OPERATING EXPERIENCE OF A MOBILE WASTE SHREDDING SYSTEM

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ABSTRACT

The disposal of low level radioactive waste (LLW) in the United States has become a significant problem challenging the commercial nuclear power industry. Over the past several years, there have been major changes in various aspects of LLW generation, shipment and disposal. These changes have been characterized by legislative uncertainty, more stringent regulations and increasing restrictions on shipments imposed by disposal sites and regulatory requirements. These effects have strongly impacted the current nationwide disposal system for LLW, and the industry is faced with higher shipping and disposal costs, on-site storage and soon, in some cases, no availability LLW disposal sites.

The industry is responding to this problem by scrutinizing and improving the way in which LLW is managed on-site. Conventional and advanced volume reduction (VR) radwaste treatment systems are receiving more attention with both short and long term solutions being considered.

INTRODUCTION

While it is generally acknowledged throughout the industry that incineration offers the highest volume reduction for many LLW, the economic conditions and site specific circumstances which define its viability are today unique only to a few nuclear power plants. In the wake of the Low Level Waste Policy Act promulgated by Congress in 1981, however, this VR radwaste treatment system may find more application with regional compacts.

In the meantime, the industry looks to the available technology and better administrative controls to manage the LLW problem more efficiently. Promising VR technologies applicable to dry active waste (DAW) are emerging that involve advanced compaction techniques and modifications to existing conventional compaction techniques currently used at nuclear power plants. These technologies include very high pressure compaction, also called supercompaction, as a substitute for conventional compaction equipment, and shredding prior to compaction as a modification to current compaction practices.

Combustion Engineering, Inc. has designed, constructed, tested and placed into commercial operation a Mobile Waste Shredding System (MWSS) that brings to nuclear power plants a DAW processing system which enhances the volume reduction capabilities of existing compaction equipment. Under the auspices of the Electric Power Research Institute (EPRI) the MWSS was tested at several nuclear power plants using conventional compaction equipment. This test showed that an increase in volume reduction due to shredding is measurable and has been found to be significant in many cases. Volume reductions due to shredding of 20% were not unique and 46% were achievable.

This paper described the MWSS, the EPRI test program and the results which are currently being published in EPRI report number 1557-15, "Advanced Radwaste Compaction Techniques", scheduled for publication in April 1985.

THE EPRI PROGRAM

The EPRI test program provides definitive information on the volume reduction capabilities of conventional compactors used in the nuclear industry for the treatment of dry active waste (DAW) and the effects of preshedding on compaction. The test program presents comprehensive data on compacted densities of DAW collected at four facilities generating DAW and using conventional compactors. A major objective of the program is to present test results in a manner which will provide guidance to utilities in evaluating DAW volume reduction options.

Two sets of DAW material compositions were used in the test program. The first was a reference composition very similar to the 1981 PWR plant average reported in EPRI RP 1557-3, "Identification of Radwaste Sources and Reduction Techniques." The reference material composition used throughout the test program included absorbant material, cloth, rubber, paper, plastic, filters, metal, PVC, conduit, dirt, glass, non-compactable and compactable material, and is referred to throughout the report as the EPRI mix. The second set of material compositions used in the program were plant specific, DAW compositions as they are normally collected and packaged at the host utilities.

Observations and data collected throughout the test program show that non-compactable DAW is a class of material that is very site specific and depends upon the type of compaction equipment used on-site, the administrative policies and controls in effect at the site and operator specific mannerisms and attitudes towards their task. Moreover, there is a variance in the interpretation of the term "non-compactable" which is also very site specific.

Some utilities consider non-compactable material "compactable" simply because it can be packaged into their waste shipping container. Usually this requires intensive manual handling and preparation of the waste to make it fit into the container. For example at one site, wooden planks which are too long to fit into their LSA boxes are broken down and individually stacked in to the box. Another site tried to decontaminate wooden planks by removing a layer of material using a planer. This was also labor intensive and subjected operators to unnecessary airborne contamination. The disposal of high efficiency particulate air (HEPA) filters posed an exceptional problem at one plant using a drum compactor, mainly because the filters didn't fit into a 55-gallon drum. Manual disassembly of the filters was time consuming and radiologically hazardous. Shredding proved to be a significant benefit in the disposal of HEPA filters at this plant.

