RETROFITTING AND OPERATION SOLID RADWASTE SYSTEM DRESDEN STATION, UNITS 2 & 3

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Introduction

Units 2 & 3 at Dresden Station are twin 794 MW (net) BWR units that became operational in 1970 and 1971. The waste streams are typical of BWR stations, namely, bead resin and filter sludge (powdered resins and diatomaceous earth), evaporator concentrate containing approximately 25% dissolved solids and dry active waste. The original solid radwaste system utilized cement for solidification in open top 55 gallon drums. Remote handling was provided by means of a monorail with moving platforms supporting the drums. A relatively light-weight compactor was used to compact DAW into 55 gallon drums. Difficulties were experienced with this system.

1. Significantly more waste was generated than the system was designed to handle. This, coupled with relatively high maintenance, resulted in electrical production being radwaste limited a number of times, primarily due to the inability to regenerate and/or backwash condensate demineralizer.

2. High maintenance, a dirty environment, and radiation exposure to operators require rotating personnel to avoid excess exposure.

3. Process control was dificult to obtain in the automatic mode, hence, manual operations were instituted to insure that waste shipments would meet transportation and burial site criteria.

4. Operating and maintenance costs were high.

5. Airborne contamination was a problem.

In 1974, studies were initiated to consider retrofitting a solid radwaste system at the station to overcome the above-listed shortcomings. Initial steps considered retrofitting a new system into the existing radwaste building. This idea was rejected for the following reasons:

1. Cost to properly modify the existing structure was considered to be prohibitive.

2. Partially due to site specific situations, shipment of radwaste during construction would be difficult, if not impossible.

3. The building could not be modified to include an indoor truck bay.

4. Sufficient solidified waste storage capacity could not be provided.

It was decided after considering various alternative building arrangements to build a new building adjacent to the existing radwaste building. The addition was 100' long, 60' wide and 23' high, as shown in plan on Fig. 1. The following were key items thought pertinent to this decision:

1. The building addition and equipment installation could be completed with minimum disruption of plant operation.

2. The existing building could be integrated with the new building to significantly increase storage capacity for DAW waste and supply emergency storage for 3000 drums of solidified waste.

3. Arrangement of equipment in the new building would provide significant operational advantage including reduction of operational exposure.

4. An enclosed truck bay, not available in the existing facility, appeared to offer additional operational and safety advantage.

The STOCK Radwaste System was selected for installation based upon detailed economic and technical evaluation of their proposal. Sargent & Lundy was selected as the architect/engineer. Both companies played a part in evaluating many building alternatives necessary to insure low cost and that the building design was optimal for equipment operation, safety and ALARA considerations.

The building shape, size and location required a number of compromises and actual construction, as with most new construction at operating stations, and required some difficult practices. Some of these items were:

1. The building design required the capability of moving feedwater heaters through the wall of the existing building into the new radwaste building if replacements should be required. An exterior building wall location was partially dictated by this requirement.

2. The location of exterior walls was also limited by the location of an existing road and high line tower that could not be moved.

3. High line cables extended over the new building requiring careful crane operation and limiting crane access above the building.

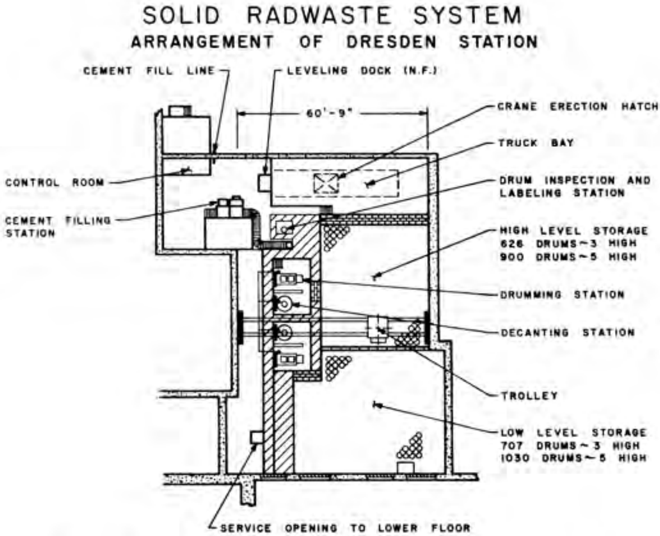

Fig. 1 - Plan View, New Dresden Radwaste Building

Fig. 2 - Drum Utilized for Solidified Waste, 55 Gallon, DOT 17C, 16 Gage with 4" Screwed Cap

4. Foundations were difficult and expensive due to the large number of pipes extending under the building location.

5. The new building was constructed to overlap the old building approximately 10 feet. This permitted remote handling of drums to and from the basement of the older building for emergency storage. The hatch to the basement of the older building is shown at the lower left corner in Fig. 1.

6. Doors to the left of the cement filling station in Fig. 1 provide access to empty and DAW filled drum storage on the main floor of the old building.

Equipment

The Dresden radwaste system was the first operational installation of the second generation STOCK cement solidification equipment. The system is briefly described below.

Containers

The system is designed to solidify waste in DOT 17C, 16 gage, 55 gallon tight head drums with a 4" screwed cap located in the center of the top head as shown in Fig. 2.

This containter was selected because it has relatively high strength, is available from many sources in a competitive market, its size minimizes potential mixing problems to obtain a uniform solidifed structure, and its first cost is a fraction of that of other containers of acceptable size due to mass production techniques. STOCK supplies the 4" cap and flange to drum manufacturers because the largest available cap from other manufacturers is 2" in diameter. The 2" cap limits process capabilities and is, therefore, not large enough for this application.

A screwed cap of 4" diameter is simple to insert, remove, and seal remotely with a capper designed for the purpose as compared to other closures. It is also sufficiently large to insert fill nozzles, vent connection and overfill sensor into the drum as believed necessary to help maintain exterior drum cleanliness.

Transportation economy utilizing these relatively small containers is obtained through the ability of the system to solidify measured quantities of relatively high and relatively low level waste in the same container. Available cask shielding can be more fully utilized using this technique.

