SOLIDIFICATION OF DRY RADIOACTIVE SALTS AND INCINERATOR ASH IN A POLYMER MATRIX

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ABSTRACT

With the current emphasis in radioactive waste disposal being placed on volume reduction, waste forms have evolved to the point where conventional solidification agents, process equipment and procedures are no longer suitable for these radwaste operations. Incineration of dry active waste and the processing of waste solutions to virtual dryness require a water independant solidification agent and process equipment designed to transfer, store and encapsulate several thousand cubic feet of radioactive powder annually. With volume reduction, the activity of the powdered waste product has increased by nearly two orders of magnitude making airborne contamination a significant factor that must be addressed in the design of the equipment and process. Solidification agents have changed from powders that were easy to handle and readily flushed from equipment with water to viscous, water insoluable fluids that stick to equipment surfaces and plug interface nozzles. Removal is accomplished with solvents that, in themselves, introduce another waste form that must be dealt with.

In approaching the problems introduced by volume reduced waste forms, STOCK engineers have developed a process and a family of equipment carefully engineered to address these problems head on. A brief description of the process equipment, the powder coating process and test solidification work are presented here. Emphasis has been placed on the problems intrinsic to handling these new waste forms and specific process and equipment solutions embodied in the STOCK approach.

CONCEPTUALIZATION OF PROCESS

Late in 1979 STOCK began a series of studies directed toward characterization of fluid bed processed sodium sulphate and borate solutions. Up to that time, radwaste development had centered on the optimization of concentrated liquid waste solidification in portland cement. Fluid bed drying of this same material and the potentials for volume reduction promised by dry active waste and low activity demineralizer resin incineration dictated a new approach to inventorying, transferring and solidifying of these materials. The most significant departures from common solidification practice derives from the characteristics of the new waste form. Being totally dry and in powdered form, the material readily becomes airborne and being a dry solid, it is not pumpable in the conventional sense; meaning the expertise developed in handling concentrated solutions of suspended solids would be of little help. Water activated solidification agents and tumble mixing, used successfully in emobilizing liquid waste materials, held little promise with dry solids.

In consideration of the above, initial system requirements can be summarized as follows. To realize the most benefit from the volume reduction process, solidification agents used with the waste form must be capable of incorporating as much waste as possible into the shipping container. The process must be capable of control by radwaste operators presently employed at existing facilities, therefore, any sophisticated process requirements that may be developed must be handled totally by the control equipment. This must include recovery from inprocess upset conditions and modification to inprocess control parameters. The control must handle all dust management related activities and be capable of returning the drumming equipment to its initial state in case of equipment failure. All equipment failure conditions must be identified with "catch 22" conditions adequately backed up by redundant equipment. Finally, a major design effort must be applied to dust control; preferably, the powdered waste would never be required to exit or be caused to transfer beyond equipment boundries during processing. The process must, therefore, be continuous from point of waste storage to point of encapsulation and final entrainment within the shipping container. Conceptually, this was the starting point for system development. The solidification process was the first problem to be resolved.

A brief test program was initiated in 1979 that considered portland cement as a potential solidification agent. Although waste loadings similar to those achieved with liquid concentrates was demonstrated, the rehydration of the salt seem incompatible with the potentials of an integrated volume reduction/waste solidification process. Further, borates were found to be incompatible with water activated solidification agents. The rehydration of this salt when its concentration in the powdered waste exceeded 20 percent, was violently exothermic leading to boiling and evolution of steam. This and the counter productive result of adding back much of the water that had previously been removed suggested that if the full *potential offered by* drying and incineration was to be realized, a different solidification agent and supporting process would have to be developed.

Although considerable research has continued with portland cement in support of liquid solidification systems, a new research program was established to evaluate other materials for dry powders. The first alternative approached was polymeric systems. Plastics were attractive for several reasons; they formed water resistant matrices, exhibited excellent compressive strength especially when combined with an inert filler such as talc, woodflour or carbon black, and they are usually readily extendable. Testing determined that most of the materials found in process solutions and incinerator ash were essentially inert in a polymeric system. The system that would be useful as a solidification agent must, however, be compatible not only with the waste but with other process elements.

One of the earliest polymeric materials evaluated at STOCK had been introduced for the solidification of liquid radwaste by DOW Chemical. DOW binder 101, a vinyl ester resin, proved not only satisfactory as a waste binder but was readily available and its relatively low viscosity and high stability allowed it to be pumped from remote storage areas with simple equipment. Further, its ability to wet the powdered waste in low energy mixing equipment led to the solution of several other problems associated with the mixing process and the control of airborne contamination.