While the materials making up the class of non-compactables varied greatly, there is a limited collection of waste materials at its core which are generally acknowledged to be truly non-compactable, although packagable. These are large metal objects such as tools, valve bodies, drill bits, dirt, glass, and concrete.

There was also observed to be a collection of waste materials considered non-compactable to one extent or another, all packable with manual preparation where necessary, that was truly compactable if preshredded. These are wood objects, such as planks, skids or filter frames, and certain light steel objects, such as conduit and reinforced hosing.

The test procedure, therefore, was divided into two major parts. The first part involved compaction and shredding tests with the EPRI mix and the second performed identical tests but with plant specific material. The test program was also structured to account for the different types of compaction equipment and capabilities that exist throughout the industry, and the different mannerisms in material loading into containers. To identify how these factors affect the volume reduction due to compaction, tests were conduced with LSA box type and 55-gallon drum type compactors of several different manufacturers. Tests were also performed at various compaction pressures, typically 25%, 50%, 75% and 100% of the maximum capability of the ram.

MOBILE WASTE SHREDDING SYSTEM

The equipment used to shred dry active waste (DAW) for the test program was a full-scale Mobile Waste Shredding System (MWSS) designed and built by Combustion Engineering, Inc. (C-E). The MWSS is a totally self-contained unit mounted in a 45 foot trailer. The only interface with site systems is a 480V, 200 Amp electrical hookup at the front of the trailer. Figure 1 shows general information pertaining to the MWSS mechanical layout.

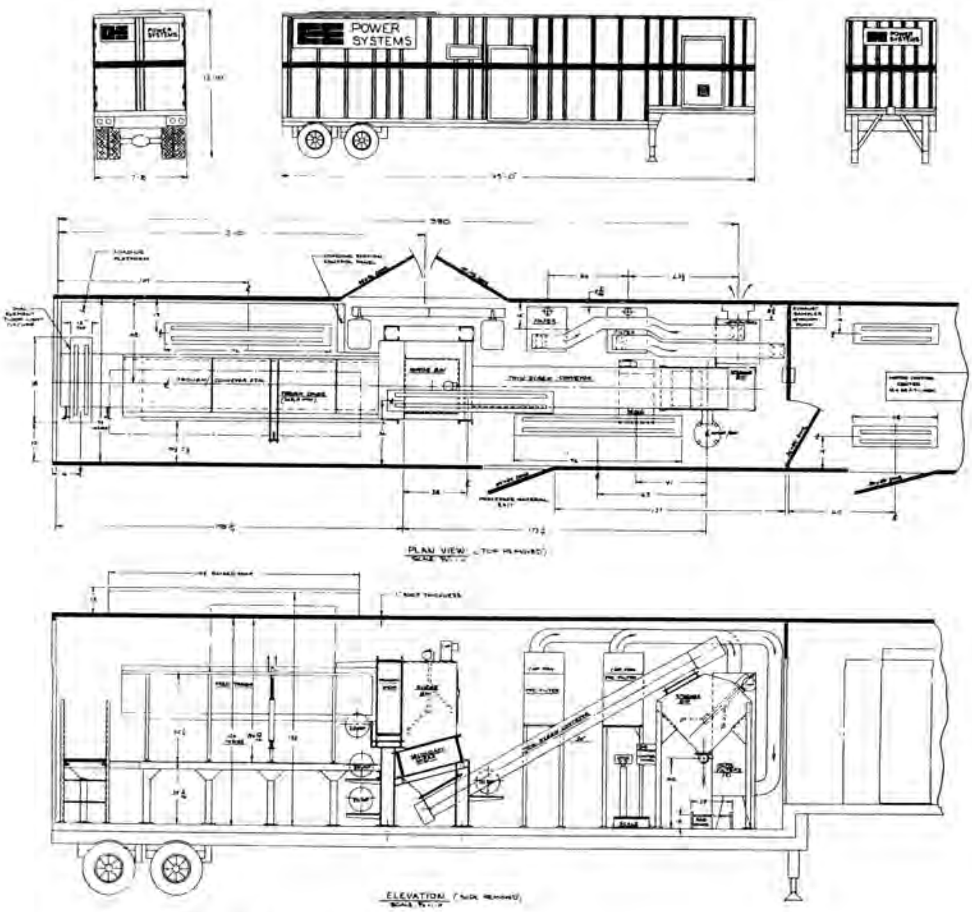

Fig. 1. Mobile Waste Shredder System.