Cement Filling Station

The process starts in the safe-access area by prefilling drums with a measured weight of dry cement in equipment shown in Fig. 3. Measuring and feeding the soldification agent and waste streams separately provides additional assurance that proper process control is obtained. The quantity of cement for a given waste mixture is predetermined by STOCK through full-scale test. This quantity is dialed into the controls providing automatic filling cutoff for accurate process control.

The drum cap is manually removed, a mixing weight inserted and the drum rolled to the scale platform. The fill nozzle and vent are next inserted into the drum by elevating the drum a few inches. The drum is then positioned for filling as shown in Fig. 3. After filling, the drum is lowered, the cap replaced and the gravity exit conveyor delivers the drum to the remotely operated crane pickup station.

This equipment normally is operated 15 to 20 minutes to fill sufficient drums to operate a full shift for each drumming station. Solidification formulas are established to provide 85-90% utilization of drum volume. This allows for potential variations in cement densities and waste characteristics without overfilling. Cement quantity is established conservatively to provide solidification without free water even in the unlikely event that a drum is overfilled with liquid waste. Prefilling the container with solidification agent also avoids potential cleaning and blockage problems that could be associated with in-line mixers. It also helps to minimize maintenance in radioactive areas.

Decant Station

This 500 gallon tank, metering pump, decanting pump, valves, piping and instrumentation assembly as shown on Fig. 4 is utilized to insure that the solid-to-water ratio of slurries is consistent and that the proper quantity is delivered to each drum. It serves the additional purpose of reducing the quantity of water disposed of to a minimum consistent with pumping requirements.

The single action piston type metering pump can deliver slurries up to 90% by volume solid particulate. It is equipped with 4 valves, each of which can operate as a suction or discharge valve providing 12 pumping modes for tank filling, emptying and flushing purposes.

A multiple propeller mixer insures a homogeneous mix within the tank. Water, water-solid interface sensors and suction for the progressive cavity decanting pump move to insure accurate

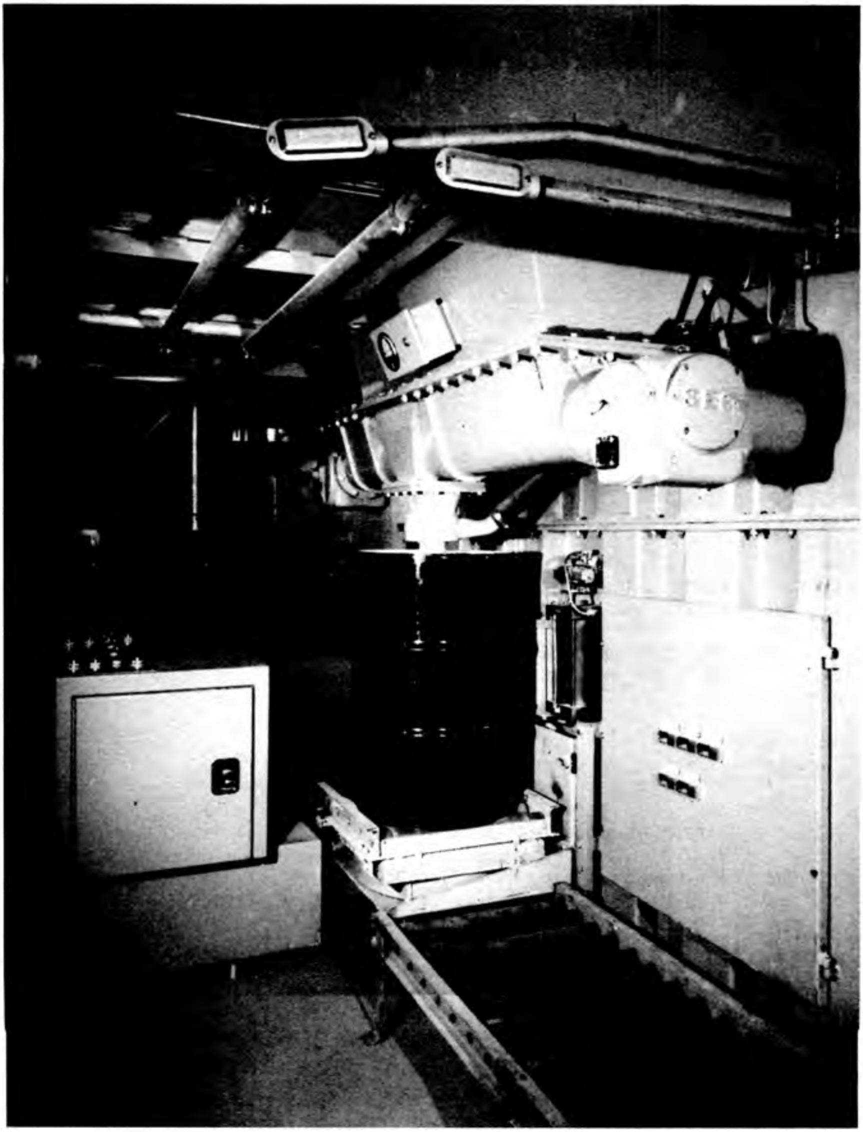

Fig. 3 - Dry Cement Filling Station (Radiation Safe Area)

