"QUICK DRY" THE ADVANCED DEWATERING PROCESS

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ABSTRACT

The "Quick Dry" Process and initial test results were first reported in a paper entitled, "Dewatering Radioactive Resins and Filter Sludge-Vacuum Compression System," by J.C. Homer and S.B. McCoy, at Waste Management '87. This paper supplements the data presented in the 1987 paper. The process has now dewatered low level waste at a commercial BWR station for over one year. Further, laboratory and field test with a wide range of filter sludge have both expanded the knowledge of system capabilities and provided additional information, influencing the operation of this and other dewatering processes applied to the task of dewatering radioactive resins and filter media.

The additional information, test results, and conclusions are included herein.

INTRODUCTION

Stock Equipment Company and LN Technologies have developed an improved dewatering process for low-level radioactive filter sludge and resin. The process results in significant filter sludge volume reduction and has demonstrated the capability to dewater media that cannot be dewatered, or are difficult to dewater, utilizing conventional dewatering techniques. It is comparatively simple to control and predict the desired end point. With most materials the process is capable of filling and dewatering liners and HICs to the moisture content of new filter media in less than 8 hours. This relatively low moisture content and high solids density eliminates the possibility of free water forming due to temperature change or cake densification during transport.

This paper discusses laboratory and full scale field operation to supplement data presented in the above mentioned paper and problems overcome by the process.

PROBLEMS AND SOLUTIONS

Conventional filtration, where a pump is utilized to pull water and air through standard filters from filter slurry and cake within a container at atmospheric pressure, has been used for many years. Under some circumstances difficulties have developed which were addressed in the development of the "Quick Dry" Vacuum Compression System.

They are:

Cake Porosity and Cracking

While porosity and cracking are two separate subjects, they both influence dewatering capability at about the same time in the process. When the slurry is forming a cake around the filters, the cake is saturated with liquid. The dewatering pump can maintain a substantial vacuum within the filters and cake. This promotes rapid water removal and cake solids densification with any dewatering process. This statement assumes, of course, the material does not blind the filters.

As the cake dries, the water seal within the cake is broken. The dewatering pump is then pumping air at a substantially lower vacuum, and direct water removal essentially stops.

For example, tests have demonstrated that with one typical filter media the water seal breaches when the moisture content of the cake is approximately 75%. Tests also indicate that water will not drain from this particular filter media cake unless the cake is at least 72% water. When moisture removal becomes dependent on air flow, further dewatering is accomplished predominantly by relatively slow evaporation. Dewatering by evaporation does not cause cake densification.

The solid particulate looses its buoyant support as water is withdrawn and settles to form a packed, reasonably plastic mass. As shrinking and drying continue, usually before the water seal is completely broken, the mass becomes brittle, and discontinuities within the cake, the filters, or other hardware, create cracking. From the pump's standpoint, cracks develop the same characteristics as cake porosity, reducing vacuum, usually to near zero. From the water's standpoint, little or no air is pulled through the cake. The water must migrate to the crack and again rely upon evaporation for removal from the cake. While the cracking patterns are difficult to predict, almost invariably they form a path from the filters to the atmosphere. The degree of loss of pump vacuum, which effectively ends dewatering, depends upon the porosity of the cake, cake thickness, the degree and location of cracking, and of course the capacity of the pump or other vacuum producing equipment.

To avoid the penalties that may be experienced by cake cracking and porosity and permitting the attainment of lower water content more quickly, the "Quick Dry" Process seals the filter and filter cake within a flexible plastic membrane that conforms to the shape of the container. After cake formation, a 12 psi vacuum within the membrane creates a total force of about 120 tons on the cake surface within a 182 cubic foot container. We have substituted mechanical force for slow evaporative dewatering. The membrane prevents air flow through the cake while the pressure further densifies the cake. Dry solids minimizes voids and forces the water through the filter. The process can be compared to wringing out a sponge versus hanging the sponge out to dry.

Significantly, by eliminating cake cracking and uneven evaporative dewatering, the process dewatering end point, normally 60 to 64.5% average water content, is predictable and controlled by tracking the rate of water discharge from the container.

Filter blindings

Filter sludge containing a substantial proportion of fines, such as ultrasonic resin cleanup material, tend to blind filters. Plant operations have reported that conventional dewatering techniques cannot successfully dewater this material.

