USE OF A SHREDDER/COMPACTOR FOR REDUCING DRY ACTIVE WASTE VOLUMES IN NUCLEAR POWER STATIONS

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ABSTRACT

A shredder/compactor system has been designed to provide for volume reduction of dry radioactive waste. The design has been tested and a volume reduction factor of 2 demonstrated when comparing compacted shred waste to compacted non-shred waste. The testing program demonstrated the ability of the shredder to process typical waste materials. A cost-benefit evaluation was performed to demonstrate the economic benefits and payback considerations for the system.

INTRODUCTION

Over the last few years, dramatic changes have taken place in the transportation and disposal of low level wastes. The changes which have occurred are: rapidly escalating costs for both transportation and disposal; packaging and waste form requirements for burial; and volume restrictions at current disposal sites.

These changes have a significant impact on waste management operations at nuclear plants, and consequently, utilities are reassessing their waste management operations relative to: operations which produce waste and radioactive waste treatment methods and packaging practices.

Dry Active Wastes (DAW) produced at operating nuclear power stations generally account for the largest fraction of the radioative waste volume shipped for disposal at a shallow land burial site. For this reason, radwaste operating budgets at operating plants with little or no Volume Reduction (VR) measures are significant. This paper focuses on the treatment of DAW.

Transportation and Disposal Costs

Table I illustrates the changes which have occurred in transportation and disposal costs from June 1975 to June 1982. This data is for transportation distances in excess of 1000 miles, and for burial of low level waste at Barnwell, South Carolina.

TABLE I

Transportation and Disposal Costs
June 1975 and June 1982

	6/75	6/82
Transportation (based on greater than 1000 miles transportation distance)	\$0.90/mile	\$1.52/mile
Burial (based on drums with less than 200 mR/hr surface radiation level buried at Barnwell, S.C.)	1.10/ft^3	14.00/ft^3

Waste Volume Restrictions

Since the 1950s, low-level wastes (LLW) have been produced in the U.S. by R&D activities, industry and nuclear utilities. Prior to the early 1960s, these wastes were packaged and shipped for burial at government (AEC) facilities. However, as the amount of commercially generated LLW increased, the private sector was encouraged to develop licensed waste disposal facilities.

Between 1962 and 1971, six LLW burial ground facilities were opened for commercial LLW disposal - Beatty, Nevada in 1962; West Valley, New York and Maxey Flats, Kentucky in 1963; Richland, Washington in 1965; Sheffield, Illinois in 1967; and Barnwell, South Carolina in 1971. During the 1970s, West Valley, Maxey Flats and Sheffield were closed and by 1979 the only commercial LLW disposal site east of the Rockies was Barnwell, which was receiving about 80% of the total commercial LLW generated in the U.S. In addition to the burial space restrictions caused by the closure of three of the six original burial sites, the State of South Carolina instituted a program in November, 1979 to reduce the volume of waste received for burial from outside the State's boundaries.

To further exacerbate the above situation, in the Fall of 1979, the Washington and Nevada sites were closed because of waste packaging and shipment requirement infractions. In November, 1980, the State of Washington passed legislation which would have banned acceptance of out-of-state non-medical wastes. While a Federal District Court has ruled this legislation unconstitutional, the State is appealing this decision. The governors of all three states with operating LLW disposal faciities also announced that they would no longer take the full burden of disposing the nation's LLW and called for the establishment of regional sites and for state responsibility for disposal of LLW. Thus it became painfully clear that the continued operation of nuclear power plants could be jeopardized by restricted burial space for low-level wastes and by political actions of the host states containing the burial sites.

Currently, a number of states in several regions are actively engaged in discussions and actions *on the development* of regional compacts. While the concept of regional burial site facilities in the U.S. is technically and economically sound, a number of institutional issues between and among the states require resolution and administrative and legislative processes remain to be completed in order to finalize the compacts. After review and acceptance of the compacts by Congress, those regions without existing burial sites must proceed to identify, license and develop a burial site. It does not appear likely, even with swift adoption of the compacts, that a new burial site can be licensed and placed into operation by January 1, 1986.

SHREDDER/COMPACTOR CONCEPT

Dry active wastes generally consist of paper, rags, wood, sheetmetal, tools and other miscellaneous materials. Operating data over the last several years indicates that 5,000 to 30,000 ft/^{3}/yr of DAW may be generated at a given operating plant. Presently, operating stations compact the compressible materials in either a drum or box compactor. Non-compressible materials are packaged in boxes or wooden crates for disposal. The ratio of compressible to non-compressible material varies at each station. For most stations, this ratio is between 0.5 and 2.0.