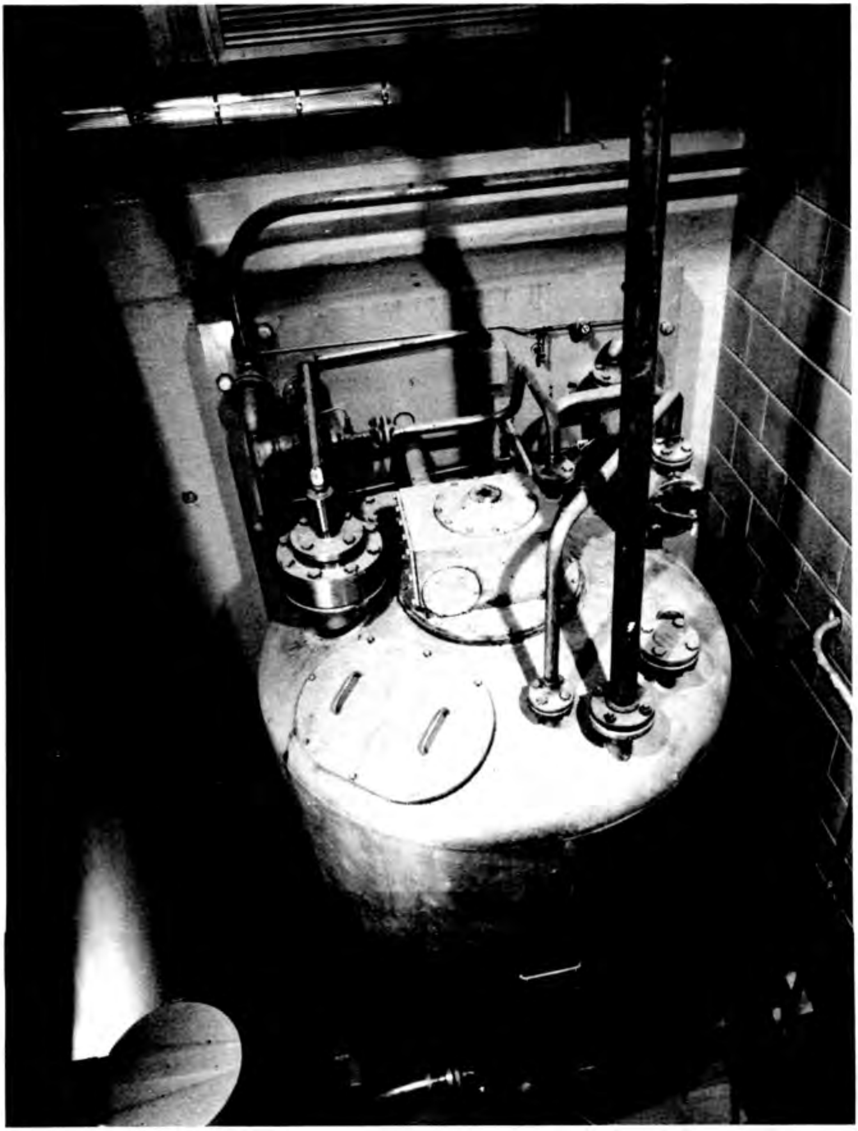

Fig. 4 - Decanting Station

measurement and removal of excess water after a timed settling period.

The tank system contains decontamination sprays and is designed to be remotely emptied and decontaminated when required.

Drumming Station

Drums prefilled with cement powder and a mixing weight are lowered into the drumming station enclosure with the remotely operated bridge crane. Fig. 5 illustrates a drum in place prior to closing the hatch. The enclosure isolates the drum from the station environment during uncapping, filling, recapping and mixing operations. The enclosure chamber is vented to the station's radioactive vent system through the fill nozzle vent. Vapors and air displaced during drum filling are vented directly to the vent system from inside the drum, helping to avoid external drum decontamination and airborne release to the station.

The enclosure is mounted upon a 12" thick steel shield wall, shown in the background of Fig. 5. This shield separates the motors, most of the gear reduction units, air cylinders, valve actuators and electronics from the radioactive zone as shown in Fig. 6 (the decanting station is constructed similar to the drumming station). A high percentage of maintenance can, therefore, be accomplished in a low radiation zone.

Drumming station internal hardware is shown in Fig. 7. The drum is placed upon the circular cradle shown at the bottom of Fig. 7. The cradle rotates around the vertical shaft to both the filling and capping-mixing positions. The cradle elevates the drum to the capper position for cap removal. It then lowers, rotates and elevates the drum to insert the fill nozzle into the drum. The fill nozzle is a multiple purpose device; separate nozzles for slurries and concentrated waste, an emergency overfill sensor and a large diameter vent pipe surrounding the fill nozzles and sensor.

Mixing is accomplished by clamping the drum utilizing the large clamps shown in the background of Fig. 7, lowering the cradle away from the drum and tumbling the drum end-over-end at a pre-determined speed and time. The first cycle serves as a "pre-mix" to wet the cement, thereby, reducing the volume of the drum contents. A second fill and mix cycle then occurs to finish filling the drum and complete mixing of the contents.

Slurries, preconditioned in the decanting station, and evaporator concentrates may be pumped into the drum individually