Filters utilized with the "Quick Dry" Process, selected after comparative tests of over 20 filters cloths, provide higher flow rates per unit of area under blinding conditions than the other materials tested.

The filters are quite large, because flow rate increases as the square of the surface area. Neglecting the positive effect of the mechanical pressure upon the cake as discussed above, a ratio of the filter surface area in containers utilized with the "Quick Dry" Process to that utilized with conventional processes indicates that the flow rate through the "Quick Dry" filters will be 9 to 50 times that obtained with most conventional processes.

The slick surface finish of the "Quick Dry" filters and their vertical orientation within the container also facilitate cake shedding during alternate fill-dewater cycles.

Yes, the "Quick Dry" filters will also blind as we will discuss later. But due to the selection of filter cloth, a large surface area, the pressure exerted on the cake, and the ability of the filter to more readily shed cake during the alternate fill-dewater cycles, blinding does not occur as readily as with most other processes.

Container Efficiency

A wise man once said that "A container is only as large as what you can get in it." This statement applies to containers utilized for disposal of dewatered materials. Filters of standard design and other internal hardware occupy in excess of 15 cubic feet of container volume in some containers used for dewatering.

The "Quick Dry" design filters are very thin. Internal hardware and filters occupy about 1.5 cubic feet within a 182 cubic foot container...less than 1% of the usable *volume.*

Figure 1 shows the full scale test liner being assembled with the internal filters and hardware.

Testing-Methods and Results

Four methods have been used to obtain dewatering results, namely:

- Hand Operated Screening Unit
- Full Scale Laboratory Tests
- Test Unit
- Field Operation

Presented below is a description along with the results from each test.

- Hand Operated Screening Unit: This unit, shown in Fig. 2, is a 100 ml clear plastic container (1). A "Quick Dry" type filter (3) is located between the water collection chamber (4) and the slurry-filter cake chamber (2). To approximate conventional filtration techniques, slurry is poured into chamber (2) and a vacuum is created in chamber (4) through nozzle (5). This procedure is repeated until chamber (2) is 100% filled with filter cake, and dewatering is complete, except that due to long term evaporation, a rubber membrane is then used to seal the top of the container and a vacuum of 12 psi is established in chamber (4) to duplicate the pressure differential across the membrane with the "Quick Dry" process.

This method and equipment was utilized to determine the relative volume reduction potential of the "Quick Dry" Process versus conventional dewatering techniques for a number of potential filtration and ion exchange media. The filter type, size, and porosity is the same for each test, and the media is identical for the comparative test. In every case tested, the sealing of chamber (2) and creating a pressure differential across the rubber diaphragm into chamber (2), which increased the solids particulate density, generated additional water discharge to chamber (4). Results of this series of tests is shown on Table I.

Conclusions from this test series are:

1. Under identical circumstances and with identical filter media, the "Quick Dry" Process will provide a reduced waste volume compared to that obtained with conventional dewatering techniques.
2. The reduction in volume becomes less as the content of non-resilient materials, such as diatomaceous earth or bead resin, increases.

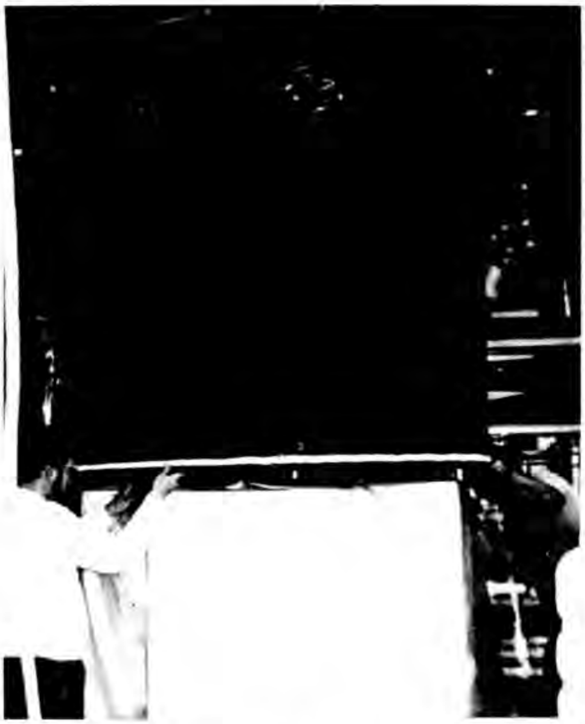

Fig. 1. Test Liner With Internals.