Unprocessed dry active waste DAW is initially staged (typically on an enclosed platform) outside the trailer rear doors. DAW is loaded onto a loading platform in the rear of the trailer through the rear doors. The work area in the trailer is ventilated through a blower, pre-filter, and HEPA filter to control potential emissions of airborne contamination when the trailer doors are opened.

The material is manually loaded into a feed trough adjacent to the loading platform. The shredding equipment internals are maintained at a slightly negative pressure relative to the trailer work area through a separate blower/filter system to minimize operator exposure to airborne contaminants. A pneumatically operated trough cover is lowered to completely isolate the equipment internals.

A pneumatically operated ram is utilized to force the DAW through a set of horizontal (primary) shears. From the primary shears the material is gravity fed through a set of vertical (secondary) shears for further size reduction. A twin screw auger conveys the shredded DAW from under the secondary shears to a storage bin.

The storage bin contents are unloaded into yellow bags through a 6 inch auger. The bags are heat sealed and manually transported to the compactor.

The MWSS is provided with a variety of safety features designed to protect operators and equipment. Limit switches are frequently used to prevent operator access to hazardous areas during system operation, such as the rotating cutters, augers and shafts. Equipment protection is provided by current sensing relays and torque limiters to detect the presence of unshreddable objects which could damage the cutters or, in general, cause jamming situations of any rotating parts. These safety devices automatically disengaged rotating parts from their drivers to prevent gross mechanical failure.

Self-contained ventilation/filtration systems are provided to preclude airborne emissions and minimize operator exposures. Air discharges from the MWSS can be periodically monitored with an air sampling system provided in the trailer consisting of a vacuum pump, paper and charcoal filters.

The air sampling system and various process instrumentation are located in a non-contaminated area in the front of the trailer. This area is also utilized for storage during transportation of the MWSS.

The MWSS is supplied with adequate tools to perform regular maintenance activities (i.e., lubrication, bolt tightening, adjustments, etc.). Grease fittings are available where required. Access doors are provided opposite the curbside to allow easy access for maintenance of the rotary shear drive equipment.

PROGRAM RESULTS

Volume Reduction Due to Shredding

The average volume reduction due to compaction of unshredded material was found to be 82.5% with individual tests ranging from 77.6% to 88.9%. The average volume reduction due to shredding alone was 20% with individual tests ranging from 0% to 46.4%. The average overall volume reduction due to shredding and compaction was 86% with individual tests ranging from 82.7% to 89.3%.

The average volume reduction due to shredding of 20% may seem at first contradictory when compared to the average volume reduction due to compaction of unshredded material of 82.5% and the average overall volume reduction due to shredding and compaction of 86%. A useful way of understanding these percentages is to consider 100 ft^3 of as generated DAW. Simple compaction will reduce this volume by 82.5% or by a factor of 5.7. This results in a final compacted volume of 17.5 ft^3. If the same volume of as generated DAW were shredded followed by compaction this would result in a 86% reduction, or a factor of 7.1. This would be a final compacted volume of 14.1 ft^3. The 20% volume reduction due to shredding is the difference between 17.5 ft^3 and 14.1 ft^3. See Fig 2.

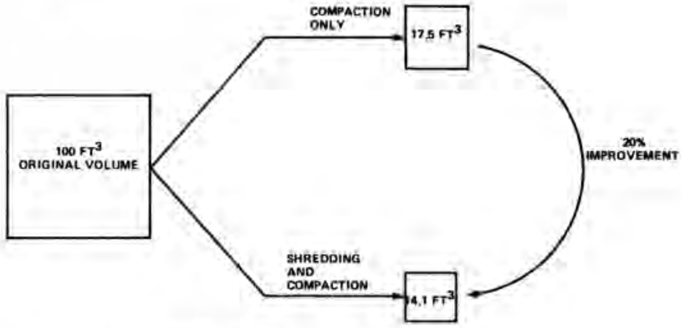

Fig. 2. Volume Reduction Due to Shredding.