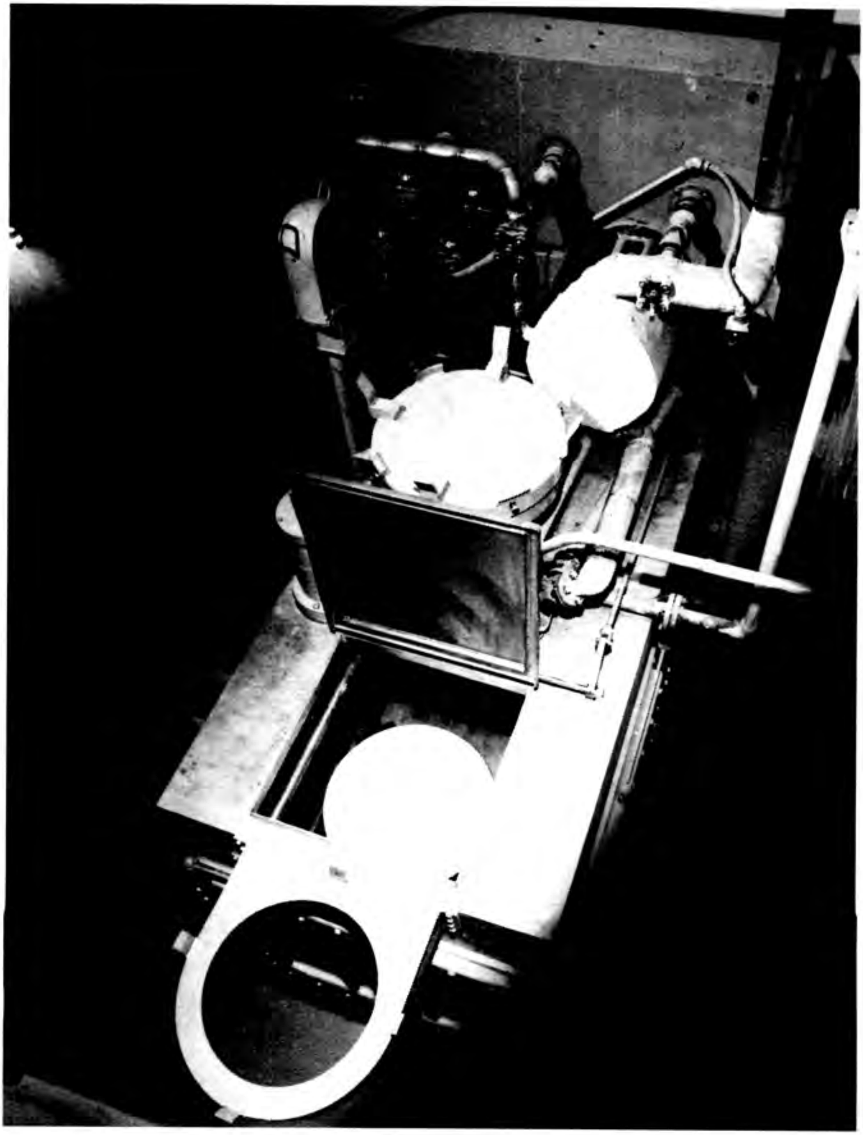

Fig. 5 - Drumming Station, Process Side

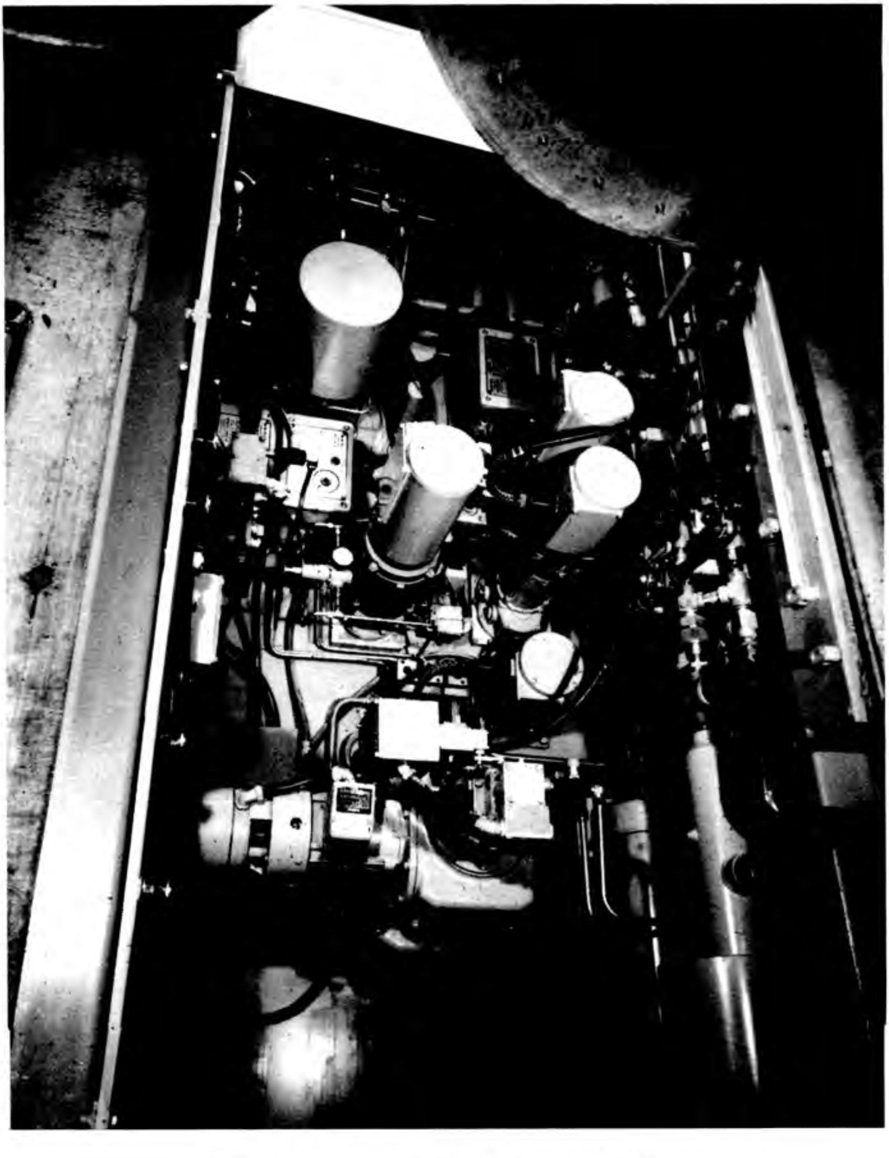

Fig. 6 - Drumming Station, Maintenance Side

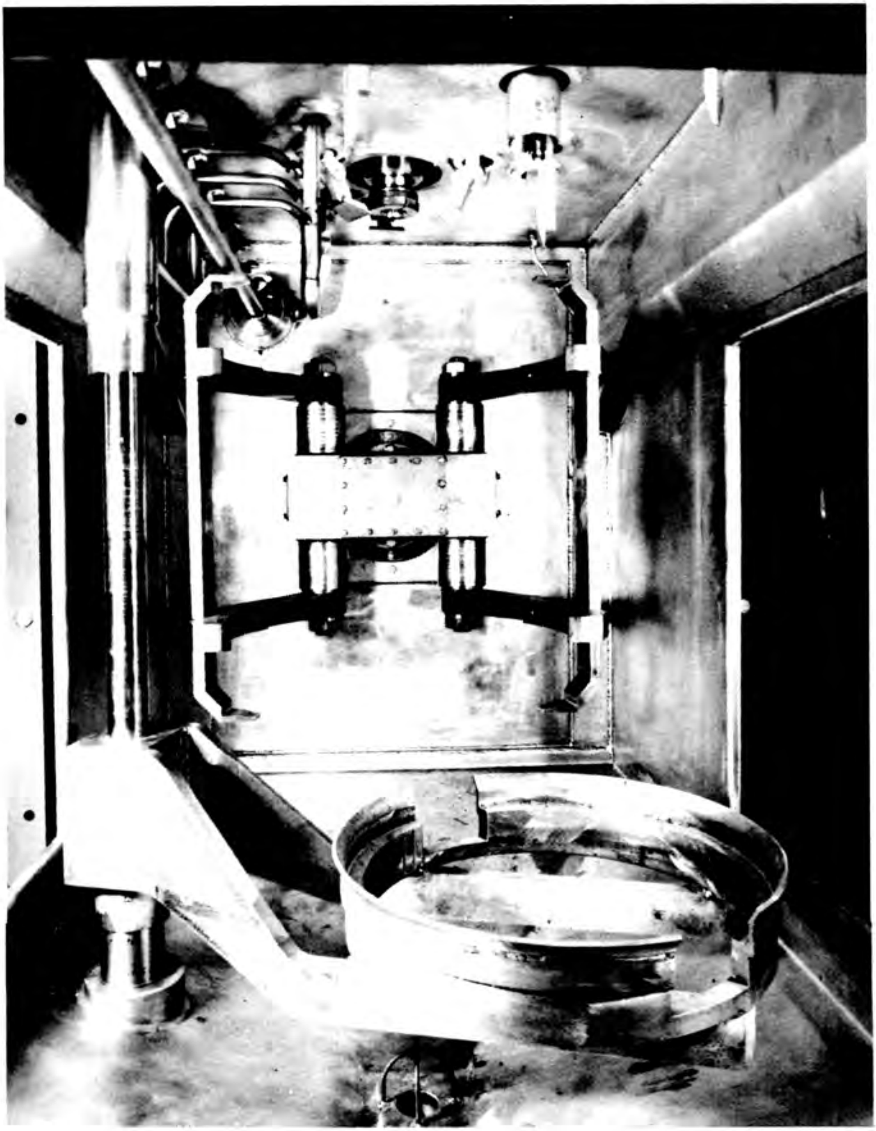

Fig. 7 - Drumming Station Enclosure, Internal View

or in sequence on both the first and second fill cycle in accurately measured quantities. This feature provides needed flexibility for drum filling and control of the drum surface radiation level. The insulated evaporator concentrate metering pump is shown above and on the right side of the enclosure.

After completion of the process, the crane removes the drum from the enclosure and places it upon the circular scale platform located behind the hatch in Fig. 5. In this position the final drum weight and radiation level may be recorded using instrumentation readouts located in the control room. Drum weight, checked against pretested formula weight, is the final check for process control purposes. Since sufficient cement is added to solidify a completely filled drum, any errors occurring in the radiation zone will be shortages of waste within the drum, insuring no free water.

Drum and internal decontamination sprays are shown in the upper left of Fig. 7. The long horizontal tube contains nozzles along its length. The tube is rotated to spray the internal chamber if required for hot side maintenance. A timed, manually actuated spray may occur to clean the drum while the drum is tumbling in the mixer clamps.

The processing equipment is capable of handling 3 drums per hour. Generally, this capacity is 5 times the average waste generating rate from any single reactor. This large excess capacity is desireable to empty the liquid storage tanks after periods of excessive waste generation and to reduce the number of shifts requiring processing equipment operation.

Remotely Operated Bridge Crane

Fig. 8 shows the remotely controlled bridge crane installed at Dresden Station, which handles all drums, cask lid removal, and truck loading of drums and pallets in radioactive areas. The equipment is designed for precise locating capability to facilitate simple, remote operation. Accurate location capability also provides for efficient use of storage areas and allows uniform stable drum stacking.

Accurate locating capability is accomplished through the use of an upward viewing TV camera which has cross hairs in its field of vision. The cross hairs are lined up with alpha-numeric targets located on the ceiling of the building. Final location occurs at a bridge or trolley speed of 2½ feet per minute. Nominal positioning accuracy is ¼ inch. Accuracy is also enhanced by a feature of the hoist that lowers the grab down a vertical

