RESIN VOLUME REDUCTION BY HIGH FORCE COMPACTION

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ABSTRACT

The packaging, transportation, and disposal of contaminated spent ion exchange resin constitutes one of the most expensive items on the utility radwaste manager's budget. The waste volume limits and surcharges imposed by the Low-Level Radioactive Waste Policy Act Amendements of 1985 have created strong incentives for the application of high force compaction to reduce the volume of ion exchange resin shipped for disposal. Lab and full-scale test results demonstrated that the volume reduction achieved by compaction is a function of compressive force, resin type, moisture and crud content, and the container/packaging method. Simulated waste resin and actual plant-generated resin was tested using compressive forces between 600 and 6680 psi. Volume reduction factors, as compared to conventional dewatering, of 2:1 to 6:1 were measured using high force compaction. The relative simplicity of compaction technology as compared to other resin volume reduction technologies, and the availability of high force compaction equipment set the stage for a very cost effective and easily implemented volume reduction system.

INTRODUCTION

This paper discusses the laboratory and full scale testing of resin volume reduction using high compaction forces. The emphasis of the testing center on compaction of various forms of powdered resin waste.

The objectives of the test program were the following:

- o Determine compressive pressure/volume reduction relationships for a range of resin waste/crud mixtures and moisture contents.
- o Determine the quantity of water removed from resin using high force compaction.
- o Measure springback occurrence.
- o Determine feasibility of full scale application.

Test Equipment - Lab Scale

The lab scale tests utilized a hydraulically powered laboratory press and a specially designed cylinder/piston as shown in Fig. 1 and Fig. 2. Both radioactive and non-radioactive powdered resin/crud samples were tested using the lab scale apparatus. The press achieves compressive forces of up to 21,000 lbs (6680 psi) using a two inch diameter ram. The sample volume was 5 cubic inches. A vacuum of at least 10" Hg was maintained on the cylinder to remove water as it was pressed out of the sample. Pressure on the sample was increased in 3,000 lb increments (955 psi), and the volume of water extracted was measured at each increment. The height of the sample "puck" was also recorded for each pressure increment, and following the release of pressure after completing maximum compaction.

Test Equipment - Full Scale

Full scale crush tests were performed on non-radioactive resin samples using COMPACT-1, a mobile 1000 ton high force compactor (see Fig. 3). This compactor unit was normally used to supercompact 52-gallon drums containing dry active waste (DAW). A pressure of 4420 psi was applied to approximately 6.6 cubic foot of waste resin contained in 20 gauge, 52-gallon drums.

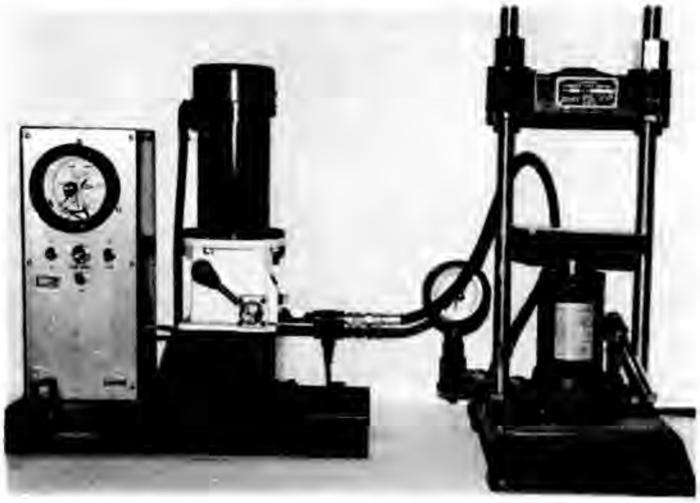

Fig. 1. Laboratory Resin Press Test Set-Up

Materials Tested

Actual radwaste resin from a boiling water reactor (BWR) was tested using the lab scale press. The samples were obtained from three phase separators within the plant. The condensate phase separator sample consisted of 50% PD-1 cation resin, 25% PD-3 anion resin, and 25% ecocote (cellulose). *One of the three* phase separators sampled also contained 10% by volume IRN-150 bead resin from the radwaste demineralizers. The moisture content of the samples varied between 53 and 57% by weight. Initial sample densities were 0.46 gm/cc for powdered resin from the condensate phase separator, and 0.50 gm/cc for the mixed radwaste/condensate waste resin.

