OPERATING EXPERIENCE WITH A DRY ACTIVE WASTE SHREDDER/COMPACTOR AT A NUCLEAR POWER PLANT

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ABSTRACT

Dry Active Waste (DAW) produced at nuclear power plants generally accounts for a large portion of the total low level radioactive waste shipped for disposal at shallow land burial sites. Dry active waste generally consists of paper, cloth, scrap wood, light metals, sheet plastics and other miscellaneous items. Most nuclear plants package the compactible waste with either a drum or box compactor. Noncompactible waste is packaged in either metal or wooden boxes. The shredder/compactor system was developed to shred normally bulky noncompactible waste and thus make it capable of being compacted into an LSA box with other compactible waste. The result is the elmination of void spaces reduced springback tendency, and an increase in the density of the waste which can be compacted into a box.

Caroline Power & Light Company installed a shredder/compactor system developed by Impell Corporation at the Brunswick Steam Electric Plant in October 1984. This paper describes the shredder/compactor system, the performance of the system using a simulated EPRI waste mixture, the system performance using a simulated Brunswick plant DAW mixture, system operating experience, a discussion on overall plant DAW waste minimization and reaches the conclusion that the shredder/compactor system is a cost effective and efficient technique for processing and achieving dry active waste volume reduction for typical BWR plant waste.

SYSTEM DESCRIPTION

Equipment

The Dry Active Waste Shredder/Compactor system has been designed for the specific purpose of processing nuclear power plant wastes. The system consists of the following major components.

- Hydraulic driven shredder
- Waste feed conveyor
- Shredded waste transfer conveyor
- Hydraulic compactor
- HEPA filter air handling systems
- System controls.

The shredder is a two shaft machine with low speed counter-rotating shafts. One shaft rotates approximately one half the speed of the other which provides excellent self cleaning and helps the shredding process for rubber and plastic material by tearing and ripping the thin tough material. The two hook cutters and the spacers used in this application are one inch thick high carbon steel carburized to a Rockwell scale range of 50 to 55.

The cutter shafts are driven through a simple large gear box by a low speed, high torque radial piston hydraulic motor. The hydraulic source is a separate skid mounted system utilizing two 75 horsepower electric motor driven, 3000 psig hydraulic pumps.

The shredder control system provides for automatic reversal of the cutter shafts should a particular object require more cutting torque. The object is dislodged momentarily and when the shafts automatically return to the forward direction, a different "bite" is taken on the object. Should the object turn out to be un-shreddable the machine will shut down after a preset number of reversals. An operator may then remove the object and place it directly in the waste container.

The waste is transferred from the floor level collection area to the shredder by an inclined, cleated belt, electric motor driven conveyor.

As the waste is processed through the shredder, it drops onto another belt conveyor. This transfer conveyor dumps into the waste container within the compactor. The conveyor comes through the end of the compactor enclosure and can be moved back and forth over the length of the box to allow even distribution of the waste in the box as it is filled.

The compactor is a standard hydraulic box compactor which uses 4'x4'x6' metal boxes. It has its own hydraulic system as well as its own HEPA filter air handling system. Ram face compaction force is 100,000 pounds.

The shredder and transfer conveyor housing operate at a slight negative pressure to minimize area contamination should the shredding process release dust contained within the waste. This negative pressure is maintained by an air handling system identical to the one on the compactor. It consists of an exhaust blower, roughing filter and a HEPA filter.

The shredder/compactor system is controlled from two separate control panels, one for the compactor and one for the shredder and conveyors. The controls consist of pushbuttons and status indicating lights arranged in a logical pattern and clearly labeled to facilitate operator control and surveillance.

The control system contains numerous interlock and permissive circuits to ensure safe operation and prevent equipment damage.

System Operation

Dry Active Waste is accumulated in an area near the feed conveyor. System operation is initiated by first placing an empty box in the compactor. The shredder hydraulic system is then started which allows, by the control system, the transfer conveyor to be moved out over the box and the shredder and conveyors to be started.

The waste is then placed on the feed conveyor at a rate which is comfortable for one man to handle. As the waste reaches the top of the feed conveyor it drops into the shredder inlet hopper and proceeds through the shredding process. The shredded wastes drop from the shredder onto the transfer conveyor. This conveyor is positioned over the box by another operator to evenly fill the box prior to compaction. When the box is full of shredded waste the operator at the compactor stops the transfer conveyor which in turn stops the feed conveyor and the shredder. He then positions the transfer conveyor back out from under the compactor ram.

The compactor hydraulic system is then started and the waste compacted. The fill and compaction steps described are repeated several times until the box is full after the last compaction.

