the Drum to Decon Discharge Conveyor sequence is used to move the drum to the full drum storage area. The decon chamber serves as an air lock between the process room and the full drum storage area.

If the drum does have surface contamination, the Decon sequence is used to decontaminate the drum. The drum enters the decon chamber through the inner air lock door, and a water spray ring passes down the side of the drum to decon the top and sides. At the same time, water is sprayed on the bottom of the drum through fixed spray nozzles mounted between the rollers. Following the water spray, the drum is air dried, and returned to the smear station where it is resmeared.

Cement Storage and Transfer Subsystem

In addition, to the need for a drum handling system, a method of keeping the cement feeder supplied with cement was required. A cement storage silo and Pneumatic Transfer System was procured for this purpose. As with the material handling system, a performance specification was used to obtain a turnkey system. Cement transfers are initiated automatically when the day bin on the gravimetric feeder reaches the low-level set point. Cement is gravity fed from the silo into a dense phase transmitter until the proper batch level is reached. The dense phase transmitter is then pressurized with air from the air receiver, and the cement is transferred to the day bin. When the dense phase transmitter is empty, the system automatically shuts off after purging the transfer line.

BUILDING DESCRIPTION

Previous Usage

The building selected to house the Cement Solidification System is known as the 01-14 Building which originated from the systems previously installed in the building. The systems were constructed as part of a plant expansion by the previous site operator, but were never put into radioactive service. By using this building rather than an area that had been operated, the need for decontamination was

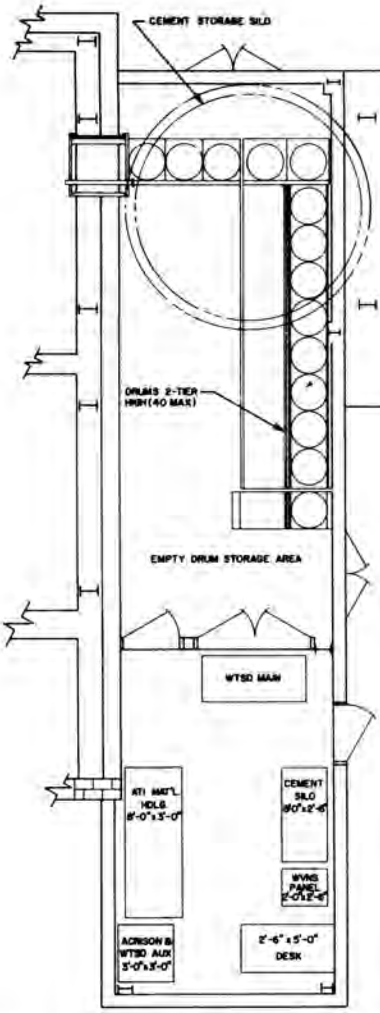

Fig. 3. CSS clean drum room.

eliminated. This allowed us to advance the schedule several months. The building is four stories, and consists of two shielded cells, and four floors of unshielded operating space.

The "01 Cell" is 4.3 m wide x 4.3 m long to a height of 7.3 m, and 2.4 m wide x 4.3 m long to a height of 13.4 m, and was used for an Off-Gas Scrubber System.

The "14 Cell" is 4.3 m wide x 3.8 m long to a height of 7.3 m, and 2.4 m wide x 3.8 m long to a height of 13.4 m, and was used for an acid fractionator system. The first floor of the operating building housed two (2) shielded pump niches. The second, third, and fourth floors were occupied by the building H&V System. The WVDP is reusing the Off-Gas System in the 01 Cell, and, the building H&V System. As a result, the space available for the CSS was the 14 Cell and the first floor operating aisle.

System Layout

The 14 Cell, the smaller of the two shielded cells, is being used to house the Waste Dispensing Vessel, the flush water and settling tanks, and the flush water, settling tank and dewatering pumps (Fig. 4).

The first floor operating aisle which is, 4.3 m wide x 11.9 m long is being used to house the waste processing operation, and a 40 drum storage area (Fig. 2). The processing area contains the waste metering pump, the mixers, and the full drum processing conveyors from the lid removal station to the drum pick-up conveyor. The gravimetric cement feeder (Fig. 5) was installed on the second floor behind the building air intake heater, to allow gravity feed to the mixers on the first floor. With the cell and the operating aisle both used for operating equipment, there was no space available for empty drum storage and a control room. A single story 2.4 m wide x 14.6 m long, metal building was added to the south side of the 01-14 Building for the control room and clean drum storage area (Fig. 3). The Cement Storage silo was installed on a structural steel support platform above the metal building.