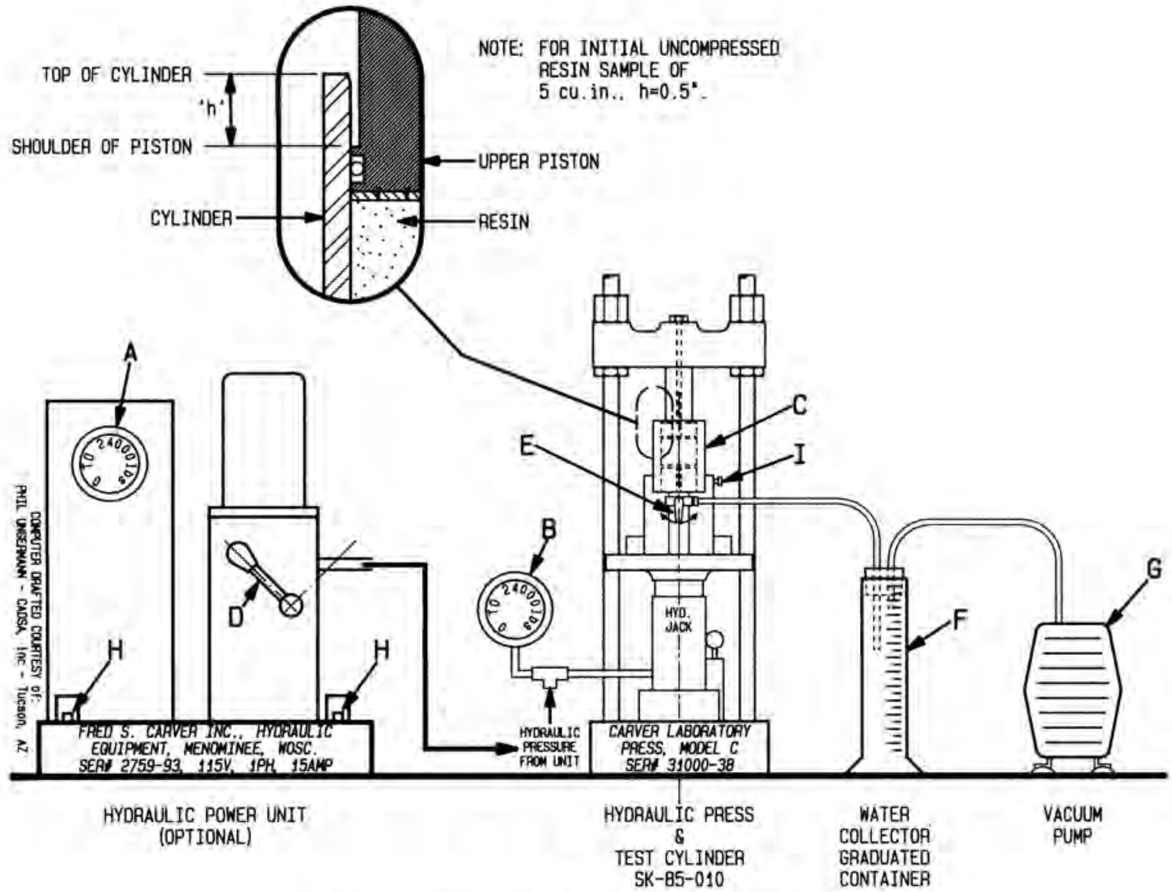

Fig. 2. Laboratory Resin Press Test Set-Up.