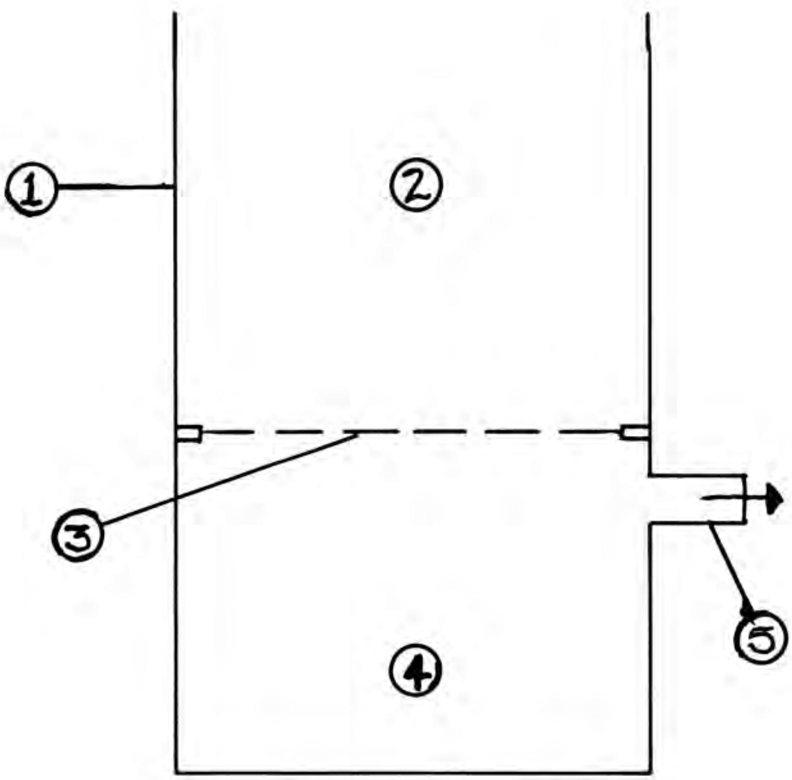

Fig. 2. Screening Test Unit.

TABLE I

"Quick Dry" Relative Water Removal and Volume Reduction Potential

Material	Conventional Cake		"Quick Dry" Cake		%Reduction	
	Wt.(gm)	Vol.(ml)	Wt.(gm)	Vol.(ml)	Wt.	Vol.
Ecodex	135.1	127.5	108.2	111.2	20	13
Ecosorb	129.5	127.5	114.4	107.9	12	15
Diatomaceous Earth	157.3	127.5	141.8	119.3	10	6
M.B. Powdex	128.0	127.5	100.2	94.8	22	26
50/50 Beads-Ecodex	130.4	127.5	116.2	116.1	11	9
100% Cation Powdex	Filter blinded (plugged)					

3. Squeezing the filter cake will quickly remove 20 to 25% of the water remaining within a resilient cake after conventional dewatering is complete, except the water that may be removed due to long term evaporation with a conventional process.

4. Filters, regardless of the dewatering process used, will blind with some materials as illustrated with 100% Cation Powdex. (This materials is not used alone for nuclear power plant applications.)

   - Test Unit: This unit utilizes a 1/12 H.P. vacuum pump, a small vertical "Quick Dry" filter, and a 60 cubic inch (983 ml) container to hold a membrane, filter, and the sludge. This testing nearly duplicates conditions obtained with the full scale process. This desk top size unit has been utilized extensively in the field and laboratory to test various media or combinations of media. Table II shows the range of materials tested to date and a relative rating of each material, dewatering time, and volume reduction potential with the "Quick Dry" Process.

Note C to Table II describing the successful dewatering of actual ultrasonic resin cleanup sludge seems particularly pertinent as a potential solution to real world problems.

Full Scale Laboratory Tests: Significant results of full *scale* tests conducted at the Stock Equipment Company, utilizing a 182 cubic foot container, are included in the W/M '87 paper mentioned above. The test liner and equipment were then moved to the LN Technologies facilities, and full scale testing continued with a variety of filter media.