The test results are presented as plots of compacted densities at various compaction pressures (Fig 3). The white bars show the range of measured compacted densities for unshredded material and the dot in the bar is the average of that range.

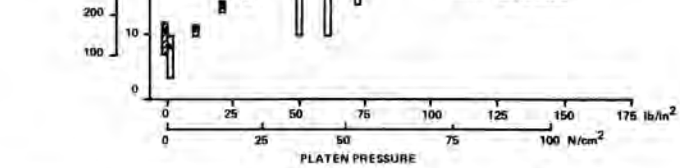

Fig. 3. Combined Data, Density vs Platen Pressure.

The cross-hatched bars show the range of compacted densities for shredded material and the dot is the average for that range. A white and cross-hatched bar are aligned at various compaction pressures to represent the effect of shredding on compacted densities. The vertical shift between the two bars represents the change in compacted densities between compaction of unshredded material to that pressure (white bars) and compaction of shredded material to the same pressure (cross-hatched bar). The length of the bars indicate how much the compacted density varied. The top of a bar is the maximum value obtained during any test and the bottom the minimum value. In general, the unshredded, compacted densities (white bars) varied more widely than the shredded, compacted densities (cross-hatched bars). This is primarily attributed to the difficult in compacting the ideal EPRI or plant specific mixtures of DAW. While several hundred cubic feet of sorted reference or plant specific DAW contained all the required ingredients, individual charges varied drastically and this strongly impacted volume reduction factors. Observation during the tests showed that for the unshredded, compacted density data (white bars) the higher values are typical of material such as metals, hoses, cans and filters, while the low values are typical of papers, rubber, cloth and plastic.

Shredding, however, mixes the material more thoroughly than sorting and results in a more uniform feed for compaction. The upper range of the shredded compacted density data (cross-hatched bars) is typical of metals, hoses, cans and filters while the lower range is typical for papers, rubbers, cloth and plastic.

The compacted density versus compaction pressure plots are accompanied by plots of the volume reduction factor due to shredding as a function of compaction pressures (Fig. 4). Again, the bar symbology is used to show the range of values and the dot represents the average value for that range. Examination of these volume reduction factors due to shredding versus compaction pressure plots shows that as compaction pressures increase the benefit due to shredding decreases.

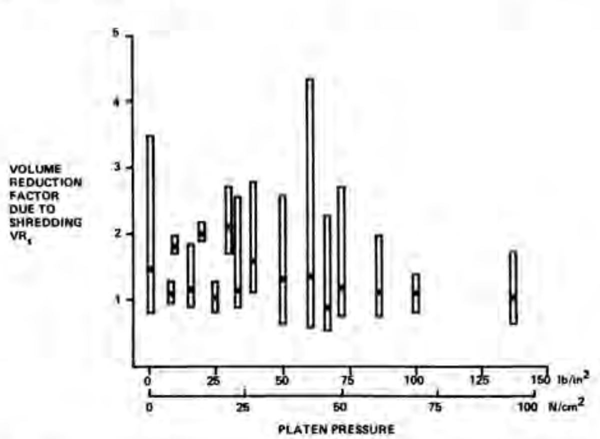

Fig. 4. Combined Data, Volume Reduction Factor vs Platen Pressure.

Reduction in Radiation Levels Due to Shredding

To identify the radiological impact of shredding as an additional operation to existing waste treatment processes used at nuclear power plants, radiation exposure to operators and equipment contamination for the MWSS were measured during the test program. Data shows that the operator exposures resulting from activities related to shredding operations were low and equipment contamination was negligible.