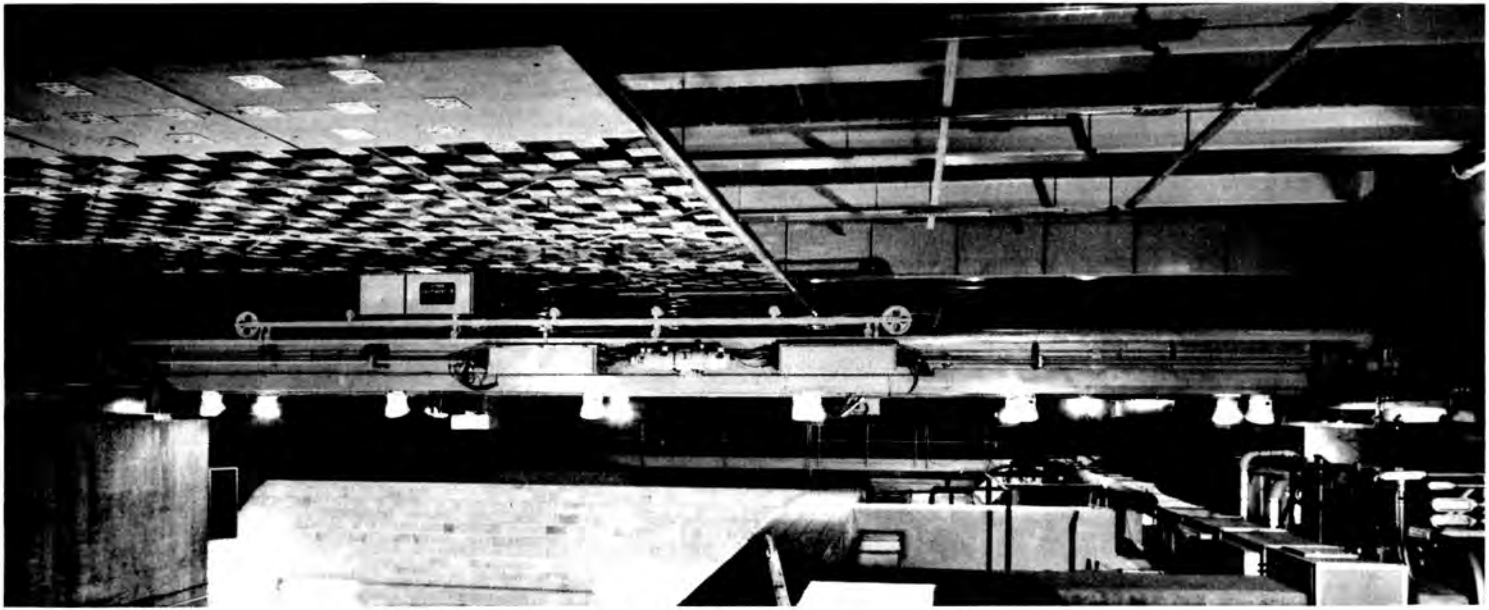

Fig. 8 - Remotely Operated Bridge Crane

centerline, which is not normally provided with conventional cranes.

Drive motors and all power and control circuits are redundant to eliminate the possibility of a single electrical failure preventing completion of a given operation or of preventing the removal of the crane from the radioactive zone for maintenance purposes.

The drum grab's multiple jaws attach to the upper chine of a drum. No space is required between drums in an array for grab jaw clearance. A downward viewing TV camera in the grab is used to inspect drums for cleanliness before removing them from the drumming station, to verifty drum numbers and positions, and to provide precise locating capability in case the upward viewing TV camera should malfunction. Two surveillance cameras, mounted at quarter points on the bridge, complete the TV equipment. The crane may be operated with one or more TV cameras out of action, but admittedly not as effectively.

Three lifting devices may be attached to the grab. The first is a standard swivel hook for routine heavy lifting; the second is a dual hook. Both will handle loads of up to 7½ tons. The dual hook permits remote lifting of, for example, cask lids without the possiblity of the lid rotating out of its original plane. This means the lid may be removed and replaced from a remote position. The third device may be utilized to upright a drum that may be on its side or drums that may be deformed which may preclude normal grab jaw interfacing. A number of redundant safety features help prevent inadvertent equipment or load damage. Some of them are:

1. The grab jaws cannot be opened unless the grab support cables are slack.

2. High speed operation of the bridge and trolley is prevented with a load in excess of one ton.

3. Redundant limit switches cut power as the bridge or trolley approaches the end of its rail. Shock absorbing Belville spring bumpers prevent damage even if the limit switches should fail.

4. The bridge and trolley will not operate in high speed unless the grab is in the "full-up" position. In this position a drum will clear everything in the station that the crane itself will clear because the drum is nestled between the bridge beams. In this position the grab and load are also supported to eliminate swinging.

5. The grab TV monitor views linkages that tell the operator whether the jaws are open or closed and indicate when each jaw clamps onto the load.

The crane may stack drums up to 12 high in 1 on 4, 1 on 2, or 1 on 1 patterns. For the 1 on 1 pattern, the crane grab may be utilized to remotely locate grating sections between each drum layer to insure stability of the stack.

Drum Inspection Station

This unit, located near the truck bay, is utilized to inspect drums and provide information for shipping documents prior to truck loading. A drum is loaded into the unit via the bridge crane. The drum rests upon a turntable permitting rotation which provides access to all drum surfaces for smear test and radiation measurement purposes.

The operator is protected by concrete and steel shielding from drums being handled by the crane and from drums being inspected. Stationary radiation instrumentation is provided with remote readout. Appropriate penetrations are provided in the steel shield wall for smear testing and indirect visual drum inspection utilizing mirrors.

Dry Waste Compactor

The dry waste compactor shown in Fig. 9 is capable of exerting 30,000 pounds of force. It is designed to withstand a full eccentric load without damage. The 7" hydraulic cylinder permits use of relatively low hydraulic pressure to minimize maintenance.

The 25" circular chamber and access door above the drum permit convenient trash loading and serves to guide the waste into the drum. This feature facilitates better utilization of the upper portion of the drum.

The empty drum is located upon a platform supporting the lower drum head which moves the drum into the compacting position by means of a hydraulic cylinder.

Roughing and dual HEPA filters (in parallel) are located behind the loading chamber instrumentation. They are provided to remotely determine when the filters require replacement. Dirty filters may be dropped into the drum for compaction without