STOCK's existing cement solidification process equipment embodied another important process technique. Mixing of liquid waste and cement was carried out entirely within the 55 gallon shipping container. The method was simple: cement was preloaded into the drum before it was placed into the processing enclosure; the waste was then metered into the drum; the drum was capped and tumbled end-over-end until mixing was complete. The significant advantage of this approach is that the additional equipment used for inline mixing were eliminated along with the problems associated with failure occurring with waste within the equipment. Should the tumbling mechanism fail during processing, all of the waste and solidification agent could be removed from the drumming enclosure permitting maintenance to proceed on the failed part with minimum personnel exposure. Considering the problems associated with handling radioactive powders, the "In-Drum" mixing process and the drumming enclosure were very desirable features to include in the new solidification equipment.

The next step was to develop a method of mixing that could take place inside a drum located within the environmental chamber. Quarter scale solidification tests, when scaled up, suggested that more than 227 kg (500 lbs) of powder were capable of being mixed with polymer yielding a density in excess of 1762 kg/m^3 (110 lbs./cu. ft.). The mixing energy required was calculated and later verified to be in excess of 15 kw (20 horsepower). Conventional mixers were tested and eliminated, either because of cost or power requirements. Large mixers could not be left with the drum nor could they be removed when the mixing was complete because the viscosity of the mixture, over 500 Pa·s (500 thousand centipoise), was such that most of the waste would be lifted out with the mixer. Even if slowly rotating the mixer permitted removal, the headroom required inside the chamber was excessive. And, having to clean the mixer between operations, beside being a formidable task, would result in considerable quantities of another waste form being generated. A unique mixing technique was required; one that would permit low power operation by processing the waste once and in low quantities but as a continuous process. This has been accomplished.

Figure 1 illustrates a sectional view of the STOCK "In-Drum" disposable mixer; better described as a device for coating and packing powdered materials. The three major elements are fully visible and include a helical device that can be fixed at one end to prevent rotation, a cylinder equipped at one end to interface with the mixer drive and a polymer film applied over the cylinder sealing the rectangular slots that penetrate the tube. As an assembly, the mixer is inserted through the four inch opening in the drum head along the drum centerline. Three articulated legs fixed to the downward end of the helix enter the drum first. As the mixer approaches the drum bottom, the legs open against the sides of the drum fixing the helix along the centerline of the drum. The importance of this feature lies in the standardization that is permitted to exist in the drums. Those utilities who have installed both STOCK cement and polymer solidifications equipment can order the same drum for either process reducing the inventory requirements and cost of expendables.

Once the mixer is all the way into the drum, it is rotated a few turns engaging the threads in the drum insert. A seal fixed to the mixer drive end is compressed thereby sealing the mixer hardware in place and preventing escape of the powdered waste. Finally, the polymer film secured along the surface of the cylinder functions to prevent premature escape of the powder into the air space above the solidification agent. The film is dissolved as the polymer solidification agent is displaced upward during the filling process.

In order to better understand the operation of the "In-Drum" mixer it is best to consider one more element of the solidification process; the preparation required prior to installing the drum into the drumming enclosure. The polymeric system used to encapsulate the waste powder is comprised of three chemical compounds: a vinyl ester resin, an appropriate catalyst and a promoter. All of these components are necessary to the polymerization process and their ratios must be precisely controlled. It was felt that, if possible, the metering of the chemicals was best accomplished away from the radioactive environment of the drumming station. This would limit the drumming station activities to control of powder flow into the drum and to mixing. Interfacing connections to the drum would remain clean of polymer that would rapidly collect powder and prevent free flow during a drumming cycle. Eliminating this potential problem would enhance the overall reliability of the drumming process and simplify the equipment required to meter the chemicals into the drum. With the polymer filling operation removed from the drumming equipment, pumps, metering equipment and controls could be selected from conventional sources and since remote operation was no longer necessary this equipment could be manufactured economically.