Before containers of DAW are shipped to disposal sites, they are surveyed for radiation levels as required by federal regulations. These surveys are used to classify the containers and determine isotopic compositions for burial purposes, and to determine Curie contents of containers which affect transportation costs. A common problem facing power plant operators is the higher cost of transportation of containers having high radiation levels caused by hot spots, highly contaminated material concentrated in a relatively small area within the container. When present, hot spots within a container define the Curie content applied for the entire container even though most of the material in the container may have very low activity. The result is a higher transportation cost incurred through Curie surcharges than otherwise would have been if the hot spot were not present or if its activity were distributed over a larger volume. Shredding was found to have an important influence on the radiological classification of such containers in several cases.

During testing at the Ginna Station, several drums of material were shredded that were labeled at 1000-1500 mR/hr. A detailed radiation survey showed that the high levels were caused by hot spots rather than a uniform distribution of high activity material. After shredding the contents of these drums with additional material of low activity, primarily wood, the shredded product collected at the bagging station was monitored at 40-80 mR/hr. This represented a 95-97% reduction in the radiation levels which permitted this material to be shipped as low specific activity (LSA) where it otherwise would have required more stringent classifications and higher shipping costs. The reduction in radiation levels of DAW due to shredding is believed to be attributed to three factors:

- o Reduction of the source activity by shredding.
- o Dispersion of the source activity throughout a larger volume of low activity material.
- o Embedment of the dispersed source material deeper within a container providing more distance from the container exterior surface where radiation levels are measured.

Operator exposures due to activities associated with shredding operations were the same or slightly less than exposures due to activities associated with compaction operations. This may be attributable to the higher background radiation in the rooms where the compactors were located than that in the MWSS trailer.

Exposures resulting from maintenance activities were negligible. This indicates, and was substantiated by smear surveys on the interior surface of process equipment that the residual contamination inside system components was very small. This is partly due to equipment design considerations. All internal surfaces that contacted contaminated material were designed to be smooth, without sharp edges or corners. This minimized the opportunity for dead spots where contaminated material could accumulate, and for embedment of contaminated material into equipment surfaces to occur. The surfaces expected to exhibit the most residual contamination, the cutters, never exceeded 22,000 DPM/100 cm^2.

Economic Benefits of Shredding

As an example of the economic impact of shredding on conventional compaction equipment, an economic evaluation was presented to illustrate several important points.

- o That economic evaluations of shredding as a volume reduction alternative is extremely site specific;

- o That the benefit due to shredding DAW prior to compaction is dependent upon the type of compaction equipment used, the material composition characterizing a site's DAW, the manner in which operations are conducted and the volume of DAW processed.

The economic evaluation example is a comparison between two alternatives for a typical Pressurized Water Reactor (PWR) and a Boiling Water Reactor (BWR) plant. The alternatives are:

- o To continue using the existing box compactor on site, or
- o To modify operations by installing a fixed Waste Shredding System (WSS).

The method of evaluation is a simple comparison of annual disposal costs for each alternative as illustrated in Table I.

For this example, the volume of DAW shipped from a site annually is taken as the average values reported in EPRI RP 1557-3, "Identification of Radwaste Sources and Reduction Techniques" for PWR's and BWR's in 1981. For a PWR, this is 12,200ft^3_{ship}/year and for BWR it is 22,650ft^3_{ship}/year.

The disposal cost for a PWR using only a box compactor was computed to be \$48.91/ft^3_{ship} and for the second \$55.34/ft^3_{ship}. The slight reduction in these costs when compared to the PWR case is due primarily to the reduction in labor costs when expressed in terms of the increased shipping volume.

For a PWR a minimum payback of 3 years was computed if the benefit due to shredding is at least 28.6% (or $VR_s \geq 1.4$). For a BWR this would result in a 1.5 year payback. To achieve an equivalent payback for a BWR, however, the benefit due to shredding need only be 20% (or $VR_s \geq 1.2$).

While simplified in content this example shows that shredding can be a viable alternative given the proper circumstances. The circumstances selected for this example demonstrate that there is ample opportunity for this volume reduction option to provide acceptable returns for typical PWR and BWR plants. More thorough economic analysis can account for life cycle costs and escalations which strongly impact economic studies. Perhaps most important, however, is an accurate definition of the plant specific DAW composition. Test results show that this signal factor is responsible for yielding increased volume reductions from 0% to as high as 46%. Such a variation strongly impacts any economic study.