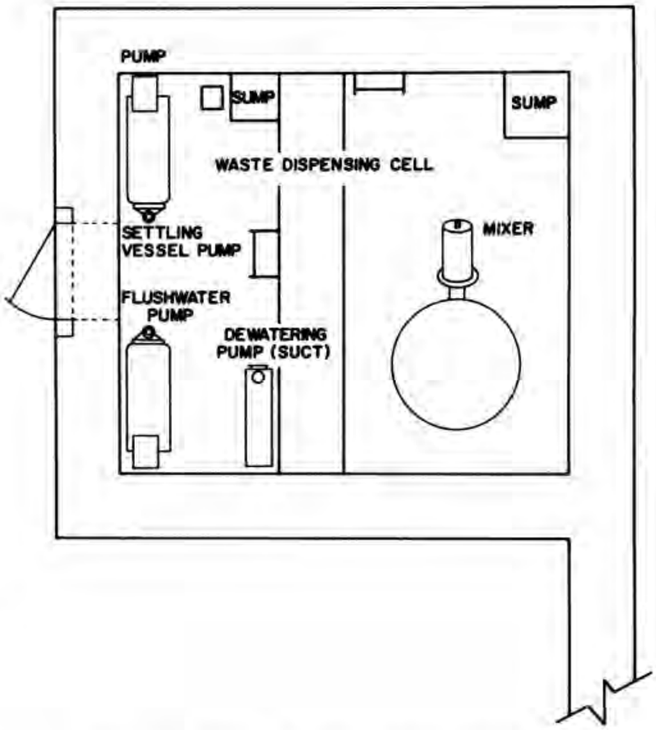

Fig. 4. CSS waste dispensing cell layout.

Operating and Maintenance Considerations

Retrofitting of the existing equipment into the existing facility led to some interesting design problems. One of the most difficult problems was laying out the equipment in the process room to allow easy and quick removal of mixers from the radioactive environment. Because of the piping around the mixers, it was apparent that there would not be enough head room to lift a mixer by itself off the skid, therefore, the entire skid must be removed. The skid contains the mixer and drive motor, and is much larger than a mixer. It was also apparent that there would be very little room to maneuver the skids, and with the fill head and capper in place, there would be no way to remove the southern most mixer. In addition, the mixers had to be mounted too close to the East Wall to be able to center a bridge crane over. This was necessary because of the cement feeder location. To solve this problem, the fill head support frame was modified so it could be easily rotated out of the way to clear a path for the mixer. In addition, an existing four-ton bridge crane in the building was modified to allow access to the mixer. The four-ton bridge was replaced by a two-ton bridge with a monorail extended off the east side of the bridge. This monorail can be centered over the mixer skid. In addition, a removable platform which can be attached to the mixer support beams was designed and fabricated to provide a working platform. As a result, both mixers can be easily and quickly removed from the process room for repair or replacement.

Fig. 5. CSS gravimetric cement feeder.

A second maintenance problem was created by the necessity of placing the gravimetric feeder behind the building air intake. There would be no space for personnel to reach the back of the unit for access to the drive motors and load cell. To overcome this problem, casters were welded to the frame (Fig. 5), allowing the unit to be rolled out into the open for maintenance. The feeder must remain stationary during operations, and jacks were added to accomplish this. The fact that the feeder could not be located any further west dictated the location of the mixers on the floor below.

One important operational concern during the design was protection of operators from exposure to radiation. The control room and clean drum storage area are adjacent to a part of the building that was unshielded, but is now being used to process waste and store full drums. To provide the shielding required, concrete was poured between the building I-beams, resulting in 35.6 cm of concrete, in addition to 30.5 cm of existing concrete block. At the east end of this wall the number and size of penetrations was so large, that it was easier to demolish a portion of the wall completely and pour a 66 cm thick wall, than to selectively remove blocks. Shielding was also a concern in the cell housing the Waste Dispensing Vessel. This vessel represents a significant exposure risk to maintenance personnel working on the pumps in the same cell. The waste dispensing vessel was isolated from other equipment in the cell by the construction of a 61 cm thick shield wall (Fig. 4).

These types of problems are a result of not being able to layout the system in an optimum manner, and design a radwaste building around this layout. However, with some extra design effort, these types of problems are solvable, and a workable system can be constructed utilizing existing equipment and facilities with savings in both dollars and schedule.

Operation

The system checkout and initial cold operations began in July of 1985, and initial hot operation was achieved on December 11, 1985. The waste selected for this initial hot operation was 16,000 litres of depleted Uranyl Nitrate Hexahydrate left from the previous reprocessing operations.

Through the cold testing and initial operations we have shown that the system is capable of producing a waste product meeting our waste form criteria, and is capable of operating at a rate of 6 drums/hr.

REFERENCES

1. "Radioactive Waste Management," DOE Order 5820, US Department of Energy, Washington, DC.

2. "Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR 61, US Nuclear Regulatory Commission, Washington, DC, dated December 27, 1982.

3. A. J. DIETRICH, S. N. PAGUY, "High-Shear Radwaste Solidification System," presented at American Concrete Institute Symposium New York, October 28 - November 2, 1984.