TABLE I

Lab Scale Results of Resin Compaction

Waste Type	Initial Density gm/cc	Initial Moisture Content, %	Final Density gm/cc	VR Factor
Actual Plant Generated				
Φ Sep 1A[1]	0.46	53.0	1.50	3.7
Φ Sep 1B[2]	0.50	55.2	1.27	3.6
Φ Sep 2B[1]	0.46	56.4	1.51	3.9
Clean Powdered Resin	0.46	53.6	1.43	4.4
Non-Radioactive				
X-203H no Crud	0.43	60	2.02	6.2
X-203H 20% Crud[3]	0.58	60	2.24	5.5
X-203H 50% Crud	0.48	50	2.21	6.2
X-203H w/25% Bead Resin, 20% Crud	0.53	50	2.02	4.3
X-203H w/50% Bead Resin, 20% Crud	0.66	50	1.84	2.3
X-203H w/75% Bead Resin, 20% Crud	1.09	50	1.61	1.8
Bead Resin	0.76	50	1.64	2.0
Powdered Resin w/25% Fiber & 20% Crud	0.47	50	1.90	5.0
P202H w/20% Crud	0.41	50	1.90	5.5
DE	0.35	50	2.8	8.2
DE w/20% Crud	0.43	50	2.7	7.1
P201H, 0% Crud	0.41	50	1.6	5.1
P201H, 5% SS[4], 0% Crud	0.46	50	1.42	4.7

[1] Samples from Phase Separator 1A and 2B consisted of 50% PD-1 cation, 25% PD-3 anion, and 25% ecocote cellulose.

[2] Sample from Phase Separator 1B same as 1A and 2B, but included 10% by volume radwaste demineralizer bead resin.

[3] Crud concentration is in terms of 20 grams dry iron oxide per 100 grams of dry X-203H.

[4] P201H chemically depleted with a 5% saline solution.

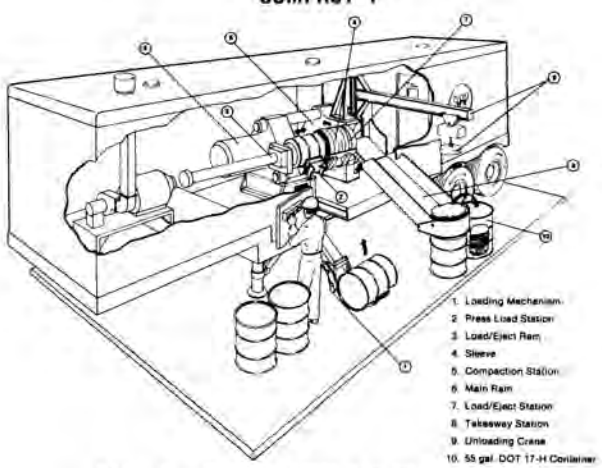

Fig. 3. Mobile 1000-Ton High Force Compactor

Thirteen other non-contaminated waste types were also tested using the lab scale press. These included powdered resin mixed with varying concentrations of crud, bead resin, and diatomaceous earth. Initial densities ranged from 0.35 gm/cc to 1.09 gm/cc, with moisture contents of 50 or 60 percent.

Dewatered resin and air dried resin with respective moisture contents of 66.7% and 44.4% were compacted by COMPACT-1 for the full scale tests. X-203H Ecodex resin was utilized as the test media. This resin was packaged in 20 gauge, 52-gallon steel drums prior to high force compaction. A critical question to be answered was the ability of the drum containing the resin to adequately act as an anti-springback device. In addition, the testing looked at the effects of multiple compactions on the same drum.

Results

The results of the lab scale compaction tests are summarized in Table I. Volume reduction (VR) factors for actual plant resin ranged from 3.6 to 4.4. Bead resin proved the most difficult to compact, yielding VR factors of approximately 2.0, and demonstrated a detrimental effect on VR when mixed with powdered resin (see Fig. 4). Compaction of diatomaceous earth provided the greatest VR factor of 8.2, while various powdered resin/crud mixes showed VR factors in the 4.3 to 6.2 range. Crud and suspended solids tended to also slightly reduce the compactability of the sample.

All VR factors are based on puck height measurements in the restrained position, that is, springback was not allowed to occur. Springback for the actual plant generated resin ranged from 24% to 39% of the final restrained volume.

Moisture contents of resin in the 60% to 70% range were found to reduce the effectiveness of compaction, and in general, a moisture content in the 40% to 50% range yielded the most optimum volume reduction (see Fig. 5 and 6).

The full scale test provided the opportunity to verify lab scale test results and investigate the feasibility of commercial operation.