SUMMARY

The circumstances that define whether shredding is a viable volume reduction option have been found to be very site specific. The test program has shown, however, that these circumstances are not unique and can occur at typical nuclear power plants. The factor which most influences the viability of shredding is DAW composition. Other important factors are the type of compactor used, the volume of DAW generated on site, and specific mannerisms in equipment operation.

The category of material presently classified as "non-compactable" has also been found to be very site specific, not only in actual material composition, but in interpretation as well. A large portion of this class of material, however, is processable by shredding with a resulting, measurable increase in volume reduction. The benefit due to shredding of "non-compactables" has been especially significant at sites using drum compactors. A good example is the disposal of HEPA filters which, without shredding or manual disassembly, do not fit into 55-gallon drums.

TABLE I

ECONOMIC EVALUATION

	TOTAL ESTIMATED DISPOSAL COST OF DAW USING (BOX) COMPACTION ONLY		TOTAL ESTIMATED DISPOSAL COST OF DAW USING SHREDDING AND (BOX) COMPACTION	
	PWR	BWR	PWR	BWR
EQUIPMENT COSTS				
Mobile Waste Shredding System (MWSS) (Rental)	\$0	\$0	\$0	\$0
Stationary Waste ShreddingSystem (WSS)(Purchase)	\$0	\$0	\$300,000/unit	\$300,000/unit
LSA Boxes	6.00/ft^3_{ship}	6.00/ft^3_{ship}	6.00/ft^3_{ship}	6.00/ft^3_{ship}
55-Gallon Drums	\$0	\$0	\$0	\$0
COST OF UTILITIES	.011/ft^3_{ship}	.011/ft^3_{ship}	.61/ft^3_{ship}	.61/ft^3_{ship}
LABOR COSTS	2.72/ft^3_{ship}	2.32/ft^3_{ship}	10.08/ft^3_{ship}	8.55/ft^3_{ship}
TRANSPORTATION COSTS	4.00/ft^3_{ship}	4.00/ft^3_{ship}	4.00/ft^3_{ship}	4.00/ft^3_{ship}
BURIAL COSTS	36.18/ft^3_{ship}	36.18/ft^3_{ship}	36.18/ft^3_{ship}	36.18/ft^3_{ship}
TOTAL ESTIMATED DISPOSAL COSTS	48.91/ft^3_{ship}	48.51/ft^3_{ship}	56.87/ft^3_{ship}	55.34/ft^3_{ship}

Certain effects have been observed during the test program concerning the shredding of material from a compacted container known to have a hot spot that resulted in significant savings in shipping costs for one of the host utilities visited. By shredding material known to have a hot spot with additional low activity material, an overall reduction in radiation levels has been observed. This effect was not expected and is believed to be attributed to source reduction, dilution and embedment of the dispersed source material.

The test program has found that the volume reduction capabilities of conventional compactors can easily achieve about 83%. An increase in volume reduction due to shredding, measured as the difference in compacted volumes of unshredded and shredded DAW, is measurable and has been found to be significant in many cases. Volume reductions due to shredding of 20% are not unique and 46% are achievable.

Finally, through the illustration of a simplified economic analysis, it has been found that the circumstances required to economically justify shredding as a modification to existing DAW management operations with short term payback are also not unique. Volume reduction due to shredding of about 29% at a typical PWR plant can realize a three year payback in shredding equipment costs. The same equipment at a typical BWR could realize a 1.5 year payback.

It is recommended that when considering the purchase or leasing of shredding equipment as a modification to existing waste compaction operations, the critical factors identified in this report as having the most influence on volume reduction factors and economic evaluations be given appropriate consideration in the light of plant specific circumstances, which only individual plant operators can identify clearly and which may give varying emphasis to the importance of these factors.

ACKNOWLEDGEMENTS

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REFERENCES

EPRI RP 1557-3, "Identification of Radwaste Sources and Reduction Techniques", Final Report, January 1984.