In order to realize this separation of function, a technique was developed to isolate the catalyst from the polymer and promoter while in the drum until released at the proper moment as required by the solidification process. Test mixtures of the vinyl ester resin and promoter were found to be stable at nominal temperatures for long periods of time. Since the solidification process would be accomplished in less than eight hours after drum preparation, the

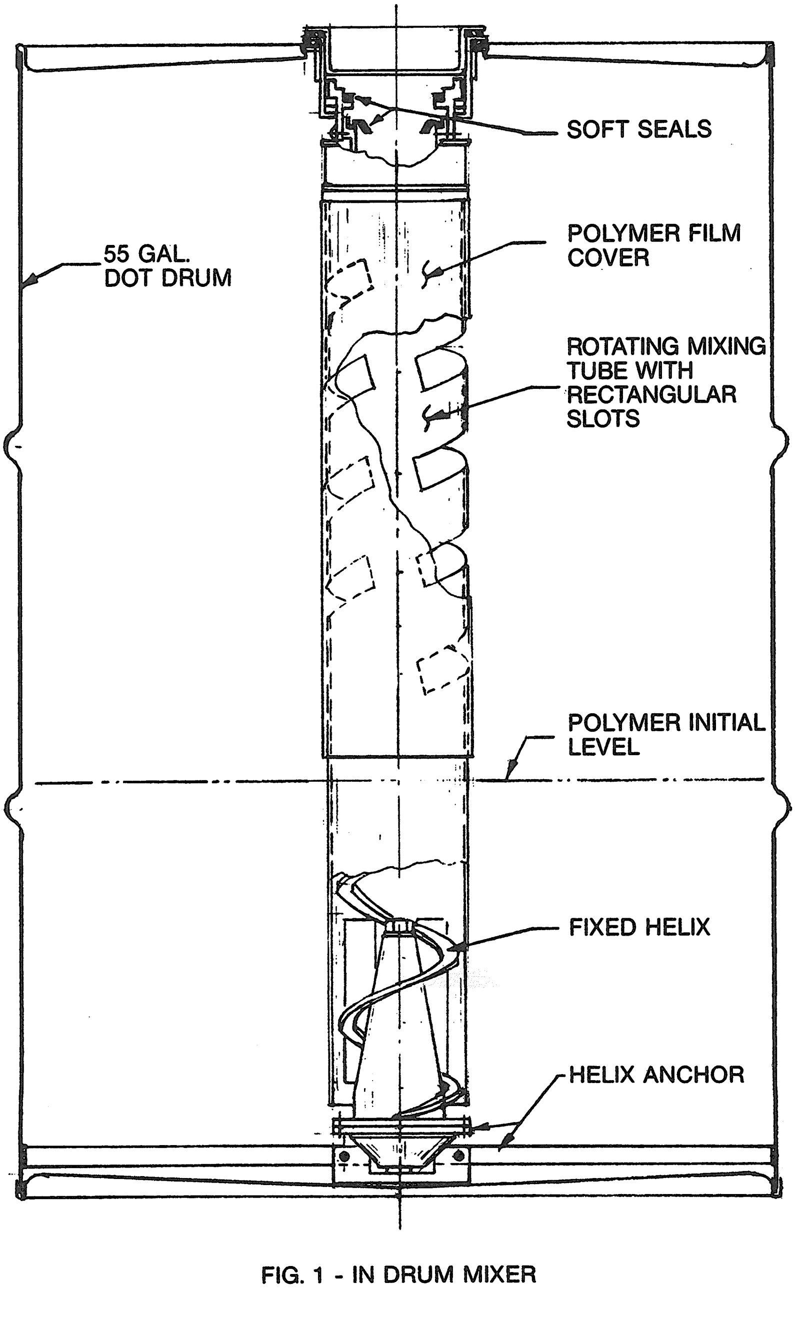

FIG. 1 - IN DRUM MIXER

fill station was designed to premix the vinyl ester resin and promoter at the fill nozzle. The catalyst is installed in friable capsules within the body of the mixer assembly. Activiation of the mixer drive just prior to the introduction of the radioactive waste disperses the catalyst and initializes the polymerization process. After the introduction of catalyst the polymerization of the polymer and powder mixture reaches completion in approximately sixty minutes.

At this point in the development, most of the essential elements of a process have been identified that are necessary for efficient incorporation of radioactive powdered waste into a polymer matrix. A solidification agent has been selected that is compatible with the waste form and can achieve high waste to solidification agent ratios providing the average particle size of the powder can be maintained above 100 mesh and that is readily handled by conventional pumping equipment. A mixing technique has been developed that permits a process similar to in-line mixing to occur within the shipping container, that requires less than 1.5 kw (two horsepower) for twelve minutes to encapsulate over 227 kg (500 pounds) of powder, that requires only a three gear transmission on the hot side of the equipment to drive the "In-Drum" mixer, thus assuring long, trouble free operation. With the chemical handling equipment separated from the radioactive process equipment, all chemical operations, including maintenance of the polymer filling equipment are carried out in a non-radioactive area. No chemical nozzles, pumps or piping will require unplugging or repair in hot areas. Since all filling operations are carried out within a sealed environmental enclosure, it is possible to perform the process at reduced air pressure. Whereas the enclosure acts as a fail-safe backup to the seals between the drum and the fill nozzle, a pressure differential maintained across the drum boundry and similar differential pressure maintained across the enclosure assure air flow from clean areas to contaminated areas of the equipment and process area. By monitoring the differential pressures the integrity of the drum and enclosure seals can be verified. Failure of seal integrity of such a magnitude that would threaten contamination of areas outside of the drum can be responded to by automatic controls that will close interface valves thus, isolating the system.