The shredder/compactor would process all DAW except for large dense objects such as pump casings, valve bodies and large pipe sections. The DAW (compressible and non-compressible) would be fed into the shredder which would shred the material to an approximate one-inch aggregate size. The shredded material would then be transferred to the DAW box and compacted. The advantages in compacting shredded material are:

- void spaces are eliminated before compacting, and
- material deformation is not required to achieve compaction
- springback is significantly reduced

These three factors result in more efficient compaction and correspondingly smaller volumes of packaged DAW.

Shredders with and without compactors have been utilized in non-nuclear industrial applications. The major non-nuclear application is volume reduction to reduce waste disposal costs. Examples of some current applications are shredding of trade-in tires, batteries, large appliances and automobile transmissions.

TESTING PROGRAM

EDS Nuclear, in conjunction with MAC Corporation, developed a test program to verify the suitability of the Saturn Shredder for DAW Volume Reduction, and to determine the VR factor achieved through shredding. The test program also provided data on waste processing rates.

The shredder utilized for the test program was a Saturn Model 52-32. The equipment is described in more detail in the SYSTEM DESIGN section.

Since the Saturn Shredder has been successfully utilized for reduction of wood and scrap metal volumes, the testing program developed, concentrated on low density materials (plastics, paper, herculite, rubber materials, tape and cloth) which had the potential to adhere to the shredder blades, and plug the shredder. Additionally, these materials represent a significant fraction of nuclear plant DAW. The densities of the compacted and shredded/compacted materials were low because of this material selection, however, the effects of shredding on waste volumes were considered representative.

The test was performed using the materials specified in Table II. These materials were unrolled and cut into sections to simulate their waste form. The materials were bagged in 55 gallon trash bags and the volume of waste measured. The waste was compacted into 55 gallon drums and the compacted waste volume measured. Compaction was accomplished using 16 psi at the ram face. The compacted material was then removed from the 55 gallon drums and shredded. The shredded material volume was measured before and after compaction. Waste material was shredded with different size cutter blades to determine the effect of cutter blade size on the VR factor. Additionally, one 55 gallon drum filled with simulated waste was shred (including the drum). The time required to shred all materials was recorded. Table III provides the measured data.

TABLE II

Material Utilized for
Shredder Testing

Item No.	Description	Weight
1	12 rolls masking tape	18
2	1 roll cheesecloth	7
3	2 rolls Herculite	95
4	1 roll visquene	18
5	25 yards heavy cotton cloth	20
6	30 ft 1 1/2" rubber hose	42
7	2 cases of polyethylene bottles (1 liter)	12
8	1 carton rubber gloves	7
9	1 roll Kraft paper (10α)	25
10	Scrap wood, metal, rubber and plastic	45
	TOTAL	289

The testing confirmed that compacting without shredding provided a VR factor of 5 for the materials selected using a compacting pressure of 16 psi. Shredding and compacting the same material using 1 1/2" cutting blades results in a VR factor of 2 over the compacted volume. Using 3/4" cutting blades increases the VR factor by 13% to 2.25 over the compacted volume.

TABLE III

Measured Data for Saturn Shredder Performance Test

Volume of waste before compacting	150 ft^3
Compacted volume	29.4 ft^3
Compacted weight	289 lbs
Volume after shredding (w/o compaction)	20.4 ft^3
Weight after shredding	289 lbs
Compacted volume after shredding (1 1/2" cutting blades)	14.7 ft^3
Shredding time (contents of compacted drum without shredding drum)	30-45 seconds
Shredding time (contents of compacted drum and drum)	1 minute

<u>Effects of Cutter Blade Size</u>

Shredded material volume before reshredding (1 1/2" blade)	7.35 ft^3
Shredded material volume after reshredding (1 1/2" blade)	6.27 ft^3
Shredded material volume before reshredding (3/4" blade)	7.35 ft^3
Shredded material volume after reshredding (3/4" blade)	5.55 ft^3

<u>Springback*</u>

Unshred/compacted material	47%
Shred/compacted material	12%

*Defined as the increase in volume from the fully compacted volume to the relaxed volume