Dewatering time, moisture content, and dry solids density continue to be in line with prediction. In all cases the moisture and dry solids content was determined by taking multiple samples from various locations within the filter cake and drying the samples, using verified procedures. Figure 3 shows a mixed bed Powdex filter cake after dissection of the cake. To obtain samples, this cake, dried to 62.8% water, exhibited no sign of free water. Further, squeezing the sample by hand did not generate free water.

Field Operation: Full scale "Quick Dry" dewatering has been in process at an operating BWR station for over one year. The station is utilizing LN Technologies' 182 cubic foot (burial volume) liners having an internal volume of about 170 cubic foot. In 1987 filter sludge, as reported by the utility, was a mixture of Ecodex 203H, Ecodex 205H, and Ecocote materials. Utility personnel have core drilled the dewatered cake, prepared and dried 6 samples taken from top to bottom of the cake, completed the calculations, and presented the results for three liners as shown in Table III.

The contract for processing waste at this BWR station was recently extended for two years through a competitive bidding process. Filter sludge content now also includes Ecosorb in addition to products mentioned above. A total of 8 liners were dewatered in 1987, and thus far, two in 1988. Bead resins are scheduled to be dewatered in the second quarter of 1988, using the same equipment but a different process.

PROBLEMS AND PROBLEM TESTING

The full scale tests at Stock and LN Technologies have included a number of situations in anticipation of potential field problems. This was done to determine the affect upon process results and to develop realistic solutions for recovery if they should occur. As expected, problems have occurred.