THE SOLIDIFICATION PROCESS

Let's consider one complete drumming operation. To begin with, it will be assumed that sufficient material has been processed by the V.R. equipment so that at least 227 kg (500 pounds) of powder are on hand in the storage hopper. The operator places a sufficient number of drums on the polymer fill station conveyor to satisfy shift requirements and inspects them for mechanical defects or damage. Then the drums are moved one by one under the fill nozzle. Normally the shift supervisor has preset the equipment with the volume of polymer and ratio of promoter required for the waste material being processed. For a particular installation, these parameters would seldom change.

For purposes of good process control, the drums have been numbered and a process log sheet has been prepared for each drum. Locating the drum under the fill nozzle, the operator enters the tare weight read from the control panel into the log. The scale is designed into the drum conveyor and includes auto tare and alarm functions. Next, the operator switches the fill station from standby to fill mode. Polymer that has been maintained below 24°C (75 degrees F.), air sparged and recirculated automatically by the fill station control, is metered into the drum until the preset quantity is satisfied. Since drum weight is continuously monitored, the scale is used as back up to the metering device and provides additional assurance that the proper quantity of polymer has been delivered and guards against overflowing the drum. The operator records the final weight and volume delivered. Any errors are recorded and reported to the shift supervisor for resolution.

Once drum filling is complete, the drum is moved beyond the fill nozzle and the next drum is placed into the filling process. The completed drum is now ready to accept the "In-Drum" mixer. The mixer may either have been pre-loaded with the proper number of catalyst capsules or they may be loaded now as required by the process control plan. The catalyst quantity is recorded and the mixer inserted into the drum and locked into place. The drum cap that seals both the mixer and drum is inspected and screwed into place. This completes the drum filling process. All chemicals required by the solidification process are inside the drum, ready to be activated by the mixer drive. The operator activates the motorized conveyor and the drum is transported to the drum pick-up point under the radwaste crane.

From the drum pick-up point, the drum is transferred by crane to a position above the hatch of the drum process enclosure. The operator activates the "open hatch" push button at the main control console and lowers the drum into the enclosure.

The polymer drumming station performs four basic functions; isolation, drum positioning, cap/uncap and drum fill. Similar in design to the STOCK cement drumming station, the assembly is divided into two areas isolated by a twelve inch thick steel slab that acts both as a machine base and radiation shield. Only those machine elements that could not be designed for safe-side operation or that require intimate contact with the drum are located on the hot side of the shield wall. Design of each "hot side" machine element has addressed the problems associated with failure during processing. They are necessarily simple in design and construction and are immune to radiation levels in this area.

Unlike the cement drumming station, the drum is not placed inside the drum process enclosure by the radwaste crane. Instead, the drum carrier is elevated within the enclosure, inline with the hatch, to permit decoupling between drum and drum grab external to the enclosure. This simplifies the interface positioning performed by the operator, eliminates the possibility of catching the grab on the lip of the hatch and permits a smaller hatch diameter which, in turn, simplifies the hatch seal and reduces stress in the hatch when the enclosure is evacuated.

Once the operator releases the drum from the drum grab and activates the "close hatch" push button, the carrier lowers the drum into the enclosure. The hatch closes over the drum and the seals in the hatch are compressed against their seats by a pair of cam activated draw bars. The drum is now sealed within the enclosure, and the only interface between the contaminated portion of the system and the environment is sealed off.

From here, the carrier positions the drum under the capper and the cap placed on the mixer by the operator is removed. Installations that include both cement and polymer drumming equipment use drums that are identical including the four inch bung. However, once the mixer is installed into a drum, the cap I.D. is necessarily reduced and neither drum cap will engage with the cap collet of the opposite drumming system. Therefore, assurance is provided that the proper drum has been installed.

The enclosure is evacuated at this time and the drum carrier locates the drum under the fill nozzle. After evacuation, the enclosure is isolated by valving off from the rest of the system and the hatch integrity is checked. If hatch seal leakage is determined to exceed five percent of the evacuation capacity of the pneumatic systems turbine compressor, a fault is annunciated at the console and the process automatically aborted.