Two drums of air dried Ecodex containing less than 45% moisture were compacted to yield a VR factor of 2.4, without squeezing out any excess water.

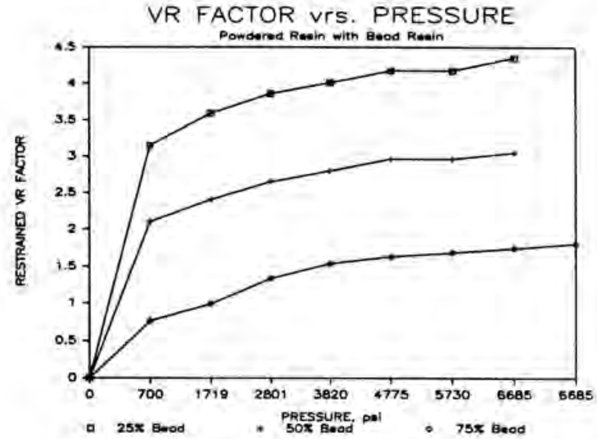

Fig. 4. Detrimental Effect of Bead Resin on Volume Reduction

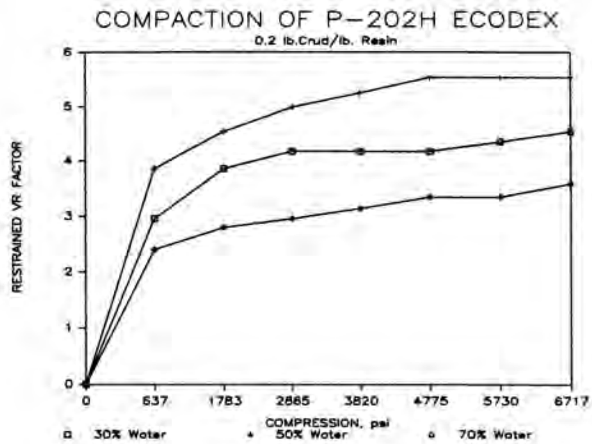

Fig. 5. Effect of Resin Moisture Content on Volume Reduction

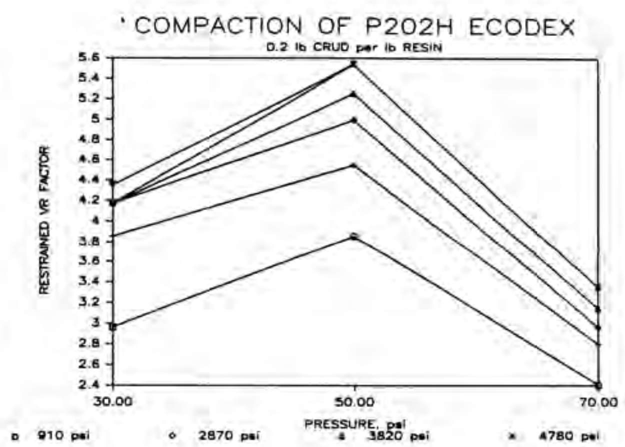

Fig. 6. Effect of Resin Moisture Content on Volume Reduction

On the other hand, the full scale test demonstrated that it is impractical to compact vacuum dewatered resin with 65% to 75% moisture without some way of separating the resin from the water. In the drum compaction of dewatered ecodex, a substantial quantity of a resin/water slurry escaped from the drum.

The effect of multiple compactions on a single drum of dried resin was significant. After one compaction cycle the volume reduction (VR) was between 2.0 and 2.1. After four to five compactions, the drum height was reduced by 17 to 19 percent further, resulting in a VR of 2.4 to 2.5

Post compaction observation of the compacted drums was performed over twenty days to check for re-expansion or swelling. It was concluded that any re-expansion that may occur does so within the first few minutes after the compacted drum is ejected from the compactor. This confirms the ability of the steel drum to act as an effective anti-springback device.

CONCLUSION

High force compaction of waste resin, particularly powdered resin, is an effective technology to achieve significant volume reduction. Full scale commercial application is feasible. Additional research is underway to determine the optimum burial package to employ for containerizing the "pucks" of compacted resin produced by the full scale press. Consideration of the optimal press size, throughput capacity, as well as water collection and radiation shielding of a full scale system is necessary.