1. Water in the annulus between the container wall and flexible pressure membrane:

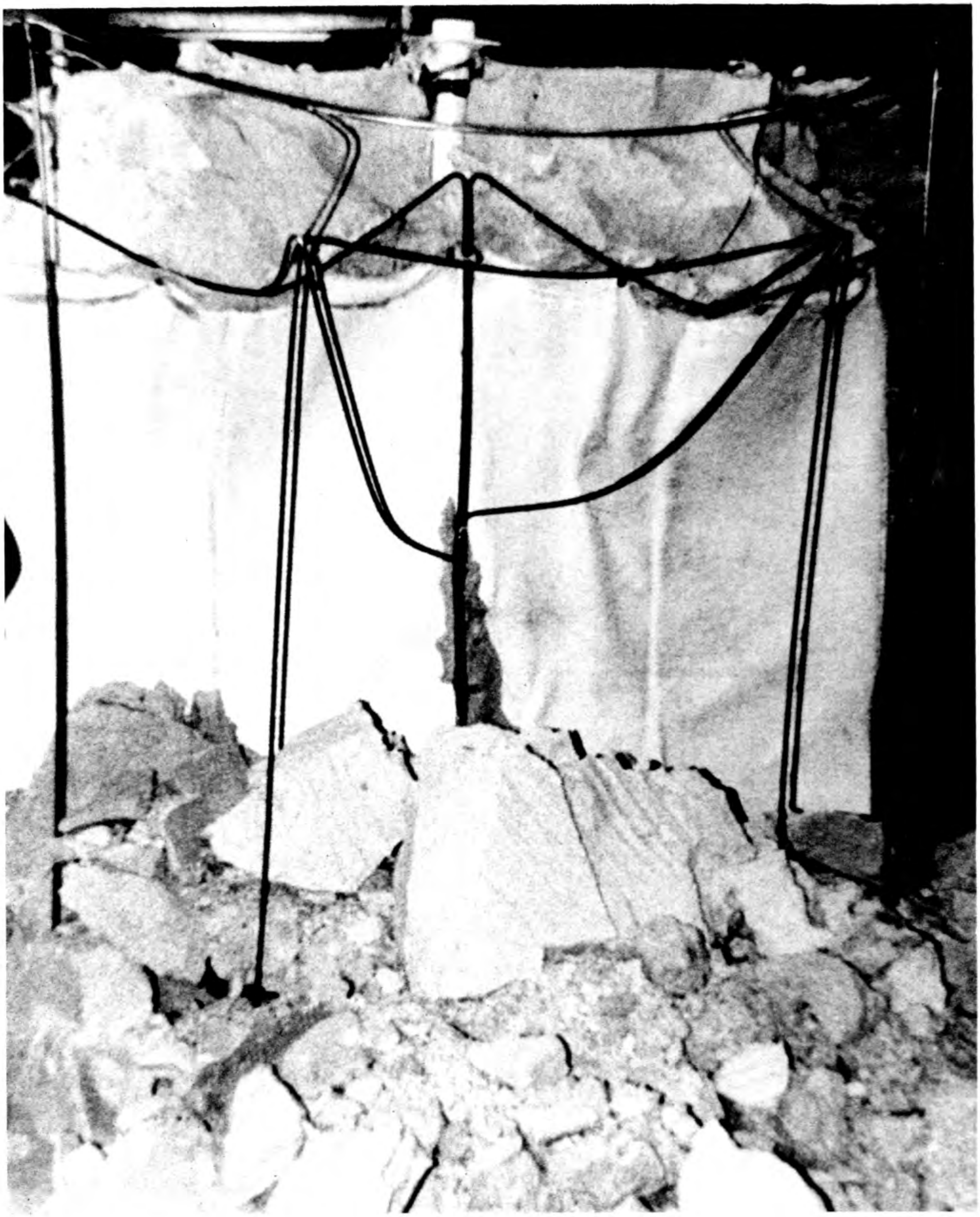

Fig. 3. Dissected Powdex Cake.

TABLE II

Filter and Ion Exchange Media Tested

Material Tested	Equipment Utilized				Rating		Remarks
	Screen Test	Test Unit	Full Scale Lab	Full Scale Field	1	2	
1. Ecodex 303N	X	X	X		E	1	
2. Ecodex 203H				X*	E	1	See Field Test Results
3. Ecodex 205H				X*		1	See Field Test Results
4. Ecocote		X*		X*	E	1	See Field Test Results
5. Powdex 50/50	X	X	X		E	1	
6. Powdex 80/20		X			E	1	
7. Powdex 20/80		X			E	1	
8. Powdex 100% Anion	X	X			M	4	See Note A
9. Powdex 100% Cation	X	X			M/U	4	See Note A
10. Diatomaceous Earth	X	X			E	3	
11. Solka Floc		X			E	1	
12. Ecosorb 502H	X	X*			E	1	
13. Ecofloc		X*			E	1	
14. No. 1 + 35% Bead		X			E	2	
15. No. 1 + 50% Bead	X	X			E	3	
16. No. 1 + No. 12		X*			E	1	
17. No. 1 + Nos. 5, 6, 7	X	X	X		E	1	
18. No. 1 + 12 + Machine oil		X*			E	1	See Note B
19. No. 1 + No. 12 + Hyd. Fluid		X*			E	1	See Note B
20. No. 13 + Nos. 1, 2, 3		X		X	E	1	
21. URC Fines	X*	X*			S/M	4	See Note C
22. Charcoal Ash		X			M/U	4	See Note D
23. Incinerator Ash		X			M/U	4	See Note D
24. Floor Spill Sample	X*				E	1	See Note E

KEY: To Table II

Rating-1: The maximum time expected to dewater the material to "new material water content" under vacuum compression in a 182 cubic foot liner (does not include liner fill time).

E. Less than 2 hours
S. 2 to 4 hours
M. 4 to 8 hours
U. Greater than 8 hours

Rating-2: The estimated volume reduction anticipated by the "Quick Dry" Process as compared to conventional dewatering processes.

1. High
2. Intermediate
3. Low
4. Not estimated or not applicable

Notes to Table II:

A. 100% Anion and 100% Cation slurry are not normal nuclear power plant waste streams. They were tested as part of the test program to form a data base from which to judge the performance with the more difficult waste streams such as URC fines. Water flow without vacuum compression was about 3% of the flow rate with mixed bed material for the first minute. The filter was then completely blinded. Flow rate was then re-established by

TABLE III

Field Operation Results

No.	Cake Wt. Lbs.	%Water	Equiv. Cu. Ft.	Dry Wt. Lbs.	%Full	Density Lb./Cu.Ft.	
						Cake	Dry Solids
87-29	8570	57.3	302	3659	91.0	55.4	23.6
87-37	8670	59.2	292	3537	92.5	55.1	22.5
87-41	9270	56.6	332	4020	94.5	57.7	25.0

a. Pipe plugs in the vessel shell at the junction of shell and lower head for inspection or drainage of liquid.

b. A sipping tube in the low part of the annulus existing at the manway for similar purpose as in 1-a above.

c. Small filter pads built into the flexible pressure membrane to pull water that may be in the annulus by vacuum from within the membrane cavity.

d. A dip stick well in the annulus area.