To better understand the next operation, a description of the fill nozzle and mixer drive assembly is required. Referring to Fig. 2, the assembly consists of four major elements. Starting from the outside of the enclosure and moving downward, it includes a three inch nominal I.D. shear seal valve used to isolate the drumming unit from the salt delivery system; a mixer drive transmission instrumented to provide mixing torque data to the control system; a fill nozzle contained within a cylindrical drive assembly that is coupled to the mixer transmission, both extending from the interior of the mixer transmission to the interior of the drumming enclosure. Finally, a pneumatically operated, pressure fit dust cap that functions to prevent powder, remaining in the downcomer below the isolation valve, from sifting into the bottom of the drumming enclosure after the drum is decoupled.

Coupling of the drum to the fill nozzle/mixer drive requires removal of the dust cap. This is accomplished as part of a nozzle pneumatic purge cycle. Now the full differential developed by the turbine compressor is placed across the fill nozzle as the isolation valve to the powder delivery system is opened. As the dust cap is removed, high velocity air flushes across the surface of the cap, up the fill nozzle and back to the storage hopper where any dust is removed from the air by back flushable filters. When the dust cap is fully clear of the nozzle, the drum is elevated to position on the nozzle causing coupling to occur between the mixer and mixer drive coupling. As the nozzle drive engages the drum, soft seals installed in the disposable "In-Drum" mixer hardware compress against mating surfaces on the nozzle and drive coupling thereby sealing the drum to the downcomer and powder delivery system. From this point in the process until the drum filling cycle is complete, a constant differential pressure is developed and maintained across the drum boundry. In this way, seal performance is continually monitored and direction of air flow, should the seals breach, is maintained from the enclosure into the drum and back to the storage hopper. Maintenance of pressure differentials across the drum and drumming enclosure are requisite during the filling operation. Seal failure of a magnitude that either differential were effected will cause immediate, automatic system isolation, annunciation of seal failure and the process will be aborted.

Once the integrity of the drum seals has been verified, the mixer drive is activated. As the "In-Drum" mixer begins to rotate, the catalyst capsules installed in the body of the mixer are driven against a restriction at the anchored end of the helix. The capsules are crushed as they pass through the discharge end of the mixer and catalyst is dispersed into the promoted polymer. The torque required to crush the capsules is monitored by the control system that verifies initiation of the polymerization process by comparing the crushing torque to a reference. If catalyst was not placed in the mixer by the operator, an error is annunciated and the process aborted.

A successful drum coupling is followed immediately by an initiation of waste flow from the storage hopper. Flow is gradually increased until the rate of transfer falls between 0.23 and 0.32 kg/s (0.5 and 0.7 pounds per second). For the next ten to fifteen minutes, the polymer drumming process maintains this mode. The controls, responding to variations in flow and system pressure, keep process variables trimmed within operating limits.

THE MIXING PROCESS

Inside of the 55 gallon drum, just before waste flow is initiated, the liquid polymer occupies about 35 to 40 percent of the drum volume. The plastic film covered rotating tube is flooded 35 to 40 percent of its length. Since very little contact occurs between the spring like helix and outer tube, torque measured at the mixer drive is very low. While catalyst was being pushed out of the bottom of the mixer, torque sporatically ran as high as 20 percent but more typically 10 percent of the operating range of the mixer drive. As dry powder begins to enter the upper dry throat of the mixer, rotation of the outer tube pulls powder between the tube and stationary helix. The helix directs the wetted waste beneath the surface of the polymer trapped inside. Outside of the mixer, polymer is carried with the spinning tube and wetted waste is just beginning to flow out of the clearance at the bottom of the mixer. As powder flow increases and begins to flood the mixer at the polymer/air interface, flow of waste against the mixer tube and helix increases and greater quantities of waste are submerged. To avoid overloading the "In-Drum" mixer, maximum powder feed to the drumming station is held to 70 percent of the mixer design capacity. Approximately 30 cm (twelve inches) of tube/helix interface exist below the polymer level. The waste is continuously pushed along this interface until it exits, fully coated, at the mixer discharge.

The specific density of all waste powders tested exceed that of the polymer, meaning if the powder can be wetted, it will not rise to the surface of the wetting agent. The powdered waste materials do exactly this. Therefore, as they exit the mixer they retain their heavy paste-like character and remain at the bottom of the drum displacing the lower density polymer upward.