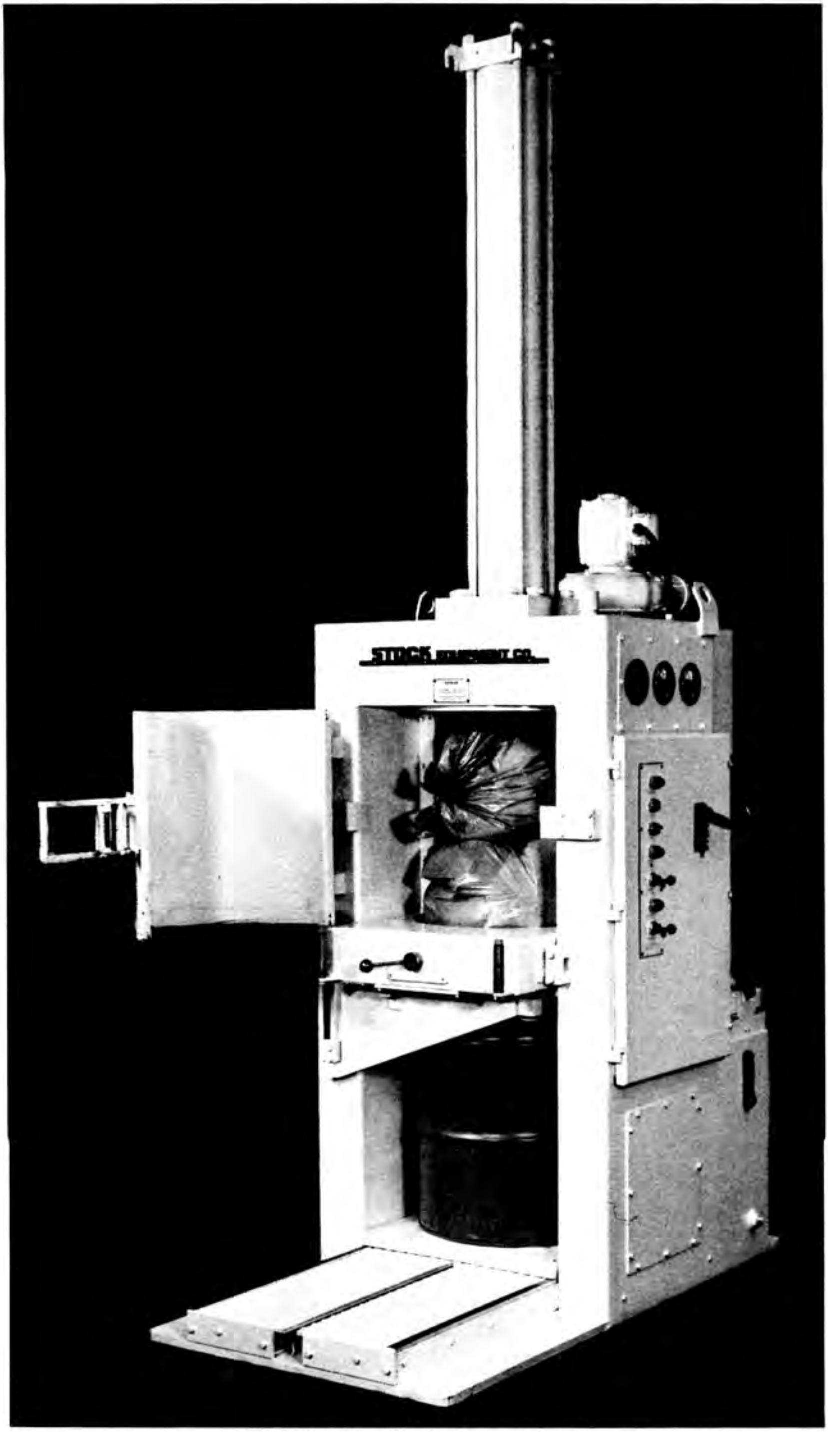

Fig. 9 - Dry Waste Compactor

touching the filters. A self-contained fan maintains a vacuum within the compaction chamber under all operating conditions to avoid the potential of airborne contamination.

Operation

The system was first utilized to solidify radioactive waste in August, 1979. The solidification agent has been ASTM Type III cement. No additives or pH control have been required for any of the waste streams. To date, approximately 5,000 drums have been solidified. The compactor has produced 2,000 drums filled with dry active waste.

A number of difficulties occurred with this "first of a kind" equipment, most of which have been corrected. The following paragraphs summarize operational results and corrective measures.

1. Throughput of the system has been adequate to handle all normal and upset conditions. No reductions in power generating rates have been necessary. Liquid radwaste system tankage has been emptied as is desirable to handle emergencies. Except in rare occasions, the waste streams from both units have been easily handled with one set of process equipment.

2. Pre-tested solidification formulas supplied by STOCK and accurate measurement capability of the equipment has permitted repeatable solidification results within the limits of regulatory and burial site requirements. This has been confirmed by periodic drum inspection.

   Some field modification to the solidification formulas have been required because field and laboratory conditions have, in some cases, varied. Additional formulas have also been requested, generally after determining system capability to improve overall economy of operation. STOCK has developed generic solidification formulas providing rapid adjustment of ratios to handle waste stream variables.

3. Radiation exposure to operational and maintenance personnel has been reduced by a factor of 10:1.

4. The quantity of waste that can be solidified and shipped in each cask compared to the capabilities of the originally installed system has increased by a factor of two to four, depending upon the individual waste stream. Uniform mixing as evidenced by uniform drum radiation survey and consistent, accurate measurement of

ingredients are believed to be primarily responsible for this improvement.

Dresden Station personnel have determined that more material can be placed in a drum if the relatively large bead resin particles are pre-mixed with the relatively small particles of filter sludge. The decanting system permits this operation to be done entirely remotely. The decanting tank is filled to a pre-determined level with resins or sludge. The tank may then be decanted to remove the excess water and then filled with the other waste providing a mixture of particle size in the same decanting tank. The mixture is, of course, allowed to settle and excess water removed prior to drum fill. This mixture of filter sludge and bead resins may also be mixed in measured quantities in each shipping container with evaporator concentrates for radiation control of the shipping container. This procedure has reduced the disposal cost of resins and sludges about 90%. Slurries mixed with evaporator concentrates are transported in 14, rather than 7 drum casks as required if the slurries were not diluted with C.W. Radiation surcharge cost at the burial grounds is also reduced.

5. System control flexibility permits simple, accurate modification of formulation if desirable for technical or economic reason.

6. The weight of DAW drums processed through the compactor averages approximately 350 pounds. The station does segregate waste prior to compaction to improve compaction effectiveness. Drums processed through the original compactor normally weighed 150 to 200 pounds.

7. Remote decontamination of the decanting tank has been accomplished. The metering pump was utilized to return the tank contents to the liquid system. The internal decontamination spray system was actuated and the metering pump was again utilized to remove the flush water. The tank surface radiation level was reduced from 68R/hour to less than 30 mr/hr.

8. Barnwell burial criteria changed requiring palletizing of solidified drums in 7 and 14 drum casks. Seven drum pallets were designed that could be staged at one end of the low level decay pit, loaded with drums and then loaded into the casks. All of these operations are handled remotely with the bridge crane. This involved, not only the design of the returnable pallets, but also

changes to the crane location grid above the low level decay pit.