Conceptual designs of a full scale system have been completed, (see Fig. 7) and the final design will depend on specific plant parameters. It is anticipated that interfaces with the plant will be minimal. The compactor unit itself will require electrical power and a single liquid return line to the plant. This technology provides one of the safest, simplest, and most cost effective means of reducing the volume of one of the most expensive waste types generated by nuclear power plants.

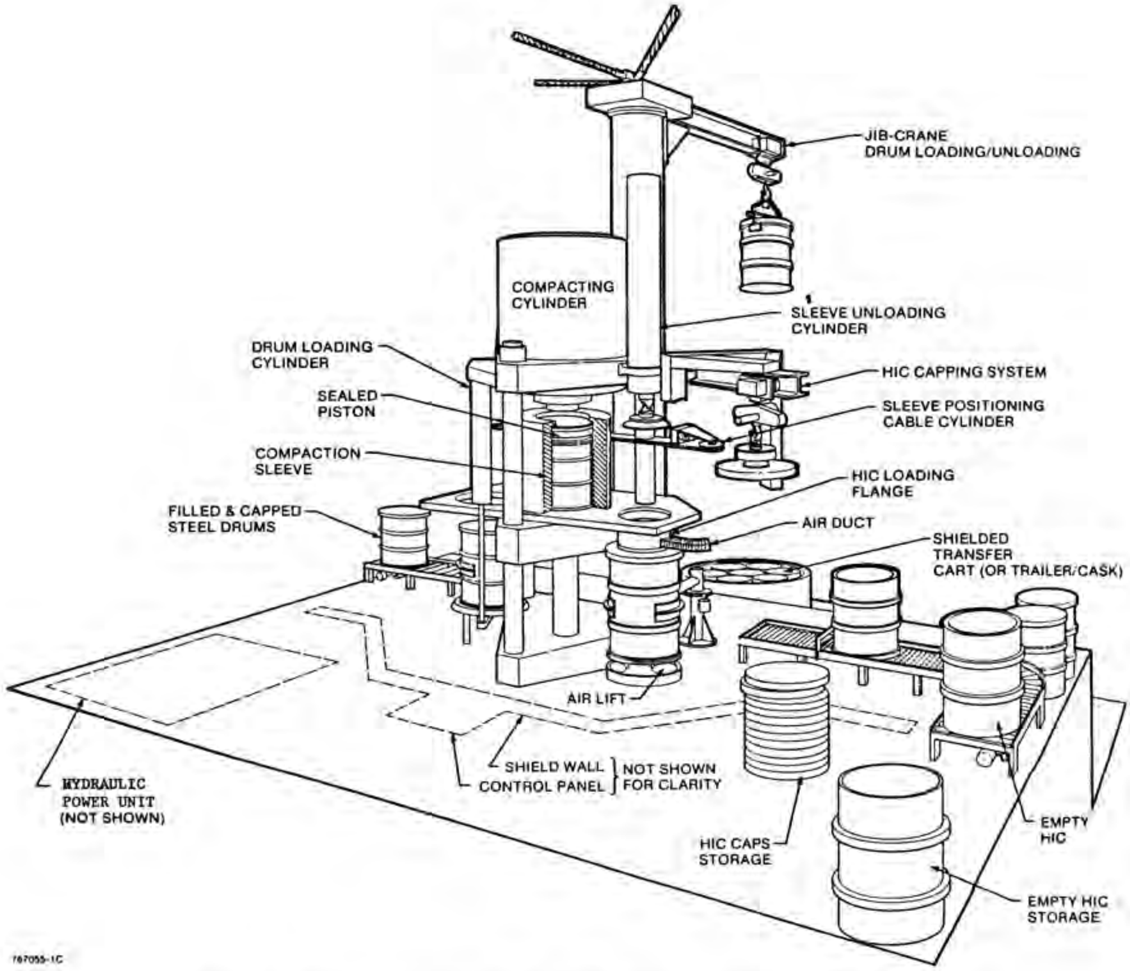

Fig. 7. Conceptual Design of Resin Press Volume Reduction System.