If the polymer initially available inside the mixer were not replenished, the viscosity of the wetted powder inside the mixer would increase until the torque requirements exceeded mixer drive torque limits. Actually, this does happen as the drum reaches full capacity but, early in the filling cycle the polymer external to the mixer, displaced by the incoming wetted powder, has contacted the plastic film covering the penetrations *in the rotating* tube. As the film is progressively covered by the free polymer, it dissolves admitting fresh polymer to the interior of the mixer. This activity continues until

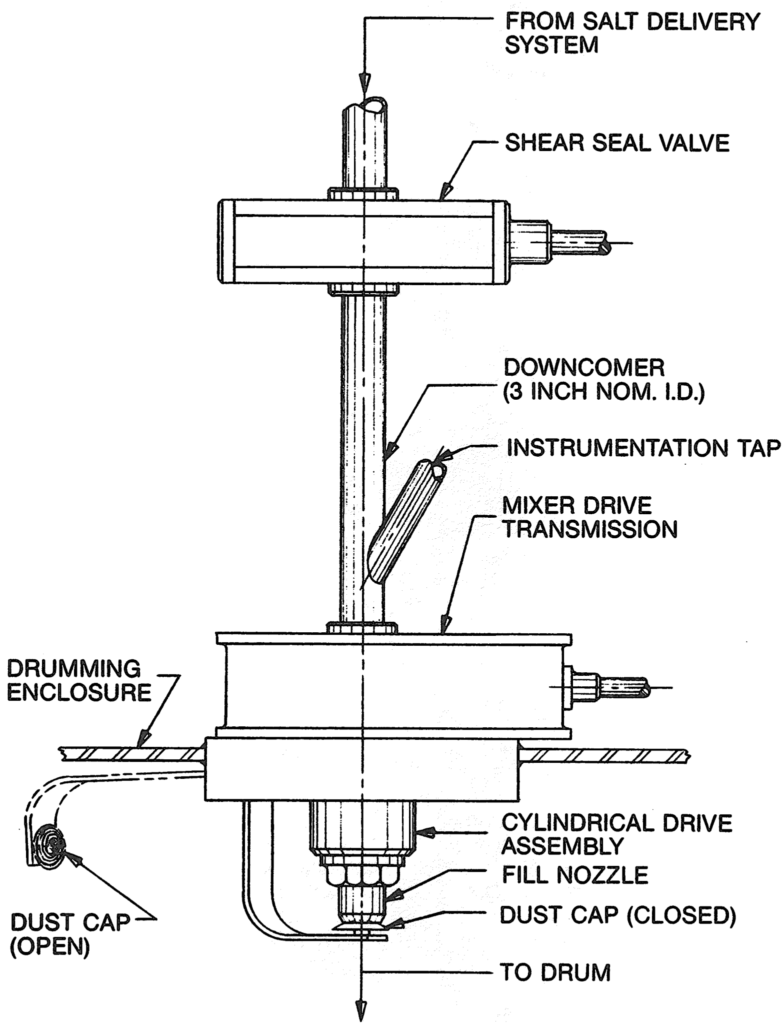

FIG. 2 - WASTE FEED AND IN DRUM MIXER DRIVE AT POLYMER DRUMMING STATION

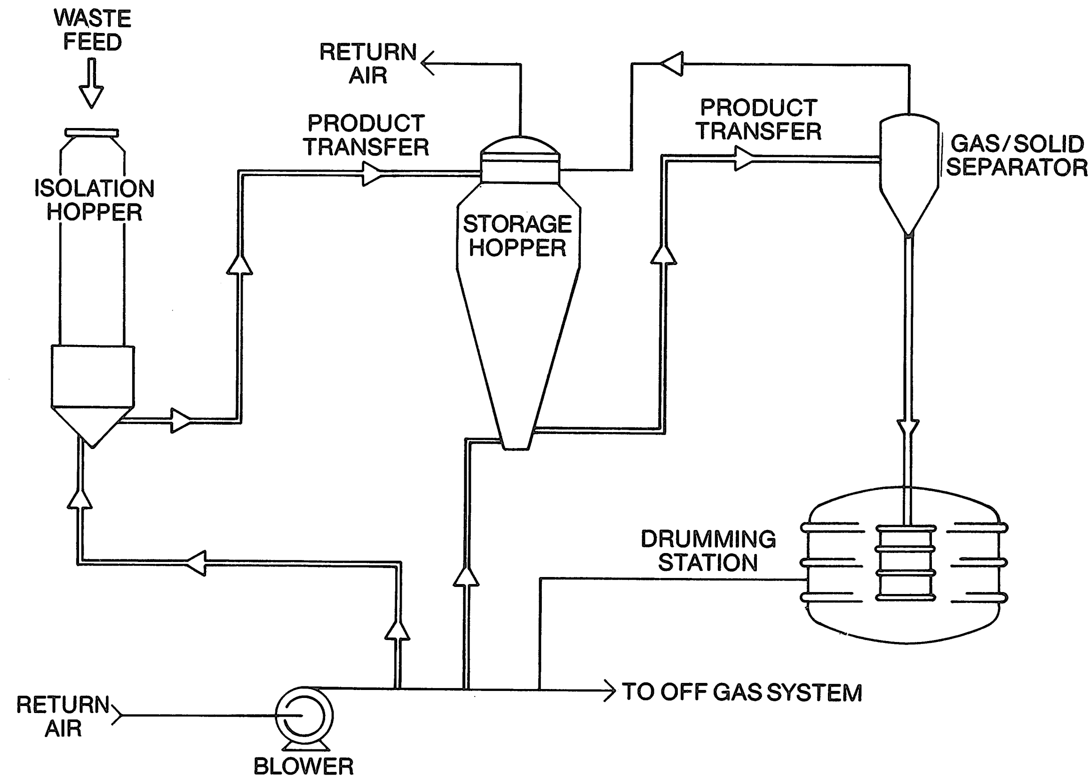

FIG. 3 - POLYMER DRUMMING STATION & DRY PRODUCT STORAGE & TRANSFER SYSTEM

either the drum is full or the free or uncombined polymer on the surface of the waste is exhausted, which is the usual case. Throughout the entire filling process, mixer torque is monitored and provides the most accurate and reliable measure of performance of the "In-Drum" mixer. The torque/time profile is essentially exponential remaining low during the first 80 percent of the mixing cycle and rising rapidly as the free polymer is diminished. Since most waste powders tested interact with the mixer in a similar fashion, the torque profile is a valuable process control parameters and is used to regulate flow of powder to the mixer, evaluate mixer bearing performance and aid in recovering from in-process upset conditions.

Available drum volume is monitored regularly throughout the fill cycle by repeatedly connecting the internal drum volume to a second vessel of known volume and pressure and monitoring the change in internal drum pressure. If the drum becomes full before the free polymer is depleted, this direct measure of drum free volume will terminate the filling process. At the end of each measurement cycle, air in the free space above the encroaching polymer is vented back to the fill nozzle. As the air exits the drum it is forced to pass through a small activated carbon filter that is built into the rotating mixer element adjacent to the drive coupling. The filter provides a convenient trap for styrene vapors released from the vinyl ester resin and expelled from the drum as it is filled. The filter adsorbs the majority of styrene gas and is disposed of with the drum.