Process Capability

The shredder itself can process Dry Active Wastes at rates up to 10,000 lbs/hr. Experience has shown, however, that the combined steps of feeding the waste and operating the compactor generally results in process rates of between 1,200 lbs/hr and 2,000 lbs/hr.

As shown in Table I, which describes the waste mixture used for the demonstration tests, the system is capable of handling a wide variety of waste materials. Typical wastes include: paper, plastic, rubber, PVC sheet, PVC piping and components, wood, concrete, scaffolding, 55 gallon drums, non-ferrous metals, and mild steel pipe, tubing, and other metal parts up to approximately 1/8" thick.

ACCEPTANCE TESTING

Following the installation in October 1984, acceptance testing was performed on the shredder/compactor system. Eight boxes were filled with a mixture of nonradioactive waste from the Brunswick clean waste area. This waste mix duplicated the EPRI 1981 BWR Plant Average Waste Composition [a]. Table I gives the composition of these boxes. This nonradioactive waste mixture had an average uncompacted density of 13.5 lb./cu. ft. As used in this report, "normally uncompactible waste" refers to waste that cannot be compacted without first being shredded. "Uncompactible residue" is that waste which can neither be shredded nor compacted.

TABLE I

EPRI 1981 BWR Plant Average Waste Composition

Compactible = 68% of total

Item - industrial mix	ft^3
Rubber - (insulation off wire)	3.1
Plastic - (sheets, rolls, buckets)	15.3
Paper - (sheets, cardboard, sheetrock)	15.9
PVC - (pipes, tubes)	6.1
Metal - (small pipes, sheets)	1.8
Wood - (small pieces of boards, plywood)	3.1
Cloth - (canvas, threaded plastic)	6.7
Others & Misc. - (tin, barrels, wiring, trailer underpinning)	9.1

Noncompactible = 32% of total

Wood - (larger boards, wood frames, pallets)	7.2
Lead - (lead sheets, bricks)	0.2
Tools - unable to process through shredder	-
Conduit - (long metal pipes)	2.3
Concrete - (blocks, asphalt)	1.1
Glass - (broken fluorescent tubes)	1.1
Dirt - (soil placed in bags)	1.4
Filters - (unused HEPA filter)	1.4
Filter Frames - (AC unit, metal/paper units)	1.4
Composite Materials - (chairs, cushions)	2.5
Pipe - (large/long metal pipes)	4.8
Misc. - (3-ply copper tubing/rubber, ladders)	5.5
Total	90.0 ft^3

The test activity was initiated by placing one of the eight boxes collected from the clean waste area into the compactor. The waste in this box was then compacted. After the initial compaction stroke, waste from several of the other boxes was used to completely refill this box. A total of eight refilling and compaction strokes were used which included the placement of two anti-springback devices. After the eighth compaction stroke, the box was removed from the compactor and the lid placed on the box. Data recorded included the time to reach full compaction pressure, the length of time the ram was in the down position, when anti-springback devices were used, the degree of springback after each compaction stroke and of course the final total weight of the filled, covered box.

a. (EPRI-NP-3370, Electric Power Research Institute, "Identification of Radwaste Sources and Reduction Techniques," January 1984, Volume II, Figures 4-9, P. 4-251)

To evaluate the effect of shredding, waste from the previously compacted box was removed and fed through the shredder into an empty box located in the compactor chamber. Additional waste to fill this box was fed to the shredder from the remaining boxes containing the EPRI mix. Using the same operating parameters and recording the same data as for the compacted only box, as much waste as possible was shredded and compacted within eight compaction strokes. This box was then removed, the lid put in place and the box weighed. This test was then repeated using the remaining EPRI waste mix. No anti-springback devices were used in this second test.

Since typical dry active waste from the Brunwsick plant has less normally uncompactible waste and a higher percentage of paper and plastic waste than the EPRI test mixture, a third test was performed. Four additional boxes of nonradioactive waste of similar composition as the plant's dry active waste stream (approximately 75% paper/plastic, 10% wood, 10% wire/rubber, and 5% metal) were collected from the Brunswick clean waste area. In every other respect, this test was identical to the previous two tests discussed above.

The results of the three tests are provided in Table II and shown graphically in Fig. 1. Tests 1 and 2 represent the EPRI waste mix and Test 3 is the typical Brunswick waste mix.

TABLE II

Results of Acceptance Testing

	Initial Waste Density (lbs/ft^3)	Final* Waste Weight (lbs)	Final Density (lbs/ft^3)	Increased Density (%)
Test 1				
Compacted	13.73	2833	31.48	
Shredded/ Compacted		4244	47.16	49.8
Test 2				
Compacted	13.72	2712	30.13	
Shredded/ Compacted		4024	44.71	48.3
Test 3				
Compacted	8.13	2372	26.35	
Shredded/ Compacted		3274	36.37	38.0

* 90 ft^3 not including box, lid fasteners and antispringback devices.