SYSTEM DESIGN

The system combines a shredder and compactor as the major components for the processing and packaging of DAW. The system consists of:

- shredder
- compactor
- shredder feed conveyor
- compactor feed conveyor
- ventilation treatment subsystem
- control panel

In addition to the above major components, the system includes hydraulic drives for the shredder and compactor instrumentation and controls for the components, power distribution equipment and the ventilation fan. Figure 1 provides an arrangement for the processing equipment. This figure shows a space requirement of 21'x9'x15' high for the processing equipment. In addition, 7'x8'x8' high is required for the hydraulic drive unit. The hydraulic drive unit is located in a non-contaminated area for ease of access and maintenance. Where floor space is not available for the equipment arrangement shown, the conveyor ramp can be redesigned to require less floor space.

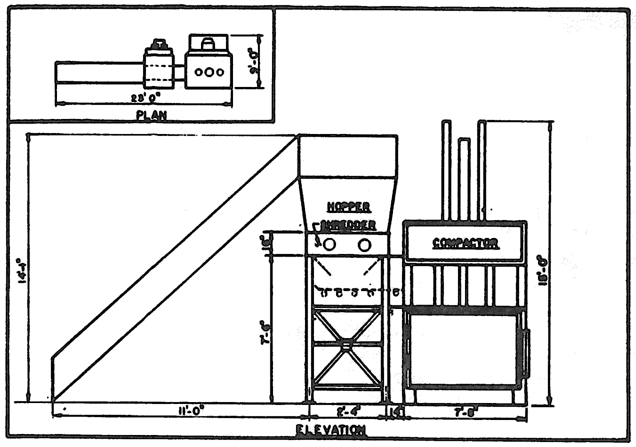

Fig. 1 Space Requirement for Processing Equipment

<u>Operation and Performance</u>

DAW is loaded onto the shredder conveyor. The feed to the shredder may be bags, 55 gallon drums or unpackaged individual items. The maximum size of the items which may be fed to the shredder is a function of the inlet opening. The shredder selected for this application has an inlet opening 52" by 32". Larger objects (eg. ladders, scaffolding) which can fit into the inlet opening but cannot be loaded by conveyor, can be fed to the shredder manually. This requires that a section of the ventilation housing be removed to feed the object.

The shredder unit is capable of shredding wood, plastics, rubber, cloth, paper and non-ferrous metals. Steel materials with a section thickness up to 1/4" may also be shred. The waste throughput rate for the shredder unit is a function of the waste material, the shredder size, input horsepower, and the size of the cutting blades. A 52-32 shredder with a 200 hp drive system and 1 1/2" cutting blades can shred a 55 gallon drum of compacted paper, plastic, rubber and wood in one minute (including the drum).

The shred material falls from the shredding chamber onto the compactor feed conveyor. The waste is conveyed to the compaction container until the compaction cycle is initiated. During the compaction cycle, the feed conveyors to the shredder and to the compactor are stopped.

The shredder unit is designed with an automatic reversal provision which reverses the cutter blades if a large object which cannot be shred in one cut enters the chamber. The unit will automatically drive the cutter blades forward and reverse a specified number of times to shred the material. If the material can not be cleared within a programmed number of reversals, the unit will automatically shut down to allow the object to be cleared. Because the hydraulic drives do not have to accelerate, as do motor drives, the full cutting force is achieved on each forward cycle following reversal.

Shredder

The shredder assembly utilizes two counterrotating shafts equipped with a series of intermeshing tool steel cutting wheels. The material is trapped between the wheels and is cut to the same size as the clearance between them depending on the material. The sizes range from 0.5 to 1.5 inches aggregate. Generally, metal and wood objects are shred to a smaller size than paper, textiles and plastics. Due to the intermeshing configuration, the cutting wheels are self-cleaning.

The two cutting shafts are driven by a high pressure hydraulic system with rotation reverse provisions. The cutting force provided is 58,000 pounds.

Due to its low speed operation, the shredder is relatively nondusting and nonsparking. The use of a hydraulic drive assures protection of the motive drive components and also results in negligible maintenance. The drive components are external to the assembly connected only by hydraulic piping. This prevents contamination of the drive equipment simplifying maintenance.

The shredder chamber, from the interface at the feed conveyor, to the interface with the box compactor is enclosed. The enclosure is maintained at slight negative pressure by an exhaust fan to preclude contamination spread.