To facilitate cask loading with pallets, a movable crane target grid system was added in the truck bay. In operation, the crane grab is centered on the case, the target is moved so that this positioning of the crane can be duplicated easily after which the cask is opened and the pallets loaded into the cask.

9. The drum inspection station design was based upon sufficient openings in the shielding to permit radiation monitoring and smear testing all surfaces conveniently with proper tools. The access openings in the shielding were quite large. The basis of the design was that only a few drums would have a surface radiation reading in excess of 10R/hr.

   When drumming slurries, drum radiation readings considerably exceeded 10R/hr. Permanent radiation instrumentation was installed to permit this function to be accomplished remotely. A thicker radiation shield was installed between the operator and the drum which contained a significantly smaller access area through the shield, and baffle shields were installed to limit radiation streaming through the remaining access port. This, plus redesign of the smear test tools permits obtaining necessary information with signifcantly less operator exposure.

10. The drumming station components are designed to safely and remotely uncap and cap drums produced to tolerances 4 times greater than normal drum manufacturing tolerances. The drum flange, the threaded portion making the closure with the cap, must withstand torque of the mechanical capper, hence, staking of the flange into the drum head must withstand capping torque without flange rotation.

    Significant problems initially occurred with drum tolerances exceeding the above limits and with flange to drum connections. The results were drums that could not be processeed in the equipment, could not be opened or closed and occasionally the fitting was driven into the drum creating spills within the drumming station enclosure during the mixing cycle.

    Tooling used to assemble drum components were revised to improve dimensional and flange staking quality and procedures for assembly of the flange were revised.

This has corrected difficulties associated with the drums.

11. Occasionally, the heads of drums filled with evaporator concentrate would be observed to have deformed while curing in the storage area. Analysis of the problem indicates that extremely hot E.C. coupled with the normal exotherm associated with cement curing can, in fact, provide sufficient heat to create steam, hence, pressurize the containers. Limiting the E.C. temperature to a maximum of 170°F prior to drumming eliminates this problem.

12. After approximately 1500 drum lifts, over a period of a few weeks, 3 drums slipped from the grab jaws. Minor modification to the grab jaws corrected this difficulty.

    Drums with severely bowed heads, resulting from pressurization, cannot be safely handled with the normal grab jaws because the bowed heads prevent proper clamping to the drum. A fixture that attaches to the grab assembly may be utilized to safely handle deformed drums. This fixture clamps upon the diameter of the drum, not the upper head chine.

13. A radiation monitor was added to measure the radiation level of slurries in the decanting tank. This instrument is utilized to determine the quantity of slurry to be added to a drum of evaporator concentrates for economic utilization of transportation cask shielding and reduce burial cost for slurries as described in Item 4 above.

    This, as well as a duplicate instrument on the drumming station, were upgraded to 0-1000R/hr units because of higher than initially expected waste radiation level.

14. While supervisors are permanently assigned to radwaste operations, the operators rotate to various work stations. As many as 40 operators have been assigned to the solid radwaste system within a 3 month period, which has complicated operator training. This is partially due to the fact that Dersden serves as a training ground for other Commonwealth Edison stations.

    Operators should know the equipment as well as have some knowledge of the chemistry of solidification, transportation regulations and burial site regulations.

When possible to do so, we recommend dedicated radwaste operators. The Control System is being redesigned from relay to microprocessor control. This step should help eliminate potential errors and simplify training.

15. Field performance of the sonic drum fill nozzle emergency overfill sensor, utilized to prevent drum overfilling caused by equipment malfunction or operator error, did not prove to be satisfactory. Its plastic housing was fragile and calibration to handle all field conditions was difficult.

    A conductivity probe, after extensive laboratory test, is replacing the sonic sensor. This instrument requires no calibration, can detect liquid slurries and foam and is ruggedly constructed.

16. When planning the new radwaste building, due to the relatively high radiation level in the radioactive pipe chases, it was decided that single lines, not return loops, would be installed to deliver waste to the new facility. While all persons concerned with this decision were aware that properly installed return pipe loops were preferred, construction of new lines in the existing pipe chases was not deemed to be feasible. Blockages in these lines have occurred, preventing delivery of waste to the new facility. Operational experience now indicates that properly constructed return loop pipe lines should have been installed initially.

17. Some control feedback in the original control system was obtained by inferential means. This fact has caused some operational difficulty. The controls were modified replacing inferential with direct feedback.

    A number of other control changes were made as operating experience indicated that safety could be improved or conditions developed that were not fully considered in the intial design. These primarily involved simplification of operation and providing the operator with additional information.

18. System design has been very effective in eliminating airborne contamination. No measurable airborne contamination exists as the result of processing waste. Truck bays and other areas are fully accessible provided radioactive material is not in the area.

    The fact that this system isolates the drum from the station environment during capping, filling, and mixing operations is believed to be primarily responsible for this improvement. While a few spills have occurred, principally during initial operation, the radioactive material has been confined within the drumming station enclosure. Decontamination sprays located inside the enclosure are not always fully effective.

19. The crane grab and "anti-swing" supports were damaged a number of times apparently due to operation of the bridge and/or trolley when the load was still resting upon the floor. This creates unacceptable load swinging when the load is finally raised. Control circuits were revised to prevent trolley or bridge motion until after the load is in the air. The "anti-swing" supports were also strengthened.

Summary

The solid radwaste system in use at Dresden provides consistent solidification acceptable at all burial sites. It provides a significant reduction in waste volume and flexibility to control the surface radiation level of shipping containers, both of which have signifcantly reduced operating cost. Airborne contamination has been eliminated; personnel radiation exposure has been reduced by a factor of 10:1. While problems have occurred, the flexibility built into the system has permitted relatively simple corrective measures after the difficulty has been identified. No chronic situations that would require major revision to basic design have occurred. The revisions made at Dresden, with the excellent cooperation of station personnel, have resulted in further improvement of the system. These "lessons learned" are being applied or offered for equipment installed or to be installed in other stations.