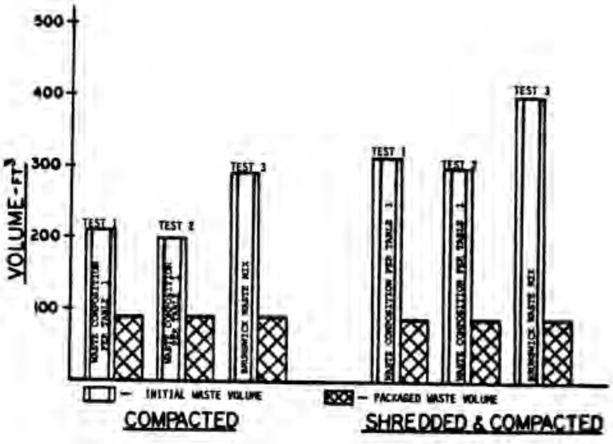

Fig. 1. Volume Reduction Benefits Compacting Vs. Shredding and Compacting

The performance of the system was determined by comparing the waste density of a full box after compacting only to that of the same waste shredded and recompacted. The performance obtained for the EPRI waste mix was an increase of 49.8% and 48.3% in waste density, respectively. The performance obtained for the Brunswick waste mix was an increase of 38% in waste density.

All three tests demonstrated that the density increase closely approached or exceeded the acceptable performance goals set by CP&L of 50% and 30%, respectively. Springback after compaction was greatly reduced in all three of the shredding/compacting tests as compared to the three compaction only tests.

OPERATING EXPERIENCE

Operational Observations

The shredder/compactor was installed in October 1984 and was placed into service processing plant DAW in November 1984. In order to achieve maximum operating efficiency and system performance, trained operators are used by CP&L. Late in December and early January the modifications discussed below were incorporated. Aside from the downtime for the described modifications, the equipment has been relatively trouble free and has required only minimal routine maintenance.

Most new systems, however, do exhibit some operational difficulty; several of these concerns are discussed below.

During routine operation, as the box gets full of shredded material, some of the material is carried backwards by the return side of the transfer conveyor belt. This material builds up behind the conveyor in an enclosed area. Although the enclosed area has been made more accessible for cleaning, the problem still exists. A different type of belt and belt scrapper should correct this problem. The installation of a bag and chute assembly on the rear of the discharge conveyor housing is also being considered as a method for removing this material.

Another issue is the availability of an anti-springback device for the compactor boxes when compacting shredded material. The available anti-springback devices utilize bars which hold the material down after compaction. Shredded material easily flows around these bars. At present, two methods are used to improve the anti-springback device performance. One is the use of a layer of unshredded bagged waste under the anti-springback devices and another is the use of contaminated scrap plywood in the same manner. An improved anti-springback device for use with shredded material needs to be developed.

Although the shredder is capable of processing metal up to 1/8 inch in thickness and can easily handle standard 55 gallon steel drums, it has some limitations: waste must be sorted to remove hardened steel which may damage the teeth or shut the system down while the material is removed. At CP&L, the waste delivered to the shredder is controlled by the monitoring/sorting facility which is operated as part of the radwaste volume reduction program.

In order to optimize the shredder volume reduction and to produce boxes of relatively high uniform weight, consideration must be given to the waste mix. Some materials such as uniformly shaped pieces of flat wood and metal will increase in volume when they are shredded and compacted. These items should be placed in the box and shredded material compacted around them. Paper and especially plastic bags become very fluffy when shredded. If these materials are shredded alone, they do not compress well. If denser materials such as hard plastic, metal, or wood are shredded with the paper and soft plastic, compaction efficiency is improved.

Highly contaminated material and that containing large amounts of loose contamination (HEPA filters, for example) should not be shredded. Although no significant levels of contamination have been discovered outside the system, processing items of this sort quickly loads the HEPA filters and builds up high levels of contamination within the system which could make maintenance difficult in the future.

Modifications

During the acceptance tests, it was observed that because of the fixed position of the discharge conveyor that feeds the compactor the shredded waste fell in a mound in the center of the container. This required opening the compactor enclosure and manually raking the shredded waste prior to each compaction stroke. Opening the compactor enclosure compromised the airborne contamination control system. The system was subsequently modified by Impell to allow variable positioning of the discharge conveyor by external operator control. The controls were conveniently installed near the compactor enclosure window.