When the filling process is terminated, flow of waste to the mixer is interrupted, and the mixer is permitted to operate for 30 to 60 seconds to permit all free salt above the wetted waste to become completely combined with polymer. This dwell time also permits waste powder still in the downcomer to settle into the drum. At the end of dwell, the mixer drive stops and the system valves are reset to repeat the pneumatic purge cycle for decoupling the drum that was used when the drum was originally coupled. As the drum is lowered, again high velocity air sweeps the drum/nozzle interface and downcomer clean of loose powder. Air flow is maintained until the dust cap is in place.

From here, until the drum is removed from the hatch, the procedures described above are simply reversed except that as part of the drum recapping operation a sample of air is withdrawn from the top of the drum near this cap and analyzed by automatic equipment. If the sample is found free of contamination, the drum is positioned at the hatch and removed to radioactive drum storage. A contaminated drum would be flushed prior to removal.

SALT AND ASH STORAGE AND TRANSFER

In 1981 STOCK introduced radwaste storage and transfer equipment expanding the capability and flexibility of the drumming system for dry active materials. The new system components are fully integrated into the control of the drumming station and permit improved equipment arrangement because the dry materials are transferred pneumatically. Other transfer methods restrict equipment to close coupled stacked or side by side arrangements.

System components include a small hopper that provides isolation between the V/R equipment and the solidification system, a storage hopper and a dry cyclone. A turbine air blower is provided and supplies air for control and transfer for all system elements including drumming. By regulating the turbine discharge to atmospheric pressure, all system control and transfer pressures are maintained at less than atmospheric. Therefore, air flow between the system components and the plant environment will always be into the system providing excellent control of airborne contamination.

Isolation between systems is accomplished through a combination of a small surge hopper that provides from 4 to 6 hours reserve capacity for the V.R. system and a group of specially designed valves that isolate system pressures. Smooth material flow is assured in the hopper through use of both vertical and divergent vessel wall slope and an unloading valve that is pneumatically operated and provides reliable feed from the bottom of the hopper to a small fluidizing chamber immediately below. Because the average flow rate of powder into the surge hopper never exceeds 15 cm^3/s (2 cubic feet per hour), heat may be removed before transfer, when required, by circulating low velocity system air through the powder in the fluidizing chamber. Momentarily increasing air flow fluidizes the powder and transfer is accomplished to the storage hopper.