Compactor

The shredder assembly can be mated with virtually any type of compactor. Due to the large throughput capacity, box compactors are more desirable than drum compactors. The shredder discharge conveyor is designed to interface with the compactor to fill the compactor containers. The compactor assembly is supplied with contamination control ventilation, including filtration treatment.

COST-BENEFIT EVALUATION

The performance of a cost-benefit evaluation of the shredder-compactor system is an important step in the decision-making process that a utility undergoes in reaching the decision to purchase such a system. The cost-benefit evaluation would typically include a comparison of the installed cost of the shredder/compactor against the savings in operating costs resulting from the transportation and disposal of a smaller volume of DAW. A utility planning to build an Interim On-Site storage facility would also include the capital cost savings associated with a smaller facility to store the reduced volume of DAW.

In the cost-benefit evaluation, the parameters of interest are:

a. the annual quantity of DAW currently being shipped;

b. the VR factor;

c. the distance to the burial site; and

d. the utilities economic factors, such as fixed charge rate, discount rate and escalation rate

The installed cost of the shredder compactor system will vary depending on the type of compactor included in the system or if the shredder assembly is to be interfaced with an existing compactor. Provided adequate space is available, the total installed cost of a shredder/compactor system utilizing a box compactor is estimated to be $450,000.

The bases for the economic evaluation are as follows:

- Cost of transportation and disposal of DAW - $\$25/ft^3$
- Installed cost of a shredder/compactor - $450,000
- Fixed charge rate - 20%/year over 25 years remaining plant life
- One-way distance to burial site - 1000 miles
- Escalation rate 9%/yr
- Discount rate 12%/yr
- Volume Reduction factor 1.7
- Annual DAW volume - 18,000 ft^3
- Ratio of compressible to non-compressible waste - 1

For these conditions, the present worth savings provided by the shredder/compactor is $3,000,000. The payback period on the shredder/compactor is 1.4 years. Table IV provides the economic comparison data for utilization of drum and/or box compactors without a shredder, and for use of a shredder/compactor system. Figure 2 presents the annual dollar savings for VR factors of 1.5 and 2.1 as a function of the annual volume of DAW currently being shipped.

TABLE IV

Comparative Costs for Processing DAW in a Shredder vs Typical Drum and Box Compactor

	Typical Drum/ Box-Compactor	Shredder/ Compactor
Disposal Volume	18,000 ft^3	10,600 ft^3
Labor (manhours)	2380	430
Labor Cost	$ 47,600	$ 8,600
Radiation Exposure (Man-Rem)	11.3	.8
Man-Rem Cost	$ 11,300	$ 800
Transportation Cost	$118,800	$ 70,000
Disposal Cost	$313,200	$184,400
Total Annual Cost	$490,900	$263,800
Net Annual Savings		$227,000

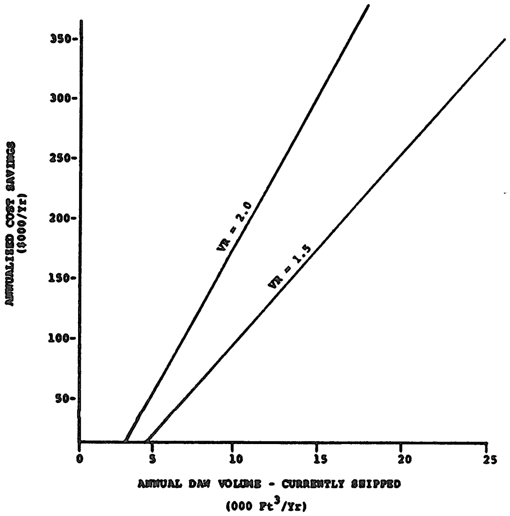

Fig. 2 Annual Cost Savings For Shredder Compactor System

CONCLUSIONS

The shredder/compactor can process materials typically found in DAW. For paper, plastics and rubber with small amounts of wood and metal, a 52-32 Saturn Shredder can process 50 to 75 ft^3/min compacted waste. The shredder/compactor can also reprocess compacted waste including 55 gallon drums containing the above materials at a rate of approximately one drum per minute. The shredder/compactor provides a volume reduction factor of 2 compared to a compactor only.

The shredder/compactor can provide cost-beneficial DAW volume reduction. Annual savings, based on processing 18,000 ft^3/year of DAW with a VR factor of 2.0 are over $300,000. The payback period for the shredder/compactor for these conditions is less than one year.