Other modifications to the system included substituting the flexible hydraulic hose with steel pipe to control the sudden movement of the flexible hoses that occurs when the shredder switches direction. Also, an enclosure was built to house the shredder hydraulic unit to eliminate the noise and heat. Following these modifications, the system has become fully operational for processing contaminated dry active waste.

DISCUSSION

After several months of operation, the overall volume reduction benefits of the shredder/compactor system have been established. The greatest benefits appear to come from selectively shredding and blending normally uncompactible waste with waste that shows no particular benefit from shredding (i.e., paper, soft plastic, and flat pieces of metal and wood). Table III documents these volume reduction benefits.

TABLE III

Selected Data from 90 Cubic Feet Boxes

Uncompacted Volume (Cu Ft)	Paper/ Plastic	Metals	Wood	Other	Final* Weight(Lbs)	Final Density (Lbs/Cu Ft)	% Volume Reduction
Group A							
490.0	Y	Y	N/A	N/A	3260	29	82
444.0	Y	Y	N	N/A	3262	29	80
467.0	Y	Y	N	N(HEPA)	3358	30	81
461.5	Y	Y	N	N/A	3862	36	80
Group B							
394.0	N	Y	N	Y(HEPA)	3991	37	77
309.0	N	Y	N	Y(CONCRETE)	4002	37	71
480.0	N	Y	N	N/A	4318	41	82
489.0	N/A	Y	N	N/A	4641	44	82
Group C							
379.5	N	Y	N	N/A	4539	43	76
304.0	N	Y	N/A	N(CONCRETE)	3901	36	70
623.5	N	N/A	N/A	N(ROCKS)	4080	38	86
492.0	N	Y	N/A	N(CONCRETE)	4347	41	82
503.5	Y	Y	N/A	N(CONCRETE)	4458	42	82
345.0	N	Y	N/A	N(CONCRETE)	5305	52	74

Y = shredded
N = not shredded
N/A = not present

*Final Weight includes box weight

Group A

Avg. Lbs./Box	3436
Avg. Lbs./Cu. Ft.	31
Age. % VR	81
% Shredded	89
% Non-shredded	11

Group B

Avg. Lbs./Box	4238
Avg. Lbs./Cu. Ft.	40
Avg. % VR	78
% Shredded	59
% Non-shredded	41

Group C

Avg. Lbs./Box	4438
Avg. Lbs./Cu. Ft.	42
Avg. % VR	78
% Shredded	24
% Non-shredded	76

Average

Avg. Lbs./Box	4095
Avg. Lbs./Cu. Ft.	38
Avg. % VR	80
% Shredded	57
% Non-shredded	43

The shredder and box compactor system described herein is an important tool for achieving the plant's volume reduction goals. However, a plant volume reduction program must address additional considerations to be totally effective. Some of the more important parts of a good program are administrative control over waste entering the plant, effective maintenance and decontamination programs, an emphasis on waste minimization in employee training sessions, utilization of dedicated operators under the supervision of a qualified radiation control technicial, monitoring and clean trash sorting, and recycling of decontaminated equipment.

Because of the shredding of normally uncompactible waste, the decontamination of tools on-site for reuse and the shipment of large pieces of scrap metal to an off-site vendor for decontamination and resource recovery, shipments of uncompacted waste to the burial sites have almost been eliminated. The decision to purchase a shredder/compactor was primarily a response to the inefficient packaging of normally uncompactible waste. But secondly, there is anticipation of an incinerator for radwaste processing being available in the future. If this option is pursued, a shredder would be a helpful and possibly necessary first step in preparing waste for incineration.

The shredder/compactor system has also resulted in a savings of time and labor. Previously, three people could compact 10-12 drums per 12 hour shift using two drum compactors. During acceptance tests which utilize difficult waste to handle, as it was either loose in 90 ft^3 boxes or previously compacted in 90 ft^3 boxes, nine manhours were used to shred and compact each box. This indicates that 90 pounds per manhour could be processed with the drum compactors whereas now 450 pounds per manhour can be processed with the shredder/compactor. As the shredder/compactor crew gains experience, the average density of the waste in the processed boxes will continue to increase.

CONCLUSION

The shredder/compactor system is a cost effective and efficient technique for processing and achieving dry active waste volume reduction for typical BWR plant waste. The shredder alone can reduce the volume of hard plastics, wood, glass, and metals that contain void spaces because of their physical shape. Selective shredding of normally uncompactible waste followed by compaction with other compactible waste yields an average volume reduction of 80% over completely untreated and packaged waste. The shredder/compactor system greatly improves packaging efficiency.