The storage hopper can accommodate up to three days of continuous product generation by the V.R. system. In addition to storage, the hopper design integrates into one assembly the additional functions of system air filtration and feed of powder to the drumming station. The hopper is the optimum location for air filtration because powder located anywhere in the pneumatic system, including the downcomer to the drumming station, can be returned to storage at any time. Feed to the drumming station is accommodated by the steep wall design of the hopper that converges to a five foot slot discharge. Feed is controlled at the slot discharge by five independently driven, pneumatic inductors. The redundant feed system assures that the hopper can be completely emptied when service is required and that reliable and uniform flow can be maintained across the hopper discharge during a drumming cycle. Feed from the hopper discharge falls into an air acceleration chamber beneath the feeders which is piped to a dry cyclone above the drum process enclosure. . Air discharged from the dry cyclone is returned to the filter assembly at the storage hopper, filtered and returned to the suction side of the turbine blower. Filtered air at or below atmospheric pressure discharged from the blower is piped to the accelerator under the storage hopper completing the air loop. Differential pressure across the conduit from hopper discharge to the dry cyclone and mixer torque are measured variables used for flow control.

Principal features of the Dry Salt and Ash Storage and Transfer System may be summarized as follows:

1. Isolation between V.R. and solidification equipment permits independent operation of systems, flexibility in equipment arrangements allowing the best possible use of building space, and dry active powder to be stored below atmospheric pressure which is compatible with solidification equipment requirements.

2. Pneumatic transfer and operation below atmospheric pressure provides the best insurance against air borne release because of natural inward flow of any air leakage but, just as important, pneumatic

components are generally simple in design and construction. There are no rotating equipment bearings, shaft seals or troublesome packings to wear, leak and require frequent maintenance attention.

3. Pneumatic control of valves and waste feed equipment is esentially immune to high radiation flux and large integrated dose, reliability that cannot be approached with electric controls.

4. Hopper design permits long term storage of radioactive salt. Divergent vessel wall or slot discharge with pneumatic fluidization on sloping vessel walls assures uninterrupted flow even after long storage intervals. Isolation from V.R. process air prevents moisture egress and caking of powdered waste.

SYSTEM CONTROLS

Controls for both the Polymer Drumming System and Dry Salt and Ash Storage and Transfer System are integrated into one custom engineered design. The major control element is a solid state microprocessor supported by a small uninterruptable power source. Program instructions are essentially permanent to the control and avoids the problems associated with booting the system with paper or magnetic media that are easily damaged and incompatible in an industrial environment. When power is applied, the microprocessor boots automatically. Microprocessor control permits control functions to be integrated into the instruction set that permit "look ahead" system verification and a comprehensive set of diagnostic sub-routines that aid in system maintenance. In addition, many process upset conditions can be analyzed and responded to without requiring operator intervention.

Automatic control of the transfer and drumming process commences when the operator closes the hatch and continues, unaided, until drumming is complete and the transfer system purged. The process can be interrupted at any time, however, by the operator should process data fail to conform to the station process control plan. For example, radiation level is continuously monitored throughout the drumming process by a radiation detector mounted through the shield wall and at mid elevation of the 55 gallon drum. If the rad level exceeds a predetermined limit, the drumming process can be aborted. Restart is managed by the microprocessor which, based on process parameters, may continue the process or abort. An abort always shuts the process down by performing a system purge, recap, check for contamination and return drum to hatch.

SUMMARY

The motivation to reduce radwaste volume by drying and incineration will produce dry, powdered waste forms, having substantially different storage, transport and solidification concerns that those waste forms pre-dating the V/R era. An integrated system, including microprocessor controls, has been conceived to meet these specific, new problems, as well as the traditional needs of ALARA, safety and reliability. This system utilizes a polymer solidification agent which enhances the volume reduction process and provides an acceptable solidified product. The system component design and operation address the waste form's dusting properties and attendant concentrated radioactivity levels.

The key elements in the system have been validated in laboratory and full-scale testing. Production components for final tests and field installation are now in fabrication with operation anticipated within the year. At this writing all domestic nuclear plants that have selected solidification systems to accompany dryer/incinerator systems will employ the equipment herein discussed.

Note: Patents are issued or pending covering original ideas presented in this paper.