Items b and d are either impractical or unreliable. Items a and c are used and have proven to be effective. While the pads permit some air flow through the cake, the small quantity of air has no significant effect upon process results.

2. Rupture of the Pressure Membrane:

a. The nylon cord reinforced membrane was tested to 15 psi without external support. Positive pressure within the membrane, supported mostly by the container, is limited to a few inches of water pressure during normal operation.

b. A rupture will cause a lower vacuum within the membrane. this is apparent on the control instrumentation. Operating for a longer period of time, in proportion to the reduction in vacuum, provides approximately the same predictable, final water content. The dry solids density of the cake will be lower.

c. Pressure test the membrane after container assembly to eliminate the possibility of manufacturing error.

d. The nylon cord and double sealed seams should eliminate large ruptures under most credible circumstances.

e. Tears or ruptures are most likely to occur where the bag is sealed to the piping connections and otherwise not supported under the container manway. If a gross rupture occurs, repair can be accomplished with tape. If the rupture is minor, continue dewatering. This type of failure has occurred in the field.

3. Failure of filters or liner internal piping and fittings:

a. Design and test to minimize possible occurrence: The same set of filters, piping, tubing and fittings were reused for multiple tests. The filter cake was removed from the internals mechanically between each test. A single filter discharge tube was found to be severed after one test. Examination indicated that the tube had been severely damaged by a shovel blow while removing filter cake from the proceeding test. No effect upon dewatering or cake density could be found, probably because of the large filter surface area within the container. It is possible that with this type of failure, some solid particulate carry-over could occur with the filtrate. None was noted in this instance.

b. Failure due to material defect: This type of failure occurred in the field. The fittings connecting the filter discharge tubes to the discharge hose at the container manway failed. Water spilled into the annulus, and suspension of normal operation was necessary. A new fitting was quickly installed. Item 1-c above removed the water from the annulus, and final dewatering results were normal.

4. Unplanned or planned process interruptions before the container is fully filled and dewatered Tests and field occurrences have demonstrated that interruptions have no effect upon final results.

While problems have occurred, recovery techniques, planned and improvised, have permitted full recovery. All containers dewatered will comply with regulatory requirements.

SUMMARY AND CONCLUSIONS

1. The "Quick Dry" Vacuum Compression Filter Sludge Dewatering Process will provide rapid dewatering capability, compared to conventional filtration processes, of all sludges or combination of sludges tested to date.

2. With the "Quick Dry" System the final water content of the dewatered cake is predictable and can be controlled by a simple process to approximate the water content of new filter media. Generally this is minimum of 7% to 12% less water than required to develop free standing water as defined by NRC and burial site criteria. At this water content, significant free standing water cannot result from changes in cake temperature.

3. The process produces a hard, dense cake that will not further densify during transportation. (Densification of cake due to vibration during transportation is another potential source of free water.)

4. The process, through the application of external force to and elimination of air flow through the cake, will rapidly produce a cake having a higher dry solids density with all material tested than is possible with conventional filtration techniques. This fact translates to greater volume reduction.

   Comparative tests also indicate that in conjunction with a higher cake density, the process will also rapidly remove significantly more water than is possible with conventional filtration techniques. The quantity of additional water removed may be as much as 1/3 of the water remaining in the cake after conventional dewatering processes loose pump suction. Conventional techniques may dewater cake to the same solids-water ratio as the "Quick Dry" Process. To do so, however, they depend upon diffusion and evaporation, which is extremely slow. It is also difficult to predict final results due to uneven drying resulting from cake cracking.

5. Tests indicate that the "Quick Dry" Process will effectively dewater waste products such as resin fines that are difficult or impossible to dewater using conventional filtration techniques

6. This document supplements data included in the above mentioned Waste Management '87 paper related only to filter sludge material. The sludge material may contain up to 50% of bead resin when using the vacuum compression process. This has been verified via full scale testing.

   If the slurry to be dewatered is predominantly bead resin, the same equipment may be utilized, but the process and liner internals are revised in keeping with substantially different functional requirements.